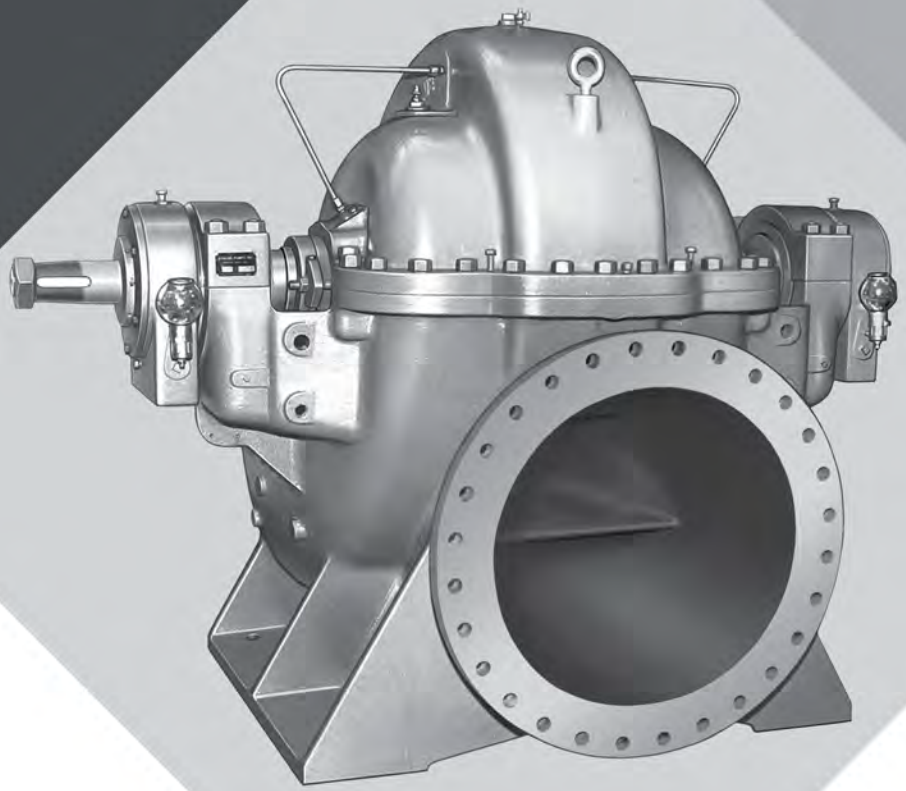
GOULDS PUMPS

Installation, Operation, and Maintenance Manual

Model 3420



ITT

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1 Introduction and Safety

1.1 Introduction

Purpose of this manual

The purpose of this manual is to provide necessary information for:

- Installation
- Operation
- Maintenance

CAUTION:
Failure to observe the instructions contained in this manual could result in personal injury and/or property damage, and may void the warranty. Read this manual carefully before installing and using the product.

NOTICE:
Save this manual for future reference and keep it readily available.

1.1.1 Requesting other information

Special versions can be supplied with supplementary instruction leaflets. See the sales contract for any modifications or special version characteristics. For instructions, situations, or events that are not considered in this manual or in the sales documents, please contact the nearest ITT representative.

Always specify the exact product type and serial number when requesting technical information or spare parts.

1.2 Safety

WARNING:

- Risk of serious personal injury. Applying heat to impellers, propellers, or their retaining devices can cause trapped liquid to rapidly expand and result in a violent explosion. This manual clearly identifies accepted methods for disassembling units. These methods must be adhered to. Never apply heat to aid in their removal unless explicitly stated in this manual.
- The operator must be aware of the pumpage and take appropriate safety precautions to prevent physical injury.
- Risk of serious injury or death. If any pressure-containing device is over-pressurized, it can explode, rupture, or discharge its contents. It is critical to take all necessary measures to avoid over-pressurization.
- Risk of death, serious personal injury, and property damage. Installing, operating, or maintaining the unit using any method not prescribed in this manual is prohibited. Prohibited methods include any modification to the equipment or use of parts not provided by ITT. If there is any uncertainty regarding the appropriate use of the equipment, please contact an ITT representative before proceeding.

- If the pump or motor is damaged or leaking, electric shock, fire, explosion, liberation of toxic fumes, physical harm, or environmental damage may result. Do not operate the unit until the problem has been corrected or repaired.
- Risk of serious personal injury or property damage. Dry running may cause rotating parts within the pump to seize to non-moving parts. Do not run dry.
- Risk of death, serious personal injury, and property damage. Heat and pressure buildup can cause explosion, rupture, and discharge of pumpage. Never operate the pump with suction and/or discharge valves closed.
- Running a pump without safety devices exposes operators to risk of serious personal injury or death. Never operate a unit unless appropriate safety devices (guards, etc.) are properly installed. See specific information about safety devices in other sections of this manual.

CAUTION:

- Risk of injury and/or property damage. Operating a pump in an inappropriate application can cause over pressurization, overheating, and/or unstable operation. Do not change the service application without the approval of an authorized ITT representative.

WARNING:
This product contains Carbon Black a chemical known to the State of California to cause cancer. For more information go to www.P65Warnings.ca.gov

1.2.1 Safety terminology and symbols

About safety messages

It is extremely important that you read, understand, and follow the safety messages and regulations carefully before handling the product. They are published to help prevent these hazards:

- Personal accidents and health problems
- Damage to the product
- Product malfunction

Hazard levels

Hazard level	Indication
 **DANGER:**	A hazardous situation which, if not avoided, will result in death or serious injury
 **WARNING:**	A hazardous situation which, if not avoided, could result in death or serious injury
 **CAUTION:**	A hazardous situation which, if not avoided, could result in minor or moderate injury
NOTICE:	• A potential situation which, if not avoided, could result in undesirable conditions • A practice not related to personal injury

Hazard categories

Hazard categories can either fall under hazard levels or let specific symbols replace the ordinary hazard level symbols.

Electrical hazards are indicated by the following specific symbol:

ELECTRICAL HAZARD:

These are examples of other categories that can occur. They fall under the ordinary hazard levels and may use complementing symbols:

- Crush hazard
- Cutting hazard
- Arc flash hazard

1.2.1.1 The Ex symbol

The Ex symbol indicates safety regulations for Ex-approved products when used in atmospheres that are potentially explosive or flammable.

1.2.2 Environmental safety

The work area

Always keep the station clean to avoid and/or discover emissions.

Waste and emissions regulations

Observe these safety regulations regarding waste and emissions:

- Appropriately dispose of all waste.
- Handle and dispose of the processed liquid in compliance with applicable environmental regulations.
- Clean up all spills in accordance with safety and environmental procedures.
- Report all environmental emissions to the appropriate authorities.

WARNING:
If the product has been contaminated in any way, such as from toxic chemicals or nuclear radiation, do NOT send the product to ITT until it has been properly decontaminated and advise ITT of these conditions before returning.

Electrical installation

For electrical installation recycling requirements, consult your local electric utility.

1.2.2.1 Recycling guidelines

Always follow local laws and regulations regarding recycling.

1.2.3 User safety

General safety rules

These safety rules apply:

- Always keep the work area clean.
- Pay attention to the risks presented by gas and vapors in the work area.
- Avoid all electrical dangers. Pay attention to the risks of electric shock or arc flash hazards.
- Always bear in mind the risk of drowning, electrical accidents, and burn injuries.

Safety equipment

Use safety equipment according to the company regulations. Use this safety equipment within the work area:

- Hardhat
- Safety goggles, preferably with side shields
- Protective shoes
- Protective gloves
- Gas mask
- Hearing protection
- First-aid kit
- Safety devices

Electrical connections

Electrical connections must be made by certified electricians in compliance with all international, national, state, and local regulations. For more information about requirements, see sections dealing specifically with electrical connections.

Noise

WARNING:
Sound pressure levels may exceed 80 dbA in operating process plants. Clear visual warnings or other indicators should be available to those entering an area with unsafe noise levels. Personnel should wear appropriate hearing protection when working on or around any equipment, including pumps. Consider limiting personnel's exposure time to noise or, where possible, enclosing equipment to reduce noise. Local law may provide specific guidance regarding exposure of personnel to noise and when noise exposure reduction is required.

Temperature

WARNING:
Equipment and piping surfaces may exceed 130ºF (54ºC) in operating process plants. Clear visual warnings or other indicators should alert personnel to surfaces that may reach a potentially unsafe temperature. Do not touch hot surfaces. Allow pumps operating at a high temperature to cool sufficiently before performing maintenance. If touching a hot surface cannot be avoided, personnel should wear appropriate gloves, clothing, and other protective gear as necessary. Local law may provide specific guidance regarding exposure of personnel to unsafe temperatures.

1.2.3.1 Precautions before work

Observe these safety precautions before you work with the product or are in connection with the product:

- Provide a suitable barrier around the work area, for example, a guard rail.
- Make sure that all safety guards are in place and secure.
- Make sure that you have a clear path of retreat.
- Make sure that the product cannot roll or fall over and injure people or damage property.
- Make sure that the lifting equipment is in good condition.
- Use a lifting harness, a safety line, and a breathing device as required.
- Allow all system and pump components to cool before you handle them.
- Make sure that the product has been thoroughly cleaned.
- Disconnect and lock out power before you service the pump.
- Check the explosion risk before you weld or use electric hand tools.

1.2.3.2 Precautions during work

Observe these safety precautions when you work with the product or are in connection with the product:

CAUTION:
Failure to observe the instructions contained in this manual could result in personal injury and/or property damage, and may void the warranty. Read this manual carefully before installing and using the product.

- Never work alone.
- Always wear protective clothing and hand protection.
- Stay clear of suspended loads.
- Always lift the product by its lifting device.
- Beware of the risk of a sudden start if the product is used with an automatic level control.
- Beware of the starting jerk, which can be powerful.
- Rinse the components in water after you disassemble the pump.
- Do not exceed the maximum working pressure of the pump.
- Do not open any vent or drain valve or remove any plugs while the system is pressurized. Make sure that the pump is isolated from the system and that pressure is relieved before you disassemble the pump, remove plugs, or disconnect piping.
- Never operate a pump without a properly installed coupling guard.

1.2.3.3 Hazardous liquids

The product is designed for use in liquids that can be hazardous to your health. Observe these rules when you work with the product:

- Make sure that all personnel who work with biologically hazardous liquids are vaccinated against diseases to which they may be exposed.
- Observe strict personal cleanliness.
- A small amount of liquid will be present in certain areas like the seal chamber.

1.2.3.4 Wash the skin and eyes

1. Follow these procedures for chemicals or hazardous fluids that have come into contact with your eyes or your skin:

Condition	Action
Chemicals or hazardous fluids in eyes	1. Hold your eyelids apart forcibly with your fingers. 2. Rinse the eyes with eyewash or running water for at least 15 minutes. 3. Seek medical attention.
Chemicals or hazardous fluids on skin	1. Remove contaminated clothing. 2. Wash the skin with soap and water for at least 1 minute. 3. Seek medical attention, if necessary.

1.3 Product approval standards

Regular standards

WARNING:
Use of equipment unsuitable for the environment can pose risks of ignition and/or explosion. Ensure the pump driver and all other auxiliary components meet the required area classification at the site. If they are not compatible, do not operate the equipment and contact an ITT representative before proceeding.

All standard products are approved according to CSA standards in Canada and UL standards in USA. The drive unit degree of protection follows IP68 according to standard IEC 60529.

1.4 Product warranty

Coverage

ITT undertakes to remedy faults in products from ITT under these conditions:

- The faults are due to defects in design, materials, or workmanship.
- The faults are reported to an ITT representative within the warranty period.
- The product is used only under the conditions described in this manual.
- The monitoring equipment incorporated in the product is correctly connected and in use.
- All service and repair work is done by ITT-authorized personnel.
- Genuine ITT parts are used.
- Only Ex-approved spare parts and accessories authorized by ITT are used in Ex-approved products.

Limitations

The warranty does not cover faults caused by these situations:

- Deficient maintenance
- Improper installation
- Modifications or changes to the product and installation made without consulting ITT
- Incorrectly executed repair work
- Normal wear and tear

ITT assumes no liability for these situations:

- Bodily injuries
- Material damages
- Economic losses

Warranty claim

ITT products are high-quality products with expected reliable operation and long life. However, should the need arise for a warranty claim, then contact your ITT representative.

1.5 Safety regulations for Ex-approved products in potentially explosive atmospheres

Special care must be taken in potentially explosive environments to ensure that the equipment is properly maintained. This includes but is not limited to:

Follow these special handling instructions if you have an Ex-approved unit.

Personnel requirements

These are the personnel requirements for Ex-approved products in potentially explosive atmospheres:

- All work on the product must be carried out by certified electricians and ITT-authorized mechanics. Special rules apply to installations in explosive atmospheres.
- All users must know about the risks of electric current and the chemical and physical characteristics of the gas, the vapor, or both present in hazardous areas.
- Any maintenance for Ex-approved products must conform to international and national standards (for example, EN 60079-17).

ITT disclaims all responsibility for work done by untrained and unauthorized personnel.

Product and product handling requirements

These are the product and product handling requirements for Ex-approved products in potentially explosive atmospheres:

- Only use the product in accordance with the approved motor data.
- The Ex-approved product must never run dry during normal operation. Dry running during service and inspection is only permitted outside the classified area.
- Before you start work on the product, make sure that the product and the control panel are isolated from the power supply and the control circuit, so they cannot be energized.
- Do not open the product while it is energized or in an explosive gas atmosphere.
- Make sure that thermal contacts are connected to a protection circuit according to the approval classification of the product, and that they are in use.
- Intrinsically safe circuits are normally required for the automatic level-control system by the level regulator if mounted in zone 0.
- The yield stress of fasteners must be in accordance with the approval drawing and the product specification.
- Do not modify the equipment without approval from an authorized ITT representative.
- Only use parts that are provided by an authorized ITT representative.

Description of Ex-Directives

The Ex-directives are a specification enforced in Europe and the United Kingdom for electrical and non-electrical equipment installed in those locations. Ex-directives deal with the control of potentially explosive atmospheres and the standards of equipment and protective systems used within these atmospheres. The relevance of the Ex-requirements is not limited to Europe or the UK. You can apply these guidelines to equipment installed in any potentially explosive atmosphere.

Guidelines for compliance

Compliance is fulfilled only when you operate the unit within its intended use. Do not change the conditions of the service without the approval of an ITT representative. When you install or maintain explosion proof products, always comply with the directive and applicable standards (for example, IEC/EN 60079-14).

1. Monitoring the liquid end temperature.
2. Maintaining proper bearing lubrication.
3. Ensuring that the pump is operated in the intended hydraulic range.

The Ex conformance is only applicable when the pump unit is operated within its intended use. Operating, installing or maintaining the pump unit in any way that is not covered in the Instruction, Operation, and Maintenance manual (IOM) can cause serious personal injury or damage to the equipment. This includes any modification to the equipment or use of parts not provided by ITT Goulds Pumps. If there is any question regarding the intended use of the equipment, please contact an ITT Goulds representative before proceeding.

Current IOMs are available at https://www.gouldspumps.com/en-US/Tools-and-Resources/Literature/IOMs/ or from your local ITT Goulds Pumps Sales representative.

All pumping unit (pump, seal, coupling, motor and pump accessories) certified for use in an Ex classified environment, are identified by an Ex tag secured to the pump or the on which it is mounted. A typical tag would look like this:

If applicable, your pump may have either a CE Ex (ATEX) tag or UKCA Ex tag affixed to the pump. See the Safety section for a description of the symbols and codes. Typical nameplate only shown below, the actual area classification may be different.

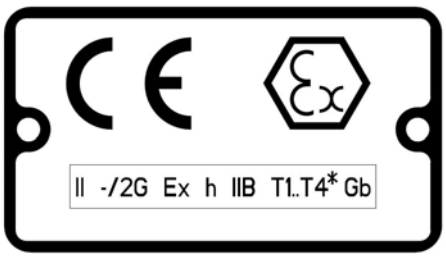


Figure 1: Typical Ex nameplate

Figure 2: Typical UKCA Ex nameplate

Table 1: Temperature class definitions

Code	Maximum permissible surface temperature in °C | °F	Maximum permissible liquid temperature in °C | °F
T1	440 | 824	372 | 700
T2	290 | 554	267 | 513
T3	195 | 383	172 | 342

Code	Maximum permissible surface temperature in °C | °F	Maximum permissible liquid temperature in °C | °F
T4	130 | 266	107 | 225
T5	Option not available	Option not available
T6	Option not available	Option not available

* Maximum liquid temperature may be limited by the pump model and order specific options. Table 1: Temperature class definitions on page 11 is for the purpose of determining T'x' code for Ex applications with liquid temperatures exceeding 107ºC | 225ºF.

The code classification marked on the equipment must be in accordance with the specified area where the equipment will be installed. If it is not, do not operate the equipment and contact your ITT Goulds Pumps sales representative before proceeding.

Equipment for monitoring

For additional safety, use condition-monitoring devices. Condition-monitoring devices include but are not limited to these devices:

WARNING:

- When pumping unit is installed in a potentially explosive atmosphere, the instructions after the Ex symbol must be followed. Personal injury and/or equipment damage may occur if these instructions are not followed. If there is any question regarding these requirements or if the equipment is to be modified, please contact a Goulds representative before proceeding.
- If equipment is to be installed in a potentially explosive atmosphere and these procedures are not followed, personal injury or equipment damage from an explosion may result.
- Particular care must be taken when the electrical power source to the equipment is energized.
- Improper impeller adjustment could cause contact between the rotating and stationary parts, resulting in a spark and heat generation.
- Lock out driver power to prevent electric shock, accidental start-up and physical injury.
- NEVER start pump without proper prime (all models), or proper liquid level in self-priming pumps (Model 3796 and SP3298).
- Equipment that will operate in a potentially explosive environment must be installed in accordance with the following instructions.
- All equipment being installed must be properly grounded to prevent unexpected static electric discharge. This includes ensuring that the PFA lined pumps (Model 3198), ETFE lined pumps (Model 3298, SP3298, V3298), and the non-metallic liquid end pumps (Model NM3196) are pumping fluids that are conductive. If not, a static electric discharge may occur when the pump is drained and disassembled for maintenance purposes.
- All equipment being installed must be properly grounded to prevent unexpected static electric discharge.
- When pumping fluids with conductivity less than 1000 ps/m follow IEC TS 60079 32-1 guidelines.
- Alignment procedures must be followed to prevent unintended contact of rotating parts. Follow coupling manufacturer’s installation and operation procedures.
- When installing in a potentially explosive environment, ensure that the motor and accessories are properly certified.
- The impeller clearance setting procedure must be followed. Improperly setting the clearance or not following any of the proper procedures can result in sparks, unexpected heat generation and equipment damage.

- The impeller and wear ring clearance setting procedures must be followed. Improperly setting the clearance or not following any of the proper procedures can result in sparks, unexpected heat generation and equipment damage.
- Service temperature in an Ex classified environment is limited to the area classification specified on the Ex tag affixed to the pump (reference Table 1 in the Safety section for Ex classifications).
- The coupling used in an Ex classified environment must be properly certified.
- The coupling guard used in an Ex classified environment must be constructed from a spark-resistant material.
- Bearings must be lubricated properly in order to prevent excess heat generation, sparks and premature failure.
- The mechanical seal used in an Ex classified environment must be properly certified.
- The mechanical seal must have an appropriate seal flush system. Failure to do so will result in excess heat generation and seal failure.
- Packed stuffing boxes are not allowed in an Ex classified environment.
- Dynamic seals are not allowed in an Ex classified environment.
- Pumps that are not self-priming must be fully primed at all times during operation. The only model lines that are self-priming is the 3796 and SP3298.
- Pumps must be fully primed at all times during operation.
- The preventive maintenance section must be adhered to in order to keep the applicable Ex classification of the equipment. Failure to follow these procedures will void the Ex classification for the equipment. Bearing replacement intervals are given in the specific pump model IOM.
- Inspection intervals should be shortened appropriately if the pumpage is abrasive and/or corrosive, or if the environment is classified as potentially explosive.
- Throughout this section on bearing lubrication, different pumpage temperatures are listed. If the equipment is Ex certified and the listed temperature exceeds the applicable value shown in Table 1 under SAFETY, then that temperature is not valid. Should this situation occur, please consult with your ITT/Goulds representative.
- Cooling systems, such as those for bearing lubrication, mechanical seal systems, etc., where provided, must be operating properly to prevent excess heat generation, sparks and premature failure.
- Rotate shaft by hand to ensure it rotates smoothly and there is no rubbing which could lead to excess heat generation, sparks and premature failure.
- Flange loads from the piping system, including those from thermal expansion of the piping, must not exceed the limits of the pump. Casing deformation can result in contact with rotating parts which can result in excess heat generation, sparks and premature failure.
- Ensure that pump and systems are free of foreign objects before operating and that objects cannot enter the pump during operation. Foreign objects in the pumpage or piping system can cause blockage of flow which can result in excess heat generation, sparks and premature failure.
- Do not insulate or allow the bearing housings to accumulate a dust layer as this can result in excess heat generation, sparks and premature failure.
- Check for magnetism on the pump shaft and demagnetize the shaft if there is any detectable magnetism. Magnetism will attract ferritic objects to the impeller, seals and bearings which can result in excess heat generation, sparks and premature failure.
- Leakage of process liquid may result in creation of an explosive atmosphere. Ensure the materials of the pump casing, impeller, shaft, sleeves, gaskets and seals are compatible with the process liquid.

- Leakage of process liquid may result in creation of an explosive atmosphere. Follow all pump and seal assembly procedures.
- A buildup of gases within the pump, sealing system and or process piping system may result in an explosive environment within the pump or process piping system. Ensure process piping system, pump and sealing system are properly vented prior to operation.
- Sealing systems that are not self purging or self venting, such as plan 23, require manual venting prior to operation. Failure to do so will result in excess heat generation and seal failure.
- Do not apply additional paint or coatings to the pump when in an Ex environment. Static electric discharge can be initiated when contacting or rubbing surfaces with excessive coating thickness.
- Potential electrostatic charging hazard. Do not rub, clean, or blast equipment with dry cloth or dry media.
- Stray electrical currents may ignite explosive atmospheres. Ensure drives are certified for variable frequency drive operation by the manufacturer.
- User shall observe necessity of using a safety device, such as a flame arrestor, to prevent flame entering or leaving the pump sump, tank, or barrel when applicable.
- For variable speed motor applications, the electric motor must be specified with shaft grounding and used with a conductive type coupling suitable for the area classification.
- In plants or pumps with cathodic corrosion protection, a small current constantly flows through the construction. This is not permissible on the complete pump or partially-assembled machinery without further precautions being taken. ITT should be consulted in this context.

2 Transportation and Storage

2.1 Inspect the delivery

2.1.1 Inspect the package

1. Inspect the package for damaged or missing items upon delivery.
2. Note any damaged or missing items on the receipt and freight bill.
3. File a claim with the shipping company if anything is out of order.
   If the product has been picked up at a distributor, make a claim directly to the distributor.

2.1.2 Inspect the unit

1. Remove packing materials from the product.
   Dispose of all packing materials in accordance with local regulations.
2. Inspect the product to determine if any parts have been damaged or are missing.
3. If applicable, unfasten the product by removing any screws, bolts, or straps.
   For your personal safety, be careful when you handle nails and straps.
4. Contact your sales representative if anything is out of order.

2.2 Transportation guidelines

2.2.1 Pump handling

WARNING:
Dropping, rolling or tipping units, or applying other shock loads, can cause property damage and/or personal injury. Ensure that the unit is properly supported and secure during lifting and handling.

CAUTION:
Risk of injury or equipment damage from use of inadequate lifting devices. Ensure lifting devices (such as chains, straps, forklifts, cranes, etc.) are rated to sufficient capacity.

2.2.2 Lifting methods

WARNING:

- Risk of serious personal injury or equipment damage. Proper lifting practices are critical to safe transport of heavy equipment. Ensure that practices used are in compliance with all applicable regulations and standards.
- Safe lifting points are specifically identified in this manual. It is critical to lift the equipment only at these points. Integral lifting eyes or eye bolts on pump and motor components are intended for use in lifting the individual components only.
- Lifting and handling heavy equipment poses a crush hazard. Use caution during lifting and handling and wear appropriate Personal Protective Equipment (PPE, such as steel-toed shoes, gloves, etc.) at all times. Seek assistance if necessary.
- Do not attach sling ropes to shaft ends.

The unit must be unloaded and handled by lifting equally at four or more points on the baseplate. The lugs on the upper half casing are designed for lifting the upper half of the casing only.

Pump mounting	Lifting method
Bare pump	Hitch a nylon sling, chain, or wire rope around both bearing housings.
Pump and base	Support the pump with a sling under the two bearing housings and a sling under the motor end of the baseplate.
Pump, base, and motor	Attach slings to the baseplate lifting lugs. Use a spreader bar so that the pump is not damaged.

- **Bare pump**

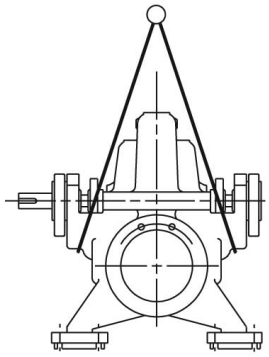
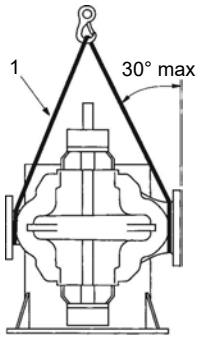


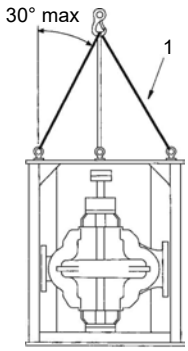
Figure 3: The proper lifting method for a bare pump

- **Pump and base**



1. Nylon sling, chain, or wire rope

Figure 4: The proper lifting method for a vertical pump mounted on a half pedestal



1. Nylon sling, chain, or wire rope

Figure 5: The proper lifting method for a vertical pump mounted on a full pedestal

- **Pump, base, and motor**

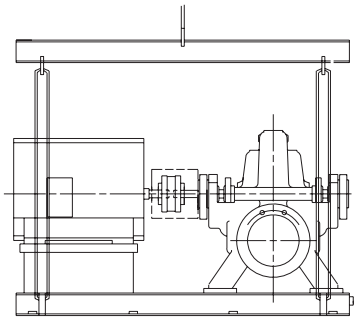


Figure 6: The proper lifting method for pump, base, and motor

2.3 Storage guidelines

2.3.1 Pump storage requirements

Storage requirements depend on the amount of time that you store the unit. The normal packaging is designed only to protect the unit during shipping.

Length of time in storage	Storage requirements
Upon receipt/short-term (less than six months)	• Store in a covered and dry location. • Store the unit free from dirt and vibrations.
Long-term (more than six months)	• Store in a covered and dry location. • Store the unit free from heat, dirt, and vibrations. • Rotate the shaft by hand several times at least every three months.

Treat bearing and machined surfaces so that they are well preserved. Refer to drive unit and coupling manufacturers for their long-term storage procedures.

You can purchase long-term storage treatment with the initial unit order or you can purchase it and apply it after the units are already in the field. Contact your local ITT sales representative.

2.3.2 Frostproofing

Table 2: Situations when the pump is or is not frostproof

Situation	Condition
Operating	The pump is frostproof.
Immersed in a liquid	The pump is frostproof.
Lifted out of a liquid into a temperature below freezing	The impeller might freeze.

3 Product Description

3.1 General Description

Product description

Model 3420 is a horizontal, centrifugal pump with these characteristics:

- Single stage
- Double suction
- Enclosed impeller

Model 3420 uses English dimensions.

Casing

- The casing is horizontally split. The upper and lower halves are held together with studs and nuts or capscrews.
  - The upper half has a vent connection, a priming connection, and one or two stuffing-box seal ring connections.
  - The lower half has two drain connections, suction and discharge gauge connections, and stuffing-box overflow connections.
- Flanged suction and discharge connections are located in the lower half of the casing and conform to ANSI 16.1/16.5 class 125/150.
- The casing is supported by integrally cast feet.
- Separate bearing housings are attached directly to machined fits in each end of the casing with capscrews or machined fits that are secured with bearing caps, studs, and nuts.
- All sizes have:
  - Dual volute casings in order to reduce radial loads on the shaft
  - Two jacking screws
  - Two lifting lugs for the upper half
  - Two tapered dowel pins for alignment
  - Non-asbestos parting gasket, 0.030 or 0.016 in. (0.75 or 0.41 mm)

Impeller

- Enclosed, double-suction design for axial hydraulic balance
- Fully machined exterior surfaces
- Receives a one- or two-plane spin balance
- Keyed to the shaft and held in place with shaft sleeves and sleeve nuts

Wear rings

- Casing and impeller wear rings maintain proper running clearances and minimize leaks between the suction and discharge chambers in the casing.
- Casing rings are held in place with a machined hook lock.
- Impeller rings are held in place with axial setscrews.

Shaft

- Maximum shaft deflection of 0.002 in. (0.051 mm) at the stuffing-box face under the worst operating conditions

- Completely dry with O-ring seals between the impeller and shaft sleeves, and between the shaft sleeves and the sleeve nuts
- Made from AISI 4340 steel with an option for 316 stainless steel

Shaft sleeves

- Standard on all pumps
- Keyed to the shaft at the impeller
- Held in place with sleeve nuts, which tighten against rotation and are secured in place with set-screws

Stuffing box

- Non-asbestos packing
- Contains a PTFE™ split lantern ring and renewable stuffing box throat bushings
- Tapped openings for water sealing from either the pump casing or an outside source
- Bypass piping, optional
- Two-piece machined split glands

3.1.1 Pump group definitions

These pumps are configured in several different groups that are based on bearing configurations and hydraulic sizes:

Group	Type of bearings	Type of lube	Bearing attachment	Type of seals	Hydraulic sizes
SX	Ball radial and duplex ball thrust bearings	Flood oil lube with constant level oiler, optional grease lube	Bearing housings bolted to the casing	Non-metallic labyrinth seals	12x14-15 16x18-17H
MX	Ball radial and duplex ball thrust bearings	Flood oil lube with constant level oiler, optional grease lube	Bearing housings bolted to the casing	Non-metallic labyrinth seals	18x20-20
M	Ball radial and duplex ball thrust bearings	Ring oil lube with constant level oiler, optional grease lube	Bearing housing secured with tongue and groove fits and a bearing cap with studs and nuts	Metallic labyrinth seals	16x18-30 18x20-30 20x24-24 20x24-30
M (modified)	(Same as M group except the shaft is longer in order to accommodate a wider pump.)				20x24-28
—	Ball radial and duplex ball thrust bearings	Ring oil lube with constant level oiler, optional grease lube	Bearing housing secured with tongue and groove fits and a bearing cap with studs and nuts	Metallic labyrinth seals	18x20-24
L	Double row roller bearings, both thrust and radial	Ring oil lube with constant level oiler, optional grease lube	Bearing housing secured with tongue and groove fits and a bearing cap with studs and nuts	Metallic labyrinth seals	24x30-32

Group	Type of bearings	Type of lube	Bearing attachment	Type of seals	Hydraulic sizes
LDS	Double row roller bearings, both thrust and radial	Ring oil lube with constant level oiler, optional grease lube	Bearing housing secured with tongue and groove fits and a bearing cap with studs and nuts	Metallic labyrinth seals	30x30-31 30x30-38
XL	Double row roller bearings, both thrust and radial	Ring oil lube with constant level oiler, optional grease lube	Bearing housing secured with tongue and groove fits and a bearing cap with studs and nuts	Metallic labyrinth seals	30x36-42 20x30-42
XXL	Double row roller bearings, both thrust and radial	Ring oil lube with constant level oiler, optional grease lube	Bearing housing secured with tongue and groove fits and a bearing cap with studs and nuts	Metallic labyrinth seals	36x42-52

3.2 Nameplate information

Important information for ordering

Every pump has nameplates that provide information about the pump. The nameplates are located on the casing and the bearing frame.

When you order spare parts, identify this pump information:

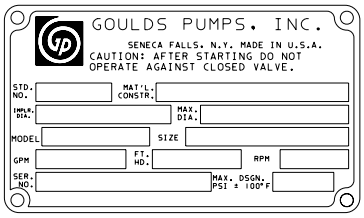
- Model
- Size
- Serial number
- Item numbers of the required parts

Refer to the nameplate on the pump casing for most of the information. See Parts List for item numbers.

Nameplate types

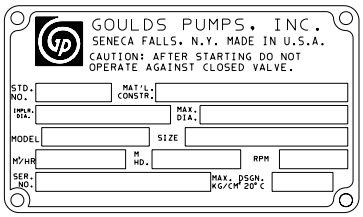
Nameplate	Description
Pump casing	Provides information about the hydraulic characteristics of the pump. The formula for the pump size is: Discharge x Suction - Nominal Maximum Impeller Diameter in inches. (Example: 2x3-8)
Bearing frame	Provides information about the lubrication system used.
Ex	If applicable, your pump unit might have an Ex nameplate affixed to the pump, the baseplate, or the discharge head. The nameplate provides information about the Ex specifications of this pump.
IECEx	If applicable, your pump unit might have the following IECEx nameplate affixed to the pump and/or baseplate. The nameplate provides information about the IECEx specifications of this pump.

Nameplate on the pump casing using English units



Nameplate field	Explanation
STD. NO.	ANSI standard designation
MAT'L. CONST.	Material of which the pump is constructed
IMPLR. DIA.	Impeller diameter, in inches
MAX. DIA.	Maximum impeller diameter, in inches
MODEL	Pump model
SIZE	Size of the pump
GPM	Rated pump flow, in gallons per minute
FT. HD.	Rated pump head, in feet
RPM	Rated pump speed, revolutions per minute
SER. NO.	Serial number of the pump
MAX. DSGN. PSI @ 100F	Maximum pressure at 100ºF according to the pump design

Nameplate on the pump casing using metric units



Nameplate field	Explanation
STD. NO.	ANSI standard designation
MAT'L. CONST.	Material of which the pump is constructed
IMPLR. DIA.	Impeller diameter
MAX. DIA.	Maximum impeller diameter
MODEL	Pump model
SIZE	Size of the pump
M^3/HR	Rated pump flow, in cubic meters per hour
M HD.	Rated pump head, in meters
RPM	Rated pump speed, revolutions per minute
SER. NO.	Serial number of the pump
MAX. DSGN KG/CM^2 @ 20°C	Maximum pressure at 20ºC according to the pump design

Nameplate on the bearing frame

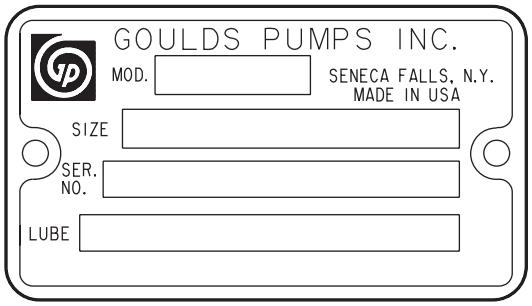


Table 3: Explanation of the nameplate on the bearing frame

Nameplate field	Explanation
MOD.	Pump model
SIZE	Size of the pump
SER. NO.	Serial number of the pump
LUBE	Lubricant, oil or grease

Ex nameplate

All pumping unit (pump, seal, coupling, motor and pump accessories) certified for use in an Ex classified environment, are identified by an Ex tag secured to the pump or baseplate on which it is mounted. A typical tag would look like this:

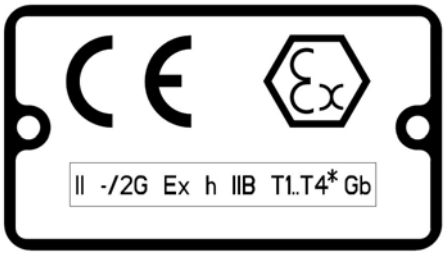


Figure 7: Typical Ex nameplate

Figure 8: Typical UKCA Ex nameplate

Refer to Table 1: Temperature class definitions on page 11 for allowable pumpage temperatures.

WARNING:
Use of equipment unsuitable for the environment can pose risks of ignition and/or explosion. Ensure the pump driver and all other auxiliary components meet the required area classification at the site. If they are not compatible, do not operate the equipment and contact an ITT representative before proceeding.

4 Installation

4.1 Pre-installation

Precautions

WARNING:

- When installing in a potentially explosive environment, ensure that the motor is properly certified.
- All equipment being installed must be properly grounded to prevent unexpected discharge. Discharge can cause equipment damage, electric shock, and result in serious injury. Test the ground lead to verify it is connected correctly.

NOTICE:

- Electrical connections must be made by certified electricians in compliance with all international, national, state and local regulations.
- Supervision by an authorized ITT representative is recommended to ensure proper installation. Improper installation may result in equipment damage or decreased performance.

4.1.1 Pump location guidelines

Guideline	Explanation/comment
Keep the pump as close to the liquid source as practically possible.	This minimizes the friction loss and keeps the suction piping as short as possible.
Make sure that the space around the pump is sufficient.	This facilitates ventilation, inspection, maintenance, and service.
If you require lifting equipment such as a hoist or tackle, make sure that there is enough space above the pump.	This makes it easier to properly use the lifting equipment and safely remove and relocate the components to a safe location.
Be sure to allow space for removing the upper half of the casing and a crane or hoist.	Refer to height requirements for removing the upper half of the casing. See Remove the casing in the Maintenance chapter.
Protect the unit from weather and water damage due to rain, flooding, and freezing temperatures. If the possibility of freezing exists during a shutdown period, then drain the pump completely and use compressed air to blow out all passages and pockets where liquid might collect.	This is applicable if nothing else is specified.
Do not install and operate the equipment in closed systems unless the system is constructed with properly-sized safety devices and control devices.	Acceptable devices: • Pressure relief valves • Compression tanks • Pressure controls • Temperature controls • Flow controls If the system does not include these devices, consult the engineer or architect in charge before you operate the pump.
Take into consideration the occurrence of unwanted noise and vibration.	The best pump location for noise and vibration absorption is on a concrete floor with subsoil underneath.

Guideline	Explanation/comment
Make sure there is a suitable power source available for the pump driver.	If the pump is motor-driven, then the electrical characteristics of the power source should be identical to those shown on motor data plate.

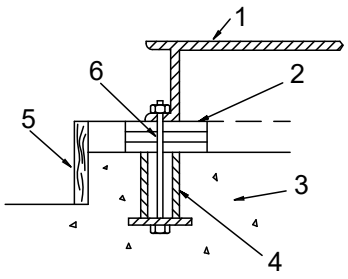
The installation must be evaluated to determine that the Net Positive Suction Head Available ($NPSH_A$) meets or exceeds the Net Positive Suction Head Required ($NPSH_R$), as stated by the pump performance curve.

4.1.2 Foundation requirements

Requirements

- The foundation must weigh at least five times the weight of the pump unit.
- Provide a flat, substantial concrete foundation in order to prevent strain and distortion when you tighten the foundation bolts.
- Allow the foundation to cure for several days before you proceed with the pump installation.
- The foundation must be poured to within 1.905 – 3.81 cm | 0.75 – 1.5 in. of the finished height.

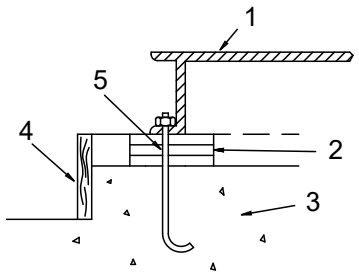
Sleeve-type bolts



Item	Description
1.	Baseplate
2.	Shims
3.	Foundation
4.	Sleeve
5.	Dam
6.	Bolt

Figure 9: Sleeve type bolts

J-type bolts



Item	Description
1.	Baseplate
2.	Shims or wedges
3.	Foundation
4.	Dam
5.	Bolt

Figure 10: J-type bolts

Foundation bolts

- Foundation bolts must be embedded in the concrete to a depth of 8â12 in. (20â30 cm) and locked with either a hook around a reinforcing bar or a nut and washer at the bottom.
- Foundation bolts must have a sleeve around them at least six times the bolt diameter in length and at least two bolt sizes larger in ID.
- If a nut and washer are used for locking, then the washer must have an OD two sizes larger than the sleeve.
- Foundation bolts must be sized 3.175 mm | 0.125 in. less than the anchor bolt holes in the base.

4.2 Baseplate-mounting procedures

4.2.1 Prepare the baseplate for mounting

This procedure assumes you have a basic knowledge of baseplate and foundation design and installation methods. Follow industry-standard procedures, such as API RP 686/ PIP REIE 686, or this procedure before you grout the baseplate.

1. Make sure that all baseplate surfaces that will contact grout are free from contamination such as rust, oil, and grime.
2. Thoroughly clean all baseplate surfaces that will come in contact with grout.
   Make sure to use a cleaner that will not leave residue.

NOTICE:

You may need to sandblast the surfaces of a baseplate that come in contact with grout, and then coat those surfaces with a primer that is grout-compatible. Make sure to remove all equipment before sandblasting.

NOTICE:

Remove all dirt from the mounting pads in order to ensure that the correct leveling is achieved. Failure to do so can result in equipment damage or decreased performance.

3. Make sure that all machined surfaces are free from burrs, rust, paint, or any other type of contamination.
   If necessary, use a honing stone to remove burrs.

4.2.2 Prepare the foundation for mounting

1. Chip the top of the foundation to a minimum of 25.0 mm | 1.0 in. in order to remove porous or low-strength concrete.
   If you use a pneumatic hammer, make sure that it does not contaminate the surface with oil or other moisture.

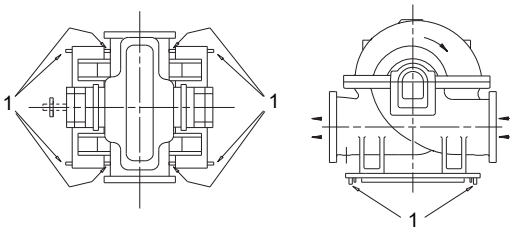
NOTICE:

Do not chip the foundation using heavy tools such as jackhammers. This can damage the structural integrity of the foundation.

2. Remove water or debris from the foundation bolt holes or sleeves.
3. If the baseplate uses sleeve-type bolts, then fill the sleeves with a non-binding, moldable material. Seal the sleeves in order to prevent the grout from entering.
4. Coat the exposed portion of the anchor bolts with a non-bonding compound such as paste wax in order to prevent the grout from adhering to the anchor bolts.
   Do not use oils or liquid wax.
5. If recommended by the grout manufacturer, coat the foundation surface with a compatible primer.

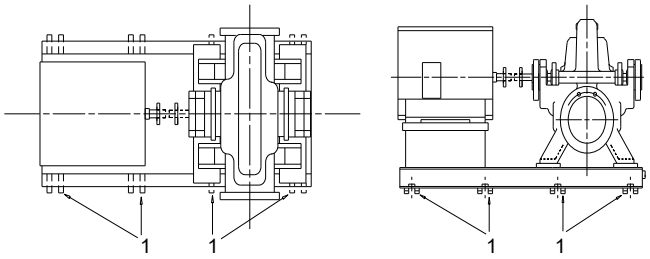
4.2.3 Install and level the baseplate

1. Place two sets of wedges or shims on the foundation, one set on each side of every foundation bolt. Make sure that the wedges extend 0.75 in. - 1.50 in. (19.05 mm - 38.10 mm) above the foundation in order to allow for adequate grouting. This provides even support for the baseplate once it is grouted.



   1. Shims or wedges

2. Remove water and/or debris from the anchor bolt holes or sleeves before you grout.
   If you use sleeve-type bolts, then fill the sleeves with rags in order to prevent grout from entering.
3. Carefully lower the baseplate onto the foundation bolts.
4. Level the baseplate to within 0.125 in. (3.175 mm) over the length of the baseplate and to within 0.088 in. (2.24 mm) over the width of the baseplate by adjusting the wedges.
   If the baseplate has vertical leveling screws, then use the screws in order to level the base.



1. Shims or wedges

5. Hand-tighten the foundation bolts.

4.3 Install the pump, driver, and coupling

Perform these steps only if the unit was not installed at the factory.

1. Mount and fasten the pump on the baseplate. Use applicable bolts.
2. Mount the driver on the baseplate. Use applicable bolts and hand tighten.
3. Install the coupling.
   See the installation instructions from the coupling manufacturer.

4.4 Pump-to-driver alignment

Precautions

WARNING:

- Failure to disconnect and lock out driver power may result in serious physical injury or death. Always disconnect and lock out power to the driver before performing any installation or maintenance tasks.
  - Electrical connections must be made by certified electricians in compliance with all international, national, state, and local rules.
  - Refer to driver/coupling/gear manufacturer's installation and operation manuals (IOM) for specific instructions and recommendations.

4.4.1 Alignment checks

When to perform alignment checks

You must perform alignment checks under these circumstances:

- The process temperature changes.
- The piping changes.
- The pump has been serviced.

Types of alignment checks

Type of check	When it is used
Initial alignment (cold alignment) check	Prior to operation when the pump and the driver are at ambient temperature.
Final alignment (hot alignment) check	After operation when the pump and the driver are at operating temperature.

Initial alignment (cold alignment) checks

When	Why
Before you grout the baseplate	This ensures that alignment can be accomplished.
After you grout the baseplate	This ensures that no changes have occurred during the grouting process.
After you connect the piping	This ensures that pipe strains have not altered the alignment. If changes have occurred, you must alter the piping to remove pipe strains on the pump flanges.

Final alignment (hot alignment) checks

When	Why
After the first run	This ensures correct alignment when both the pump and the driver are at operating temperature.
Periodically	This follows the plant operating procedures.

4.4.2 Permitted indicator values for alignment checks

NOTICE:
The specified permitted reading values are valid only at operating temperature. For cold settings, other values are permitted. The correct tolerances must be used. Failure to do so can result in misalignment. Contact ITT for further information.

When dial indicators are used to check the final alignment, the pump and drive unit are correctly aligned when the total indicator runout is a maximum of 0.05 mm | 0.002 in. at operating temperature.

Alignment values during installation

During the installation phase, you must set the parallel alignment in the vertical direction to a different criteria due to differences in expansion rates of the pump and driver. This table shows the recommended preliminary (cold) settings for electric motor-driven pumps based on different pumped fluid temperatures. Consult the driver manufacturers for recommended cold settings for other types of drivers such as steam turbines and engines.

Table 4: Cold setting of parallel vertical alignment

Temperature of pumped fluid	Set driver shaft
ambient	N/A
37.7°C | 100°F	0.000 to 0.0508 mm | 0.000 to 0.002 in. high
93.3°C | 200°F	0.0508 to 0.1016 mm | 0.002 to 0.004 in. high
148.8°C | 300°F	0.1016 to 0.1524 mm | 0.004 to 0.006 in. high

4.4.3 Alignment measurement guidelines

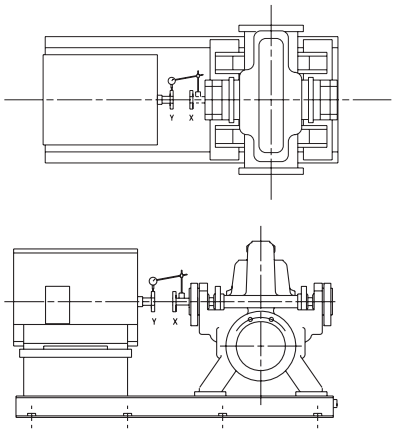
Guideline	Explanation
Rotate the pump coupling half and the driver coupling half together so that the indicator rods have contact with the same points on the driver coupling half.	This prevents incorrect measurement.
Move or shim only the driver in order to make adjustments.	This prevents strain on the piping installations.
Make sure that the hold-down bolts for the driver are tight when you take indicator measurements.	This keeps the driver stationary since movement causes incorrect measurement.

Guideline	Explanation
Make sure that the hold-down bolts for the driver are loose before you make alignment corrections.	This makes it possible to move the driver when you make alignment corrections.
Check the alignment again after any mechanical adjustments.	This corrects any misalignments that an adjustment may have caused.

4.4.4 Attach the dial indicators for alignment

You must have two dial indicators in order to complete this procedure.

1. Attach two dial indicators on the pump coupling half (X):
   a) Attach one indicator (P) so that the indicator rod comes into contact with the perimeter of the driver coupling half (Y).
   This indicator is used to measure parallel misalignment.
   b) Attach the other indicator (A) so that the indicator rod comes into contact with the inner end of the driver coupling half.
   This indicator is used to measure angular misalignment.



2. Rotate the pump coupling half (X) in order to check that the indicators are in contact with the driver coupling half (Y) but do not bottom out.
3. Adjust the indicators if necessary.

4.4.5 Perform angular alignment for a vertical correction

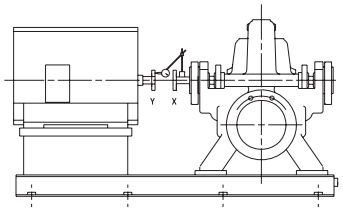
Before you start this procedure, make sure that the dial indicators are properly attached for measurement.

1. Set the angular alignment indicator to zero at the top-center position (12 o'clock) of the driver coupling half (Y).
2. Rotate the indicator to the bottom-center position (6 o'clock).
3. Record the indicator reading.

When the reading value is...	Then...
Negative	The coupling halves are farther apart at the bottom than at the top. Perform one of these steps: • Add shims in order to raise the feet of the driver at the shaft end. • Remove shims in order to lower the feet of the driver at the other end.

When the reading value is...	Then...
Positive	The coupling halves are closer at the bottom than at the top. Perform one of these steps: • Remove shims in order to lower the feet of the driver at the shaft end. • Add shims in order to raise the feet of the driver at the other end.

4. Repeat these steps until indicator A reads 0.05 mm | 0.002 in. or less.



4.4.6 Perform angular alignment for a horizontal correction

1. Set the angular alignment indicator (A) to zero on left side of the driver coupling half (Y), 90° from the top-center position (9 o'clock).
2. Rotate the indicator through the top-center position to the right side, 180° from the start position (3 o'clock).
3. Record the indicator reading.

When the reading value is...	Then...
Negative	The coupling halves are farther apart on the right side than the left. Perform one of these steps: • Slide the shaft end of the driver to the left. • Slide the opposite end to the right.
Positive	The coupling halves are closer together on the right side than the left. Perform one of these steps: • Slide the shaft end of the driver to the right. • Slide the opposite end to the left.

4.4.7 Perform parallel alignment for a vertical correction

Refer to the alignment table in "Permitted indicator values for alignment checks" (see Table of Contents for location of table) for the proper cold alignment value based on the motor temperature rise and the pump operating temperature.

Before you start this procedure, make sure that the dial indicators are correctly set up.

A unit is in parallel alignment when the parallel indicator (P) does not vary by more than 0.05 mm | 0.002 in. as measured at four points 90° apart at the operating temperature.

1. Set the parallel alignment indicator (P) to zero at the top-center position (12 o'clock) of the driver coupling half (Y).
2. Rotate the indicator to the bottom-center position (6 o'clock).
3. Record the indicator reading.

When the reading value is...	Then...
Negative	The pump coupling half (X) is lower than the driver coupling half (Y). Remove shims of a thickness equal to half of the indicator reading value under each driver foot.
Positive	The pump coupling half (X) is higher than the driver coupling half (Y). Add shims of a thickness equal to half of the indicator reading value to each driver foot.

4. Repeat the previous steps until the permitted reading value is achieved.

NOTICE:

The specified permitted reading values are valid only at operating temperature. For cold settings, other values are permitted. The correct tolerances must be used. Failure to do so can result in misalignment. Contact ITT for further information.

- 0.05 mm | 0.002 in. total indicated runout at operating temperature

4.4.8 Perform parallel alignment for a horizontal correction

Refer to the alignment table in "Permitted indicator values for alignment checks" (see Table of Contents for location of table) for the proper cold alignment value based on the motor temperature rise and the pump operating temperature.

A unit is in parallel alignment when the parallel indicator (P) does not vary by more than 0.05 mm | 0.002 in. as measured at four points 90° apart at the operating temperature.

1. Set the parallel alignment indicator (P) to zero on the left side of the driver coupling half (Y), 90° from the top-center position (9 o’clock).
2. Rotate the indicator through the top-center position to the right side, 180° from the start position (3 o’clock).
3. Record the indicator reading.

When the reading value is...	Then...
Negative	The driver coupling half (Y) is to the left of the pump coupling half (X).
Positive	The driver coupling half (Y) is to the right of the pump coupling half (X).

4. Slide the driver carefully in the appropriate direction.

NOTICE:

Make sure to slide the driver evenly. Failure to do so can negatively affect horizontal angular correction.

5. Repeat the previous steps until the permitted reading value is achieved.
   - 0.05 mm | 0.002 in. total indicated runout at operating temperature

4.4.9 Perform complete alignment for a vertical correction

A unit is in complete alignment when both the angular indicator (A) and the parallel indicator (P) do not vary by more than 0.05 mm | 0.002 in. as measured at four points 90° apart.

1. Set the angular and parallel dial indicators to zero at the top-center position (12 o’clock) of the driver coupling half (Y).
2. Rotate the indicators to the bottom-center position (6 o’clock).
3. Record the indicator readings.

4. Make corrections according to the separate instructions for angular and parallel alignment until you obtain the permitted reading values.

4.4.10 Perform complete alignment for a horizontal correction

A unit is in complete alignment when both the angular indicator (A) and the parallel indicator (P) do not vary by more than 0.05 mm | 0.002 in. as measured at four points 90° apart.

1. Set the angular and parallel dial indicators to zero at the left side of the driver coupling half (Y), 90° from the top-center position (9 o'clock).
2. Rotate the indicators through the top-center position to the right side, 180° from the start position (3 o'clock).
3. Record the indicator readings.
4. Make corrections according to the separate instructions for angular and parallel alignment until you obtain the permitted reading values.

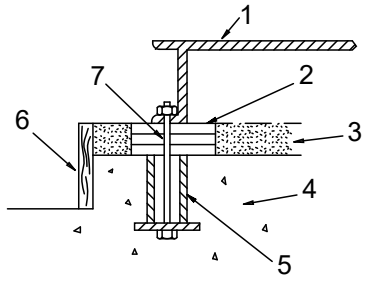
   Maximum permitted value for parallel alignment:

4.5 Grout the baseplate

Required equipment:

- Cleaners: Do not use an oil-based cleaner because the grout will not bond to it. See the instructions provided by the grout manufacturer.
- Grout: Non-shrink grout is recommended.

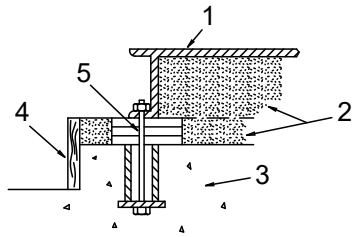
1. Clean all the areas of the baseplate that will come into contact with the grout.
2. Build a dam around the foundation.
3. Thoroughly wet the foundation that will come into contact with the grout.
4. Pour grout through the grout hole into the baseplate up to the level of the dam.
   When you pour the grout, remove air bubbles from it by using one of these methods:
   - Puddle with a vibrator.
   - Pump the grout into place.
5. Allow the grout to set.



Item	Description
1.	Baseplate
2.	Shims or wedges
3.	Grout
4.	Foundation
5.	Sleeve
6.	Dam
7.	Bolt

Figure 11: Pour grout into baseplate

6. Fill the remainder of the baseplate with grout, and allow the grout to set for at least 48 hours.



Item	Description
1.	Baseplate
2.	Grout
3.	Foundation
4.	Dam
5.	Bolt

Figure 12: Fill remainder of baseplate with grout

7. Tighten the foundation bolts.

4.6 Piping checklists

4.6.1 General piping checklist

Precautions

WARNING:

- Risk for expansion joint failure. All expansion joints must be properly supported, anchored, and restrained.

WARNING:

- Risk of premature failure. Casing deformation can result in misalignment and contact with rotating parts, causing excess heat generation and sparks. Flange loads from the piping system, including those from the thermal expansion of the piping, must not exceed the limits of the pump.
- Risk of serious personal injury or property damage. Fasteners such as bolts and nuts are critical to the safe and reliable operation of the product. Ensure appropriate use of fasteners during installation or reassembly of the unit.
    - Use fasteners of the proper size and material only.
    - Replace all corroded fasteners.
    - Ensure that all fasteners are properly tightened and that there are no missing fasteners.

CAUTION:
Do not move the pump to the pipe. This could make final alignment impossible.

CAUTION:
Never draw piping into place at the flanged connections of the pump. This can impose dangerous strains on the unit and cause misalignment between the pump and driver. Pipe strain adversely affects the operation of the pump, which results in physical injury and damage to the equipment.

Flange loads from the piping system, including those from the thermal expansion of the piping, must not exceed the limits of the pump. Casing deformation can result in contact with rotating parts, which can result in excess heat generation, sparks, and premature failure.

NOTICE:
Vary the capacity with the regulating valve in the discharge line. Never throttle the flow from the suction side. This action can result in decreased performance, unexpected heat generation, and equipment damage.

Piping guidelines

Guidelines for piping are given in the Hydraulic Institute Standards available from the Hydraulic Institute at 9 Sylvan Way, Parsippany, NJ 07054-3802. You must review this document before you install the pump.

Checklist

Check	Explanation/comment	Checked
Check that all piping is supported independently of, and lined up naturally with, the pump flange.	• Strain on the pump • Misalignment between the pump and the drive unit	
Keep the piping as short as possible.	This helps to minimize friction losses.	
Keep the piping as straight as possible. Avoid unnecessary bends. Use 45° or long radius 90° fittings where necessary.	This helps to minimize friction losses.	
Check that only necessary fittings are used.	This helps to minimize friction losses.	
Make sure that the inside diameters match properly when you use flange joints.	—	
Do not connect the piping to the pump until: • The grout for the baseplate or sub-base becomes hard. • The grout for the pit cover becomes hard. • The hold-down bolts for the pump are tightened.	—	
Make sure that all the piping joints and fittings are airtight.		
If the pump handles corrosive fluids, make sure that the piping allows you to flush out the liquid before you remove the pump.		

Check	Explanation/comment	Checked
	This helps to prevent misalignment due to thermal expansion of the piping.	
Make sure that all piping components, valves and fittings, and pump branches are clean prior to assembly.	—	
Make sure that the isolation and check valves are installed in the discharge line.	Locate the check valve between the isolation valve and the pump. This will permit inspection of the check valve. The isolation valve is required for regulation of flow, and for inspection and maintenance of the pump. The check valve prevents pump or seal damage due to reverse flow through the pump when the driver is turned off.	
Use cushioning devices.	This protects the pump from surges and water hammer if quick-closing valves are installed in the system.	
In no case should loads on the pump flanges exceed the limits stated in API Standard 610, 11th Edition (ISO 13709).	Bottom of casing should be supported by a solid foundation or casing feet should be used.	

4.6.2 Suction-piping checklist

Suction-piping checks

Check	Explanation/comment	Checked
	This minimizes the risk of cavitation in the suction inlet of the pump due to turbulence.	
Check that elbows in general do not have sharp bends.	—	
Check that the suction piping is one or two sizes larger than the suction inlet of the pump. Install an eccentric reducer between the pump inlet and the suction piping.	The suction piping must never have a smaller diameter than the suction inlet of the pump.	
Check that the eccentric reducer at the suction flange of the pump has the following properties: • Sloping side down • Horizontal side at the top		
If more than one pump operates from the same liquid source, check that separate suction-piping lines are used for each pump.	This recommendation helps you to achieve a higher pump performance and prevent vapor locking especially with specific gravity of liquid less than 0.60.	
If necessary, make sure that the suction piping includes a drain valve and that it is correctly installed.	—	
Assure adequate insulation is applied for liquids with specific gravity less than 0.60.	To assure sufficient NPSHa.	

Liquid source below the pump

Check	Explanation/comment	Checked
Make sure that the suction piping is free from air pockets.	This helps to prevent the occurrence of air and cavitation in the pump inlet.	

Check	Explanation/comment	Checked
Check that the suction piping slopes upwards from the liquid source to the pump inlet.	—	
If the pump is not self-priming, check that a device for priming the pump is installed.	Use a foot valve with a diameter that is at least equivalent to the diameter of the suction piping.	

Liquid source above the pump

Check	Explanation/comment	Checked
Check that an isolation valve is installed in the suction piping at a distance of at least two times the pipe diameter from the suction inlet.	This permits you to close the line during pump inspection and maintenance. Do not use the isolation valve to throttle the pump. Throttling can cause these problems: • Loss of priming • Excessive temperatures • Damage to the pump • Voiding the warranty	
Make sure that the suction piping is free from air pockets.	This helps to prevent the occurrence of air and cavitation in the pump inlet.	
Check that the piping is level or slopes downward from the liquid source.	—	
Make sure that no part of the suction piping extends below the suction flange of the pump.	—	
Make sure that the suction piping is adequately submerged below the surface of the liquid source.	This prevents air from entering the pump through a suction vortex.	

4.6.3 Final piping checklist

Check	Explanation/comment	Checked
Check that the shaft rotates smoothly.	Rotate the shaft by hand. Make sure there is no rubbing that can lead to excess heat generation or sparks.	
	If pipe strain exists, then correct the piping.	

5 Commissioning, Startup, Operation, and Shutdown

5.1 Preparation for startup

WARNING:

- Risk of serious physical injury or death. Exceeding any of the pump operating limits (e.g. - pressure, temperature, power, etc.) could result in equipment failure, such as explosion, seizure, or breach of containment. Assure that the system operating conditions are within the capabilities of the pump.
- Risk of death or serious injury. Leaking fluid can cause fire and/or burns. Ensure all openings are sealed prior to filling the pump.
- Breach of containment can cause fire, burns, and other serious injury. Failure to follow these precautions before starting the unit may lead to dangerous operating conditions, equipment failure, and breach of containment.
- Risk of explosion and serious physical injury. Do not operate pump with blocked system piping or with suction or discharge valves closed. This can result in rapid heating and vaporization of pumpage.
- Risk of breach of containment and equipment damage. Ensure the pump operates only between minimum and maximum rated flows. Operation outside of these limits can cause high vibration, mechanical seal and/or shaft failure, and/or loss of prime.

WARNING:

- Risk of death, serious personal injury, and property damage. Heat and pressure buildup can cause explosion, rupture, and discharge of pumpage. Never operate the pump with suction and/or discharge valves closed.
- Running a pump without safety devices exposes operators to risk of serious personal injury or death. Never operate a unit unless appropriate safety devices (guards, etc.) are properly installed.
- Failure to disconnect and lock out driver power may result in serious physical injury or death. Always disconnect and lock out power to the driver before performing any installation or maintenance tasks.
    - Electrical connections must be made by certified electricians in compliance with all international, national, state, and local rules.
    - Refer to driver/coupling/gear manufacturer's installation and operation manuals (IOM) for specific instructions and recommendations.
- Leakage of pumped liquid can create an explosive environment. Make sure that the pumped liquid is compatible with all pump materials it comes in contact with.
- Risk of seizure, breach of containment, or explosion. Ensure balance line is installed and piped back to either the pump suction or suction vessel. This prevents rapid vaporization of the pumped fluid.

Precautions

WARNING:
The mechanical seal used in an Ex-classified environment must be properly certified.

CAUTION:
When a cartridge mechanical seal is used, ensure that the set screws in the seal locking ring are tightened and that the centering clips have been removed prior to startup. This prevents seal or shaft sleeve damage by ensuring that the seal is properly installed and centered on the sleeve.

NOTICE:

- Verify the driver settings before you start any pump. Refer to the applicable drive equipment IOMs and operating procedures.

NOTICE:
You must follow these precautions before you start the pump:

- Flush and clean the system thoroughly to remove dirt or debris in the pipe system in order to prevent premature failure at initial startup.
- Bring variable-speed drivers to the rated speed as quickly as possible.
- If temperatures of the pumped fluid will exceed 93°C | 200°F, then warm up the pump prior to operation. Circulate a small amount of fluid through the pump until the casing temperature is within 38°C | 100°F of the fluid temperature. Accomplish this by flowing fluid from pump inlet to discharge drain (optionally, the casing vent can be included in warm-up circuit but not required). Soak for (2) hours at process fluid temperature.

At initial startup, do not adjust the variable-speed drivers or check for speed governor or over-speed trip settings while the variable-speed driver is coupled to the pump. If the settings have not been verified, then uncouple the unit and refer to instructions supplied by the driver manufacturer.

5.1.1 Check the rotation

WARNING:

- Starting the pump in reverse rotation can result in the contact of metal parts, heat generation, and breach of containment. Ensure correct driver settings prior to starting any pump.
- Failure to disconnect and lock out driver power may result in serious physical injury or death. Always disconnect and lock out power to the driver before performing any installation or maintenance tasks.
    - Electrical connections must be made by certified electricians in compliance with all international, national, state, and local rules.
    - Refer to driver/coupling/gear manufacturer's installation and operation manuals (IOM) for specific instructions and recommendations.
- Do not jog a coupled pump.

1. Lock out power to the driver.

2. Make sure that the coupling hubs are fastened securely to the shafts.
3. Unlock power to the driver.
4. Make sure that everyone is clear, and then jog the driver long enough to determine that the direction of rotation corresponds to the arrow on the pump.
5. Lock out power to the driver.

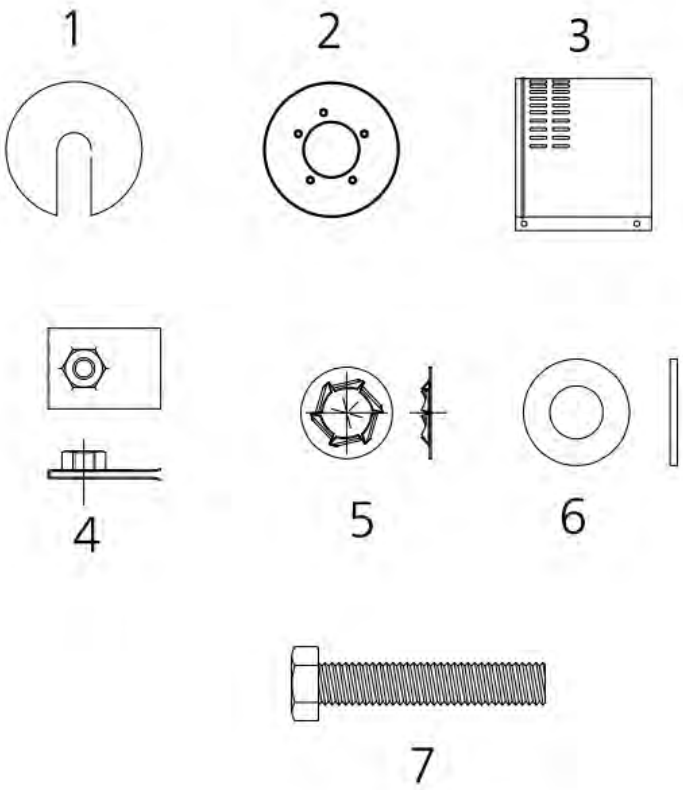
5.1.2 Couple the pump and driver

WARNING:
Failure to disconnect and lock out driver power may result in serious physical injury or death. Always disconnect and lock out power to the driver before performing any installation or maintenance tasks.

- Electrical connections must be made by certified electricians in compliance with all international, national, state, and local rules.
- Refer to driver/coupling/gear manufacturer's installation and operation manuals (IOM) for specific instructions and recommendations.

CAUTION:

-  The coupling guard used in an Ex classified environment must be properly certified and constructed from a spark resistant material.
- Running a pump without safety devices exposes operators to risk of serious personal injury or death. Never operate a unit unless appropriate safety devices (guards, etc.) are properly installed.



Part No.	Description	Part No.	Description
1	Cover driver	5	Retainer (Qty 3)
2	Cover pump	6	Washer (Qty 4)
3	Guard (Qty 2)	7	Hex head bolt (Qty 3)
4	U-nut (Qty 3)		

Figure 13: Coupling guard components

5.1.3 Install the coupling guard

1. Is the already installed?
   - If yes: Make any necessary coupling adjustments and then proceed to Step 2.
   - If no: Complete these steps:

   a) Remove the spacer portion of the coupling.
   Refer to the instructions from the coupling manufacturer for assistance.

   b) If the coupling hub diameter is larger than the diameter of the opening in the end plate, then remove the coupling hub.

   c) Remove the thrust bearing end-cover screws.

   d) Replace the four outboard end cover bolts (371D) and torque to the value shown in the 6.7.4 Assembly references on page 82.

e) Align the end plate to the thrust bearing end cover so that the holes in the end plate align with the holes in the end cover.

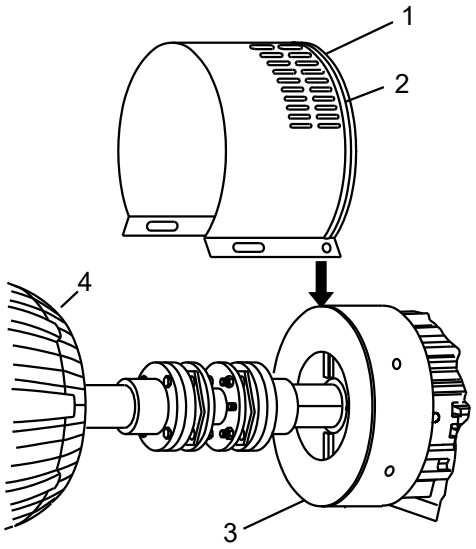
f) Replace the three to five thrust bearing end cover screws and torque to the values shown in the Bolt torque values table in the Maintenance chapter.

g) Replace the coupling hub (if removed) and the spacer portion of the coupling.

Refer to the instructions from the coupling manufacturer for assistance.

Complete any coupling adjustments before you proceed with the coupling guard assembly.

2. Slightly spread the opening of the coupling guard half and place it over the pump end plate.

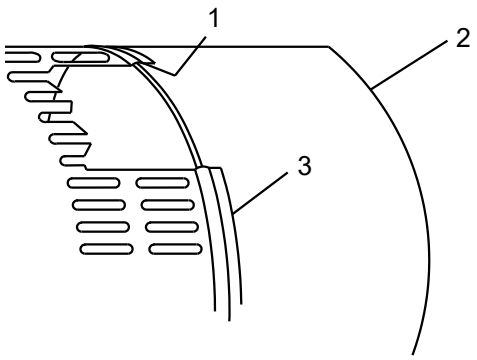


Item	Description
1.	Pump half of the coupling guard
2.	Annular groove
3.	Deflector fan guard
4.	Driver

Figure 14: Align pump end guard with the annual groove

The annular groove in the guard is located around the end plate.

Position the opening (flange) so that it does not interfere with the piping but still allows for access when you install the bolts.



Item	Description
1.	Annular groove
2.	Deflector fan guard
3.	Coupling guard half

Figure 15: Coupling guard

3. Place one washer over the bolt and insert the bolt through the round hole at the front end of the guard half.
4. Install the bolt retainer over the exposed end of the bolt, and the U-Nut into the slot in the coupling guard if it was not done from the factory.

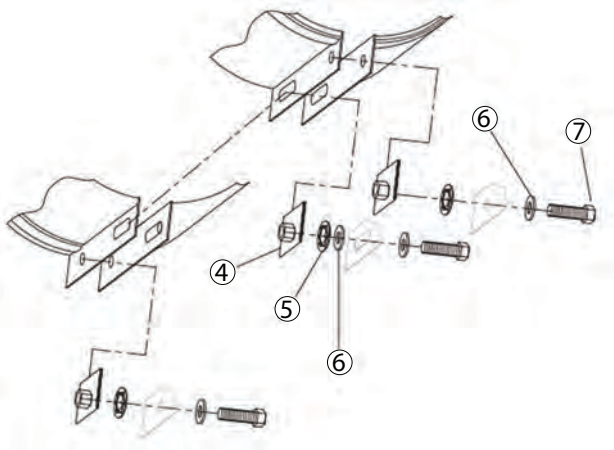


Figure 16: Captured hardware component assembly

5. Thread bolt into the U-Nut and tighten firmly.
6. Slightly spread the opening of the remaining coupling guard half and place it over the installed coupling guard half so that the annular groove in the remaining coupling guard half faces the driver.
7. Place the end plate over the driver shaft and locate the end plate in the annular groove at the rear of the coupling guard half.

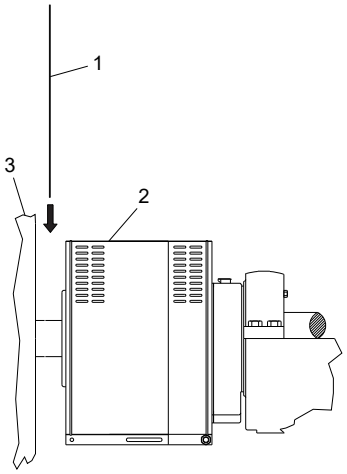
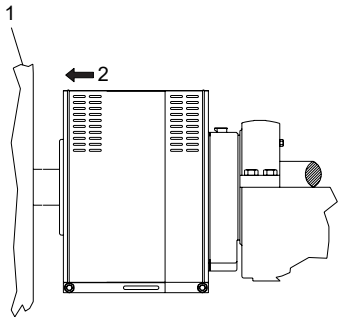


Figure 17: End plate and annular grrove

8. Repeat Steps 3 through 5 for the rear end of the coupling guard half, except that you hand tighten the nut.
9. Slide the rear coupling guard half towards the motor so that it completely covers the shafts and coupling.



Item	Description
1.	Driver
2.	Slide to fit

Figure 18: Slide to fit

10. Repeat Steps 3 through 5 for the center slots in the coupling guard.
11. Firmly tighten all nuts on the guard assembly.

5.2 Bearing lubrication

Precautions

WARNING:

Risk of explosive hazard and premature failure from sparks and heat generation. Ensure bearings are properly lubricated prior to startup.

Pumps are shipped without oil

You must lubricate oil-lubricated bearings at the job site.

Ring oil lubrication

Ring oil-lubricated bearings are standard.Sleeve/ball bearings are optional. Bearing housings are supplied with constant-level oilers and sight glasses. Make sure that oil rings are properly seated in the grooves in the shaft.

Pure or purge oil-mist lubrication

Pure or purge oil mist are optional features. Follow the oil-mist generator manufacturer's instructions. The inlet and outlet connections are located on the top and bottom of the bearing housing, respectively.

5.2.1 Lubricating-oil requirements

Oil quality requirements

Use a high-quality turbine oil with rust and oxidation inhibitors with rated viscosity shown below at 38°C | 100°F.

Oil requirements based on temperature

For the majority of operating conditions, bearing temperatures run between 49°C | 120°F and 82°C | 180°F, and you can use an oil of ISO viscosity grade 68 at 38°C | 100°F. If temperatures exceed 82°C | 180°F, refer to the table for temperature requirements.

Temperature	Oil requirement
Bearing temperatures exceed 82°C | 180°F	Use ISO viscosity grade 100. Bearing temperatures are generally about 11°C | 20°F higher than bearing-housing outer surface temperatures.

5.2.2 Acceptable oil for lubricating bearings

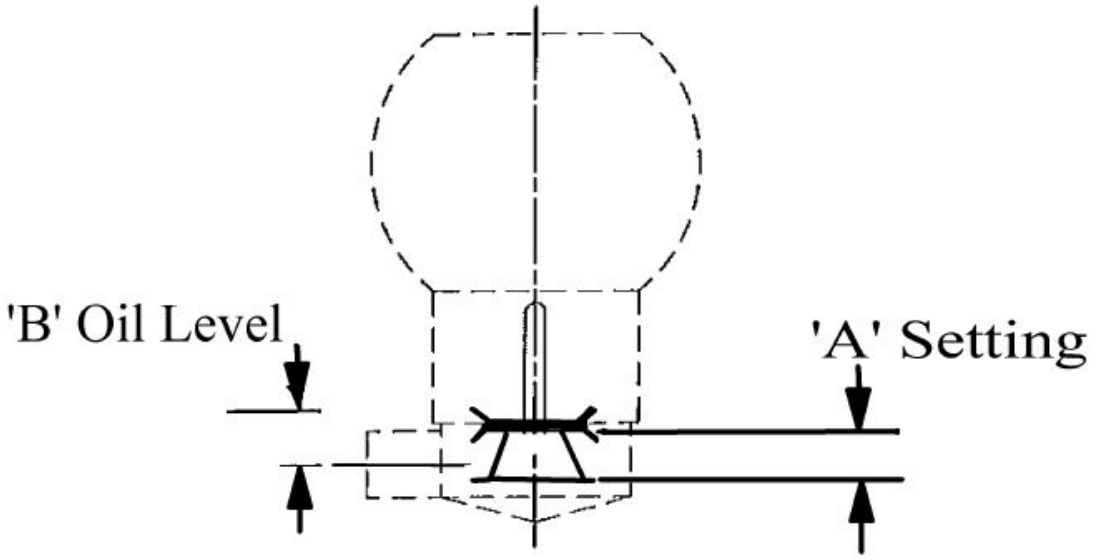
Table 5: Acceptable oil for lubricating bearings

Brand	Lubricating type
Exxon	Teresstic EP 68
Mobil	DTE 68 Heavy Medium
Sunoco	Sunvis 968
Royal Purple	SYNFILM ISO VG 68 Synthetic Oil

5.2.3 Lubricating the bearings

NOTICE:
Do not expose an idle pump to freezing conditions. Drain all liquid that is inside the pump and any auxiliary equipment. Failure to do so can cause liquid to freeze and damage the pump.

Oil lubricated pumps are not lubricated at the factory. Constant level oilers are supplied with oil lubricated pumps. The oiler can be found in the box of fittings that accompanied the pump during shipment. The oiler is to be set per Figure 19: Oiler adjustment settings on page 45 and dimensions A and B given in Oil Settings table below. Fill the bearing housing with oil using the oil bottle. Continue to refill the oil bottle until the oil stops draining from the oiler into the housing. Refer to Table 5: Acceptable oil for lubricating bearings on page 44 for recommended oil.



A. Setting

B Oil level

Figure 19: Oiler adjustment settings

Instructions:

1. Remove Adjustment assembly from oiler.
2. Adjust bar to dimension "A".
3. Lock in position.
4. Replace adjustment assembly in oiler.

Table 6: Oil settings mm | inches

Group	Sizes	Flood oil ball / ring oil ball / ring oil roller		
		Oiler size	"A" mm | inches	"B" mm | inches
SX	12x14-5 16x18-17H	#3 4 oz	21.4 | 27/32	19 | 3/4
MX	18x20-20	#3 4 oz	21.4 | 27/32	19 | 3/4
M	16x18-30 18x20-30 20x24-24 20x24-30	#10 16 oz	14.3 | 9/16	12.7 | 1/2
M Modified	20x24-28	#10 16 oz	21.4 | 27/32	19 | 3/4
-	18x20-24	#10 16 oz	21.4 | 27/32	19 | 3/4
L	24x30-32	#10	22.2 | 7/8	20.6 | 13/16

Group	Sizes	Flood oil ball / ring oil ball / ring oil roller		
		Oiler size	"A" mm | inches	"B" mm | inches
		16 oz		
LDS	30x30-31 30x30-38	#10 16 oz	14.3 | 9/16	12.7 | 1/2
XL	30x36-42 20x30-42	#10 16 oz	14.3 | 9/16	12.7 | 1/2
XXL	36x42-52	#10 16 oz	9.7 | 3/8	11.1 | 7/16

Pure/Purge oil mist

For pure oil mist, connect the oil mist system according to the manufacturer's recommendations. For purge oil mist, connect the oil mist system according to the manufacturer's recommendations. Fill the pump with oil as detailed for oil lubrication as above. In both cases, refer to the pump dimensional drawing for the location of oil mist connections to the bearing housings. Refer to Oil Settings table above for oil bottle settings and Table 5: Acceptable oil for lubricating bearings on page 44.

Grease lubrication

Pumps are shipped with grease installed, sufficient for 2,000 hours operation. It is recommended that additional or replacement lubrication be added every 2,000 hours or at three month intervals. The lubricant should be renewed in the housings at least once each year. Refer to 6.2.4 Lubricating-grease requirements on page 57.

5.3 Shaft-sealing options

In most cases, the manufacturer seals the shaft before shipping the pump. If your pump does not have a sealed shaft, see the Shaft-seal maintenance section in the Maintenance chapter.

This model uses these types of shaft seals:

- Cartridge mechanical seal

5.3.1 Connection of sealing liquid for mechanical seals

Seal lubrication is required

Seal faces must have liquid film between them for proper lubrication. Locate the taps using the illustrations shipped with the seal.

Seal flushing methods

Table 7: You can use these methods in order to flush or cool the seal:

Method	Description
Product flush	Run the piping so that the pump pushes the pumped fluid from the casing and injects it into the seal gland. If necessary, an external heat exchanger cools the pumped fluid before it enters the seal gland.
External flush	Run the piping so that the pump injects a clean, cool, compatible liquid directly into the seal gland. The pressure of the flushing liquid must be 0.35 to 1.01 kg/cm^2 | 5 to 15 psi greater than the seal chamber pressure. The injection rate must be 2 to 8 lpm | 0.5 to 2 gpm.

Method	Description
Other	You can use other methods that employ multiple gland or seal chamber connections. Refer to the mechanical seal reference drawing and piping diagrams.

5.3.2 Packed stuffing box option

WARNING:
Packed stuffing boxes are not allowed in an Ex-classified environment.

The factory does not install the packing, lantern ring, or split gland.

These parts are included with the pump in the box of fittings. Before you start the pump, you must install the packing, lantern ring, and split gland according to the Packed stuffing box maintenance section in the Maintenance chapter.

5.3.3 Connection of sealing liquid for a packed stuffing box

NOTICE:
Make sure to lubricate the packing. Failure to do so may result in shortening the life of the packing and the pump.

You must use an external sealing liquid under these conditions:

- The pumped fluid includes abrasive particles.
- The stuffing-box pressure is below atmospheric pressure when the pump is running with a suction lift or when the suction source is in a vacuum. Under these conditions, packing is not cooled and lubricated and air is drawn into pump.

Conditions for application of an external liquid

Condition	Action
The stuffing box pressure is above atmospheric pressure and the pumped fluid is clean.	Normal gland leaks of 40 to 60 drops per minute is usually sufficient to lubricate and cool the packing. You do not need sealing liquid.
The stuffing box pressure is below atmospheric pressure or the pumped fluid is not clean.	An outside source of clean compatible liquid is required.
An outside source of clean compatible liquid is required.	You must connect the piping to the lantern ring connection with a 40 to 60 drops-per-minute leak rate. The pressure must be 1.01 kg/cm^2 | 15 psi above the stuffing box pressure.

5.3.4 Seal the shaft with a packed stuffing box

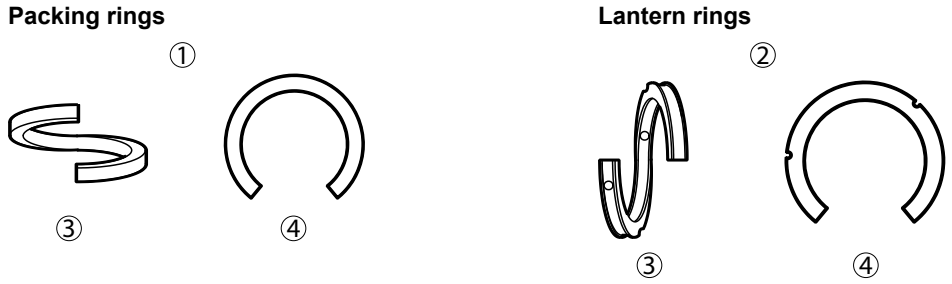
WARNING:

- Packed stuffing boxes are not allowed in an Ex-classified environment.

WARNING:
Failure to disconnect and lock out driver power may result in serious physical injury. Never attempt to replace the packing until the driver is properly locked out.

Pumps are shipped without the packing, lantern ring, or split gland installed. These parts are included with the box of fittings shipped with each pump and must be installed before startup.

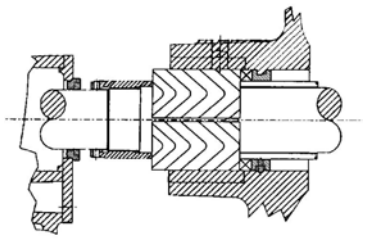
1. Carefully clean the stuffing-box bore.
2. Twist the packing enough to get it around the shaft.



1. Packing rings
2. Lantern rings
3. Correct
4. Incorrect

Figure 20: Packing rings and lantern rings

3. Use a wooden split bushing in order to properly seat the first two rings of packing.



4. Insert the packing and stagger the joints in each ring by 90°.
   Install the stuffing-box parts in this order:
   a) Two packing rings
   b) One lantern ring (two-piece)
   c) Three packing rings

NOTICE:

Make sure that the lantern ring is located at the flushing connection to ensure that flush is obtained. Failure to do so may result in decreased performance.

5. Install the gland halves and evenly hand-tighten the nuts .

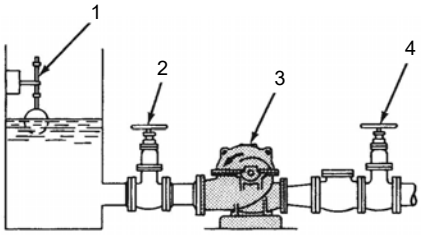
5.4 Pump priming

CAUTION:
Do not run the pump dry.

Never start the pump until it has been properly primed. Several different methods of priming can be used, depending on the type of installation and service involved.

5.4.1 Prime with the suction supply above the pump

When the pump is installed as this figure shows, the pump primes itself:



1. Float switch
2. Suction gate valve
3. Vent plug
4. Discharge gate valve

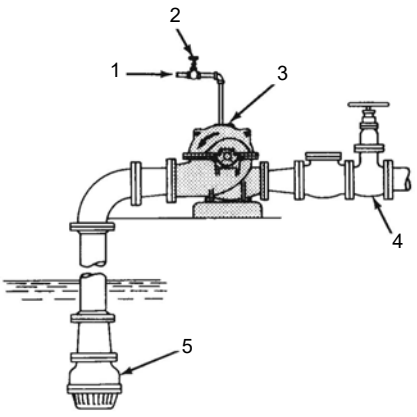
Complete these steps in order to prime the pump with the suction supply above the pump:

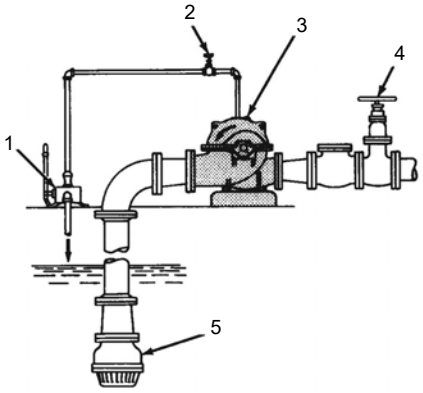
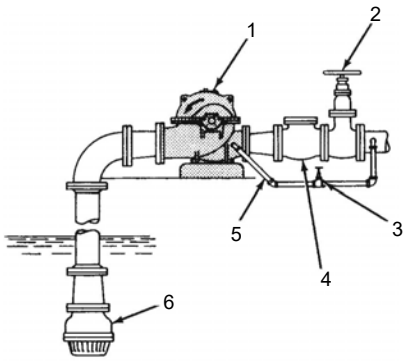
1. Close the discharge valve.
2. Open the suction valve.
3. Remove the vent plugs or open the vent valves on the top of the pump and the two suction lobes until all air is expelled and fluid flows through the openings.
4. Replace the vent plugs or close the vent valves.
5. Start the pump and open the discharge valve.

The pump continues to be primed for any future startup. This method is the simplest and the safest. You can arrange a float switch in the suction reservoir in order to stop the pump if the liquid supply falls below the minimum levels.

5.4.2 Prime with the suction supply below the pump

With the pump installed on a suction lift and with a foot valve at the end of the suction line, you can prime the pump with one of these three methods:

Method	Parts list
Method A: Outside supply 	1. From outside supply 2. Shutoff valve 3. Vent plug 4. Discharge gate valve 5. Foot valve
Method B: Prime with a separate hand or manually-controlled priming pump	1. Priming pump 2. Shutoff valve 3. Vent plug 4. Discharge gate valve 5. Foot valve

Method	Parts list
	
Method C: Prime by bypassing around the discharge check valve Only use this method when there is liquid under some pressure in the discharge line. The original prime must be effected from an outside source. 	1. Vent plug 2. Discharge gate valve 3. Shutoff valve 4. Discharge check valve 5. Bypass line 6. Foot valve

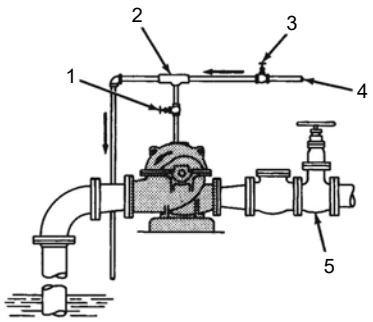
1. Close the discharge valve.
2. For methods A and C, remove the vent plugs or open the vent valves on the top of the pump and the two suction lobes.
3. Open the valve:

If you use...	Then...
Method A	1. Open the valve in the priming supply line. 2. Fill the pump until all air is expelled and fluid flows through the vents.
Method B	1. Open the valve in the priming line. 2. Exhaust the air from the pump and the suction piping until water flows from the priming pump.
Method C	1. Open the valve in the check valve bypass line. 2. Exhaust the air from the pump and the suction piping until water flows from vent connections.

4. For method B, close the valve in the priming line and shut off the priming pump.
5. For methods A and C, replace the vent plugs or close the vent valves, and then close the valve in the priming supply line.
6. Start the pump and open the discharge valve.

5.4.3 Prime with an ejector

On suction lift applications, you can connect an ejector to the top of the casing in order to remove air from the casing and suction line. This action primes the pump.



1. Valve S
2. Ejector
3. Valve E
4. Steam, compressed air, or water that is under pressure
5. Discharge gate valve

Complete these steps in order to prime the pump with an ejector:

1. Close the discharge valve.
2. Open the ejector supply valve E in the steam, air, or water line.
3. Open the priming isolation valve, S.
4. After you prime the unit, close the priming isolation valve, S.
5. Close the ejector supply valve, E.
6. Start the pump and open the discharge valve.

5.5 Start the pump

WARNING:

- Risk of equipment damage, seal failure and breach of containment. Ensure all flush and cooling systems are operating correctly prior to starting pump.
-

NOTICE:

- Risk of equipment damage due to dry operation. Immediately observe the pressure gauges. If discharge pressure is not quickly attained, stop the driver immediately, reprime, and attempt to restart the pump.
- On frame mounted units, ensure that the oil level is correct prior to starting pump. Close coupled pumps do not have oil lubricated bearings.

NOTICE:

Risk of equipment damage on pure or purge-oil mist-lubricated units. Remove the viewing port plugs to verify that oil mist is flowing properly. Reinstall the plugs after confirming.

Before you start the pump, you must perform these tasks:

- Open the suction valve.
- Open any recirculation or cooling lines.

1. Fully close or partially open the discharge valve, depending on system conditions.
2. Start the driver.

3. Slowly open the discharge valve until the pump reaches the desired flow.
4. Immediately check the pressure gauge to ensure that the pump quickly reaches the correct discharge pressure.
5. If the pump fails to reach the correct pressure, perform these steps:
   a) Stop the driver.
   b) Prime the pump again.
   c) Restart the driver.
6. Monitor the pump while it is operating:
   a) Check the pump for bearing temperature, excessive vibration, and noise.
   b) If the pump exceeds normal levels, then shut down the pump immediately and correct the problem.
7. Repeat steps 5 and 6 until the pump runs properly.

5.6 Pump operation precautions

General considerations

WARNING:

- Risk of serious personal injury or property damage. Dry running may cause rotating parts within the pump to seize to non-moving parts. Do not run dry.
- Risk of explosion and serious physical injury. Do not operate pump with blocked system piping or with suction or discharge valves closed. This can result in rapid heating and vaporization of pumpage.

NOTICE:

- Vary the capacity with the regulating valve in the discharge line. Never throttle the flow from the suction side. This action can result in decreased performance, unexpected heat generation, and equipment damage.
- Risk of equipment damage from unexpected heat generation. Do not overload the driver. Ensure that the pump operating conditions are suitable for the driver. The driver can overload in these circumstances:
  - The specific gravity or viscosity of the fluid is greater than expected
  - The pumped fluid exceeds the rated flow rate.
- Do not operate pump below hydraulic or thermal minimum flow. For hydraulic minimum flows refer to technical manual and pump performance curves. To calculate thermal minimum flow, refer to HI Centrifugal Pump Design and Application ANSI/HI 1.3-2000.

Operation at reduced capacity

WARNING:

- Risk of breach of containment and equipment damage. Excessive vibration levels can cause damage to bearings, stuffing box, seal chamber, and/or mechanical seal. Observe pump for vibration levels, bearing temperature, and excessive noise. If normal levels are exceeded, shut down and resolve.

- Risk of explosion and serious physical injury. Do not operate pump with blocked system piping or with suction or discharge valves closed. This can result in rapid heating and vaporization of pumpage.
- Risk of equipment damage and serious physical injury. Heat build-up can cause rotating parts to score or seize. Observe pump for excessive heat build-up. If normal levels are exceeded, shut down and resolve.

NOTICE:

- Cavitation can cause damage to the internal surfaces of the pump. Ensure net positive suction head available ($NPSH_A$) always exceeds NPSH required ($NPSH_3$) as shown on the published performance curve of the pump.
-

Operation under freezing conditions

NOTICE:
Do not expose an idle pump to freezing conditions. Drain all liquid that will freeze that is inside the pump and any auxiliary equipment. Failure to do so can cause liquid to freeze and damage the pump. Note that different liquids freeze at different temperatures. Some pump designs do not drain completely and may require flushing with a liquid that doesn't freeze.

5.7 Shut down the pump

WARNING:
Precautions must be taken to prevent physical injury. The pump may handle hazardous and/or toxic fluids. Proper personal protective equipment should be worn. Pumpage must be handled and disposed of in conformance with applicable environmental regulations.

1. Slowly close the discharge valve.
2. Shut down and lock out the driver to prevent accidental rotation.

5.8 Make the final alignment of the pump and driver

WARNING:

- Failure to disconnect and lock out driver power may result in serious physical injury or death. Always disconnect and lock out power to the driver before performing any installation or maintenance tasks.
  - Electrical connections must be made by certified electricians in compliance with all international, national, state, and local rules.
  - Refer to driver/coupling/gear manufacturer's installation and operation manuals (IOM) for specific instructions and recommendations.
- Misalignment can cause decreased performance, equipment damage, and even catastrophic failure of frame-mounted units leading to serious injury. Proper alignment is the responsibility of the installer and the user of the unit. Check the alignment of all drive components prior to operating the unit.

- Follow the coupling installation and operation procedures from the coupling manufacturer.

You must check the final alignment after the pump and driver are at operating temperature. For initial alignment instructions, see the Installation chapter.

1. Run the unit under actual operating conditions for enough time to bring the pump, driver, and associated system to operating temperature.
2. Shut down the pump and the driver.
3. Remove the coupling guard.
   See Remove the coupling guard in the Maintenance chapter.
4. Check the alignment while the unit is still hot.
   Refer to 4.4 Pump-to-driver alignment on page 27 in the Installation chapter.
5. Reinstall the coupling guard.
6. Restart the pump and driver.

6 Maintenance

6.1 Maintenance schedule

Maintenance inspections

A maintenance schedule includes these types of inspections:

- Routine maintenance
- Routine inspections
- Three-month inspections
- Annual inspections

Shorten the inspection intervals appropriately if the pumped fluid is abrasive or corrosive or if the environment is classified as potentially explosive.

Routine maintenance

Perform these tasks whenever you perform routine maintenance:

- Lubricate the bearings.
- Inspect the seal.
- Perform a vibration analysis.
- Monitor the discharge pressure.
- Monitor the temperature.

Routine inspections

Perform these tasks whenever you check the pump during routine inspections:

- Check the level and condition of the oil through the sight glass on the bearing frame.
- Check for unusual noise vibration, and bearing temperatures.
- Check the pump and piping for leaks.
- Analyze the vibration.*
- Check the seal chamber and stuffing box for leaks.
    - Ensure that there are no leaks from the mechanical seal.
    - Adjust or replace the packing in the stuffing box if you notice excessive leaking.

NOTICE:
*If equipped, temperature and vibration levels can be retrieved by using your i-ALERT® monitoring sensor and app.

Three-month inspections

Perform these tasks every three months:

- Check that the foundation and the hold-down bolts are tight.
- Check the packing if the pump has been left idle, and replace as required.
- Change the oil every three months (2000 operating hours) at minimum.
- Check the shaft alignment, and realign as required.

Annual inspections

Perform these inspections one time each year:

- Check the pump capacity.
- Check the pump pressure.
- Check the pump power.

If the pump performance does not satisfy your process requirements, and the process requirements have not changed, then perform these steps:

1. Disassemble the pump.
2. Inspect it.
3. Replace worn parts.

6.2 Bearing maintenance

These bearing lubrication sections list different temperatures of the pumped fluid. If the pump is Ex-certified and the temperature of the pumped fluid exceeds the permitted temperature values, then consult your ITT representative.

For Ex applications bearing replacement (all) is recommended after 50K hours of operation.

Bearing lubrication schedule

Type of bearing	First lubrication	Lubrication intervals
Oil-lubricated bearings	Add oil before you install and start the pump. Change the oil after 200 hours for new bearings.	After the first 200 hours, change the oil every 2000 operating hours or every three months.
Grease-lubricated bearings	Grease-lubricated bearings are initially lubricated at the factory.	Regrease bearings every 2000 operating hours or every three months.

6.2.1 Bearing and oil requirements

Bearing arrangement	Group	Size	Bearing size		Required oil volume (per housing)	
			Thrust	Radial	mL	Pints
Flood oil ball bearing	SX	12x14-15 16x18-17H	7313	6313	Thrust = 850 Radial = 580	Thrust = 1.80 Radial = 1.23
	MX	18x20-20	7316	6316	Thrust = 1350 Radial = 857	Thrust = 2.85 Radial = 1.81
Ring oil ball bearing	M	16x18-30 18x20-30 20x24-24 20x24-30	7321	6321	1170	2.47
	M (modified)	20x24-28	7321	6321	1350	2.85
	—	18x20-24	7318	6318	620	1.32

Bearing arrangement	Group	Size	Bearing size		Required oil volume (per housing)	
			Thrust	Radial	mL	Pints
Ring oil roller bearing	L	24x30-32	22226		1700	3.60
	LDS	30x30-31 30x30-38	22228		1720	3.64
	XL	20x30-42 30x36-42	22230		1350	2.85
	XXL	36x42-52	22240		4350	9.20

6.2.2 Acceptable oil for lubricating bearings

Acceptable lubricants

Table 8: Acceptable lubricants

Brand	Lubricant type
Exxon	Teresstic EP 68
Mobil	DTE Heavy Medium
Royal Purple	SYNFILM ISO VG 68 Synthetic Oil

6.2.3 Lubricate the bearings

Refer to 5.2.3 Lubricating the bearings on page 44.

6.2.4 Lubricating-grease requirements

Note that a constant level oiler is not used with a pure mist system.

Precautions

NOTICE:

- Avoid equipment damage or decreased performance. Never mix greases of different consistencies (NLGI 1 or 3 with NLGI 2) or with different thickeners. For example, never mix a lithium-based grease with a polyurea based grease. If it is necessary to change the grease type or consistency, remove the rotor and old grease from the housing before re-greasing.

Bearing temperature

Bearing temperatures are generally about 18°C | 20°F greater than bearing-housing outer surface temperatures.

This table shows the type of grease required for the operating temperature of the pump.

Bearing temperature	Type of grease
-15°C to 110°C | 5°F to 230°F	Use a lithium-based mineral-oil grease with a consistency of NLGI 2.
Exceed 177°C | 350°F	Use a high-temperature grease. Mineral-oil greases should have oxidation stabilizers and a consistency of NGLI 3.

Grease recommendations based on temperature

Most pumps use Sunoco 2EP grease.

This table shows which brand of grease to use when lubricating the pump.

Brand	When temperature of pumped fluid is less than 177°C | 350°F - NLGI consistency 2
Mobil	Mobilux EP2
Exxon	Unirex N2
Sunoco	Mutipurpose 2EP
SKF	LGMT 2

6.2.5 Regrease the grease-lubricated bearings

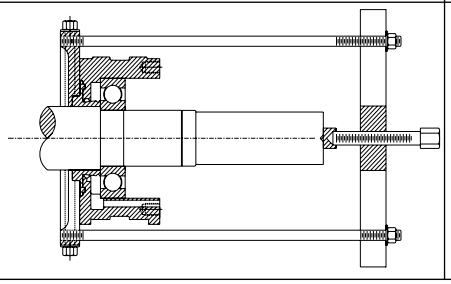
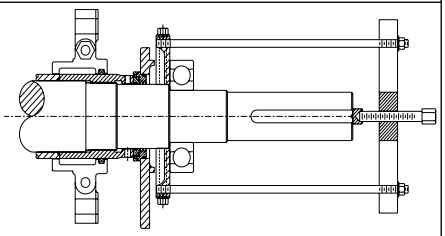
NOTICE:
Risk of equipment damage. Ensure that the grease container, the greasing device, and the fittings are clean. Failure to do so can result in impurities entering the bearing housing while regreasing the bearings.

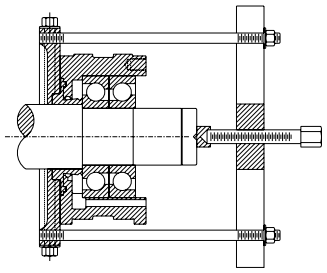
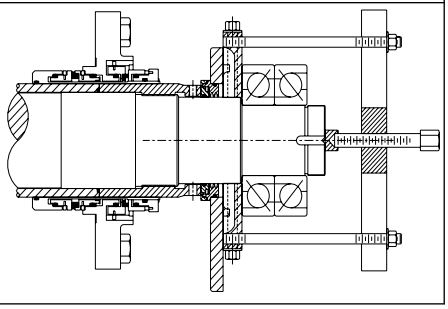
1. Wipe dirt from the grease fittings.
2. Remove the two grease-relief plugs on the bearing housings.
3. Fill both of the grease cavities through the fittings with a recommended grease until the fresh grease comes out of the relief holes.
4. Run the pump for about 30 minutes or until grease no longer comes out of the housing.
5. Reinstall the grease-relief plugs.
6. Wipe off any excess grease.
7. Recheck the alignment.

The bearing temperature usually rises after you regrease due to an excess supply of grease. Temperatures return to normal in about two to four operating hours as the pump runs and purges the excess grease from the bearings.

6.2.6 Remove the ball bearings

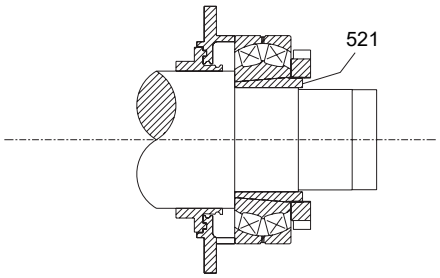
1. Square the puller bar with the end of the shaft.
   The bar must be square at all times in order to keep even pressure on the outer circumference of the bearing.
2. Steadily tighten the puller screw in order to enable the bearing to slide smoothly off the shaft. Do not damage the end of the shaft.

Bearing removal for all except SX and MX	Bearing removal for SX and MX
	

Bearing removal for all except SX and MX	Bearing removal for SX and MX
	

6.2.7 Remove the roller bearings

1. Screw the adapter sleeve removal nut onto the adapter sleeves (521).
   When you tighten the nut, it loosens the sleeves out from under the inner race of the bearings.



2. Slide the adapter sleeves and bearings off of the shaft and protect them from contamination.
3. Unscrew the adapter removal nut and store it for future use.

6.3 Mechanical-seal maintenance

WARNING:

- The mechanical seal used in an Ex-classified environment must be properly certified.
-

CAUTION:
Running a mechanical seal dry, even for a few seconds, can cause seal failure and physical injury. Never operate the pump without liquid supplied to the mechanical seal.

Cartridge-type mechanical seals

Cartridge-type mechanical seals are commonly used. Cartridge seals are preset by the seal manufacturer and require no field settings. Cartridge seals installed by the user require disengagement of the holding clips prior to operation, allowing the seal to slide into place. If the seal has been installed in the pump by ITT, these clips have already been disengaged.

Other mechanical seal types

For other types of mechanical seals, refer to the instructions provided by the seal manufacturer for installation and setting.

Reference drawing

The manufacturer supplies a reference drawing with the data package. Keep this drawing for future use when you perform maintenance and seal adjustments. The seal drawing specifies the required flush fluid and attachment points.

Before you start the pump

Check the seal and all flush piping.

Mechanical seal life

The life of a mechanical seal depends on the cleanliness of the pumped fluid. Due to the diversity of operating conditions, it is not possible to give definite indications as to the life of a mechanical seal.

6.4 Packed stuffing-box maintenance

WARNING:
Packed stuffing boxes are not allowed in an Ex-classified environment.

WARNING:
Failure to disconnect and lock out driver power may result in serious physical injury. Never attempt to replace the packing until the driver is properly locked out.

Accepted leakage rate

It is not necessary to shut down or disassemble the pump to inspect the packing operation. During normal operation, the packing should leak approximately one drop per second.

Adjustment of gland

Adjust the gland if the leakage rate is greater than or less than the specified rate.

Evenly adjust each of the two gland bolts with a one-quarter (1/4) turn until the desired leakage rate is obtained. Tighten the bolts to decrease the rate. Loosen the bolts to increase the rate.

Tightening of packing

NOTICE:
Never over-tighten packing to the point where less than one drop per second is observed. Over-tightening can cause excessive wear and power consumption during operation.

If you cannot tighten the packing to obtain less than the specified leakage rate, then replace the packing.

6.5 Disassembly

6.5.1 Disassembly precautions

WARNING:

- Failure to disconnect and lock out driver power may result in serious physical injury or death. Always disconnect and lock out power to the driver before performing any installation or maintenance tasks.
  - Electrical connections must be made by certified electricians in compliance with all international, national, state, and local rules.
  - Refer to driver/coupling/gear manufacturer's installation and operation manuals (IOM) for specific instructions and recommendations.
- Risk of serious personal injury. Applying heat to impellers, propellers, or their retaining devices can cause trapped liquid to rapidly expand and result in a violent explosion. This manual clearly identifies accepted methods for disassembling units. These methods must be adhered to. Never apply heat to aid in their removal unless explicitly stated in this manual.
- Handling heavy equipment poses a crush hazard. Use caution during handling and wear appropriate Personal Protective Equipment (PPE, such as steel-toed shoes, gloves, etc.) at all times.
- Precautions must be taken to prevent physical injury. The pump may handle hazardous and/or toxic fluids. Proper personal protective equipment should be worn. Pumpage must be handled and disposed of in conformance with applicable environmental regulations.
- Risk of serious physical injury or death from rapid depressurization. Ensure pump is isolated from system and pressure is relieved before disassembling pump, removing plugs, opening vent or drain valves, or disconnecting piping.
- Risk of serious personal injury from exposure to hazardous or toxic liquids. A small amount of liquid will be present in certain areas like the seal chamber upon disassembly.

CAUTION:

- Avoid injury. Worn pump components can have sharp edges. Wear appropriate gloves while handling these parts.

6.5.2 Drain the pump

CAUTION:

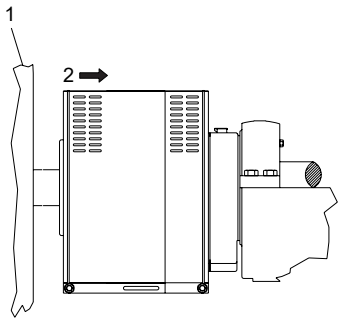
- Risk of physical injury. Allow all system and pump components to cool before handling.
- If the pumped fluid is non-conductive, drain and flush the pump with a conductive fluid under conditions that will not allow for a spark to be released to the atmosphere.

1. Leave the drain valve open.
   Do not close the drain valve until the reassembly is complete.
2. Disconnect the coupling.
3. Remove the coupling guard endplate.
4. Oil Lubrication: Drain the oil from the bearing housings by removing the bearing housing drain plugs (item 358). Replace the plugs after the oil is drained. Remove the oiler.
5. Remove these parts based on your seal type:

If your seal type is...	Then...
Packing	Remove the gland nuts (355) and slide the glands (107) away from the stuffing boxes.
Conventional mechanical seal	Remove the gland nuts (355) and slide the gland and the stationary seat away from the seal chamber.
Cartridge mechanical seal	1. Replace the spacer clips on the mechanical seal sleeve. 2. Loosen the set screws in the locking collar on the mechanical seal. 3. Remove the gland nuts (355) and slide the mechanical seal away from the seal chamber.

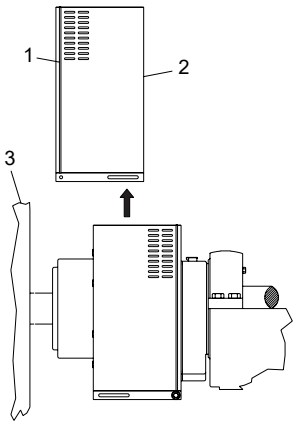
6.5.3 Remove the coupling guard

1. Remove the nut, bolt, and washers from the slotted hole in the center of the coupling guard.
2. Slide the driver half of the coupling guard toward the pump.



Item	Description
1.	Driver
2.	Slide to remove

3. Remove the nut, bolt, and washers from the driver half of the coupling guard.
4. Remove the driver half of the coupling guard:
   a) Slightly spread the bottom apart.
   b) Lift upwards.

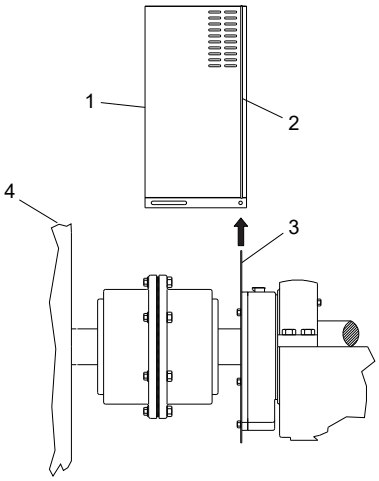


Item	Description
1.	Annular groove
2.	Coupling guard half
3.	Driver

5. Remove the remaining nut, bolt, and washers from the pump half of the coupling guard.

It is not necessary to remove the end plate from the pump side of the bearing housing. You can access the bearing-housing tap bolts without removing this end plate if maintenance of internal pump parts is necessary.

6. Remove the pump half of the coupling guard:
   a) Slightly spread the bottom apart.
   b) Lift upwards.



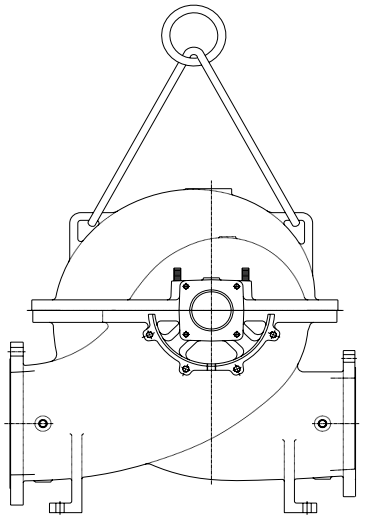
Item	Description
1.	Coupling guard half
2.	Annular groove
3.	Pump end plate
4.	Driver

6.5.4 Remove the casing

WARNING:
Do not use lifting lugs on the top half of the casing.

1. Remove the casing parting nuts (425B).
2. Remove the dowel pins (469G).
3. Loosen the upper half of the casing (100) by using the casing jack bolts (418).
4. Remove the upper half of the casing evenly using the lifting lugs.
   Make sure adequate clearance is available in order to remove the upper half.

Use care in order to prevent any tears to the casing gasket.



Frame	Pump size	Minimum headroom U.H. removal in inches (millimeters)
SX	12 x 14-15	25 (635)
	16 x 18-17h	31 (787)
MX	18 x 20-20	34 (864)
M	16 x 18-30	41 (1048)
	18 x 20-30	42 (1061)
	20 x 24-24	38 (959)
	20 x 24-30	43 (1080)
M (Mod)	20 x 24-28	44 (1118)
—	18 x 20-24	38 (965)
L	24 x 30-32	45 (1143)
LDS	30 x 30-31	51 (1288)
	30 x 30-38	53 (1353)
XL	20 x 30-42	70 (1778)
	30 x 36-42	62 (1575)
XXL	36x42-52	76 (1930)

6.5.5 Bearing housing and bearings removal

6.5.5.1 Remove the bearing housing and bearings for the SX and MX groups

Table 9: SX and MX groups - 12 x 14-15, 16 x 18-17H, and 18 x 20-20

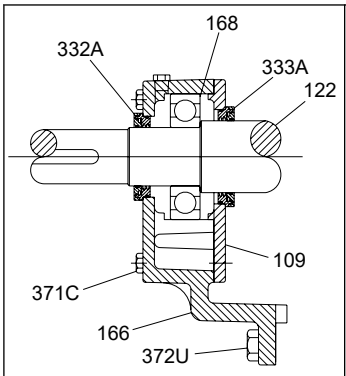


Figure 21: Flood oil, radial

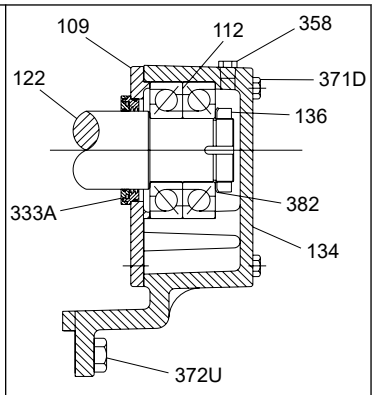


Figure 22: Flood oil, thrust

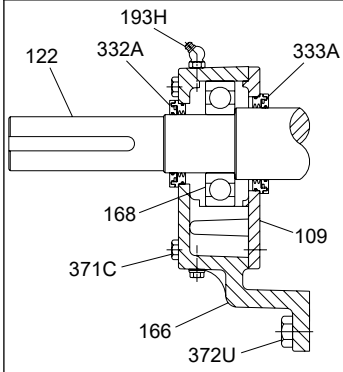


Figure 23: Grease, radial

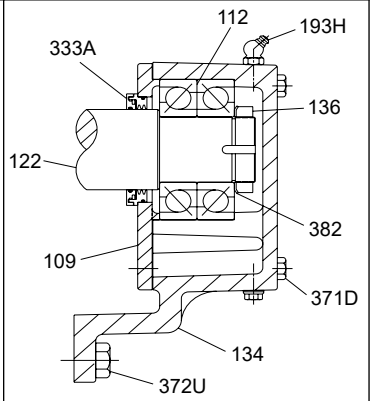
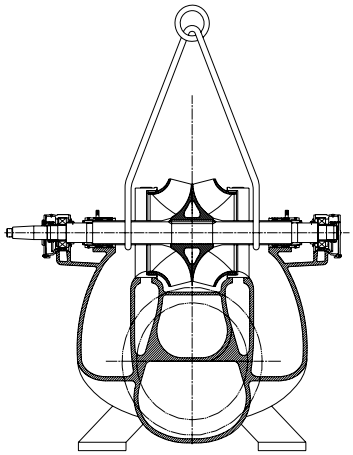


Figure 24: Grease, thrust

1. Remove the eight bearing housing-to-casing capscrews (372U).
2. Place the sling in position and remove the rotating element:
   a) Adjust the sling tension in order to take weight off of the rotating element.
   b) Make sure all stationary parts of the rotating element are loose before you remove the rotating element.
   c) Rotate the casing wearing rings (127) 180° in order to disengage the tongue and groove locks.
   d) Remove the element and place it on padded supports.



3. Slide the casing rings off the rotating element.
4. Scribe the coupling position on the shaft (122) and remove the coupling and the coupling key (400).
5. Remove the eight bearing housing-to-bearing end cover capscrews (371C and 371D).
6. Remove the outboard bearing housing (134) by sliding it over the thrust bearings (112).
7. Remove the coupling-end bearing housing (166) and labyrinth seal (332A) together by sliding them over the radial bearing (168) and off the shaft.
8. Press the labyrinth seal out of the bearing housing from the inside with a properly-sized arbor.
9. Straighten the tangs in the bearing lockwasher (382) and remove the bearing locknut (136) and lockwasher from the outboard end of the shaft.
10. Remove the thrust and radial bearings using a bearing puller.
    See 6.2.6 Remove the ball bearings on page 58 for more information. Save the bearings for inspection.
11. Slide the bearing end covers (109) and labyrinth seals (333A) off of the shaft.
    Press the labyrinth seals out of the end covers from the inside using a properly-sized arbor.

6.5.5.2 Remove the bearing housing and bearings for the M group

Table 10: M group - 16 x 18-30, 18 x 20-30, 20 x 24-24, 20 x 24-30, 20 x 24-28, and 18 x 20-24

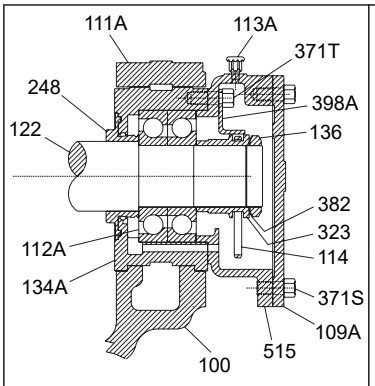


Figure 25: Ring oil, thrust

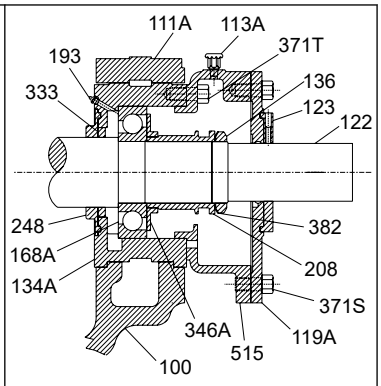


Figure 26: Ring oil, radial

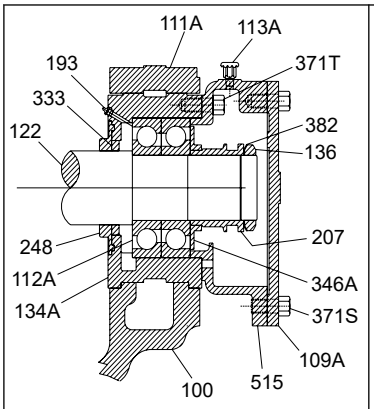


Figure 27: Grease, thrust

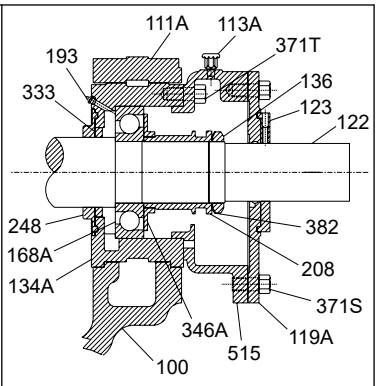


Figure 28: Grease, radial

CAUTION:
In order to prevent damage to the pump, make sure that the bearing caps are in the correct position when the pump is reassembled.

1. Loosen the setscrew (222P) and slide the dust cover (123A) towards the coupling.
2. Remove the bearing cap hex nuts (425A) and the bearing caps (111A). Match-mark each bearing cap.
   They must be replaced on the same end and in the same position on the pump during reassembly. The casing and the bearing caps are machined as a matched set.
3. Place the sling in position and adjust the sling tension in order to take weight off of the rotating element. Make sure all stationary parts of the rotating element are loose before you remove the rotating element.
4. Rotate the casing wearing rings (127), stuffing box bushings (125), and the bearing housings (134A) 180° to disengage the tongue and groove locks.
5. Remove the element and place it on padded supports.
6. Slide the casing rings off the rotating element.
7. Scribe the coupling position on the shaft (122) and remove the coupling and the coupling key (400).
8. Unbolt and remove both bearing end covers (109A and 119A).
9. Remove these items based on your lubrication type:
   - For oil lubrication, remove the oil rings (114) and the oil ring housings (515).
   - For grease lubrication, remove the oil ring housings (515).
10. Loosen the setscrews (363B) in the oil throwers (248) and slide them toward the shaft sleeves (126).
11. Straighten the tangs in the lockwashers (382) and remove both bearing locknuts (136) and lockwashers.
12. Slide the oil ring sleeves (324/323 or 207/208) off of the shaft.
    On grease-lubricated units, a grease shield (346A) is mounted on the oil ring sleeves (207 and 208).
13. Remove the bearings (112A and 168A) using the bearing puller. Save the bearings for inspection.
14. Slide the bearing housings off of the shaft.
15. Slide the oil throwers off of the shaft.

6.5.5.3 Remove the bearing housing and bearings for the L group

Table 11: L group - 24 x 30-32

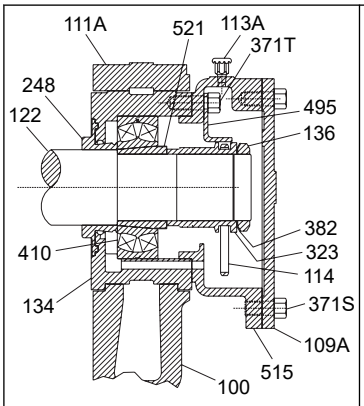


Figure 29: Ring oil, thrust

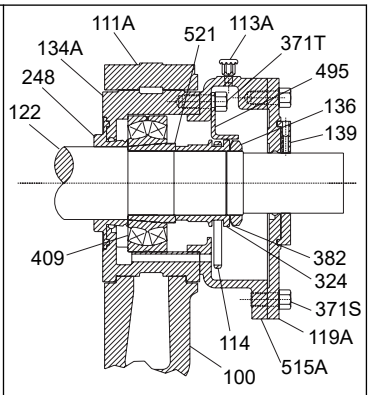


Figure 30: Ring oil, radial

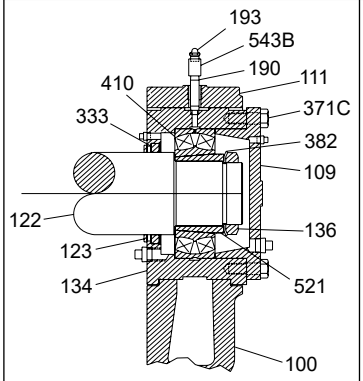


Figure 31: Grease, thrust

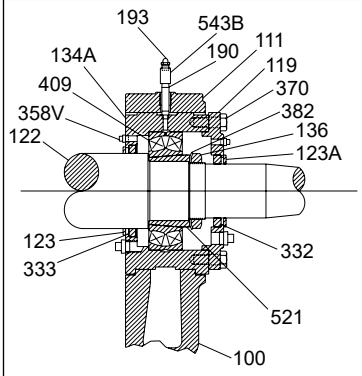


Figure 32: Grease, radial

CAUTION:
In order to prevent damage to the pump, make sure that the bearing caps are in the correct position when the pump is reassembled.

1. Slide these parts toward the coupling based on the lubrication of your pump:

If the lubrication of your pump is...	Then...
Oil	Loosen the setscrew (364) in the dust cover (123A) on the coupling end and slide it towards the coupling.
Grease	Slide the deflector (332) on the coupling end towards the coupling.

2. Remove the bearing cap hex nuts (425A) and the bearing cap (111). Scribe matching marks on each bearing cap.
   You must replace them on the same end and in the same position on the pump during reassembly. The casing and the bearing caps are machined as a matched set.
3. Place the sling in position and remove the rotating element:
   a) Adjust the sling tension to take weight off of the rotating element.
   b) Make sure all stationary parts of the rotating element are loose before the rotating element is removed.

c) Rotate the casing wearing rings (127), stuffing box bushings (125), and the bearing housings (134 and 134A) 180° to disengage the tongue and groove locks.

d) Remove the element and place it on padded supports.

4. Slide the casing rings off the rotating element.
5. Scribe the coupling position on the shaft (122) and remove the coupling and the coupling key (400).
6. Remove these items based on your lubrication type:
   - For oil lubrication, slide the dust cover (139) off of the coupling end of the shaft.
   - For grease lubrication, slide the deflector (123A) off of the coupling end of the shaft.
7. Unbolt and remove both bearing end covers (109A and 119A).
8. For oil lubricated pumps, remove the oil rings (114) and the oil ring housings (515).
9. Straighten the tangs in the lockwashers (382) and remove both bearing locknuts (136) and lockwashers.
10. Remove these items based on your lubrication type:
    - For oil lubrication, slide the oil ring sleeves (324 and 323) off of the shaft (122).
    - For grease lubrication, remove the grease shield (346A) and the oil ring sleeves (207 and 208).
11. Slide the bearing housings off of the shaft.
12. Remove these items based on your lubrication type:
    - For oil lubrication, loosen the setscrews (363B) in the oil throwers (248) and slide the oil throwers off of the shaft.
    - For grease lubrication, slide the deflectors (123) off of the shaft.

6.5.5.4 Remove the bearing housing and bearings for the LDS, XL, and XXL groups

Table 12: LDS and XL groups - 30 x 30-31, 30 x 30-38, 30 x 36-42, 36 x 42-52

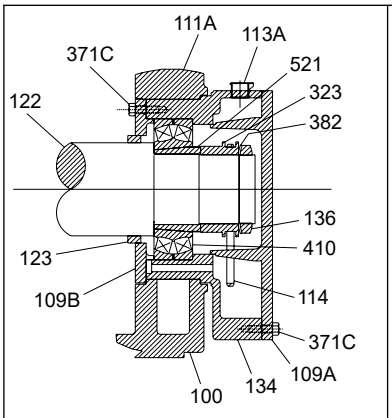


Figure 33: LDS ring oil, thrust

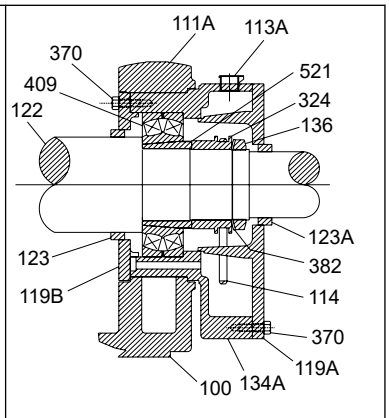


Figure 34: LDS ring oil, radial

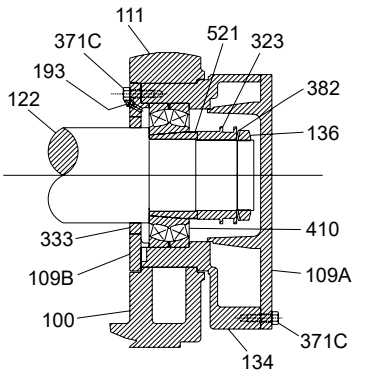


Figure 35: LDS grease, thrust

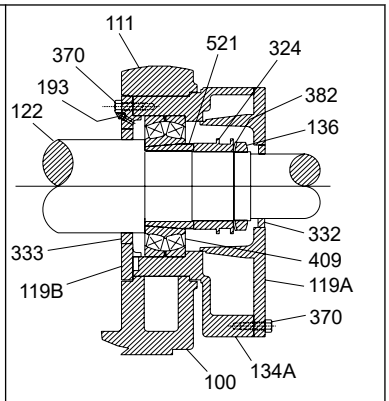


Figure 36: LDS grease, radial

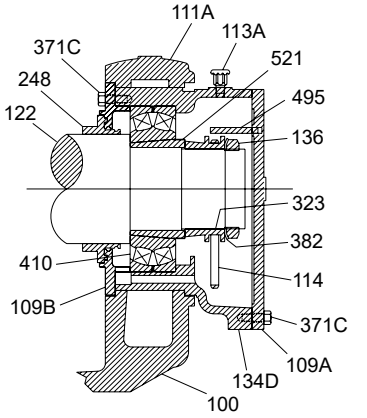


Figure 37: XL ring oil, thrust

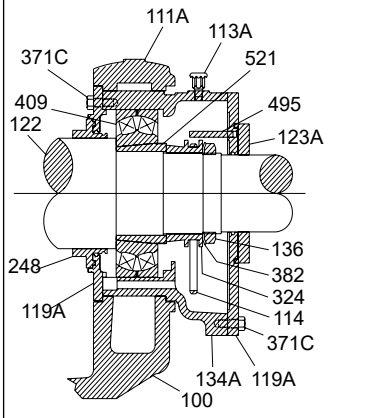


Figure 38: XL ring oil, radial

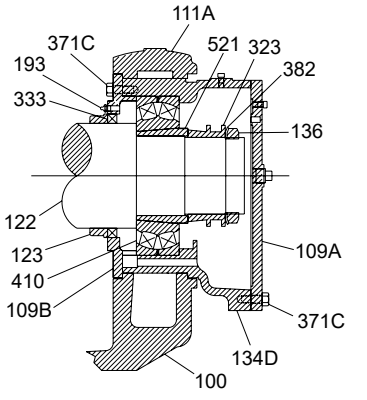


Figure 39: XL grease, thrust

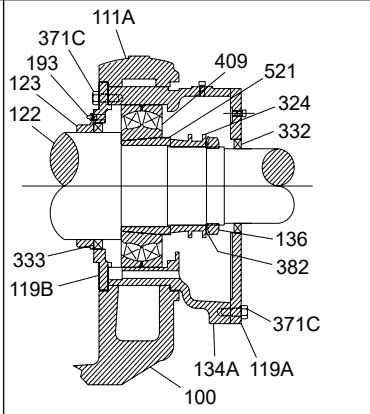


Figure 40: XL grease, radial

CAUTION:
In order to prevent damage to the pump, make sure that the bearing caps are in the correct position when the pump is reassembled.

1. Slide these parts toward the coupling, based on the lubrication of your pump:

If the lubrication of your pump is...	Then...
Oil	Loosen the setscrew (364) in the dust cover (123A) on the coupling end and slide it towards the coupling.

If the lubrication of your pump is...	Then...
Grease	Slide the deflector (332) on the coupling end towards the coupling.

2. Remove the bearing cap hex nuts (425A) and the bearing cap (111). Scribe matching marks on each bearing cap.
   You must replace them on the same end and in the same position during reassembly. The casing and the bearing caps are machined as a matched set.
3. Place the sling in position and remove the rotating element:
   a) Adjust the sling tension in order to take weight off of the rotating element.
   b) Make sure all stationary parts of the rotating element are loose before you remove the rotating element.
   c) Rotate the casing wearing rings (127), stuffing box bushings (125), and the bearing housings (134 and 134A or 134A and 134D) 180° in order to disengage the tongue and groove locks.
   d) Remove the rotating element and place it on padded supports.
4. Slide both casing rings off the rotating element.
5. Scribe the coupling position on the shaft (122) and remove the coupling and the coupling key (400).
6. Slide these items off of the coupling end of the shaft based on the lubrication of your pump:
   - For oil lubrication, slide off the dust cover (123A).
   - For grease lubrication, slide off the deflector (332).
7. Unbolt and remove both bearing end covers (109A and 119A).
8. For oil lubricated pumps, remove the oil rings (114).
9. Straighten the tangs in the lockwashers (382) and remove both bearing locknuts (136) and lockwashers.
10. Remove these parts based on the lubrication of your pump:
    - For oil lubrication, slide the oil ring sleeves (324 and 323) off of the shaft (122).
    - For grease lubrication, remove the grease shield (346A) and the oil ring sleeves (207 and 208).
11. Slide the bearing housings and the inboard bearing end covers (109B and 119B) off of the shaft.
    If desired, you can remove the inboard bearing end covers from the bearing housings at this time in order to replace the end cover to housing gasket (360N or 360B).
12. Remove these parts based on the lubrication of your pump:
    - For oil lubrication, loosen the set screws (364) in the oil throwers (248) and slide the oil throwers off of the shaft.
    - For grease lubrication, slide the deflectors (333) off of the shaft.

6.5.6 Disassemble the rotating element

WARNING:
Damage to the hub surface could result in a failed seal, which can result in serious physical injury. Make sure not to damage the impeller hub surface, which is an O-ring sealing surface.

1. Remove these parts from the shaft:

If you have a...	Then...
Conventional mechanical seal	Slide the gland off of the shaft while you also make sure to keep the stationary seats in place. Use care in order to prevent damage to the seal faces.
Cartridge mechanical seal	Slide the mechanical seal (383) off of the shaft.
Packed stuffing box	1. Slide the glands (107) off of the shaft. 2. Remove the packing (106), lantern rings (105), and stuffing box bushings (125).

2. Loosen the setscrews (222B) in the sleeve nuts (124).
3. Use a spanner or strap wrench in order to remove the sleeve nuts and discard the sleeve O-rings (497).
   One sleeve has right-hand threads and one has left-hand threads. The nuts tighten against the rotation of the pump.
4. Smooth the shaft (122) with a fine emery cloth so that the sleeves do not bind upon removal.
5. Carefully slide the sleeves (126) off of the shaft. Discard the impeller O-rings (412A).
   If the pump has conventional mechanical seals, then the stuffing box bushings and the rotary elements of the mechanical seals are still mounted to the sleeves.
6. Scribe a line on the shaft at the impeller hub (101).
   Use this line in order to help you determine the proper position of the impeller on the shaft for reassembly.
7. Press the impeller off of the shaft.
8. Remove the impeller key (178).

6.6 Pre-assembly inspections

Guidelines

Before you assemble the pump parts, make sure you follow these guidelines:

- Inspect the pump parts according to the information in these pre-assembly topics before you reassemble your pump. Replace any part that does not meet the required criteria.
- Make sure that the parts are clean. Clean the pump parts in solvent in order to remove oil, grease, and dirt.

NOTICE:

Protect machined surfaces while cleaning the parts. Failure to do so may result in equipment damage.

6.6.1 Replacement guidelines

Casing check and replacement

WARNING:
Risk of death or serious injury. Leaking fluid can cause fire and/or burns. Inspect and ensure gasket sealing surfaces are not damaged and repair or replace as necessary.

Inspect the casing for cracks and excessive wear or pitting. Thoroughly clean gasket surfaces and alignment fits in order to remove rust and debris.

Repair or replace the casing if you notice any of these conditions:

- Localized wear or grooving that is greater than 3.2 mm | 1/8 in. deep
- Pitting that is greater than 3.2 mm | 1/8 in. deep
- Irregularities in the casing-gasket seat surface

Casing areas to inspect

The arrows point to the areas to inspect for wear on the casing:

Labyrinth seal replacement

Replace the labyrinth-seal O-ring if it has cuts and cracks.

Oil ring replacement

Oil rings must be as round as possible in order to function properly. Replace oil rings if they are worn, distorted, or damaged beyond reasonable repair.

Gaskets, O-rings, and seats replacement

WARNING:
Risk of death or serious injury. Leaking fluid can cause fire and/or burns. Replace all gaskets and O-rings at each overhaul or disassembly.

WARNING:
Risk of serious personal injury or property damage. Fasteners such as bolts and nuts are critical to the safe and reliable operation of the product. Ensure appropriate use of fasteners during installation or reassembly of the unit.

- Use fasteners of the proper size and material only.
- Replace all corroded fasteners.
- Ensure that all fasteners are properly tightened and that there are no missing fasteners.

6.6.2 Bearings inspection

Condition of bearings

Do not reuse bearings. The condition of the bearings provides useful information on operating conditions in the bearing frame.

Do not re-use anti-friction bearings after they have been disassembled and inspected.

Checklist

Perform these checks when you inspect the bearings:

- Inspect the bearings for contamination and damage.
- Note any lubricant condition and residue.
- Inspect the ball bearings to see if they are loose, rough, or noisy when you rotate them.
- Investigate any bearing damage to determine the cause. If the cause is not normal wear, correct the issue before you return the pump to service.

Bearing housings

Perform these checks when you inspect the bearing housings:

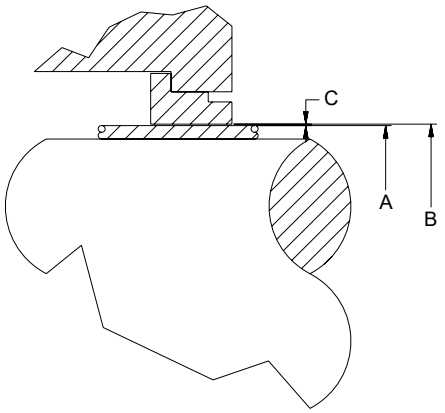
- Check that the bearing housings are very clean, with no burrs.
- Remove all loose and foreign material.
- Make sure that all lubrication passages are clear.
- Inspect the bearing bores according to the tolerances in the 6.7.4.5 Bearing fits and tolerances (inches) on page 95 tables.
- Repair or replace housings as necessary.

6.6.3 Shaft inspection

Checklist

Perform these checks when you inspect the shaft and sleeve.

- Check the bearing fits.
- Check the straightness of the shaft.
- Check the shaft and sleeve (126) surface for grooves and pitting. Replace if any are found.
- Check that the bearing seats and oil seal are smooth and free from scratches and grooves.
- Shaft threads must be in good condition.
- Make sure that the O-ring groove is in good condition.
- Check the diametrical clearance between the sleeve and the stuffing box bushing. Replace the sleeve and/or stuffing box if the clearance is more than 0.030 in. (0.762 mm).



6.6.4 Shaft replacement guidelines

Shaft measurement check

Check the bearing fits of the shaft. If any are outside the tolerances shown in the Bearing fits and tolerances table, then replace the shaft.

Shaft inspection

NOTICE:
Do not use shaft centers for the runout check as they may have been damaged during the removal of the bearings or impeller.

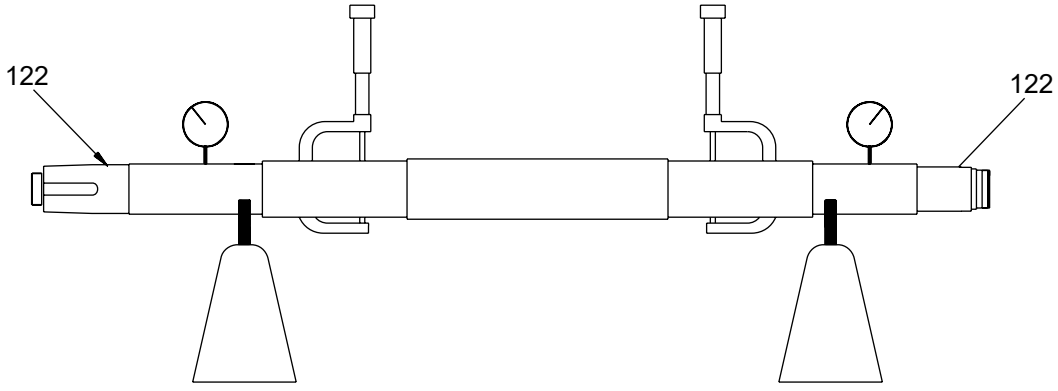


Figure 41: Shaft inspection

6.6.5 Parting gasket inspection and replacement

- Inspect the parting flange gaskets (351S and 351D) and replace them if they are damaged. The recommended gasket materials are Garlock Blue Gard 3000™ or Armstrong N8090.
- Check the gasket thickness. See the 6.7.4.2 Impeller bore diameter tolerances on page 85 for the correct gasket thickness.

  Use the upper half of the casing as a template. If you do not have the correct thickness, then strike the sheet with a soft-face hammer. This cuts the gasket against the edge of the casing.

  For pumps with mechanical seals, cut the gasket approximately 0.25 in (6.35 mm) long at the face of the stuffing box. Then trim the excess to a perfect fit after the pump casing is assembled.

  SX and MX pump parting flange gaskets are supplied with pre-cut outer edges and fastener holes.

CAUTION:

Make sure not to chip any internal coatings that may have been applied to the internal passages of the casing. If the casing has an internal coating, then it may be easier to cut the gasket using a knife.

- Make sure that the gasket covers the entire surface of the parting flange. Pay special attention to the areas around the wear ring locks.

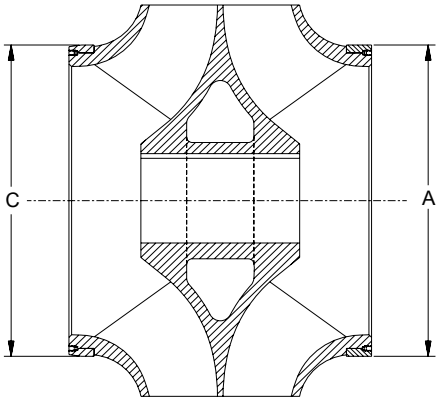
  Leaks occur if the area around the wear ring locks are not properly sealed. This results in lost performance and efficiency.

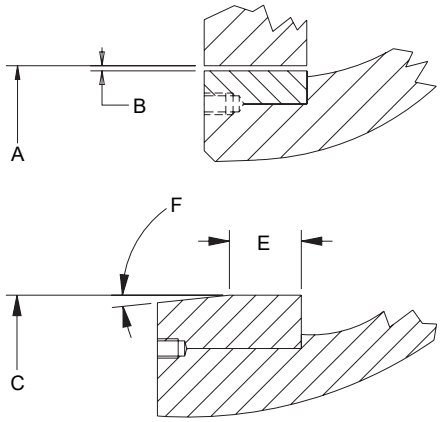
6.6.6 Replace the impeller wear rings

1. Remove the old rings by removing the three setscrews (320) and pulling the ring (142) off of the impeller hub.
2. Clean the impeller hub and press on a new wear ring.
3. Drill and tap three holes in the ring/hub seam 120° apart, offset from the original setscrew holes.
4. Insert new setscrews (320) and lightly upset the threads.

NOTICE:

Replacement impeller wear rings are supplied 0.020 - 0.030 in. (0.508 - 0.762 mm) oversized and must be turned to size after you mount them on the impeller. SX and MX size rings are supplied turned to the finished diameter.

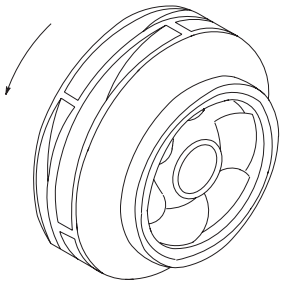




6.7 Reassembly

6.7.1 Install the impeller

1. Determine the correct position of the impeller (101) on the shaft (122) based on the direction of rotation.



2. Insert the impeller key (178) in the shaft and slide the impeller on the shaft. Press the shaft into the impeller.
3. Line up the impeller hub with the scribe mark that you made on the shaft during disassembly. If a new shaft is being used, then center the impeller on the keyway.
4. Place the impeller O-rings (412A) in the grooves in the end of the sleeves (126) and then slide the shaft sleeves on the shaft.
5. Place the sleeve O-rings (497) in the grooves in the end of the sleeve nuts (124 and 130).
6. Slide the sleeve nuts on the shaft and tighten the nuts against shaft rotation using a spanner or strap wrench.
   One sleeve has right-hand threads and one has left-hand threads. The nuts tighten against the rotation of the pump.
7. Tighten the setscrews (222B) in the sleeve nuts.
8. Install these parts:

If your pump is sealed with...	**Then...**
Packing	1. Slide the stuffing box bushings (125) over the sleeves. 2. Position the bushings so that the lock faces the packing. 3. Slide the lantern ring (105) on the shaft.
Conventional mechanical seal	1. Carefully slide the rotary portion on the sleeve and fasten it into position according to the manufacturer's instructions. 2. Carefully slide the seal glands with the stationary seats and the gland gaskets on the shaft.

If your pump is sealed with...	Then...
Cartridge mechanical seal	Carefully slide the cartridge unit on the sleeve.

6.7.2 Bearing housing and bearings installation

WARNING:
Risk of physical injury from hot bearings. Wear insulated gloves when using a bearing heater.

NOTICE:

- There are several methods you can use to install bearings. The recommended method is to use an induction heater that heats and demagnetizes the bearings.
- Coat the internal bearing surfaces with lubricant for in-service use. Failure to do so may result in equipment damage or decreased performance.
- This pump uses duplex bearings mounted back-to-back. Make sure orientation of the bearings is correct.

6.7.2.1 Install the bearing housing and bearings for the SX and MX group

1. Press the inboard labyrinth seals (333A) into the end covers (109) with a properly-sized arbor.
2. Slide the end covers with the seals installed onto the shaft (122) up to the sleeve nuts (130). Make sure that the labyrinth seals face the sleeve nuts. See the figures in 6.5.5.1 Remove the bearing housing and bearings for the SX and MX groups on page 65.
3. Install the radial bearing (168) on the shaft.
4. Install the thrust bearing (112) on the shaft.
5. Place the bearing lockwasher (382) on the shaft. Be sure to place the tang of the lockwasher in the keyway of the shaft.
6. Install the bearing on the shaft:
   a) Thread the bearing locknut (136) onto the shaft.
   b) After the bearing and the shaft have cooled to ambient temperature, tighten the locknut to the values shown the 6.7.4.7 Bolt torque values on page 98 table.
   c) Bend any tang of the lockwasher into a slot in the locknut.
7. Assemble the radial bearing housing:
   a) Press the outboard labyrinth seal (332A) into the radial bearing housing (166) with a properly-sized arbor.
   b) Install the radial bearing housing with the labyrinth seal installed and a bearing housing gasket (360).
   c) Slide the housing assembly over the radial bearing.
8. Secure the bearing housing by installing four bearing housing-to-end cover capscrews (371C). Tighten the capscrews to the torque values shown in the 6.7.4.7 Bolt torque values on page 98 table.
9. Install the thrust bearing housing (134) with a bearing housing gasket (360).
10. Slide the bearing housing over the thrust bearing.
11. Secure the bearing housing by installing four bearing housing-to-end cover capscrews (371C). Tighten the capscrews to the torque values shown in the 6.7.4.7 Bolt torque values on page 98 table.

6.7.2.2 Install the bearing housing and bearings for the M group, 18 x 20-24, and 20 x 24-28

1. Install these parts on the shaft based on the lubrication of your pump:

If your lubrication is...	Then...
Oil	Slide both oil throwers (248) on the shaft (122).
Grease	Slide both deflectors (248) on the shaft (122).

2. For grease-lubricated pumps, install the grease seals (333) in the bearing housings (134A) using a properly-sized arbor.
3. Slide the bearing housings (134A) on the shaft and install the bearings.
   The radial bearing (168A) is a single-row ball bearing and the thrust bearing (112A) is a duplex-angular contact bearing.
4. For grease-lubricated pumps, install the grease shields (346A) on the oil ring sleeves (207 and 208).
5. Slide the oil ring sleeves (207N and 208 or 323 and 324) on the shaft against the bearings.
6. Place the bearing lockwashers (382) and the bearing locknuts (136) on the shaft.
7. After the bearings and shaft have cooled to ambient temperature, tighten the locknut to the torque value shown in the Bolt torque values table.
8. Bend any tang of the lockwasher into a slot on the locknut.
9. Bolt the oil ring housings (515) with a gasket (360G) to the bearing housing on each end of the shaft.
10. Tighten the oil-ring housing-to-bearing housing capscrews (371T) to the torque values shown in the Bolt torque values table.
    The total travel of the rotating element is adjusted by adding oil-ring housing-to-bearing housing gaskets (360G) on the thrust end of the pump in a later step.
11. For oil-lubricated pumps, install the oil rings:

    a) Place the oil rings (114) in position on the groove in the oil ring sleeves (323 and 324).

    b) Install the oil ring retaining bracket (398A) in the oil ring housing (515).

    c) Bolt the end covers (109A and 119A) to the oil ring housings and tighten the capscrews (371S) to the torque values shown in the Bolt torque values table.

    d) Slide the coupling end dust covers (123 and 123A) on the shaft.

6.7.2.3 Install the bearing housing and bearings for the L group

1. Slide these parts on the shaft (122) based on your lubrication type:
   - For oil lubrication, slide the oil throwers (248) and the bearing housings (134 and 134A).
   - For grease lubrication, slide the deflectors (123) and the bearing housings (134 and 134A).
2. Slide the roller bearings (409 and 410) on the shaft until they contact the shaft shoulder.
   The inner race of the roller bearing has a tapered bore. Make sure the large bore end of the bearing faces the end of the shaft. The lip of the adapter sleeve slides under the inner race of the bearing.
3. Lightly oil the shaft and the outside diameter of the adapter sleeve.
4. Slide the lip of the sleeve under the inner race of the bearing.
5. For oil-lubricated pumps, slide the oil ring sleeves (324) on the shaft.
6. Place the bearing lockwashers (382) and the bearing locknuts (136) on the shaft and hand-tighten.
7. Adjust the clearances for the roller bearings:

    a) Rotate the shaft until a roller is in the top-vertical position.

    b) Measure the clearance between the roller and the outer race with a feeler gauge.
    The amount of adjustment to the internal clearance is based on this initial clearance. Consult the bearing manufacturer’s installation procedure for the proper amount of residual internal clearance.

    c) Tighten the bearing locknut until you reach the recommended clearance.

d) Check the clearance by rotating the shaft 90° and measuring the clearance.

e) Tighten the locknut, if required.

Do this several times in order to make sure that the bearing is not distorted.

8. Bend a tang of the lockwasher into a locknut groove.
9. Complete these steps for oil-lubricated pumps:

   a) Bolt the oil ring housings (515 and 515A) to the bearing housings (134 and 134A) using capscrews (371T).

   b) Place the oil rings (114) in the grooves on the oil ring sleeve.

   c) Bolt the end covers (109A and 119A) to the bearing housings using capscrews (371S) and hand-tighten.

   d) Slide the dust cover (139) and the coupling on the shaft.

10. For grease-lubricated pumps, slide the dust cover (123A) with the seal installed and the coupling on the shaft.

6.7.2.4 Install the bearing housing and bearings for the LDS, XL, and XXL groups

1. Install these parts based on the lubrication of your pump:

If your lubrication type is...	Then...
Oil	1. Slide the oil throwers (123) on the shaft (122). 2. Install the bearing end covers (109B and 119B) on the bearing housings (134 and 134A) with capscrews (370). Tighten the capscrews to the torque values shown in the Bolt torque values table. 3. Slide the bearing housing sub-assemblies on the shaft.
Grease	1. Slide the deflectors (333) on the shaft (122). 2. Install the grease seals (333) in the inboard bearing end covers (109B and 119B). 3. Install the bearing end covers on the bearing housings (134 and 134A) with capscrews (370). Tighten the capscrews to the torque values shown in the Bolt torque values table. 4. Slide the bearing housing sub-assemblies on the shaft.

2. Slide the roller bearings (409 and 410) on the shaft until they contact the shaft shoulder.
   The inner race of the roller bearing has a tapered bore. Make sure the large bore end of the bearing faces the end of the shaft. The lip of the adapter sleeve slides under the inner race of the bearing.
3. Lightly oil the shaft and the outside diameter of the adapter sleeve. Slide the lip of the sleeve under the inner race of the bearing.
4. Slide the oil ring sleeves (324) on the shaft.
5. Place the bearing lockwashers (382) and the bearing locknuts (136) on the shaft and hand-tighten.
6. Adjust the roller bearing clearances:
   L, LDS, XL, and XXL frames use spherical roller bearings mounted on tapered sleeves which require you to tighten the bearing locknut in order to draw the bearing up on the taper.

   a) Place the bearing axis in a horizontal position with no upward force on the outer race of the bearing.

   b) Rotate the inner race so that a set of rollers is at the bottom.

   c) Measure and record the clearance between the bottom roller OD and the ID of the bearing outer race using a feeler gauge.

   d) Tighten the locknut (136) until a reduction in bearing clearance is reached as given in this table. Use the measurement from steps a through c minus the measurement after you tighten the locknut.

Group	SKF Bearing Size	Clearance Reduction		Minimum clearance	
		Inches	Millimeters	Inches	Millimeters
L	22226 CN	0.0025 - 0.0035	0.065 - 0.09	0.002	0.055
LDS	22228 CN	0.0025 - 0.0035	0.065 - 0.09	0.002	0.055
XL	22230 CN	0.003 - 0.004	0.075 - 0.10	0.0022	0.06
XXL	22240 CN	0.0032 - 0.0043	0.08 - 0.11	0.0024	0.06

e) Verify that the minimum clearance is not less than the value given in the table.

f) Rotate the bearing through 90° increments and verify the clearance in a few positions.

g) The end play should be no more than .025" max.

7. Bend a tang of the lockwasher into a locknut groove.
8. Bolt the bearing housings (134 and 134A or 134D and 134A) to the bearing end covers (109A and 119B) using capscrews (370 or 371C).
9. Tighten the capscrews to the torque values shown in the Bolt torque values table.
10. Install the end covers and the dust cover:

If your lubrication-type is...	Then...
Oil	1. Place the oil rings (114) in the grooves on the oil ring sleeve. 2. Bolt the end covers (109A and 119A) to the bearing housings using capscrews (370 or 371C) and hand-tighten. 3. Slide the dust cover (123A) and the coupling on the shaft.
Grease	1. Bolt the end covers (109A and 119A) to the bearing housings using capscrews (370 or 371C) and hand-tighten. 2. Slide the dust cover (332) and the coupling on the shaft.

6.7.3 Install the rotating element

WARNING:
Wear insulated gloves to handle the coupling hub. The coupling hub will get hot and can cause physical injury.

NOTICE:
Make sure the caps are replaced on the same end from which they were removed and that the match marks are lined up.

1. Install and position the coupling hub on the shaft (122):

   a) Heat the hub in an oven or hot oil bath until the hub reaches 300°F (150°C).

   b) Slide the hub on the shaft until it is positioned in the same location as it was originally.
2. Clean the wear ring, bearing housing, and stuffing box bushing in both the upper and lower half of the casing.
3. Slide the casing wear rings (127) onto the impeller.
   Be sure the continuous lock on the rings faces the impeller.
4. Carefully lower the rotating element into the lower half of the casing and make sure these parts are situated correctly:
   - For SX and MX group pumps, make sure the double locks on the wear rings are facing up and the anti-rotation pins (445A) in the stuffing box bushings and the rabbet fit of the bearing housings are facing down. Make sure that the pin engages the hole in bushing fit bore.
   - For all other pumps, make sure the double locks on the wear rings, bearing housings, and stuffing box bushings are facing up.

5. After you properly seat the rotating element, rotate these parts 180° so that the double locks are located in the lower half of the casing:
   - SX and MX: Rings
   - All other pumps: Rings, bearing housings, and stuffing box bushings
6. Check the location of the impeller with respect to the casing. Make sure the impeller is centered in the casing.
   If it is not centered, then loosen the sleeve nuts and shift the sleeves and the impeller. Then rotate the shaft by hand in order to make sure the shaft rotates freely.
7. Fasten these bolts based on your pump group:

If your pump group is...	Then...
SX and MX	1. Bolt the thrust end of the bearing housing to the casing using the bearing housing-to-casing capscrews (372U). 2. Tighten the capscrews to the torque values shown in the Bolt torque values table.
All other pump groups	1. Replace the thrust-end bearing cap (111A) and tighten the nuts (425A) evenly to the torque values shown in the Bolt torque values table. 2. Rotate the shaft by hand in order to make sure the shaft rotates freely.

8. For SX, MX, M, 18 x 20-24, and 20 x 24-28 group pumps, adjust the shaft end play:
   a) Clamp a dial indicator to the pump and make sure the button rests against the end of the shaft.
   b) Push the shaft back and forth as far as possible. The total end play must be at least 0.001 in. (0.025 mm) and not more than 0.008 in. (0.203 mm).
   c) If the end play is less than 0.001 in. (0.025 mm), add thrust-end bearing end-cover gaskets or bearing housing-to-oil ring housing gaskets (360 or 360G) until you reach the proper clearance.

   If the end play is greater than 0.008 in. (0.203 mm), then remove the gaskets.
   Because of manufacturing tolerances, duplex bearings can vary in width up to 0.030 in. (0.762 mm). A correctly assembled pump might require several gaskets in order to correctly set the bearing end play.
9. Bolt the radial end according to your pump group:
   - For SX and MX group pumps, bolt the radial end bearing housing to the casing using the bearing housing-to- casing capscrews (372U). Tighten the capscrews to the torque values shown in the Bolt torque values table.
   - For all other pumps, replace the radial end bearing cap and tighten the nuts evenly to the torque values shown in the Bolt torque values table.
10. Make sure that you can rotate the shaft freely by hand.
11. Replace any grease fittings (193), if required.
12. Place the parting gasket (351) in position on the lower half of the casing.
    Make sure the edge of the gasket is tight against the wear rings and the stuffing box bushings.

NOTICE:

Risk of leakage from the high to the low pressure zones in the pump, which will result in lost performance and efficiency. Make sure the area around the wear ring locks is properly sealed.

13. Assemble the upper and lower halves of the casing:
    a) Carefully lower the upper half of the casing onto the lower half. Make sure that it settles into place without resistance.
    b) Replace the dowel pins (469G).
    c) Make sure that you can rotate the shaft freely by hand.
    d) Tighten the parting nuts alternately on each side starting from the center.

e) Make sure that you can rotate the shaft freely by hand.

f) Trim the parting gasket at the stuffing box face, if required.

NOTICE:

Make sure the gasket is flush to the stuffing box face to prevent leakage.

14. For oil-lubricated pumps, slide the oil throwers (248) and dust covers (139) to within 0.0312 in. (0.792 mm) of the bearing end covers or adapters.
15. For grease-lubricated pumps, slide the deflectors (123) to within 0.0312 in. (0.792 mm) of the bearing end covers or adapters.
16. Tighten the setscrews (364).
17. Repack the stuffing box and replace the gland assembly.
18. Install all auxiliary piping.

6.7.4 Assembly references

6.7.4.1 Impeller balancing tolerances

SX group impeller balancing tolerances

Size	Impeller drawing	Pattern	Maximum speed of pump in rpm	Static D/b | 6 G2.5 X/N		Dynamic D/b | 6 G2.5 X/N	
				oz in./lb per plane	g mm/kg per plane	oz in./lb per plane	g mm/kg per plane
12x14-15	D06911A	69117	1800	0.009	14.29	0.0045	7.14
	D07551A	69407	1800	0.009	14.29	0.0045	7.14
16x18-17H	D06983A	69171	1200	0.013	20.64	0.0065	10.32
	D07603A	69686	1200	0.013	20.64	0.0065	10.32

MX group impeller balancing tolerance

Size	Impeller drawing	Pattern	Maximum speed of pump in rpm	Static D/b | 6 G2.5 X/N		Dynamic D/b | 6 G2.5 X/N	
				oz in./lb per plane	g mm/kg per plane	oz in./lb per plane	g mm/kg per plane
18x20-20	—	—	1200	0.013	20.64	0.0065	10.32

M group impeller balancing tolerances

Size	Impeller drawing	Pattern	Maximum speed of pump in rpm	Static D/b | 6 G2.5 X/N		Dynamic D/b | 6 G2.5 X/N	
				oz in./lb per plane	g mm/kg per plane	oz in./lb per plane	g mm/kg per plane
16x18-30	D00038A	54341	1200	0.013	20.64	0.0065	10.32
	D00039A	55147	1200	0.013	20.64	0.0065	10.32
16x18-30G	113-13	57068	1200	0.013	20.64	0.0065	10.32
	D00016A	57068	1200	0.013	20.64	0.0065	10.32
16x18-30H	112-62	57024	1200	0.013	20.64	0.0065	10.32
	D00321A	57024	1200	0.013	20.64	0.0065	10.32
18x20-30	250-2	54342	1200	0.013	20.64	0.0065	10.32

Size	Impeller drawing	Pattern	Maximum speed of pump in rpm	Static D/b | 6 G2.5 X/N		Dynamic D/b | 6 G2.5 X/N	
				oz in./lb per plane	g mm/kg per plane	oz in./lb per plane	g mm/kg per plane
	252-121	55148	1200	0.013	20.64	0.0065	10.32
20x24-24	253-6	55098	1200	0.013	20.64	0.0065	10.32
	253-12	55197	1200	0.013	20.64	0.0065	10.32
20x24-30	254-105	55442	1200	0.013	20.64	0.0065	10.32
	257-89	55796	1200	0.013	20.64	0.0065	10.32

M (modified) group impeller balancing tolerances

Size	Impeller drawing	Pattern	Maximum speed of pump in rpm	Static D/b | 6 G2.5 X/N		Dynamic D/b | 6 G2.5 X/N	
				oz in./lb per plane	g mm/kg per plane	oz in./lb per plane	g mm/kg per plane
20x24-28	D01533A	58714	900	0.018	28.58	0.009	14.29
	D01536A	58717	900	0.018	28.58	0.009	14.29
	D00225A	57692	900	0.018	28.58	0.009	14.29
	D01109A	58337	900	0.018	28.58	0.009	14.29
20x24-28G	D02282A	58954	900	0.018	28.58	0.009	14.29
	D02283A	58955	900	0.018	28.58	0.009	14.29
20x24-28H	D01539A	58719	900	0.018	28.58	0.009	14.29
20x24-28N	D02299A	58976	900	0.018	28.58	0.009	14.29
	D02300A	58977	900	0.018	28.58	0.009	14.29

Standard group impeller balancing tolerances

Size	Impeller drawing	Pattern	Maximum speed of pump in rpm	Static D/b | 6 G2.5 X/N		Dynamic D/b | 6 G2.5 X/N	
				oz in./lb per plane	g mm/kg per plane	oz in./lb per plane	g mm/kg per plane
18x20-24	D01532A	58713	1200	0.013	20.64	0.0065	14.29
	D01535A	58716	1200	0.013	20.64	0.0065	14.29
18x20-24G	D02280A	58952	1200	0.013	20.64	0.0065	14.29
	D02281A	58953	1200	0.013	20.64	0.0065	14.29
18x20-24N	D02301A	58978	1200	0.013	20.64	0.0065	14.29
	D02302A	58979	1200	0.013	20.64	0.0065	14.29

L group impeller balancing tolerances

Size	Impeller drawing	Pattern	Maximum speed of pump in rpm	Static D/b | 6 G2.5 X/N		Dynamic D/b | 6 G2.5 X/N	
				oz in./lb per plane	g mm/kg per plane	oz in./lb per plane	g mm/kg per plane
24x30-32	265-84	56879	900	0.018	28.58	0.009	14.29
	262-25	56529	900	0.018	28.58	0.009	14.29
24x30-32G	267-21	56884	900	0.018	28.58	0.009	14.29
	D00013A	57618	900	0.018	28.58	0.009	14.29

Size	Impeller drawing	Pattern	Maximum speed of pump in rpm	Static D/b | 6 G2.5 X/N		Dynamic D/b | 6 G2.5 X/N	
				oz in./lb per plane	g mm/kg per plane	oz in./lb per plane	g mm/kg per plane
24x30-323H	267-27	56890	700	0.024	38.10	0.012	19.05
	D00014A	57643	700	0.024	38.10	0.012	19.05
24x30-32N	265-82	56848	700	0.024	38.10	0.012	19.05
	262-22	56528	700	0.024	38.10	0.012	19.05

LDS group impeller balancing tolerances

Size	Impeller drawing	Pattern	Maximum speed of pump in rpm	Static D/b | 6 G2.5 X/N		Dynamic D/b | 6 G2.5 X/N	
				oz in./lb per plane	g mm/kg per plane	oz in./lb per plane	g mm/kg per plane
30x30-31	D02370A	63131	700	0.024	38.10	0.012	19.05
	D02414A	63030	700	0.024	38.10	0.012	19.05
30x30-31G	D05540A	68567	900	0.018	28.58	0.009	14.29
30x30-38	D02257A	57783	700	0.024	38.10	0.012	19.05
	D02259	58685	700	0.024	38.10	0.012	19.05
30x30-38G	D02284A	58596	700	0.024	38.10	0.012	19.05
	D02285A	58597	700	0.024	38.10	0.012	19.05
30x30-38N	D02297A	58973	700	0.024	38.10	0.012	19.05
	D02298A	58974	700	0.024	38.10	0.012	19.05

XL group impeller balancing tolerances

Size	Impeller drawing	Pattern	Maximum speed of pump in rpm	Static D/b | 6 G2.5 X/N		Dynamic D/b | 6 G2.5 X/N	
				oz in./lb per plane	g mm/kg per plane	oz in./lb per plane	g mm/kg per plane
30x36-42	D01537A	58718	700	0.024	38.10	0.012	19.05
	D01534A	58715	700	0.024	38.10	0.012	19.05
	D00147A	58644	700	0.024	38.10	0.012	19.05
	267-56	57038	700	0.024	38.10	0.012	19.05
30x36-42G	D02286A	58958	700	0.024	38.10	0.012	19.05
	D02287A	58959	700	0.024	38.10	0.012	19.05
30x36-42H	267-57	57039	600	0.0304	48.26	0.0152	24.13
	272-80	57039	600	0.0304	48.26	0.0152	24.13
30x36-42N	D07751A	69830	600	0.0304	48.26	0.0152	24.13
20x30-42	D11284A	IE994	600	0.0304	48.26	0.0152	24.13

XXL group impeller balancing tolerances

Size	Impeller drawing	Pattern	Maximum speed of pump in rpm	Static D/b | 6 G2.5 X/N		Dynamic D/b | 6 G2.5 X/N	
				oz in./lb per plane	g mm/kg per plane	oz in./lb per plane	g mm/kg per plane
36x42-52	E02707A	IE922	600	0.0304	48.26	0.0152	24.13

6.7.4.2 Impeller bore diameter tolerances

Impeller bore diameter tolerances (inches)

Group	Size	Model	S.B. bushing ID	Shaft sleeve OD	Diameter clearance	Impeller hub ID	Impeller shaft OD	Tolerances	Parting flange gasket thickness
SX	12x14-15 16x18-17H	3420	4.191/4.195	4.125/4.123	0.066/0.072	3.5433/3.5447	3.5428/3.5420	0.0005/0.0027	1/32
		3425	4.191/4.195	4.134/4.132	0.057/0.063				
MX	18x20-20	3420	4.932/4.936	4.875/4.873	0.057/0.063	4.5276/4.5289	4.5271/4.5262	0.0005/0.0027	1/32
		3425	4.978/4.982	4.921/4.919	0.057/0.063				
M	16x18-30 18x20-30 20x24-24 20x24-30	3420/25	5.548/5.553	5.498/5.496	0.050/0.057	5.125/5.126	5.124/5.123	0.001/0.003	1/64
M (modified)	20x24-28	3420/25	5.548/5.553	5.498/5.496	0.050/0.057	5.125/5.126	5.124/5.123	0.001/0.003	1/64
—	18x24-24	3420/25	5.050/5.055	5.000/4.998	0.050/0.057	4.375/4.376	4.374/4.373	0.001/0.003	1/64
L	24x30-32	3420/25	6.552/6.557	6.492/6.490	0.060/0.067	6.125/6.126	6.124/6.123	0.001/0.003	1/64
LDS	30x30-31 30x30-38	3420/25	7.560/7.565	7.500/7.498	0.060/0.067	6.875/6.876	6.874/6.873	0.001/0.003	1/32
XL	30x36-42	3420/25	8.060/8.065	8.00/7.998	0.060/0.067	7.250/7.251	7.249/7.248	0.001/0.003	1/64
	20x30-42	3420/25	7.560/7.565	7.500/7.498	0.060/0.067	6.875/6.876	6.874/6.873	0.001/0.003	1/32
XXL	36x42-52	3420/25	9.060/9.065	9.000/8.998	0.060/0.067	8.250/8.251	8.248/8.249	0.001/0.003	1/32

Impeller bore tolerances (millimeters)

Group	Sizes	Model	S.B. bushing ID	Shaft sleeve OD	Diameter clearance	Impeller hub ID	Impeller shaft OD	Tolerances	Parting flange gasket thickness
SX	12x14 -15 16x18-17H	3420	106.45/106.55	104.78/104.72	1.68/1.83	90.00/90.04	89.99/89.97	0.0127/0.0686	0.794
		3425	106.45/106.55	105.00/104.95	1.45/1.60				
MX	18x20-20	3420	125.27/125.37	123.83/123.77	1.45/1.60	115.00/115.03	114.99/114.97	0.0127/0.0686	0.794
		3425	126.44/126.54	124.99/124.94	1.45/1.60				
M	16x18-30 18x20-30	3420/25	140.92/141.05	139.65/139.60	1.27/1.45	130.18/130.20	130.15/130.12	0.0254/0.0762	0.397

Group	Sizes	Model	S.B. bushing ID	Shaft sleeve OD	Diameter clearance	Impeller hub ID	Impeller shaft OD	Tolerances	Parting flange gasket thickness
	20x24-24 20x24-30								
M (modified)	20x24-28	3420/25	140.92/141.05	139.65/139.60	1.27/1.45	130.18/130.20	130.15/130.12	0.0254/0.0762	0.397
—	18x24-24	3420/25	128.27/128.49	139.65/139.60	1.27/1.45	111.13/111.15	111.10/111.07	0.0254/0.0762	0.397
L	24x30-32	3420/25	166.42/166.55	164.90/164.85	1.52/1.70	155.58/155.60	155.55/155.52	0.0254/0.0762	0.397
LDS	30x30-31 30x30-38	3420/25	190.02/192.15	190.50/190.45	1.52/1.70	174.63/174.65	174.60/174.57	0.0254/0.0762	0.397
XL	30x36-42	3420/25	204.72/204.85	203.20/203.15	1.52/1.70	184.15/184.18	184.12/184.10	0.0254/0.0762	0.794
	20x30-42	3420/25	192.02/192.15	190.50/190.45	1.52/1.70	174.63/174.65	174.60/174.57	0.0254/0.0762	
XXL	36x42-52	3420/25	230.12/230.25	228.60/228.55	1.52/1.70	209.55/209.58	209.50/209.52	0.0254/0.0762	0.794

6.7.4.3 Wear ring clearances (inches)

SX wear ring clearances

Impeller size	Material	Vanes	Standard impeller wear rings and casing wear rings			Flashed impeller wear rings				
			Impeller ring (A)	Casing ring	Diameter clearance	Impeller ring (C)	Casing ring	Diameter clearance	Length (E)	Angle (F)
12x14-15	Iron and bronze	7	11.214	11.227	0.013	11.214	11.227	0.013	0.38	8°
			11.212	11.229	0.017	11.212	11.229	0.017		
	Steel	7	11.214	11.237	0.023	11.224	11.237	0.023	0.38	8°
			11.212	11.239	0.027	11.222	11.239	0.027		
16x18-17H	Iron and bronze	7	13.970	13.983	0.013	13.970	13.983	0.013	0.50	8°
			13.968	13.985	0.017	13.968	13.985	0.017		
	Steel	7	13.970	13.993	0.023	13.970	13.993	0.023	0.50	8°
			13.968	13.995	0.027	13.968	13.995	0.027		

MX wear ring clearances

Impeller size	Material	Vanes	Standard impeller wear rings and casing wear rings			Flashed impeller wear rings				
			Impeller ring (A)	Casing ring	Diameter clearance	Impeller ring (C)	Casing ring	Diameter clearance	Length (E)	Angle (F)
18x20-20	Iron and bronze	5 and 6	16.529	16.542	0.013	16.529	16.542	0.013	0.87	8°
			16.527	16.544	0.017	16.527	16.544	0.017		
	Steel	5 and 6	16.529	17.373	0.023	16.529	17.373	0.023	0.87	8°
			16.527	17.376	0.027	16.527	17.376	0.027		

M wear ring clearances

Impeller size	Material	Vanes	Standard impeller wear rings and casing wear rings			Flashed impeller wear rings				
			Impeller ring (A)	Casing ring	Diameter clearance	Impeller ring (C)	Casing ring	Diameter clearance	Length (E)	Angle (F)
16x18-30	Iron and bronze	5	17.355	17.383	0.018	17.355	17.383	0.018	0.38	8°
			17.352	17.386	0.024	17.352	17.386	0.024		
	Steel	5	17.355	17.373	0.028	17.355	17.373	0.028	0.38	8°
			17.352	17.376	0.034	17.352	17.376	0.024		
16x18-30 H	Iron and bronze	7	17.355	17.383	0.018	17.355	17.383	0.018	0.62	8°
			17.352	17.386	0.024	17.352	17.386	0.024		
	Steel	7	17.355	17.373	0.028	17.355	17.373	0.028	0.62	8°
			17.352	17.886	0.034	17.352	17.376	0.034		
16x18-30 G	Iron and bronze	7	17.355	17.383	0.018	17.355	17.383	0.018	0.62	8°
			17.353	17.866	0.024	17.352	17.886	0.024		
	Steel	7	17.355	17.383	0.028	17.355	17.383	0.028	0.62	8°
			17.352	17.386	0.034	17.352	17.886	0.024		
18x20-30	Iron and bronze	5	19.528	19.548	0.020	18.595	18.615	0.020	0.38	8°
			19.525	19.551	0.026	18.592	18.618	0.026		
	Steel	5	19.528	19.558	0.030	18.595	18.625	0.030	0.38	8°
			19.525	19.561	0.036	18.592	18.628	0.036		
20x24-24	Iron and bronze	5 and 6	18.345	18.365	0.020	18.345	18.365	0.020	0.38	8°
			18.342	18.368	0.026	18.342	18.368	0.026		
	Steel	5 and 6	18.345	18.375	0.030	18.345	18.375	0.030	0.38	8°
			18.342	18.378	0.036	18.342	18.378	0.036		
20x24-30	Iron and bronze	5 high RPM	19.528	19.548	0.020	18.595	18.615	0.020	0.38	8°
			19.525	19.551	0.026	18.592	18.618	0.026		
	Steel	5 high RPM	19.528	19.548	0.030	18.595	18.625	0.030	0.38	8°
			19.525	19.551	0.036	18.592	18.628	0.036		
20x24-30	Iron and bronze	5 low RPM	21.903	19.558	0.022	20.968	20.990	0.022	0.38	8°
			21.900	19.561	0.028	20.965	20.993	0.028		
	Steel	5 low RPM	21.903	21.928	0.032	20.968	21.000	0.032	0.38	8°
			21.900	21.928	0.038	20.965	21.003	0.038		

M (modified) wear ring clearances

Impeller size	Material	Vanes	Standard impeller wear rings and casing wear rings			Flashed impeller wear rings				
			Impeller ring (A)	Casing ring	Diameter clearance	Impeller ring (C)	Casing ring	Diameter clearance	Length (E)	Angle (F)
20x24-28	Iron and bronze	6 and 7	18.480	18.500	0.020	18.480	18.500	0.020	0.38	8°
			18.477	18.503	0.026	18.477	18.503	0.026		

Impeller size	Material	Vanes	Standard impeller wear rings and casing wear rings			Flashed impeller wear rings				
			Impeller ring (A)	Casing ring	Diameter clearance	Impeller ring (C)	Casing ring	Diameter clearance	Length (E)	Angle (F)
	Steel	6 and 7	18.470	18.500	0.030	18.470	18.500	0.030	0.38	8°
			18.477	18.503	0.036	18.477	18.503	0.036		
20x24-28 H	Iron and bronze	7	19.538	19.558	0.020	19.538	19.558	0.020	0.38	8°
			19.535	19.561	0.026	19.535	19.561	0.026		
	Steel	7	19.528	19.558	0.030	19.528	19.558	0.030	0.38	8°
			19.525	19.561	0.036	19.525	19.561	0.036		
20x24-28 N	Iron and bronze	5	18.980	19.000	0.020	18.980	19.000	0.020	0.38	8°
			18.977	19.003	0.026	18.977	19.003	0.026		
	Steel	5	18.980	19.000	0.020	18.980	19.000	0.020	0.38	8°
			18.977	19.003	0.026	18.977	19.003	0.026		
20x24-28 G	Iron and bronze	5	17.607	17.625	0.018	17.607	17.625	0.018	0.38	8°
			17.604	17.628	0.024	17.604	17.628	0.024		
	Steel	5	17.607	17.635	0.028	17.635	17.635	0.028	0.38	8°
			17.604	17.638	0.034	17.638	17.638	0.034		

Standard wear ring clearances

Impeller size	Material	Vanes	Standard impeller wear rings and casing wear rings			Flashed impeller wear rings				
			Impeller ring (A)	Casing ring	Diameter clearance	Impeller ring (C)	Casing ring	Diameter clearance	Length (E)	Angle (F)
18x20-24	Iron and bronze	6	15.492	15.508	0.016	15.492	15.508	0.016	0.38	8°
			15.489	15.511	0.022	15.489	15.511	0.022		
	Steel	6	15.482	15.508	0.026	15.492	15.508	0.016	0.38	8°
			15.479	15.511	0.032	15.489	15.511	0.022		
18x20-24 G	Iron and bronze	5	14.734	14.750	0.016	14.734	15.508	0.016	0.38	8°
			14.731	14.753	0.022	14.731	15.511	0.022		
	Steel	5	14.724	14.750	0.026	14.724	14.750	0.026	0.38	8°
			14.721	14.753	0.032	14.721	14.753	0.032		
18x20-24 N	Iron and bronze	5	15.984	16.000	0.016	15.984	16.000	0.016	0.38	8°
			15.981	16.003	0.022	15.981	16.003	0.022		
	Steel	5	15.974	16.000	0.026	15.984	16.000	0.026	0.38	8°
			15.971	16.003	0.032	15.971	16.003	0.032		

L wear ring clearances

Impeller size	Material	Vanes	Standard impeller wear rings and casing wear rings			Flashed impeller wear rings				
			Impeller ring (A)	Casing ring	Diameter clearance	Impeller ring (C)	Casing ring	Diameter clearance	Length (E)	Angle (F)
24x30-32	Iron and bronze	6	23.707	23.731	0.024	23.707	23.731	0.024	0.50	8°
			23.702	23.734	0.032	23.702	23.734	0.032		
	Steel	6	23.707	23.741	0.034	23.707	23.741	0.034	0.50	8°

Impeller size	Material	Vanes	Standard impeller wear rings and casing wear rings			Flashed impeller wear rings				
			Impeller ring (A)	Casing ring	Diameter clearance	Impeller ring (C)	Casing ring	Diameter clearance	Length (E)	Angle (F)
			23.702	23.744	0.042	23.702	23.744	0.042		
24x30-32 N	Iron and bronze	6	23.707	23.731	0.024	23.707	23.730	0.024	0.50	8°
			23.702	23.734	0.032	23.702	23.734	0.032		
	Steel	6	23.707	23.741	0.034	23.707	23.741	0.034	0.50	8°
			23.702	23.744	0.042	23.702	23.744	0.042		
24x30-32 H	Iron and bronze	7	21.959	21.981	0.022	21.959	21.981	0.022	0.50	8°
			21.956	21.984	0.028	21.956	21.984	0.028		
	Steel	7	21.959	21.991	0.032	21.959	21.991	0.032	0.50	8°
			21.956	21.994	0.038	21.956	21.994	0.038		
24x30-32 G	Iron and bronze	6	21.959	21.981	0.022	21.959	21.981	0.022	0.50	8°
			21.956	21.984	0.028	21.956	21.984	0.028		
	Steel	6	21.959	21.991	0.032	21.959	21.991	0.032	0.50	8°
			21.956	21.994	0.038	21.956	21.994	0.038		

LDS wear ring clearances

Impeller size	Material	Vanes	Standard impeller wear rings and casing wear rings			Flashed impeller wear rings				
			Impeller ring (A)	Casing ring	Diameter clearance	Impeller ring (C)	Casing ring	Diameter clearance	Length (E)	Angle (F)
30x30-31	Iron and bronze	7	23.382	23.406	0.024	23.382	23.406	0.024	0.38	8°
			23.378	23.410	0.032	23.378	23.410	0.032		
	Steel	7	23.372	23.406	0.034	23.372	23.406	0.034	0.38	8°
			23.368	23.410	0.042	23.368	23.410	0.042		
30x30-31 G	Iron and bronze	5	23.382	23.406	0.024	23.385	23.406	0.024	2.25	8°
			23.378	23.410	0.032	23.378	23.410	0.032		
	Steel	5	23.372	23.406	0.034	23.372	23.406	0.034	2.25	8°
			23.368	23.410	0.042	23.368	23.410	0.042		
30x30-31 G	Iron and bronze	7	20.728	20.750	0.022	20.728	20.750	0.022	0.38	8°
			20.725	20.753	0.028	20.725	20.753	0.028		
	Steel	7	20.718	20.750	0.032	20.718	20.750	0.032	0.38	8°
			20.715	20.753	0.038	20.715	20.753	0.038		
30x30-38	Iron and bronze	6	24.286	24.312	0.026	24.286	24.312	0.026	0.38	8°
			24.282	24.316	0.034	24.282	24.316	0.034		
	Steel	6	24.276	24.312	0.036	24.276	24.312	0.036	0.38	8°
			24.272	24.316	0.044	24.272	24.316	0.044		
30x30-38 G	Iron and bronze	5	24.286	24.312	0.026	24.286	24.312	0.026	0.38	8°
			24.282	24.316	0.034	24.282	24.316	0.034		
	Steel	5	24.276	24.312	0.036	24.276	24.312	0.036	0.38	8°
			24.272	24.316	0.044	24.272	24.316	0.044		
30x30-38 N	Iron and bronze	5	24.974	25.000	0.026	24.974	25.000	0.026	0.38	8°
			24.970	25.004	0.034	24.970	25.004	0.034		
	Steel	5	24.964	25.000	0.036	24.964	25.000	0.036	0.38	8°

Impeller size	Material	Vanes	Standard impeller wear rings and casing wear rings			Flashed impeller wear rings				
			Impeller ring (A)	Casing ring	Diameter clearance	Impeller ring (C)	Casing ring	Diameter clearance	Length (E)	Angle (F)
			24.960	25.004	0.044	24.960	25.004	0.044		

XL wear ring clearances

Impeller size	Material	Vanes	Standard impeller wear rings and casing wear rings			Flashed impeller wear rings				
			Impeller ring (A)	Casing ring	Diameter clearance	Impeller ring (C)	Casing ring	Diameter clearance	Length (E)	Angle (F)
30x36-42	Iron and bronze	6 and 7	26.978	27.000	0.022	26.978	27.000	0.022	0.50	8°
			26.975	27.003	0.028	26.975	27.003	0.028		
	Steel	6 and 7	26.968	27.000	0.032	26.968	27.000	0.032	0.50	8°
			26.965	27.003	0.038	26.965	27.003	0.038		
30x36-42 G	Iron and bronze	5	25.726	25.750	0.024	25.726	25.750	0.024	0.50	8°
			25.722	25.754	0.032	25.722	25.754	0.032		
	Steel	5	25.716	25.750	0.034	25.716	25.750	0.034	0.50	8°
			25.712	25.754	0.042	25.712	25.754	0.042		
30x36-42 H	Iron and bronze	7	28.978	29.000	0.022	28.978	29.000	0.022	0.50	8°
			28.975	29.003	0.028	28.975	29.003	0.028		
	Steel	7	28.968	29.000	0.032	28.968	29.000	0.032	0.50	8°
			28.965	29.003	0.038	28.965	29.003	0.038		
30x36-42 N	Iron and bronze	5	27.978	28.000	0.022	27.978	28.000	0.022	0.38	8°
			27.975	28.003	0.028	27.975	28.003	0.028		
	Steel	5	27.968	28.000	0.032	27.968	28.000	0.032	0.38	8°
			27.965	28.003	0.038	27.965	28.003	0.038		
20x30-42	Iron and bronze	6	20.849	20.878	0.032	N/A	N/A	N/A	N/A	N/A
			20.846	20.874	0.025					
	Steel	6	20.842	20.878	0.038	N/A	N/A	N/A	N/A	N/A
			20.840	20.874	0.032					

XXL wear ring clearances

Impeller size	Material	Vanes	Standard impeller wear rings and casing wear rings			Flashed impeller wear rings				
			Impeller ring (A)	Casing ring	Diameter clearance	Impeller ring (C)	Casing ring	Diameter clearance	Length (E)	Angle (F)
36x42-52	Iron and bronze	5	33.470	33.523	0.057	N/A	N/A	N/A	N/A	N/A
			33.474	33.527	0.049					
	Steel	5	33.590	33.523	0.067	N/A	N/A	N/A	N/A	N/A
			33.585	33.527	0.058					

6.7.4.4 Wear ring clearances (millimeters)

SX wear ring clearances

Impeller size	Material	Vanes	Standard impeller wear rings and casing wear rings			Flashed impeller wear rings				
			Impeller ring (A)	Casing ring	Diameter clearance (B)	Impeller ring (C)	Casing ring	Diameter clearance	Length (E)	Angle (F)
12x14-15	Iron and bronze	7	284.84	285.17	0.33	284.84	285.17	0.33	9.65	8°
			284.78	285.22	0.43	284.78	285.22	0.43		
	Steel	7	284.84	285.42	0.58	285.09	285.42	0.58	9.65	8°
			284.78	285.47	0.69	285.04	285.47	0.69		
16x18-17 H	Iron and bronze	7	354.84	355.17	0.33	354.84	355.17	0.33	12.70	8°
			354.79	355.22	0.43	354.84	355.17	0.33		
	Steel	7	354.84	355.42	0.58	354.84	355.42	0.58	12.70	8°
			354.79	355.47	0.69	354.79	355.47	0.69		

MX wear ring clearances

Impeller size	Material	Vanes	Standard impeller wear rings and casing wear rings			Flashed impeller wear rings				
			Impeller ring (A)	Casing ring	Diameter clearance (B)	Impeller ring (C)	Casing ring	Diameter clearance	Length (E)	Angle (F)
18x20-20	Iron and bronze	5 and 6	419.84	420.17	0.33	419.84	420.17	0.33	22.10	8°
			419.79	420.22	0.43	419.79	420.22	0.43		
	Steel	5 and 6	419.84	441.27	0.58	419.84	441.27	0.58	22.10	8°
			419.79	441.35	0.69	419.79	441.35	0.69		

M wear ring clearances

Impeller size	Material	Vanes	Standard impeller wear rings and casing wear rings			Flashed impeller wear rings				
			Impeller ring (A)	Casing ring	Diameter clearance (B)	Impeller ring (C)	Casing ring	Diameter clearance	Length (E)	Angle (F)
16x18-30	Iron and bronze	5	440.82	441.53	0.46	440.82	441.53	0.46	9.65	8°
			440.74	441.60	0.61	440.74	441.60	0.61		
	Steel	5	440.82	441.27	0.71	440.82	441.27	0.71	9.65	8°
			440.74	441.35	0.86	440.74	441.35	0.86		
16x18-30 H	Iron and bronze	7	440.82	441.53	0.46	440.82	441.53	0.46	15.75	8°
			440.74	441.60	0.61	440.74	441.60	0.61		
	Steel	7	440.82	441.27	0.71	440.82	441.27	0.71	15.75	8°
			440.74	441.35	0.86	440.74	441.35	0.86		
16x18-30 G	Iron and bronze	7	440.82	441.53	0.46	440.82	441.53	0.46	15.75	8°
			440.74	454.30	0.61	440.74	441.30	0.61		
	Steel	7	440.82	441.53	0.71	440.82	441.53	0.71	15.75	8°
			440.74	441.60	0.86	440.74	441.60	0.86		

Impeller size	Material	Vanes	Standard impeller wear rings and casing wear rings			Flashed impeller wear rings				
			Impeller ring (A)	Casing ring	Diameter clearance (B)	Impeller ring (C)	Casing ring	Diameter clearance	Length (E)	Angle (F)
18x20-30	Iron and bronze	5	496.01	496.52	0.51	472.31	472.82	0.51	9.65	8°
			495.94	496.60	0.66	472.24	472.90	0.66		
	Steel	5	496.01	496.77	0.76	472.31	473.08	0.76	9.65	8°
			495.94	496.85	0.91	472.24	473.15	0.91		
20x24-24	Iron and bronze	5 and 6	465.96	466.47	0.51	465.96	466.47	0.51	9.65	8°
			465.89	466.55	0.66	465.89	466.55	0.66		
	Steel	5 and 6	465.96	466.73	0.76	465.96	466.73	0.76	9.65	8°
			465.89	466.80	0.91	465.89	466.80	0.91		
20x24-30	Iron and bronze	5 high RPM	496.01	496.52	0.51	472.31	472.82	0.51	9.65	8°
			495.94	496.60	0.66	472.24	472.90	0.66		
	Steel	5 high RPM	496.01	496.52	0.51	472.31	473.08	0.76	9.65	8°
			495.94	496.60	0.66	472.24	473.15	0.91		
20x24-30	Iron and bronze	5 low RPM	556.34	556.97	0.64	532.59	533.15	0.56	9.65	8°
			556.26	556.90	0.64	532.51	533.22	0.71		
	Steel	5 low RPM	556.34	556.97	0.64	532.59	533.40	0.81	9.65	8°
			556.26	556.90	0.64	532.51	533.48	0.97		

M (modified) wear ring clearances

Impeller size	Material	Vanes	Standard impeller wear rings and casing wear rings			Flashed impeller wear rings				
			Impeller ring (A)	Casing ring	Diameter clearance (B)	Impeller ring (C)	Casing ring	Diameter clearance	Length (E)	Angle (F)
20x24-28	Iron and bronze	6 and 7	469.39	469.90	0.51	469.39	469.90	0.51	9.65	8°
			469.32	469.98	0.66	469.32	469.98	0.66		
	Steel	6 and 7	469.14	469.90	0.76	469.14	469.90	0.76	9.65	8°
			469.32	470.66	0.91	469.32	469.98	0.91		
20x24-28 H	Iron and bronze	7	496.27	496.77	0.51	496.27	496.77	0.51	9.65	8°
			496.19	496.85	0.66	496.19	496.85	0.66		
	Steel	7	496.01	496.77	0.76	496.01	496.77	0.76	9.65	8°
			495.94	496.85	0.91	495.94	496.85	0.91		
20x24-28 N	Iron and bronze	5	482.09	482.60	0.51	482.09	482.60	0.51	9.65	8°
			482.02	482.68	0.66	482.02	482.68	0.66		
	Steel	5	482.09	482.60	0.51	482.09	482.60	0.51	9.65	8°
			482.02	482.68	0.66	482.02	482.68	0.66		
20x24-28 G	Iron and bronze	5	447.22	447.68	0.46	447.22	447.68	0.46	9.65	8°
			447.14	447.75	0.61	447.14	447.75	0.61		
	Steel	5	447.22	447.93	0.71	447.22	447.93	0.71	9.65	8°
			447.14	448.01	0.86	448.14	448.01	0.86		

Standard wear ring clearances

Impeller size	Material	Vanes	Standard impeller wear rings and casing wear rings			Flashed impeller wear rings				
			Impeller ring (A)	Casing ring	Diameter clearance (B)	Impeller ring (C)	Casing ring	Diameter clearance	Length (E)	Angle (F)
18x20-24	Iron and bronze	6	393.50	393.90	0.41	393.50	393.90	0.41	9.65	8°
			393.42	393.98	0.56	393.42	393.98	0.56		
	Steel	6	393.24	393.90	0.66	393.50	393.90	0.41	9.65	8°
			393.17	393.98	0.81	393.42	393.98	0.56		
18x20-24 G	Iron and bronze	5	374.24	374.65	0.41	374.24	393.90	0.41	9.65	8°
			374.17	374.73	0.56	374.17	393.98	0.56		
	Steel	5	373.99	374.65	0.66	373.99	374.65	0.66	9.65	8°
			373.91	374.73	0.81	373.91	374.73	0.81		
18x20-24 N	Iron and bronze	5	405.99	406.40	0.41	405.99	406.40	0.41	9.65	8°
			405.92	406.48	0.56	405.92	406.48	0.56		
	Steel	5	405.74	406.40	0.66	405.74	406.40	0.66	9.65	8°
			405.66	406.48	0.81	405.66	406.48	0.81		

L wear ring clearances

Impeller size	Material	Vanes	Standard impeller wear rings and casing wear rings			Flashed impeller wear rings				
			Impeller ring (A)	Casing ring	Diameter clearance (B)	Impeller rng (C)	Casing ring	Diameter clearance	Length (E)	Angle (F)
24x30-32	Iron and bronze	6	602.16	602.77	0.61	602.16	602.77	0.61	12.70	8°
			602.03	602.84	0.81	602.03	602.84	0.81		
	Steel	6	602.16	552.22	0.86	602.16	552.22	0.86	12.70	8°
			602.03	552.30	0.61	602.03	552.30	1.07		
24x30-32 N	Iron and bronze	6	602.16	602.77	0.61	602.16	602.74	0.61	12.70	8°
			602.03	602.84	0.81	602.03	602.84	0.81		
	Steel	6	602.16	552.22	0.86	602.16	552.22	0.86	12.70	8°
			602.03	552.30	1.07	602.03	552.30	1.07		
24x30-32 H	Iron and bronze	7	557.76	558.32	0.56	557.76	558.32	0.56	12.70	8°
			557.68	558.39	0.71	557.68	558.39	0.71		
	Steel	7	557.76	558.57	0.81	557.76	558.57	0.81	12.70	8°
			557.68	558.65	0.97	557.68	558.65	0.97		
24x30-32 G	Iron and bronze	6	557.76	558.32	0.56	557.76	558.32	0.56	12.70	8°
			557.68	558.39	0.71	557.68	558.39	0.71		
	Steel	6	557.76	558.57	0.81	557.76	558.57	0.81	12.70	8°
			557.68	558.65	0.97	557.68	558.65	0.97		

LDS wear ring clearances

Impeller size	Material	Vanes	Standard impeller wear rings and casing wear rings			Flashed impeller wear rings				
			Impeller ring (A)	Casing ring	Diameter clearance (B)	Impeller ring (C)	Casing ring	Diameter clearance	Length (E)	Angle (F)
30x30-31	Iron and bronze	7	593.90	594.51	0.61	593.90	594.51	0.61	9.65	8°
			593.80	594.61	0.81	593.80	594.61	0.81		
	Steel	7	593.65	594.51	0.86	593.65	594.51	0.86	9.65	8°
			593.55	594.61	1.07	593.55	594.61	1.07		
30x30-31 G	Iron and bronze	5	593.90	594.51	0.61	593.90	594.51	0.61	9.65	8°
			593.80	594.61	0.81	593.80	594.61	0.81		
	Steel	5	593.65	594.51	0.86	593.65	594.51	0.86	9.65	8°
			593.55	594.61	1.07	593.55	594.61	1.07		
30x30-31 G	Iron and bronze	7	526.49	527.05	0.56	526.49	527.05	0.56	9.65	8°
			526.42	527.13	0.71	526.42	527.13	0.71		
	Steel	7	526.24	527.05	0.81	526.24	527.05	0.81	12.70	8°
			526.16	527.13	0.97	526.16	527.13	0.97		
30x30-38	Iron and bronze	6	616.86	617.52	0.66	616.86	617.52	0.66	12.70	8°
			616.76	617.63	0.86	616.76	617.63	0.86		
	Steel	6	616.61	617.52	0.91	616.61	617.52	0.91	9.65	8°
			616.51	617.63	1.12	616.51	617.63	1.12		
30x30-38 G	Iron and bronze	5	616.86	617.52	0.66	616.86	617.52	0.66	9.65	8°
			616.76	617.63	0.86	616.76	617.63	0.86		
	Steel	5	616.61	617.52	0.91	616.61	617.52	0.91	9.65	8°
			616.51	617.63	1.12	616.51	617.63	1.12		
30x30-38 N	Iron and bronze	5	634.34	635.00	0.66	634.34	635.00	0.66	9.65	8°
			634.24	635.10	0.86	634.24	635.10	0.86		
	Steel	5	634.09	635.00	0.91	634.09	635.00	0.91	9.65	8°
			633.98	635.10	1.12	633.98	635.10	1.12		

XL wear ring clearances

Impeller size	Material	Vanes	Standard impeller wear rings and casing wear rings			Flashed impeller wear rings				
			Impeller ring (A)	Casing ring	Diameter clear-ance (B)	Impeller ring (C)	Casing ring	Diameter clear-ance	Length (E)	Angle (F)
30x36-42	Iron and bronze	6 and 7	685.24	685.80	0.56	685.24	685.80	0.56	12.70	8°
			685.17	685.88	0.71	685.17	685.88	0.71		
	Steel	6 and 7	684.99	685.80	0.81	684.99	685.80	0.81	12.70	8°
			684.91	685.88	0.97	684.91	685.88	0.97		
30x36-42 G	Iron and bronze	5	653.44	654.05	0.61	653.44	654.05	0.61	12.70	8°
			653.34	654.15	0.81	653.34	654.15	0.81		
	Steel	5	653.19	654.05	0.86	653.19	654.05	0.86	12.70	8°
			653.08	654.15	1.07	653.08	654.15	1.07		

Impeller size	Material	Vanes	Standard impeller wear rings and casing wear rings			Flashed impeller wear rings				
			Impeller ring (A)	Casing ring	Diameter clearance (B)	Impeller ring (C)	Casing ring	Diameter clearance	Length (E)	Angle (F)
30x36-42 H	Iron and bronze	7	736.04	736.60	0.56	736.04	736.60	0.56	12.70	8°
			735.97	736.68	0.71	735.97	736.68	0.71		
	Steel	7	735.79	736.60	0.81	735.79	736.60	0.81	12.70	8°
			735.71	736.68	0.97	735.71	736.68	0.97		
30x36-42 N	Iron and bronze	5	710.64	711.20	0.56	710.64	711.20	0.56	9.65	8°
			710.57	711.28	0.71	710.57	711.28	0.71		
	Steel	5	710.39	711.20	0.81	710.39	711.20	0.81	9.65	8°
			710.31	711.28	0.97	710.31	711.28	0.97		
20x30-42	Iron and bronze	6	529.56	530.30	0.81	N/A	N/A	N/A	N/A	N/A
			529.49	530.20	0.64					
	Steel	6	529.39	530.30	0.97	N/A	N/A	N/A	N/A	N/A
			529.34	530.20	0.81					

XXL wear ring clearances

Impeller size	Material	Vanes	Standard impeller wear rings and casing wear rings			Flashed impeller wear rings				
			Impeller ring (A)	Casing ring	Diameter clearance	Impeller ring (C)	Casing ring	Diameter clearance	Length (E)	Angle (F)
36x42-52	Iron and bronze	5	850.14	851.48	1.45	N/A	N/A	N/A	N/A	N/A
			850.24	851.59	1.24					
	Steel	5	853.19	851.48	1.70	N/A	N/A	N/A	N/A	N/A
			853.06	851.59	1.47					

6.7.4.5 Bearing fits and tolerances (inches)

Inboard

Bearing	Group	Size	Bearing size		Shaft OD	Bearing ID	Tolerance	Hsg ID	Bearing OD	Tolerance
			Thrust	Radial						
Ball	SX	12x14-15	7313	6313	2.5596	2.5585	0.0011	5.5118	5.5118	-0.0000
		16x18-17H			2.5591	2.5591	0.0000	5.5111	5.5111	-0.0017
	MX	18x20-20	7316	6316	3.1502	3.1490	0.0012	6.6929	6.6929	-0.0000
					3.1497	3.1496	0.0001	6.6939	6.6919	-0.0020
	M	16x18-30	7321	6321	4.1346	4.1331	0.0015	8.8590	8.8590	8.8583
		18x20-30			4.1340	4.1339	0.0001	8.8602	8.8602	8.8571
		20x24-24								
		20x24-30								

Bearing	Group	Size	Bearing size		Shaft OD	Bearing ID	Toler-ance	Hsg ID	Bearing OD	Toler-ance
			Thrust	Radial						
	M, modi-fied	20x24-28	7321	6321	4.1346 4.1340	4.1331 4.1339	0.0015 0.0001	8.8590 8.8602	8.8590 8.8602	8.8583 8.8571
	—	18x20-24	7318	6318	3.5440 3.5434	3.5425 3.5433	0.0015 0.0001	7.4803 7.4815	7.4803 7.4791	-0.0000 -0.0024
Roller	L	24x30-32	22226	22226	N/A	N/A	N/A	9.0557 9.0575	9.0551 9.0539	-0.0006 -0.0036
	LDS	30x30-31 30x30-38	22228	22228	N/A	N/A	N/A	9.8431 9.8449	9.8425 9.8413	-0.0006 -0.0036
	XL	30x36-42 20x30-42	22230	22230	N/A	N/A	N/A	10.6306 10.6326	10.6299 10.6285	-0.0007 -0.0041
	XXL	36x42-52	22240	22240	N/A	N/A	N/A	14.1762 14.1739	14.1716 14.1732	-0.0007 -0.0046

Outboard

Bearing	Group	Size	Bearing size		Shaft OD	Bearing ID	Toler-ance	Hsg ID	Bearing OD	Toler-ance
			Thrust	Radial						
Ball	SX	12x14-15 16x18-17H	7313	6313	2.5596 2.5591	2.5585 2.5591	0.0011 0.0000	5.5118 5.5128	5.5118 5.5111	-0.0000 -0.0017
	MX	18x20-20	7316	6316	3.1502 3.1497	3.1490 3.1496	0.0012 0.0001	6.6929 6.6939	6.6929 6.6919	-0.0000 -0.0020
	M	16x18-30 18x20-30 20x24-24 20x24-30	7321	6321	-.0007 -.0031	4.1346 4.1340	0.0015 0.0001	8.8590 8.8602	8.8583 8.8571	-0.0007 -0.0031
	M, modi-fied	20x24-28	7321	6321	-.0007 -.0031	4.1346 4.1340	0.0015 0.0001	8.8590 8.8602	8.8583 8.8571	-0.0007 -0.0031
	—	18x20-24	7318	6318	3.5440 3.5434	3.5425 3.5433	0.0015 0.0001	7.4803 7.4815	7.4803 7.4791	-0.0000 -0.0024
Roller	L	24x30-32	22226	22226	N/A	N/A	N/A	9.0557 9.0575	9.0551 9.0539	-0.0006 -0.0036
	LDS	30x30-31 30x30-38	22228	22228	N/A	N/A	N/A	9.8431 9.8449	9.8425 9.8413	-0.0006 -0.0036

Bearing	Group	Size	Bearing size		Shaft OD	Bearing ID	Toler-ance	Hsg ID	Bearing OD	Toler-ance
			Thrust	Radial						
	XL	30x36-42 20x30-42	22230	22230	N/A	N/A	N/A	10.6306 10.6326	10.6299 10.6285	-0.0007 -0.0041
	XXL	36x42-52	22240	22240	N/A	N/A	N/A	14.1762 14.1739	14.1716 14.1732	-0.0007 -0.0046

6.7.4.6 Bearing fits and tolerances (millimeters)

Bear-ing	Grou p	Size	Bearing size		Inboard			Inboard			Outboard			Outboard		
			Thru st	Radi-al	Shaft OD	Bear-ing ID	Toler-ance	Hsg ID	Bear-ing OD	Tol-eranc e	Shaft OD	Bear-ing ID	Tol-eran ce	Hsg ID	Bear-ing OD	Tol-eranc e
Ball	SX	12 x 14-15 16 x 18-17H	7313	6313	65.014 65.001	64.986 65.001	0.028 0.000	140.000 139.982	140.000 139.982	0.0000 -0.043	65.014 65.001	64.986 65.001	+0.028 +0.000	140.000 140.025	140.000 139.982	0.0000 -0.043
	MX	18 x 20-20	7316	6316	80.015 80.002	79.985 80.000	0.030 0.003	170.000 170.025	170.000 169.974	-0.0000 -0.051	80.015 80.002	79.985 80.000	+0.030 +0.0031	170.000 170.025	170.000 169.974	0.0000 -0.051
	M	16 x 18-30 18 x 20-30 20 x 24-24 20 x 24-30	7321	6321	105.019 105.004	104.981 105.001	0.038 0.003	225.019 225.049	225.001 224.970	-0.018 -0.079	105.019 105.004	104.981 105.001	+0.038 +0.0003	225.019 225.049	225.001 224.970	-0.018 -0.079
	M, modi-fied	20 x 24-28	7321	6321	105.019 105.004	104.981 105.001	0.038 0.000	225.019 225.040	225.001 224.970	-0.018 -0.079	105.019 105.004	104.981 105.001	+0.038 +0.0003	225.019 225.049	225.001 224.970	-0.018 -0.079
	—	18 x 20-24	7318	6318	90.018 90.002	89.980 90.000	0.038 0.003	190.000 190.030	190.000 189.969	-0.0000 -0.061	90.018 90.002	89.980 90.000	+0.038 +0.0003	190.000 190.030	190.000 189.969	0.0000 0.061
Roller	L	24 x 30-32	22226	22226	N/A	N/A	N/A	230.015 230.061	230.000 229.969	-0.015 -0.091	N/A	N/A	N/A	230.015 230.061	230.000 229.969	-0.015 -0.091

Bearing	Group	Size	Bearing size		Inboard			Inboard			Outboard			Outboard		
			Thrust	Radial	Shaft OD	Bearing ID	Tolerance	Hsg ID	Bearing OD	Tolerance	Shaft OD	Bearing ID	Tolerance	Hsg ID	Bearing OD	Tolerance
	LDS	30 x 30-31 30 x 30-38	22228	22228	N/A	N/A	N/A	250.015 250.060	250.000 249.969	-0.015 -0.091	N/A	N/A	N/A	230.015 230.061	230.000 229.969	-0.015 -0.091
	XL	30 x 36-42 20 x 30-42	22230	22230	N/A	N/A	N/A	270.017 270.068	269.999 269.964	-0.018 -0.104	N/A	N/A	N/A	270.017 270.068	269.999 269.964	-0.018 -0.104
	XXL	36 x 42-52	22240	22240	N/A	N/A	N/A	360.075 360.017	359.959 359.999	-0.018 -0.117	N/A	N/A	N/A	360.075 360.017	359.959 359.999	-0.018 -0.017

6.7.4.7 Bolt torque values

Bolt sizes	Dry threads **2210 *** **2442 ***	Lubricated threads **2210 *** **2442 ***	Dry threads **2239 *** **2443 ***	Lubricated threads **2239 *** **2443 ***
*** See the Bolt materials of construction table for the meaning of materials codes.**				
1/2 in.	30 ft-lb (41 Nm)	20 ft-lb (27 Nm)	90 ft-lb (122 Nm)	60 ft-lb (81 Nm)
5/8 in.	60 ft-lb (81 Nm)	40 ft-lb (54 Nm)	175 ft-lb (237 Nm)	115 ft-lb (156 Nm)
3/4 in.	105 ft-lb (142 Nm)	70 ft-lb (95 Nm)	305 ft-lb (414 Nm)	295 ft-lb (278 Nm)
7/8 in.	170 ft-lb (231 Nm)	115 ft-lb (156 Nm)	495 ft-lb (671 Nm)	330 ft-lb (447 Nm)
1 in.	255 ft-lb (346 Nm)	170 ft-lb (231 Nm)	740 ft-lb (1003 Nm)	495 ft-lb (671 Nm)
1-1/8 in.	360 ft-lb (488 Nm)	240 ft-lb (325 Nm)	1050 ft-lb (1424 Nm)	700 ft-lb (949 Nm)
1-1/2 in.	885 ft-lb (1200 Nm)	590 ft-lb (800 Nm)	2580 ft-lb (3498 Nm)	1720 ft-lb (2332 Nm)
1-3/4 in.	1400 ft-lb (1898 Nm)	935 ft-lb (1268 Nm)	5025 ft-lb (6813 Nm)	3350 ft-lb (4542 Nm)
2 in.	2625 ft-lb (3560 Nm)	1750 ft-lb (2373 Nm)	7650 ft-lb (10372 Nm)	5100 ft-lb (6915 Nm)
M12	30 ft-lb (41 Nm)	20 ft-lb (27 Nm)	85 ft-lb (115 Nm)	55 ft-lb (75 Nm)
M16	60 ft-lb (81 Nm)	40 ft-lb (54 Nm)	175 ft-lb (237 Nm)	115 ft-lb (156 Nm)
M20	130 ft-lb (176 Nm)	85 ft-lb (115 Nm)	375 ft-lb (509 Nm)	250 ft-lb (339 Nm)
M24	220 ft-lb (298 Nm)	145 ft-lb (197 Nm)	640 ft-lb (868 Nm)	425 ft-lb (576 Nm)
M30	440 ft-lb (597 Nm)	295 ft-lb (400 Nm)	1275 ft-lb (1729 Nm)	850 ft-lb (1153 Nm)

- **Bolt materials of construction**

Materials code	Designation	Material
2210	ASTM A108 GR. 1211	Carbon steel
2239	ASTM A193 GR. B7	AISI 4140 steel
2442	ASTM A108 GR. 1018	Carbon steel

Materials code	Designation	Material
2443	ASTM A108 GR. 1212	Carbon steel

6.7.4.8 Pipe tap data

Small and medium sized pumps

Purpose of tap	12x14-15	16x18-17H	16x18-30	18x20-24	18x20-30	20x24-24	20x24-28	20x24-30
Suction chamber vent	2-3/4 in.	2-3/4 in.	2-2 in.	2-2 in.	2-2 in.	2-2 in.	2-2 in.	2-2 in.
Stuffing box seal ring	2-1/2 in.	2-1/2 in.	4-1/2 in.	4-3/8 in.	4-1/2 in.	4-1/2 in.	4-3/8 in.	4-1/2 in.
Gland quenching (packing)	2-1/2 in.	2-1/2 in.	2-3/8 in.	4-1/2 in.	2-3/8 in.	2-3/8 in.	4-3/8 in.	2-3/8 in.
Stuffing box overflow	2-3/4 in.	2-3/4 in.	4-1 in.	4-3/4 in.	4-1 in.	4-1 in.	4-3/4 in.	4-1 in.
Casing vent	1-1/2 in.	1-1/2 in.	1-1/4 in.	1-1/4 in.	1-1/4 in.	1-1/4 in.	1-1/4 in.	1-1/4 in.
Priming	1-3/4 in.	1-3/4 in.	1-2 in.	1-2 in.	1-2 in.	1-2 in.	1-2 in.	1-2 in.
Ball bearing cooling (optional)	4-1/4 in.	4-1/4 in.	4-3/4 in.	4-1-1/4 in.	4-3/4 in.	4-3/4 in.	4-1-1/4 in.	4-3/4 in.
Oil drain	2-1/4 in.	2-1/4 in.	2-1/2 in.	2-1/2 in.	2-1/4 in.	2-1/4 in.	2-1/2 in.	2-1/4 in.
Suction and discharge gauge	2-1/2 in.	2-1/2 in.	4-1/4 in.	4-1/4 in.	4-1/4 in.	4-1/4 in.	4-1/4 in.	4-1/4 in.
Casing drain	2-3/4 in.	2-3/4 in.	2-1 in.	2-1 in.	2-1 in.	2-1 in.	2-1 in.	2-1 in.
Bypass, casing to stuffing box	—	—	2-1/2 in.	2-3/8 in.	2-1/2 in.	2-1/2 in.	2-3/8 in.	2-1/2 in.

Large sized pumps

Purpose of tap	24x30-32	20x30-42 and 30x36-42	30x30-31 and 30x30-38	36x42-52
Suction chamber vent	2-2 in.	2-2 in.	2-2 in.	2-2 in.
Stuffing box seal ring	4-3/8 in.	4-3/8 in.	4-3/8 in.	4-3/8 in.
Gland quenching, packing	4-3/8 in.	4-3/8 in.	4-3/8 in.	4-3/8 in.
Stuffing box overflow	4-1 in.	4-3/4 in.	4-3/4 in.	4-3/4 in.
Casing vent	1-1/4 in.	1-1/4 in.	1-1/4 in.	1-1/4 in.
Priming	1-2 in.	1-2 in.	1-2 in.	1-2 in.
Ball bearing cooling (optional)	4-1 in.	—	—	—
Oil drain	2-1/2 in.	2-1/4 in.	2-1/4 in.	2-1/4 in.
Suction and discharge guage	4-1/4 in.	4-1/4 in.	4-1/4 in.	4-1/4 in.
Casing drain	2-1 in.	2-1 in.	2-1 in.	2-1 in.
Bypass, casing to stuffing box	2-3/8 in.	2-3/8 in.	2-3/8 in.	2-3/8 in.

6.7.4.9 WR2 impeller values

Table 13: WR2 values for small and medium pumps in lb-ft (Nm)

These values include bronze impeller rings.

Diameter in in. (mm)	12x14-15		16x18-17H		16x18-30		18x20-24		18x20-30		20x24-24		24x24-28		20x24-30	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
10.50 (266.70)	7 (9)	8 (11)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
11.00 (279.40)	8.5 (11.5)	10 (14)	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Diameter in in. (mm)	12x14-15		16x18-17H		16x18-30		18x20-24		18x20-30		20x24-24		24x24-28		20x24-30	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
11.50 (292.10)	11 (15)	13 (18)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12.00 (304.80)	13 (18)	15 (20)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12.50 (317.50)	16 (22)	19 (26)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
13.00 (330.20)	19 (26)	22 (30)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
13.50 (342.90)	22 (30)	26 (35)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14.00 (355.60)	26 (35)	30 (41)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14.50 (368.30)	32 (43)	37 (50)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
15.00 (381.00)	35 (47)	41 (56)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
15.50 (393.70)	43 (58)	50 (68)	43 (58)	50 (68)	—	—	—	—	—	—	—	—	—	—	—	—
16.00 (406.40)	—	—	48 (65)	56 (76)	—	—	—	—	—	—	—	—	—	—	—	—
16.50 (419.10)	—	—	55 (75)	65 (88)	—	—	—	—	—	—	—	—	—	—	—	—
17.00 (431.80)	—	—	62 (84)	73 (99)	—	—	—	—	—	—	—	—	—	—	—	—
17.50 (444.50)	—	—	68 (92)	80 (108)	—	—	—	—	—	—	—	—	—	—	—	—
18.00 (457.20)	—	—	77 (104)	90 (122)	—	—	—	—	—	—	—	—	—	—	—	—
19.00 (482.60)	—	—	—	—	—	—	77 (104)	105 (142)	—	—	—	—	—	—	—	—
19.50 (495.3.0)	—	—	—	—	—	—	84 (114)	111 (150)	—	—	—	—	—	—	—	—
20.00 (508.00)	—	—	—	—	—	—	90 (122)	119 (161)	—	—	131 (178)	153 (207)	128 (174)	192 (260)	—	—
20.50 (520.70)	—	—	—	—	—	—	98 (133)	124 (168)	—	—	141 (191)	165 (224)	137 (186)	202 (274)	—	—
21.00 (533.40)	—	—	—	—	—	—	106 (144)	131 (178)	—	—	151 (205)	176 (239)	145 (197)	211 (286)	—	—

Diameter in in. (mm)	12x14-15		16x18-17H		16x18-30		18x20-24		18x20-30		20x24-24		24x24-28		20x24-30	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
21.50 (546.10)	—	—	—	—	—	—	113 (153)	139 (188)	—	—	161 (218)	190 (258)	155 (210)	222 (301)	—	—
22.00 (558.80)	—	—	—	—	213 (289)	230 (312)	123 (167)	148 (201)	217 (294)	229 (310)	172 (233)	204 (277)	166 (225)	232 (315)	159 (216)	174 (236)
22.50 (571.50)	—	—	—	—	224 (304)	242 (328)	133 (180)	156 (212)	225 (305)	238 (323)	187 (254)	221 (300)	179 (243)	245 (332)	167 (226)	184 (249)
23.00 (584.20)	—	—	—	—	235 (319)	255 (346)	145 (197)	163 (221)	235 (319)	247 (335)	201 (273)	238 (323)	190 (258)	255 (346)	175 (237)	194 (263)
23.50 (596.90)	—	—	—	—	240 (325)	268 (363)	158 (214)	173 (235)	245 (332)	258 (350)	216 (293)	256 (347)	202 (274)	267 (362)	184 (249)	204 (277)
24.00 (609.60)	—	—	—	—	260 (353)	281 (381)	170 (230)	183 (248)	255 (346)	269 (365)	231 (314)	275 (373)	218 (296)	280 (380)	197 (267)	214 (290)
24.50 (622.30)	—	—	—	—	272 (369)	295 (400)	—	—	265 (359)	281 (381)	—	—	230 (312)	295 (400)	208 (282)	228 (309)
25.00 (635.00)	—	—	—	—	288 (390)	312 (423)	—	—	278 (377)	293 (397)	—	—	249 (338)	310 (420)	219 (297)	239 (324)
25.50 (647.70)	—	—	—	—	306 (415)	330 (447)	—	—	290 (393)	309 (418)	—	—	265 (359)	325 (441)	234 (317)	254 (344)
26.00 (660.40)	—	—	—	—	329 (446)	347 (470)	—	—	303 (411)	322 (437)	—	—	282 (382)	340 (461)	249 (338)	271 (367)
26.50 (673.10)	—	—	—	—	337 (457)	365 (495)	—	—	319 (433)	339 (460)	—	—	305 (414)	355 (481)	269 (365)	289 (392)
27.00 (685.80)	—	—	—	—	355 (481)	385 (522)	—	—	333 (451)	353 (479)	—	—	325 (441)	375 (508)	288 (390)	309 (419)
27.50 (698.50)	—	—	—	—	375 (508)	414 (561)	—	—	350 (475)	371 (503)	—	—	345 (468)	392 (531)	309 419)	334 (453)
28.00 (711.20)	—	—	—	—	395 (536)	430 (583)	—	—	365 (495)	389 (527)	—	—	370 (502)	415 (563)	329 (446)	357 (484)
28.50 (723.90)	—	—	—	—	418 (567)	455 (617)	—	—	385 (522)	409 (555)	—	—	397 (538)	430 (583)	354 (480)	380 (515)
29.00	—	—	—	—	440	481	—	—	403	429	—	—	—	—	379	409

Diameter in in. (mm)	12x14-15		16x18-17H		16x18-30		18x20-24		18x20-30		20x24-24		24x24-28		20x24-30	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
(736.60)					(597)	(652)			(546)	(582)					(514)	(555)
29.50 (749.30)	—	—	—	—	470 (637)	510 (691)	—	—	424 (575)	449 (609)	—	—	—	—	409 (555)	439 (595)
30.00 (762.00)	—	—	—	—	495 (671)	540 (732)	—	—	443 (601)	473 (641)	—	—	—	—	447 (606)	478 (648)
30.50 (774.70)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
31.00 (787.40)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
31.50 (800.10)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
32.00 (812.80)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	——	—

Table 14: WR2 values for large pumps in lb-ft (Nm)

These values include bronze impeller rings.

Diameter in in. (mm)	24x30-32		30x30-31		30x30-38		30x36-42		20x30-42		36x42-52	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
26.00 (660.40)	474 (643)	564 (765)	—	—	—	—	—	—	—	—	—	—
26.50 (673.10)	494 (670)	594 (805)	—	—	—	—	—	—	—	—	—	—
27.00 (685.80)	514 (697)	624 (846)	—	—	—	—	—	—	—	—	—	—
27.50 (698.50)	544 (738)	654 (887)	316 (428)	395 (536)	—	—	—	—	—	—	—	—
28.00 (711.20)	574 (778)	684 (927)	344 (466)	430 (583)	425 (576)	1,025 (1,390)	—	—	—	—	—	—
28.50 (723.90)	604 (819)	714 (968)	368 (499)	460 (624)	520 (705)	1,125 (1,525)	—	—	—	—	—	—
29.00 (736.60)	634 (860)	744 (1,009)	400 (542)	500 (678)	615 (834)	1,200 (1,627)	—	—	—	—	—	—
29.50 (749.30)	664 (900)	784 (1,063)	432 (586)	540 (732)	715 (969)	1,285 (1,742)	—	—	—	—	—	—
30.00 (762.00)	694 (941)	824 (1,117)	464 (629)	580 (786)	815 (1,105)	1,375 (1,864)	—	—	—	—	—	—
30.50 (774.70)	734 (995)	864 (1,171)	500 (678)	625 (847)	910 (1,234)	1460 (1,979)	—	—	—	—	—	—

Diameter in in. (mm)	24x30-32		30x30-31		30x30-38		30x36-42		20x30-42		36x42-52	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
31.00 (787.40)	764 (1,036)	904 (1,226)	540 (732)	675 (915)	1,000 (1,356)	1,550 (2,102)	—	—	—	—	—	—
31.50 (800.10)	804 (1,090)	944 (1,280)	576 (781)	720 (976)	1,100 (1,491)	1,630 (2,210)	—	—	—	—	—	—
32.00 (812.80)	844 (1,144)	994 (1,348)	620 (840)	775 (1,051)	1,200 (1,627)	1,725 (2,339)	1,355 (1,837)	1,900 (2,576)	—	—	—	—
32.50 (825.50)	—	—	656 (889)	820 (1,112)	1,300 (1,763)	1,810 (2,454)	1,415 (1,918)	1,960 (2,657)	—	—	—	—
33.00 (838.20)	—	—	709 (961)	885 (1,200)	1,390 (1,885)	1,900 (2,576)	1,485 (2,013)	2,025 (2,745)	—	—	—	—
33.50 (850.90)	—	—	—	—	1,490 (2,020)	1,985 (2,691)	1,555 (2,108)	2,085 (2,827)	—	—	—	—
34.00 (863.60)	—	—	—	—	1,585 (2,149)	2,090 (2,834)	1,625 (2,203)	2,150 (2,915)	—	—	—	—
34.50 (876.30)	—	—	—	—	1,685 (2,285)	2,160 (2,929)	1,695 (2,298)	2,215 (3,003)	—	—	—	—
35.00 (889.00)	—	—	—	—	1,785 (2,420)	2,240 (3,037)	1,765 (2,393)	2,285 (3,098)	397 (538)	497 (674)	—	—
35.50 (901.70)	—	—	—	—	1,880 (2,549)	2,325 (3,152)	1,845 (2,501)	2,360 (3,200)	414 (561)	522 (708)	—	—
36.00 (914.40)	—	—	—	—	1,975 (2,678)	2,410 (3,268)	1,935 (2,624)	2,445 (3,315)	431 (584)	549 (744)	—	—
36.50 (927.10)	—	—	—	—	2,080 (2,820)	2,500 (3,390)	2,025 (2,746)	2,515 (3,410)	449 (609)	576 (781)	—	—
37.00 (939.80)	—	—	—	—	2,175 (2,949)	2,575 (3,491)	2,105 (2,854)	2,600 (3,525)	467 (633)	605 (820)	—	—
37.50 (952.50)	—	—	—	—	2,275 (3,084)	2,650 (3,593)	2,205 (2,990)	2,675 (3,627)	487 (660)	635 (861)	—	—
38.00 (965.20)	—	—	—	—	2,375 (3,220)	2,725 (3,695)	2,305 (3,125)	2,760 (3,742)	508 (689)	665 (902)	—	—
38.50 (977.90)	—	—	—	—	—	—	2,415 (3,274)	2,860 (3,878)	529 (717)	698 (946)	—	—
39.00 (990.60)	—	—	—	—	—	—	2,535 (3,437)	2,955 (4,006)	552 (748)	732 (992)	—	—
39.50 (1,003.30)	—	—	—	—	—	—	2,645 (3,586)	3,055 (4,142)	575 (780)	767 (1,040)	—	—
40.00 (1,016.00)	—	—	—	—	—	—	2,785 (3,776)	3,155 (4,278)	600 (813)	803 (1089)	—	—
40.50 (1,028.70)	—	—	—	—	—	—	2,885 (3,912)	3,235 (4,386)	624 (846)	841 (1,140)	—	—
41.00	—	—	—	—	—	—	3,015	3,340	650	881	—	—

Diameter in in. (mm)	24x30-32		30x30-31		30x30-38		30x36-42		20x30-42		36x42-52	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
(1,041.40)							(4,087)	(4,528)	(881)	(1,194)		
41.50 (1,054.10)	—	—	—	—	—	—	3,155 (4,278)	3,445 (4,671)	677 (918)	922 (1,250)	—	—
42.00 (1,066.80)	—	—	—	—	—	—	3,300 (4,474)	3,555 (4,820)	705 (956)	965 (1,308)	—	—
45.00 (61.01)	—	—	—	—	—	—	—	—	—	—	6,700 (9,084)	9,100 (12,338)
46.00 (62.37)	—	—	—	—	—	—	—	—	—	—	7,200 (9,762)	9,600 (13,016)
47.00 (63.72)	—	—	—	—	—	—	—	—	—	—	8,160 (11,063)	10,300 (13,965)
48.00 (65.08)	—	—	—	—	—	—	—	—	—	—	8,600 (11,660)	10,700 (14,507)
49.00 (66.44)	—	—	—	—	—	—	—	—	—	—	9,560 (12,962)	11,500 (15,592)
50.00 (67.80)	—	—	—	—	—	—	—	—	—	—	10,070 (13,653)	12,100 (16,405)
51.00 (69.15)	—	—	—	—	—	—	—	—	—	—	11,000 (14,914)	12,700 (17,219)
52.00 (70.50)	—	—	—	—	—	—	—	—	—	—	11,500 (15,592)	13,200 (17,897)

6.7.4.10 Recommended minimum flows

Size	CDS reference number	Impeller drawing	Diameter	Speed				
				1,180	960	885	710	590
12x14-15	5147	D06911A	Maximum	4,000	3,300	2,500	2,000	1,850
		D07551A	Minimum	4,000	3,300	2,500	2,000	1,850
16x18-17H	5219	D06983A	Maximum	8,000	6,500	6,000	4,800	4,000
		D07603A	Minimum	8,000	6,500	6,000	4,800	4,000
16x18-30G	2538	113-13	Maximum	4,728	3,847	3,546	2,845	2,364
		D00016A	Minimum	4,728	3,847	3,546	2,845	2,364
16x18-30	2539	D00038A	Maximum	7,500	6,102	5,625	4,543	3,750
		D00039A	Minimum	7,500	6,102	5,625	4,513	3,750
16x18-30H	2540 1	112-62	Maximum	7,500	6,102	5,625	4,513	3,750
			Minimum	7,500	6,102	5,625	4,513	3,750
18x20-24	3145 1	D01532A	Maximum	7,619	6,199	5,714	4,584	3,810
		D01535A	Minimum	7,619	6,199	5,714	4,584	3,810

Size	CDS reference number	Impeller drawing	Diameter	Speed				
				1,180	960	885	710	590
18x20-24G	3223	D02280A	Maximum	6,203	5,047	4,652	3,732	3,102
		D02281A	Minimum	6,203	5,047	4,652	3,732	3,102
18x20-24N	3253	D02301A	Maximum	7,000	5,695	5,250	4,212	3,500
		D02302A	Minimum	7,000	5,695	5,250	4,212	3,500
18x20-30	1747 6	250-2	Maximum	8,100	6,590	6,075	4,874	4,050
		252-121	Minimum	8,100	6,590	6,075	4,874	4,050
20x24-24	1999 4	253-6	Maximum	9,000	7,322	9,288	7,451	6,192
		253-12	Minimum	9,000	7,322	9,288	7,451	6,192
20x24-28	3149 1	D01533A	Maximum	—	—	9,288	7,451	6,192
		D01536A	Minimum	—	—	9,288	7,451	6,192
20x24-28G	3224	D02282A	Maximum	—	—	6,800	5,455	4,533
		D02283A	Minimum	—	—	6,800	5,455	4,533
20x24-28H	3746	D21539A	Maximum	—	—	13,800	11,071	9,200
			Minimum	—	—	13,800	11,071	9,200
20x24-28N	3252	D02299A	Maximum	—	—	7,200	5,776	4,800
		D02300	Minimum	—	—	7,200	5,776	4,800
20x24-30	1929 2	254-105	Maximum	9,600	7,810	7,200	5,776	4,800
		257-89	Minimum	9,600	7,810	7,200	5,776	4,800
24x24-26	1896	256-44	Maximum	—	—	7,690	6,169	5,127
		257-90	Minimum	—	—	7,690	6,169	5,127
24x30-32	2288	262-25	Maximum	—	—	15,032	12,060	10,021
		265-84	Minimum	—	—	15,032	12,060	10,021
24x30-32	2289	262-22	Maximum	—	—	—	12,073	10,032
		265-82	Minimum	—	—	—	12,073	10,032
24x30-32G	2498 2	267-21	Maximum	—	—	12,558	10,075	8,372
		D00013A	Minimum	—	—	12,558	10,075	8,372
24x30-32N	2289 3	262-22	Maximum	—	—	—	12,073	10,032
		265-82	Minimum	—	—	—	12,073	10,032
24x30-32H	2500 4	267-27	Maximum	—	—	—	12,249	17,179
		D00014A	Minimum	—	—	—	12,249	17,179
30x30-31G	5031	D05540A	Maximum	—	—	20,000	15,000	12,500
			Minimum	—	—	20,000	15,000	12,500
30x30-31	3355	D02370A	Maximum	—	—	—	21,500	17,866
			Minimum	—	—	—	21,500	17,866
30x30-38G	3225	D02284A	Maximum	—	—	—	14,909	12,389
		D02285A	Minimum	—	—	—	14,909	12,389
30x30-38N	3251 1	D02297A	Maximum	—	—	—	20,454	16,997
		D02298A	Minimum	—	—	—	20,454	16,997
30x30-38	3162 1	D02259A	Maximum	—	—	—	19,218	15,970
		D02257A	Minimum	—	—	—	19,218	15,970
30x36-42G	3246	D02286A	Maximum	—	—	—	—	18,359
		D02287A	Minimum	—	—	—	—	18,359

Size	CDS reference number	Impeller drawing	Diameter	Speed				
				1,180	960	885	710	590
30x36-42N	3256 1	D02393A	Maximum	—	—	—	29,378	24,413
		D02394A	Minimum	—	—	—	29,378	24,413
30x36-42	3152 2	D01534A	Maximum	—	—	—	26,379	21,921
		D01537A	Minimum	—	—	—	26,379	21,921
30x36-42	2401	267-56	Maximum	—	—	—	36,338	30,196
		D00147A	Minimum	—	—	—	36,338	30,196
30x36-42H	2404 4	267057	Maximum	—	—	—	30,200	25,096
		272-80	Minimum	—	—	—	30,200	25,096
20x30-42	6948	D11284A	All	—	—	10,000	9,000	6,500
36x42-52	6462	E02707A	All	—	—	—	—	20,000

6.7.4.11 Mechanical seal horsepower draw

Small- and medium-sized pumps

This table provides a tabulation of mechanical seal horsepower draw values for common seal types and pump power end sizes. Refer to 700.7.1 for procedures in order to apply mechanical seal drag.

Seal type	Speed in rpm	Seal diameter in inches (centimeters)							
		4.14 (10.52)		5.00 (12.70)	5.50 (13.97)				
		12x14-15	16x18-17H	18x20-24	16x18-30	18x20-30	20x24-24	20x24-28	20x24-30
Single inside	1,780	0.62	—	—	—	—	—	—	—
	1,450	0.51	—	—	—	—	—	—	—
	1,180	0.41	0.41	0.57	0.67	0.67	0.67	—	0.67
	960	0.33	0.33	—	—	—	—	—	—
	885	0.31	0.31	0.42	0.50	0.50	0.50	0.50	0.50
	710	—	—	—	0.40	0.40	—	0.40	0.40
	590	—	—	—	0.33	0.33	—	0.33	0.33
	505	—	—	—	—	—	—	—	—
Double or tandem	1,780	1.12	—	—	—	—	—	—	—
	1,450	0.92	—	—	—	—	—	—	—
	1,180	0.74	0.74	1.02	1.20	1.20	1.20	—	1.20
	960	0.60	0.60	—	—	—	—	—	—
	885	0.56	0.56	0.76	0.90	0.90	0.90	0.90	0.90
	710	—	—	—	0.72	0.72	—	0.72	0.72
	590	—	—	—	0.60	0.60	—	0.60	0.60
	505	—	—	—	—	—	—	—	—

Large size pumps

Seal type	Speed in rpm	Seal diameter in inches (centimeters)				
		6.50 (16.51)	7.50 (19.05)		8.00 (20.32)	9.00 (22.86)
		24x30-32	30x30-31	30x30-38	20x30-42 30x36-42	36x42-52
Seal inside	1,780	—	—	—	—	—
	1,450	—	—	—	—	—

Seal type	Speed in rpm	Seal diameter in inches (centimeters)				
		6.50 (16.51)	**7.50 (19.05)**		**8.00 (20.32)**	**9.00 (22.86)**
		24x30-32	**30x30-31**	**30x30-38**	**20x30-42** **30x36-42**	**36x42-52**
	1,180	—	—	—	—	—
	960	—	—	—	—	—
	885	0.67	0.88	—	—	—
	710	0.54	0.71	0.71	0.80	—
	590	0.45	0.59	0.59	0.66	0.75
	505	0.39	0.50	0.50	0.57	0.64
Double or tandem	1,780	—	—	—	—	—
	1,450	—	—	—	—	—
	1,180	—	—	—	—	—
	960	—	—	—	—	—
	885	1.62	1.58	—	—	—
	710	0.97	1.27	1.27	1.43	—
	590	0.81	1.06	1.06	1.19	1.34
	505	0.69	0.90	0.90	1.02	1.15

7 Troubleshooting

7.1 Alignment troubleshooting

Symptom	Cause	Remedy
Horizontal (side-to-side) alignment cannot be obtained (angular or parallel).	The driver feet are bolt-bound.	Loosen the pump's hold-down bolts, and slide the pump and driver until you achieve horizontal alignment.
	The baseplate is not leveled properly and is probably twisted.	1. Determine which corners of the baseplate are high or low. 2. Remove or add shims at the appropriate corners. 3. Realign the pump and driver.

7.2 Operation troubleshooting

Problem	Probably cause	Remedy
No liquid is being delivered to the pump.	The pump is not primed.	Reprime the pump, and check that the pump and the suction line are full of liquid.
	The suction line is clogged.	Remove any obstructions.
	The impeller is clogged with foreign material.	Backflush the pump in order to clean the impeller.
	The pump is rotating in the wrong direction.	Change the rotation to match with the direction indicated by an arrow on the bearing housing or pump casing.
	The foot valve or suction pipe opening is not adequately submerged.	Consult your ITT representative for the proper depth. Use a baffle in order to eliminate vortices.
	The suction lift is too high.	Shorten the suction pipe.
The pump is not producing the rated flow or head.	Air is leaking through the gasket.	Replace the gasket.
	Air is leaking through the stuffing box or seal chamber.	Replace or readjust the packing or mechanical seal.
	The impeller is partially clogged.	Backflush the pump in order to clean the impeller.
	The wear rings are worn.	Replace any defective parts.
	There is not enough suction head.	Make sure that the suction line shutoff valve is fully open and the line is not obstructed.
	The impeller is worn or broken.	Inspect and replace any damaged parts.
The pump starts, and then stops pumping.	The pump is not primed properly.	Reprime the pump.
	There are air or vapor pockets in the suction line.	Rearrange the piping in order to eliminate air pockets.
	Air is leaking from the suction line.	Repair or plug the leak.
Bearings are running hot.	The alignment is not done properly.	Re-align the pump and driver.
	The bearings are not being lubricated properly.	Make sure that you are using a suitable lubricant and that it is at the proper level.
	Lubrication is not being cooled properly.	Check the lubrication cooling system.

Problem	Probably cause	Remedy
The pump is noisy or it is vibrating.	The pump or the driver is not properly aligned.	Align the shafts.
	The impeller is partially clogged, which causes an imbalance.	Backflush the pump in order to clean the impeller.
	The impeller or the shaft is broken or bent.	Replace any damaged parts.
	The foundation is not rigid.	Tighten the hold-down bolts of the pump and motor, or adjust the stilts.
	The bearings are worn.	Replace the bearings.
	The suction or discharge piping is not anchored or properly supported.	Anchor the piping according the recommendations in the Hydraulic Institute Standards Manual.
	The pump is cavitating.	Locate and correct the system problem.
There are excessive leaks from the stuffing box and/or the seal chamber.	The packing gland is not properly adjusted.	Tighten the gland nuts.
	The stuffing box is not properly packed.	Check the packing and repack the box.
	The mechanical seal parts are worn.	Replace the worn parts.
	The shaft sleeve is scored.	Check the lubrication and cooling lines.
The motor requires excessive power.	The head is lower than it should be according to the pump rating. The pump is pumping too much liquid.	Re-machine or replace the pump as required.
	The liquid is heavier than expected.	Check specific gravity and viscosity.
	The packing is too tight.	Readjust the packing. Replace the packing if it is worn.
	Rotating parts are binding.	Make sure that there are proper clearances for the internal wearing parts.

8 Parts List and Cross-Sectionals

8.1 SX and MX group parts list

Item	Quantity per pump	Part name	All iron	Bronze fitted	Iron/316 trim	All 316 SS
100	1	Casing	A48 Class 30B			A743 CF-8M
101	1	Impeller	A48 Class 25B	B584 C87500	A743 CF-8M	
105	2	Lantern ring	25% glass filled TFE			
106	1 set	Stuffing box packing	Non-asbestos			
107	2	Gland, stuffing box	A743 CF-8M			
109	2	End cover	A48 Class 25B			
112	2	Ball bearing, thrust	Steel			
122	1	Shaft	A434 GR 4140			A564 Type 630
124	1	Sleeve nut, right	A48 Class 25B	B584 C87500	A743 CF-8M	
125	2	Stuffing box bushing	B584 C87500		A743 CF-8M	
126	2	Shaft sleeve	B584 C87500		A743 CF-8M	
127	2	Casing wear ring	A48 Class 25B	B584 C87500	A743 CF-8M	
130	1	Sleeve nut, left	A48 Class 25B	B584 C87500	A743 CF-8M	
134	1	Bearing housing, thrust	A48 Class 25B			
136	1	Bearing locknut	Steel			
142	2	Impeller wear ring	A48 Class 20B	B584 C87500	A743 CF-8M	
166	1	Bearing housing, radial	A48 Class 25B			
168	1	Ball bearing, radial	Steel			
178	1	Impeller key	Steel		A582 Type 303	
190E	2	Pipe nipple	A53			
193H	2	Grease fitting	Steel			
222B	2	Setscrew, sleeve nut	F738M Class A4-50			
251	2	Sight oiler	Metal / Glass			
320	6	Setscrew, impeller wear ring	F738M Class A4-50			
332A	1	Seal, labyrinth - O.B.	Carbon/Graphite filled PTFE with Viton O-rings			
333A	2	Seal, labyrinth - I.B.	Carbon/Graphite filled PTFE with Viton O-rings			
351D	1	Gasket, casing discharge	Non-asbestos sheet packing			
351S	1	Gasket, casing suction	Non-asbestos sheet packing			
353	4	Stud, gland	Steel - 2441			
355	4	Hex nut, gland stud	Steel - 2441			
356A	Varies	Stud, casing	Steel - 2443			
357H	2	Hex nut, casing taper pin	Steel - 2442			

Item	Quantity per pump	Part name	All iron	Bronze fitted	Iron/316 trim	All 316 SS
358	8	Pipe plug , casing (not shown)	Steel			
360	8	Gasket, cover-to-housing	Vellumoid sheet packing D-1170			
371C	4	Hex capscrew, cover-to-housing	Steel - 2442			
371D	4	Hex capscrew, cover-to-housing	Steel - 2442			
372U	8	Hex capscrew, housing-to-cover	Steel - 2442			
382	1	Bearing lockwasher	Steel			
400	1	Key, coupling (not shown)	Steel			
408	10	Pipe plug (not shown)	Steel			
412A	2	O-ring, impeller	Nutrile (BUNA-N) rubber			
418	2	Hex capscrew, casing stud	Steel - 2442			
425	Varies	Hex nut, casing stud	Steel - 2442			
426	Varies	Hex capscrew, casing parting	Steel			
445A	2	Pin, anti-rotation	F738M Class A2-70			
469G	2	Taper pin	Steel			A276 Type 316
497	2	O-ring, sleeve nut	Nitrile (BUNA-N) rubber			

8.2 M, M-modified, and 20x24-28 group parts list

Item	Quantity per pump	Part name	All iron	Bronze fitted	Iron/316 trim	All 316 SS
100	1	Casing	A48 Class 30B			A743 CF-8M
101	1	Impeller	A48 Class 25B	B584 C87500	A743 CF-8M	
105	2	Lantern ring	25% Glass Filled TFE			
106	1 set	Stuffing box packing	Non-asbestos			
107	2	Quench gland, stuffing box	A48 Class 25B	B584 C87500	A743 CF-8M	
109A	1	Bearing end cover	A48 Class 25B			
111A	2	Bearing cap	A48 Class 30B			
112A	1	Ball bearing, thrust	Steel			
113A	2	Breather	Steel			
114	2	Oil ring	B584 C87500			
119A	1	Bearing end cover	A48 Class 25B			
122	1	Shaft	A322 GR 4340		A276 Type 316	
123	1	Deflector - O.B., grease	A48 Class 20B			
123A	1	Deflector - O.B.	A48 Class 20B			
124	1	Sleeve nut, right	A48 Class 25B	B584 C87500	A743 CF-8M	

Item	Quantity per pump	Part name	All iron	Bronze fitted	Iron/316 trim	All 316 SS
125	2	Stuffing box bushing	A48 Class 25B	B584 C87500	A743 CF-8M	
126	2	Shaft sleeve	A48 Class 25B	B584 C87500	A743 CF-8M	
127	2	Casing wear ring	A48 Class 25B	B584 C87500	A743 CF-8M	
130	1	Sleeve nut, left	A48 Class 25B	B584 C87500	A743 CF-8M	
134A	2	Bearing housing	A48 Class 25B			
136	2	Bearing locknut	Steel			
142	2	Impeller wear ring	A48 Class 20B	B584 C87500	A743 CF-8M	
168A	1	Ball bearing, radial	Steel			
178	1	Impeller key	A582 Type 303		A276 Type 316	
190E	2	Pipe nipple	A53			
193	2	Grease fitting	Steel			
207	1	Oil ring sleeve, grease	Steel			
208	1	Oil ring sleeve, grease	Steel			
210	2	Packing, gland	Non-Asbestos			
222B	4	Setscrew, sleeve nut	A276 Type 316			
222P	6	Setscrew, deflector	A276 Type 316			
222Q	4	Setscrew, grease shield	A276 Type 316			
229	4	Swing bolt	Steel		A276 Type 316	
248	2	Oil thrower - I.B.	A48 Class 20B			
251	2	Sight oiler	Metal / Glass			
251C	2	Pipe plug (sight oiler)	Steel			
320	12	Setscrew, impeller wear ring	A276 Type 316			
323	1	Oil ring sleeve, thrust	Steel			
324	1	Oil ring sleeve, radial	Steel			
328	4	Hex capscrew, gland	Steel	A276 Type 316		
333	2	Oil seal - I.B., grease	BUNA rubber and steel			
346A	2	Grease shield	Steel			
351D	1	Gasket, casing discharge	Non-asbestos sheet packing			
351S	1	Gasket, casing suction	Non-asbestos sheet packing			
355	4	Hex nut, gland stud	Steel		A276 Type 316	
355B	4	Hex nut, quench gland	Steel	A276 Type 316		
356A	Varies	Stud, casing	Steel - 2443			
356P	8	Stud, casing bearing cap	Steel - 2210			
356Q	Varies	Stud, casing parting	Steel - 2210			
358C	Varies	Pipe plug, casing (not shown)	Steel - 2210			
358V	Varies	Pipe plug frame (not shown)	Steel			
360E	2	Gasket, cover-to-housing	Kraft paper			

Item	Quantity per pump	Part name	All iron	Bronze fitted	Iron/316 trim	All 316 SS
360G	8	Gasket, housing-to-housing	Kraft paper			
363B	6	Insert, setscrew	Non-asbestos sheet packing			
364	4	Insert, setscrew	Non-asbestos sheet packing			
371S	14	Hex capscrew, cover-to-housing	Steel - 2210			
371T	12	Hex capscrew, housing-to-housing	Steel - 2210			
382	2	Bearing lockwasher	Steel			
398A	2	Retaining bracket, oil ring	Steel			
400	1	Key, coupling (not shown)	Steel			
412A	2	O-ring, impeller	O-ring Nutrile (BUNA-N) rubber			
418	2	Hex capscrew, casing stud	Steel - 2442			
425A	8	Hex nut, casing bearing cap	Steel - 2442			
425B	Varies	Hex nut, casing parting	Steel - 2210			

8.3 Standard group parts list (18x20-24)

Item	Quantity per pump	Part name	All iron	Bronze fitted	Iron/316 trim	All 316 SS
100	1	Casing	A48 Class 30B			A743 CF-8M
101	1	Impeller	A48 Class 25B	B584 C87500	A743 CF-8M	
105	2	Lantern ring	25% glass filled TFE			
106	1 set	Stuffing box packing	Non-asbestos			
107	2	Quench gland, stuffing box	A48 Class 25B	B584 C87500	A743 CF-8M	
109A	1	Bearing end cover	A48 Class 20B			
111A	2	Bearing cap	A48 Class 30B			
112A	1	Ball bearing, thrust	Steel			
113A	2	Breather	Steel			
114	2	Oil ring	B584 C87500			
119A	1	Bearing end cover	A48 Class 25B			
122	1	Shaft	A322 GR 4340		A276 Type 316	
123	2	Deflector - I..B., grease	A48 Class 20B			
123A	1	Deflector - O.B.	A48 Class 20B			
124	1	Sleeve nut, RH	A48 Class 25B	B584 C87500	A743 CF-8M	
125	2	Stuffing box bushing	A48 Class 25B	B584 C87500	A743 CF-8M	
126	2	Shaft sleeve	A48 Class 25B	B584 C87500	A743 CF-8M	
127	2	Casing wear ring	A48 Class 25B	B584 C87500	A743 CF-8M	

Item	Quantity per pump	Part name	All iron	Bronze fitted	Iron/316 trim	All 316 SS
130	1	Sleeve nut, left	A48 Class 25B	B584 C87500	A743 CF-8M	
134A	2	Bearing housing	A48 Class 25B			
136	2	Bearing locknut	Steel			
142	2	Impeller wear ring	A48 Class 20B	B584 C87500	A743 CF-8M	
168A	1	Ball bearing, radial	Steel			
178	1	Impeller key	A582 Type 303		A276 Type 316	
190E	2	Pipe nipple	A53			
193	2	Grease fitting	Steel			
210	2	Packing, gland	Non-asbestos			
222B	4	Setscrew, sleeve nut	A276 Type 316			
222P	6	Setscrew, deflector	A276 Type 316			
222Q	4	Setscrew, grease shield	A276 Type 316			
229	4	Swing bolt	Steel		A276 Type 316	
248	2	Oil thrower	A48 Class 20B			
251	2	Sight Oiler	Metal / Glass			
251C	2	Pipe plug (sight oiler)	Steel			
320	12	Setscrew , impeller wear ring	A276 Type 316			
323	1	Oil ring sleeve, thrust	Steel			
324	1	Oil ring sleeve, radial	Steel			
328	4	Hex capscrew, gland	A276 Type 316			
333	2	Oil seal - I.B., grease	BUNA rubber and steel			
346A	2	Grease shield	Steel			
351D	1	Gasket, casing discharge	Non-asbestos sheet packing			
351S	1	Gasket, casing suction	Non-asbestos sheet packing			
355	4	Hex nut, gland stud	Steel		A276 Type 316	
355B	4	Hex nut, quench gland	Steel	A276 Type 316		
356G	52	Stud, casing parting	Steel - 2210			
356P	8	Stud, casing bearing cap	Steel - 2210			
358C	Varies	Pipe plug, casing (not shown)	Steel - 2210			
358V	Varies	Pipe plug, frame (not shown)	Steel - 2210			
360E	2	Gasket, cover-to-housing	Kraft paper			
360G	8	Gasket, housing-to-housing	Kraft paper			
363B	6	Insert, setscrew	Non-asbestos sheet packing			
364	4	Insert, setscrew	Non-asbestos sheet packing			
371S	12	Hex capscrew, cover-to-housing	Steel - 2210			
371T	14	Hex capscrew, housing-to-housing	Steel - 2210			
382	2	Bearing lockwasher	Steel			

Item	Quantity per pump	Part name	All iron	Bronze fit-ted	Iron/316 trim	All 316 SS
400	1	Key, coupling (not shown)	Steel			
412A	2	O-ring, impeller	Nutrile (BUNA-N) rubber			
418	4	Hex capscrew, casing jacking	Steel - 2210			
425A	8	Hex nut, casing bearing cap	Steel - 2210			
425B	52	Hex nut, casing parting	Steel - 2210			
469G	2	Dowel pin, casing	Steel - 2210			
469L	2	Dowel pin, end cover	Steel - 2210			

8.4 L group parts list

Item	Quantity per pump	Part name	All iron	Bronze fit-ted	Iron/316 trim	All 316 SS
100	1	Casing	A48 Class 30B			A743 CF-8M
101	1	Impeller	A48Class 25B	B584 C87500	A743 CF-8M	
105	2	Lantern ring	25% glass filled TFE			
106	1 set	Stuffing box packing	Non-asbestos			
107	2	Quench gland, stuffing box	A48Class 20B	B584 C87500	A743 CF-8M	
109	1	Bearing end cover, grease	A48 Class 25B			
109A	1	Bearing end cover	A48 Class 25B			
111	2	Bearing cap, grease	A48 Class 30B			
111A	2	Bearing cap	A48 Class 30B			
113A	2	Breather	Steel			
114	2	Oil ring	B584 C87500			
119	1	Bearing end cover, grease	A48 Class 25B			
119A	1	Bearing end cover	A48 Class 20B			
122	1	Shaft	A322 GR 4340		A276 Type 316	
123	2	Deflector - I..B., grease	Laminated plastic - NEMA GR. C			
123A	1	Deflector - O.B., grease	Laminated plastic - NEMA GR. C			
124	1	Sleeve nut, right	A48 Class 25B	B584 C87500	A743 CF-8M	
125	2	Stuffing box bushing	A48 Class 25B	B584 C87500	A743 CF-8M	
126	2	Shaft sleeve	A48 Class 25B	B584 C87500	A743 CF-8M	
127	2	Casing wear ring	A48 Class 25B	B584 C87500	A743 CF-8M	
130	1	Sleeve nut, left	A48 Class 25B	B584 C87500	A743 CF-8M	
134	1	Bearing housing, thrust	A48 Class 25B			
134A	2	Bearing housing, radial	A48 Class 25B			

Item	Quantity per pump	Part name	All iron	Bronze fitted	Iron/316 trim	All 316 SS
136	2	Bearing locknut	Steel			
139	1	Dust cover	A48 Class 20B			
142	2	Impeller wear ring	A48 Class 25B	B584 C87500	A743 CF-8M	
178	1	Impeller key	A582 Type 303		A276 Type 316	
190	2	Pipe nipple, grease	A53			
190E	2	Pipe nipple	A53			
193	2	Grease fitting	Steel			
210	6	Packing , gland	Non-asbestos			
222B	6	Setscrew, sleeve nuts	A276 Type 316			
222N	4	Setscrew, oil thrower	A276 Type 316			
229	2	Swing bolt	Steel		A276 Type 316	
248	2	Oil thrower, I.B.	A48 Class 20B			
251	2	Sight oiler	Metal / glass			
320	12	Setscrew, impeller wear ring	A276 Type 316			
323	1	Oil ring sleeve, thrust	B584 C87500			
324	1	Oil ring sleeve, radial	B584 C87500			
328	4	Hex capscrew, gland	Steel	A276 Type 316		
332	1	Oil seal - O.B., grease	BUNA rubber and steel			
333	2	Oil seal - I.B., grease	BUNA rubber and steel			
351D	1	Gasket, casing discharge	Non-asbestos sheet packing			
351S	1	Gasket, casing parting	Non-asbestos sheet packing			
355	4	Hex nut, gland stud	Steel		A276 Type 316	
355B	4	Hex nut, quench gland	Steel		A276 Type 316	
356P	8	Stud, casing bearing cap	Steel - 2210			
356Q	38	Stud, casing parting	Steel - 2210			
358C	Varies	Pipe plug , casing (not shown)	Steel - 2210			
358V	Varies	Pipe plug, frame (not shown)	Steel			
360	2	Gasket, cover-to-housing, grease	Kraft paper			
360E	2	Gasket, cover-to-housing	Kraft paper			
360G	2	Gasket, housing-to-housing	Kraft paper			
363B	6	Insert, setscrew	Non-asbestos sheet packing			
364	6	Insert, setscrew	Non-asbestos sheet packing			
370	8	Hex capscrew, cover-to-housing, grease	Steel - 2210			
371C	8	Hex capscrew, cover-to-housing, grease	Steel - 2210			
371S	12	Hex capscrew, cover-to-housing	Steel - 2210			

Item	Quantity per pump	Part name	All iron	Bronze fit-ted	Iron/316 trim	All 316 SS
371T	16	Hex capscrew, housing-to-housing	Steel - 2210			
382	2	Bearing lockwasher	Steel			
388Q	4	Hex capscrew, retainer	Steel - 2210			
400	1	Key, coupling (not shown)	Steel			
409	1	Roller bearing, radial	Steel			
410	1	Roller bearing, thrust	Steel			
412A	2	O-ring, impeller	Nutrile (BUNA-N) rubber			
418	4	Hex capscrew, casing jacking	Steel - 2210			
425A	8	Hex nut, casing bearing cap	Steel - 2210			
425B	38	Hex nut, casing parting	Steel - 2210			
469G	2	Dowel pin, casing	Steel - 2210			
469L	2	Dowel pin, end cover (oil lube)	Steel - 2210			
495	2	Retainer pin, oil ring	Steel - 2210			
497	2	O-ring, sleeve nut	Nutrile (BUNA-N) rubber			
515	1	Oil ring housing, thrust	A48 Class 25B			
515A	1	Oil ring housing, radial	A48 Class 25B			
518	1	Nut, bearing removal (not shown)	Steel			
519	1	Locking plate, coupling (not shown)	Steel			
520	1	Nut, coupling (not shown)	Steel			
521	2	Sleeve, roller bearing	Steel			
543B	2	Coupling, grease fitting	Steel			

8.5 LDS group parts list

Item	Quantity per pump	Part name	All iron	Bronze fit-ted	Iron/316 trim	All 316 SS
100	1	Casing	A48 Class 30B			A743 CF-8M
101	1	Impeller	A48Class 25B	B584 C87500	A743 CF-8M	
105	2	Lantern ring	25% glass filled TFE			
106	1 set	Stuffing box packing	Non-asbestos			
107	2	Quench gland, stuffing box	A743 CF-8M			
109A	1	Bearing end cover	A48 Class 25B			
109B	1	Bearing end cover	A48 Class 25B			
111	2	Bearing cap, grease	A48 Class 25B			
111A	2	Bearing cap	A48 Class 25B			
113A	2	Breather	Steel			
114	2	Oil ring	B584 C87500			

Item	Quantity per pump	Part name	All iron	Bronze fitted	Iron/316 trim	All 316 SS
119A	1	Bearing end cover	A48 Class 25B			
119B	1	Bearing end cover	A48 Class 25B			
122	1	Shaft	A322 GR 4340		A276 Type 316	
123	2	Deflector - I..B.	A48 Class 20B			
123A	1	Deflector - O.B	A48 Class 20B			
124	1	Sleeve nut, right	A48 Class 20B	B584 C87500	A743 CF-8M	
125	2	Stuffing box bushing	A48 Class 20B	B584 C87500	A743 CF-8M	
126	2	Shaft sleeve	A48 Class 20B	B584 C87500	A743 CF-8M	
127	2	Casing wear ring	A48 Class 20B	B584 C87500	A743 CF-8M	
130	1	Sleeve nut, left	A48 Class 20B	B584 C87500	A743 CF-8M	
134	1	Bearing housing, thrust	A48 Class 25B			
134A	2	Bearing housing, radial	A48 Class 25B			
136	2	Bearing locknut	Steel			
142	2	Impeller wear ring	A48 Class 25B	B584 C87500	A743 CF-8M	
178	1	Impeller key	A582 Type 303		A276 Type 316	
190E	2	Pipe nipple	A53			
193	2	Grease fitting	Steel			
210	2	Packing, gland	Non-asbestos			
222B	2	Setscrew, sleeve nuts	A276 Type 316			
222P	6	Setscrew, deflector	A276 Type 316			
229	2	Swing bolt	A276 Type 316			
251	2	Sight oiler	Metal / Glass			
320	12	Setscrew, impeller wear ring	A276 Type 316			
323	1	Oil ring sleeve, thrust	Steel			
324	1	Oil ring sleeve, radial	Steel			
328	4	Hex capscrew, gland	A276 Type 316			
332	1	Oil seal - O.B., grease	BUNA rubber and steel			
333	2	Oil seal - I.B., grease	BUNA rubber and steel			
351D	1	Gasket, casing discharge	Non-asbestos sheet packing			
351S	1	Gasket, casing suction	Non-asbestos sheet packing			
355	4	Hex nut, gland stud	A276 Type 316			
356P	8	Stud, casing bearing cap	Steel - 2210			
356Q	58	Stud, casing parting	Steel - 2210			
357P	2	Hex nut, casing taper pin	Steel - 2210			
358C	Varies	Pipe plug, casing (not shown)	Steel - 2210			
358V	Varies	Pipe plug, frame (not shown)	Steel - 2210			

Item	Quantity per pump	Part name	All iron	Bronze fitted	Iron/316 trim	All 316 SS
360K	2	Gasket, cover-to-housing	Kraft paper			
360N	2	Gasket, cover-to-housing	Kraft paper			
364	6	Insert, setscrew	Non-asbestos sheet packing			
370	13	Hex capscrew, cover-to-housing	Steel - 2210			
371C	13	Hex capscrew, cover-to-housing	Steel			
382	2	Bearing lockwasher	Steel			
400	1	Key, coupling (not shown)	Steel			
409	1	Roller bearing, radial	Steel			
410	1	Roller bearing, thrust	Steel			
412A	2	O-ring, impeller	Nutrile (BUNA-N) rubber			
418	4	Hex capscrew, casing jacking	Steel - 2210			
425A	8	Hex nut, casing bearing cap	Steel - 2210			
425B	58	Hex nut, casing parting	Steel - 2210			
469G	2	Dowel pin, casing	Steel - 2210			
495	2	Retainer pin, oil ring	Steel - 2210			
497	2	O-ring, sleeve nut	Nutrile (BUNA-N) rubber			

8.6 XL and XXL group parts list

Item	Quantity per pump	Part name	All iron	Bronze fitted	Iron/316 trim	All 316 SS
100	1	Casing	A48 Class 30B			A743 CF-8M
101	1	Impeller	A48 Class 25B	B584 C87500	A743 CF-8M	
105	2	Lantern ring	25% glass filled TFE			
106	1 set	Stuffing box packing	Non-asbestos			
107	2	Quench gland, stuffing box	A48 Class 25B	B584 C87500	A743 CF-8M	
109A	1	Bearing end cover	A48 Class 25B			
109B	1	Bearing end cover	A48 Class 25B			
111A	2	Bearing cap	A48 Class 25B			
113A	2	Breather	Steel			
114	2	Oil ring	B584 C87500			
119A	1	Bearing end cover	A48 Class 25B			
119B	1	Bearing end cover	A48 Class 25B			
122	1	Shaft	A322 GR 4340		A276 Type 316	
123	2	Deflector - I..B., grease	A48 Class 25B			
123A	1	Deflector - O.B	A48 Class 25B			
124	1	Sleeve nut, right	A48 Class 25B	B584 C87500	A743 CF-8M	

Item	Quantity per pump	Part name	All iron	Bronze fitted	Iron/316 trim	All 316 SS
125	2	Stuffing box bushing	A48 Class 25B	B584 C87500	A743 CF-8M	
126	2	Shaft sleeve	A48 Class 25B	B584 C87500	A743 CF-8M	
127	2	Casing wear ring	A48 Class 25B	B584 C87500	A743 CF-8M	
130	1	Sleeve nut, left	A48 Class 25B	B584 C87500	A743 CF-8M	
134A	1	Bearing housing, radial	A48 Class 25B			
134D	1	Bearing housing, thrust	A48 Class 25B			
136	2	Bearing locknut	Steel			
142	2	Impeller wear ring	A48 Class 25B	B584 C87500	A743 CF-8M	
178	1	Impeller key	A582 Type 303		A276 Type 316	
190E	2	Pipe nipple	A53			
193	2	Grease fitting	Steel			
210	2	Packing, gland	Non-asbestos			
222B	4	Setscrew, sleeve nuts	A276 Type 316			
222N	4	Setscrew, oil thrower	A276 Type 316			
222P	2	Setscrew, deflector	A276 Type 316			
229	4	Swing bolt	Steel	A276 Type 316		
248	2	Oil thrower	A48 Class 25B			
251	2	Sight oiler	Metal / Glass			
320	12	Setscrew, impeller wear ring	A276 Type 316			
323	1	Oil ring sleeve, thrust	A48 Class 25B			
324	2	Oil ring sleeve, radial	A48 Class 25B			
328	4	Hex capscrew, gland	Steel	A276 Type 316		
332	1	Oil seal - O.B., grease	BUNA rubber and steel			
333	1	Oil seal - I.B., grease	BUNA rubber and steel			
351D	1	Gasket, casing discharge	Non-asbestos sheet packing			
351S	1	Gasket, casing suction	Non-asbestos sheet packing			
355	4	Hex nut, gland stud	Steel	A276 Type 316		
355B	4	Hex nut, quench gland	Steel	A276 Type 316		
356P	8	Stud, casing bearing cap	Steel - 2210			
356Q	Varies	Stud, casing parting	Steel - 2210			
358C	Varies	Pipe plug, casing (not shown)	Steel - 2210			
358V	Varies	Pipe plug, frame (not shown)	Steel - 2210			
360B	2	Gasket I.B.- cover-to-housing	Kraft paper			
360E	2	Gasket O.B.- cover-to-housing	Kraft paper			
363B	2	Insert, setscrew	Non-asbestos sheet packing			
364	4	Insert, setscrew	Non-asbestos sheet packing			
365	4	Insert, setscrew	Non-asbestos sheet packing			

Item	Quantity per pump	Part name	All iron	Bronze fitted	Iron/316 trim	All 316 SS
371C	38	Hex capscrew, cover-to-housing	Steel - 2210			
382	2	Bearing lockwasher	Steel			
400	1	Key, coupling (not shown)	Steel			
409	1	Roller bearing, radial	Steel			
410	1	Roller bearing, thrust	Steel			
412A	2	O-ring, impeller	Nutrile (BUNA-N) rubber			
418	4	Hex capscrew, casing jacking	Steel - 2210			
425A	8	Hex nut, casing bearing cap	Steel - 2210			
425B	Varies	Hex nut, casing parting	Steel - 2210			
469G	2	Dowel pin, casing	Steel - 2210			
469L	2	Dowel pin, end cover	Steel - 2210			
495	2	Retainer pin, oil ring	Steel - 2210			
497	2	O-ring, sleeve nut	Nutrile (Buna-N) rubber			
518	1	Nut, bearing removal (not shown)	Steel			
519	1	Locking plate, coupling (not shown)	Steel			
520	1	Nut, coupling (not shown)	Steel			
521	2	Sleeve, roller bearing	Steel			

8.7 Construction details

Table 15: Small- and medium-sized pumps

Feature	Size							
	12x14-15	16x18-17H	18x20-24	16x18-30	18x20-30	20x24-24	20x24-28	20x24-30
Weight in lbs (kg)								
BF bare pump	2,520 (1,143)	5,060 (2,295)	5,650 (2,563)	7,060 (3,202)	7,500 (3,402)	7,200 (3,266)	8,650 (3,924)	8,000 (3,629)
BF upper case	610 (277)	1,160 (526)	1,200 (544)	1,300 (590)	1,500 (680)	1,400 (635)	1,800 (816)	1,700 (771)
BF rotating element	500 (227)	760 (345)	1,000 (454)	1,150 (522)	1,450 (658)	950 (431)	1,550 (703)	
Casing thickness	0.813 in. (20.65mm)		1.00 in. (25.40 mm)				1.19 in. (30.23 mm)	1.00 in. (25.40 mm)
Stuffing box								
Bore	5.38 in. (136.65 mm)		6.25 in. (158.75 mm)	7.50 in. (190.50 mm)				
Depth, to bushing	4.31 in. (109.47 mm)		4.63 in. (117.60 mm)	6.75 in. (171.45 mm)				
Packing size	0.63 in. x 0.63 in. (16.00 mm x 16.00 mm)			1.00 in. x 1.00 in. (25.40 mm x 25.40 mm)				

Feature	Size							
	12x14-15	**16x18-17H**	**18x20-24**	**16x18-30**	**18x20-30**	**20x24-24**	**20x24-28**	**20x24-30**
Number of rings per box	5							
Lantern ring width	0.94 in. (23.88 mm)		1.25 in. (31.75 mm)					
Shaft sleeve OD	4.13 in. (104.90 mm)		5.00 in. (127.00 mm)	5.50 in. (139.70 mm)				
Shaft diameters in inches (millimeters)								
At impeller	3.54 (87.63)		4.38 (111.25)	5.13 (130.30)				
Under sleeve	3.50 (88.90)		4.25 (107.95)	5.00 (127.00)				
At coupling	2.36 (59.94)		3.25 (82.55)	3.88 (98.55)				
Bearing, coupling end								
Ball	6313		318S	321M				
Bearing, thrust								
Ball	7313		7318PDU	7321PDU				
Sleeve, coupling - thrust end								
Length	—	—	—	6.00 in. (15.24 cm)			—	6.00 in. (15.24 cm)
Bore, approximate	—	—	—	4.69 in. (11.91 cm)			—	4.69 in. (11.91 cm)
Bearing centers (1)	48.50 in. (123.19 cm)		49.50 in. (125.73 cm)	55.00 in. (139.70 cm)			62.00 in. (157.48 cm)	55.00 in. (139.70 cm)
Maximum shaft HP/100 RPM	90		125	170				
Maximum total working pressure	175 psi		150 psi	200 psi			150 psi	200 psi
Hydrotest pressure	263 psi		225 psi	300 psi			225 psi	300 psi
Maximum liquid temperature without quench	180°F (82°C)							
Maximum liquid with quench gld.	275°F (135°C)							
Flanges								
Discharge size	12	16	18	16	18	20		
Suction size	14	18	20	18	20	24		
ANSI rating	125 lb.		Class 125 lb. FF					

Feature	Size							
	12x14-15	16x18-17H	18x20-24	16x18-30	18x20-30	20x24-24	20x24-28	20x24-30
1.	Bearing centers are for a standard oil lube bearing configuration.							

Table 16: Large sized pumps

Feature	Size					
	24x30-32	30x30-31	30x30-38	30x36-42	20x30-42	36x42-52
Weight in lbs (kg)						
BF bare pump	11,500 (5,216)	16,200 (7,348)	15,400 (6,985)	25,250 (11,453)	20,000 (9,072)	43,200 (19,595)
BF upper case	2,350 (1,065)	3,640 (1,651)	3,060 (1,388)	5,350 (2,427)	60,000 (27,215)	18,000 (8,164)
BF rotating element	1,850 (839)	3,060 (1,388)	3,120 (1,415)	4,600 (2,087)	3,500 (1,587)	6,500 (2,948)
Casing thickness	1.13 in. (28.70 mm)	1.25 in. (31.75 mm)				1.75 (44.45 mm)
Stuffing box						
Bore	8.50 in. (215.90 mm)	9.50 in. (241.30 mm)		10.00 in. (254.00)	9.50 in. (241.30 mm)	11.00 in. (279.40 mm)
Depth, to bushing	7.13 in. (181.10 mm)	6.50 in. (165.10 mm)		7.63 in. (193.80 mm)	6.50 in. (165.10 mm)	6.65 in. (168.91 mm)
Packing size	1.00 in. x 1.00 in. (25.40 mm x 25.40 mm)					
Number of rings/box	5					
Width of lantern ring	1.50 in. (38.10 mm)	1.13 in. (28.70 mm)		1.50 in. (38.10 mm)	1.13 in. (28.70 mm)	1.12 in. (28.45 mm)
Shaft sleeve OD	6.50 in. (165.10 mm)	7.50 in. (190.50 mm)		8.00 in. (203.20 mm)	7.50 in. (190.50 mm)	9.00 in. (228.60 mm)
Shaft diameters						
At impeller	6.13 in. (155.70 mm)	6.88 in. (174.75 mm)		7.25 in. (184.15 mm)	6.88 in. (174.75 mm)	8.25 in. (209.55 mm)
Under sleeve	5.75 in. (146.05 mm)	6.75 in. (171.45 mm)		7.19 in. (182.63 mm)	6.75 in. (171.45 mm)	8.13 in. (206.50 mm)
At coupling	4.13 in. (104.90 mm) (2)					6.88 in. (174.75 mm)
Bearing, coupling end - SKF						
Roller	22,226	22,2228		22,230		22,240
Bearing, thrust - SKF						
Roller	22,226	22,2228		22,230		22,240
Sleeve, coupling - thrust end						
Length	6.00 in. (15.24 cm)	—	—	7.50 in. (190.50 mm)	—	2.63 in. (66.80 mm)
Bore, approximate	5.19 in. (13.18 cm)	—	—	7.00 in. (177.80 mm)	—	7.08 in. (179.83 mm)
Bearing centers (1)	63.50 in. (161.29 cm)	72.50 in. (184.15 cm)		80.19 in. (203.68 cm)	76.12 in. (193.34 cm)	94.65 in. (240.41 cm)
Maximum shaft HP/100 rpm	265	383		500		760
Maximum total working pressure	150 psi	125 psi		150 psi		150
Hydrotest pressure	225 psi	188 psi		225 psi		225

Feature	Size					
	24x30-32	**30x30-31**	**30x30-38**	**30x36-42**	**20x30-42**	**36x42-52**
Maximum liquid temperature without quench	180°F (82°C)					
Maximum liquid with quench gld.	275°F (135°C)					
Flanges						
Discharge size	24	30			20	36
Suction size	30			36	30	42
ANSI rating	Class 125 lb. FF				Class 250 FF	
1. Bearing centers are for a standard oil lube bearing configuration.						
2. The pump shaft has taper of 1.24 in. (31.75 mm) per foot (meter).						

8.8 Impeller description

Table 17: Impeller description

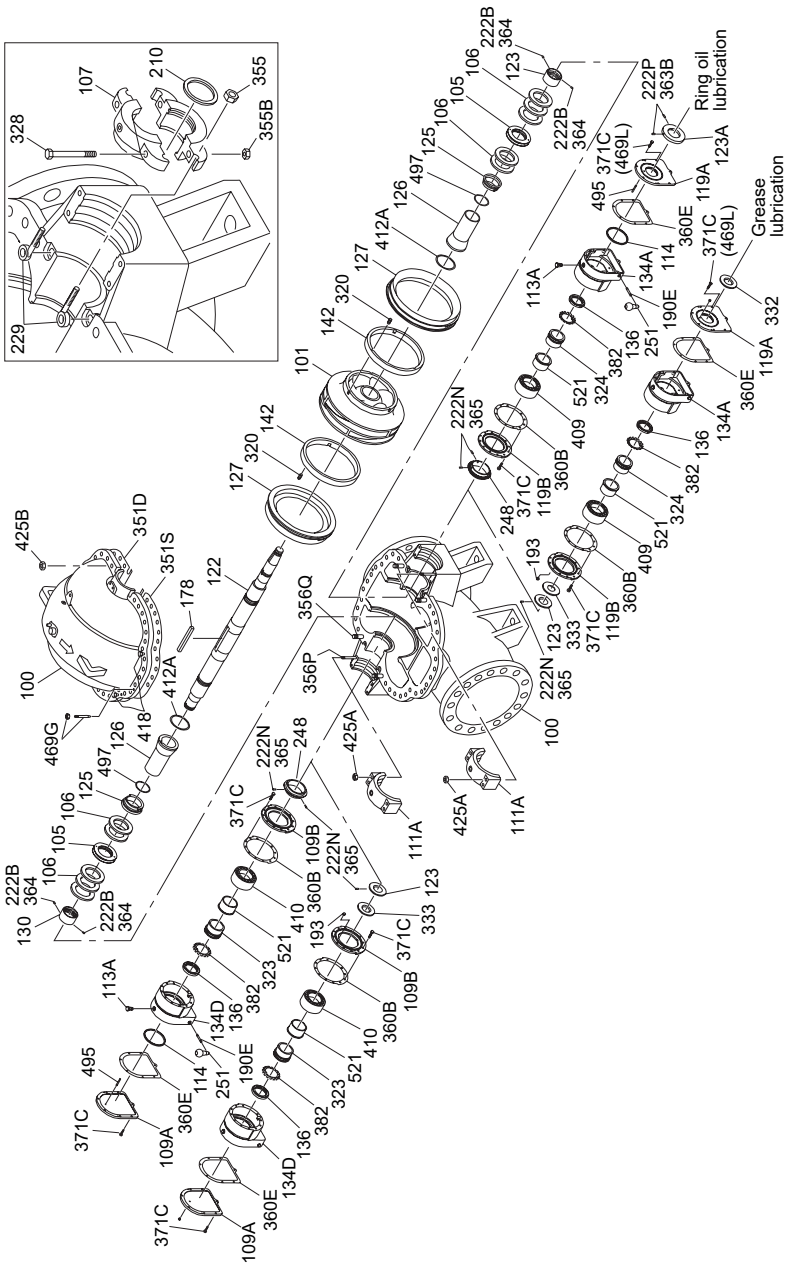
Size (In.)	Maximum impeller in in. (cm)	Effective peripheral width in in. (cm)	No. of Vanes	Eye Area in square in. (square cm)	Split	Staggered/ Skewed	Iron/Bronze		Steel	
							Dwg. No.	Pattern	Dwg. No.	Pattern
12x14-15	15.38 (39.07)	5.06 (12.85)	7	121.70 (785.16)	No	No/No	D06911A	69117	D07551A	69407
16x18-17 H	17.63 (44.78)	7.00 (17.78)	7	200.00 (1290.32)	Yes	Yes/No	D06983A	69171	D07603A	69686
16x18-30	30.00 (76.20)	2.63 (6.68)	5	244.00 (1574.19)	Yes	Yes/Yes	D00038A	54341	D00039A	55147
16x18-30 G	30.00 (76.20)	2.88 (7.32)	7	179.00 (1155.84)	No	No/No	113-13	57068	D00016A	57068
16x18-30 H	30.00 (76.20)	3.50 (8.89)	7	202.00 (1303.22)	No	No/No	112-62	57024	D00321A	57024
18x20-24	24.00 (60.96)	5.13 (13.03)	6	238.00 (1535.48)	Yes	Yes/No	D01532A	58713	D01535A	58716
18x20-24	24.00 (60.96)	5.13 (13.03)	7	238 (1535.48)	Yes	Yes/No	D00161A	57572	D00356A	57831
18x20-24 G	24.00 (60.96)	5.75 (14.60)	5	227.40 (1467.09)	Yes	Yes/No	D02280A	58952	D02281A	58953
18x20-24 N	24.00 (60.96)	6.75 (17.15)	5	281.30 (1814.83)	Yes	Yes/No	D02301A	58978	D02302A	58979
18x20-30	30.00 (76.20)	3.19 (8.100	5	286.00 (1845.16)	Yes	Yes/Yes	250-2	54342	252-121	55148
20x24-24	24.00 (60.96)	5.19 (13.18)	6	308.40 (1989.67)	Yes	Yes/Yes	253-6	55098	253-12	55197
20x24-28	28.50	6.06	6	320.00	Yes	Yes/No	D01533A	58714	D01536A	58717

Size (In.)	Maximum impeller in in. (cm)	Effective peripheral width in in. (cm)	No. of Vanes	Eye Area in square in. (square cm)	Split	Staggered/ Skewed	Iron/Bronze		Steel	
							Dwg. No.	Pattern	Dwg. No.	Pattern
	(72.39)	(15.39)		(2064.51)						
20x24-28	28.50 (72.39)	6.06 (15.39)	7	320.00 (2064.51)	Yes	Yes/No	D00225A	57692	D01109A	58337
20x24-28 G	28.50 (72.39)	6.63 (16.84)	5	328.50 (2119.35)	Yes	Yes/No	D02282A	58954	D02283A	58955
20x24-28 N	28.50 (72.39)	8.00 (20.32)	5	404.50 (2609.67)	No	No/No	D02229A	58976	D02300A	58977
20x24-28 H	28.50 (72.39)	8.75 (22.23)	7	441.00 (2845.15)	Yes	Yes/No	—	—	D01539A	58719
20x24-30	30.00 (76.20)	3.75 (9.53)	5	318.40 (2054.19)	Yes	Yes/Yes	254-105	55442	257-89	55796
24x30-32 N	32.00 (81.28)	6.63 (16.84)	6	521.00 (3361.28)	Yes	Yes/No	265-82	56848	262-22	56828
24x30-32 STD	32.00 (81.28)	6.13 (15.57)	6	460.00 (2967.74)	Yes	Yes/No	265-84	56879	262-25	56529
24x30-32 G	32.00 (81.28)	6.13 (15.57)	6	385.00 (2483.87)	Yes	Yes/No	267-21	56884	D00013A	57618
24x30-32 H	32.00 (81.28)	9.06 (23.01)	7	460.00 (2967.74)	Yes	Yes/No	267-27	56890	D00014A	57643
30x30-31	31.00 (78.74)	12.13 (30.81)	7	609.50 (3932.25)	Yes	Yes/No	D02414A	63030	D02370A	63131
30x30-31 G	33.00 (83.82)	10.25 (26.04)	5	254.00 (1638.71)	Yes	Yes/No	—	—	D05540A	68567
30x30-38	38.00 (96.52)	8.13 (20.65)	6	610.00 (3935.47)	Yes	Yes/No	D02257A	58783	D02259A	58785
30x30-38 G	38.00 (96.52)	8.75 (22.22)	5	567.90 (3663.86)	Yes	Yes/No	D02284A	58956	D02285A	58957
30x30-38 N	38.00 (96.52)	10.50 (26.67)	5	703.10 (4536.12)	Yes	Yes/No	D02297A	58973	D02298A	58974
20x30-42	42.75 (108.59)	4.04 (10.26)	6	104.6 (2656.84)	No	No/No	D11284A	1E944	-	-
30x36-42	42.00 (106.68)	9.00 (22.86)	6	745.00 (4806.44)	Yes	Yes/No	D01534A	58715	D01537A	58718
30x36-42	42.00 (106.68)	9.00 (22.86)	7	745.00 (4806.44)	Yes	Yes/No	267-56	57038	D00147A	57644
30x36-42 H	42.00 (106.68)	11.25 (28.58)	7	905.00 (5838.70)	Yes	Yes/No	267-57	57039	272-80	57039
30x36-42 G	42.00 (106.68)	10.13 (25.73)	5	716.00 (4619.34)	Yes	Yes/No	D02286A	58958	D02287A	58959

Size (In.)	Maximum impeller in in. (cm)	Effective peripheral width in in. (cm)	No. of Vanes	Eye Area in square in. (square cm)	Split	Staggered/ Skewed	Iron/Bronze		Steel	
							Dwg. No.	Pattern	Dwg. No.	Pattern
30x36-42 N	42.00 (106.68)	11.63 (29.54)	5	881.20 (5685.15)	Yes	Yes/No	D02293A	58968	D02294A	58970
30x42-46	46.00 (116.84)	9.88 (25.10)	6	894.00 (5767.73)	Yes	Yes/No	D02258A	58784	D02260A	58786
30x42-46 G	46.00 (116.84)	11.00 (27.94)	5	822.40 (5305.80)	Yes	Yes/No	D02288A	58960	D02289A	58961
30x42-46 N	46.00 (116.84)	12.75 (32.89)	5	1020.50 (6583.86)	No	No/No	D02295A	58971	D02296A	58972

8.9 Cross-sectional drawings

XL and XXL



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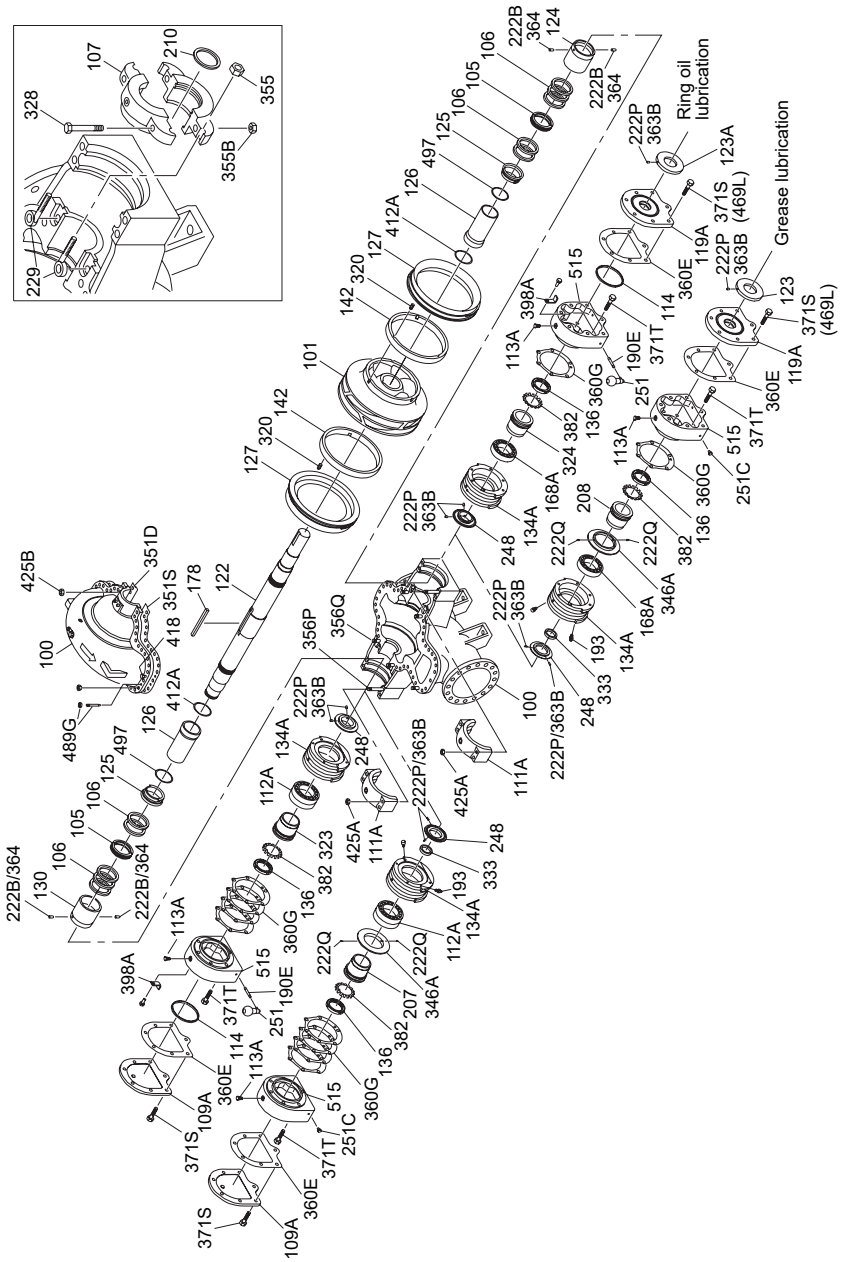

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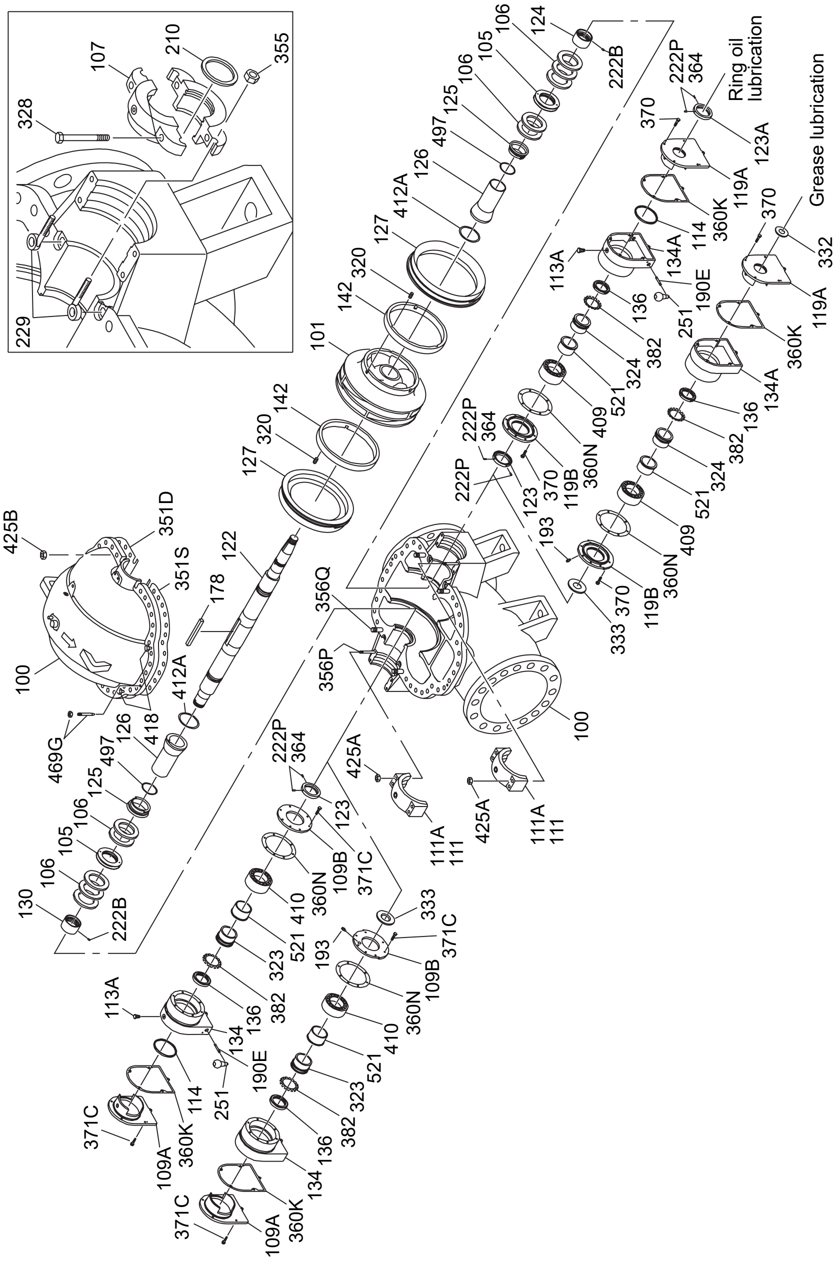
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Ring oil lubrication
Grease lubrication
370
123A
119A
360K
114
134A
113A
190E
251
136
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409
360N
119B
123
193
333
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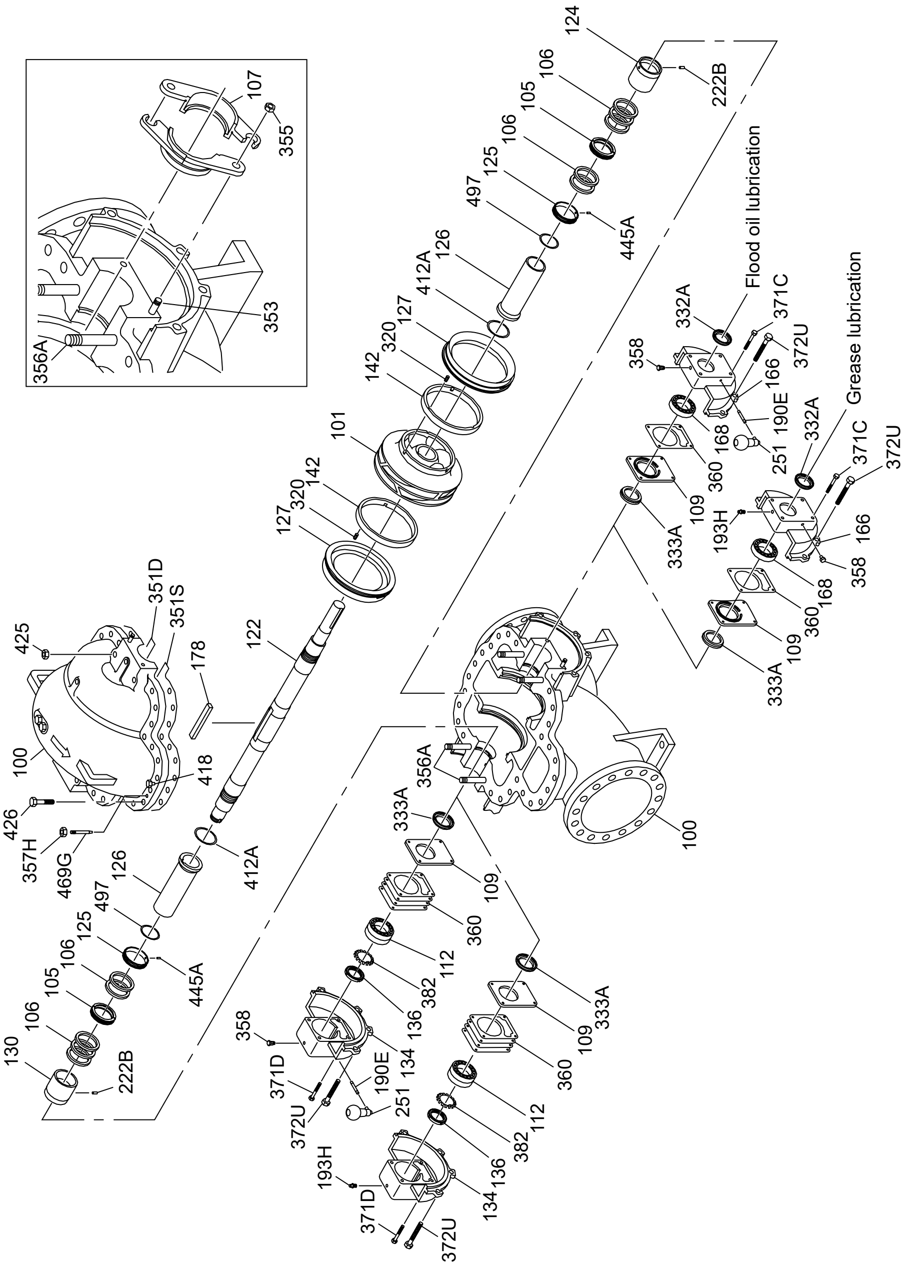
SX and MX



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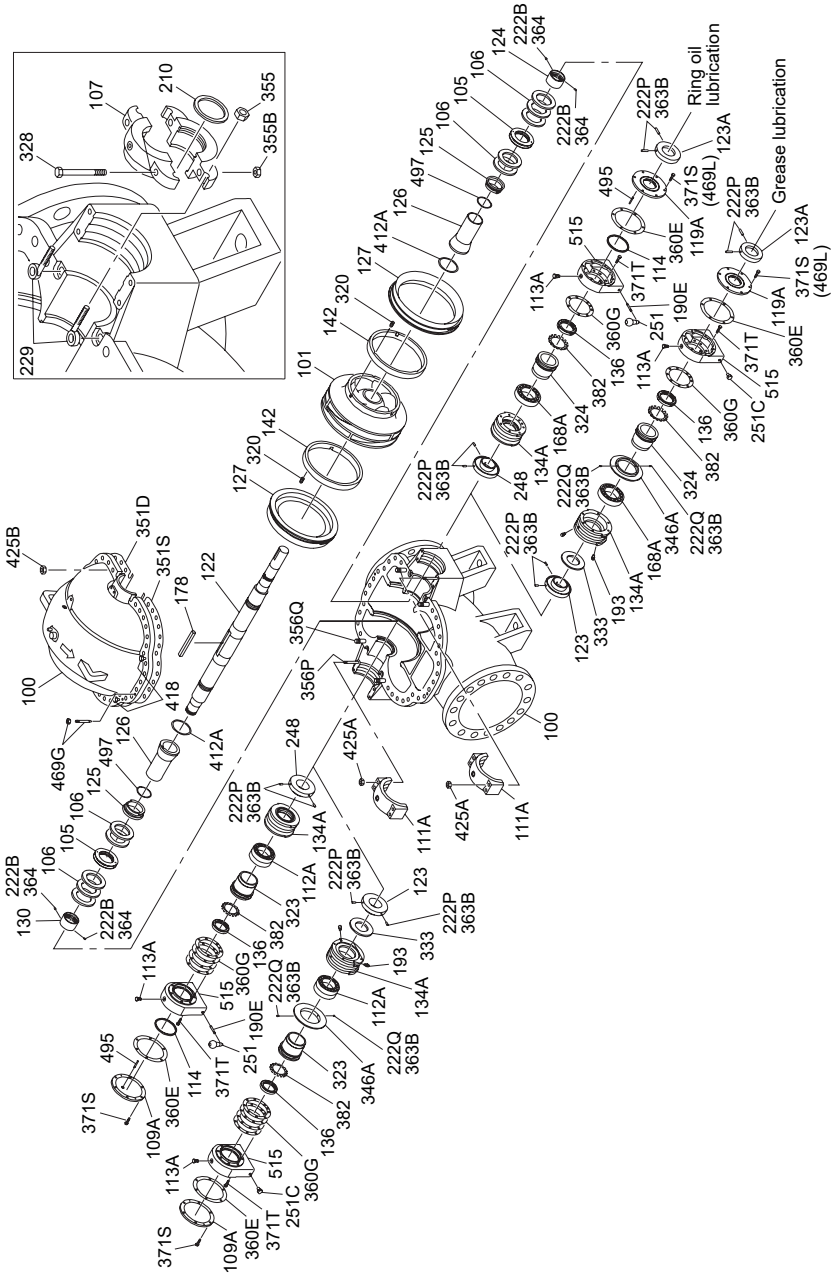

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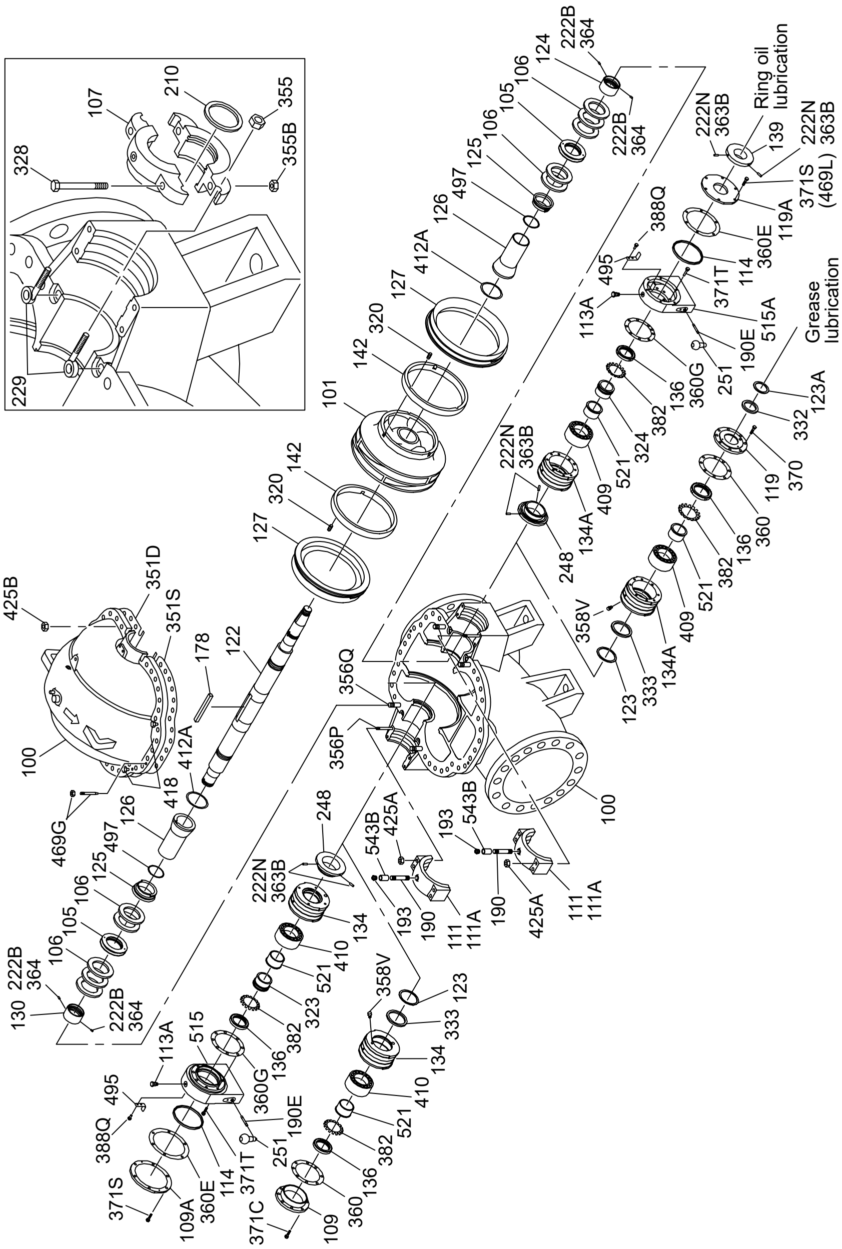
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412A
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360E
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Ring oil
lubrication
Grease
lubrication
123A
332
370
119
360
136
382
521
409
134A
333
123
358V

9 Other Relevant Documentation or Manuals

9.1 For additional documentation

For any other relevant documentation or manuals, contact your ITT representative.

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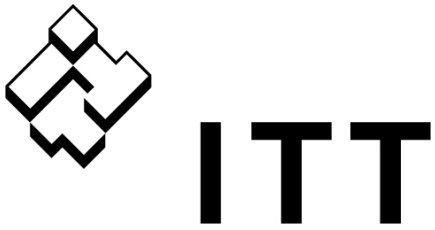

Goulds Pumps
240 Fall Street
Seneca Falls, NY 13148
USA

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