



# Installation, Operation, and Maintenance Manual

3620 i-FRAME API type BB2 single stage / ISO  
13709 2nd Ed/API 11th Ed



**ITT**

ENGINEERED FOR LIFE



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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.

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### 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 identification code 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.




## 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   |
|---|--|
|  <b>DANGER:</b>  | A hazardous situation which, if not avoided, will result in death or serious injury  |
|  <b>WARNING:</b> | A hazardous situation which, if not avoided, could result in death or serious injury   |
|  <b>CAUTION:</b> | A hazardous situation which, if not avoided, could result in minor or moderate injury  |
| <b>NOTICE:</b>  | <ul style="list-style-type: none"> <li>• A potential situation which, if not avoided, could result in undesirable conditions</li> <li>• A practice not related to personal injury</li> </ul> |

### 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.



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### **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:

- Helmet
- 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.

## 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.
-  The coupling guard used in an ATEX classified environment must be constructed from a non-sparking material.

### 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 | <ol style="list-style-type: none"> <li>1. Hold your eyelids apart forcibly with your fingers.</li> <li>2. Rinse the eyes with eyewash or running water for at least 15 minutes.</li> <li>3. Seek medical attention.</li> </ol> |
| Chemicals or hazardous fluids on skin | <ol style="list-style-type: none"> <li>1. Remove contaminated clothing.</li> <li>2. Wash the skin with soap and water for at least 1 minute.</li> <li>3. Seek medical attention, if necessary.</li> </ol>                      |

### 1.2.4 Ex-approved products

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, IEC/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.

#### 1.2.4.1 Description of ATEX

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

#### 1.2.4.2 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).

### 1.2.5 Monitoring equipment

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

- Pressure gauges
- Flow meters
- Level indicators
- Motor load readings
- Temperature detectors
- Bearing monitors
- Leak detectors
- PumpSmart control system
- Filter

## 1.3 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.

# 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 and lifting

#### Precautions for moving the pump

Use care when moving pumps. Consult with a lifting and rigging specialist before lifting or moving the pump to avoid possible damage to the pump or injury to personnel.




---

#### **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.

---




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#### **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.

---

#### Precautions for lifting the pump




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#### **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.
- 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.

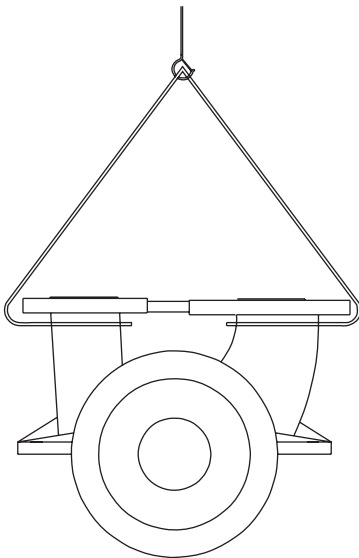
- Lifting and handling heavy equipment poses a crush hazard. Use caution during lifting and handling and wear appropriate Personal Protective Equipment (PPE, such as steel-toed shoes, gloves, etc.) at all times. Seek assistance if necessary.
  - Safe lifting points are specifically identified in this 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.
- 
- 

**NOTICE:**

- Make sure that the lifting equipment supports the entire assembly and is only used by authorized personnel.
  - Do not attach sling ropes to shaft ends.
- 

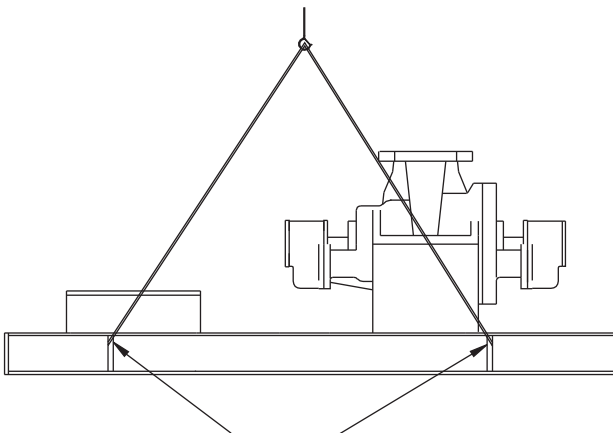
**Lifting the pump**

Hoist a bare pump using suitable slings under the bearing housing saddle on each end.

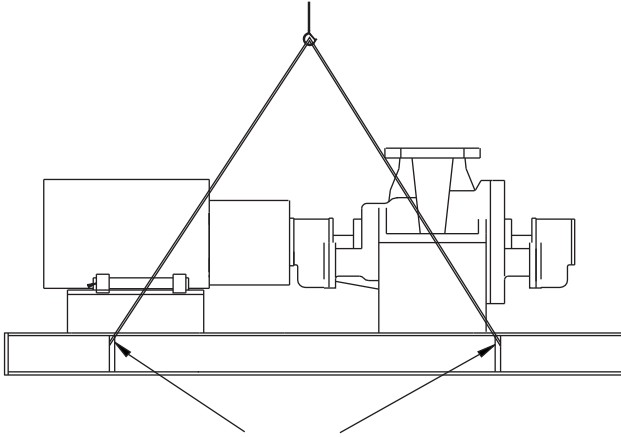


**Figure 1: Example of the proper lifting method for a bare pump**

Baseplate-mounted units have lifting points for use with proper lifting devices.



**Figure 2: Example of the proper lifting method for baseplate-mounted units without a driver**



**Figure 3: Example of the proper lifting method for baseplate-mounted units with a driver**

## 2.3 Storage guidelines

### 2.3.1 Long-term storage

If the unit is stored for more than 6 months, these requirements apply:

- 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 the drive unit and coupling manufacturers for their long-term storage procedures.

For questions about possible long-term storage treatment services, please contact your local ITT sales representative.

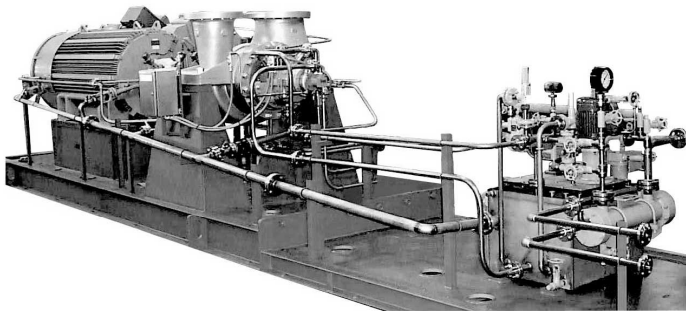
# 3 Product Description

## 3.1 General description

### Product description

The Model 3620 i-FRAME is a horizontal centrifugal pump that meets the latest editions of API 610 and ISO 13709 and has these characteristics:

- Safety, Reliability, and Versatility
- Axially-Split
- Single-stage
- Between the bearings



### **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.

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### Casing

The casing is centerline mounted with top-suction and top-discharge nozzles. The compression gaskets at the two metal-to-metal sealing faces are fully confined.

The flanges are ASME Class 300 and 600 raised-face serrated with a 125-250 RMS finish. Other flanges are also available:

- ASME Class 300 ring joint
- ASME Class 600 ring joint

### Impeller

The impeller is fully closed and key driven.

### Seal chamber

The seal chamber meets API Edition dimensions for improved performance of mechanical seals. Customer-selected cartridge mechanical seals are standard.

### Power end

The power end has these characteristics:

- Carbon steel bearing housings are standard.



- The oil level is viewed through a sight glass.
- Constant-level oilers and labyrinth seals are standard.
- No machining is required in order to convert the standard ring oil lube to either purge or pure mist. Pure mist applications require minor bearing end cover modifications.
- Pressure lubrication is required with hydrodynamic thrust bearings.

### Bearings

| Bearing type      | Characteristics   |
|-------------------|---|
| Inboard (radial)  | <ul style="list-style-type: none"> <li>• Consists of a single-row deep-groove ball bearing (standard)</li> <li>• Carries only radial load</li> <li>• Optional sleeve bearings</li> </ul>  |
| Outboard (thrust) | <ul style="list-style-type: none"> <li>• Consists of a pair of single-row angular contact ball bearings mounted back-to-back (standard)</li> <li>• Shouldered and locked to the shaft</li> <li>• Retained in the bearing frame to enable the bearing to carry both radial and thrust loads</li> <li>• Optional hydrodynamic thrust bearing for use with sleeve type journal bearings</li> </ul> |

### Shaft

The heavy duty shaft has these characteristics:

- Designed for cartridge mechanical seals
- Minimal shaft deflection at the seal faces (0.002 in. [0.051 mm]) when run in the worst-case condition (typically minimum flow)
- Critical speed at least 20% above design operating speed
- Fully compliant with the latest editions of API 610 and ISO 13709

### Baseplate

The fabricated steel baseplate supports the pump, driver, and accessories in accordance with API-610 latest Edition (ISO 13709) requirements.

### Direction of rotation

The shaft rotates counterclockwise when viewed from the power end.

## 3.2 General description i-ALERT®2 Equipment Condition Monitor

### Description

The i-ALERT®2 Equipment Condition Monitor is a compact, battery-operated monitoring device that continuously measures the vibration and temperature of the pump power end. The i-ALERT®2 sensor uses blinking red LEDs and wireless notification to alert the pump operator when the pump exceeds vibration and temperature limits. This allows the pump operator to make changes to the process or the pump before a catastrophic failure occurs. The Condition Monitor is also equipped with a single green LED to indicate when it is operational and has sufficient battery life. (i-ALERT®2 Bluetooth Equipment Condition Monitor option available. The i-ALERT®2 monitor allows customers to identify potential problems before they become costly failures. It tracks vibration, temperature and run-time hours and wirelessly syncs the data with a smart phone or tablet the i-ALERT®2 mobile app. More information available on

More information available on <http://www.itproservices.com/aftermarket-products/monitoring/i-alert2/i-ALERT2.com>

### 3.3 Nameplate information

#### Important information for ordering

Every pump has a nameplate that provides information about the pump. The nameplate is located on the pump casing.

When you order spare parts, identify this pump information:

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

Item numbers can be found in the spare parts list.

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

#### Nameplate types

| Nameplate | Description   |
|-----------|---|
| Pump      | Provides information about the hydraulic characteristics of the pump.<br><br>The formula for the pump size is: Discharge x Suction - Nominal Maximum Impeller Diameter in inches.<br><br>(Example: 2x3-8) |
| ATEX      | If applicable, your pump unit might have an ATEX nameplate affixed to the pump, the base-plate, or the discharge head. The nameplate provides information about the ATEX specifications of this pump.     |

#### Nameplate on the pump casing using English units

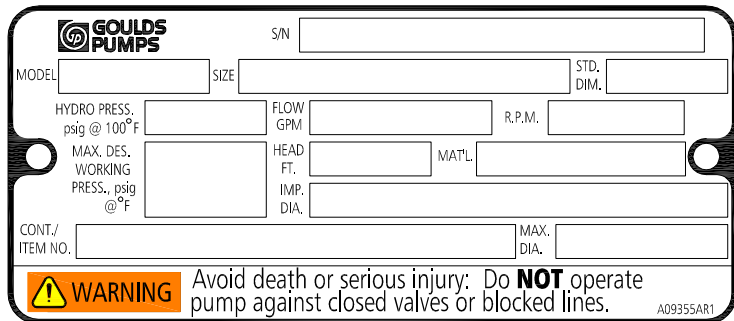


Figure 4: Nameplate on the pump casing using English units

| Nameplate field         | Explanation   |
|-------------------------|---|
| MODEL                   | Pump model  |
| SIZE                    | Size of the pump  |
| FLOW                    | Rated pump flow, in gallons per minute                                |
| HEAD                    | Rated pump head, in feet  |
| RPM                     | Rated pump speed, in revolutions per minute                           |
| HYDRO PRESS             | Hydrostatic pressure at 100°F, in pounds per square inch              |
| MAX. DES. WORKING PRESS | Maximum working pressure at temperature °F, in pounds per square inch |

| Nameplate field | Explanation                       |
|-----------------|-----------------------------------|
| S/N             | Serial number of the pump         |
| CONT./ITEM NO.  | Customer contract or item number  |
| IMP. DIA.       | Rated impeller diameter, inches   |
| MAX. DIA.       | Maximum impeller diameter, inches |
| STD. DIM.       | Standard ANSI dimensional code    |
| MAT'L           | Material of construction          |

### Nameplate on the pump casing using metric units

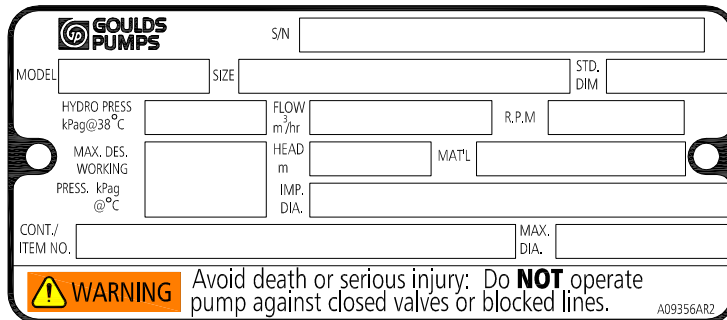


Figure 5: Nameplate on the pump casing using metric units

| Nameplate field         | Explanation   |
|-------------------------|---|
| MODEL                   | Pump model  |
| SIZE                    | Size of the pump  |
| FLOW                    | Rated pump flow, in cubic meters per hour                       |
| HEAD                    | Rated pump head, in meters                                      |
| RPM                     | Rated pump speed, in revolutions per minute                     |
| HYDRO PRESS             | Hydrostatic pressure at 38°C in kilopascals gauge               |
| MAX. DES. WORKING PRESS | Maximum working pressure at temperature °C in kilopascals gauge |
| S/N                     | Serial number of the pump                                       |
| CONT./ITEM NO.          | Customer contract or item number                                |
| IMP. DIA.               | Rated impeller diameter, millimeters                            |
| MAX. DIA.               | Maximum impeller diameter, millimeters                          |
| STD. DIM.               | Standard ANSI dimensional code                                  |
| MAT'L                   | Material of construction  |

### ATEX nameplate

Figure 6: ATEX nameplate

| Nameplate field | Explanation                       |
|-----------------|-----------------------------------|
| II              | Group 2                           |
| 2               | Category 2                        |
| G/D             | Use when gas and dust are present |
| T4              | Temperature class                 |



#### 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

### 3.3 Nameplate information

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classification at the site. If they are not compatible, do not operate the equipment and contact an ITT representative before proceeding.

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# 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

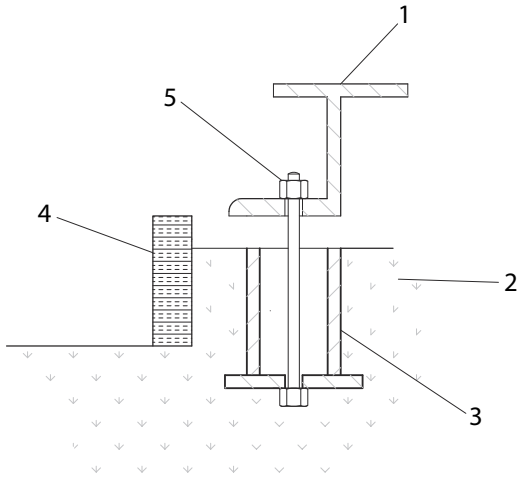
| Guideline   | Explanation/comment  |
|---|--|
| Keep the pump as close to the liquid source as practically possible.  | This minimizes the friction loss and keeps the suction piping as short as possible.  |
| Make sure that the space around the pump is sufficient.   | This facilitates ventilation, 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.   |
| Protect the unit from weather and water damage due to rain, flooding, and freezing temperatures.  | 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: <ul style="list-style-type: none"> <li>• Pressure relief valves</li> <li>• Compression tanks</li> <li>• Pressure controls</li> <li>• Temperature controls</li> <li>• Flow controls</li> </ul> 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.  |
| If the pump location is overhead, undertake special precautions to reduce possible noise transmission.  | Consider a consultation with a noise specialist.   |

## 4.1.2 Foundation requirements

### Requirements

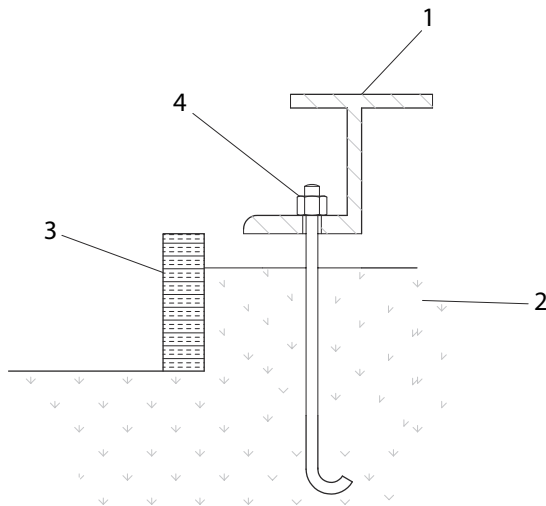
- The foundation must weigh not less than three times the combined weight of the pump, driver, baseplate and auxiliaries.
- Provide a flat, substantial concrete foundation in order to prevent strain and distortion when you tighten the foundation bolts.

### Sleeve-type bolts



| Item | Description |
|------|-------------|
| 1.   | Baseplate   |
| 2.   | Foundation  |
| 3.   | Sleeve      |
| 4.   | Dam         |
| 5.   | Bolt        |

**Figure 7: Sleeve type bolts**

**J-type bolts**

| Item | Description |
|------|-------------|
| 1.   | Baseplate   |
| 2.   | Foundation  |
| 3.   | Dam         |
| 4.   | Bolt        |

**Figure 8: J-type bolts**

## 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.

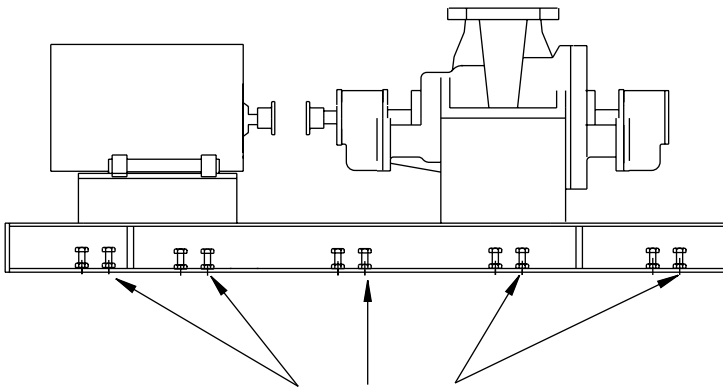
### 4.2.3 Install and level the baseplate

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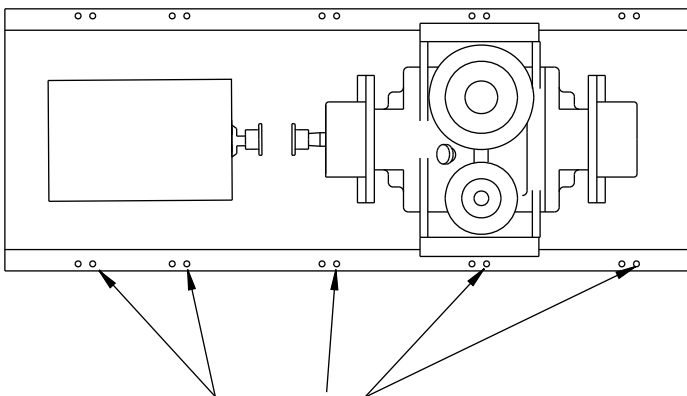
**NOTICE:**

Illustrations are for reference only and may not depict the particular pump model.

---



**Figure 9: Jackscrew locations, side view**



**Figure 10: Jackscrew locations, top view**

1. Lower the baseplate carefully onto the foundation bolts.



- The baseplate will rest on top of the foundation on the jackscrews provided on the baseplate.
2. Adjust the leveling jackscrews, located adjacent to the foundation bolt holes, until the baseplate rests 25 to 50 mm | 1 to 2 in. above the foundation in order to allow for adequate grouting. This provides even support for the baseplate after grouting.
  3. Level the baseplate to within 0.167 mm/m | 0.002 in./ft. of the length or width of the baseplate by adjusting the jackscrews.
    - The maximum total variation from one end or side of the baseplate to the other is 0.38 mm | 0.015 in.
    - Use the equipment mounting surfaces in order to establish the level.
  4. Use a non-bonding (anti-seize) compound such as paste wax to coat the portions of the jackscrews that will contact the grout. This facilitates removal of the screws after grouting.

---

**NOTICE:**

Do not use oils or liquid wax.

5. Thread the nuts onto the foundation bolts and hand-tighten.

## 4.3 Install the pump, driver, and coupling

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




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**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.
- 

### Alignment methods

Three common alignment methods are used:

- Dial indicator
- Reverse dial indicator
- Laser

Follow the instructions from the equipment manufacturer when you use the reverse dial indicator or laser methods. Detailed instructions for using the dial indicator method are contained in this chapter.

## 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.<br><br>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.

### IMPORTANT

- The driver shaft initial (cold) parallel vertical alignment setting should be lower than the pump shaft. Follow the driver manufacturer's recommendations.

When dial indicators are used to check the final alignment, the pump and drive unit are correctly aligned when these conditions are true:

- The Total Indicated Reading (T.I.R.) is at 0.05 mm | 0.002 in. or less at operating temperature.
- The tolerance of the indicator is 0.0127 mm per mm | 0.0005 in. per in. of indicator separation for the reverse dial indicator or laser method when the pump and driver are at operating temperature.

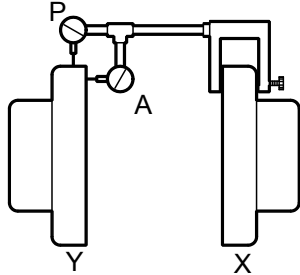
### 4.4.3 Alignment measurement guidelines

| 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.  |
| 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.



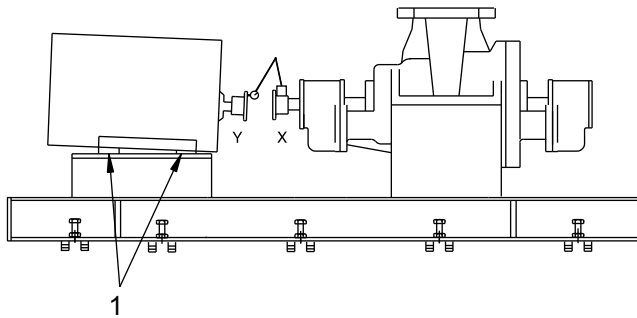
**Figure 11: Dial indicator attachment**

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

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: <ul style="list-style-type: none"> <li>• Add shims in order to raise the feet of the driver at the shaft end.</li> <li>• Remove shims in order to lower the feet of the driver at the other end.</li> </ul> |
| Positive                     | The coupling halves are closer at the bottom than at the top. Perform one of these steps: <ul style="list-style-type: none"> <li>• Remove shims in order to lower the feet of the driver at the shaft end.</li> <li>• Add shims in order to raise the feet of the driver at the other end.</li> </ul>        |



| Item | Description |
|------|-------------|
| 1.   | Shims       |

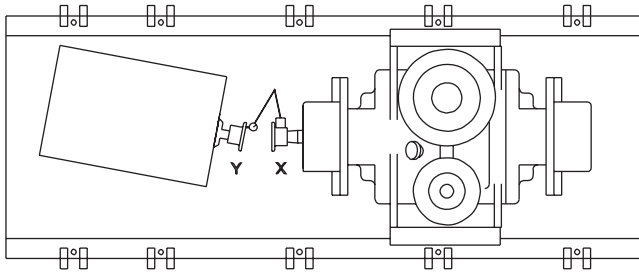
**Figure 12: Example of incorrect vertical alignment (side view)**

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

#### 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: <ul style="list-style-type: none"> <li>• Slide the shaft end of the driver to the left.</li> <li>• Slide the opposite end to the right.</li> </ul>   |
| Positive                     | The coupling halves are closer together on the right side than the left. Perform one of these steps: <ul style="list-style-type: none"> <li>• Slide the shaft end of the driver to the right.</li> <li>• Slide the opposite end to the left.</li> </ul> |



**Figure 13: Example of incorrect horizontal alignment (top view)**

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

#### 4.4.7 Perform parallel alignment for a vertical correction

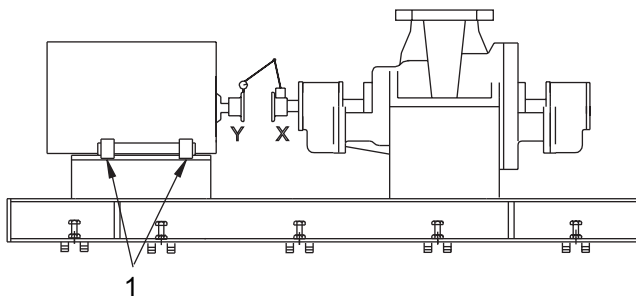
Refer to the alignment table in "Permitted indicator values for alignment checks" (see Table of Contents for location of table) for the proper cold alignment value based on the driver temperature rise and the pump operating temperature.

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.      |



| Item | Description |
|------|-------------|
| 1.   | Shims       |

**Figure 14: Example of incorrect vertical alignment (side view)**

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.

**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 driver 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.

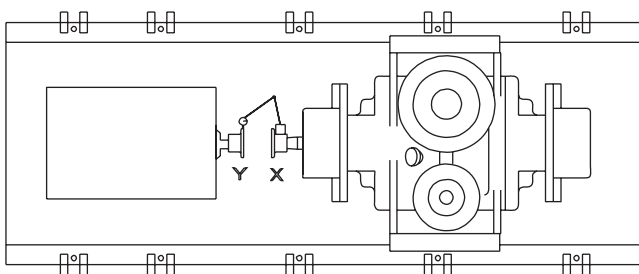
1. Set the parallel alignment indicator (P) to zero on the left side of the driver coupling half (Y), 90° from the top-center position (9 o'clock).
2. Rotate the indicator through the top-center position to the right side, 180° from the start position (3 o'clock).
3. Record the indicator reading.

| 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.



**Figure 15: Example of incorrect horizontal alignment (top view)**

5. 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.

**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.

### 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.

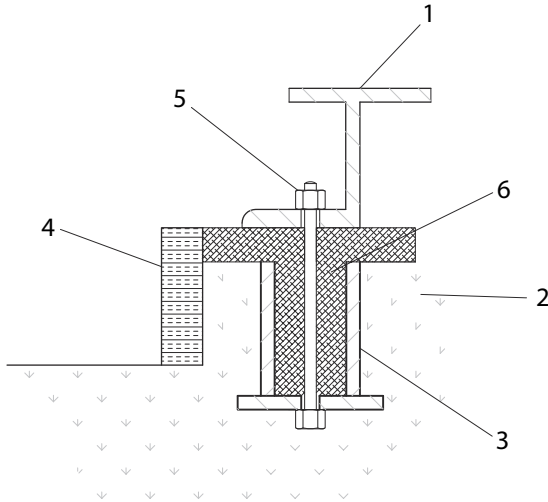
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**NOTICE:**

It is assumed that the installer who grouts the baseplate has knowledge of acceptable methods. More detailed procedures are described in various publications, including API Standard 610, latest edition, Appendix L; API RP 686, Chapter 5; and other industry standards.

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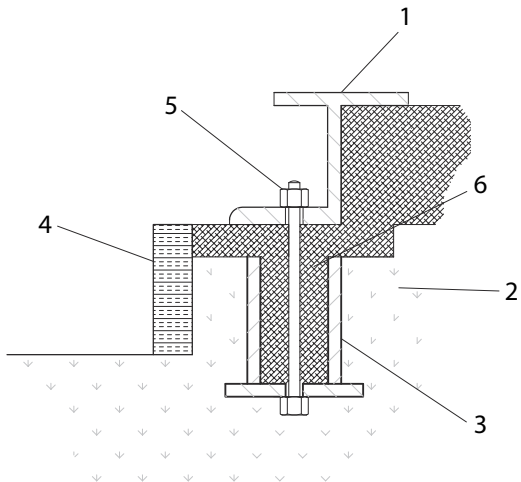
1. Clean all the areas of the baseplate that will come into contact with the grout.
2. Build a dam around the foundation.
3. Thoroughly wet the foundation that will come into contact with the grout.
4. Pour grout through the grout hole into the baseplate up to the level of the dam.  
When you pour the 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.   | Foundation  |
| 3.   | Sleeve      |
| 4.   | Dam         |
| 5.   | Bolt        |
| 6.   | Grout       |

**Figure 16: 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.   | Foundation  |
| 3.   | Sleeve      |
| 4.   | Dam         |
| 5.   | Bolt        |
| 6.   | Grout       |

**Figure 17: Fill remainder of baseplate with grout**

7. Remove the leveling jackscrews after the grout hardens in order to remove any stress points.



8. Tighten the foundation bolts.
9. Recheck the alignment.

## 4.6 Piping checklists

### 4.6.1 General piping checklist

#### Precautions




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#### 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.
- 




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#### CAUTION:

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

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#### 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.

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#### 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.

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#### 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.<br>See Alignment criteria for pump flanges.  | <ul style="list-style-type: none"> <li>Strain on the pump</li> <li>Misalignment between the pump and the drive unit</li> </ul>  |         |
| Keep the piping as short as possible.   | This helps to minimize friction losses.   |         |
| Check that only necessary fittings are used.  | This helps to minimize friction losses.   |         |
| Do not connect the piping to the pump until: <ul style="list-style-type: none"> <li>The grout for the baseplate or sub-base becomes hard.</li> <li>The hold-down bolts for the pump are tightened.</li> </ul> | —   |         |
|   | 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.  |         |

**Alignment criteria for pump flanges**

| Type       | Criteria  |
|------------|---|
| Axial      | The flange gasket thickness $\pm 0.8$ mm   0.03 in.   |
| Parallel   | Align the flange to be within 0.001 mm per mm   in. per in. of the flange diameter to 0.8mm   0.03 in. max. |
| Concentric | You can easily install the flange bolts by hand.  |

The above criteria are based on the following references from API RP 686, 2nd Edition:

4.6.3 The machine and piping flange faces shall be parallel to less than 10 micrometers per centimeter | 0.001 in. per in. of pipe flange outer diameter up to a maximum of 750 micrometers | 0.030 in. For piping flange outer diameters smaller than 25 cm | 10 in., the flanges shall be parallel to 250 micrometers | 0.010 in. or less. For special- purpose machinery, pipe to machinery flange spacing measurements shall be recorded on the Piping alignment datasheet shown in Figure B.4. For raised face flanges, feeler gauge readings shall be taken at the raised face. For flat faced flanges, feeler gauge readings shall be taken at the flange outside diameter.

4.6.4 Flange face separation shall be within the gasket spacing  $\pm 1.5$  mm | 1/16 in. Only one gasket per flanged connection shall be used.

### 4.6.1.1 Fastening



#### 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.

### 4.6.2 Suction-piping checklist

#### Performance curve reference

Net positive suction head available (NPSH<sub>A</sub>) must always exceed NPSH required (NPSH<sub>R</sub>) as shown on the published performance curve of the pump.

#### Suction-piping checks

| Check  | Explanation/comment   | Checked |
|--|---|---------|
| Check that the distance between the inlet flange of the pump and the closest elbow is at least five pipe diameters.  | 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.<br>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: <ul style="list-style-type: none"> <li>• Sloping side down</li> <li>• Horizontal side at the top</li> </ul> |   |         |

#### 4.6 Piping checklists

| Check   | Explanation/comment  | Checked |
|---|--|---------|
| <p>It is recommended that a commissioning (temporary) suction strainer be used.</p> <p>After commissioning it is recommended an operating (permanent) suction strainer be used.</p> <p>Check that the strainer has at least three times the area of the suction piping.</p> <p>Check the location of the suction strainer is at least 5 pipe diameters from the suction nozzle.</p> <p>Continuously monitor the pressure drop across the suction strainer.</p> <p>Limit the pressure drop across the strainer to 68.9 kPa   10 psi, or the vapor pressure of the pumped fluid, or the resulting NPSHr is not adequate.</p> <p>After a period of time (24 hours minimum) system flushing should be complete and the commissioning (temporary) suction strainer can be removed.</p> | <p>Suction strainers help to prevent debris from entering the pump</p> <p>Recommended commissioning (temporary) strainer mesh size:</p> <ul style="list-style-type: none"> <li>• Viscosity ≤ 100cP use 60 mesh</li> <li>• Viscosity &gt; 100cP use 40 mesh</li> <li>• Viscosity &gt; 300cP use 20 mesh</li> </ul> <p>Recommended operating (permanent) strainer mesh size:</p> <ul style="list-style-type: none"> <li>• Viscosity ≤ 100cP use 40 mesh</li> <li>• Viscosity &gt; 100cP use 20 mesh</li> <li>• Viscosity &gt; 300cP use 12 mesh</li> </ul> |         |
| 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 that the suction piping slopes upwards from the liquid source to the pump inlet.  | —   |         |
| Check that all joints are air-tight.  | —   |         |
| 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.<br>Do not use the isolation valve to throttle the pump. Throttling can cause these problems: <ul style="list-style-type: none"> <li>• Loss of priming</li> <li>• Excessive temperatures</li> <li>• Damage to the pump</li> <li>• Voiding the warranty</li> </ul> |         |
| 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 Discharge piping checklist

### Checklist

| Check   | Explanation/comment   | Checked |
|---|---|---------|
| Check that an isolation valve is installed in the discharge line. For specific gravity less than 0.60, minimize distance from pump discharge. | The isolation valve is required for: <ul style="list-style-type: none"> <li>• Priming</li> <li>• Regulation of flow</li> <li>• Inspection and maintenance of the pump</li> <li>• Reduce risk of pumpage vaporization and vapor locking at low flow rates for low specific gravity liquids.</li> </ul> |         |
| Check that a check valve is installed in the discharge line, between the isolation valve and the pump discharge outlet.                       | The location between the isolation valve and the pump allows inspection of the check valve.<br>The check valve prevents damage to the pump and seal due to the back flow through the pump, when the drive unit is shut off. It is also used to restrain the liquid flow.                              |         |
| If increasers are used, check that they are installed between the pump and the check valve.   | —   |         |
| If quick-closing valves are installed in the system, check that cushioning devices are used.  | This protects the pump from surges and water hammer.  |         |

## 4.6.4 Bypass-piping considerations

### When to use a bypass line

Provide a bypass line for systems that require operation at reduced flows for prolonged periods. Connect a bypass line from the discharge side (before any valves) to the source of suction.

**When to install a minimum-flow orifice**

You can size and install a minimum-flow orifice in a bypass line in order to prevent bypassing excessive flows. Consult your ITT representative for assistance in sizing a minimum-flow orifice.

**When a minimum-flow orifice is unavailable**

Consider an automatic recirculation control valve or solenoid-operated valve if a constant bypass (minimum-flow orifice) is not possible.

**4.6.5 Auxiliary-piping checklist****Precautions****CAUTION:**

- Risk of heat generation, seal failure, and possible physical injury. Sealing systems that are not self-purging or self-venting, such as plan 23, require manual venting prior to operation.
- 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.

**NOTICE:**

Auxiliary cooling and flush systems must be operating properly to prevent excess heat generation, sparks, and/or premature failure. Ensure auxiliary piping is installed as specified on the pump data sheet prior to startup.

**When to install**

You may need to install auxiliary piping for bearing cooling, mechanical seal flush, or other special features supplied with the pump. Consult the pump data sheet for specific auxiliary piping recommendations.

**Checklist**

| Check   | Explanation/comment | Checked |
|---|---------------------|---------|
| Check that the minimum flow for each component is 4 lpm   1 gpm.                          | –                   |         |
| Check that the cooling water pressure does not exceed 7.0 kg/cm <sup>2</sup>   100 psig . | –                   |         |

**4.6.6 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. |         |
| Re-check the alignment to make sure that pipe strain has not caused any misalignment. | 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.
- 



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**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.
- 

**Precautions**

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**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.
  - Excessive warm-up rates can cause equipment damage. Ensure the warm-up rate does not exceed 1.4°C | 2.5°F per minute.
  - The maximum allowable temperature change for an abnormal transient event such as thermal shock is 160°C | 325°F.
  - The mechanical seal used in an Ex-classified environment must be properly certified.
- 

**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 150°C | 300°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 at 1 GPM (or 0.0025 the pump rated flow) into the pump drain and out the discharge nozzle (optionally, the casing vent can be included in warm-up circuit but not required). The recommended warm up rate is 3°C to 5°C | 5°F to 9°F per minute. During the warm up process confirm the temperature differential between the top and bottom of the pump is less than 17°C | 30°F. Soak for (2) hours at process fluid temperature.
- 

**NOTICE:**

For pumps with austenitic or duplex stainless steel casing construction, the temperatures stated above must be halved. E.g. for D-1 construction the recommended warm up rate is 1.5°C to 3°C | 2.5°F to 4.5°F per minute.

---

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.

## 5.2 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.
3. Remove the nut, bolt, and washers from the driver half of the coupling guard.
4. Remove the driver-side end plate.
5. Remove the driver half of the coupling guard:
  - a) Slightly spread the bottom apart.
  - b) Lift upwards.
6. 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.
7. Remove the pump half of the coupling guard:



- a) Slightly spread the bottom apart.
- b) Lift upwards.

## 5.3 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.

1. Lock out power to the driver.
2. Make sure that the coupling hubs are fastened securely to the shafts.
3. Make sure that the coupling spacer is removed.  
The pump ships with the coupling spacer removed.
4. Unlock power to the driver.
5. 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 bearing housing or close-coupled frame.
6. Lock out power to the driver.

## 5.4 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.

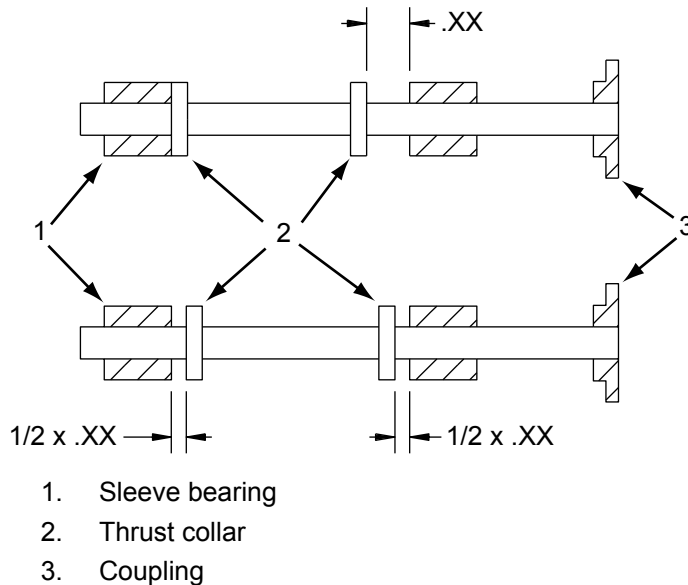
1. Check the gap between the coupling hubs against the dimensions shown on the general arrangement drawing or as stamped on the coupling hub. For any necessary adjustment, move the driver not the pump.

Motors with sleeve bearings may be manufactured with 6.35 or 12.7 mm | 1/4 or 1/2 in. end movement (float) in the motor rotor. For limited end-float arrangement, the gap between the coupling halves must be set in a different manner. If specific directions are not indicated in the motor instructions, then follow this procedure:

### NOTICE:

If the driver was mounted at the factory, the setting for the coupling is already determined.

- a) Slide the rotor towards the outboard end of the motor as far as it will go and mark the shaft at the motor frame.
  - b) Slide the rotor towards the inboard end of the motor as far as it will go and mark the shaft again.
- The distance between the marks should be either 6.35 or 12.7 mm | 1/2 or 1/4 in. if the motor is arranged for limited end-float travel.
- c) Scribe a third mark on the shaft halfway between the scribe marks made in the previous steps.
  - d) Clamp the rotor in place.



**Figure 18: Driver shaft centering**


2. Use the instructions from the coupling manufacturer to lubricate and install the coupling.
3. Check the angular and parallel alignment of the coupling halves. See Pump-to-driver alignment in the Installation chapter.

### 5.4.1 Coupling guard assembly

#### Precautions

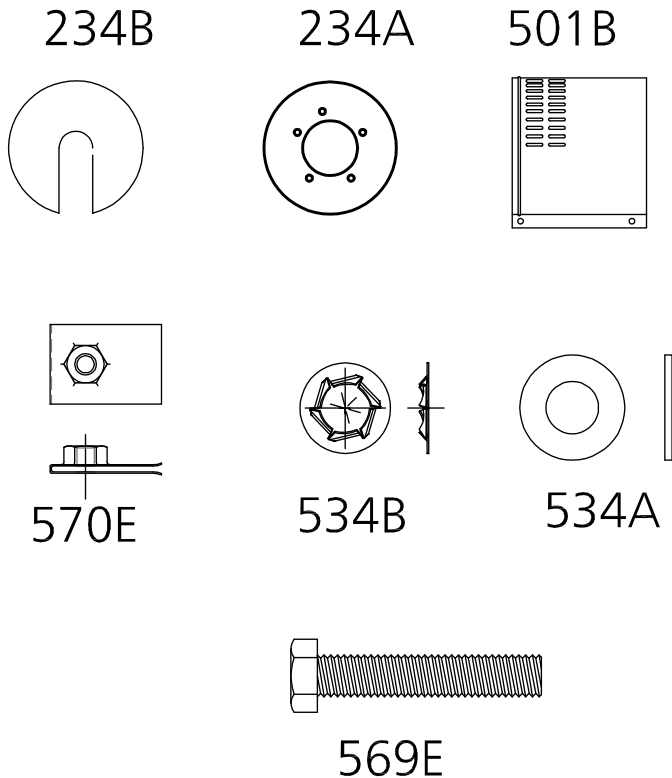


#### WARNING:

-  The coupling guard used in an ATEX classified environment must be 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.
- Avoid death or serious injury. Assure mechanical seal guard is properly installed using supplied fastening hardware.
- 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.

### Parts required



| Part No. | Description           | Part No. | Description      |
|----------|-----------------------|----------|------------------|
| 569E     | Hex head bolt (Qty 3) | 534A     | Washer (Qty 4)   |
| 501B     | Guard (Qty 2)         | 534B     | Retainer (Qty 3) |
| 234A     | Cover pump            | 234B     | Cover driver     |
| 570E     | U-nut (Qty 3)         |          |                  |

**Figure 19: Coupling guard required parts**

#### 5.4.1.1 Install the coupling guard

1. Is the pump cover (234A) 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 outboard end cover (160) bolts (371D).

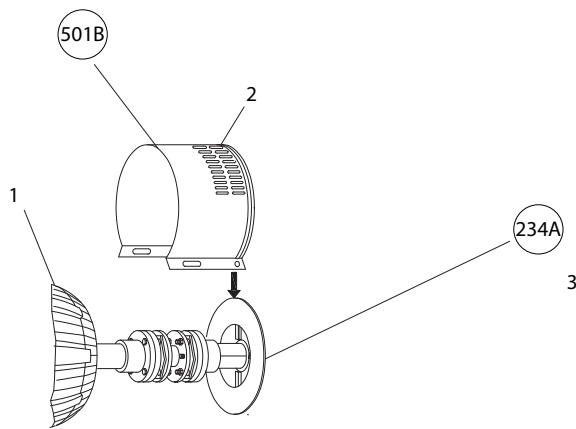
- d) Align the pump cover (234A) to the outboard end cover (160) so the holes in the pump cover align with the holes in the outboard end cover.
- e) Replace the four outboard end cover bolts (371D) and torque to the value shown in the [6.6.11 Assembly references on page 111](#).
- f) Replace the coupling 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 (501B) and place it over the pump end plate (234A).

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

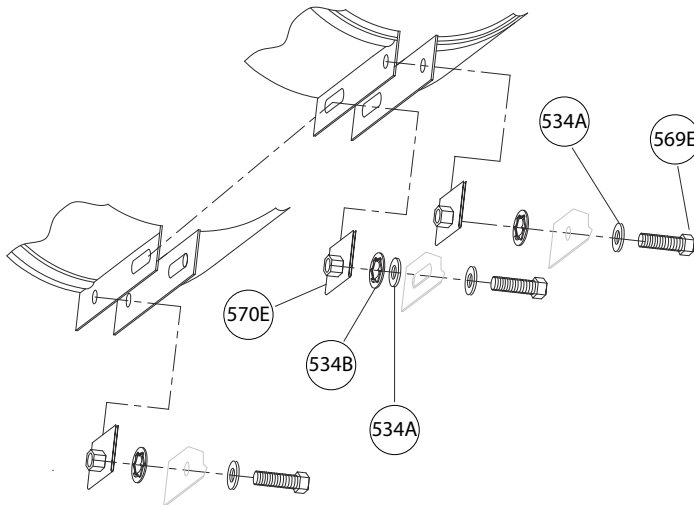
Position the opening (flange) so that it does not interfere with the piping but still allows for access when you install the bolts.



| Item | Description    | Part No. |
|------|----------------|----------|
| 1.   | Driver         |          |
| 2.   | Annular groove | 501B     |
| 3.   | Pump endplate  | 234A     |

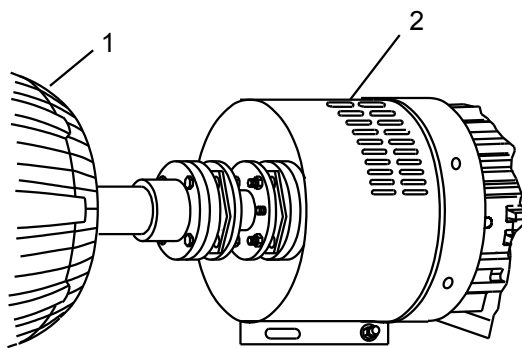
**Figure 20: Align pump end guard half with annular groove**

3. Place one washer (534A) over the bolt (569E) and insert the bolt through the round hole at the front end of the guard half.



**Figure 21: Captured hardware component assembly**

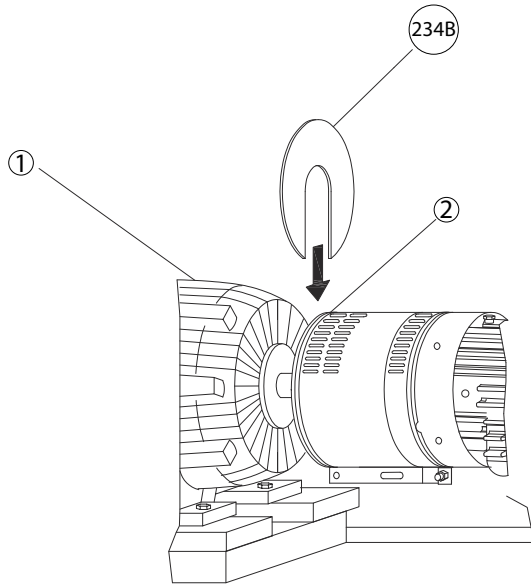
4. Install the bolt retainer (534B) over the exposed end of the bolt, and the U-Nut (570E) into the slot in the coupling guard if it was not done from the factory.
5. Thread bolt (569E) into the U-Nut (570E) and tighten firmly.  
This figure shows the proper sequence of components:



| Item | Description         |
|------|---------------------|
| 1.   | Driver              |
| 2.   | Coupling guard half |

**Figure 22: Coupling guard assembly – pump end**

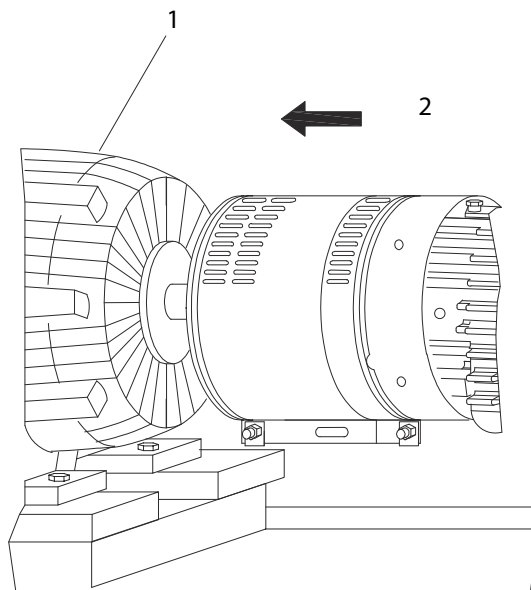
6. Slightly spread the opening of the remaining coupling guard half and place it over the installed coupling guard half so that the annular groove in the remaining coupling guard half faces the driver.
7. Place the end plate over the driver shaft and locate the end plate in the annular groove at the rear of the coupling guard half.



| Item | Description    |
|------|----------------|
| 1.   | Driver         |
| 2.   | Annular groove |

**Figure 23: Align driver end guard half with annular groove in endplate**

8. Repeat Steps 3. through 5. for the rear end of the coupling guard half, except that you hand tighten the bolt.
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 24: Slide to fit**

10. Repeat Steps 3. through 5. for the center slots in the coupling guard.
11. Firmly tighten all bolts (569E) on the guard assembly.

## 5.5 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. 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.

### Pressurized Lubrication

Pressurized lubrication is a feature provided on Sleeve/Tilt bearing arrangement only. A separate lubrication oil skid is required to provide the pressurized lubrication to the inlet connections on the bearing housings. The lubrication oil skid shall be turned on and providing positive oil flow to the bearing housings prior to pump operation.

## 5.5.1 Oil volumes

### Oil volume requirements for ball/ball

This table shows the required amount of oil for oil-lubricated bearings.

All frames in this table use a Watchdog Oiler, which has a capacity of 118 ml | 4 oz.

| Size | Radial Bearing | Drive End Bearing Housing Oil Volume |        | Thrust Bearing | Non Drive End Bearing Housing Oil Volume |        |
|------|----------------|--------------------------------------|--------|----------------|--|--------|
|      |                | ml                                   | ounces |                | ml                                       | ounces |
| 10D  | 6309           | 976                                  | 33     | 7309           | 976                                      | 33     |
| 20G  | 6312           | 1331                                 | 45     | 7312           | 1331                                     | 45     |
| 21G  | 6312           | 1331                                 | 45     | 7312           | 1331                                     | 45     |
| 30H  | 6313           | 1834                                 | 62     | 7313           | 1834                                     | 62     |
| 31H  | 6313           | 1834                                 | 62     | 7313           | 1834                                     | 62     |
| 40N  | 6318           | 2573                                 | 87     | 7318           | 2573                                     | 87     |
| 50Q  | 6320           | 3401                                 | 115    | 7320           | 3401                                     | 115    |
| 52Q  | 6320           | 3401                                 | 115    | 7320           | 3401                                     | 115    |
| 54Q  | 6224           | 3401                                 | 115    | 7320           | 3401                                     | 115    |
| 58Q  | 6320           | 3401                                 | 115    | 7320           | 3401                                     | 115    |

### Oil volume requirements for sleeve/ball

This table shows the required amount of oil for oil-lubricated bearings.

All frames in this table use a Watchdog Oiler, which has a capacity of 118 ml | 4 oz.

| Size | Radial Bearing | Drive End Bearing Housing Oil Volume |        | Thrust Bearing | Non Drive End Bearing Housing Oil Volume |        |
|------|----------------|--------------------------------------|--------|----------------|--|--------|
|      |                | ml                                   | ounces |                | ml                                       | ounces |
| 30H  | Sleeve         | 2425                                 | 82     | 7313           | 4199                                     | 142    |
| 31H  | Sleeve         | 2425                                 | 82     | 7313           | 4199                                     | 142    |
| 40N  | Sleeve         | 3076                                 | 104    | 7318           | 5826                                     | 197    |
| 50Q  | Sleeve         | 3667                                 | 124    | 7320           | 7334                                     | 248    |
| 52Q  | Sleeve         | 3667                                 | 124    | 7320           | 7334                                     | 248    |
| 54Q  | Sleeve         | 3667                                 | 124    | 7320           | 7334                                     | 248    |

### Oil volume requirements for sleeve/tilt pad type bearings

The sleeve/tilt pad type bearing is a pressurized lubrication system where oil is flowed into the bearing. This system does not have an oil sump. The required system flow rate is dependent upon the bearing size and shaft speed.

## 5.5.2 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. |
| Pumped-fluid temperatures are extreme    | Refer to the factory or a lubrication expert.   |

## 5.5.3 Acceptable oil for lubricating bearings

### Acceptable lubricants

| Brand        | Lubricant type |             |                 |
|--------------|----------------|-------------|-----------------|
|              | Ball/Ball      | Sleeve/Ball | Sleeve/Tilt Pad |
| Exxon        | ISO VG 68      | ISO VG 46   | ISO VG 32       |
| Mobil        |                |             |                 |
| Sunoco       |                |             |                 |
| Royal Purple |                |             |                 |

## 5.5.4 Lubricate the bearings with oil



### WARNING:

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



Ring oil-lubricated pumps are supplied with an oiler that maintains a constant oil level in the bearing housing.

1. Fill the oil reservoir in the bearing frame:
  - a) Fill the bearing chamber through the main body of the Watchdog until it reaches the optimum fluid level visible in the bullseye sight.
  - b) Fill the watchdog reservoir using a funnel.
  - c) Verify o-ring is on the Watchdog oiler spout.
  - d) Place your thumb over the reservoir spout. Invert and insert the spout into the internal threaded boss on the main body.
  - e) Tighten reservoir. Do not over-tighten.
  - f) Verify that proper oil level is maintained per the following diagram.

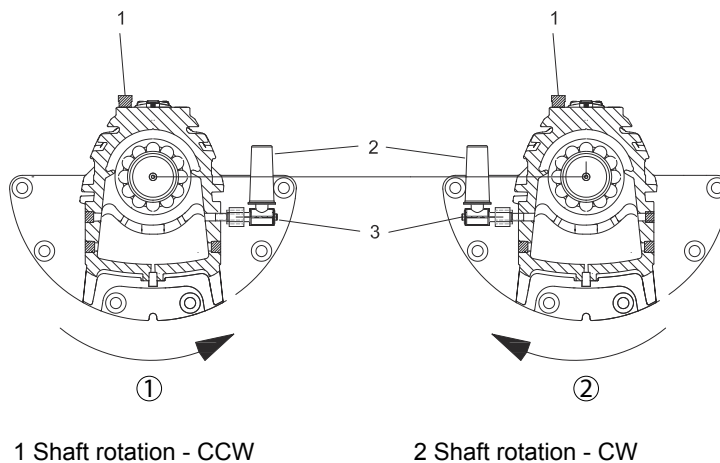
---

### NOTICE:

Do not fill the oil reservoir of the bearing frame through the plug at the top.

---

2. Check that the oil level is correct. The correct oil level is centered in the bullseye sight glass, when the pump is not in operation. During operation, bullseye sight gives a false oil level reading. Shown is general schematic. Oil level is below outer race of bearing.

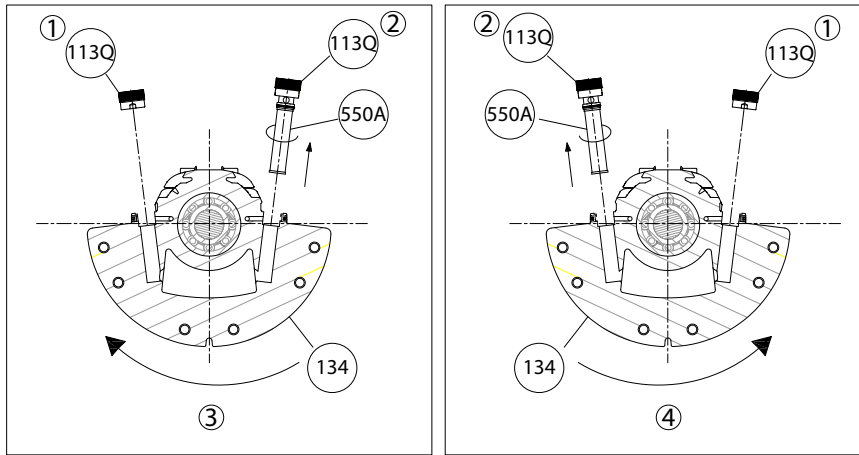


| Item | Description |
|------|-------------|
| 1.   | Plug        |
| 2.   | Reservoir   |
| 3.   | Main body   |

**Figure 25: Correct oiler location based on pump rotation**

### 5.5.5 Replace the oil filter

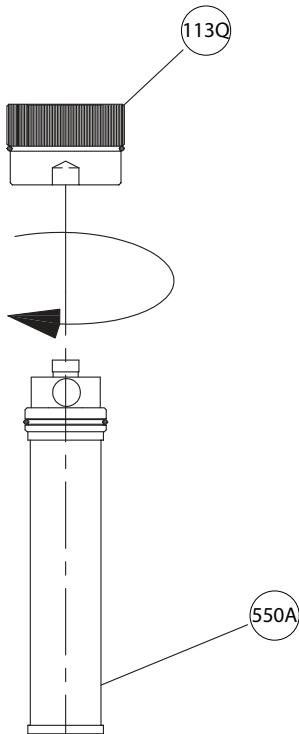
1. Remove the oil filter (550A) and the oil filter plug (113Q) from the bearing frame (134). See [Figure 26: Oil filter and plug removal on page 48](#).



1. Non-filter side
2. Filter side
3. Shaft rotation C.W.
4. Shaft rotation C.C.W.

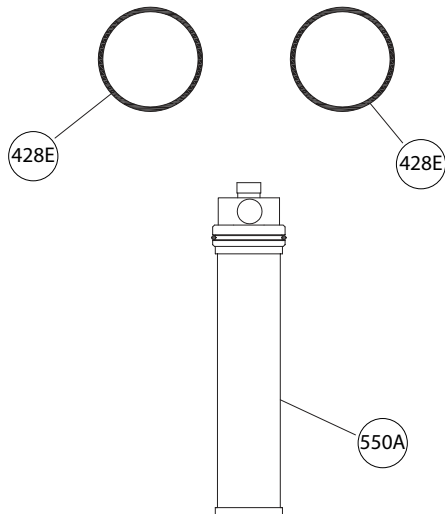
**Figure 26: Oil filter and plug removal**

2. Unscrew the filter (550A), part number K08174A from the plug (113Q), part number K06818A. Keep the plug (113Q) and discard the old filter (550A). Please discard the oil filter per your local waste disposal requirements. See [Figure 27: Filter removal on page 48](#).



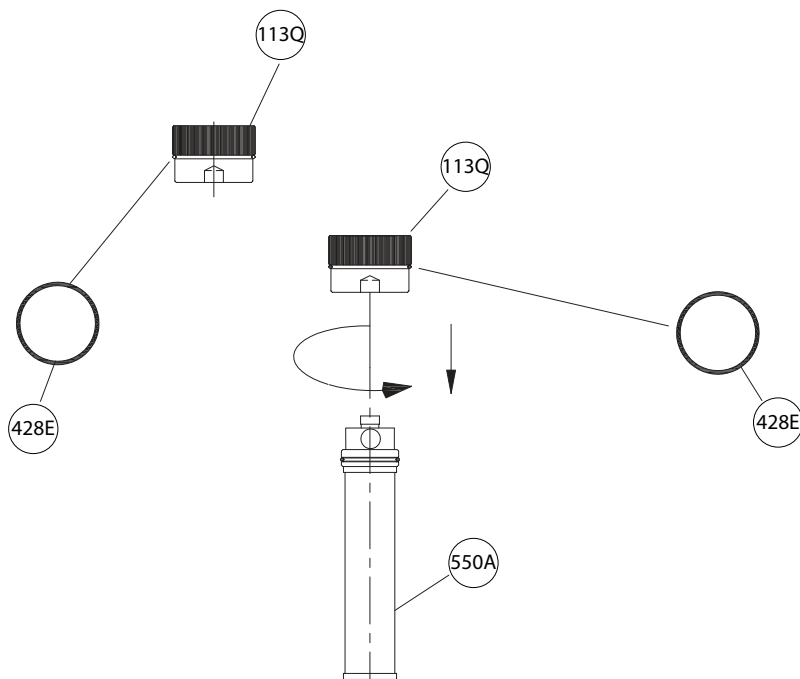
**Figure 27: Filter removal**

3. Repair Filter kit RK08174A consists of a new filter (550A) and two o-rings (428E). Two kits should be purchased at each filter change one for the drive end and one for the non-drive end. See [Figure 28: Filter kit on page 49](#).



**Figure 28: Filter kit**

4. Screw the new filter (550A) into the existing plug (113Q) and install the new o-rings (428E) to the filter side plug (113Q) and the non-filter side plug (113Q). See [Figure 29: New filter installation on page 49](#).



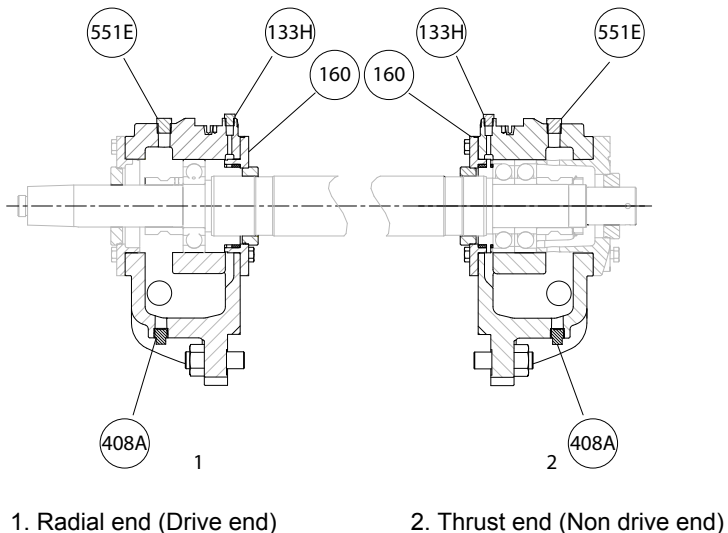
**Figure 29: New filter installation**

### 5.5.6 Lubricate the bearings with pure or purge-oil mist (optional)

Before lubricating with purge-oil mist, make sure that the bearing frame is properly lubricated. See Lubricating the bearings with oil.

1. Prepare the oil-mist generator according to the manufacturer's instructions.
2. Connect the oil-mist supply lines to the oil ring inspection plug connections. The oil requirements for ring-oil-lubricated bearings also apply to oil-mist-lubricated bearings. Oil mist is recommended for use on ball bearing arrangements only.

Note that only one of the two connection ports in the radial bearing housing is used (immediately above the single row radial bearing). You must connect to both connections on the thrust bearing housing, because there are two rows of bearings.



| Description             | Part No. |
|-------------------------|----------|
| Radial and thrust       | 133H     |
| Bearing end cover       | 160      |
| Thrust only             | 551E     |
| Radial and thrust drain | 408A     |

**Figure 30: Oil-mist connections**

- For pure-oil mist, connect the drain lines (408A) to the outlet connections. This is not required for purge-oil mist.

### 5.5.6.1 Convert to oil-mist lubrication

**NOTICE:**

Make sure that pipe threads are clean and apply thread sealant to plugs and fittings.

**NOTICE:**

In both housings install bearing end cover (160) designed for oil mist.

You can convert from ring-oil lubrication to oil-mist lubrication in pumps with ball bearing construction. The radial and thrust end bearing housings (134) have pre-drilled connections for oil mist:

- 1/4 in. NPT connection on the inboard side of each housing (133H)
- 1/2 in. NPT connection on the outboard side (551E)

Purge-oil mist lubrication provides intermittent oil mist in the bearing housing. This system uses the oil sump in the housing, and requires the oil ring and the constant-level oiler.

Pure-oil mist lubrication provides constant oil mist in the bearing housing. This system does not use the oil sump, oil ring, or constant-level oiler. The drain connections in the bearing housing are used as part of the oil recirculation system.

- On the radial housing, replace the 1/4 in. NPT plug (133H) with an oil-mist fitting provided by the oil-mist system manufacturer.

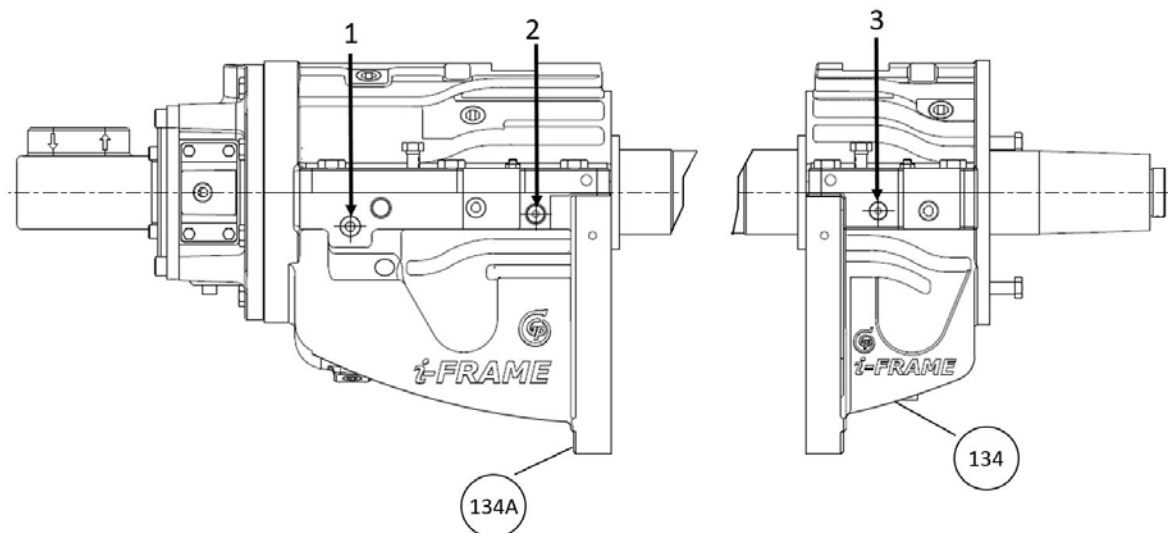
The 1/2 in. NPT connection (551E) remains plugged because it is not required in the oil-mist system.

2. On the thrust housing, replace the 1/4 in. NPT plug (133H) with an oil-mist fitting. Replace the 1/2 in. NPT plug (551E) with a 1/2 in. to 1/4 in. bushing and insert an oil-mist fitting provided by the oil-mist system manufacturer.
3. For pure-oil mist, connect the drain lines (408A) to the outlet connections. This is not required for purge-oil mist.

### 5.5.7 Lubricate the bearings with pressurized lubrication

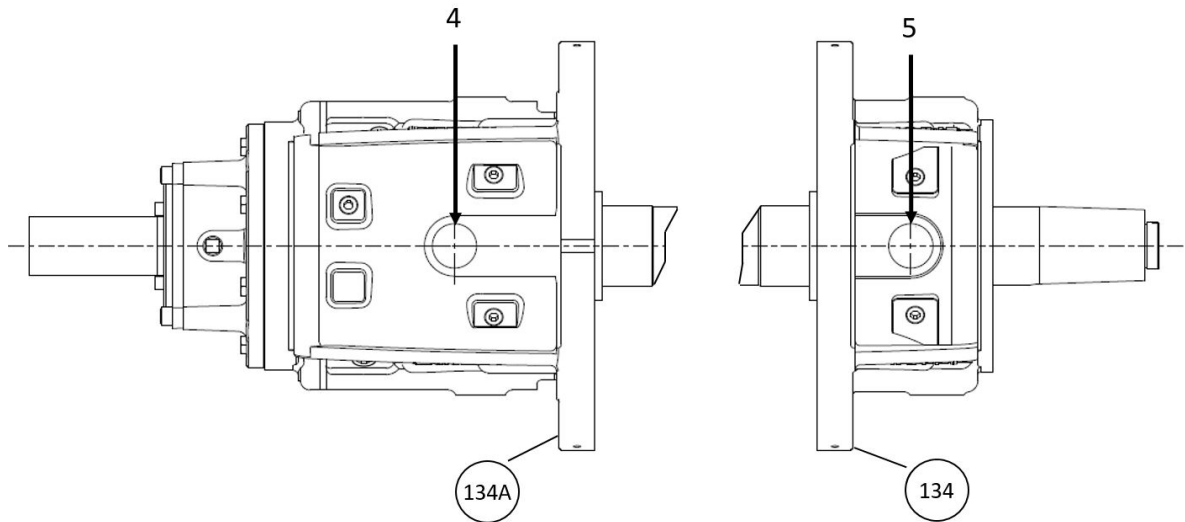
Pressurized lubrication requires a separate lubrication oil skid to provide cool, clean oil to the bearing housings. The lubrication oil skid shall be in operation to ensure oil flow into the bearings prior to pump operation. The pump may have been supplied with orifices or valves to control inlet flow to each bearing. Refer to the General Arrangement drawing for additional detail.

1. Prepare the lubrication oil skid according to the manufacturer's instructions.
2. Connect the lubrication oil skid supply lines to the bearing housing connections as shown in [Figure 31: Oil feed location on page 51](#).
3. Connect the bearing housing drain piping back to the lubrication oil skid as shown in [Figure 32: Oil drain locations on page 52](#).



| Item | Description                      |
|------|----------------------------------|
| 1    | Thrust bearing oil inlet         |
| 2    | Sleeve bearing oil inlet, thrust |
| 3    | Sleeve bearing oil inlet, radial |

**Figure 31: Oil feed location**



| Item | Description                      |
|------|----------------------------------|
| 4    | Thrust bearing housing oil drain |
| 5    | Radial bearing housing oil drain |

Figure 32: Oil drain locations

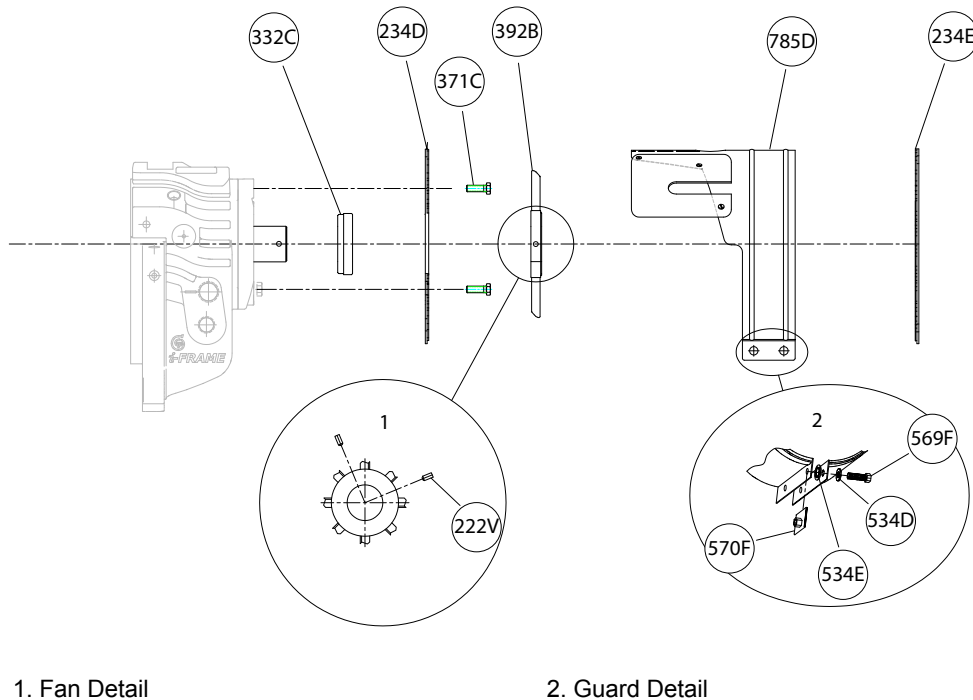
### 5.5.8 Thrust Bearing Cooling Fan (Optional)

**Precautions**



**WARNING:**

- 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.



1. Fan Detail

2. Guard Detail

**Figure 33: Cooling fan assembly**

### 5.5.8.1 Install the fan guard

1. Is the pump endplate (234D) already installed?
  - a) If yes; install fan (392B) and tighten set screws (222V) and then proceed to step 2.
  - b) If no; complete these steps.
    - Remove the thrust bearing end cover (109A) and quantity 4 bolts (371C).
    - Align the pump end plate (234D) to the thrust bearing end cover (109A) so the holes in the pump end plate align with the holes in the thrust bearing end cover.
    - Align the pump end plate (234D) to the thrust bearing end cover (109A) so the holes in the pump end plate align with the holes in the thrust bearing end cover.
2. Slightly spread the opening of the fan cowling (785D) and place it over the pump end plate (234D). The annular groove of the guard is to be located around the pump endplate.
3. Place one washer (534E) over each bolt (569F) and insert the bolts through the round holes at the front end of the guard half.
4. Install bolt retainers (534D) and U Nuts (570F).
5. Thread bolt (569F) into the U Nut (570F) and tighten firmly.

### 5.5.9 Lubricate the bearings after a shutdown period

1. Flush out the bearings and bearing frame with a light oil to remove contaminants. During flushing, make sure to rotate the shaft slowly by hand.
2. Flush the bearing housing with the proper lubricating oil to ensure oil quality after cleaning.
3. Refer to *Reassembly* section for proper bearing greasing procedure.

## 5.6 Shaft sealing with a mechanical seal

### Precautions



---

**WARNING:**

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

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**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.

---

---

**NOTICE:**

-  The mechanical seal must have an appropriate seal-flush system. Failure to do so will result in excess heat generation and seal failure.
  -  Cooling systems such as those for bearing lubrication and mechanical-seal systems must be operating properly to prevent excess heat generation, sparks, and premature failure.
  -  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.
  -  Follow seal manufacturer's guidelines for proper seal installation procedures.
- 

### Shipping

Pumps may be shipped with or without a mechanical seal installed.

### 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.

## 5.7 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 1: 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 <sup>2</sup>   5 to 15 psi greater than the seal chamber pressure. The injection rate must be 2 to 8 lpm   0.5 to 2 gpm. |
| Other          | You can use other methods that employ multiple gland or seal chamber connections. Refer to the mechanical seal reference drawing and piping diagrams.  |

## 5.8 Pump priming



### WARNING:

These pumps are not self priming and must be fully primed at all times during operation. Loss of prime can lead to excessive heat and severe damage to the pump and seal.



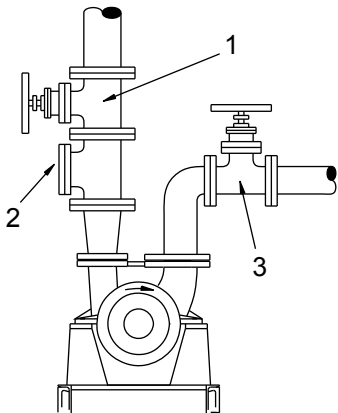
### WARNING:

A build-up of gases within the pump, sealing system, or process piping system may result in an explosive environment. Make sure the process piping system, pump and sealing system are properly vented prior to operation.

Before the pump is started, the pump must be fully primed and the suction pipe must be full of liquid. If pump is run dry, then rotating parts within the pump can seize to stationary parts because they depend upon the pumped liquid for lubrication. Several methods of priming can be used depending upon the type of installation and service involved.

## 5.9 Prime the pump with the suction supply above the pump

1. Slowly open the suction isolation valve.
2. Open the air vents on the suction and discharge piping, the casing, the seal chamber, and the seal piping, if provided, until all air is vented and only the pumped fluid flows out.
3. Close the air vents.



| Item | Description               |
|------|---------------------------|
| 1.   | Discharge isolation valve |
| 2.   | Check valve               |
| 3.   | Suction isolation valve   |

Figure 34: Suction supply above pump

## 5.10 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.
- To avoid risk of equipment damage, observe the pump for vibration levels, bearing temperature, and excessive noise. If normal levels are exceeded, shut down the pump and resolve the issue.
- 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.  
A pump can exceed normal levels for several reasons. See Troubleshooting for information about possible solutions to this problem.
7. Repeat steps 5 and 6 until the pump runs properly.

## 5.11 i-ALERT®2 Equipment Health Monitor



### WARNING:

Explosive hazard and risk of personal injury. Heating to high temperatures could cause combustion of the condition monitor. Never heat the condition monitor to temperatures in excess of 149°C | 300°F or dispose of in a fire.

For all information refer to the i-ALERT®2 Equipment Health Monitor Installation, Operation and Maintenance manual. <http://www.itproservices.com/aftermarket-products/monitoring/i-alert2/i-ALERT2.com>

## 5.12 Pump operation precautions

### General considerations

#### NOTICE:

On ring oil-lubricated pumps, remove oil ring viewing port plugs to verify the following:

- The oil rings are properly positioned in the grooves on the shaft.
- The oil rings are turning.
- The oil rings are throwing oil.

#### 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.
- Check the bearing temperatures using a pyrometer or other temperature-measuring device. Monitor the bearing temperature frequently during initial operation in order to determine if a bearing problem exists, as well as to establish normal bearing operating temperature.
- For pumps with auxiliary piping, make sure that proper flows have been established and that the equipment is operating properly.

- Establish baseline vibration readings in order to determine normal running conditions. If the unit is running roughly, then consult the factory.
  - Monitor all gauges to ensure that the pump is running at or near rating and that the suction screen (when used) is not clogged.
- 

#### 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<sub>A</sub>) always exceeds NPSH required (NPSH<sub>3</sub>) 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.

---

## 5.13 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.
- 

## 5.14 Deactivate the i-ALERT<sup>®</sup>2 Equipment Health Monitor

---

#### **NOTICE:**

Always deactivate the health monitor when the pump is going to be shut down for an extended period of time. Failure to do so will result in reduced battery life.

---

**NOTICE:**

Always reset the health monitor when the pump is started after maintenance, system change, or being shut down for an extended period of time. Failure to do so may result in false baseline levels that could cause the condition monitor to alert in error.

1. To deactivate or reset the i-ALERT®2 Equipment Health Monitor, please refer to the i-ALERT®2 Equipment Health Monitor IOM or visit <http://www.itproservices.com/aftermarket-products/monitoring/i-alert2/i-ALERT2.com>

## 5.15 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.  
See Pump-to-driver alignment in the Installation chapter.
5. Reinstall the coupling guard.
6. Restart the pump and driver.

## 5.16 Doweling the pump casing

The pump casing must be doweled to the baseplate in order to maintain the proper pump position.

There are two methods for doweling the pump casing, depending on whether the pump is operated in an application with a low or high temperature differential between the ambient temperature during setup and the temperature of the pumped fluid.

If the temperature differential is low the pump foot on the drive end of the pump will require taper pins installed to secure the pump to the pedestal.

If the temperature differential is high the baseplate is supplied with provision to accommodate differential temperature doweling. This design ensures the alignment between the pump and driver is maintained while allowing the case to thermally move.

When the driver is mounted at the factory, the driver is not doweled in order to allow for final field alignment.

---

**NOTICE:**

You should dowel the driver only after completing the final hot alignment.

---

### 5.16.1 Installing the driver

1. Confirm the pump is centered on its pedestal so that the hold-down studs are centered in the pump foot clearance holes with the pump dowel pins installed.
2. Place the driver on the baseplate with proper shaft separation (DBSE = distance between shaft ends).
3. Tighten the pump hold-down bolts as described in the applicable pump doweling sections below.
4. If the driver was installed at the factory and the driver hold-down bolt holes have already been drilled and tapped in the baseplate pedestal, proceed to step 9.
5. After you have determined the correct driver location on the driver pedestal, mark the location of the driver on the pedestal with a hole punch through the hold-down bolt holes in the driver feet.
6. Remove the driver, then drill and tap the punched holes on the driver pedestal.

---

**NOTICE:**

Scribe the driver shims in order to return them to the correct location on the driver pedestal.

---

7. Set the driver back onto the baseplate with the shims in the correct location.
8. Confirm the driver is not bolt-bound.
9. Tighten the driver hold-down bolts and confirm alignment.
10. Run the unit under actual operating conditions for enough time to bring the pump, driver, and associated system to operating temperature.
11. Shut down the pump and the 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.

- 
12. Remove the coupling guard.

Refer to [5.2 Remove the coupling guard on page 38](#).

13. Check and confirm the alignment while the unit is still hot.
14. Dowel the driver feet. See the driver IOM for details.

### 5.16.2 Doweling for low differential temperature service

Use this method to dowel the drive end pump foot to the baseplate pedestal when there is not a high temperature differential between the ambient temperature during setup and the temperature of the pumped fluid.

---

**NOTICE:**

This procedure should not be followed if the pump and baseplate have been supplied with differential temperature doweling (See Doweling for high differential temperature service).

---

**Required tools**

- Two number 7 taper pins
  - One number 7 taper pin reamer
  - 21/64 in. or Q size drill
  - Hardwood block or soft-faced hammer
- 

**NOTICE:**

This procedure must be done only after the pump is properly aligned with the baseplate pedestal.

---

1. Confirm the pump is centered on its pedestal so that the hold-down studs are centered in the pump foot clearance holes.
2. Tighten the pump hold-down bolts.
3. Drill two holes through the pump foot and pump pedestal. Position each hole between the hold-down bolt and the end of the pump foot at the coupling end on both sides.
4. Ream the holes with a number 7 taper pin reamer to the proper fit with the taper dowel pins. Insert the pins deep enough so that only the threaded portions are exposed when the pins are fully seated.
5. Seat the taper pins firmly in the holes with a hardwood block or soft-faced hammer.

If you should ever need to remove the dowel pins, tighten the hex nuts provided on the pins. If the pins are not seated deeply enough, put a spacer under the hex nuts in order to lift the pins free when the hex nuts are tightened.

---

**NOTICE:**

Always remove the dowel pins before removing the casing. Failure to do so can result in casing damage.

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### 5.16.3 Doweling for high differential temperature service

The factory will incorporate this method to dowel the pump to the baseplate pedestal if there is a high temperature differential between the ambient temperature during setup and the temperature of the pumped fluid.

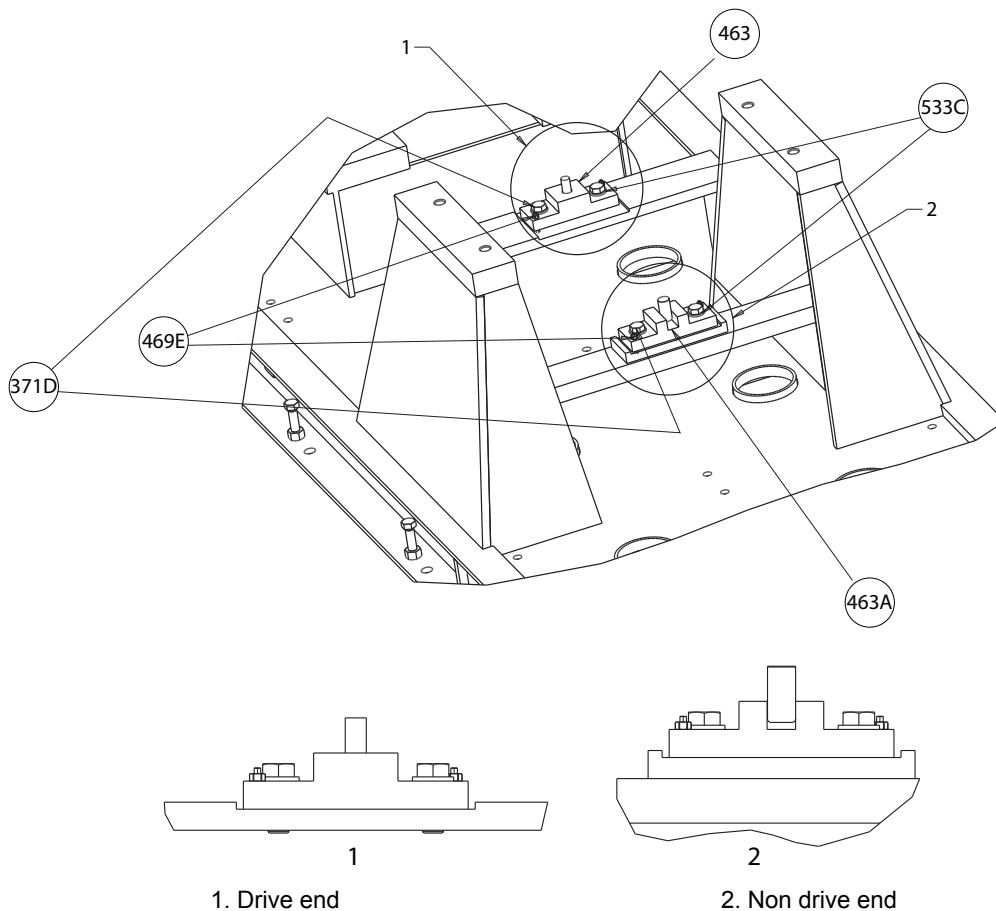
When the differential is high the baseplate is supplied with provision to accommodate differential temperature doweling. This design ensures the alignment between the pump and driver is maintained while allowing the case to thermally move.

Differential temperature doweling uses a fixed dowel pin block (Detail 1) on the drive end of the pump to maintain alignment to the driver. The non drive end of the pump uses a dowel pin block with a slot parallel to the pump shaft (Detail 2) to allow the pump case to thermally move.

---

**NOTICE:**

- During installation verify the bolts (item 371D) are torqued properly.
  - During installation verify the taper pins (item 469E) are installed.
-



| Item | Description                                 | Part no. |
|------|---|----------|
| 1.   | Drive end dowel pin (installed in case)     |          |
| 2.   | Non drive end dowel pin (installed in case) |          |
|      | Hex cap screws                              | 371D     |
|      | Drive end guide block                       | 463      |
|      | Non drive end guide block                   | 463A     |
|      | Taper pins                                  | 469E     |

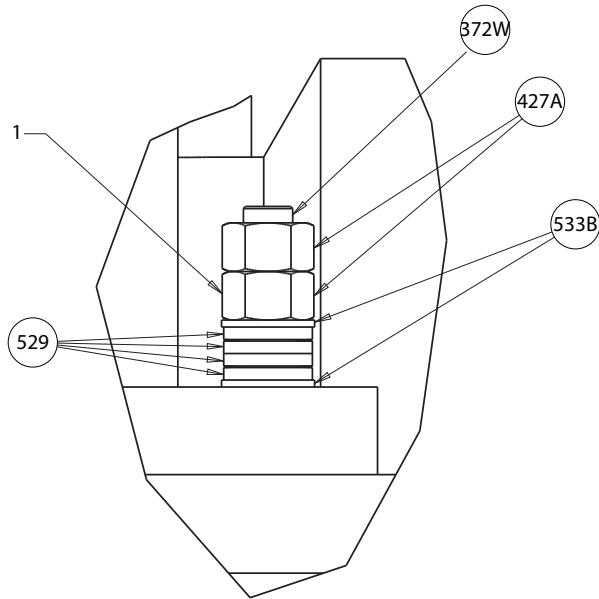
**Figure 35: Differential temperature doweling assembly**

Drive end and Non-drive end pump feet are secured to the baseplate pedestal as shown below.

**NOTICE:**

- Verify the hex lower nuts (426A) are tightened 1/3 to 1/2 turn beyond hand tight.
- Note - the Belleville washers will not be fully compressed when tightened properly.





| Item | Description  | Part No. |
|------|--|----------|
| 1.   | Tighten lower hex nut 1/3 to 1/2 turn beyond hand tight to ensure Belleville washers are compressed. |          |
|      | Stud   | 372W     |
|      | Hex nuts   | 427A     |
|      | Belleville washers   | 529      |
|      | Hardened flat washers  | 533B     |

**Figure 36: Pump foot mounting detail**

1. Tighten lower hex nut 1/3 to 1/2 turn beyond hand tight to ensure belleville washers are compressed.

# 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.

### 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.
- Inspect the discharge pressure.
- Inspect the temperature.
- Check that there is no leakage from the mechanical seal.

### Three-month inspections

Perform these tasks every three months:

- Check that the foundation and the hold-down bolts are tight.
- Check the mechanical seal if the pump has been left idle, and replace as required.
- Change the oil every three months (2000 operating hours) at minimum.
- Change the oil filter assembly (550A) every 2000 hours.
- Change the oil and oil filter more often if there are adverse atmospheric or other conditions that might contaminate or break down the oil.
- 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 ATEX-certified and the temperature of the pumped fluid exceeds the permitted temperature values, then consult your ITT representative.

### Bearing lubrication schedule

| Type of lubrication    | First lubrication  | Lubrication intervals   |
|------------------------|--|---|
| Ring oil<br>Purge oil  | Add oil before you install and start the pump. Change the oil and oil filter after 200 hours for new bearings. | After the first 200 hours, change the oil filter every 2000 operating hours and the oil every 6000 operating hours. If you do not change the oil filter as recommended, oil must be changed every 2000 hours. |
| Pure oil<br>Forced oil | Follow the recommendations from the manufacturer.  | Follow the recommendations from the manufacturer.   |

## 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 Disassembly

### 6.4.1 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.
- 

### 6.4.2 Tools required

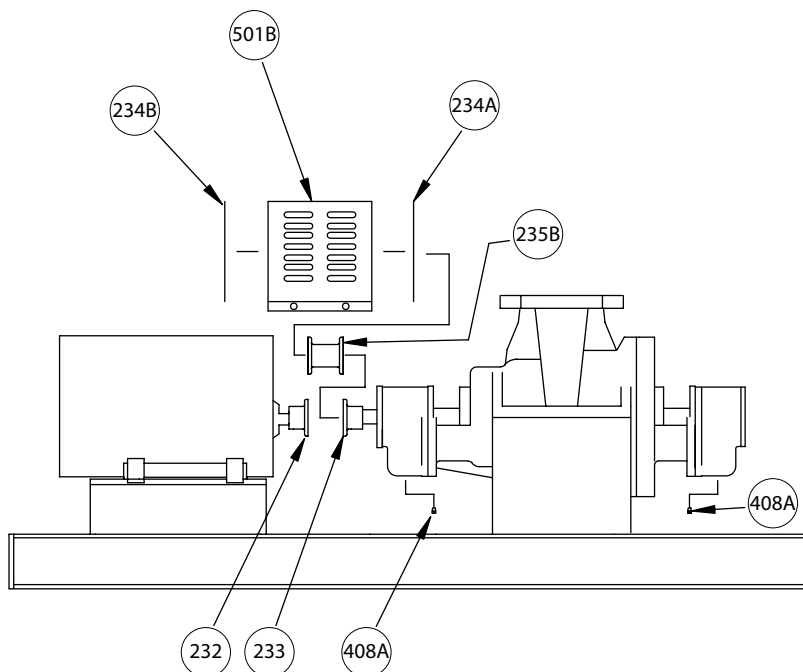
In order to disassemble the pump, you need these tools:

- Brass drift punch
- Cleaning agents and solvents
- Dial indicators

- Drill
- Feeler gauges
- Hex wrenches
- Induction heater
- Lifting sling
- Micrometers (inside and outside)
- Open end wrenches
- Press
- Soft face hammer
- Spanner wrench
- Spanning type puller
- Tap
- Torque wrench with sockets
- Lifting eyebolt (dependent on pump / motor size)

### 6.4.3 Prepare for disassembly

1. Close the isolation valves on the suction and discharge sides of the pump.
2. Drain the liquid from the piping; flush the pump if necessary.
3. Disconnect all auxiliary piping, tubing, and equipment that will interfere with the removal of the head and the rotor.
4. Remove the oil drain plugs (408A) from the bottom of the bearing housings (134, 134A) and drain the oil.  
Dispose of the oil in accordance with applicable regulations.

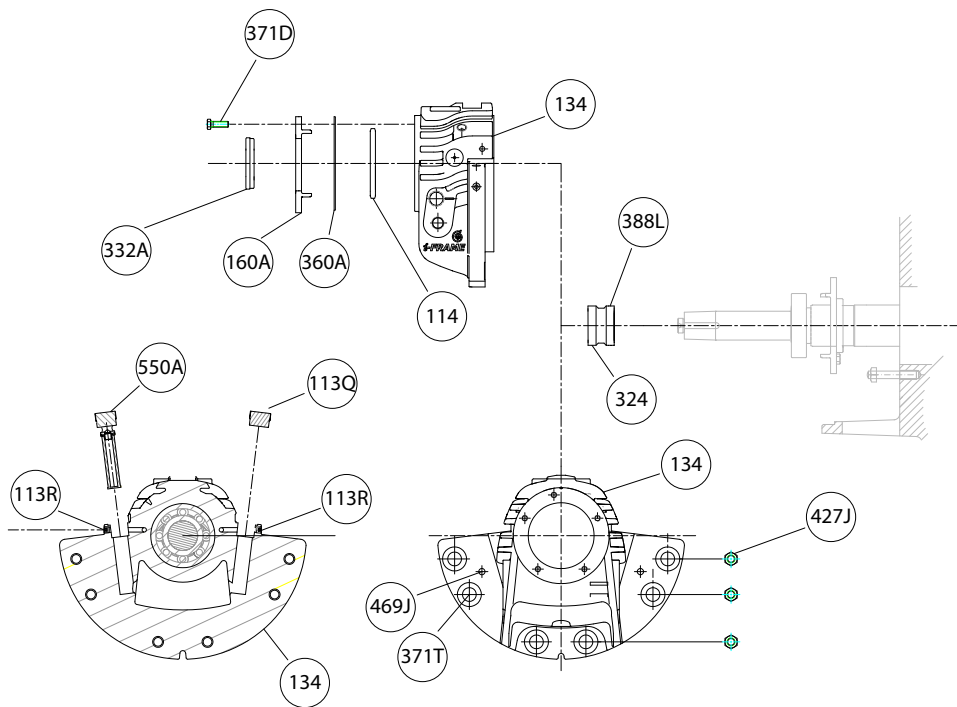


**Figure 37: Coupling guard disassembly**

5. Remove the oiler bottle (251) and store it in a safe place.
6. Remove the coupling guard (501B).  
Refer to Remove the coupling guard in the Commissioning, Startup, Operation, and Shutdown chapter.

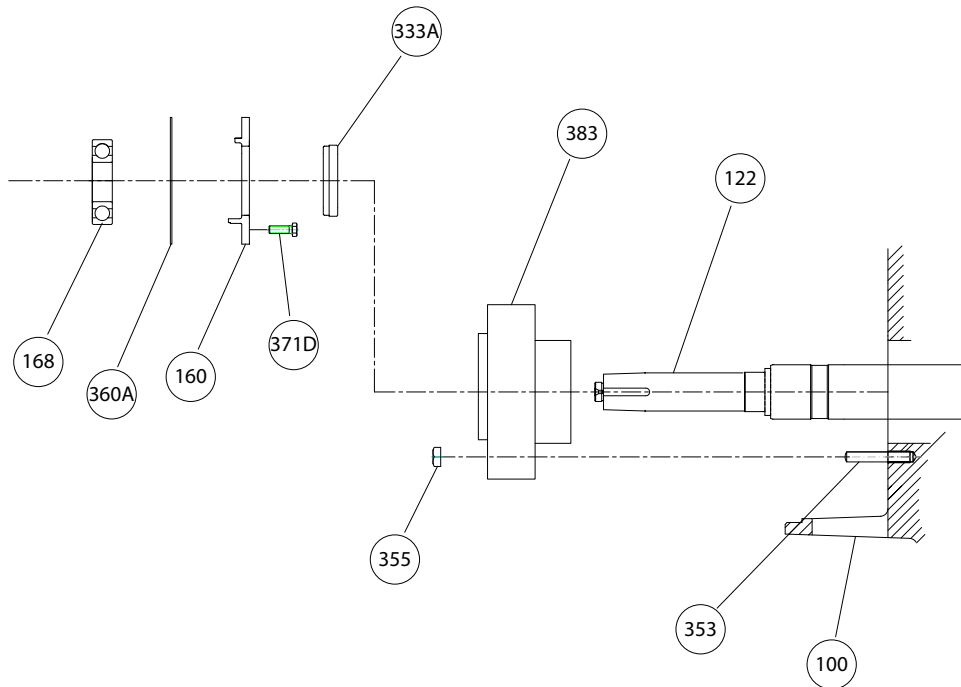
7. Unbolt and remove the coupling spacer (235B).  
Follow the instructions provided by the coupling manufacturer for assistance.
8. Remove the coupling guard pump endplate (234A).
9. Remove the coupling nut (520) from the tapered shaft end on the pump.
10. Remove the coupling hub (233) from the pump.
  - Scribe the shaft (122) for relocating the coupling hub during reassembly.
  - Use a spanner type puller or puller holes provided in the hub. Refer to the instructions provided by the coupling manufacturer for further assistance.
  - At this point, you can remove the pump from the baseplate.
11. Reposition the setting tabs in order to maintain the position of the mechanical seal, for both seals.  
Refer to the seal installation drawing provided by the manufacturer.

### 6.4.4 Disassemble the radial end (ball bearing pumps)



**Figure 38: Radial bearing housing disassembly**

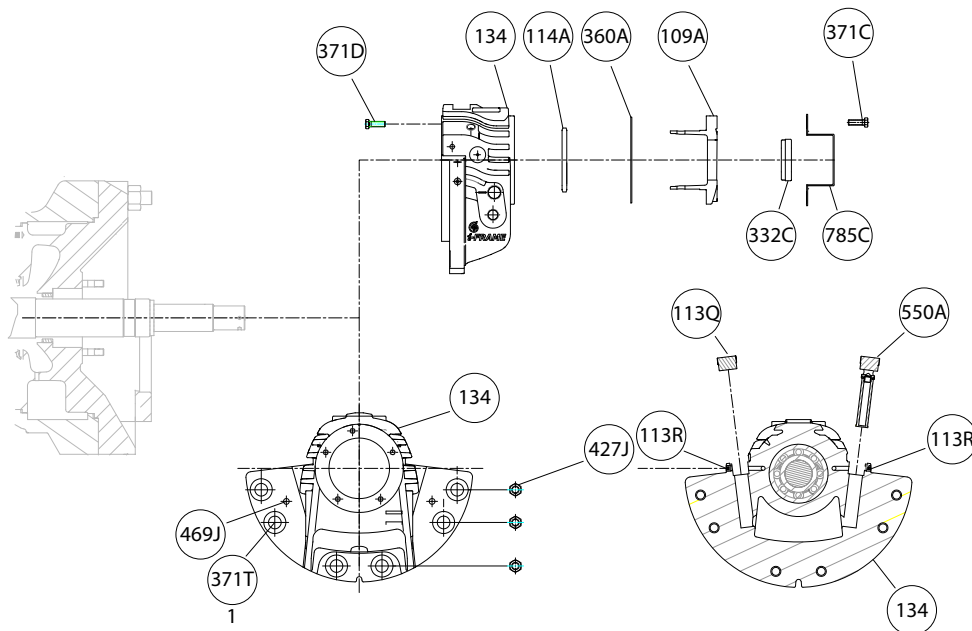
1. Remove the oil filter (550A) and the oil filter plug (113Q) from the bearing frame (134). The set screws (113R) do not need to be removed.
2. Remove the cover bolts (371D) from both inboard (160) and outboard (160A) bearing end covers. See Step 6..
3. The outboard labyrinth seal (332A) and the bearing housing gasket (360A) will come off with the outboard cover (160A).
4. Remove the dowel pins (469J) between the bearing housing flange and the casing flange. The connection point of the housing to the casing is referred to as the saddle.
5. Unbolt the bearing housing from the saddle by removing the four nuts (427J).
6. (Optional) Remove the studs (371T). It may be necessary to rotate the bearing housing in order to remove the inboard bearing end cover bolts (371D).
7. Remove the oil ring (114).
8. Pull the bearing housing (134) off the shaft.
9. Loosen the setscrew (388L) on the oil ring sleeve (324) and remove the sleeve.
10. Use a bearing puller in order to remove the radial bearing (168) from the shaft.



**Figure 39: Radial bearing removal**

11. Remove the inboard bearing end cover (160), the inboard labyrinth seal (333A), and the bearing housing gasket (360A) will come off with the inboard cover (160).
12. Remove the seal gland nuts (355) and the mechanical seal (383). Refer to the instructions provided by the mechanical seal manufacturer.

### 6.4.5 Disassemble the thrust end (ball bearing pumps)



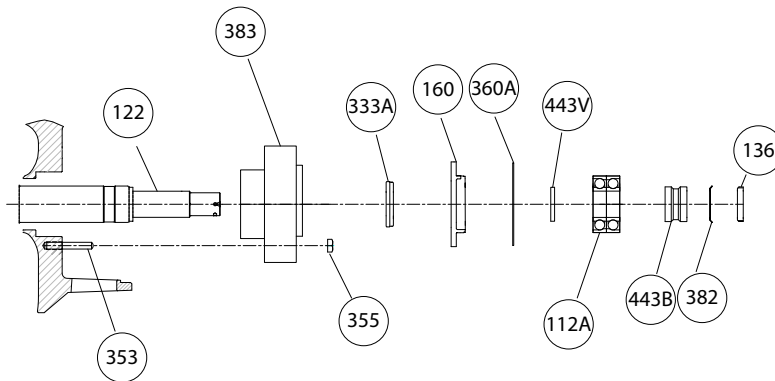
**Figure 40: Thrust bearing housing disassembly**

1. Remove the oil filter (550A) and filter plug (113Q) from the bearing frame (134). The set screws (113R) do not need to be removed.

2. If the pump has the optional bearing cooling fan, remove the guard endplate (234E), guard (785D), cooling fan (392B) and pump endplate (234D).
3. Remove the bearing end cover bolts (371C and 371D) from the outboard thrust bearing end cover (109A).
4. Remove the outboard bearing end cover (109A) and top hat (785C). The outboard labyrinth seal (332C) and the bearing housing gasket (360A) will come off with the outboard bearing end cover (109A).
5. Remove the dowel pins (469J) between the bearing housing flange and the head flange. The connection point of the housing to the casing is referred to as the saddle.
6. Unbolt the bearing housing from the saddle by removing the four nuts (427J).
7. (Optional) Remove the studs (371T). It may be necessary to rotate the bearing housing in order to remove the inboard end cover bolts (371D).
8. Remove the oil ring (114A).
9. Pull the bearing housing (134) off the shaft.
10. Bend lockwasher tab to allow removal of the thrust locknut (136) and the lockwasher (382).
11. Remove the oil ring sleeve (443B), which is held in place by the thrust locknut (136).
12. Use a bearing puller in order to remove the thrust bearing (112A) from the shaft (122). The inner race on this inner duplex bearing remains on the shaft when the bearing is pulled. Remove this inner race by applying heat. Do this away from the pump site.

**WARNING:**

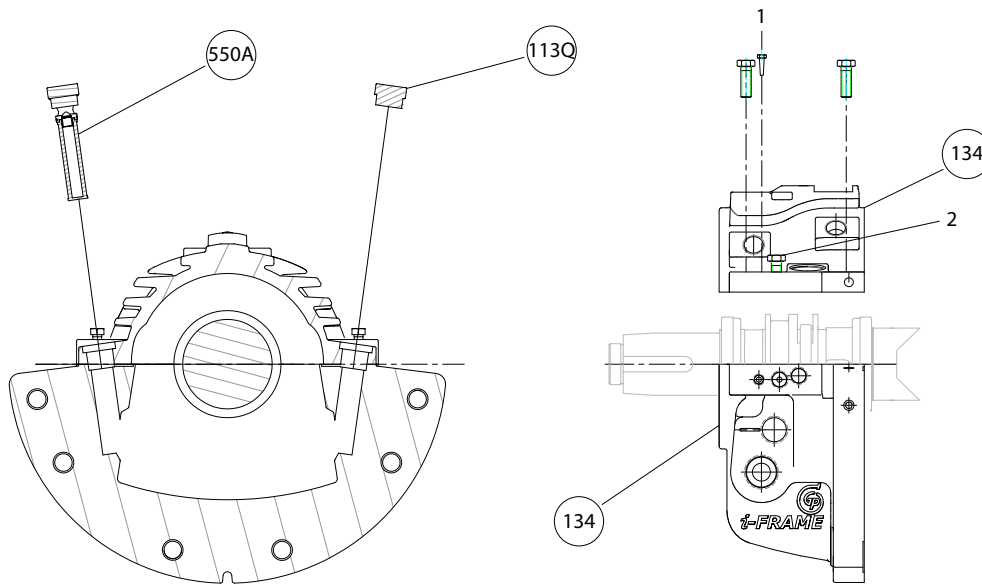
The pump may handle hazardous and/or toxic liquids. Trapped or undrained liquid can cause explosions when heat is applied. Never apply heat at the pump site for this reason. Heat can also distort machined surfaces.

**Figure 41: Thrust bearing disassembly**

13. If applicable - Remove the bearing spacer (443V).
14. Remove the inboard bearing cover (160), the inboard labyrinth seal (333A), and the bearing housing gasket (360A) will come off with the inboard bearing end cover (160).
15. Remove the seal gland nuts (355) and the mechanical seal (383). Refer to the instructions provided by the mechanical seal manufacturer.



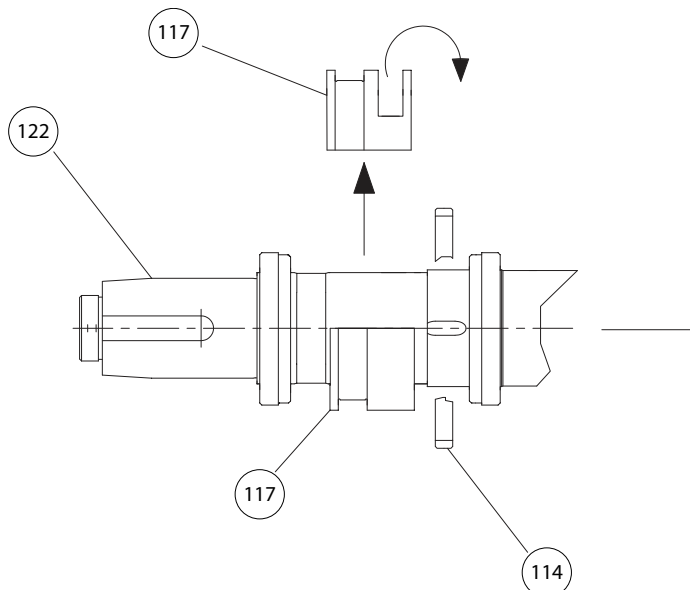
## 6.4.6 Disassemble the radial end (sleeve/ball bearing pumps)



| Item | Description |
|------|-------------|
| 1.   | Taper pin   |
| 2.   | Jack bolt   |

**Figure 42: Disassemble the radial end**

1. Remove the oil filter (550A) and filter plug (113Q) from the bearing frame (134)
2. Remove the two taper pins between the upper and lower halves of the bearing housing (134).
3. Remove the hex cap screws that connect the upper and lower halves of the bearing housing.
4. Tighten the two jack bolts on the horizontal parting flanges of the bearing housing in order to separate the two halves.
5. Remove the top half of the bearing housing (134).



**Figure 43: Remove radial sleeve bearing**

6. Move the oil ring (114) aside; it cannot be removed until the lower bearing frame is removed.

7. Remove the upper half of the sleeve bearing (117).

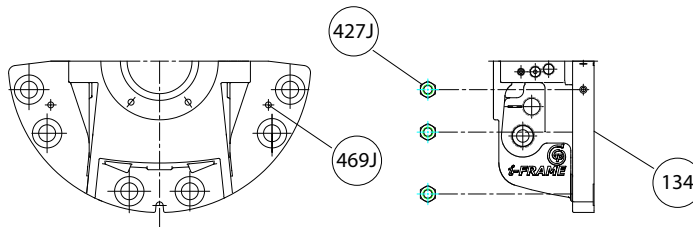
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**NOTICE:**

There is an anti-rotation pin on the lower half of the sleeve bearing (117) at the parting flange of the bearing frame (134).

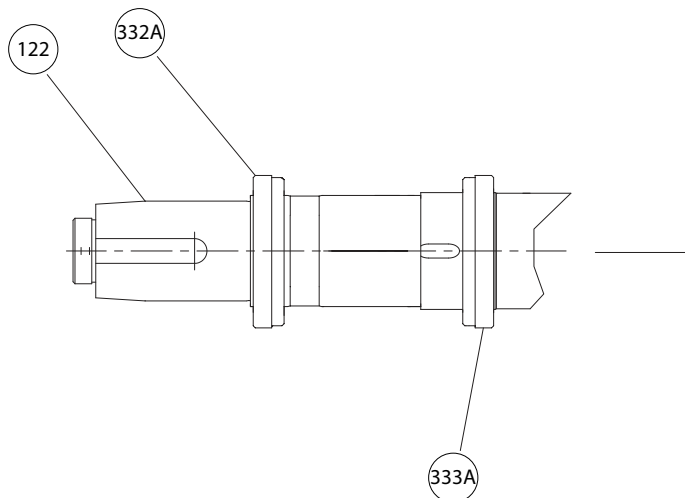
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8. Remove the dowel pins (469J) that hold the lower half of the bearing housing to the casing flange.



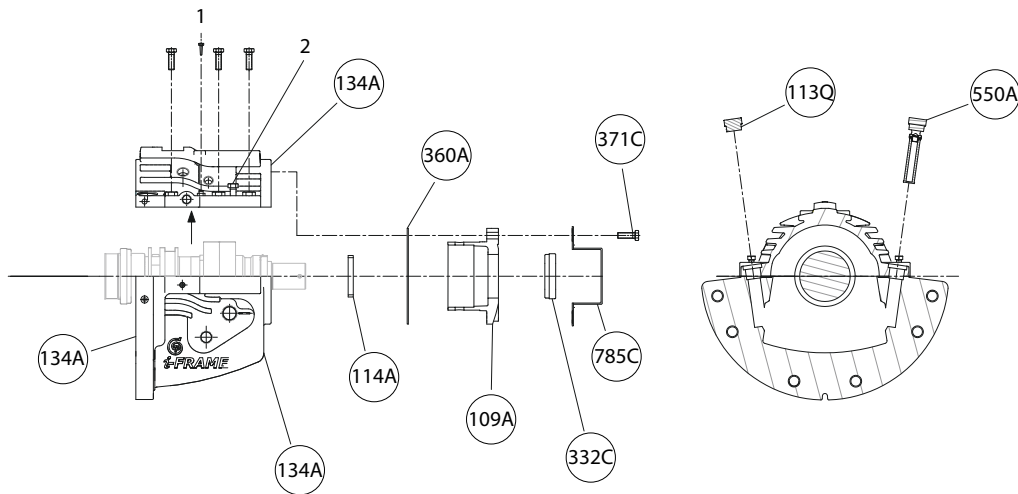
**Figure 44: Dowel pin removal**

9. Loosen and remove the nuts (427J) that hold the bearing housing in place.
10. Rotate the lower half of the sleeve bearing (117) around the shaft (122) in order to remove the bearing from the lower housing.
11. Remove the lower half of the bearing housing.
12. (Optional) Remove the studs (371T).
13. Remove the outboard labyrinth seal (332A) and the inboard labyrinth seal (333A) and oil ring (114).



**Figure 45: Labyrinth seal removal**

## 6.4.7 Disassemble the thrust end (sleeve/ball bearing pumps)



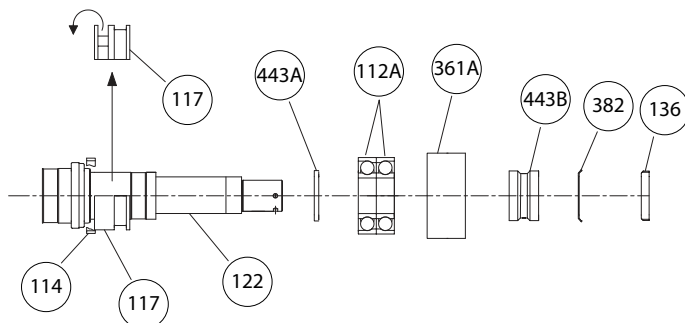
| Item | Description |
|------|-------------|
| 1.   | Taper pin   |
| 2.   | Jack bolt   |

**Figure 46: Thrust end disassembly**

1. Remove the oil filter (550A) and filter plug (113Q) from the bearing housing (134A).
2. If the pump has the optional thrust bearing cooling fan, remove the guard endplate (234E), cowling (785D), cooling fan (392B), and pump endplate (234D).
3. Remove the outboard end cover (109A) and shaft guard (785C), by removing the end cover bolts (371C).  
The bearing housing gasket (360A) and outboard labyrinth seal (332C) will remain on the end cover (109A). Remove the thrust oil ring (114A).
4. Remove the taper pins between the upper and lower halves of the bearing housing (134A).
5. Remove the hex head screws that connect the upper and lower halves of the bearing housing (134A).
6. Tighten the jack bolts in order to separate the housing halves.
7. Remove the top half of the thrust bearing housing (134A).
8. Move the oil ring (114) aside, it cannot be removed until the lower bearing housing is removed.
9. Remove the upper half of the sleeve bearing (117).

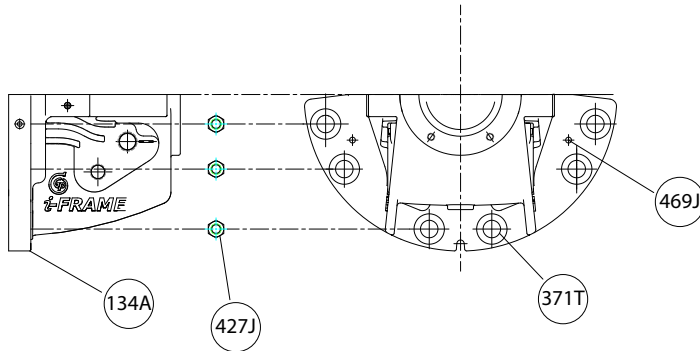
### NOTICE:

There is an anti rotation pin on the lower half of the sleeve bearing (117) at the parting flange of the bearing housing (134A).



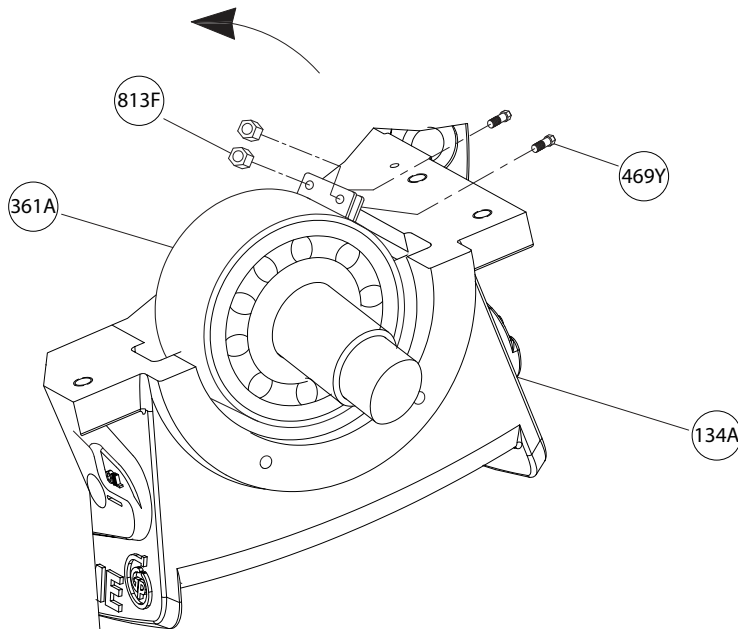
**Figure 47: Sleeve and thrust bearing removal**

10. Remove the dowel pins (469J) that hold the lower half of the bearing housing to the casing flange.



**Figure 48: Dowel pin removal**

11. Loosen the nuts (427J) that hold the bearing housing in place. The bearing housing will rest on the studs.
12. Rotate the lower half of the sleeve bearing (117) around the shaft (122) in order to remove it from the lower bearing housing.
13. Remove the nuts (427J).
14. Remove the lower half of the bearing housing (134A) using a crane. Remove the studs (371T).
15. Bend lockwasher tab to allow removal of the thrust locknut (136) and the lockwasher (382) from the shaft. Remove the thrust locknut (136) and the lockwasher (382) from the shaft.
16. Remove the oil ring sleeve (443B).
17. Remove bearing retainer (361A).



**Figure 49: Bearing retainer removal**

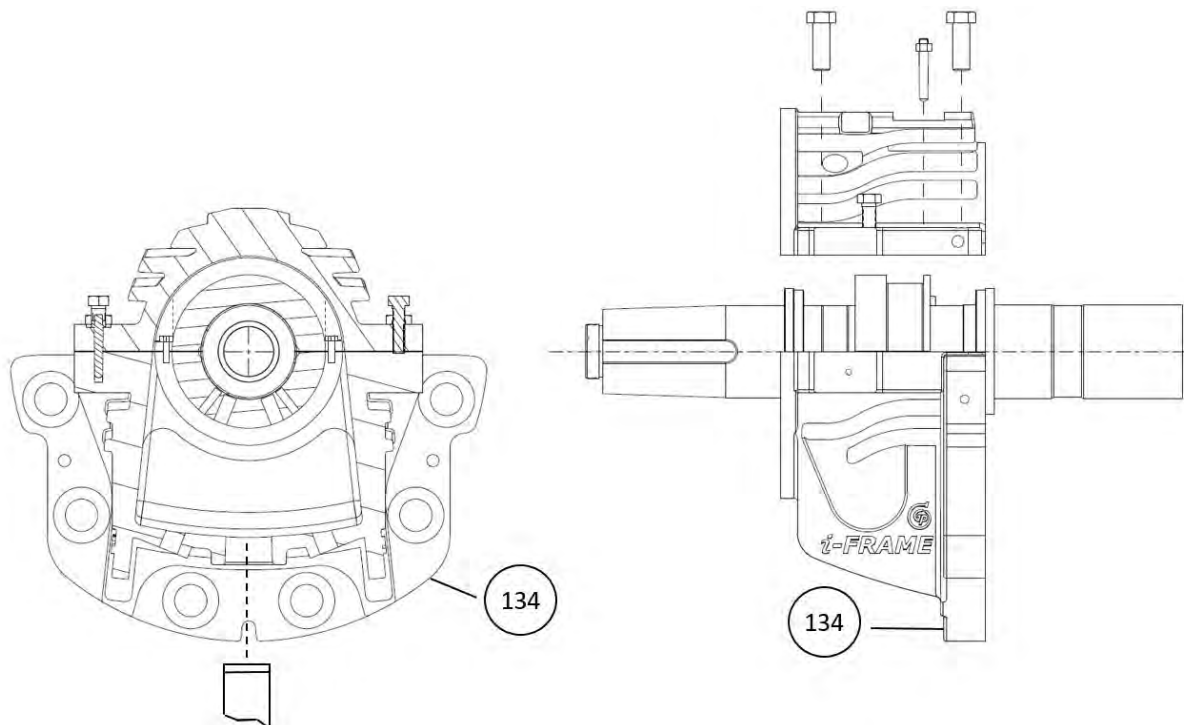
18. Use a bearing puller tool in order to remove the thrust bearing (112A) from the shaft. The inner race on this inner duplex bearing will likely remain on the shaft when the bearing is pulled. Remove this inner race by applying heat. Do this away from the pump site.

**WARNING:**

The pump may handle hazardous and/or toxic liquids. Trapped or undrained liquid can cause explosions when heat is applied. Never apply heat at the pump site for this reason. Heat can also distort machined surfaces.

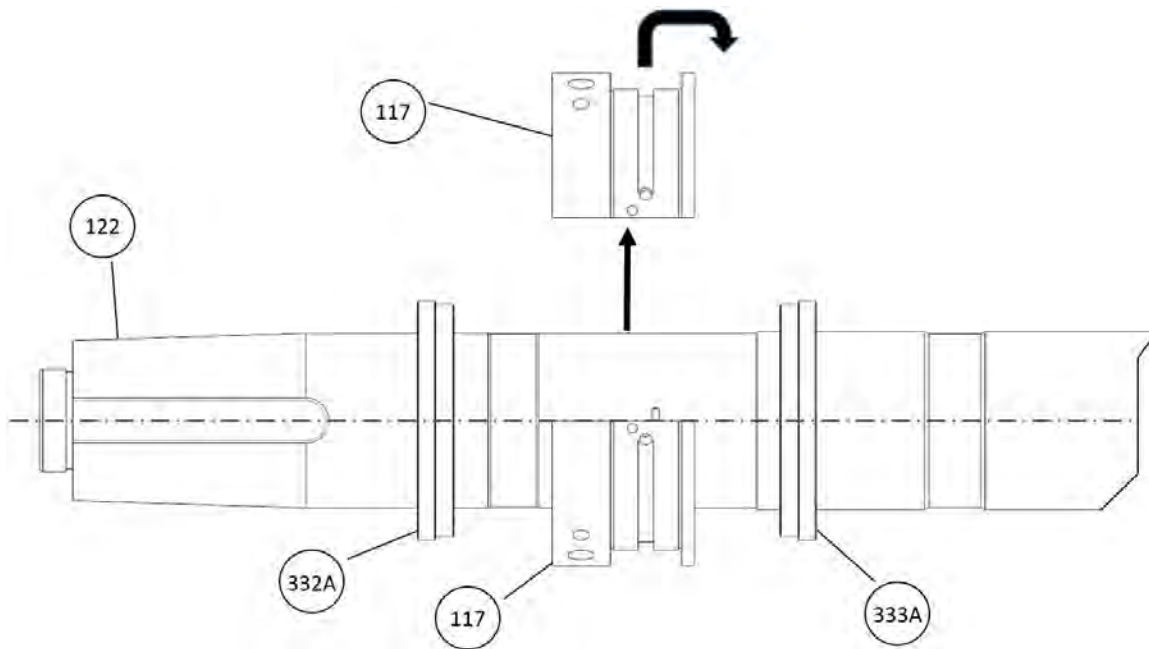
19. If applicable - Remove bearing spacer (443V).
20. Remove the inboard labyrinth seals (333A) and oil ring (114).

### 6.4.8 Disassemble the radial end (sleeve/tilt pumps)



**Figure 50: Radial end (sleeve/tilt) disassembly**

1. Remove all instrumentation from the upper and lower half bearing housing (134). Plug any open connections.
2. Remove oil feed piping from the lower half bearing housing (134).
3. Remove drain piping from the lower half bearing housing (134)
4. Remove the two taper pins between the upper and lower half of the bearing housing (134).
5. Remove the hex cap screws that connect the upper and lower half of the bearing housing (134).
6. Tighten the two jack bolts on the horizontal parting flanges of the bearing housing (134) in order to separate the two halves.
7. Remove the top half of the bearing housing (134).



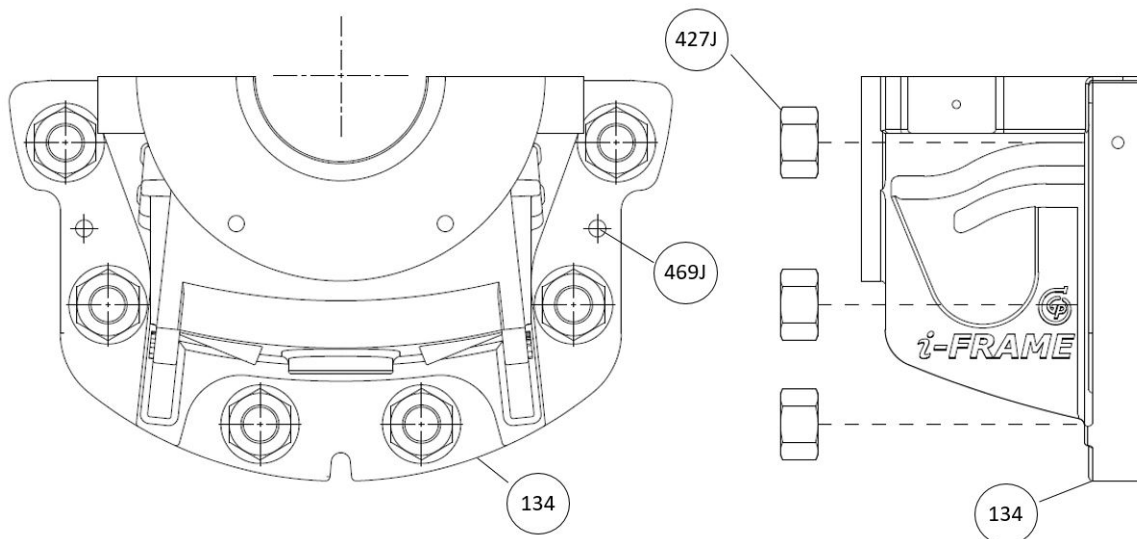
**Figure 51: Radial sleeve bearing removal**

8. Remove the two socket head cap screws that connect the upper and lower halves of the sleeve bearing (117).
9. Remove the upper half of the sleeve bearing (117).

**NOTICE:**

There is an anti-rotation pin on the lower half of the sleeve bearing (117) at the parting flange of the bearing frame (134).

10. Remove the dowel pins (469J) that hold the lower half of the bearing housing to the casing flange.



**Figure 52: Radial dowel pin removal**

11. Loosen and remove the nuts (427J) that hold the bearing housing (134) in place.

12. Rotate the lower half of the sleeve bearing (117) around the shaft (122) in order to remove the bearing from the lower housing.
13. Remove the lower half of the bearing housing (134).
14. Remove the outboard labyrinth seal (332A) and the inboard labyrinth seal (333A).

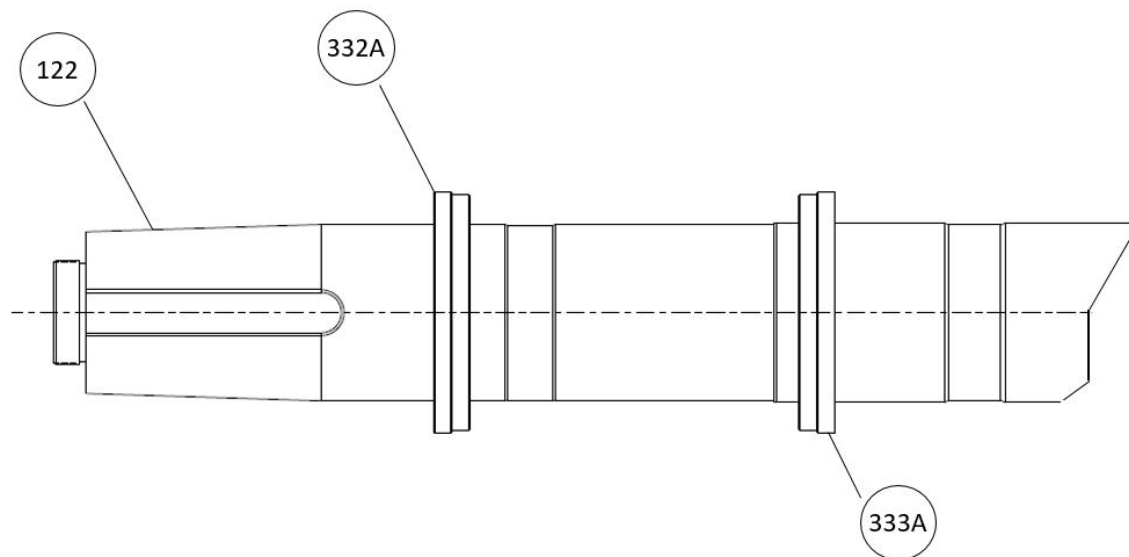


Figure 53: Labyrinth seal removal

### 6.4.9 Disassemble the thrust end (sleeve/tilt pumps)

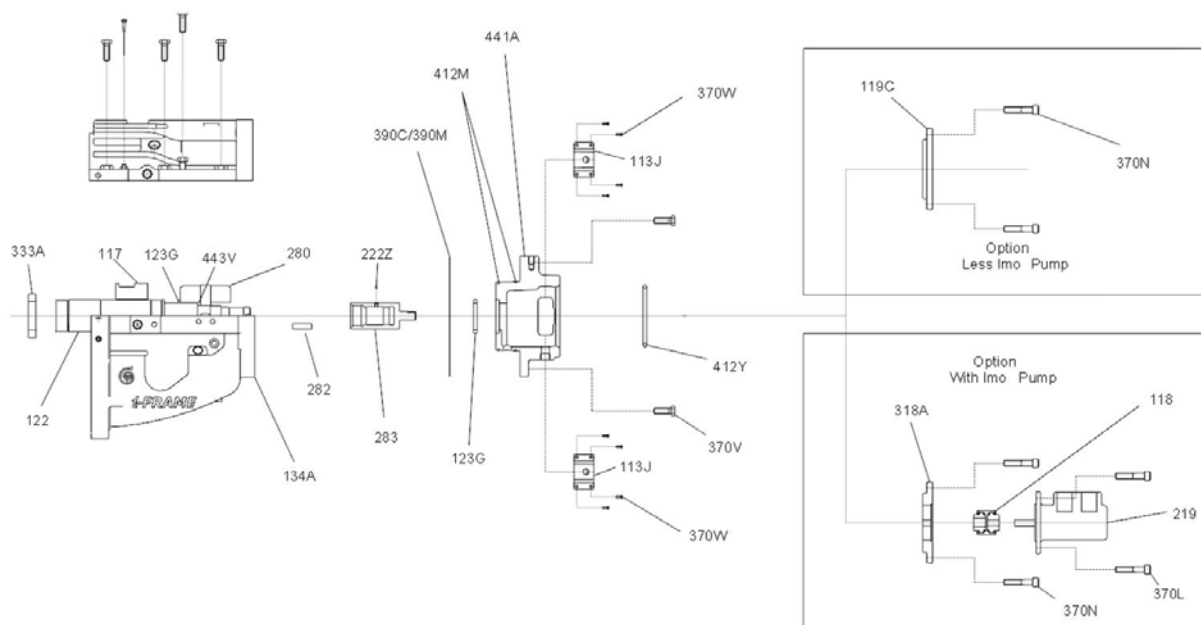


Figure 54: Thrust bearing housing disassembly

1. If the pump is supplied with a main shaft oil pump (219), remove the hex cap screws (370L) and remove the main shaft oil pump (219). Half of the coupling (118) will remain on the main shaft oil pump (219). If the pump was not supplied with a main oil shaft pump (219), go to step 4.
2. Remove the hex cap screws (370N) to remove the oil pump adapter (318A).

3. Remove the other half of the coupling (118) from the pump shaft (122) by removing the set screw located above the key. Remove the coupling key.
4. If the pump was not supplied with a main shaft oil pump (219), remove the hex cap screws (370N) to remove the adapter cover (119C).
5. If the pump was provided with axial proximity probes, remove the connection heads from both sides of the filler plate (441A). The wires to the axial proximity probes will be exited through the cover filler plate (113J). If axial proximity probes were not provided, go to step 8.
6. Remove the hex cap screws (370W) to remove both cover filler plates (113J).
7. Access to remove the axial proximity probes will be through the window on each side of the filler plate (441A). Loosen the nut on the axial proximity probe and unscrew each axial proximity probe from the filler plate (441A). Remove the axial proximity probes from the bearing housing assembly.
8. Remove the hex cap screws (370V) to remove the filler plate (441A). The shim pack (390C/390M) can be removed at the same time. O-rings (412M) will remain on the filler plate (441A).
9. Remove all instrumentation from the upper and lower half bearing housing (134A). Plug any open connections.
10. Remove oil feed piping from the lower half bearing housing (134A).
11. Remove drain piping from the lower half bearing housing (134A).
12. Remove the two taper pins between the upper and lower half of the bearing housing (134A).
13. Remove the hex cap screws that connect the upper and lower half of the bearing housing (134A).
14. Tighten the two jack bolts on the horizontal parting flanges of the bearing housing (134A) in order to separate the two halves.
15. Remove the top half of the bearing housing (134A).
16. Remove the floating oil seal (123G) from the outboard end.
17. Loosen the set screw (222Z) from the thrust collar nut (283). Use the flats on the thrust collar nut (283) to loosen and remove from the shaft (122). Note the thrust collar nut (283) is threaded to tighten against rotation. For CCW pump rotation (when viewed from the drive end) the thrust collar nut (283) has a left hand thread. For CW rotation, the thread is right hand.
18. Remove the floating oil seal (123G) from the inboard end.
19. Remove the inboard and outboard ends of the tilt pad bearing (280). The thrust collar will remain on the shaft.
20. Reassemble the thrust collar nut onto the shaft to hold the thrust collar in place. Tighten to hand tight.
21. Remove the two socket head cap screws that connect the upper and lower halves of the sleeve bearing (117).
22. Remove the upper half of the sleeve bearing (117).

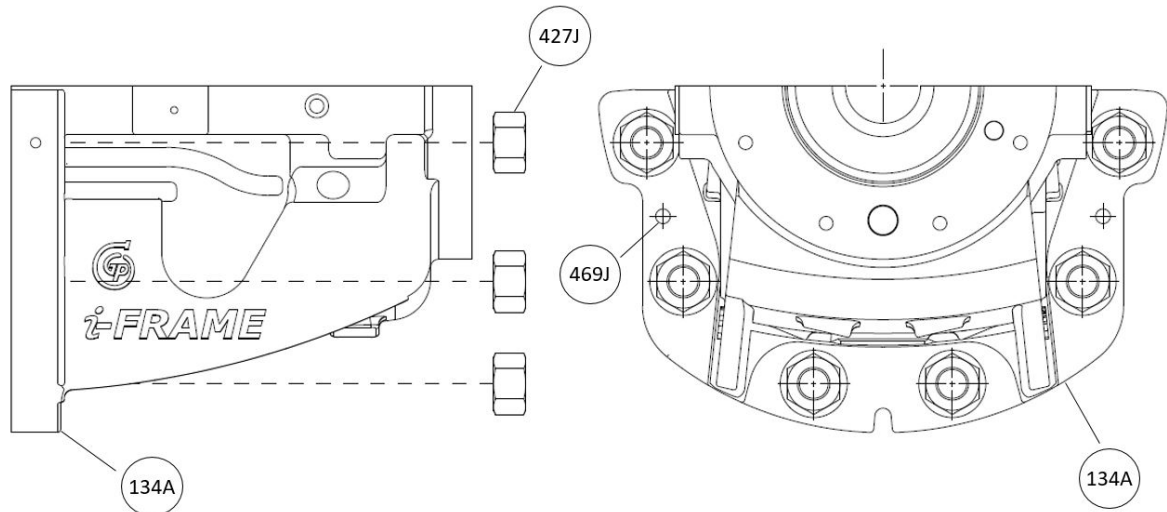
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**NOTICE:**

There is an anti-rotation pin on the lower half of the sleeve bearing (117) at the parting flange of the bearing frame (134A).

- 
23. Remove the dowel pins (469J) that hold the lower half of the bearing housing to the casing flange.





**Figure 55: Thrust dowel pin removal**

24. Loosen and remove the nuts (427J) that hold the bearing housing (134A) in place.
25. Rotate the lower half of the sleeve bearing (117) around the shaft (122) in order to remove the bearing from the lower housing.
26. Remove the lower half of the bearing housing (134A).
27. Remove the thrust collar nut (283) to remove the thrust collar, thrust collar key (282), and bearing spacer (443V).
28. Remove the inboard labyrinth seal (333A).

## 6.4.10 Guidelines for i-ALERT<sup>®</sup>2 Equipment Health Monitor disposal

### Precautions



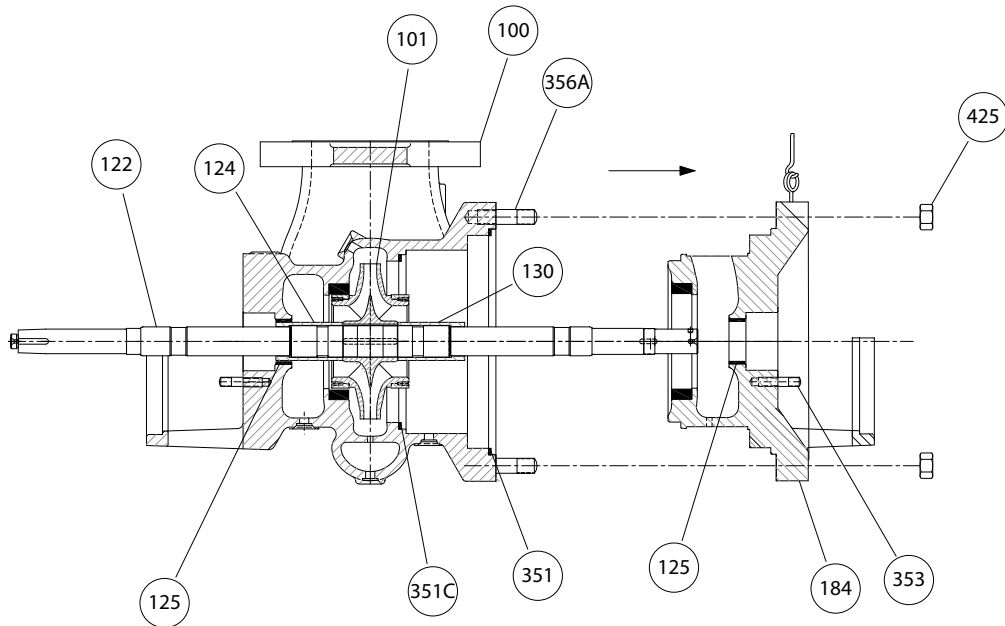
#### WARNING:

- Explosive hazard and risk of personal injury. Heating to high temperatures could cause combustion of the condition monitor. Never heat the condition monitor to temperatures in excess of 149°C | 300°F or dispose of in a fire.

### Guidelines

This product contains Lithium Thionyl Chloride. Contact your local waste management companies to provide assistance in the disposal of the device that contain this type of battery.

### 6.4.11 Disassemble the rotating assembly



**Figure 56: Head removal**

1. Loosen and remove the head to case nuts (425).
2. Use the jackscrews provided with the pump in order to loosen the head (184) from the casing (100).



**WARNING:**

Risk of severe physical injury or death from explosion of trapped liquid. Never use heat to remove parts unless explicitly stated in this manual.

3. Push the shaft assembly towards the radial end until it stops. Maintain this position until the next step is completed.
4. Insert eyebolts (not supplied) in the pre-drilled threaded holes in the top outside perimeter of the head.



**WARNING:**

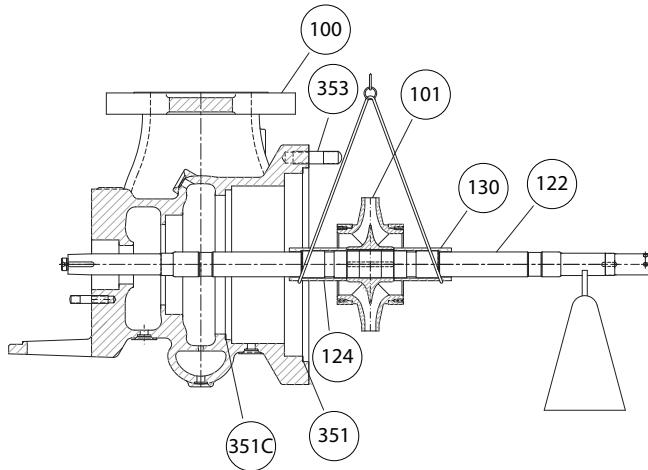
Use the eyebolts to lift only the head. They will not support the weight of the entire pump.

5. Slide the head out of the pump without the rotor.
6. Remove the head (184) from the casing (100) to the work area.
7. Use a sling in order to pull the shaft out of the pump only as far as the radial end is still supported by the radial end throat bushing (125).



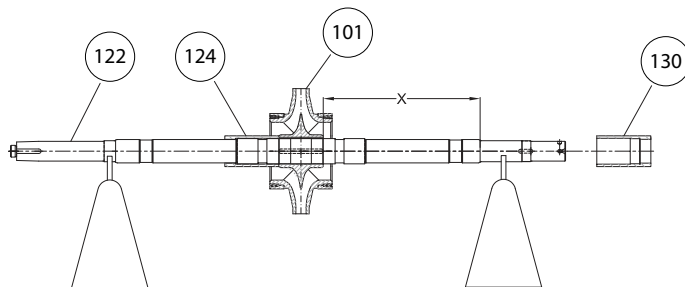
**CAUTION:**

Support the thrust end of the shaft before you position the slings to remove the rotor.



**Figure 57: Lifting rotating element using sling**

8. Reposition the slings around the impeller (101) on the locknuts (124 and 130).
9. Pull the rotor out of the pump.
10. Remove the casing gaskets (351 and 351C).
11. Remove the thrust end impeller locknut (130).  
You do not need to remove the radial locknut (124) from the shaft unless you plan to replace either the radial locknut or the shaft.



**Figure 58: Rotor disassembly**

12. Measure and record the X dimension where indicated in the figure.  
This value is required for the correct positioning of the impeller in the casing at reassembly. The X dimension is pre-set at the factory. Refer to the Impeller setting table.

This table shows the factory settings for positioning the impeller. The X dimension is given in millimeters | inches. These dimensions are not applicable to other size groups.

| Size | Radial Bearing | Size                     | Ball/Ball Arrangement | Sleeve/Ball Arrangement | Sleeve/Tilt Pad Arrangement |
|------|----------------|--------------------------|-----------------------|-------------------------|-----------------------------|
|      |                |                          |                       |                         |                             |
| 10D  | 6309           | All                      | 342   13.49           | NA                      |                             |
| 20G  | 6312           | All                      | 333   13.11           | NA                      |                             |
| 21G  |                | 10X12-17SQ<br>10X12-18SQ | 418   16.45           | NA                      |                             |
| 30H  | 6313           | All                      | 386   15.20           | TBD                     |                             |

| Size | Radial Bearing | Size       | Ball/Ball Arrangement              | Sleeve/Ball Arrangement | Sleeve/Tilt Pad Arrangement |
|------|----------------|------------|------------------------------------|-------------------------|-----------------------------|
|      |                |            | X <sup>1</sup> Dimension mm   inch |                         |                             |
| 31H  |                | 14X18-20Q  | 405   15.94                        | TBD                     |                             |
| 40N  | 6318           | All others | 414   16.32                        | TBD                     |                             |
|      |                | 18X20-21A  | 451   17.76                        | TBD                     |                             |
| 50Q  | 6320           | All        | 402   15.82                        | TBD                     |                             |
| 52Q  |                | All others | 520   20.46                        | TBD                     |                             |
|      |                | 20X24-25A  | 559   22.00                        | TBD                     |                             |
| 54Q  | 6224           | 14X20-26A  | 498   19.61                        | TBD                     |                             |
|      |                | 14X20-30A  | 524   20.61                        | TBD                     |                             |
| 58Q  | 6320           | All        | 571   22.49                        | NA                      |                             |

X<sup>1</sup> - Includes spacer (443V) if applicable

- Remove the impeller (101).

## 6.5 Preassembly inspections

### 6.5.1 Replacement guidelines

#### Casing check and replacement



**WARNING:**

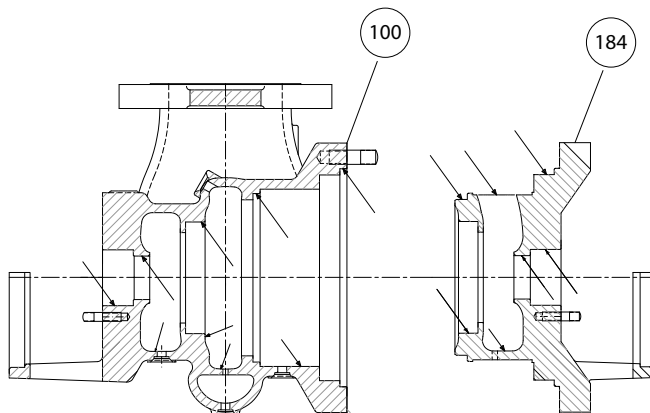
Risk of death or serious injury. Leaking fluid can cause fire and/or burns. Inspect and ensure gasket sealing surfaces are not damaged and repair or replace as necessary.

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

Repair or replace these parts if you notice any of these conditions:

#### Casing areas to inspect

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



**Figure 59: Case and head inspection**

#### Impeller replacement

This table shows the criteria for replacing the impeller:

| Impeller parts     | When to replace  |
|--------------------|--|
| Impeller vanes     | <ul style="list-style-type: none"> <li>When grooved deeper than 1.6 mm   1/16 in., or</li> <li>When worn evenly more than 0.8 mm   1/32 in.</li> </ul> |
| Pumpout vanes      | When worn or bent more than 0.8 mm   1/32 in.  |
| Vane edges         | When you see cracks, pitting, or corrosion damage  |
| Wear ring surfaces | When the clearance to the casing wear ring has increased by 50% over the values in the Minimum running clearances table                                |

### Impeller checks

---

#### **NOTICE:**

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

---

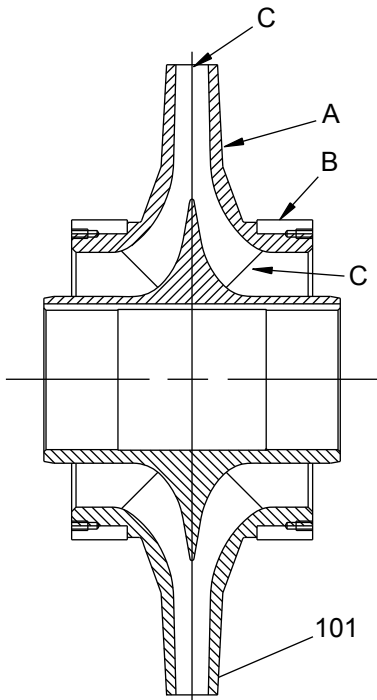
- Check and clean the impeller bore diameter.
  - Check the impeller balance. Rebalance the impeller if it exceeds ISO 1940-1, grade G2.5.
- 

#### **NOTICE:**

You must have extremely accurate tooling equipment to balance impellers to ISO 1940-1, grade G2.5. Do not attempt to balance impellers to this criteria unless this type of tooling and equipment is available.

---

**Impeller areas to inspect**



- A. Shroud
- B. Wear ring
- C. Vane

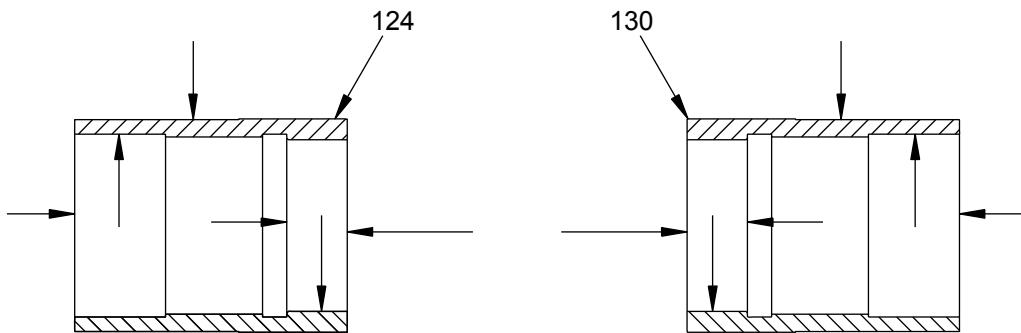
**Figure 60: Impeller inspection**

**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.

**Impeller locknut areas to inspect**

Locknut surfaces must be smooth and free of grooves and scratches, especially in the areas indicated by arrows in the figure. Also check the outside diameter of the locknuts.



**Figure 61: Impeller locknut inspection**

### Cartridge mechanical seal replacement

Cartridge-type mechanical seals should be serviced by the seal manufacturer. Refer to the instructions from the mechanical seal manufacturer for assistance.

### Coupling guard replacement

Repair or replace the coupling guard if you notice corrosion or other defects.

### 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.

- Replace all gaskets and O-rings at each overhaul and disassembly.
- Inspect the seats. They must be smooth and free of physical defects.
- In order to repair worn seats, skin cut them in a lathe while you maintain dimensional relationships with other surfaces.
- Replace parts if the seats are defective.

### Fasteners



#### **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.

### Additional parts

Inspect and either repair or replace all other parts, if inspection indicates continued use would be harmful to satisfactory and safe pump operation.

Inspection must include these items:

- Bearing end covers (109A, 160 and 360A)
- Labyrinth seals (332A, 333A and 332C)
- Bearing locknut (136)
- Impeller key (178) and coupling key (400)
- Bearing lockwasher (382)
- All nuts, bolts, and screws

## 6.5.2 Shaft replacement guidelines

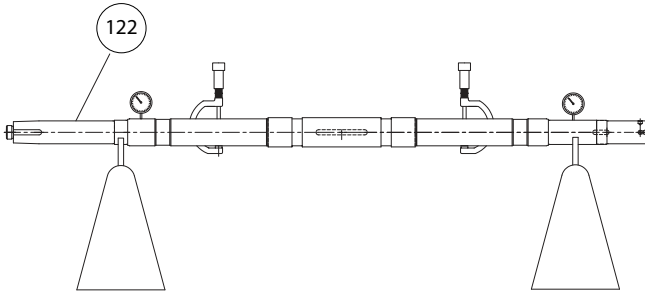
### Shaft measurement check

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 62: Shaft inspection**

**Shaft surface check**

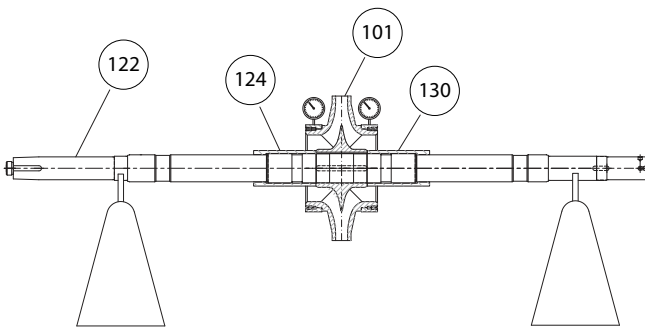
Check the shaft surface for damage. Replace the shaft if it is damaged beyond reasonable repair.

**Rotor**

Allowable runouts of the fully assembled rotor are listed in the Shaft and rotor runout requirements table.

**Table 2: Shaft and rotor runout requirements**

| Characteristic                                       | Requirement                                    |
|--|--|
| Flexibility factor, $L^4/D^2$                        | $>1.9 \times 10^9$ mm   $>3.0 \times 10^6$ in. |
| Allowable shaft runout, TIR                          | 25 micrometers   0.0010 in.                    |
| Component fit to shaft                               | Clearance                                      |
| Allowable rotor radial runout, TIR*                  | 76 micrometers   0.003 in.                     |
| *Total indicated runout of impeller hubs and sleeves |  |



**Figure 63: Fully assembled rotor**

**6.5.3 Bearings inspection**

**Condition of bearings**

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



## 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.

## Replacement bearings

Replacement bearings must be the same as, or equivalent to, those listed in this table.

### NOTICE:

Thrust bearings must have machined bronze cages (retainers).

Bearing numbers are based on SKF designations.

| Size | Radial Bearing | Thrust Bearing | Bearing Housing Bore<br>mm   inch           | Shaft Turn Thrust<br>mm   inch           | Shaft Turn Radial<br>mm   inch           |
|------|----------------|----------------|---|--|--|
| 10D  | 6309           | 7309           | 100.841   3.9701<br>to<br>100.788   3.9680  | 45.014   1.7722<br>to<br>45.004   1.7718 | 45.014   1.7722<br>to<br>45.004   1.7718 |
| 20G  | 6312           | 7312           | 131.025   5.1585                            | 60.014   2.3628                          | 60.014   2.3628                          |
| 21G  |                |                | to<br>130.963   5.1560                      | to<br>60.002   2.3623                    | to<br>60.002   2.3623                    |
| 30H  | 6313           | 7313           | 140.829   5.5445                            | 65.016   2.5597                          | 65.016   2.5597                          |
| 31H  |                |                | to<br>140.767   5.5420                      | to<br>65.004   2.5592                    | to<br>65.004   2.5592                    |
| 40N  | 6318           | 7318           | 192.095   7.5628<br>to<br>192.0241   7.5600 | 90.017   3.5440<br>to<br>90.003   3.5434 | 90.017   3.5440<br>to<br>90.003   3.5434 |
| 50Q  | 6320           | 7320           | 215.972   8.5028                            | 100.017   3.9377                         | 100.017   3.9377                         |
| 52Q  |                |                | to<br>215.900   8.5000                      | to<br>100.003   3.9371                   | to<br>100.003   3.9371                   |
| 58Q  | 6224           |                |   |  | 120.017   4.7251                         |
| 54Q  |                |                |   |  | to<br>120.003   4.7245                   |

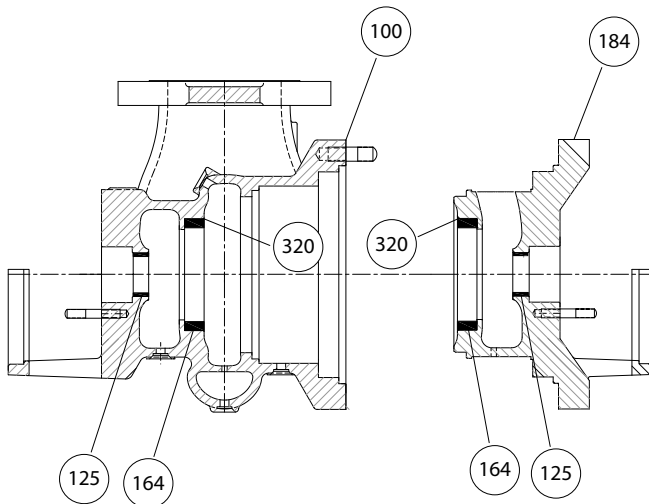
## Bearing housings

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.
- Check the bearing housing bores against the values in the Ball bearing fits table.
- Repair or replace housings as necessary.

## 6.5.4 Replace the wear parts

### 6.5.4.1 Replace the case wear rings and throat bushings



**Figure 64: Wear rings and bushing replacement**

The wear rings and bushings (164, 125) are held in place by a press fit and three tack welds or three setscrews.

1. Remove the wear ring / bushing:
  - a) Grind out the tack weld or if applicable remove setscrews.
  - b) Press the wear ring / bushing out of the mating components bore.
2. Install the wear ring / bushing:
  - a) Thoroughly clean the bushing fit in the mating components bore.
  - b) Chill the new wear ring / bushing using dry ice or other suitable chilling substance, and install the wear ring / bushing into the fit of the mating component.

Be prepared to tap the wear ring / bushing in place with a hardwood block or soft-faced hammer.



#### **WARNING:**

Dry ice and other chilling substances can cause physical injury. Contact the supplier for information and advice for proper handling precautions and procedures.

- c) Tack weld the wear ring / bushing in place at three equidistant places.
  - d) If using setscrews to secure the wear rings / bushings, locate, drill, and tap three new setscrew holes equally spaced between the original holes in each new wear ring / bushing and wear ring / bushing seat area. Install setscrews and upset threads.
3. Confirm the bore diameter of the wear rings / bushings after installation.
4. Check the wear-ring (164) runout and distortion by measuring the bore at each tack weld / setscrew location with inside micrometers or vernier calipers. Machine any distortion in excess of 0.08 mm | 0.003 in. prior to trimming the new impeller wear ring (142), if supplied.



#### **CAUTION:**

Excessive machining can damage ring fits and render parts unusable.

### 6.5.4.2 Replace the impeller wear rings

The impeller wear rings (142) are held in place by a press fit and three setscrews (320).

1. Remove the impeller wear rings:
  - a) Remove the setscrews.
  - b) Remove the wear rings from the impeller (101). Use suitable pry or puller tools to force the rings from the fits.

You can also machine the rings for removal.




---

#### CAUTION:

Excessive machining can damage ring fits and render parts unusable.

---

2. Install the impeller wear rings:
  - a) Thoroughly clean the wear-ring seats, and make sure that they are smooth and free of scratches.
  - b) Heat the new impeller wear rings to 132°C–143°C | 180°F–200°F using a uniform method for heating, such as an oven, and place them on the impeller (101) wear-ring seats.

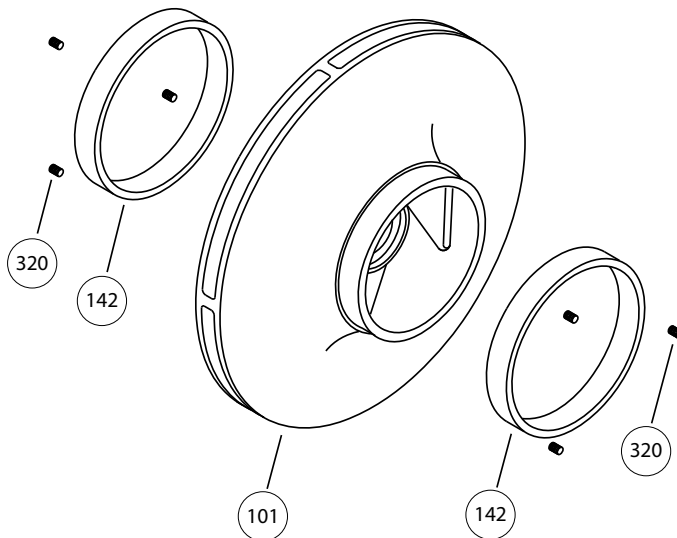



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#### WARNING:

Wear insulated gloves when you handle rings. Rings will be hot and can cause physical injury.

---



**Figure 65: Wear ring replacement**

- c) Locate, drill, and tap three new setscrew holes equally spaced between the original holes in each new ring and ring seat area.
  - d) Install the setscrews (320) and upset threads.
3. Turn the impeller wear ring (142) to size after you mount it on the impeller (101).

**NOTICE:**

⚠ 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.

All replacement impeller wear rings, except those that are hard-faced, are supplied 0.508 mm to 0.762 mm | 0.020 in. to 0.030 in. oversize. See the table Minimum running clearances for final running clearances. Machine the impeller rings accordingly.

Spare hard-faced impeller wear rings are not supplied oversize but are supplied to pre-established proper running clearances when both impeller and casing wear rings are renewed.

When the impeller assembly is supplied as a spare part (impeller with wear rings), the wear rings are machined to the required dimension.

### 6.5.4.3 Minimum running clearances

#### Impeller wear rings

Replace wear rings when the diametrical clearance exceeds 1.5X the values shown in this table or when the hydraulic performance has decreased to unacceptable levels:

| Diameter of rotating member at clearance |                  | Minimum diametrical clearance |       |
|--|------------------|-------------------------------|-------|
| mm                                       | in.              | mm                            | in.   |
| <50.00                                   | <2.000           | 0.25                          | 0.010 |
| 50.00 to 64.99                           | 2.000 to 2.4999  | 0.28                          | 0.011 |
| 65.00 to 79.99                           | 2.500 to 2.999   | 0.30                          | 0.012 |
| 80.00 to 89.99                           | 3.000 to 3.499   | 0.33                          | 0.013 |
| 90.00 to 99.99                           | 3.500 to 3.999   | 0.36                          | 0.014 |
| 100.00 to 114.99                         | 4.000 to 4.499   | 0.38                          | 0.015 |
| 115.00 to 124.99                         | 4.500 to 4.999   | 0.41                          | 0.016 |
| 125.00 to 149.99                         | 5.000 to 5.999   | 0.43                          | 0.017 |
| 150.00 to 174.99                         | 6.000 to 6.999   | 0.46                          | 0.018 |
| 175.00 to 199.99                         | 7.000 to 7.999   | 0.48                          | 0.019 |
| 200.00 to 224.99                         | 8.000 to 8.999   | 0.51                          | 0.020 |
| 225.00 to 249.99                         | 9.000 to 9.999   | 0.53                          | 0.021 |
| 250.00 to 274.99                         | 10.000 to 10.999 | 0.56                          | 0.022 |
| 275.00 to 299.99                         | 11.000 to 11.999 | 0.58                          | 0.023 |
| 300.00 to 324.99                         | 12.000 to 12.999 | 0.61                          | 0.024 |
| 325.00 to 349.99                         | 13.000 to 13.999 | 0.63                          | 0.025 |
| 350.00 to 374.99                         | 14.000 to 14.999 | 0.66                          | 0.026 |
| 375.00 to 399.99                         | 15.000 to 15.999 | 0.69                          | 0.027 |
| 400.00 to 424.99                         | 16.000 to 16.999 | 0.71                          | 0.028 |
| 425.00 to 449.99                         | 17.000 to 17.999 | 0.74                          | 0.029 |
| 450.00 to 474.99                         | 18.000 to 18.999 | 0.76                          | 0.030 |
| 475.00 to 499.99                         | 19.000 to 19.999 | 0.79                          | 0.031 |
| 500.00 to 524.99                         | 20.000 to 20.999 | 0.81                          | 0.032 |
| 525.00 to 549.99                         | 21.000 to 21.999 | 0.84                          | 0.033 |
| 550.00 to 574.99                         | 22.000 to 22.999 | 0.86                          | 0.034 |
| 575.00 to 599.99                         | 23.000 to 23.999 | 0.89                          | 0.035 |

| Diameter of rotating member at clearance |                  | Minimum diametrical clearance |       |
|--|------------------|-------------------------------|-------|
| 600.00 to 624.99                         | 24.000 to 24.999 | 0.91                          | 0.036 |
| 625.00 to 649.99                         | 25.000 to 25.999 | 0.94                          | 0.037 |

For diameters greater than 649.99 mm | 25.999 in., the minimum diametrical clearances shall be 0.94 mm | 0.037 in. plus 1 mm for each additional 1 mm | 0.001 inch for each additional inch of diameter or fraction thereof .

## 6.6 Reassembly


### 6.6.1 Assemble the rotating element



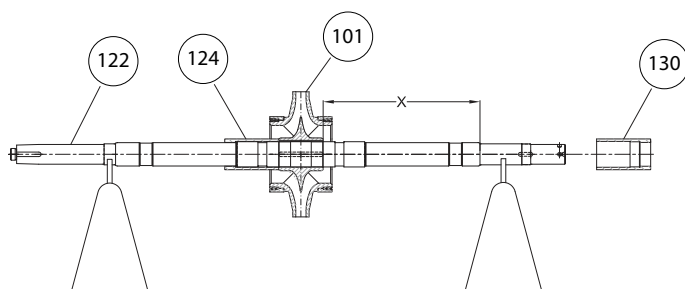
#### WARNING:

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.

#### NOTICE:

- Make sure that all parts and threads are clean and that you have followed all directions under the Preassembly inspections section.
-  Check for magnetism on the pump shaft and demagnetize the shaft if there is any detectable magnetism. Magnetism attracts ferritic objects to the impeller, seal, and bearings which can result in excessive heat generation, sparks, and premature failure.

1. Assemble the impeller onto the shaft. The impeller is a slip fit onto the shaft (0.0127 mm to 0.0508 mm | 0.0005 in. to 0.002 in. clearance). Position the impeller to the X value recorded during disassembly, or refer to the Impeller setting table in the Disassembly section. Apply a liberal amount of an anti-seize compound onto the shaft.



**Figure 66: Rotor assembly**

2. Assemble the impeller locknuts.

One locknut has a right-hand thread, the other one has a left-hand thread.

If this is a repair, it is likely that only one locknut was removed. Keep the second locknut on the shaft in order to maintain the impeller centering. Use the previously recorded dimension from the bearing shoulder to the face of the impeller hub, or refer to the Impeller setting table in the Disassembly section.

**NOTICE:**

Make sure the threads are clean. Deburr if necessary. Apply an anti-seize compound to the threads.

3. Install the impeller wear ring (142).  
See Replace the wear rings in the Preassembly inspections section.
4. Install the casing and head wear rings (164).  
See Replace the wear rings in the Preassembly inspections section.
5. Install the throat bushings (125).  
See Replace the throat bushings in the Preassembly inspections section.

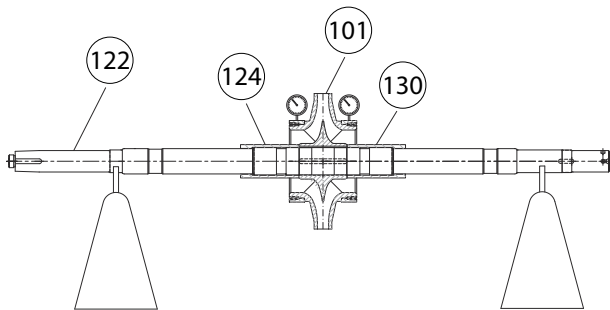
**NOTICE:**

⚠ 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.

6. Measure the TIR on the impeller wear rings, impeller locknuts, and bearing fits.

The shaft is the datum point. Measure the runout of wear rings and impeller nuts to the shaft with a dial indicator.

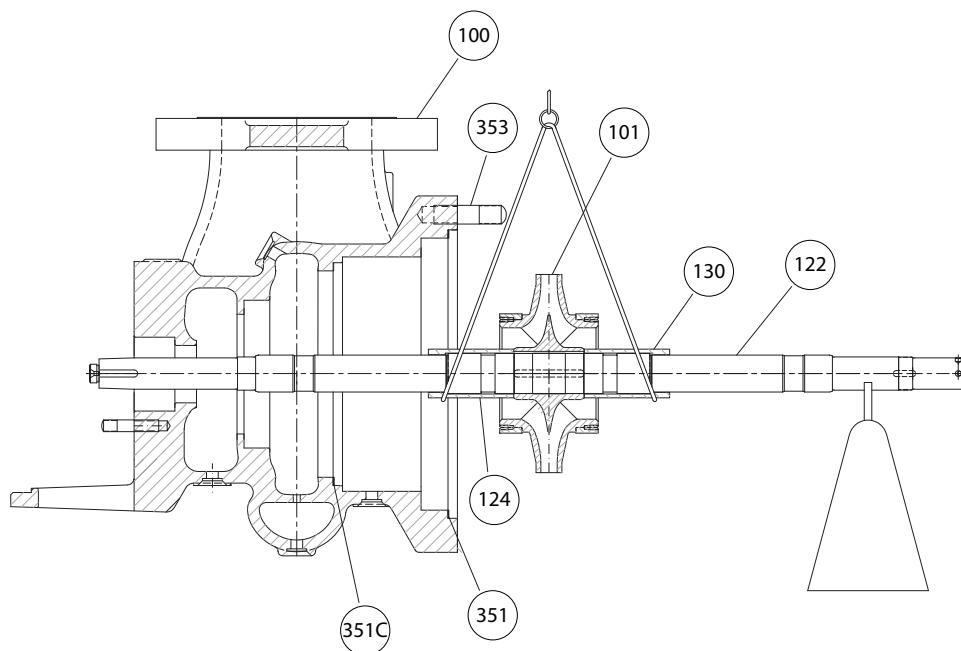
API limits are listed in the Shaft and rotor runout requirements table.



**Figure 67: Rotor preassembly inspection**

### 6.6.2 Install the rotating element assembly

1. Use straps and a crane to insert the rotating element into the casing. Use precaution to not scuff the impeller (101), impeller nuts (124) and (130), or throat bushing surface.
  - a) Insert the rotating element enough to support the radial end of the shaft in the throat bushing bore of the casing (100). This will prevent the pump from slipping and causing possible human injury.
  - b) Reposition the straps and slide the rotating element the remainder of the way into the casing (100).

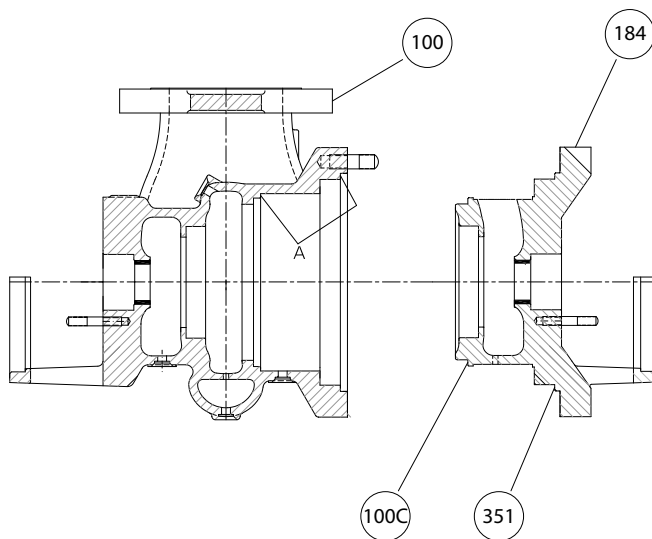


**Figure 68: Lifting rotating element using sling**

**NOTICE:**

Make sure to position the shaft fully into the radial end of the pump before starting the head-to-casing assembly. This prevents damage to the internal components.

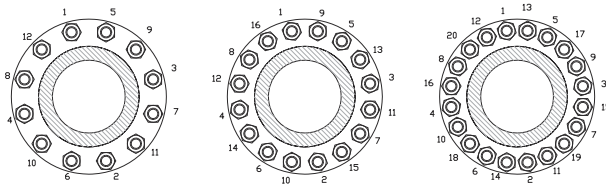
2. Assemble new inner (351C) and head (351) gaskets on the head (184). Apply a liberal amount of high-vacuum grease to hold the gaskets in place.



**Figure 69: Gasket assembly**

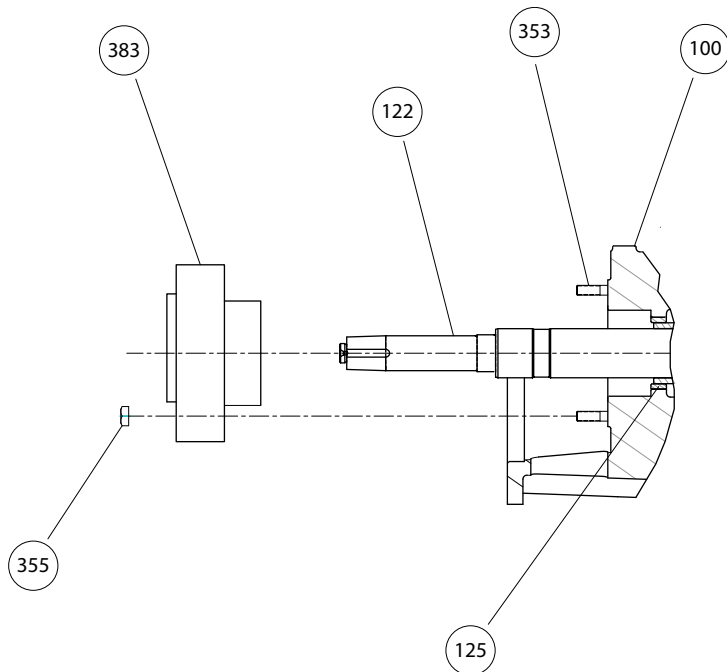
3. Spray grease or lubrication on the casing sealing fits (A).
4. Use straps and a crane assembly to assemble the head (184) into the casing (100).
5. Torque the head bolts to the values found in the maximum torque values for fasteners table as detailed below.
  - a) Apply LPS (or equivalent) Nickel or Moly anti-seize compound to the studs (356A) and to the face of the head (184) where the nuts (425) make contact.

- b) Install a nut (425) on each stud (356A).
- c) Mark each stud (356A) as shown below.



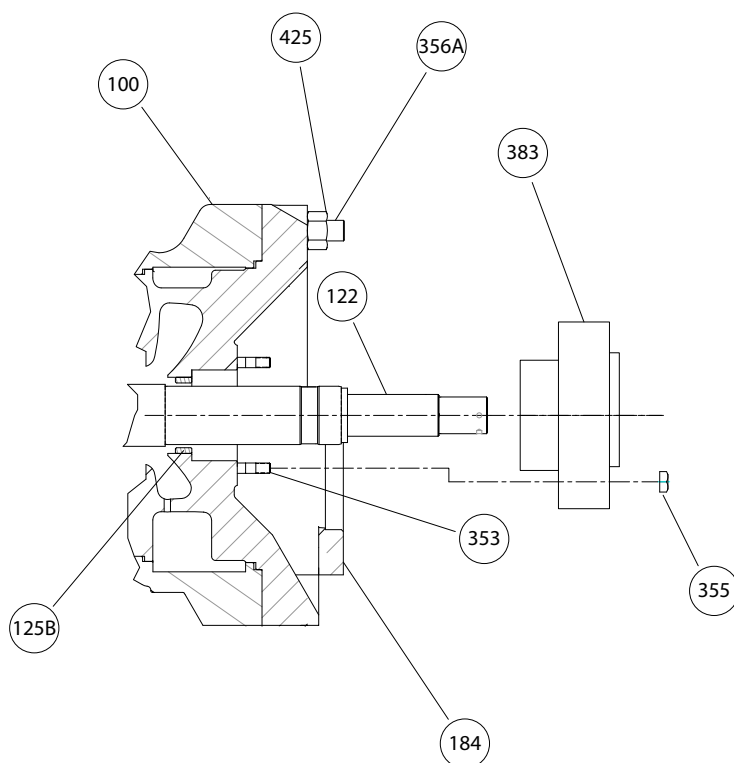
**Figure 70: Stud marking**

- d) Tighten the nuts (425) to 30% full torque using the star pattern shown starting with stud (356A) no. 1.
  - e) Tighten the nuts (425) to 60% full torque using the star pattern shown starting with stud (356A) no. 1.
  - f) Tighten the nuts (425) to 100% full torque using the star pattern shown starting with stud (356A) no. 1.
  - g) Tighten the nuts (425) to 100% full torque using a clockwise sequential process starting with stud (356A) no. 1.
6. Mount the cartridge mechanical seal (383) on the shaft (122). Do not tighten the gland nuts (355) at this time.



**Figure 71: Mount the cartridge mechanical seal on the radial end**





**Figure 72: Mount the cartridge mechanical seal on the thrust end**

### 6.6.2.1 Confirm the seal chamber runout

The bearing housings are doweled to the head (184) and casing (100) during the original build. However, in order to assure the correct running position of the shaft, use this procedure in order to confirm the seal chamber runout before you install the cartridge mechanical seals:

1. Install the old bearings on the shaft and bolt the bearing housings to the casing and head.
2. Mount the dial indicator on the shaft (122). Rotate the shaft (122) so that the indicator rides along the seal chamber bore for 360°.
3. If the total indicator reading exceeds 0.127 mm | 0.005 in., determine the cause and make corrections.  
It may be necessary to readjust the housing.
  - a) Remove the dowel pins and use the adjusting screws to bring the runout to within 0.0508 mm | 0.002 in.
  - b) Redowel the housings in a different location.
4. Check the seal-chamber face runout.
  - a) With a dial indicator mounted on the shaft, rotate the shaft so that the indicator rides along the seal-chamber face for 360°.
  - b) If the total indicator reading exceeds the allowable runout as this table shows, determine the cause and make corrections.

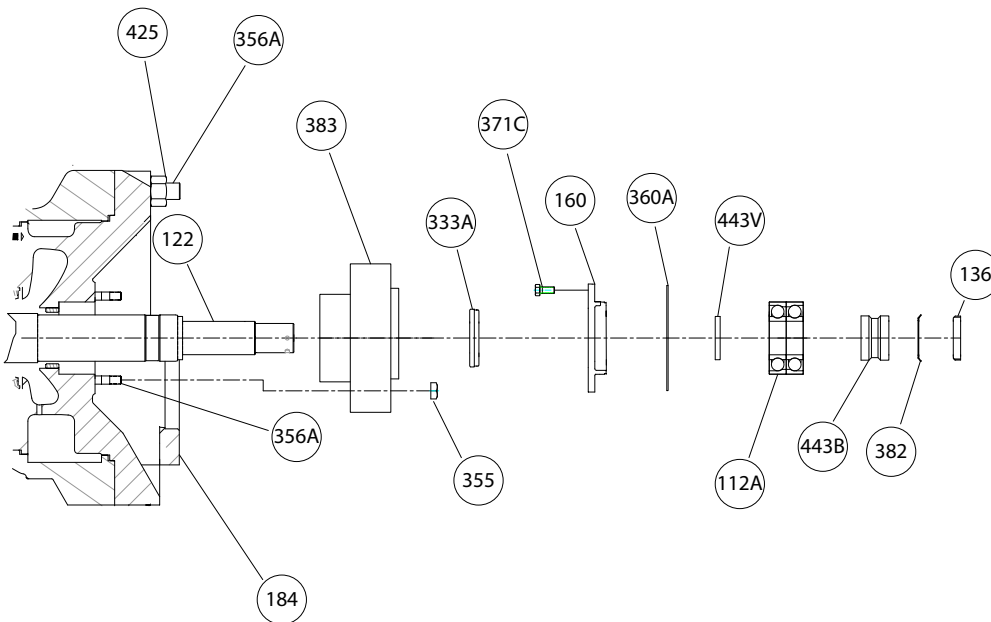
| Pump Size Group | Radial bearing | Thrust bearing | Maximum Allowable Total Indicated Runout |
|-----------------|----------------|----------------|--|
|                 |                |                | mm   inch                                |
| 13D/15D         | 6309           | 7309/BECBM     | 0.0508   0.0020                          |
| 22G             | 6312           | 7312/BECBM     | 0.0635   0.0025                          |
| 33H             | 6313           | 7313/BECBM     | 0.0762   0.0030                          |

| Pump Size Group | Radial bearing | Thrust bearing | Maximum Allowable Total Indicated Run-out<br>mm   inch |
|-----------------|----------------|----------------|--|
| 43N             | 6318           | 7318/BECBM     | 0.0889   0.0035  |
| 53Q/55Q         | 6320           | 7320/BECBM     | 0.0889   0.0035  |
| 59Q             | 6224           | 7320/BECBM     | 0.0889   0.0035  |

| Size | Seal Chamber Bore<br>mm   inch | Maximum Allowable Total Indicated Runout<br>mm   inch |
|------|--------------------------------|---|
| 10D  | 100.0   3.937                  | 0.050   0.0020  |
| 20G  | 130.0   5.118                  | 0.065   0.0025  |
| 21G  | 160.0   6.299                  | 0.080   0.0031  |
| 30H  | 160.0   6.299                  | 0.080   0.0031  |
| 31H  | 170.0   6.693                  | 0.085   0.0033  |
| 40N  | 170.0   6.693                  | 0.085   0.0033  |
| 50Q  | 180.0   7.087                  | 0.090   0.0035  |
| 52Q  | 180.0   7.087                  | 0.090   0.0035  |
| 54Q  | 200.0   7.874                  | 0.010   0.004   |
| 58Q  | 190.0   7.481                  | 0.095   0.0037  |

- Remove the dowel pins and unbolt the bearing housings. Discard the old bearings.

### 6.6.3 Assemble the thrust end (ball bearing pumps)



**Figure 73: Thrust bearing assembly**

- Install the cartridge mechanical seal (383) on the shaft (122) and align the mechanical seal pilot with the seal chamber bore of the casing. Install the mechanical seal studs (355) and hex nuts (356A).

**NOTICE:**

Do not set the mechanical seal sleeve set screws at the time; endplay must be checked first or damage to the seal faces could occur.

2. Assemble the inboard labyrinth seal (333A) into the inboard thrust end cover (160):
  - a) Clean the end cover with a solvent.
  - b) Fit the labyrinth seal (333A) into the bore of the cover (160).
  - c) Tap the seal in with a hammer.

**NOTICE:**

Make sure that the expulsion port is at the 6 o'clock position and is properly seated.

3. Assemble the inboard end cover (160) and the inboard bearing end-cover gasket (360A) onto the shaft.
4. Assemble the thrust bearings (112A) in a back-to-back arrangement onto the shaft (122): The bearings are interference fit.
  - a) Preheat the bearings to 120°C | 250°F with an induction-type bearing heater. Be sure to also demagnetize the bearings after heating.

**CAUTION:**

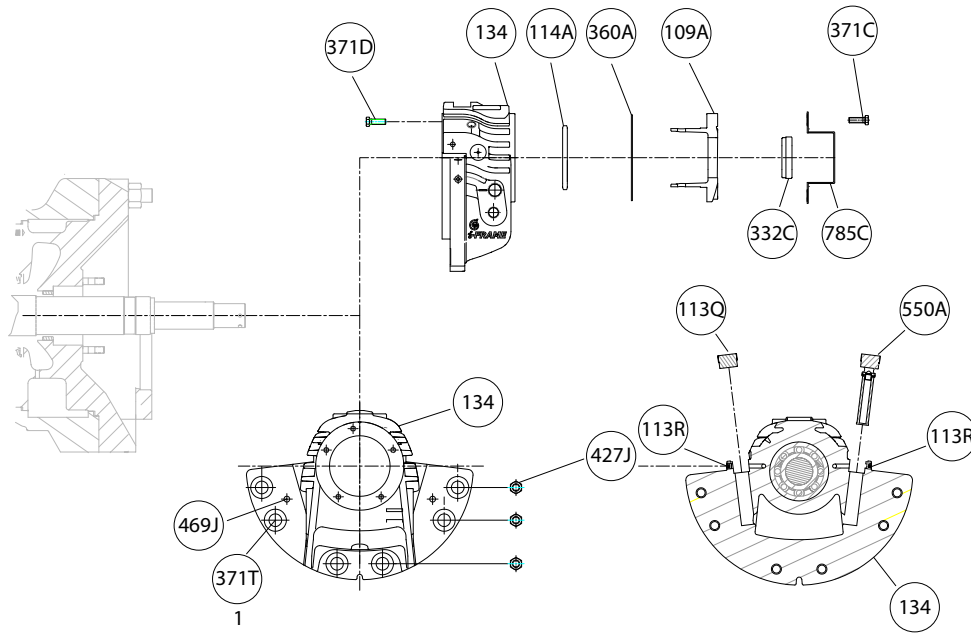
- Risk of physical injury from hot bearings. Wear insulated gloves when using a bearing heater.

**NOTICE:**

Do not use a torch and do not force.

- b) Install the bearing spacer (443V) if applicable, bearings (112A), the oil ring sleeve (443B), and the bearing locknut (136) onto the shaft.
- c) While the bearings are hot, tighten the locknut by hand with a spanner wrench until the bearing is snug against the shaft shoulder.
- d) Allow the bearing assembly to cool slowly to room temperature. Do not rapidly cool the bearings with compressed air or other means.
- e) When the bearing assembly is fully cooled, remove the locknut, install the lockwasher (382), and install the locknut.
- f) Hand-tighten the locknut with a spanner wrench. Do not over-tighten the bearing. Tap the end of the spanner wrench with light strikes from a dead blow hammer while you note the location of the next available lockwasher tab that aligns with the slots in the locknut. The turning resistance of the nut increases as it tightens. Plan the alignment of the lockwasher tab with the locknut fully tightened. If the locknut is still turning with light strikes with the hammer, then continue to tighten the locknut until the next available tab is aligned with a slot. Do not use heavy strikes with the hammer. If it is not possible to reach the next tab, then loosen the locknut to align with the previous tab.
- g) Check the condition of the outer races by rotating the bearings by hand in opposite directions:
  - The outer races generally cannot be counter-rotated by hand, but if they do move, the resistance must be high.
  - If the outer races are loose, the bearing is not properly seated and must be retightened.

- h) When you have achieved the proper bearing assembly, set the lockwasher tab in the slot in the locknut.



**Figure 74: Thrust bearing housing assembly**

5. Install the bearing housing (134) over the bearings. Finger-tighten the nuts (427J) on the studs (371T). Insert the dowel pins (469J); then tighten the nuts (427J). The bearing housing is doweled to the casing (100) during the original build to assure the correct running position of the shaft.

**NOTICE:**

The bearing housing flange must fit metal-to-metal (no gap) to the bearing saddle flange.

6. Tighten the inboard end-cover capscrews (371D).
7. Install the oil ring (114A).
8. Assemble the outboard labyrinth seal (332C) into the outboard thrust end cover (109A):
  - a) Clean the end cover with a solvent.
  - b) Fit the labyrinth seal (332C) into the bore of the cover (160).
  - c) Tap the seal in with a hammer.

**NOTICE:**

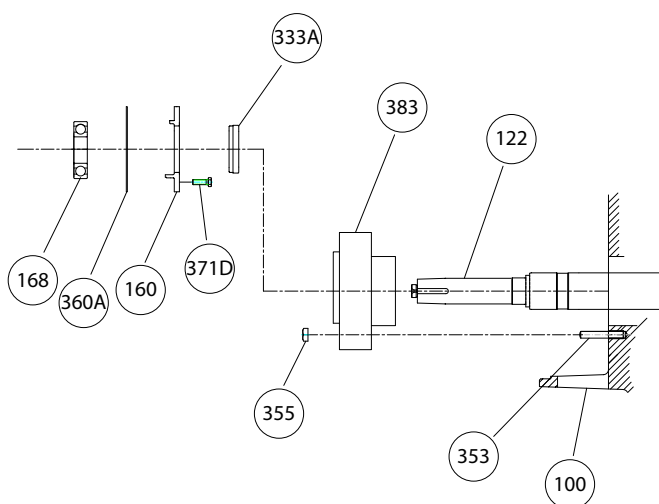
Make sure that the expulsion port is at the 6 o'clock position and is properly seated.

9. Install the bearing end cover (109A) and the bearing end-cover gasket (360A) with the end-cover capscrews (371C).
10. Install a new oil filter (550A) and filter plug (113Q).
11. When new bearings are installed, you must measure the axial end play:
  - a) Bolt the end cover to the thrust housing.
  - b) Move the shaft axially from the coupling end.

This table shows the clearance requirements between the thrust bearing end cover and the bearing:

| Bearing type    | Clearance in millimeters   inches |
|-----------------|-----------------------------------|
| Ball/ball       | 0.127-0.254   0.005-0.010         |
| Sleeve/ball     | 0.127-0.254   0.005-0.010         |
| Sleeve/tilt pad | 0.127-0.254   0.005-0.010         |

### 6.6.4 Assemble the radial end (ball bearing pumps)



**Figure 75: Radial bearing assembly**

1. Install the cartridge mechanical seal (383) on the shaft (122) and align the mechanical seal pilot with the seal chamber bore of the casing. Install the mechanical seal studs (353) and hex nuts (355).

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#### NOTICE:

Do not set the mechanical seal sleeve set screws at the time; endplay must be checked first or damage to the seal faces could occur.

---

2. Assemble the inboard labyrinth seal (333A) into the inboard radial-end cover (160):
    - a) Clean the end cover with a solvent.
    - b) Fit the labyrinth seal (333A) into the bore of the cover (160).
    - c) Tap the seal in with a hammer.
- 

#### NOTICE:

Make sure that the expulsion port is at the 6 o'clock position and is properly seated.

---

3. Assemble the inboard end cover (160) and the inboard bearing end-cover gasket (360A) onto the shaft.
4. Assemble the radial bearing (168) onto the shaft (122). The bearings are interference fit.
  - a) Preheat the bearings with an electronic induction heater. The induction heater also demagnetizes the bearings.

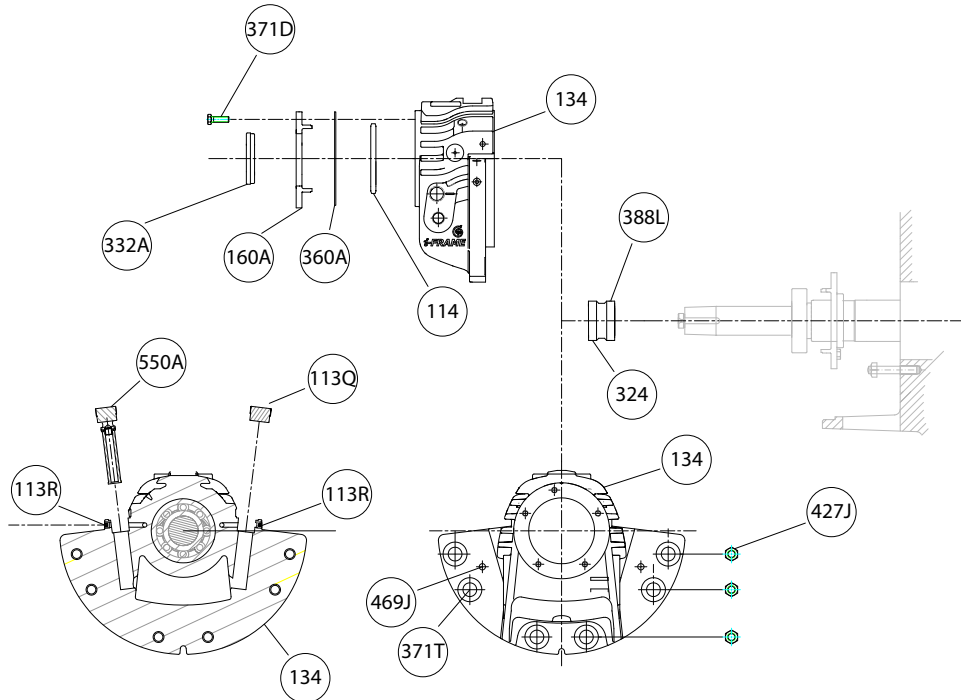
**CAUTION:**

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

**NOTICE:**

Do not use a torch and do not force.

- b) Coat the internal surface of the bearings with the lubricant that is to be used in service.
  - c) Assemble the radial-end bearing (168) onto the shaft (122).
5. Install the oil-ring sleeve (324) and tighten the setscrew (388L).



**Figure 76: Radial bearing housing assembly**

6. Install the bearing housing (134).  
The bearing housing is doweled to the casing (100) during the original build to assure the correct running position of the shaft.

**NOTICE:**

The bearing housing flange must fit metal-to-metal (no gap) to the bearing saddle flange.

7. Install the oil ring (114).
8. Install the end-cover gasket on the outboard side (360A).
9. Assemble the outboard labyrinth seal (332A) into the outboard radial-end cover (160):
  - a) Clean the end cover with a solvent.
  - b) Fit the labyrinth seal (332A) into the bore of the cover (160).
  - c) Tap the seal in with a hammer.

**NOTICE:**

Make sure that the expulsion port is at the 6 o'clock position and is properly seated.

10. Install the end cover (160). Tighten all end-cover capscrews (371D).
11. Install a new oil filter (550A) and filter plug (113Q).

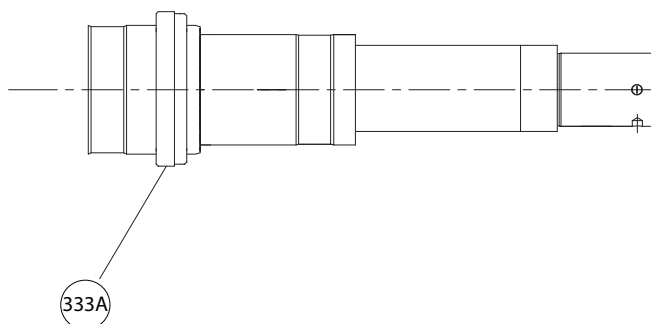
**6.6.5 Assemble the thrust end (sleeve/ball bearing pumps)**

1. Prior to beginning assembly, push the rotor assembly towards the thrust end until it stops.
2. Install the cartridge mechanical seal (383) on the shaft (122) and align the mechanical seal pilot with the seal chamber bore of the casing. Install the mechanical seal studs (353) and hex nuts (355).

**NOTICE:**

Do not set the mechanical seal sleeve set screws at this time; endplay must be checked first or damage to the seal faces could occur.

3. Install the inboard labyrinth seal (333A).

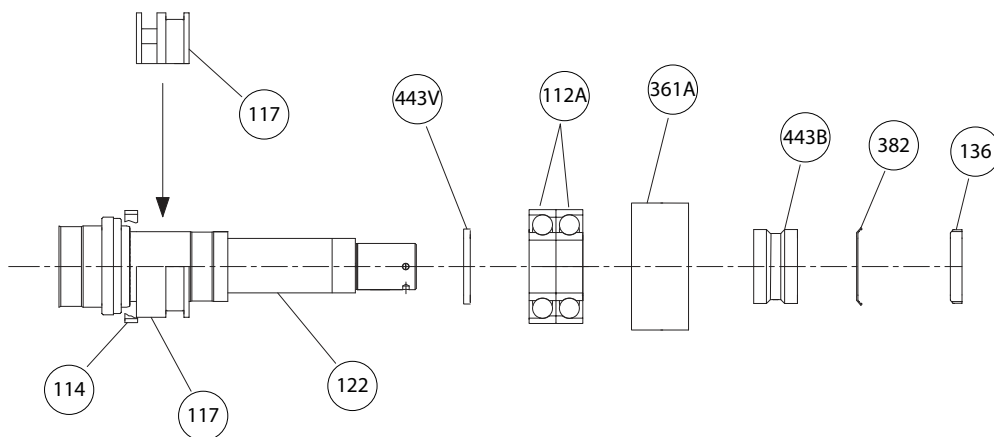


**Figure 77: Inboard labyrinth seal installation**

**NOTICE:**

Make sure that the expulsion port is at the 6 o'clock position and is properly seated.

4. Place the inboard oil ring (114) on the shaft (122).



**Figure 78: Sleeve and thrust bearing assembly**

5. If applicable - Assemble the bearing spacer (443V) onto the shaft.
6. Assemble the thrust bearings (112A) in a back-to-back arrangement onto the shaft (122):

The bearings are interference fit.

- a) Preheat the bearings to 120°C | 250°F with an induction-type bearing heater. Be sure to also demagnetize the bearings after heating.



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**CAUTION:**

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

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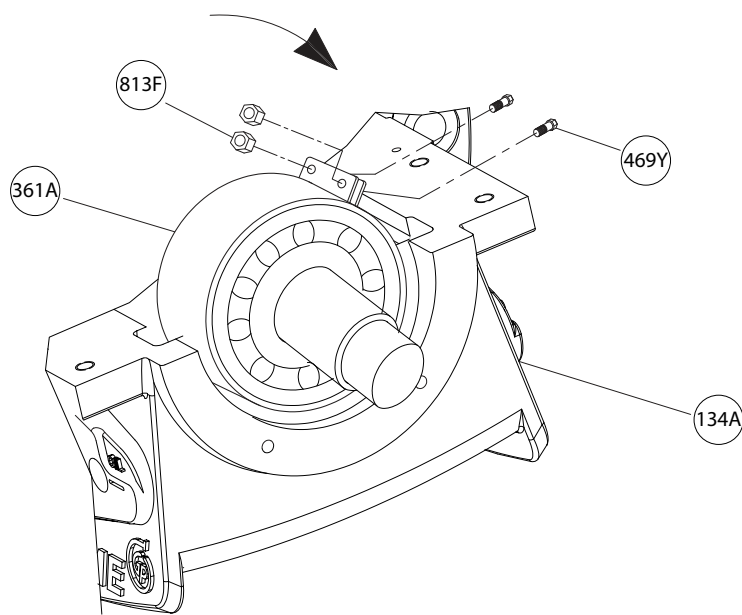
**NOTICE:**

Do not use a torch and do not force.

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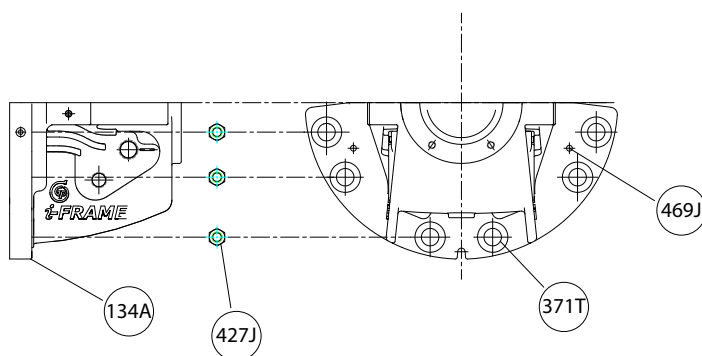
- b) Install the bearings (112A), the oil ring sleeve (443B), and the bearing locknut (136) onto the shaft.
- c) While the bearings are hot, tighten the locknut by hand with a spanner wrench until the bearing is snug against the shaft shoulder.
- d) Allow the bearing assembly to cool slowly to room temperature. Do not rapidly cool the bearings with compressed air or other means.
- e) When the bearing assembly is fully cooled, remove the locknut, install the lockwasher (382), and install the locknut.
- f) Hand-tighten the locknut with a spanner wrench. Do not over-tighten the bearing. Tap the end of the spanner wrench with light strikes from a dead blow hammer while you note the location of the next available lockwasher tab that aligns with the slots in the locknut. The turning resistance of the nut increases as it tightens. Plan the alignment of the lockwasher tab with the locknut fully tightened. If the locknut is still turning with light strikes with the hammer, then continue to tighten the locknut until the next available tab is aligned with a slot. Do not use heavy strikes with the hammer. If it is not possible to reach the next tab, then loosen the locknut to align with the previous tab.
- g) Check the condition of the outer races by rotating the bearings by hand in opposite directions:
- The outer races generally cannot be counter-rotated by hand, but if they do move, the resistance must be high.
  - If the outer races are loose, the bearing is not properly seated and must be retightened.
- h) When you have achieved the proper bearing assembly, set the lockwasher tab in the slot in the locknut.





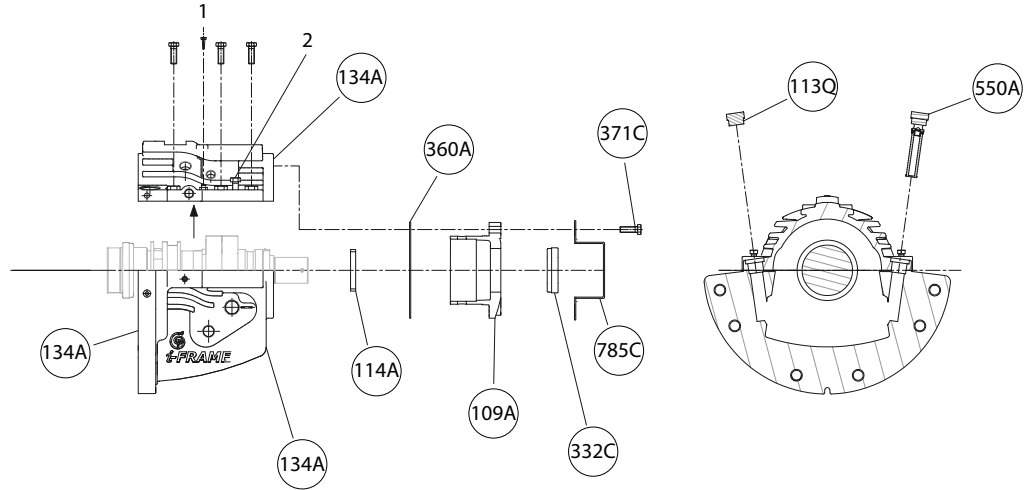
**Figure 79: Installation of bearing retainer**

7. Install the thrust bearing retainer (361A). Secure the retainer with the screws (469Y) and nuts (813F). Position the retainer tab into the lower bearing frame (134A) slot.
8. Lift the lower half of the bearing housing (134A) into place, positioning the sleeve bearing oil ring (114) in the bearing housing groove.
9. Install head-to-bearing housing studs (371T).
10. Place the installed inboard labyrinth seal (333A) in the lower housing.
11. Finger tighten the lower housing to the head-bearing flange with the head-to-bearing housing studs (371T) and nuts (427J).



**Figure 80: Assemble the thrust bearing housing lower half**

12. Install the sleeve bearing (117):
  - a) Apply Lucas Heavy Duty Oil Stabilizer, or equivalent lubricant to the lower half of the sleeve bearing. Place the lower half of the sleeve bearing (117) onto the shaft (122) and slide it around the shaft into the lower bearing housing, moving the oil ring accordingly.  
(May need to use adjusters to lift frame first) Install the dowel pins in the pre-drilled dowel pin holes between the housing flange and the head-bearing flange.
  - b) Tighten the nuts (427J) on the bearing housing to the head studs (371T).
  - c) Apply Lucas Heavy Duty Oil Stabilizer, or equivalent lubricant to the upper half of the sleeve bearing. Place the upper half of the sleeve bearing (117) on the shaft, moving the oil ring (114) aside. When the bearing top half is in place, move the oil ring back into the bearing housing and sleeve groove.



| Item | Description |
|------|-------------|
| 1.   | Taper pin   |
| 2.   | Jackbolt    |

**Figure 81: Thrust bearing housing assembly**

13. Install the upper half of the bearing housing (134A).  
Prior to installing the upper half, apply a thin even coat of Permatex® Aviation Form-A-Gasket® (or equivalent) to the lower half bearing housing to prevent possible oil seepage.
14. Place the outboard oil ring (114A) on the oil-ring sleeve (443B).
15. Adjust the end play with the gasket (361A) and the thrust end cover (109A).  
When new bearings are installed, you must measure the axial end play:
  - a) Bolt the end cover to the thrust housing.
  - b) Move the shaft axially from the coupling end.
  - c) Measure the shaft axial movement with a dial indicator mounted on the radial bearing housing.

This table shows the clearance requirements between the thrust bearing end cover and the bearing:

| Bearing type    | Clearance in millimeters   inches |
|-----------------|-----------------------------------|
| Ball/ball       | 0.127–0.254   0.005–0.010         |
| Sleeve/ball     | 0.127–0.254   0.005–0.010         |
| Sleeve/tilt-pad | 0.127–0.254   0.005–0.010         |

16. Assemble the outboard labyrinth seal (332C) into the outboard thrust end cover (109A):
  - a) Clean the end cover with a solvent.
  - b) Fit the labyrinth seal (332C) into the bore of the cover (160).
  - c) Tap the seal in with a hammer.

**NOTICE:**

Make sure that the expulsion port is at the 6 o'clock position and is properly seated.

17. Install the thrust bearing outboard-end cover (109A) , with the gasket (360A), and shaft guard (785C). Tighten the end cover to the housing with the cap screws (371C).
18. Install a new oil filter (550A) and filter plug (113Q).

### 6.6.6 Assemble the radial end (sleeve/ball bearing pumps)

1. Install the cartridge mechanical seal (383) on the shaft (122) and align the mechanical seal pilot with the seal chamber bore of the casing. Install the mechanical seal studs (353) and hex nuts (355).

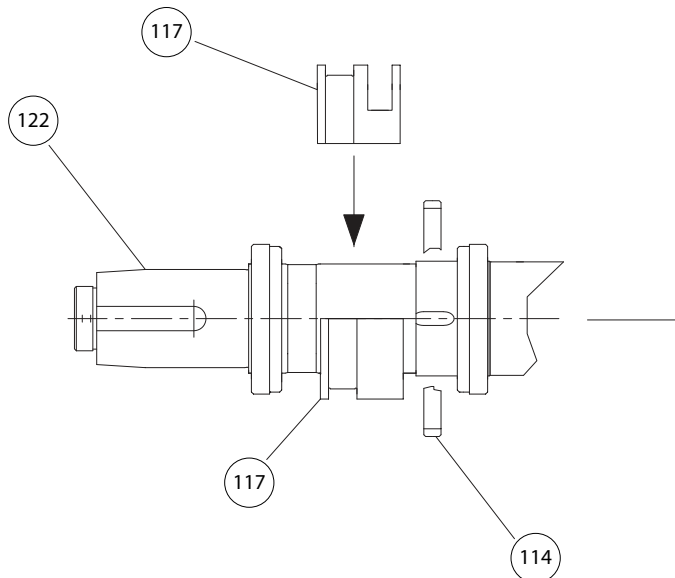
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#### NOTICE:

Do not set the mechanical seal sleeve set screws at this time; endplay must be checked first or damage to the seal faces could occur.

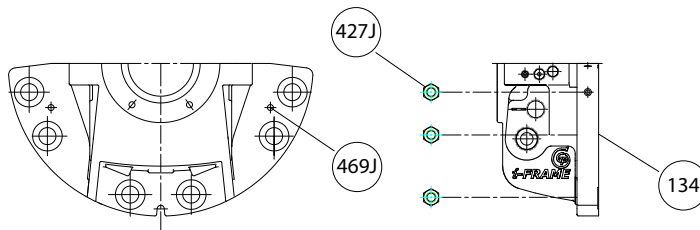
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2. Install the inboard labyrinth seal (333A).



**Figure 82: Radial sleeve bearing assembly**

3. Place the oil ring (114) on the shaft (122).
4. Place the outboard labyrinth seal (332A) onto the shaft (122).
5. Lift the lower half of the housing into place, positioning the inner oil rings (114) in the bearing housing groove.



**Figure 83: Radial bearing housing installation**

6. Place the installed inboard labyrinth seals (332A and 333A) in the lower housing.

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#### NOTICE:

Make sure that the expulsion port is at the 6 o'clock position and is properly seated.

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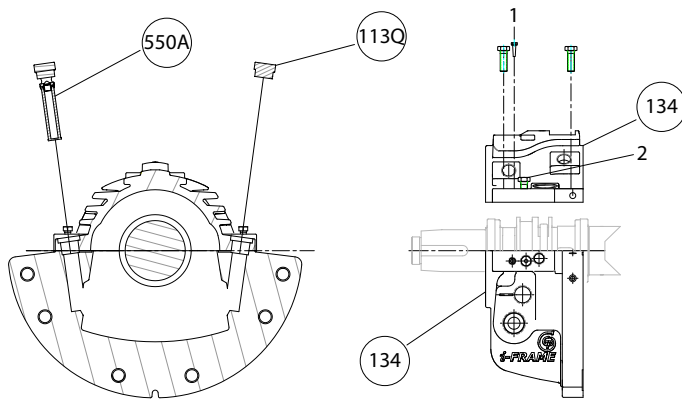
7. Hand-tighten the lower housing to the case bearing flange with the case-to-bearing housing studs (371T) and nuts (427J).
8. Install the sleeve bearing (117):

- a) Apply Lucas Heavy Duty Oil Stabilizer, or equivalent lubricant to the lower half of the sleeve bearing (117). Place the lower half of the sleeve bearing (117) onto the shaft (122) and slide it around the shaft into the lower bearing housing, moving the oil ring accordingly.
  - b) Install the dowel pins (469J) in the pre-drilled dowel pin holes between the housing flange and the case bearing flange.
  - c) Tighten the nuts (427J) on the bearing housing to the case studs (371T).
  - d) Apply Lucas Heavy Duty Oil Stabilizer, or equivalent lubricant to the upper half of the sleeve bearing (117). Place the upper half of the sleeve bearing (117) on the shaft, moving the oil ring aside. When the bearing top half is in place, move the oil ring back into the bearing housing and sleeve groove.
9. Install the outboard labyrinth seal (332A).

**NOTICE:**

Make sure that the expulsion port is at the 6 o'clock position and is properly seated.

10. Install the upper half of the bearing housing (134).  
 Prior to installing the upper half, apply a thin even coat of Permatex® Aviation Form-A-Gasket® (or equivalent) to the lower half bearing housing to prevent possible oil seepage.



| Item | Description |
|------|-------------|
| 1.   | Taper pin   |
| 2.   | Jack bolt   |

**Figure 84: Radial sleeve bearing housing assembly**

11. Position the dowel pins between the upper and lower halves of the bearing housing. Tighten the bearing-housing hex screws.
12. Install a new oil filter (550A) and filter plug (113Q).

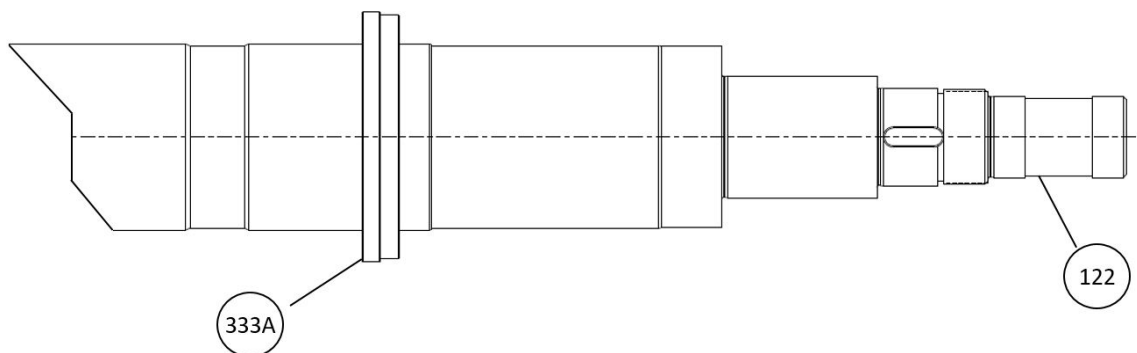
**6.6.7 Assemble the thrust end (sleeve/tilt pumps)**

1. Prior to beginning assembly, push the rotor assembly towards the thrust end until it stops.
2. Install the cartridge mechanical seal (383) on the shaft (122) and align the mechanical seal pilot with the seal chamber bore of the casing. Install the mechanical seal studs (353) and hex nuts (355).

**NOTICE:**

Do not set the mechanical seal sleeve set screws at this time; endplay must be checked first or damage to the seal faces could occur.

3. Install the inboard labyrinth seal (333A).

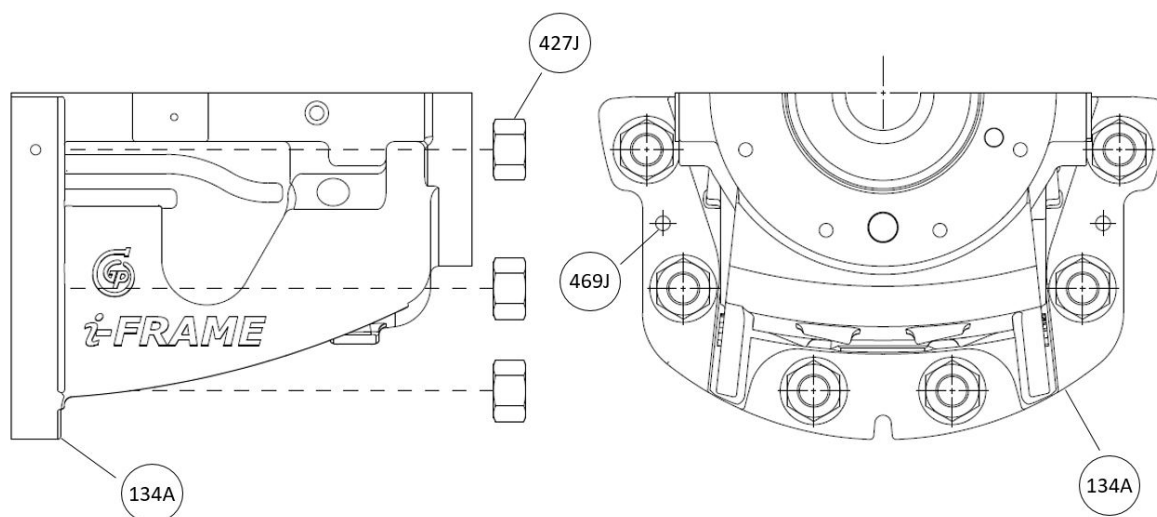


**Figure 85: Thrust inboard labyrinth seal installation**

**NOTICE:**

Make sure the expulsion port is at the 6 o'clock position and is properly seated.

4. Lift the lower half of the bearing housing (134A) into place.
5. Install the case-to-bearing housing studs (371T).
6. Place the installed inboard labyrinth seal (333A) in the lower housing.
7. Finger tighten the lower housing to the case-to bearing housing flange with the case-to-bearing housings studs (371T) and nuts (427J).



**Figure 86: Assemble thrust end**

8. Install the sleeve bearing (117).
  - a) Apply Lucas Heavy Duty Oil Stabilizer, or equivalent lubricant to the lower half of the sleeve bearing (117). Place the lower half of the sleeve bearing (117) on the shaft (122) and slide it around the shaft into the lower bearing housing. One may need to use the adjusters to lift the frame first. Install the dowel pins in the pre-drilled dowel pin holes between the housing flange and the head-bearing flange.
  - b) Tighten the nuts (427J) on the bearing housing to the head studs (371T).
  - c) Apply Lucas Heavy Duty Oil Stabilizer, or equivalent lubricant to the upper half of the sleeve bearing (117). Place the upper half of the sleeve bearing (117) on the shaft (122).

- d) Install the two socket head cap screws that hold the upper and lower halves of the sleeve bearing (117) together.
9. Install the inboard floating oil seal (123G).
10. Install the bearing spacer (443V) and thrust collar key (282).
11. Install the thrust collar onto the shaft (122) using the thrust collar key (282).
12. Install the inboard and outboard ends of the tilt pad bearing (280) between the thrust collar.
13. Install the thrust collar nut (283) onto the shaft (122). Utilize the flats on the thrust collar nut (123) to tighten against the thrust collar. Note the thrust collar nut (283) is threaded to tighten against rotation. For CCW pump rotation (when viewed by the drive end) the thrust collar nut (283) is left handed. For CW rotation, the thread is right hand.
14. Install the floating oil seal (123G) to the outboard end.
15. Install the upper half of the bearing housing (134A).
16. Install the two taper pins to line up the upper and lower halves of the bearing housing (134A).
17. Install the hex cap screws that connect the upper and lower halves of the bearing housing (134A).
18. Install new O-ring (412M) onto the filler plate (441A).
19. Install the shim pack (390C/M) onto the filler plate (441A).
20. Install the filler plate (441A) into the bearing housing (134A). Tighten the hex cap screws between the bearing housing (134A) and the filler plate (441A).
21. If pump has been supplied with axial proximity probes, screw the axial proximity probes into the filler plate (441A). Do not tighten the axial proximity probes all the way down until they come into contact with the thrust collar. The axial proximity probes should be set at .050" away from the thrust collar.

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**NOTICE:**

If the axial proximity probes are touching the thrust collar during operation, the axial proximity probes will break and fill the bearing housing with debris resulting in premature bearing failure.

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22. Use the hex cap screws (370W) to install the cover filler plate (113J). Make sure the cable from the axial proximity probe is exiting through the pipe tap connection on the cover filler plate (113J). There is one cover filler plate (113J) on each side of the bearing housing (134A).
  23. If the pump was supplied with a main shaft oil pump (219), install the coupling key, coupling hub, and spacer to the pump shaft (122). If the pump was not supplied with a main shaft oil pump go to step 26.
  24. Install a new o-ring (412Y) onto the oil pump adapter (318A). Use the hex cap screws (370N) to install the oil pump adapter (318A) to the filler plate (441A).
  25. Use the hex cap screws (370L) to install the main shaft oil pump (219) to the oil pump adapter. Ensure the coupling half on the main shaft oil pump (219) is inserted into the coupling spacer.
  26. If the pump was not supplied with a main shaft oil pump (219), install a new o-ring (412Y) onto the adapter cover (119C). Use the hex cap screws (370N) to install the adapter cover (119C) to the filler plate (441A).

### 6.6.8 Assemble the radial end (sleeve/tilt pumps)

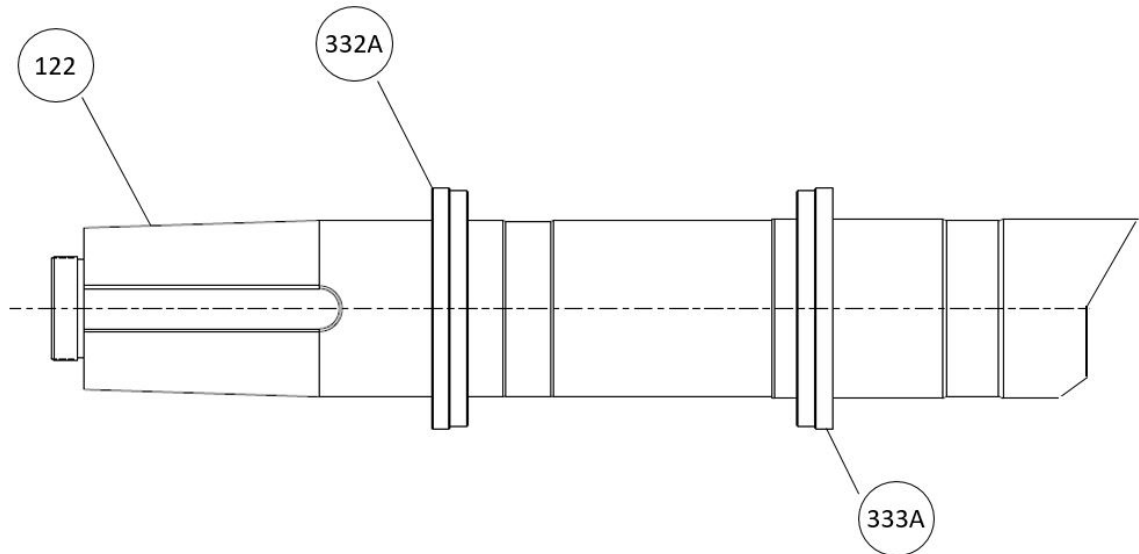
1. Install the cartridge mechanical seal (383) on the shaft (122) and align the mechanical seal pilot with the seal chamber bore of the casing. Install the mechanical seal studs (353) and hex nuts (355).

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**NOTICE:**

Do not set the mechanical seal sleeve set screws at this time; endplay must be checked first or damage to the seal faces could occur.

- 
2. Install the inboard labyrinth seal (333A).

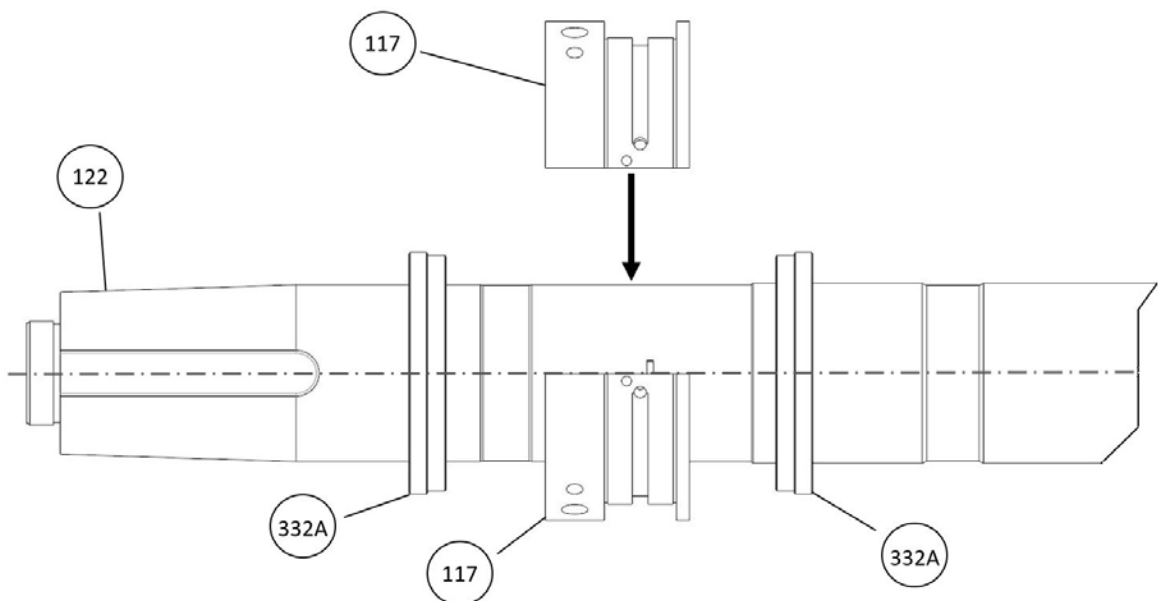


**Figure 87: Radial inboard labyrinth seal installation**

**NOTICE:**

Make sure the expulsion port is at the 6 o'clock position and is properly seated.

3. Lift the lower half of the bearing housing (134) into place.
4. Install the case-to-bearing housing studs (371T).
5. Place the installed inboard labyrinth seal (333A) in the lower housing.
6. Finger tighten the lower housing to the case-to bearing housing flange with the case-to-bearing housings studs (371T) and nuts (427J).



**Figure 88: Radial sleeve bearing assembly**

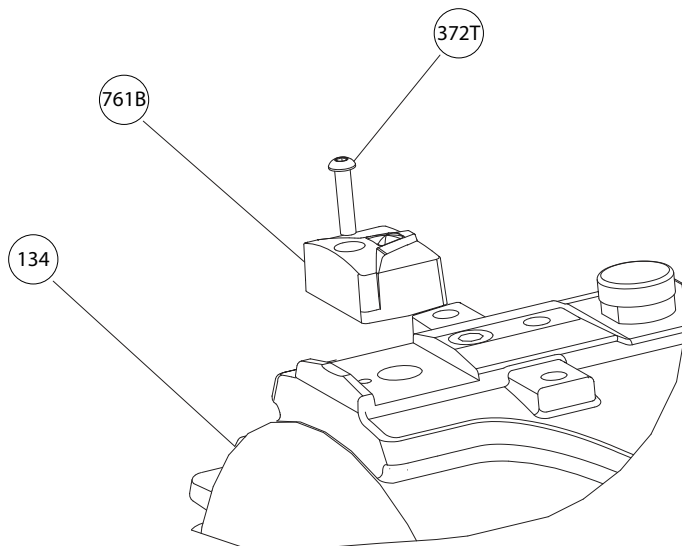
7. Install the sleeve bearing (117).

- a) Apply Lucas Heavy Duty Oil Stabilizer, or equivalent lubricant to the lower half of the sleeve bearing (117). Place the lower half of the sleeve bearing (117) on the shaft (122) and slide it around the shaft into the lower bearing housing. One may need to use the adjusters to lift the frame first. Install the dowel pins in the pre-drilled dowel pin holes between the housing flange and the head-bearing flange.
  - b) Tighten the nuts (427J) on the bearing housing to the head studs (371T).
  - c) Apply Lucas Heavy Duty Oil Stabilizer, or equivalent lubricant to the upper half of the sleeve bearing (117). Place the upper half of the sleeve bearing (117) on the shaft (122).
  - d) Install the two socket head cap screws that hold the upper and lower halves of the sleeve bearing (117) together.
8. Install the outboard labyrinth seal (332A).
  9. Install the upper half of the bearing housing (134). Prior to installing the upper half, apply a thin coat of Permatex® Aviation Form-A-Gasket® (or equivalent) to the lower half bearing housing to prevent possible oil seepage.
  10. Install the two taper pins to line up the upper and lower halves of the bearing housing (134).
  11. Install the hex cap screws that connect the upper and lower halves of the bearing housing (134).

### 6.6.9 Attach the i-ALERT®2 Equipment Health Monitor to the pump

#### Tools required:

- 5/32 inch hex wrench
1. Attach the condition monitor (761B) to the bearing frame (134, 134A) using the hex-head screw (372T) provided.



**Figure 89: Attaching the condition monitor to bearing the frame**

2. Tighten the hex-head screw to 8 Nm | 6 ft-lbs.

More detailed information is available on:

<http://www.itproservices.com/aftermarket-products/monitoring/i-alert2/i-ALERT2.com>

### 6.6.10 Post-assembly checks

Perform these checks after you assemble the pump, then continue with pump startup:

- Rotate the shaft by hand in order to make sure that it rotates easily and smoothly and that there is no rubbing.



- Open the isolation valves and check the pump for leaks.

## 6.6.11 Assembly references

### 6.6.11.1 Maximum torque values for fasteners

Goulds 2226, 2228, 2229, ASTM A193 B8 and B8M, ASTM A276 Tp 304, ASTM A582 Tp 303, SAE F593

Table 3: 300 Series Stainless Steel Fasteners

| Bolt Dia. (D)<br>(in.– threads/<br>inch) | Tensile Stress<br>Area (Ab), (sq.–<br>in.) | 2226, 2228: 303, 304SS, SAE F593<br>Group 1 2229: 316SS, SAE F593<br>Group 2 Yield strength:<br><br>65000 psi for 0.25 <=dia<=0.625<br><br>45000 psi for 0.75<=dia<=1.5 |  | A193 B8, B8M Cl 1, A276 Tp 304,<br>A582 Tp 303<br><br>Yield strength=30000 psi<br><br>Ultimate tensile=75000 psi |  |
|--|--|---|--|--|--|
|  |  | Max. preload (lbs)  | Torque N-m   ft-lb<br>Nickel or Moly Anti-<br>seize K=0.15 | Max. preload<br>(lbs)  | Torque N-m   ft-lb<br>Nickel or Moly Anti-<br>seize K=0.15 |
| 1/4-20                                   | 0.0318                                     | 1447  | 7   5  | 668  | 3   2  |
| 5/16-18                                  | 0.0524                                     | 2384  | 12   9   | 1100   | 5   4  |
| 3/8-16                                   | 0.0775                                     | 3526  | 23   17  | 1628   | 11   8   |
| 7/16-14                                  | 0.1063                                     | 4837  | 35   26  | 2232   | 16   12  |
| 1/2-13                                   | 0.1419                                     | 6456  | 54   40  | 2980   | 26   19  |
| 9/16-12                                  | 0.1819                                     | 8276  | 79   58  | 3820   | 37   27  |
| 5/8-11                                   | 0.226                                      | 10283   | 108   80   | 4746   | 50   37  |
| 3/4-10                                   | 0.3345                                     | 10537   | 134   99   | 7025   | 89   66  |
| 7/8-9                                    | 0.4617                                     | 14544   | 210   155  | 9696   | 140   103  |
| 1-8                                      | 0.6058                                     | 19083   | 324   239  | 12722  | 216   159  |
| 1.125-7                                  | 0.7633                                     | 24044   | 458   338  | 16029  | 305   225  |
| 1.125-8                                  | 0.7904                                     | 24898   | 475   350  | 16598  | 316   233  |
| 1.25-7                                   | 0.9691                                     | 30527   | 647   477  | 20351  | 431   318  |
| 1.25-8                                   | 1.000                                      | 31500   | 667   492  | 21000  | 445   328  |
| 1.375-6                                  | 1.155                                      | 36383   | 847   625  | 24255  | 565   417  |
| 1.375-8                                  | 1.234                                      | 38871   | 906   668  | 25914  | 603   445  |
| 1.5-6                                    | 1.405                                      | 44258   | 1125   830   | 29505  | 750   553  |
| 1.5-8                                    | 1.492                                      | 46998   | 1194   881   | 31332  | 796   587  |
| 1.5-12                                   | 1.581                                      | 49802   | 1266   934   | 33201  | 845   623  |
| 1.625-8                                  | 1.775                                      | 55913   | 1540   1136  | 37275  | 1026   757   |
| 1.75-5                                   | 1.899                                      | 59819   | 1775   1309  | 39879  | 1182   872   |
| 1.75-8                                   | 2.082                                      | 65583   | 1946   1435  | 43722  | 1296   956   |
| 1.875-8                                  | 2.414                                      | 76041   | 2416   1782  | 50964  | 1611   1188  |
| 2-4.5                                    | 2.498                                      | 78687   | 2667   1967  | 52458  | 1777   1311  |
| 2-8                                      | 2.771                                      | 87287   | 2958   2182  | 58191  | 1973   1455  |
| 2.125-8                                  | 3.152                                      | 99288   | 3575   2637  | 66192  | 2384   1758  |
| 2.25-4.5                                 | 3.248                                      | 102312  | 3902   2878  | 68208  | 2600   1918  |
| 2.25-8                                   | 3.557                                      | 112046  | 4272   3151  | 74697  | 2849   2101  |
| 2.375-8                                  | 3.987                                      | 125591  | 5054   3728  | 83727  | 3371   2486  |
| 2.5-4                                    | 3.999                                      | 125969  | 5338   3937  | 83979  | 3558   2624  |
| 2.5-8                                    | 4.442                                      | 139923  | 5929   4373  | 93282  | 3952   2915  |

| Bolt Dia. (D)<br>(in.– threads/<br>inch) | Tensile Stress<br>Area (Ab), (sq.–<br>in.) | 2226, 2228: 303, 304SS, SAE F593<br>Group 1 2229: 316SS, SAE F593<br>Group 2 Yield strength:<br><br>65000 psi for 0.25 ≤dia≤0.625<br><br>45000 psi for 0.75≤dia≤1.5 |  | A193 B8, B8M Cl 1, A276 Tp 304,<br>A582 Tp 303<br><br>Yield strength=30000 psi<br><br>Ultimate tensile=75000 psi |  |
|--|--|---|--|--|--|
|  |  | Max. preload (lbs)  | Torque N-m   ft-lb<br>Nickel or Moly Anti-<br>seize K=0.15 | Max. preload<br>(lbs)  | Torque N-m   ft-lb<br>Nickel or Moly Anti-<br>seize K=0.15 |
| 2.625-8                                  | 4.921                                      | 155012  | 6896   5086  | 103341   | 4598   3391  |
| 2.75-4                                   | 4.934                                      | 155421  | 7244   5343  | 103614   | 4829   3562  |
| 2.75-8                                   | 5.425                                      | 170888  | 7964   5874  | 113925   | 5309   3916  |
| 2.875-8                                  | 5.953                                      | 187520  | 9137   6739  | 125013   | 6092   4493  |
| 3-4                                      | 5.967                                      | 187961  | 9557   7049  | 125307   | 6371   4699  |
| 3-8                                      | 6.506                                      | 204939  | 10419   7685   | 136626   | 6946   5123  |

### 6.6.11.2 Maximum torque values for fasteners

Goulds 2238, 2239, ASTM A193 B7 and Goulds 2299 ASTM A320 L7

Table 4: High strength steel fasteners

| Bolt Dia. (D) (in.–<br>threads/inch) | Tensile Stress Area<br>(Ab), (sq.-in.) | 2238, 2239 (A 193 B7) ¼-2 ½ dia: Sult = 125<br>ksi, Sy=105 ksi over 2 ½ – 4: Sult = 115 ksi,<br>Sy=95 ksi over 4 – 7: Sult = 100 ksi, Sy=75 ksi |  |  | 2299 (A 320 L7) ¼-2 ½<br>dia: Sult = 125 ksi,<br>Sy=105 ksi |
|--------------------------------------|--|---|--|--|---|
|                                      |  | Max. Preload (lbs)  | Torque N-m   ft-lb<br>Nickel or Moly Anti-<br>seize K=0.15 | Torque N-m   ft-lb<br>Nickel or Moly Anti-<br>seize K=0.15 |   |
| 1/4-20                               | 0.0318                                 | 2337  | 9   7  | 9   7  |   |
| 5/16-18                              | 0.0524                                 | 3851  | 20   15  | 20   15  |   |
| 3/8-16                               | 0.0775                                 | 5696  | 37   27  | 37   27  |   |
| 7/16-14                              | 0.1063                                 | 7813  | 58   43  | 58   43  |   |
| 1/2-13                               | 0.1419                                 | 10430   | 88   65  | 88   65  |   |
| 9/16-12                              | 0.1819                                 | 13370   | 127   94   | 127   94   |   |
| 5/8-11                               | 0.2260                                 | 16611   | 176   130  | 176   130  |   |
| 3/4-10                               | 0.3345                                 | 24586   | 312   230  | 312   230  |   |
| 7/8-9                                | 0.4617                                 | 33935   | 503   371  | 503   371  |   |
| 1-8                                  | 0.6058                                 | 44526   | 755   557  | 755   557  |   |
| 1.125-7                              | 0.7633                                 | 56103   | 1070   789   | 1070   789   |   |
| 1.125-8                              | 0.79045                                | 58098   | 1108   817   | 1108   817   |   |
| 1.25-7                               | 0.9691                                 | 71229   | 1509   1113  | 1509   1113  |   |
| 1.25-8                               | 1.000                                  | 73500   | 1556   1148  | 1556   1148  |   |
| 1.375-6                              | 1.155                                  | 84893   | 1978   1459  | 1978   1459  |   |
| 1.375-8                              | 1.234                                  | 90699   | 2114   1559  | 2114   1559  |   |
| 1.5-6                                | 1.405                                  | 103268  | 2625   1936  | 2625   1936  |   |
| 1.5-8                                | 1.492                                  | 109662  | 2788   2056  | 2788   2056  |   |
| 1.5-12                               | 1.581                                  | 116204  | 2954   2179  | 2954   2179  |   |
| 1.625-8                              | 1.775                                  | 130463  | 3593   2650  | 3593   2650  |   |
| 1.75-5                               | 1.899                                  | 139577  | 4139   3053  | 4139   3053  |   |
| 1.75-8                               | 2.082                                  | 153027  | 4538   3347  | 4538   3347  |   |
| 1.875-8                              | 2.414                                  | 177429  | 5637   4158  | 5637   4158  |   |

| Bolt Dia. (D) (in.– threads/inch) | Tensile Stress Area (Ab), (sq.-in.) | 2238, 2239 (A 193 B7) ¼-2 ½ dia: Sult = 125 ksi, Sy=105 ksi over 2 ½ – 4: Sult = 115 ksi, Sy=95 ksi over 4 – 7: Sult = 100 ksi, Sy=75 ksi |  | 2299 (A 320 L7) ¼-2 ½ dia: Sult = 125 ksi, Sy=105 ksi                 |
|-----------------------------------|-------------------------------------|---|--|---|
|                                   |                                     | Max. Preload (lbs)  | Torque N-m   ft-lb<br>Nickel or Moly Anti-seize K=0.15 | Torque N-m   ft-lb<br>Nickel or Moly Anti-seize K=0.15                |
| 2-4.5                             | 2.498                               | 183603  | 6223   4590  | 6223   4590   |
| 2-8                               | 2.771                               | 203669  | 6904   5092  | 6904   5092   |
| 2.125-8                           | 3.152                               | 231672  | 8344   6154  | 8344   6154   |
| 2.25–4.5                          | 3.248                               | 238728  | 8371   6714  | 8371   6714   |
| 2.25-8                            | 3.557                               | 261440  | 9969   7353  | 9969   7353   |
| 2.375-8                           | 3.987                               | 293045  | 11796   8700   | 11796   8700  |
| 2.5-4                             | 3.999                               | 293927  | 12453   9185   | 12453   9185  |
| 2.5-8                             | 4.442                               | 326487  | 13833   10203  | 13833   10203   |
| 2.625-8                           | 4.921                               | 327427  | 14559   10738  | Not Applicable due to size restrictions in the material specification |
| 2.75-4                            | 4.934                               | 328111  | 15292   11279  |   |
| 2.75-8                            | 5.425                               | 360763  | 16814   12401  |   |
| 2.875-8                           | 5.953                               | 395875  | 19289   14227  |   |
| 3-4                               | 5.967                               | 396806  | 20175   14880  |   |
| 3-8                               | 6.506                               | 432649  | 21997   16224  |   |

### 6.6.11.3 Maximum torque values for fasteners

Table 5: Carbon steel fasteners - Goulds 2210, 2294, ASTM A307 Gr B, SAE Gr2

| Bolt Dia. (D) (in.– threads/inch) | Tensile Stress Area (Ab) (sq-in) | Max. Preload (lbs) | Torque N-m   ft-lbs Nickel or Moly Anti-seize, K=0.15 |
|-----------------------------------|----------------------------------|--------------------|---|
| 1/4-20                            | 0.0318                           | 801                | 4   3   |
| 5/16-18                           | 0.0524                           | 1320               | 7   5   |
| 3/8–16                            | 0.0775                           | 1953               | 12   9  |
| 7/16–14                           | 0.1063                           | 2679               | 20   15   |
| 1/2–13                            | 0.1419                           | 3576               | 30   22   |
| 9/16–12                           | 0.1819                           | 4584               | 43   32   |
| 5/8–11                            | 0.226                            | 5695               | 60   44   |
| 3/4–10                            | 0.3345                           | 8429               | 107   79  |
| 7/8–9                             | 0.4617                           | 11635              | 168   124   |
| 1–8                               | 0.6058                           | 15266              | 259   191   |
| 1.125-7                           | 0.7633                           | 19235              | 366   270   |
| 1.125-8                           | 0.7904                           | 19918              | 380   280   |
| 1.25-7                            | 0.9691                           | 24421              | 518   382   |
| 1.25-8                            | 1.000                            | 25200              | 534   394   |
| 1.375-6                           | 1.155                            | 29106              | 678   500   |
| 1.375-8                           | 1.234                            | 31097              | 724   534   |
| 1.5-6                             | 1.405                            | 35406              | 900   664   |
| 1.5-8                             | 1.492                            | 37598              | 956   705   |
| 1.5-12                            | 1.581                            | 39841              | 1013   747  |
| 1.625-8                           | 1.775                            | 44730              | 1232   909  |
| 1.75-5                            | 1.899                            | 47855              | 1420   1047   |
| 1.75-8                            | 2.082                            | 52466              | 1556   1148   |

| Bolt Dia. (D) (in.– threads/<br>inch) | Tensile Stress Area<br>(Ab) (sq-in) | Max. Preload (lbs) | Torque N-m   ft-lbs Nickel<br>or Moly Anti-seize, K=0.15 |
|---------------------------------------|-------------------------------------|--------------------|--|
| 1.875-8                               | 2.414                               | 60833              | 1933   1426  |
| 2-4.5                                 | 2.498                               | 62950              | 2134   1574  |
| 2-8                                   | 2.771                               | 69829              | 2367   1746  |
| 2.125-8                               | 3.152                               | 79430              | 2861   2110  |
| 2.25-4.5                              | 3.248                               | 81850              | 3121   2302  |
| 2.25-8                                | 3.557                               | 89636              | 3418   2521  |
| 2.375-8                               | 3.987                               | 100472             | 4044   2983  |
| 2.5-4                                 | 3.999                               | 100775             | 4269   3149  |
| 2.5-8                                 | 4.442                               | 111938             | 4743   3498  |
| 2.625-8                               | 4.921                               | 124009             | 5517   4069  |
| 2.75-4                                | 4.934                               | 124337             | 5795   4274  |
| 2.75-8                                | 5.425                               | 136710             | 6371   4699  |
| 2.875-8                               | 5.953                               | 150016             | 7309   5391  |
| 3-4                                   | 5.967                               | 150368             | 7645   5639  |
| 3-8                                   | 6.506                               | 163951             | 8336   6148  |

### 6.6.11.4 Spare parts

#### Critical service spare parts

For critical services, stock these parts, where applicable:

- Impeller (101)
- Thrust bearing end cover, outboard (ball and sleeve bearing construction only) (109A)
- Shaft (122)
- Radial bearing end cover, inboard (ball bearing construction only) (160) and (160A)
- Impeller key (178)

An alternative approach is to stock a complete rotating element. This is a group of assembled parts that includes all rotating components except the bearings (and parts), mechanical seals, and coupling.

#### Recommended spare parts

When ordering spare parts, always state the serial number, and indicate the part name and item number from the relevant sectional drawing. It is imperative for service reliability to have a sufficient stock of readily available spare parts.

Stock these spare parts, where applicable:

- Cartridge mechanical seal
- Thrust bearing (duplex pair) (112A)
- Oil rings (114, 114A)
- Sleeve bearings, two (117) (sleeve bearing construction only)
- Impeller locknut, radial (124)
- Throat bushing (125)
- Impeller locknut, thrust (130)
- Bearing locknut (136)
- Impeller wear rings (142)
- Casing wear rings (164)
- Radial bearing (168) (ball bearing construction only)

- Labyrinth seal, outboard (332A)
- Labyrinth seal, outboard (332C)
- Labyrinth seal, inboard (333A)
- Head gasket (351)
- Head gasket, inner (351C)
- Bearing lockwasher (382)
- Bearing end-cover gasket (360A)

# 7 Troubleshooting

## 7.1 Operation troubleshooting

| Symptom  | Cause   | Remedy  |  |
|--|---|---|--|
| The pump is not delivering liquid.                                   | The pump is not primed.   | Re-prime the pump and check that the pump and suction line are full of liquid.                              | Replace the gasket or O-ring.  |
|  | The suction line is clogged.                                    | Remove the obstructions.  |  |
|  | The impeller is clogged.  | Back-flush the pump in order to clean the impeller.   |  |
|  | The shaft is rotating in the wrong direction.                   | Change the rotation. The rotation must match the arrow on the bearing housing or pump casing.               |  |
|  | The foot valve or suction pipe opening is not submerged enough. | Consult an ITT representative for the proper submersion 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.                    | The gasket or O-ring has an air leak.                           |   |  |
| The stuffing box has an air leak.                                    |   | Replace or readjust the mechanical seal.  | Re-prime the pump and check that the pump and suction line are full of liquid. |
| The impeller is partly clogged.                                      |   | Back-flush the pump in order to clean the impeller.   |  |
| The clearance between the impeller and the pump casing is excessive. |   | Adjust the impeller clearance.  |  |
| The suction head is not sufficient.                                  |   | Make sure that the suction-line shutoff valve is fully open and that the line is unobstructed.              |  |
| The impeller is worn or broken.                                      |   | Inspect and replace the impeller if necessary.  |  |
| The pump starts and then stops pumping.                              |   | The pump is not primed.   |  |
|  | The suction line has air or vapor pockets.                      | Rearrange the piping in order to eliminate air pockets.   |  |
|  | The suction line has an air leak.                               | Repair the leak.  |  |
| The bearings are running hot.  | The pump and driver are not aligned properly.                   | Realign the pump and driver.  |  |
|  | There is not sufficient lubrication.                            | Check the lubricant for suitability and level.  |  |
|  | The lubrication was not cooled properly.                        | Check the cooling system.   |  |
| The pump is noisy or vibrates.                                       | The pump and driver are not aligned properly.                   | Realign the pump and driver.  |  |
|  | The impeller is partly clogged.                                 | Back-flush the pump in order to clean the impeller.   |  |
|  | The impeller or shaft is broken or bent.                        | Replace the impeller or shaft as necessary.   |  |

| Symptom                                     | Cause  | Remedy   |
|---|--|--|
|   | The foundation is not rigid.   | Tighten the hold-down bolts of the pump and motor. Make sure the baseplate is properly grouted without voids or air pockets.                   |
|   | The bearings are worn.   | Replace the bearings.  |
|   | The suction or discharge piping is not anchored or properly supported.               | Anchor the suction or discharge piping as necessary according to recommendations in the Hydraulic Institute Standards Manual.                  |
|   | The pump is cavitating.  | Locate and correct the system problem.   |
| The mechanical seal is leaking excessively. | The packing gland is not adjusted properly.  | Tighten the gland nuts.  |
|   | The stuffing box is not packed properly.   | Check the packing and repack the box.  |
|   | The mechanical seal parts are worn.  | Replace the worn parts.  |
|   | The mechanical seal is overheating.  | Check the lubrication and cooling lines.   |
|   | The shaft or shaft sleeve is scored.   | Machine or replace the shaft sleeve as necessary.  |
| The motor requires excessive power.         | The discharge head has dropped below the rated point and is pumping too much liquid. | Install a throttle valve. If this does not help, then trim the impeller diameter. If this does not help, then contact your ITT representative. |
|   | The liquid is heavier than expected.   | Check the specific gravity and viscosity.  |
|   | The stuffing-box packing is too tight.   | Readjust the packing. If the packing is worn, then replace the packing.  |
|   | Rotating parts are rubbing against each other.                                       | Check the parts that are wearing for proper clearances.  |
|   | The impeller clearance is too tight.   | Adjust the impeller clearance.   |

## 7.2 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. | <ol style="list-style-type: none"> <li>Determine which corners of the baseplate are high or low.</li> <li>Remove or add shims at the appropriate corners.</li> <li>Realign the pump and driver.</li> </ol>                  |
| Vertical (top-to-bottom) alignment cannot be obtained (angular or parallel).  | The baseplate is not leveled properly and is probably bowed.   | <ol style="list-style-type: none"> <li>Determine if the center of the baseplate should be raised or lowered.</li> <li>Level screws equally at the center of the baseplate.</li> <li>Realign the pump and driver.</li> </ol> |

## 7.3 i-ALERT®2 Equipment Health Monitor troubleshooting

To troubleshoot the i-ALERT®2 Equipment Health Monitor, please refer to the i-ALERT®2 Equipment Health Monitor IOM or <https://www.itproservices.com/Our-Services/Aftermarket-Products/Monitoring/i-ALERT2-condition-monitor/>



# 8 Parts Listings and Cross-Sectionals

## 8.1 Parts list

| Item         | Part Description  | S-4           | S-5           | S-6           | S-8           | C-6           | A-8           | D-1           | S-8N          | A-8N          |
|--------------|---|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 100          | Casing  | 9734/12<br>12 | 9734/12<br>12 | 9734/12<br>12 | 9734/12<br>12 | 9495/12<br>34 | 9497/12<br>96 | 9523/13<br>62 | 9734/12<br>12 | 9497/12<br>96 |
| 101          | Impeller  | 9803/12<br>12 | 9166/12<br>12 | 9168/12<br>34 | 9436/12<br>65 | 9168/12<br>34 | 9436/12<br>65 | 9524/13<br>62 | 9365/12<br>65 | 9365/12<br>65 |
| 108F         | Coupling,<br>Threaded -<br>Watchdog                     | -             |               |               |               |               |               |               |               |               |
| 109A         | Bearing End<br>Cover, Thrust                            | 1212          |               |               |               |               |               |               |               |               |
| 112A         | Bearing,<br>Thrust                                      | -             |               |               |               |               |               |               |               |               |
| 113A         | Breather  | 316SS         |               |               |               |               |               |               |               |               |
| 113B         | Plug, Inspec-<br>tion for bear-<br>ing journal<br>rings | 2210          |               |               |               |               |               |               |               |               |
| 114          | Oil Ring  | 1618          |               |               |               |               |               |               |               |               |
| 114A         | Oil Ring -<br>Thrust                                    | 1618          |               |               |               |               |               |               |               |               |
| 117          | Sleeve, Bear-<br>ing                                    | -             |               |               |               |               |               |               |               |               |
| 122          | Shaft   | 2238          | 2238          | 2238*         | 2351          | 2244          | 2351          | 2435          | 2351          | 2351          |
| 123          | Inpro Seal,<br>VB45-U, with<br>flinger                  | 1618          |               |               |               |               |               |               |               |               |
| 124          | Impeller Nut -<br>Radial End                            | 2446          |               |               | 6983          | 2446          | 6983          | 6186          | 2229          |               |
| 125          | Throat Bush-<br>ing                                     | 1001          | 2245          | 2245          | 6983          | 2245          | 6983          | 6187          | 2445          |               |
| 130          | Impeller Nut -<br>Thrust                                | 2446          |               |               | 6983          | 2446          | 6983          | 6186          | 2229          | 2229          |
| 133A         | Pipe Nipple,<br>Watch Dog                               | 6501          |               |               |               |               |               |               |               |               |
| 134,<br>134A | Bearing<br>Housing                                      | 1212          |               |               |               |               |               |               |               |               |
| 142          | Impeller Wear<br>Ring                                   | 1001          | 2446          | 2446          | 6983          | 2446          | 6983          | 6186          | 1071          | 1071          |
| 160          | Bearing End<br>Cover - In-<br>board                     | 1212          |               |               |               |               |               |               |               |               |
| 160A         | Bearing End<br>Cover, Out-<br>board Radial              | 1212          |               |               |               |               |               |               |               |               |
| 164          | Casing Wear<br>Ring                                     | 1001          | 2245          | 2245          | 6983          | 2245          | 6983          | 6187          | 1265          | 1265          |

## 8.1 Parts list

| Item                                       | Part Description                          | S-4                                | S-5           | S-6           | S-8           | C-6           | A-8           | D-1                 | S-8N                               | A-8N          |
|--|---|------------------------------------|---------------|---------------|---------------|---------------|---------------|---------------------|------------------------------------|---------------|
| 168  | Radial Bearing                            | -                                  |               |               |               |               |               |                     |                                    |               |
| 178  | Impeller Key                              | 2226                               |               |               |               | 2244          | 2226          | 2435                | 2226                               | 2226          |
| 178Y                                       | Key, Coupling - IMO Pump                  | 2213                               |               |               |               |               |               |                     |                                    |               |
| 184  | Head                                      | 9734/12<br>12                      | 9734/12<br>12 | 9734/12<br>12 | 9734/12<br>12 | 9495/12<br>34 | 9497/12<br>96 | 9523/13<br>62       | 9734/12<br>12                      | 9497/12<br>96 |
| 219  | IMO Oil Pump                              | -                                  |               |               |               |               |               |                     |                                    |               |
| 222B                                       | Set Screw, Impeller Nut                   | 2229                               |               |               |               |               |               | 2435                | 2229                               | 2229          |
| 222E                                       | Set Screw, Casing Head Rings              | 2229                               |               |               |               |               |               | 2435                | 2229                               | 2229          |
| 222S                                       | Set Screw, Coupling Nut                   | 2229                               |               |               |               |               |               |                     |                                    |               |
| * Use 2244 for Temperature > 177°C   350°F |   |                                    |               |               |               |               |               |                     |                                    |               |
| 222V                                       | Set Screw, Cooling Fan                    | 2229                               |               |               |               |               |               |                     |                                    |               |
| 234D                                       | Pump End-plate, Thrust Fan Guard          | 3201                               |               |               |               |               |               |                     |                                    |               |
| 234E                                       | Guard End-plate, Thrust Fan Guard         | 3201                               |               |               |               |               |               |                     |                                    |               |
| 280  | Kingsbury Bearing Assembly                | -                                  |               |               |               |               |               |                     |                                    |               |
| 282  | Key, Thrust Collar                        | 2213                               |               |               |               |               |               |                     |                                    |               |
| 283  | Thrust Collar Nut                         | 2210                               |               |               |               |               |               |                     |                                    |               |
| 318A                                       | Oil Pump Adapter                          | 1212                               |               |               |               |               |               |                     |                                    |               |
| 320  | Set Screw, Impeller Rings                 | 2229                               |               |               |               |               |               | 2435                | 2229                               |               |
| 324  | Oil Ring Sleeve, Radial                   | 2210                               |               |               |               |               |               |                     |                                    |               |
| 332A                                       | INPRO Seal, VB45-U, - Coupling (Outboard) | -                                  |               |               |               |               |               |                     |                                    |               |
| 333A                                       | INPRO VB45-U (Inboard)                    | -                                  |               |               |               |               |               |                     |                                    |               |
| 332C                                       | INPRO VB45-U - Thrust (Outboard)          | -                                  |               |               |               |               |               |                     |                                    |               |
| 351  | Gasket, Head                              | Spiral Wound Stainless Steel (316) |               |               |               |               |               | Spiral Wound Duplex | Spiral Wound Stainless Steel (316) |               |

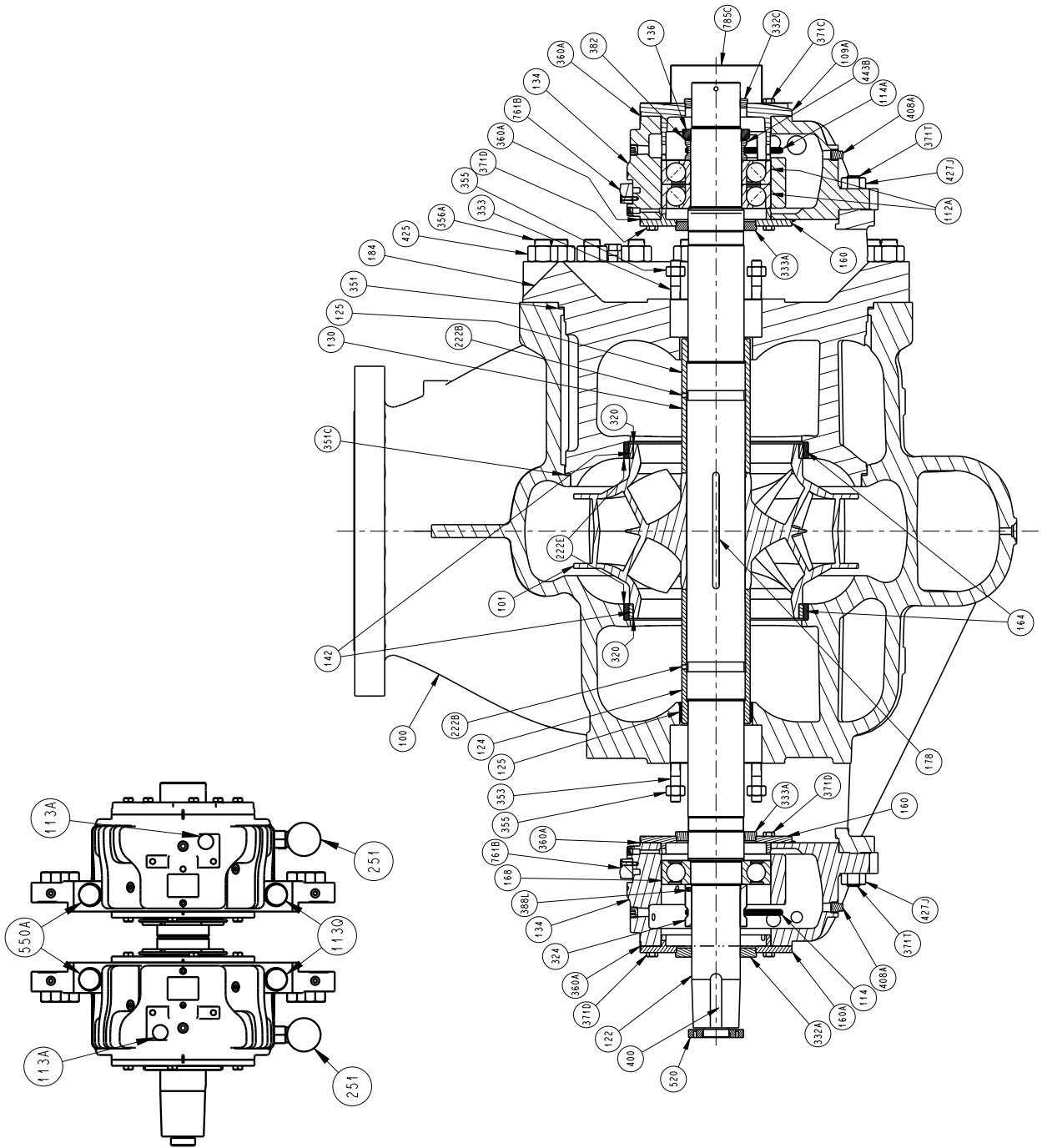
| Item | Part Description                   | S-4                                | S-5 | S-6 | S-8 | C-6 | A-8 | D-1                 | S-8N                               | A-8N |
|------|------------------------------------|------------------------------------|-----|-----|-----|-----|-----|---------------------|------------------------------------|------|
| 351C | Gasket, Heads (Inner)              | Spiral Wound Stainless Steel (316) |     |     |     |     |     | Spiral Wound Duplex | Spiral Wound Stainless Steel (316) |      |
| 353  | Stud - Gland                       | 5426                               |     |     |     |     |     |                     |                                    |      |
| 355  | Nut - Gland                        | 5427                               |     |     |     |     |     |                     |                                    |      |
| 356A | Stud - Casing                      | 2239                               |     |     |     |     |     |                     |                                    |      |
| 358M | 1/2" 14 NPT Pipe Plug              | 2210                               |     |     |     |     |     |                     |                                    |      |
| 360A | Gaskets, Bearing End Cover         | 5130-0007                          |     |     |     |     |     |                     |                                    |      |
| 361A | Bearing Retainer - Thrust          | 3211                               |     |     |     |     |     |                     |                                    |      |
| 370L | Cap Screw, Oil Pump To adapter     | 2210                               |     |     |     |     |     |                     |                                    |      |
| 370V | Cap Screw, Adapter To Housing      | 2210                               |     |     |     |     |     |                     |                                    |      |
| 371C | Bolts, Thrust End Cover to Housing | 2210                               |     |     |     |     |     |                     |                                    |      |
| 371D | Bolts, Radial End Cover To Housing | 2210                               |     |     |     |     |     |                     |                                    |      |
| 371T | Stud - Bearing Housing to Casing   | 2210                               |     |     |     |     |     |                     |                                    |      |
| 372T | Cap Screw, i-ALERT2                | 2367                               |     |     |     |     |     |                     |                                    |      |
| 382  | Bearing Lockwasher, Thrust         | -                                  |     |     |     |     |     |                     |                                    |      |
| 388L | Screw, Socket Head, Oil Sleeve     | 2229                               |     |     |     |     |     |                     |                                    |      |
| 390C | Shim Pack, Tilt Pad                | -                                  |     |     |     |     |     |                     |                                    |      |
| 392B | Cooling Fan - CW                   | 1425                               |     |     |     |     |     |                     |                                    |      |
| 394  | Roll Pin, Filler Plate             | -                                  |     |     |     |     |     |                     |                                    |      |
| 400  | Coupling Key                       | 2213                               |     |     |     |     |     |                     |                                    |      |
| 408A | Plug, Drain                        | -                                  |     |     |     |     |     |                     |                                    |      |
| 408H | Pipe Plug                          | 2210                               |     |     |     |     |     |                     |                                    |      |
| 408M | Pipe Plug                          | 2210                               |     |     |     |     |     |                     |                                    |      |
| 408R | Pipe Plug, (RTD's)                 | 2210                               |     |     |     |     |     |                     |                                    |      |
| 412M | O-Ring, Filler Plate               | 5304                               |     |     |     |     |     |                     |                                    |      |

## 8.1 Parts list

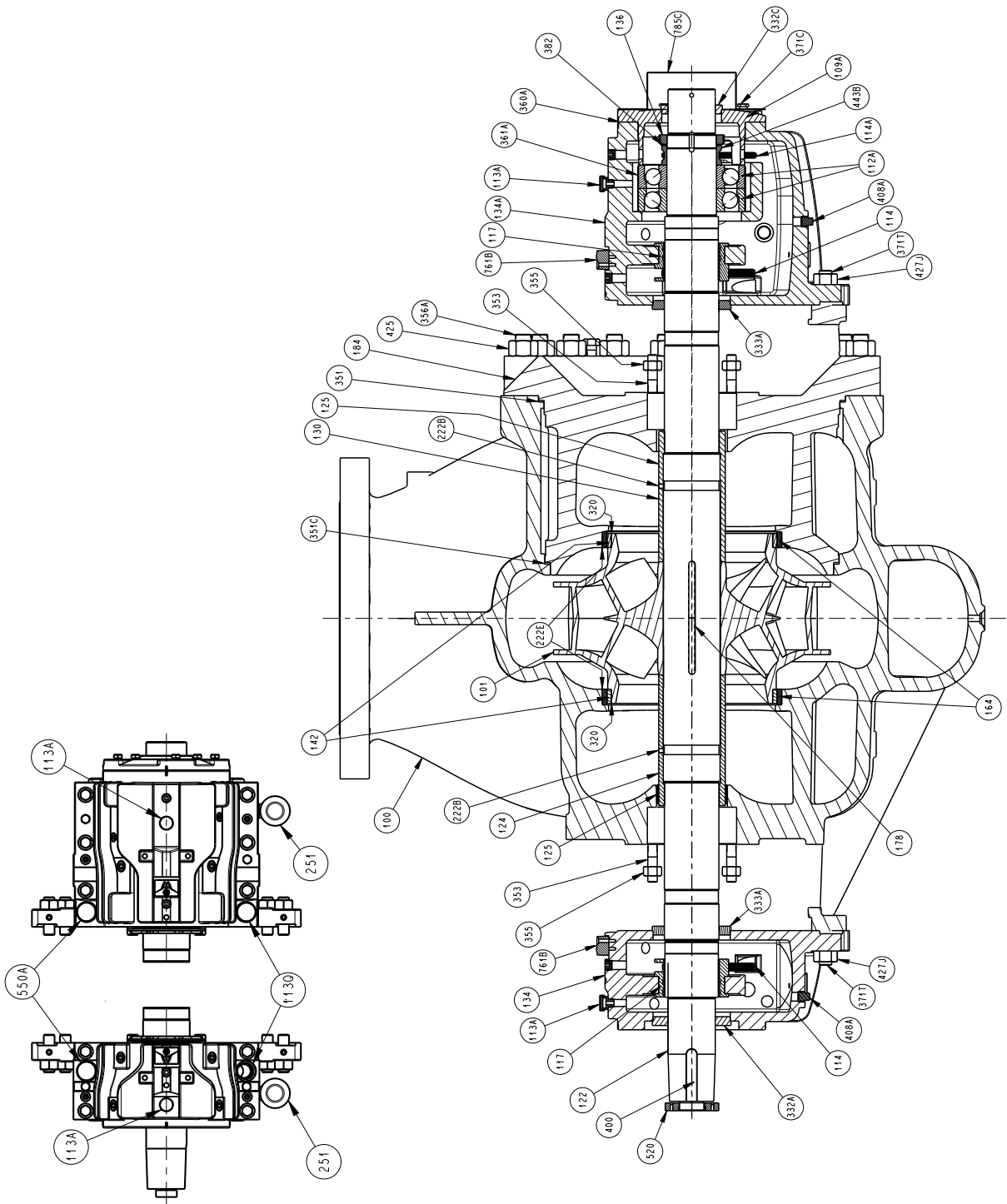
| Item | Part Description                   | S-4 | S-5 | S-6 | S-8 | C-6  | A-8 | D-1 | S-8N | A-8N |
|------|------------------------------------|-----|-----|-----|-----|--|-----|-----|------|------|
| 409L | Pipe Plug (Bearing Cooling)        |     |     |     |     | 2210   |     |     |      |      |
| 418  | Bolt, Hex Tap (Jacking)            |     |     |     |     | 2210   |     |     |      |      |
| 425  | Hex Nut, Casing Stud               |     |     |     |     | 2285   |     |     |      |      |
| 427J | Hex Flanged Nut, Housing to Casing |     |     |     |     | 2341   |     |     |      |      |
| 441A | Filler Plate                       |     |     |     |     | 2210   |     |     |      |      |
| 443B | Sleeve Oil Ring (Thrust)           |     |     |     |     | 2210   |     |     |      |      |
| 443V | Bearing Spacer - Thrust            |     |     |     |     | 2229   |     |     |      |      |
| 469D | Pin, Roll - Sleeve Bearing         |     |     |     |     | -  |     |     |      |      |
| 492V | Pipe Plug, Vibration               |     |     |     |     | 2210   |     |     |      |      |
| 494  | Bearing Cooling Option             |     |     |     |     | -  |     |     |      |      |
| 497G | O-Ring, Baffle                     |     |     |     |     | 5304   |     |     |      |      |
| 520  | Coupling Nut                       |     |     |     |     | 2210   |     |     |      |      |
| 534D | Washer – Fan Cooling               |     |     |     |     | 2229   |     |     |      |      |
| 534E | Bolt Retainer – Fan Cooling        |     |     |     |     | 300 Series Stainless Steel                     |     |     |      |      |
| 569F | Hex Tap Bolt - Thrust Fan          |     |     |     |     | 2228   |     |     |      |      |
| 570F | U-Nut, Thrust Fan                  |     |     |     |     | SAE 1045 Steel with Electroless Nickel Plating |     |     |      |      |
| 761B | i-ALERT2                           |     |     |     |     | 18-8 Stainless with Nylon 12 Cover             |     |     |      |      |
| 785C | Shaft Fan Guard - Top Hat          |     |     |     |     | 3201   |     |     |      |      |
| 785D | Cowling                            |     |     |     |     | 3201   |     |     |      |      |

# 8.2 Cross-sectional diagrams

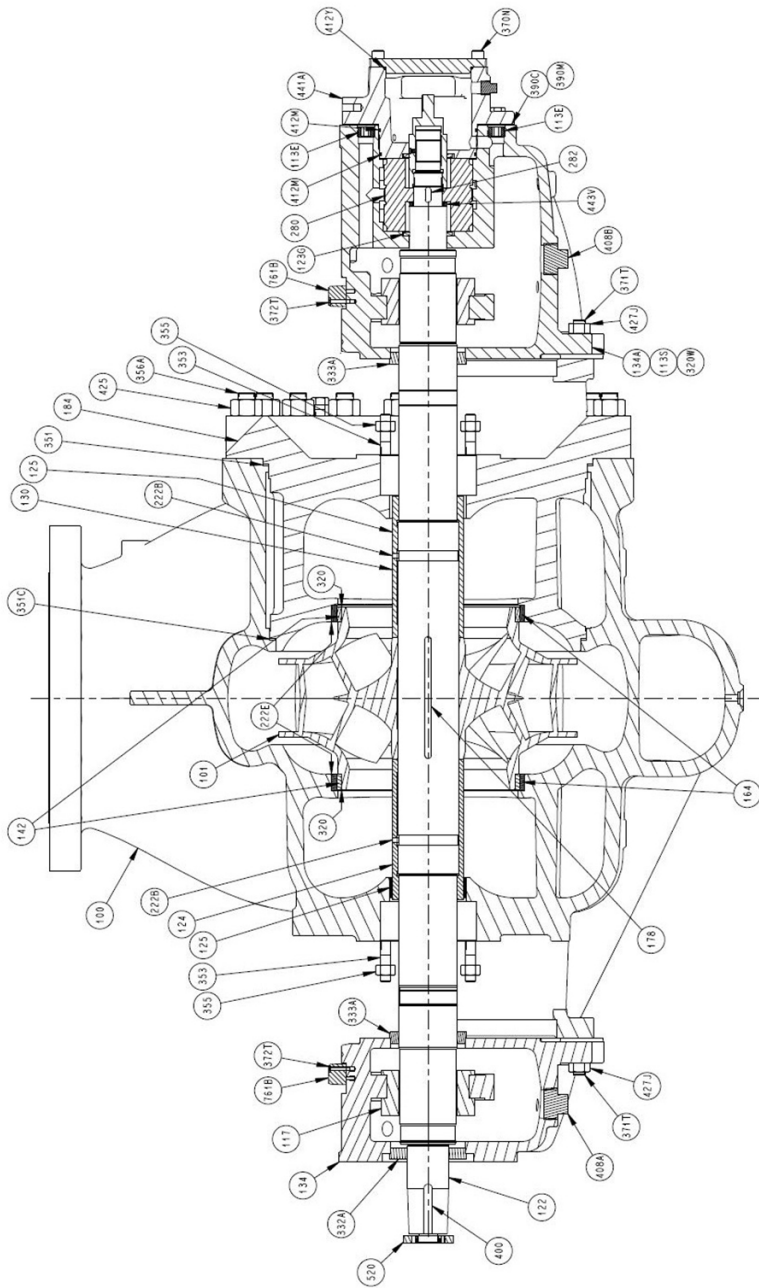
Model 3620 i-FRAME - Ball Ball



**Model 3620 i-FRAME - Sleeve Ball**



**Model 3620 i-FRAME - sleeve/tilt**



# 9 Other Relevant Documentation or Manuals

## 9.1 For additional documentation

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



# 10 Local ITT Contacts

## 10.1 Regional offices

| Region                       | Address  | Telephone        | Fax              |
|------------------------------|--|------------------|------------------|
| North America (Headquarters) | ITT - Goulds Pumps<br>240 Fall Street<br>Seneca Falls, NY 13148<br>USA   | +1 315-568-2811  | +1 315-568-2418  |
| Houston office               | 12510 Sugar Ridge Boulevard<br>Stafford, TX 77477<br>USA   | +1 281-504-6300  | +1 281-504-6399  |
| Los Angeles                  | Vertical Products Operation<br>3951 Capitol Avenue<br>City of Industry, CA 90601-1734<br>USA                               | +1 562-949-2113  | +1 562-695-8523  |
| Asia Pacific                 | ITT Fluid Technology Asia Pte Ltd<br>1 Jalan Kilang Timor<br>#04-06 Singapore 159303                                       | +65 627-63693    | +65 627-63685    |
| Europe                       | ITT - Goulds Pumps<br>Millwey Rise Industrial Estate<br>Axminster, Devon, England<br>EX13 5HU                              | +44 1297-639100  | +44 1297-630476  |
| Latin America                | ITT - Goulds Pumps<br>Camino La Colina # 1448<br>Condominio Industrial El Rosal<br>Huechuraba Santiago<br>8580000<br>Chile | +562 544-7000    | +562 544-7001    |
| Middle East and Africa       | ITT - Goulds Pumps<br>Achileos Kyrou 4<br>Neo Psychiko 115 25 Athens<br>Greece   | +30 210-677-0770 | +30 210-677-5642 |

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