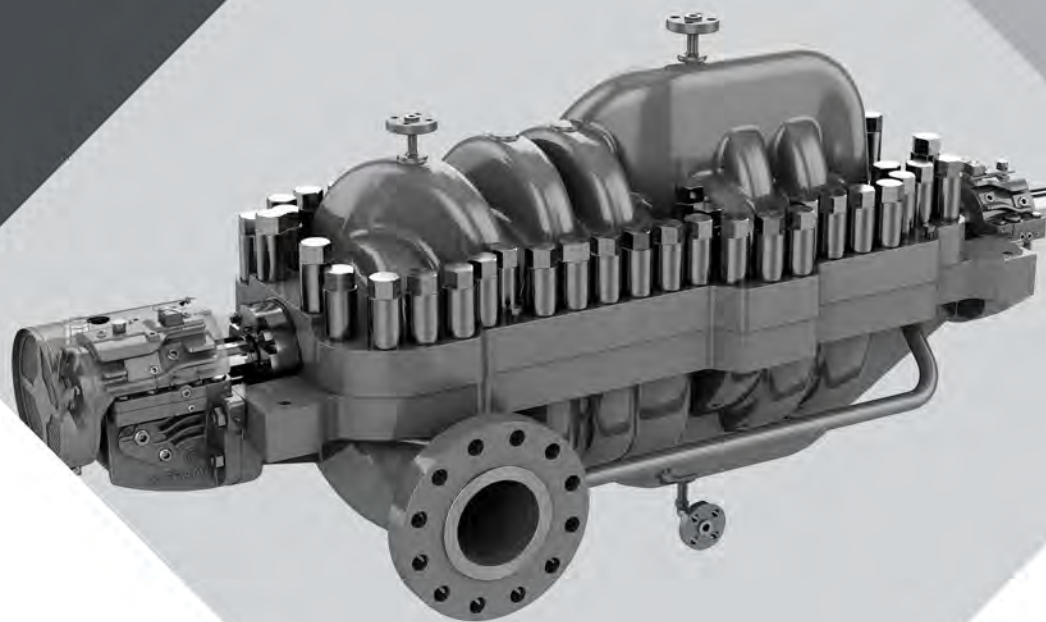




# Installation, Operation, and Maintenance Manual

Model 3600 i-FRAME API610 11th Edition / ISO  
13709 2nd Edition to current API BB3 Multi-  
Stage, Axially Split



**ITT**



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# 1 Introduction and Safety

## 1.1 Introduction

### Purpose of this manual

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

- Installation
- Operation
- Maintenance



### **CAUTION:**

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

---

### **NOTICE:**

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

---

### 1.1.1 Requesting other information

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

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

## 1.2 Safety



### **WARNING:**

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

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

**CAUTION:**

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

**WARNING:**

This product contains Carbon Black a chemical known to the State of California to cause cancer. For more information go to [www.P65Warnings.ca.gov](http://www.P65Warnings.ca.gov)




## 1.2.1 Safety terminology and symbols

### About safety messages

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

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

### Hazard levels

Hazard level		Indication
	<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.



---

#### **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.

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#### 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.



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## 1.2.3 User safety

### General safety rules

These safety rules apply:

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

### Safety equipment

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

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

### Electrical connections

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

### Noise



#### **WARNING:**

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

---

### Temperature



#### **WARNING:**

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

---

### 1.2.3.1 Precautions before work

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

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

### 1.2.3.2 Precautions during work

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



---

**CAUTION:**

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

---

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

### 1.2.3.3 Hazardous liquids

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

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

### 1.2.3.4 Wash the skin and eyes

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

Condition	Action
Chemicals or hazardous fluids in eyes	<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>

## 1.3 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.



## 1.4 Ex Considerations and Intended Use

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



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

### Personnel requirements

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

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

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

### Product and product handling requirements

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

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

### Description of Ex-Directives

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

### Guidelines for compliance

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

1. Monitoring the pump frame liquid end temperature.
2. Maintaining proper bearing lubrication.

3. Ensuring that the pump is operated in the intended hydraulic range.

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

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

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

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

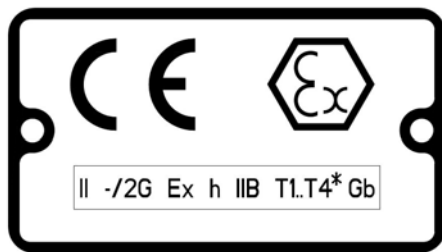


Figure 1: Typical Ex nameplate



Figure 2: Typical UKCA Ex nameplate

Table 1: Temperature class definitions

Code	Maximum permissible surface temperature in °C   °F	Maximum permissible liquid temperature in °C   °F
T1	440   824	372   700
T2	290   554	267   513
T3	195   383	172   342
T4	130   266	107   225
T5	Option not available	Option not available
T6	Option not available	Option not available

\* Maximum liquid temperature may be limited by the pump model and order specific options. [Table 1: Temperature class definitions on page 11](#) is for the purpose of determining 'T' code for Ex applications with liquid temperatures exceeding 107°C | 225°F.

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

#### ISO 80079-37:2016 Section 5.7

Recommended bearing replacement interval (based on L10 life) = 25,000 hours of operation.

# 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.

---



---

**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



---

**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.

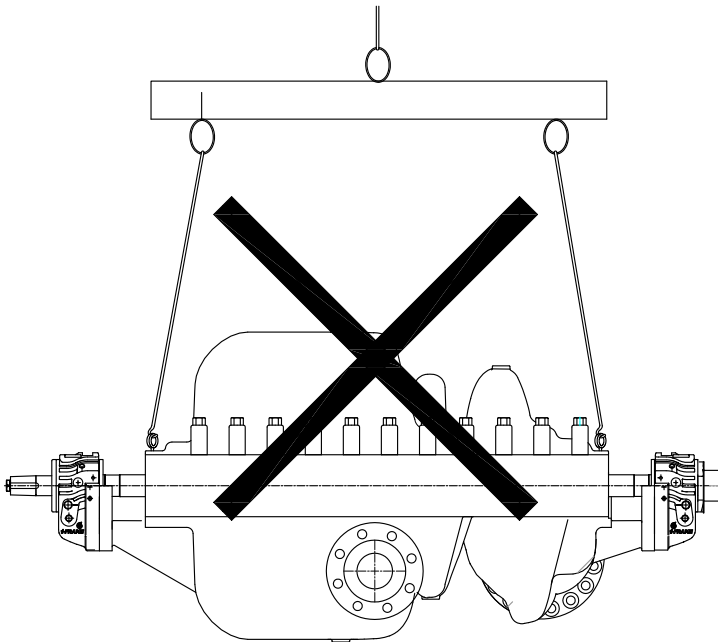
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**NOTICE:**

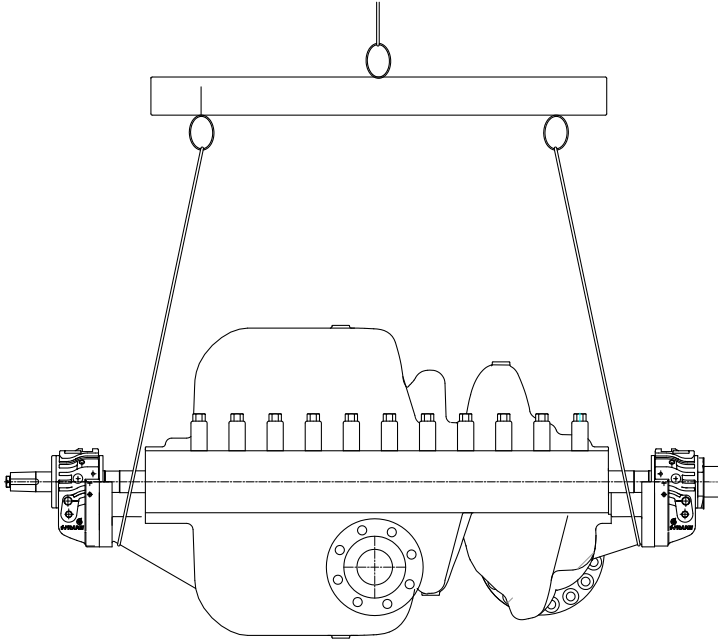
- Make sure that the lifting equipment supports the entire assembly and is only used by authorized personnel.
  - Do not attach sling ropes to shaft ends.
- 

**Lifting the pump**

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



**Figure 3: Example of improper lifting method for a bare pump**

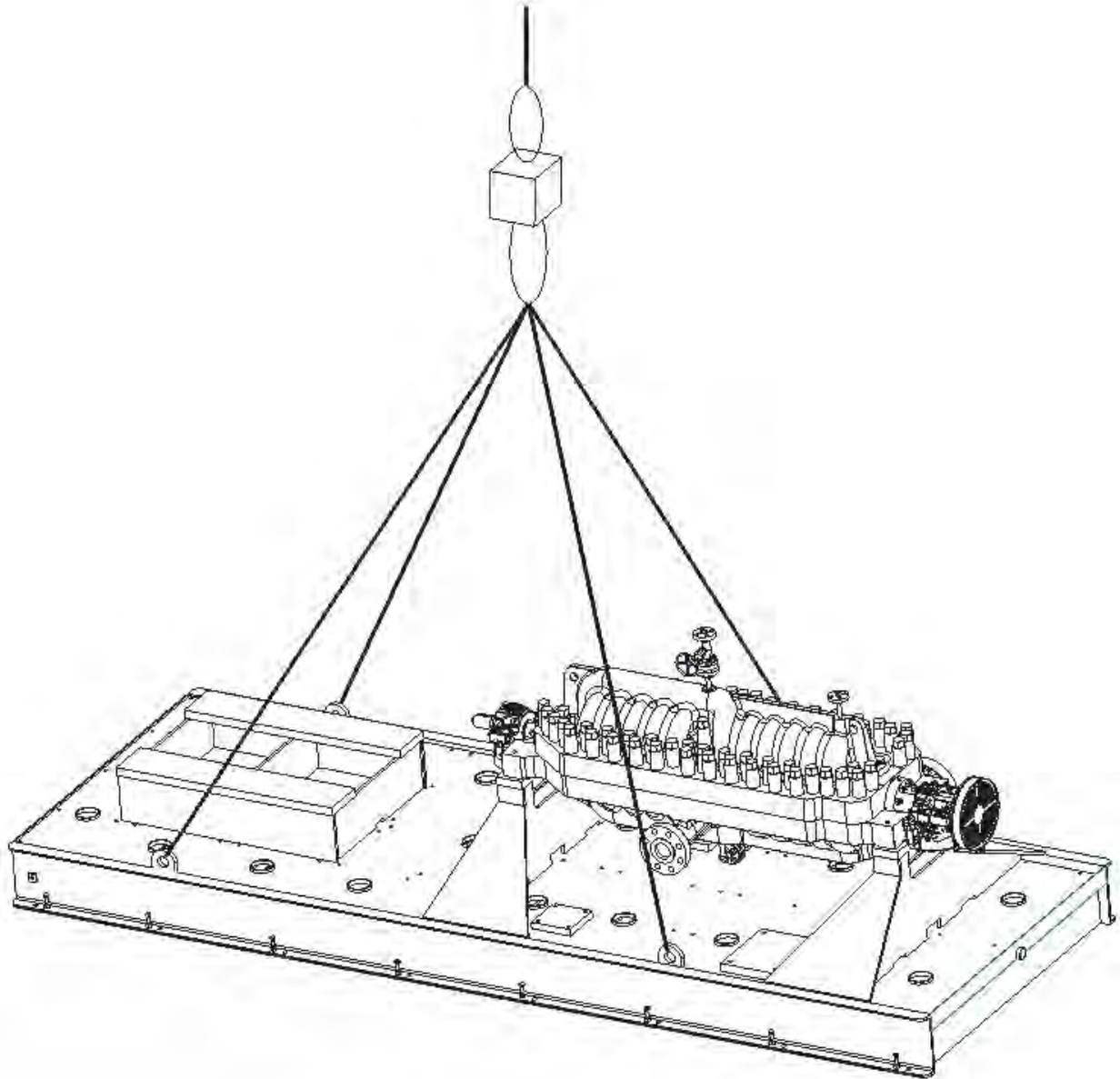


**Figure 4: Example of the proper lifting method for a bare pump**

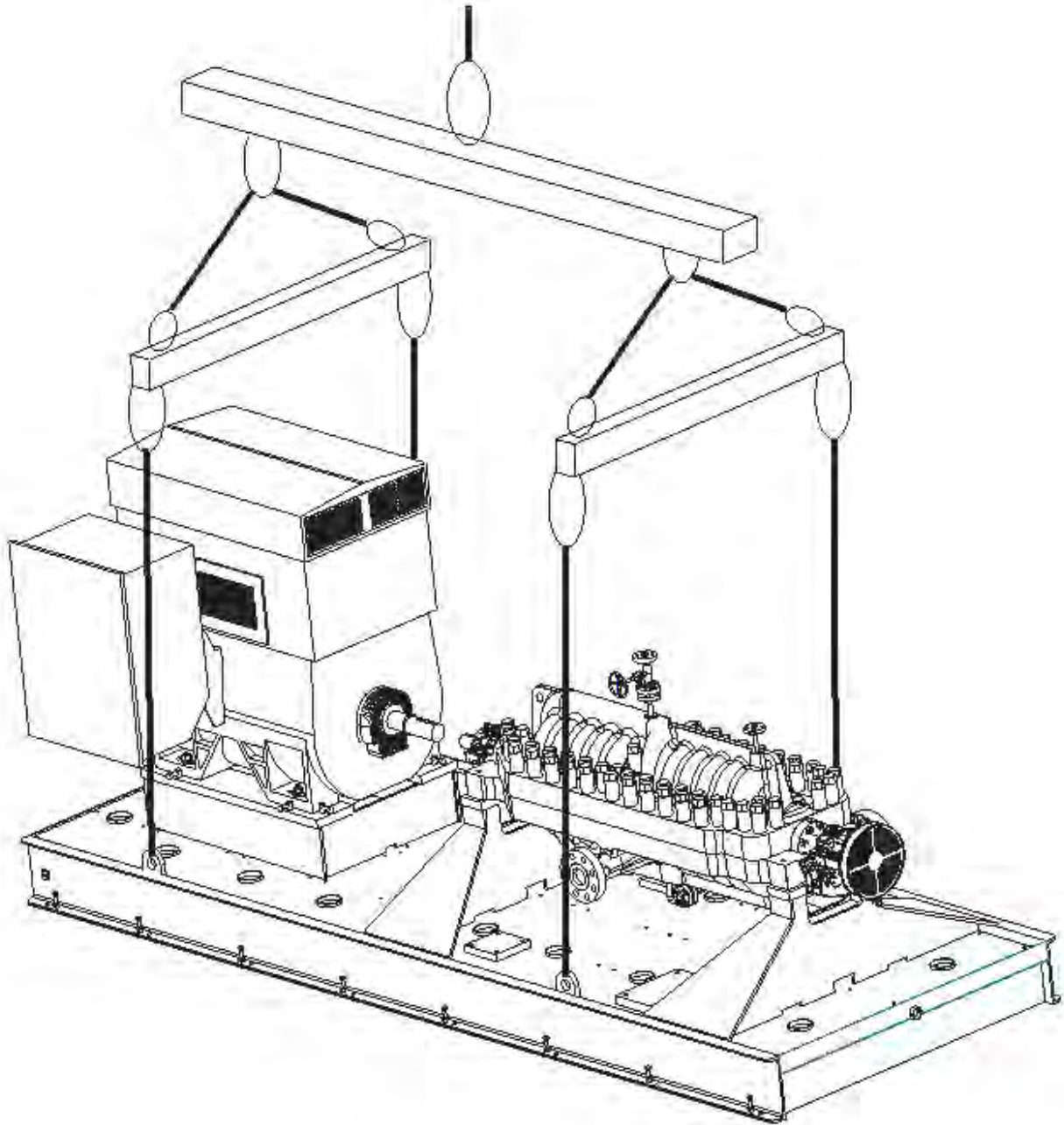
Baseplate-mounted units have lifting points for use with proper lifting devices; the approved lifting points are identified on the General Arrangement Drawing supplied with the pump. Due to design constraints, a spreader bar may be required for lifting in either scenario of [Figure 5: Example of the proper lifting method for baseplate-mounted units without a driver on page 15](#) or [Figure 6: Example of the proper lifting method for baseplate-mounted units with a driver on page 16](#) so that chains or slings do not to bind on or damage pump nozzles, tanks, reservoirs, junction boxes, etc.

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





**Figure 5: Example of the proper lifting method for baseplate-mounted units without a driver**



**Figure 6: 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

Model 3600 i-FRAME is a high-pressure, multistage, between bearings, horizontal centrifugal pump that meets the requirements of API 610 current edition ISO 13709.

### Impeller

The impeller is fully enclosed and key driven by the shaft.

### Seal chamber

The seal chamber meets API 610 dimensions for improved performance of mechanical seals.

### Power end

The power end has the following characteristics:

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

### Bearings

Bearing type	Characteristics
Drive End (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>
Non Drive End (thrust)	<ul style="list-style-type: none"> <li>• Consists of a pair of single-row angular contact ball bearings mounted back-to-back with machined brass cages (standard)</li> <li>• Shouldered and locked into place, enabling the bearing to carry both radial and axial thrust loads</li> <li>• Optional hydrodynamic thrust bearing (used with sleeve-type journal bearings)</li> </ul>

### Shaft

The heavy-duty shaft has the following characteristics:

- Designed for cartridge mechanical seals
- Minimal shaft deflection at the seal faces (0.002) when run in the worst-case condition (typically minimum flow)
- Fully compliant with API 610 and ISO 13709 requirements

### Baseplate

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

**Direction of rotation**

The shaft rotates counterclockwise when viewed from the power end.

**Intended applications**

Model 3600 is designed to meet the rigorous demands of the petroleum and petrochemical industry.

## 3.2 General description i-ALERT® Equipment Health Monitor

**Description**

The i-ALERT® Equipment Health Monitor is a compact, battery-operated monitoring device that continuously measures the vibration and temperature of the pump power end. The i-ALERT® sensor uses blinking LED 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 i-ALERT® monitor allows customers to identify potential problems before they become costly failures. It tracks vibration, temperature, change in electromagnetic field and run-time hours and wirelessly syncs the data with the i-ALERT Gateway or with a smart phone or tablet using i-ALERT® mobile app.

More information available on <https://www.i-alert.com/products/>

Current IOMs are available at <http://www.gouldspumps.com/en-us/tools-and-resources/literature/> - and - [resources/literature/](https://www.i-alert.com/) IOMs, <https://www.i-alert.com/> or your local ITT Goulds Pumps Sales Rep.

**Alarm mode**

The condition monitor enters alarm mode when either vibration or temperature limits are exceeded over two consecutive readings within a user defined period. Alarm mode is indicated with red flashing LED.

**Table 2: Temperature and vibration limits**

Variable	Limit
Temperature	100°C   195°F Surface Temperature
Vibration	100% increase over the baseline level

**Battery life**

The i-ALERT® Condition Monitor battery is replaceable.

The battery life is not covered as part of the standard pump warranty.

This table shows the average condition monitor battery life under normal and alarm-mode operating conditions.

Condition monitor operational state	Battery life
Normal operating and environmental conditions	Three to five years
Alarm mode	One year

## 3.3 Nameplate information

**Important information for ordering**

When you order spare parts, identify this pump information:

- Model

### 3.3 Nameplate information

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

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

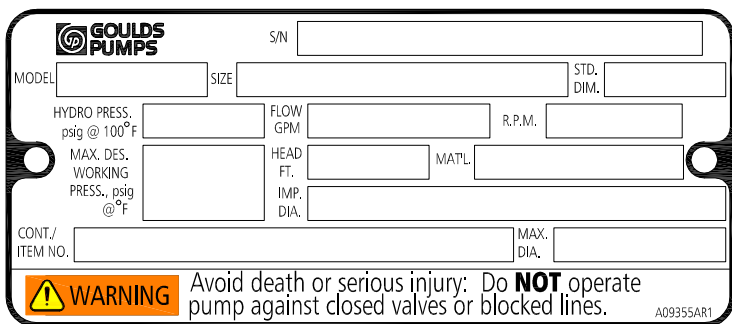
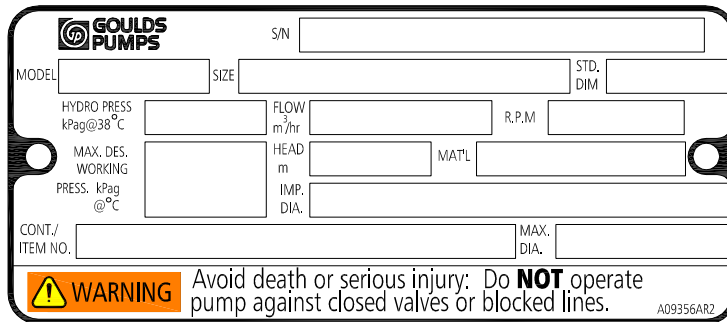


Figure 7: Nameplate on the pump casing using English units

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
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

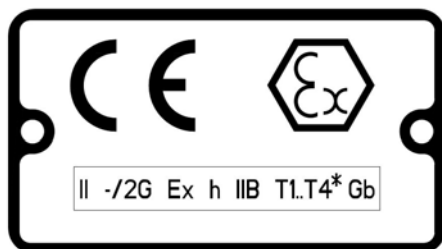


**Figure 8: Nameplate on the pump casing using metric units**

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

### Ex nameplate

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



**Figure 9: Typical Ex nameplate**



**Figure 10: Typical UKCA Ex nameplate**

### ISO 80079-37:2016 Section 5.7

Recommended bearing replacement interval (based on L10 life) = 25,000 hours of operation.

The code classification marked on the equipment should be in accordance with the specified area where the equipment will be installed. If it is not, please contact your ITT/Goulds representative before proceeding.



**WARNING:**

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

---



# 4 Installation

## 4.1 Pre-installation

### Precautions



#### WARNING:

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

#### NOTICE:

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

### 4.1.1 Pump location guidelines

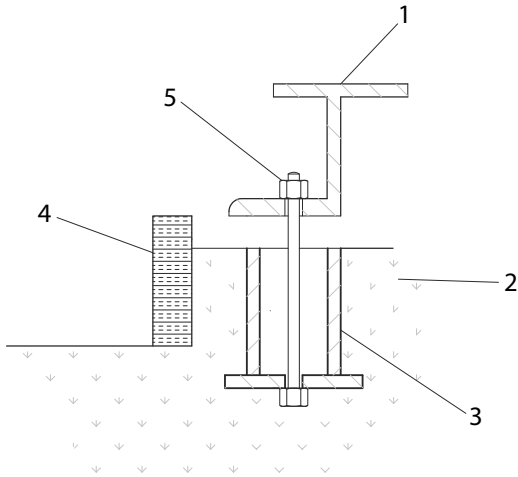
Guideline	Explanation/comment
Keep the pump as close to the liquid source as practically possible.	This minimizes the friction loss and keeps the suction piping as short as possible.
Make sure that the space around the pump is sufficient.	This facilitates ventilation, inspection, maintenance, and service.
If you require lifting equipment such as a hoist or tackle, make sure that there is enough space above the pump.	This makes it easier to properly use the lifting equipment and safely remove and relocate the components to a safe location.
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

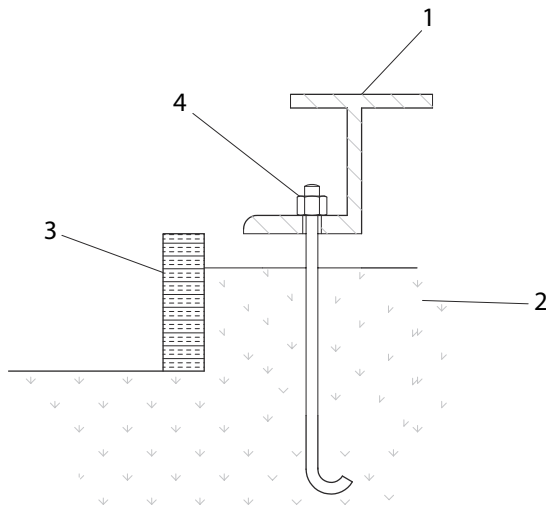
- The foundation must weigh not less than three times the combined weight of the pump, driver, baseplate and auxiliaries.
- Provide a flat, substantial concrete foundation in order to prevent strain and distortion when you tighten the foundation bolts.

### Sleeve-type bolts



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

**Figure 11: Sleeve type bolts**

**J-type bolts**

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

**Figure 12: 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-binding 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.

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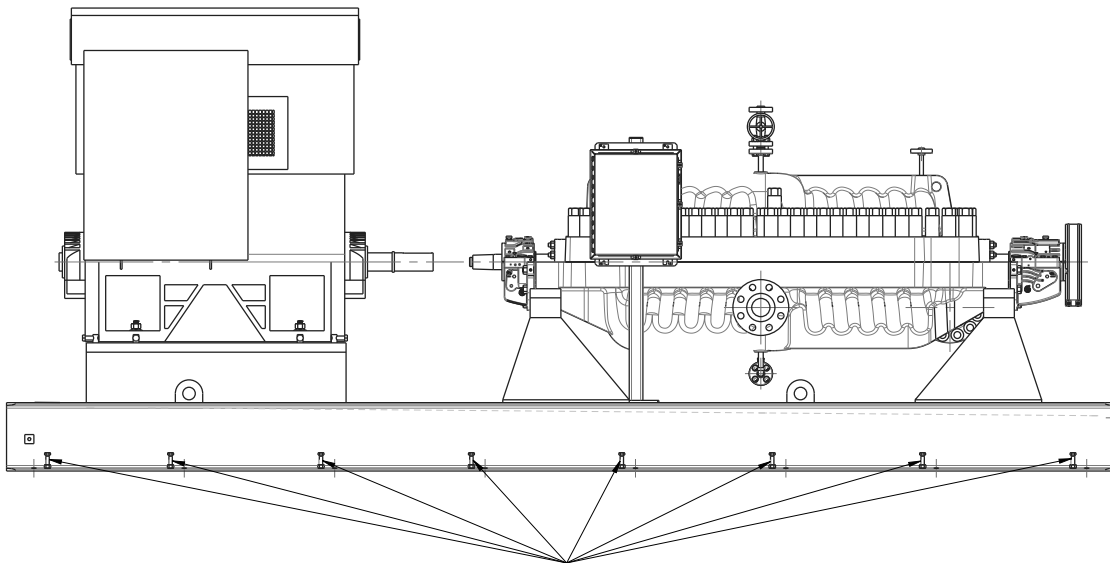
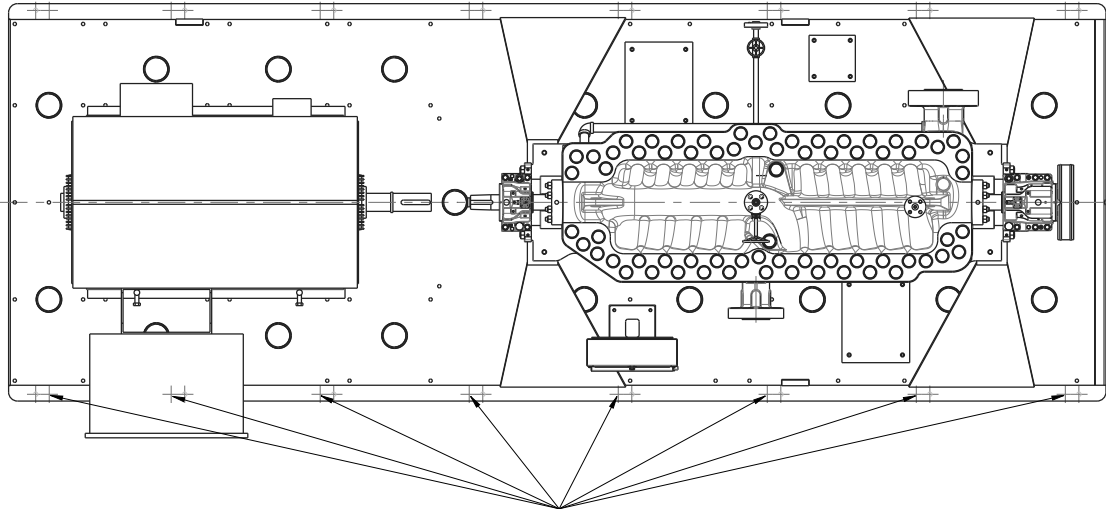


Figure 13: Jackscrew locations, side view



**Figure 14: 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



#### 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.  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.

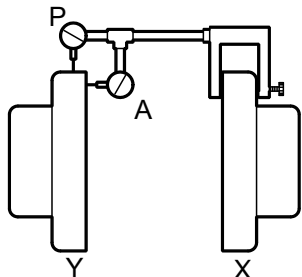
## 4.4.3 Alignment measurement guidelines

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.

- Attach two dial indicators on the pump coupling half (X):
  - 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.
  - 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.



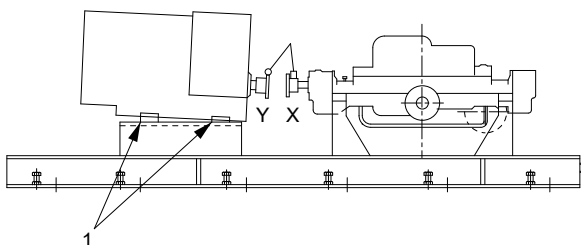
**Figure 15: Dial indicator attachment**

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 16: Example of incorrect vertical alignment (side view)**

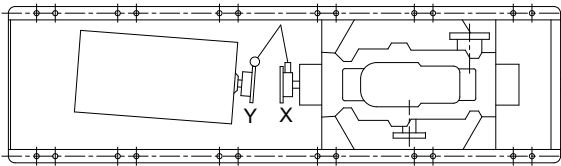
4. Repeat the previous steps until the permitted reading value is achieved.

### 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 17: Example of incorrect horizontal alignment (top view)**

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

Maximum permitted value for angular alignment:

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

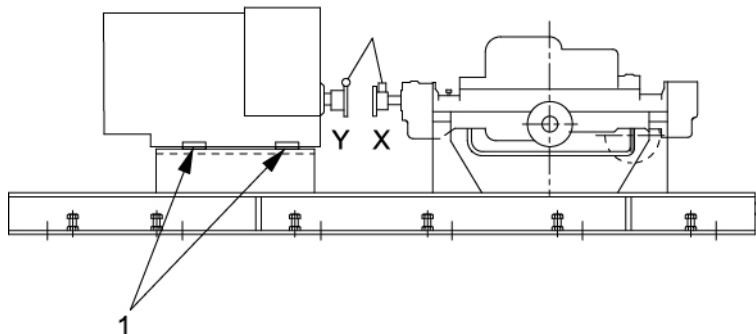
Refer to the alignment table in "Permitted indicator values for alignment checks" (see Table of Contents for location of table) for the proper cold alignment value based on the driver temperature rise and the pump operating temperature.

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 18: Example of incorrect vertical alignment (side view)**

- 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.

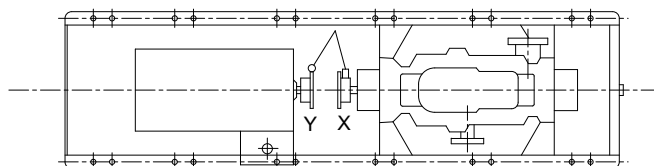
- Set the parallel alignment indicator (P) to zero on the left side of the driver coupling half (Y), 90° from the top-center position (9 o'clock).
- Rotate the indicator through the top-center position to the right side, 180° from the start position (3 o'clock).
- Record the indicator reading.

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).

- 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 19: 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.

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#### 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.

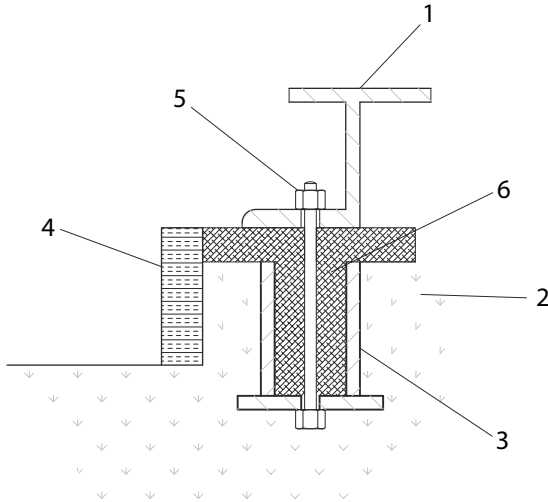
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**NOTICE:**

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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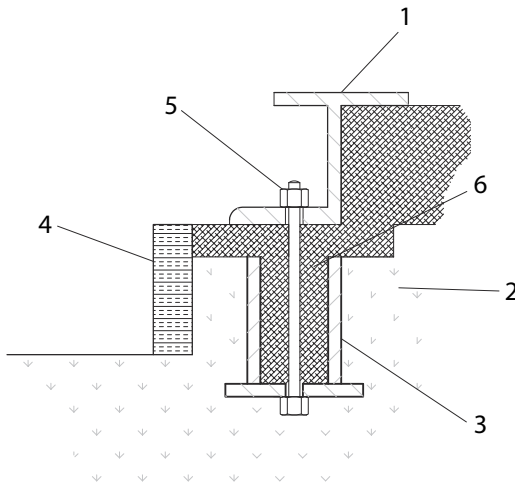
1. Clean all the areas of the baseplate that will come into contact with the grout.
2. Build a dam around the foundation.
3. Thoroughly wet the foundation that will come into contact with the grout.
4. Pour grout through the grout hole into the baseplate up to the level of the dam.  
When you pour the 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 20: 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 21: 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 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.

---

#### **NOTICE:**

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

---

#### Piping guidelines

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

**Checklist**

Check	Explanation/comment	Checked
Check that all piping is supported independently of, and lined up naturally with, the pump flange. 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.	
Keep the piping as straight as possible. Avoid unnecessary bends. Use 45° or long radius 90° fittings where necessary.	This helps to minimize friction losses.	
Check that only necessary fittings are used.	This helps to minimize friction losses.	
Make sure that the inside diameters match properly when you use flange joints.	—	
Do not connect the piping to the pump until: <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>	—	
Make sure that all the piping joints and fittings are airtight.	This prevents air from entering the piping system or leaks that occur during operation.	
If the pump handles corrosive fluids, make sure that the piping allows you to flush out the liquid before you remove the pump.		
	This helps to prevent misalignment due to thermal expansion of the piping.	
Make sure that all piping components, valves and fittings, and pump branches are clean prior to assembly.	—	
Make sure that the isolation and check valves are installed in the discharge line.	Locate the check valve between the isolation valve and the pump. This will permit inspection of the check valve. The isolation valve is required for regulation of flow, and for inspection and maintenance of the pump. The check valve prevents pump or seal damage due to reverse flow through the pump when the driver is turned off.	
Use cushioning devices.	This protects the pump from surges and water hammer if quick-closing valves are installed in the system.	
In no case should loads on the pump flanges exceed the limits stated in API Standard 610, 11th Edition (ISO 13709).	Bottom of casing should be supported by a solid foundation or casing feet should be used.	

**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.

Type	Criteria
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. 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 80 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 60 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. 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. 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, seal-chamber cover 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




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### 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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### WARNING:

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

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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 79°C | 175°F.
- 

**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 121°C | 250°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 fluid may also be allowed to enter the suction nozzle in addition to the drain.). The recommended warm up rate is 2°C to 3°C | 3°F to 5°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°C to 2°C | 1.5°F to 2.5°F per minute.

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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. Remove the bolt from the slotted hole in the center of the coupling guard.
3. Slide the driver half of the coupling guard toward the pump.
4. Remove the nut, bolt, and washers from the driver half of the coupling guard.
5. Remove the driver-side end plate.
6. Remove the driver half of the coupling guard:
  - a) Slightly spread the bottom apart.

- b) Lift upwards.
7. 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.
8. 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:

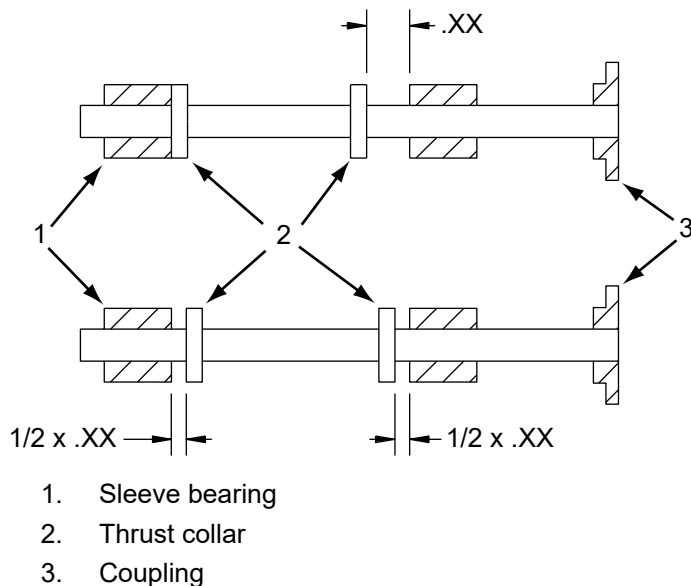
**NOTICE:**

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 22: 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**

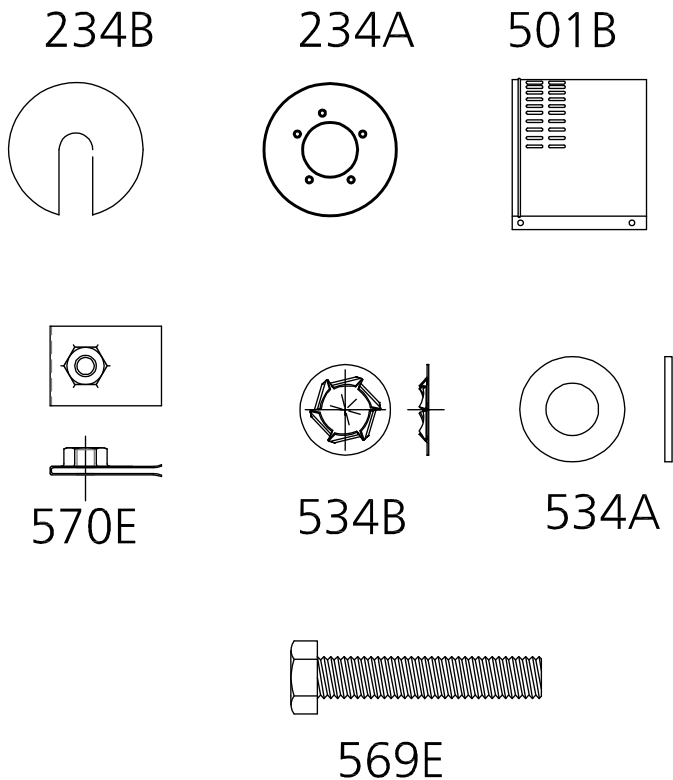


**WARNING:**

- 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 23: Coupling guard required parts**

#### 5.4.1.1 Install the coupling guard

1. Is the pump cover 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.

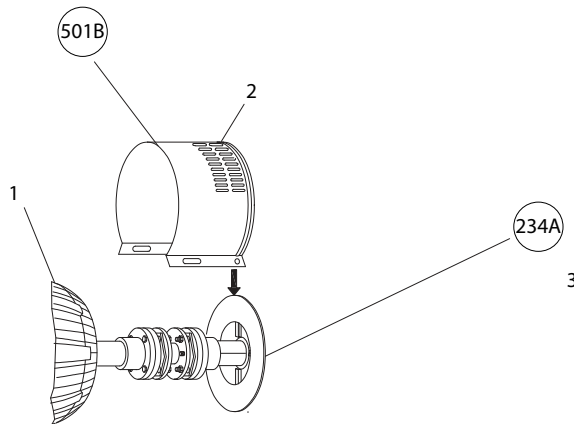
- b) If the coupling hub diameter is larger than the diameter of the opening in the end plate, then remove the coupling hub.
- c) Remove the outboard end cover (160) bolts (371D).
- d) Align the pump cover (234A) to the outboard end cover (160) so the holes in the pump cover align with the holes in the outboard end cover.
- e) Replace the outboard end cover and torque to the value shown in the Assembly references. This section contains reference information for reassembly procedures..
- 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.

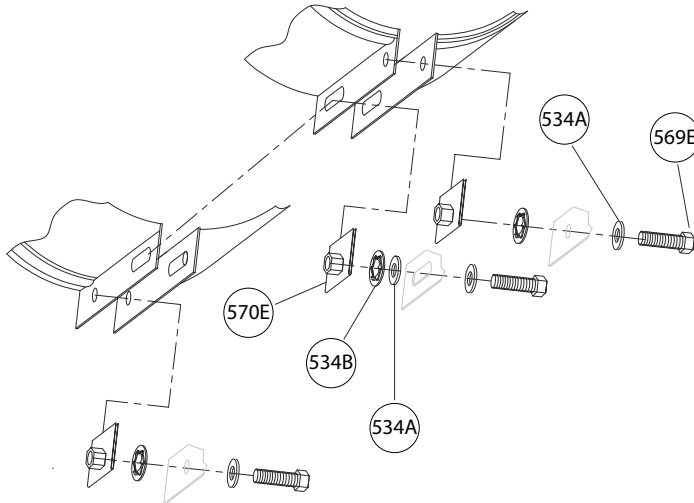


Item	Description	Part No.
1.	Driver	
2.	Annular groove	501B
3.	Pump endplate	234A

**Figure 24: Align pump end guard half with annular groove**

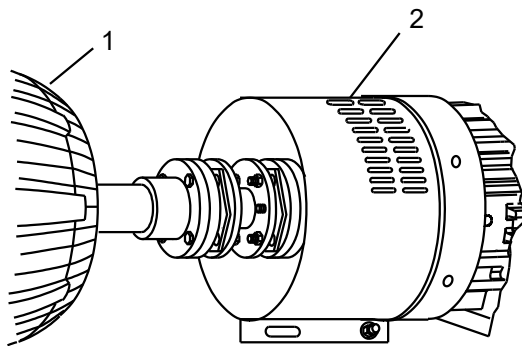
3. Place one washer (534A) over the bolt (569E) and insert the bolt through the round hole at the front end of the guard half.





**Figure 25: Captured hardware component assembly**

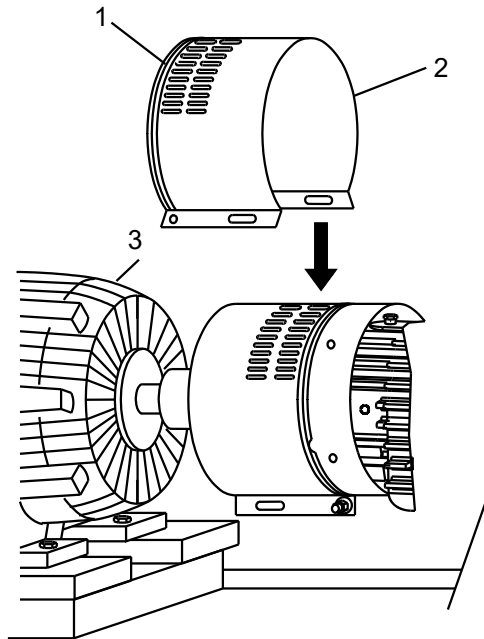
4. Install the bolt retainer (534B) over the exposed end of the bolt, and the U-Nut (570E) into the slot in the coupling guard if it was not done from the factory.
5. Thread bolt (569E) into the U-Nut (570E) and tighten firmly.  
This figure shows the proper sequence of components:



Item	Description
1.	Driver
2.	Coupling guard half

**Figure 26: Coupling guard assembly – pump end**

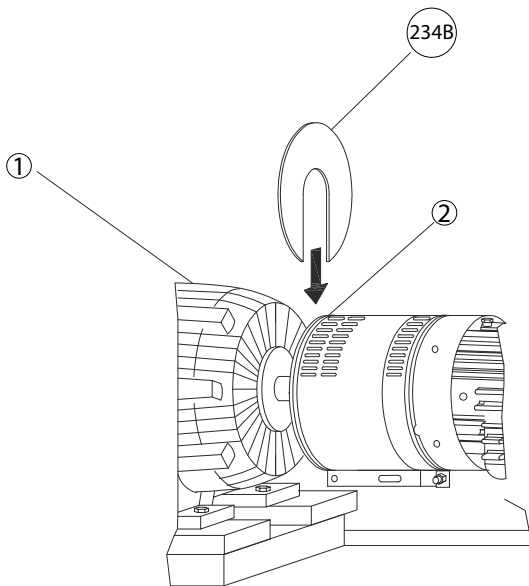
6. Slightly spread the opening of the remaining coupling guard half and place it over the installed coupling guard half so that the annular groove in the remaining coupling guard half faces the driver.



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

**Figure 27: Coupling guard assembly - driver end**

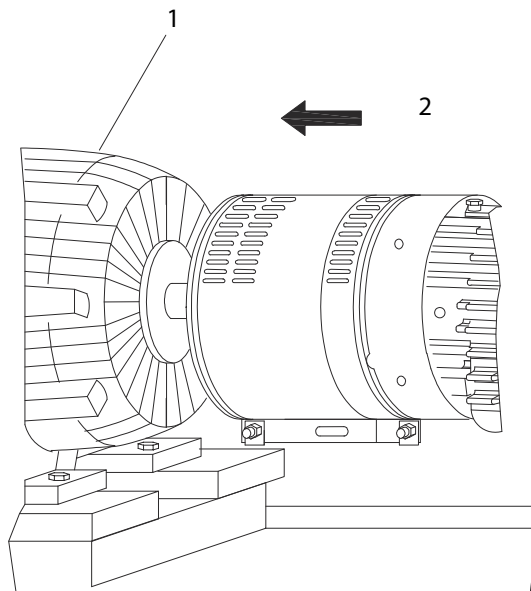
- Place the end plate over the driver shaft and locate the end plate in the annular groove at the rear of the coupling guard half.



Item	Description
1.	Driver
2.	Annular groove

**Figure 28: 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 29: 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 ring 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 bearings

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 4 oz. (118 ml).

Size	Radial Bearing	Drive End Bearing Housing Oil Volume		Thrust Bearing	Non Drive End Bearing Housing Oil Volume	
		ounces	milliliters		ounces	milliliters
24F	6311	45	1331	7311	45	1331
25G	6312	45	1331	7312	45	1331
34H	6313	87	2573	7313	87	2573
35J	6314	87	2573	7314	87	2573
36H	6216	87	2573	7313	87	2573

### Oil volume requirements for sleeve/ball type bearings

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	
		ounces	milliliters		ounces	milliliters
24F	Sleeve	Not Available	Not Available	Not Available	Not Available	Not Available
25G	Sleeve	Not Available	Not Available	Not Available	Not Available	Not Available
34H	Sleeve	82	2425	7313	142	5826
35J	Sleeve	82	2425	7314	142	5826
36H	Sleeve	82	2425	7313	142	5826
57Q	Sleeve	124	3667	TBD	248	7334

### 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. 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			

\*Acceptable oil brands are not limited to those listed above, brands listed are typically used by the OEM.

## 5.5.4 Lubricate the bearings with oil



### WARNING:



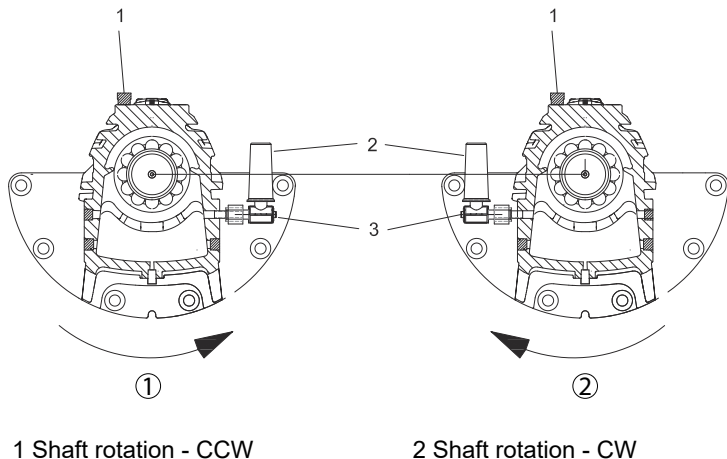
Risk of explosive hazard and premature failure from sparks and heat generation. Ensure bearings are properly lubricated prior to startup.

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 bulls-eye sight glass, when the pump is not in operation. During operation, bulls-eye sight gives a false oil level reading. Shown is general schematic.

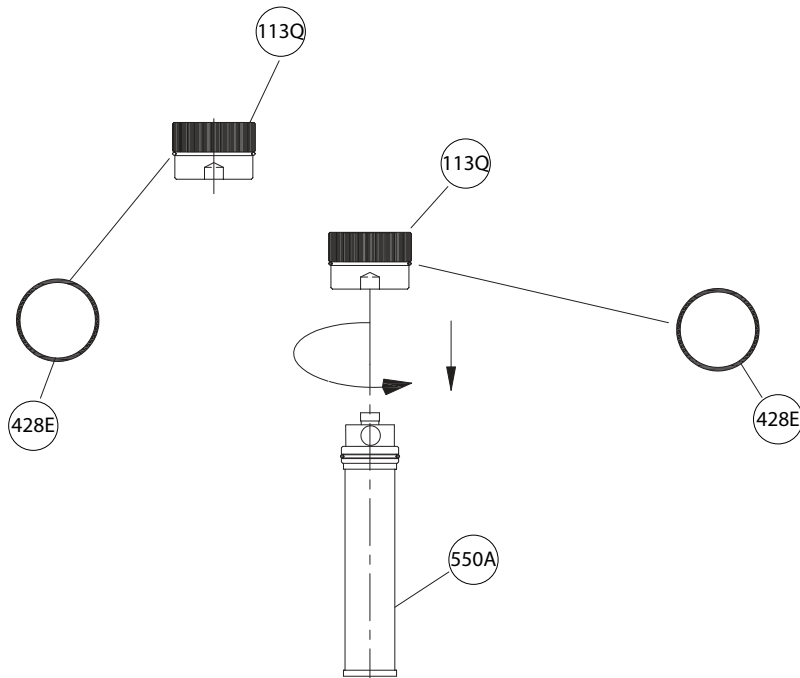


Item	Description
1.	Plug
2.	Reservoir
3.	Main body

**Figure 30: 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 [5.5.5 Replace the oil filter on page 52](#).
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.
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.
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)..



**Figure 31: 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.

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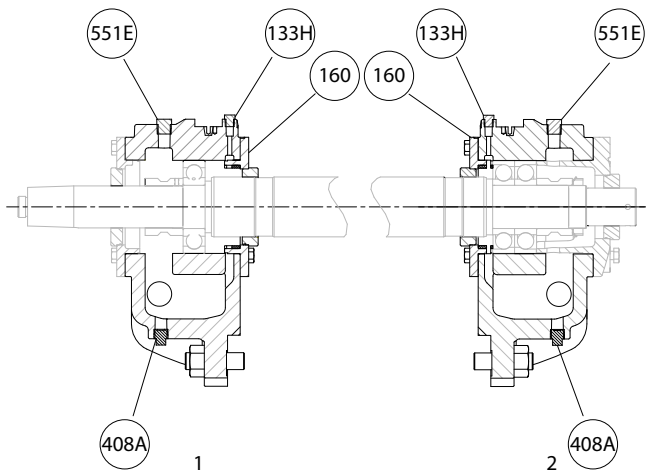
**NOTICE:**

Oil mist is recommended for use on ball bearing arrangements only. See convert to oil mist lubrication.

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1. Prepare the oil-mist generator according to the manufacturer's instructions.
2. Connect the oil-mist supply lines to the plug connections as shown below. 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 bearing housing is used.



1. Radial end (Drive end)

2. Thrust end (Non drive end)

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

**Figure 32: 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.

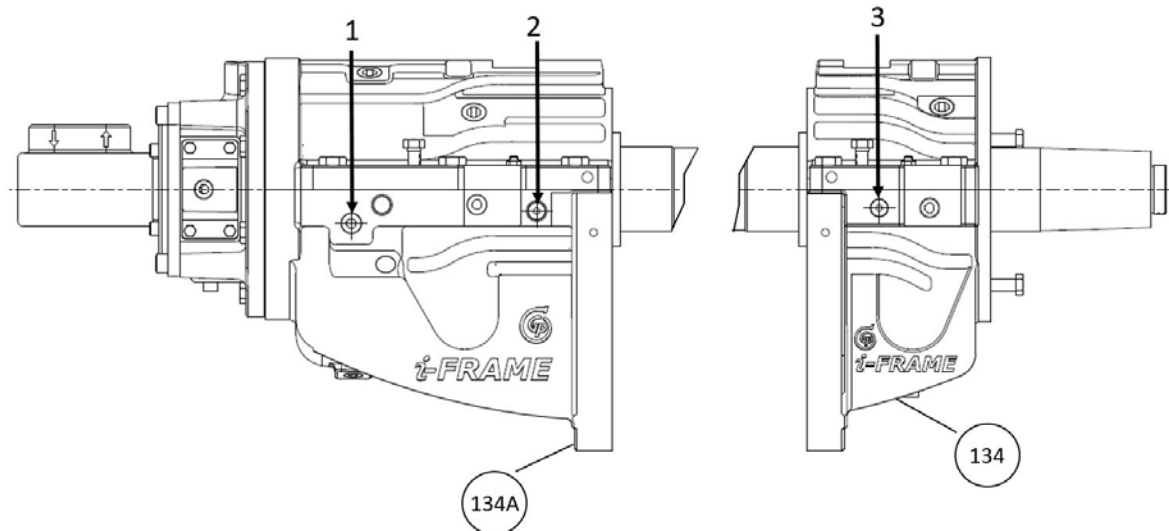


2. On the thrust housing, replace the 1/4 in. NPT plug (133H) with an oil-mist fitting. Replace the 1/2 in. NPT plug (551E) with a 1/2 in. to 1/4 in. bushing and insert an oil-mist fitting provided by the oil-mist system manufacturer.
3. For pure-oil mist, connect the drain lines (408A) to the outlet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

### 5.5.7 Lubricate the bearings with pressurized lubrication

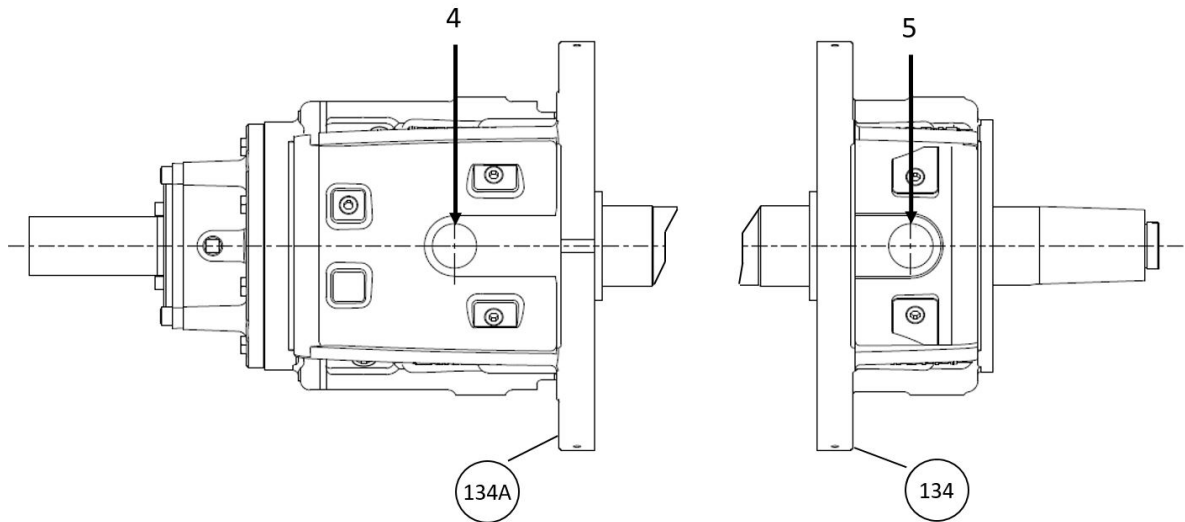
Pressurized lubrication requires a separate lubrication oil skid to provide cool, clean oil to the bearing housings. The lubrication oil skid shall be in operation to ensure oil flow into the bearings prior to pump operation. The pump may have been supplied with orifices or valves to control inlet flow 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 33: Oil feed location on page 55](#).
3. Connect the bearing housing drain piping back to the lubrication oil skid as shown in [Figure 34: Oil drain locations on page 56](#).



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

**Figure 33: Oil feed location**



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

Figure 34: Oil drain locations

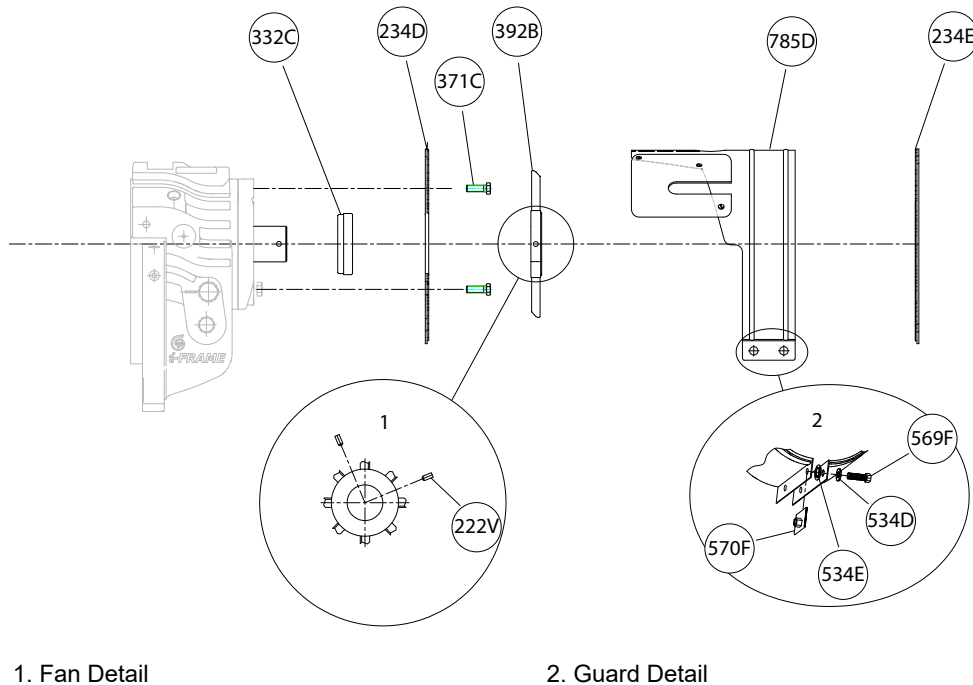
### 5.5.8 Thrust Bearing Cooling Fan (Optional)

#### 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 35: 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.



#### **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:**

- 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, however this should be verified by the customer prior to start-up.

Customers should always check to make sure the clips have been disengaged prior to starting the pump.

### 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 3: 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.

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

## 5.8 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.



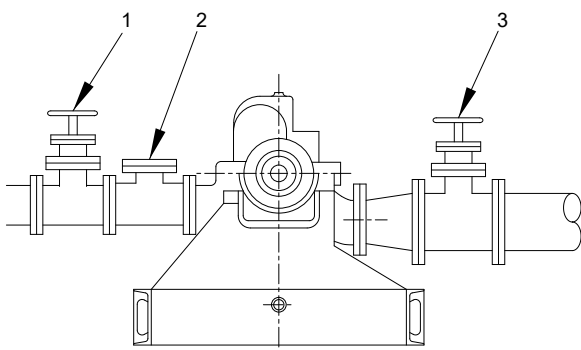
### WARNING:

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.

### 5.8.1 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 36: Suction supply above pump**

## 5.9 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.
- 

**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.

## 5.10 i-ALERT<sup>®</sup> Equipment Health Monitor

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**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® Equipment Health Monitor Installation, Operation and Maintenance manual. <https://www.i-alert.com/support/>

## 5.11 Pump operation precautions

### General considerations



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**WARNING:**

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

---

**NOTICE:**

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.
  - Make sure to operate the pump at or near the rated conditions. Failure to do so can result in pump damage from cavitation or recirculation.
  - 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.
  - Risk of explosion and serious physical injury. Do not operate the pump below the thermal minimum flow. This can cause excessive heat build-up and vaporization of the pumpage.
- 

#### **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.

---

## 5.12 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.

## 5.13 Deactivate the i-ALERT® 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.

Disengage the snap fit of the i-ALERT® using a flat head tool as shown below:





**Figure 37: Disengage the battery from the sensor when shutting the pump for an extended period of time**

## 5.14 Reset the i-ALERT® Health Monitor

To deactivate or reset the i-ALERT® monitor, please refer to the i-ALERT® IOM, <http://i-alert.com/>

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 health monitor to alert in error.

## 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.  
Refer to [4.4 Pump-to-driver alignment on page 28](#) 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 Remove the coupling guard.

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

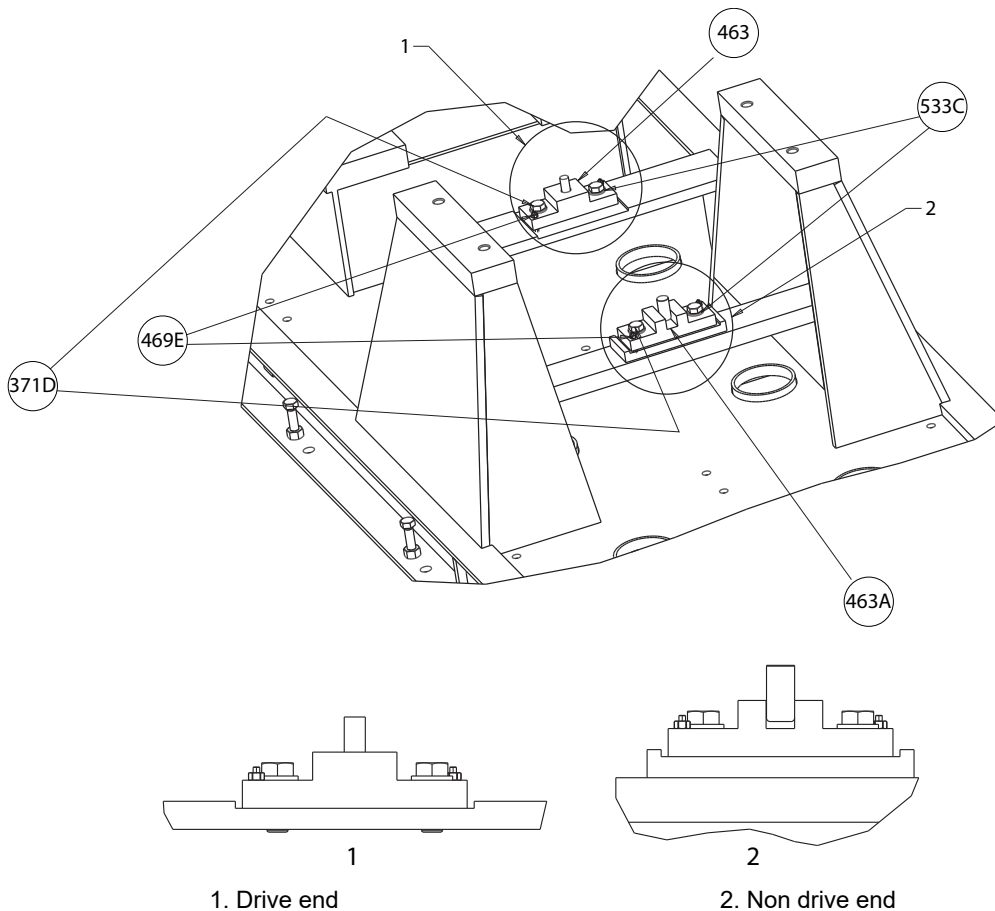
The factory will incorporate this method to dowel the pump to the baseplate pedestal if there is a high temperature differential between the ambient temperature during setup and the temperature of the pumped fluid.

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.



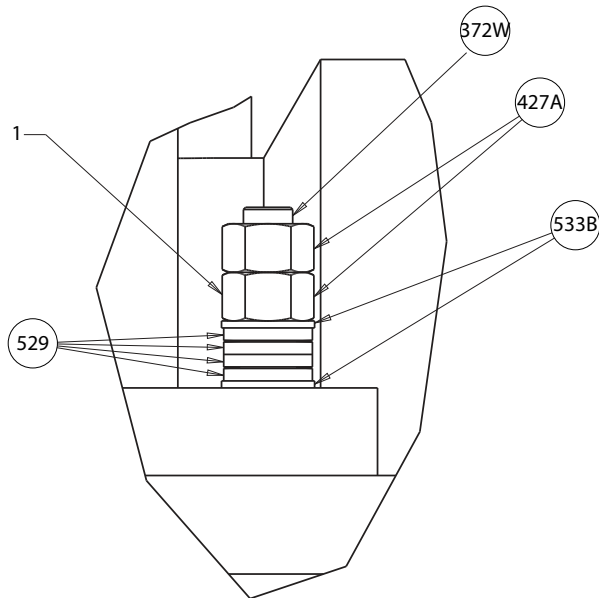
Item	Description	Part no.
1.	Drive end dowel pin (installed in case)	
2.	Non drive end dowel pin (installed in case)	
	Hex cap screws	371D
	Drive end guide block	463
	Non drive end guide block	463A
	Taper pins	469E

**Figure 38: Differential temperature doweling assembly**

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

**NOTICE:**

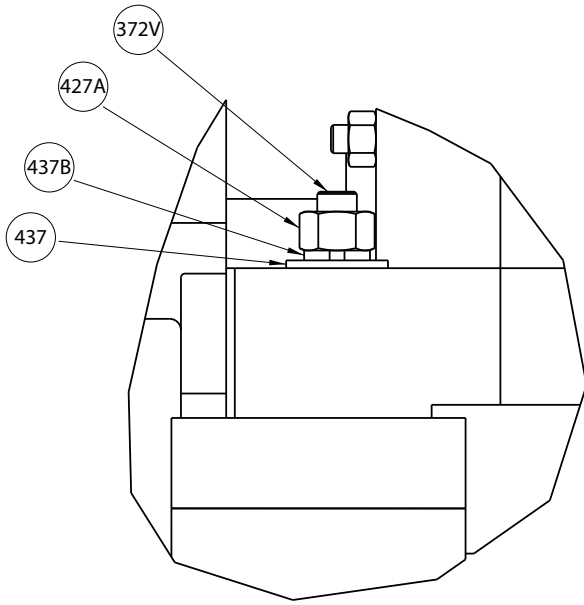
- Verify the hex lower nuts (427A)(426A) are tightened 1/3 to 1/2 turn beyond hand tight.
- Note - the Belleville washers will not be fully compressed when tightened properly.
- During installation verify the taper pins (item 469E) are installed.



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 39: Non drive end pump mounting detail**

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



Item	Description	Part No.
	Stud	372V
	Hex nuts	427A
	Flat washers	437
	Lock washers	437B

**Figure 40: Drive end only pump mounting detail**

---

# 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.

---

#### **NOTICE:**

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

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### 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 Ex-certified and the temperature of the pumped fluid exceeds the permitted temperature values, then consult your ITT representative.



For Ex applications bearing replacement (all) is recommended after 25,000 hours of operation.

**Bearing lubrication schedule**

Type of lubrication	First lubrication	Lubrication intervals
Ring oil 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 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.
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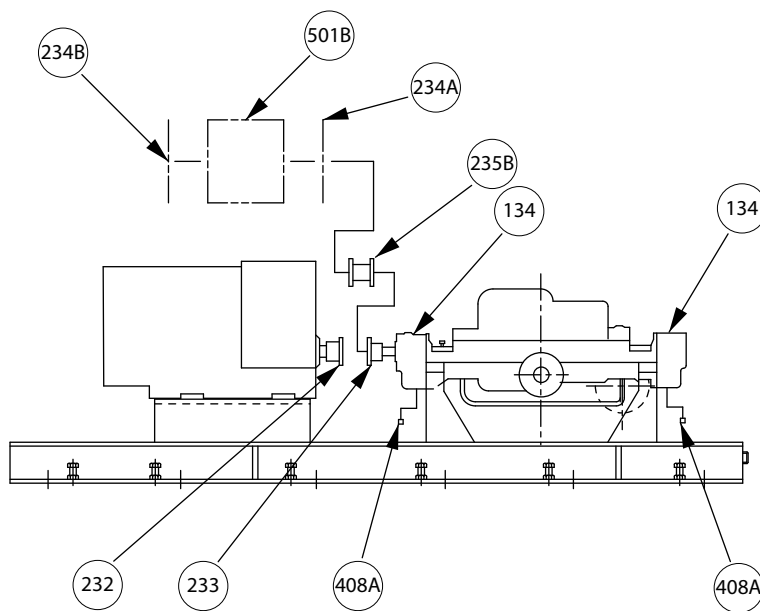
## 6.4.2 Tools required

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.

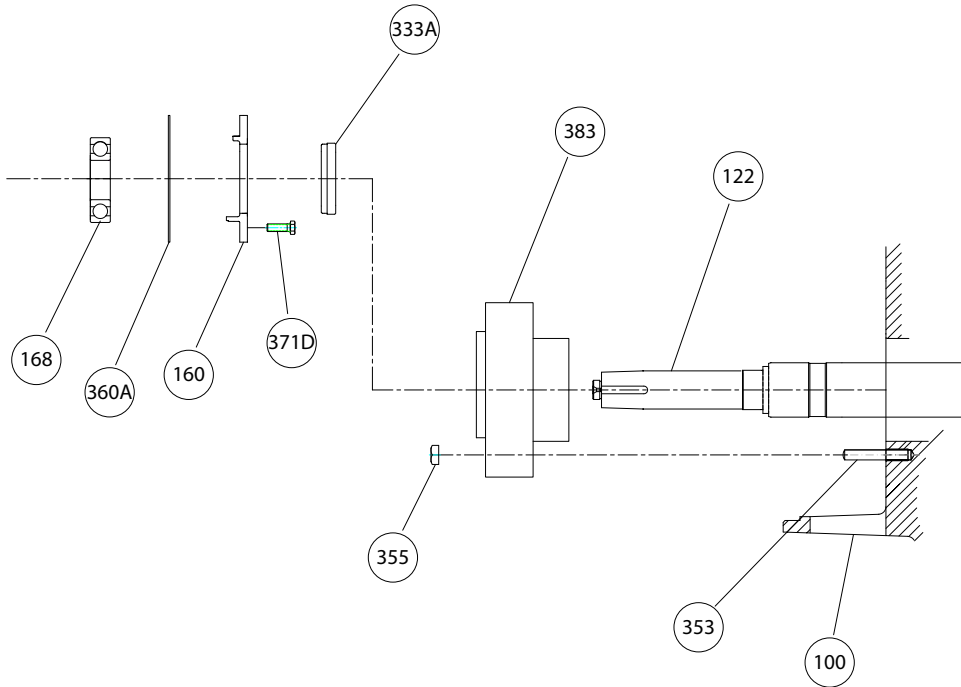


**Figure 41: Coupling guard disassembly**

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)

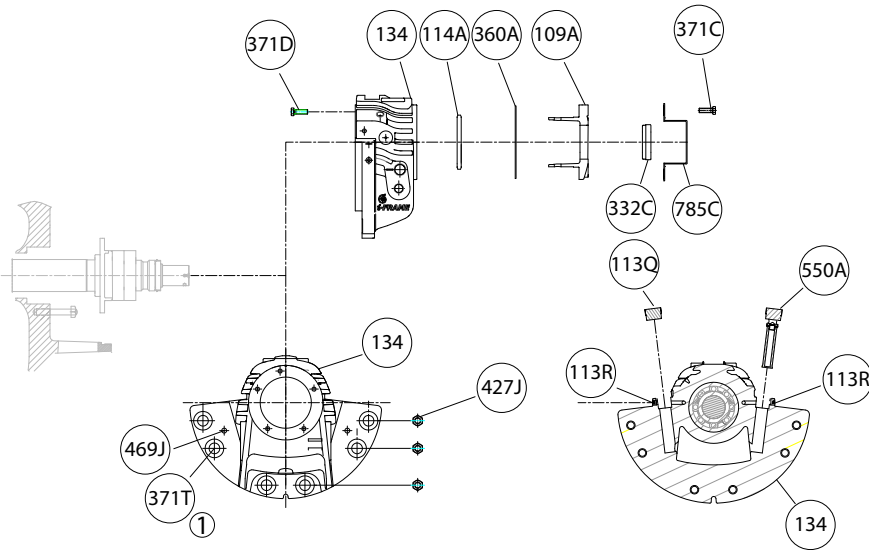
1. Remove the oil filter (550A) and the oil filter plug (113Q) from the bearing frame (134). The set screws (113R) do not need to be removed.
2. Remove the bearing end cover bolts (371D) from both inboard (160) and outboard (160A) bearing end covers. See Step 6..
3. The outboard labyrinth seal (332A) 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 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 42: Radial bearing removal**

11. 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 .
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 43: Thrust bearing housing disassembly**

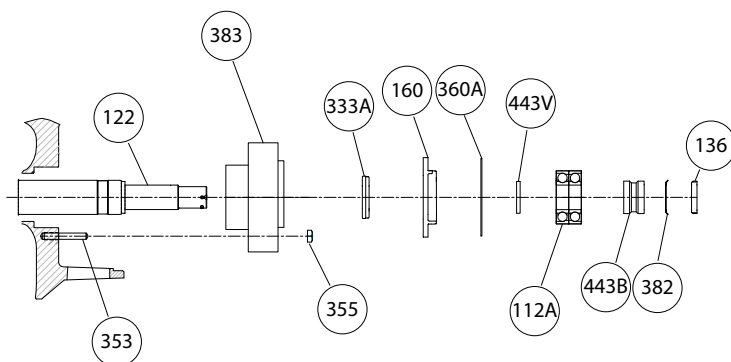
1. Remove the oil filter (550A) and filter plug (113Q) from the bearing frame (134). The set screws (113R) do not need to be removed.
2. If the pump has the optional bearing cooling fan, remove the guard endplate (234E), cowling (785D), cooling fan (392B) and pump endplate (234D).
3. Remove the bearing end cover bolts (371C and 371D) from the outboard thrust bearing end cover (109A) See Step 5..

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:

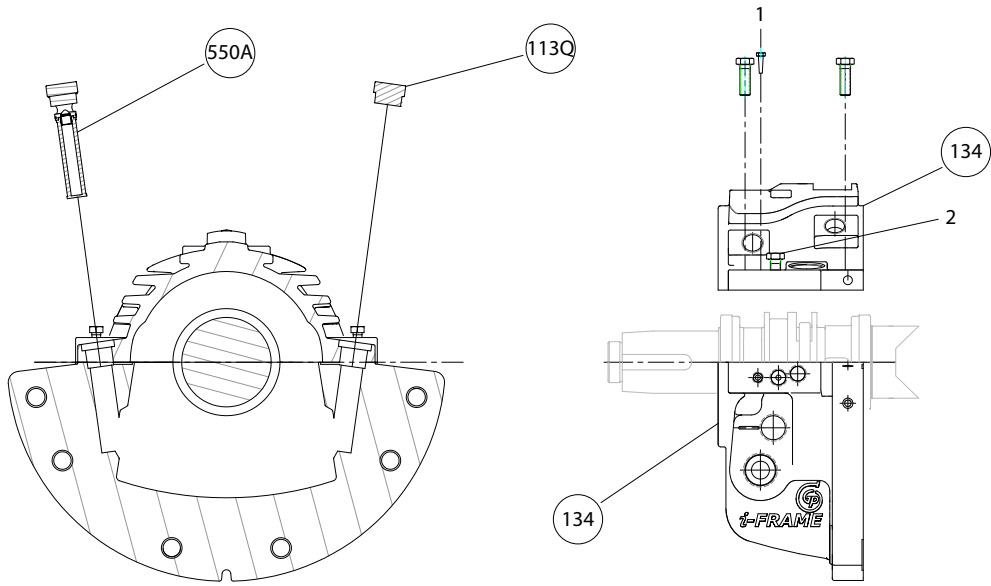
The pump may handle hazardous and/or toxic liquids. Trapped or undrained liquid can cause explosions when heat is applied. Never apply heat at the pump site for this reason. Heat can also distort machined surfaces.



**Figure 44: 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.

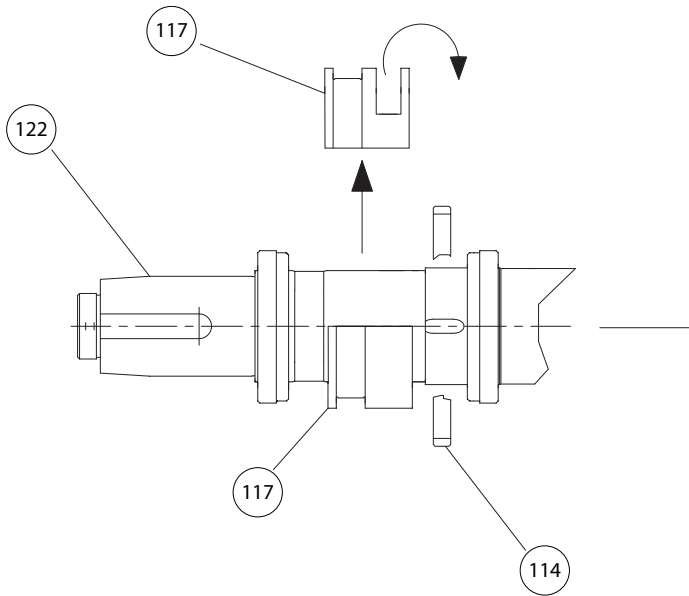
### 6.4.6 Disassemble the radial end (sleeve/ball bearing pumps)



Item	Description
1.	Taper pin
2.	Jack bolt

**Figure 45: 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 46: 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).

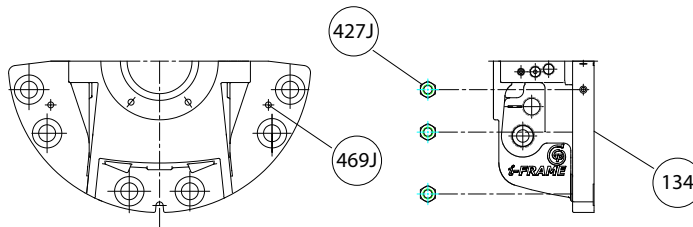
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**NOTICE:**

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

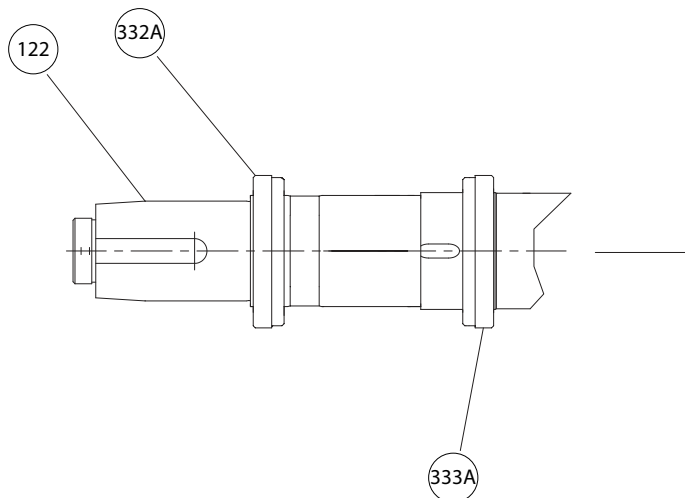
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8. Remove the dowel pins (469J) that hold the lower half of the bearing housing to the casing flange.



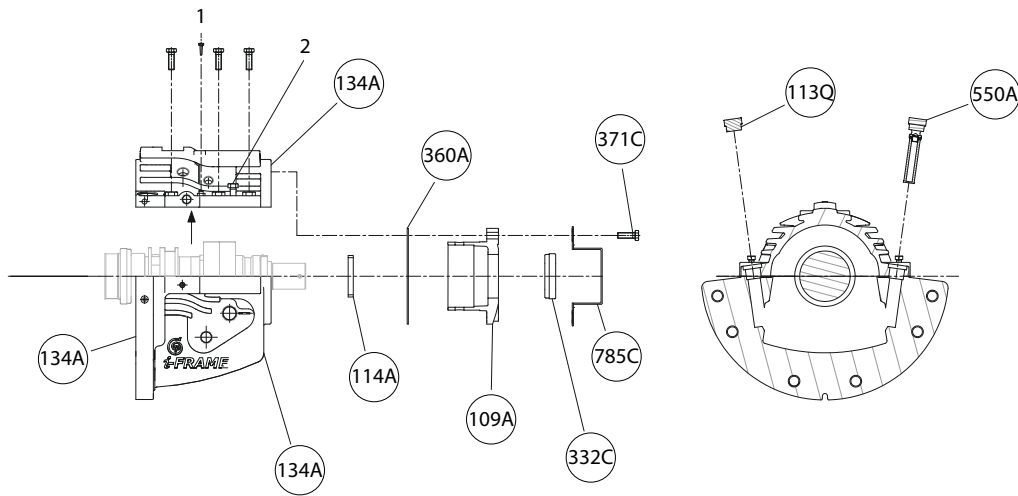
**Figure 47: Dowel pin removal**

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 48: Labyrinth seal removal**

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



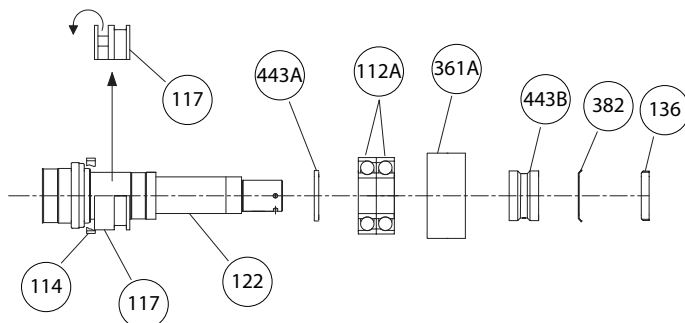
Item	Description
1.	Taper pin
2.	Jack bolt

**Figure 49: 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:

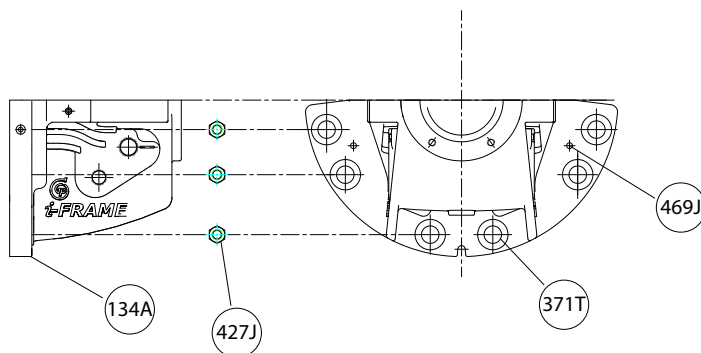
There is an anti rotation pin on the lower half of the sleeve bearing (117) at the parting flange of the bearing housing (134A).



**Figure 50: Sleeve and thrust bearing removal**

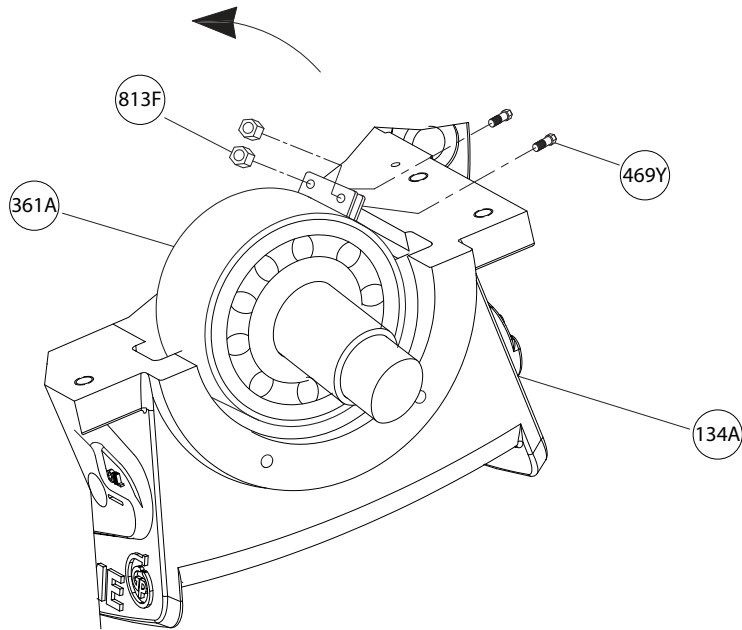


10. Remove the upper half of the bearing housing (134A) from the lower half:
  - a) Remove the dowel pins between the upper and lower halves of the bearing housing (134A).
  - b) Remove the hex head screws that connect the upper and lower halves of the bearing housing (134A).
  - c) Tighten the jackscrews in order to separate the housing halves.
  - d) Remove the top half of the thrust bearing housing (134A) with the upper half of the sleeve bearing (117). Notice that the bearing is pinned to the housing.
11. Remove the dowel pins (469J) that hold the lower half of the bearing housing to the casing flange.



**Figure 51: Dowel pin removal**

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



**Figure 52: Bearing retainer removal**

19. 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.

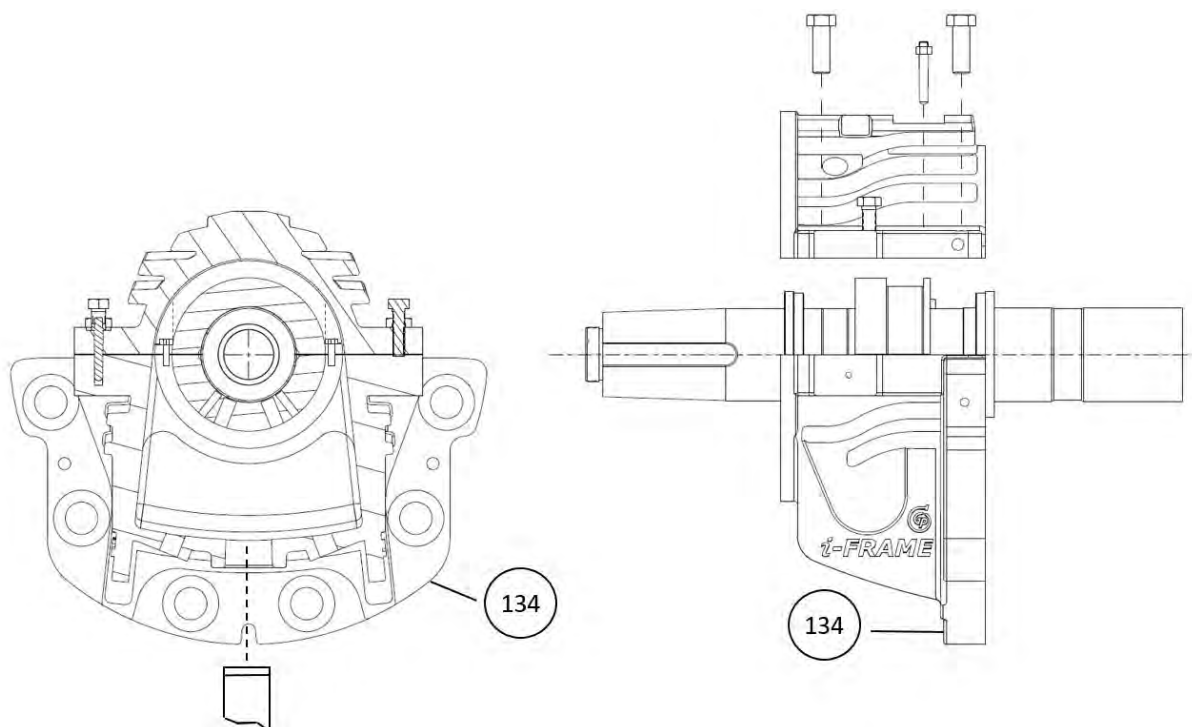


**WARNING:**

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.

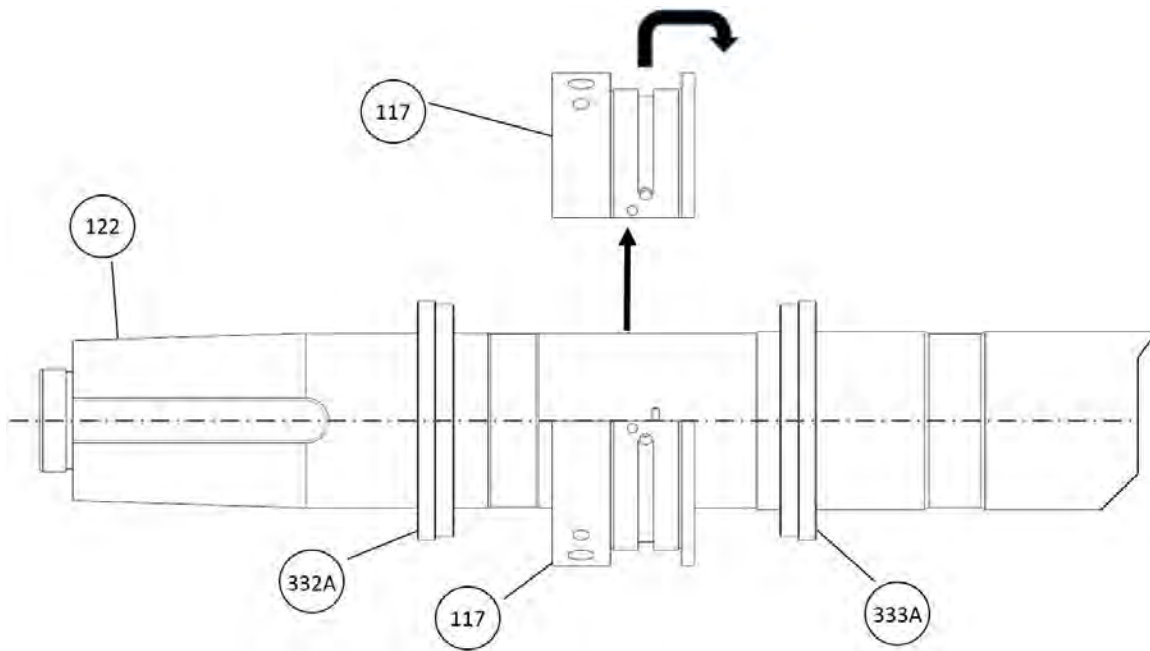
20. Remove bearing spacer (443V).
21. Remove the inboard labyrinth seals (333A) and oil ring (114).

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



**Figure 53: 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).



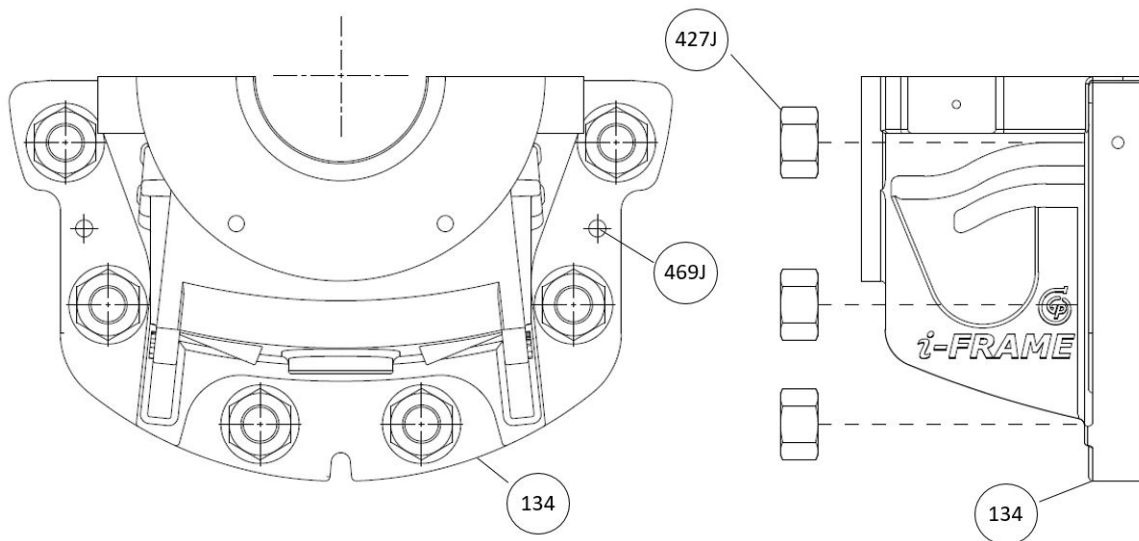
**Figure 54: Radial sleeve bearing removal**

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 55: 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).

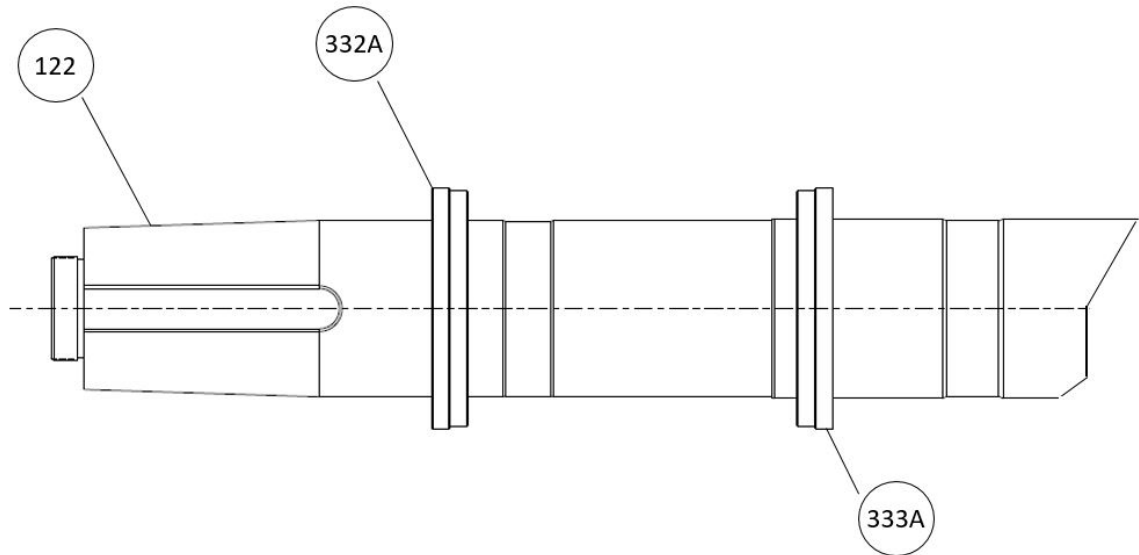


Figure 56: Labyrinth seal removal

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

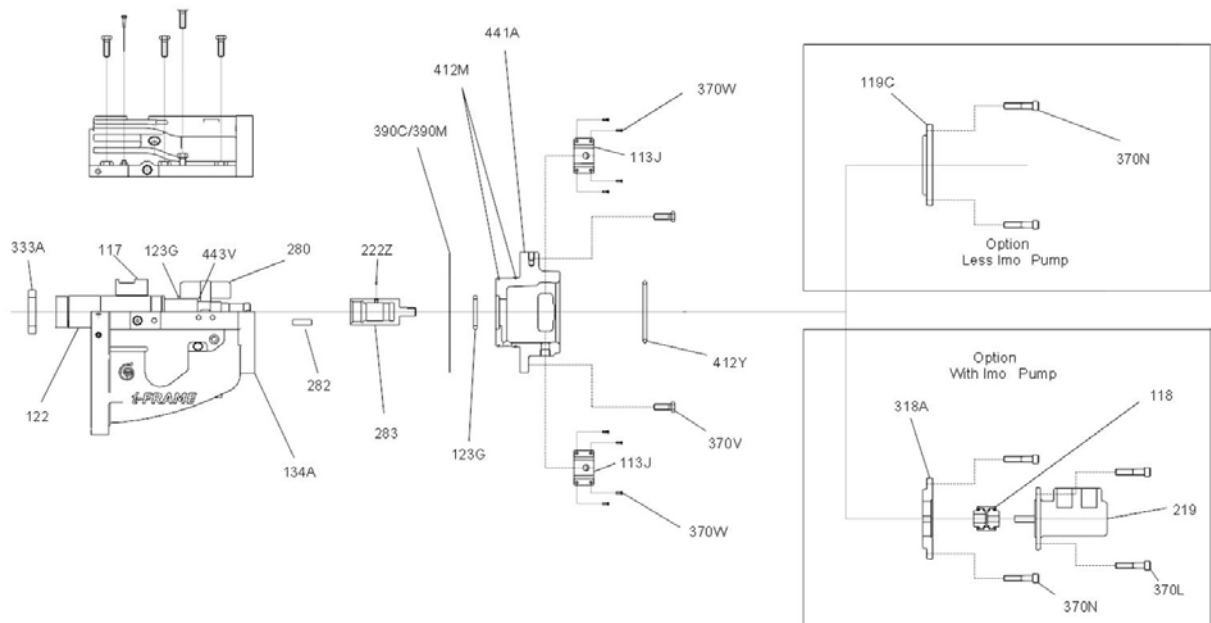


Figure 57: Thrust bearing housing disassembly

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).

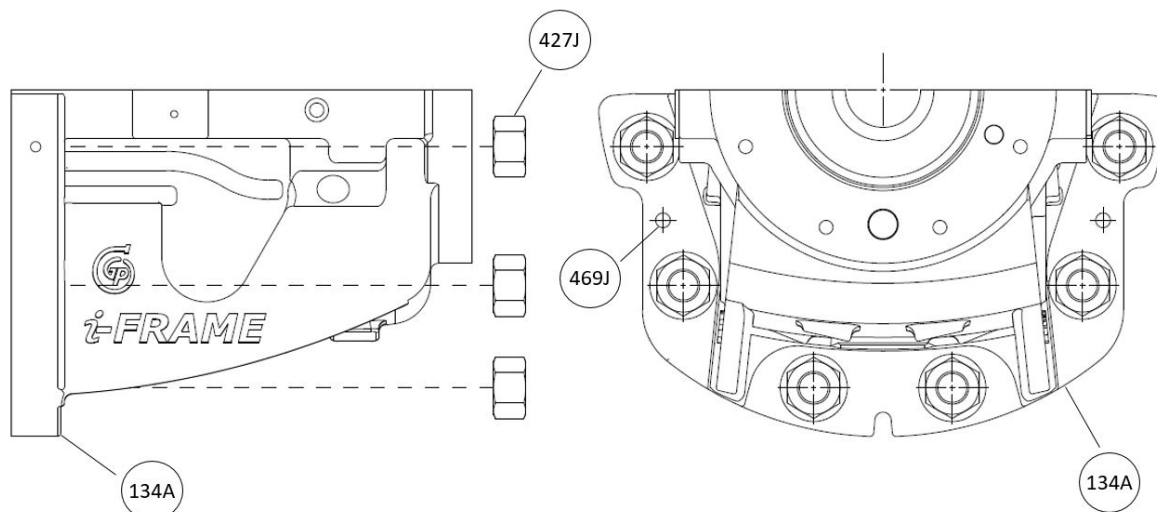
3. Remove the other half of the coupling (118) from the pump shaft (122) by removing the set screw located above the key. Remove the coupling key.
4. If the pump was not supplied with a main shaft oil pump (219), remove the hex cap screws (370N) to remove the adapter cover (119C).
5. If the pump was 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).

---

**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 58: 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> 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.

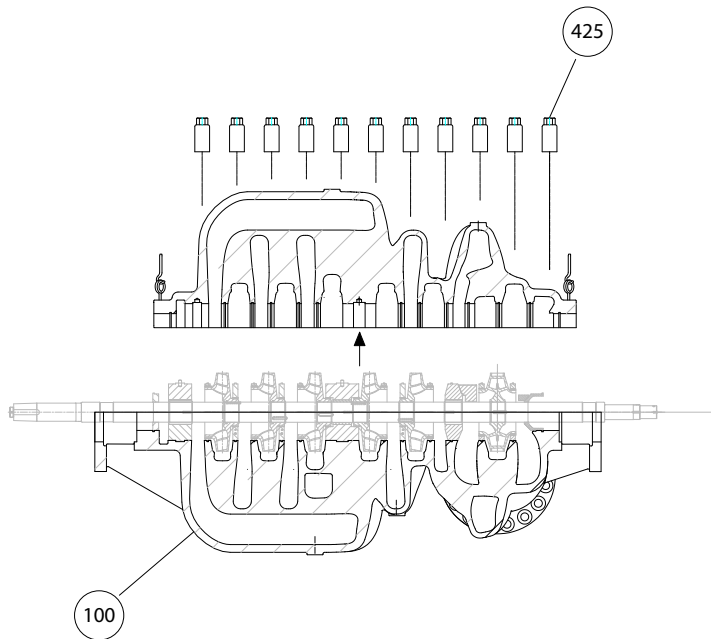
### Guidelines

The battery contained in the condition monitor does not contain enough lithium to qualify as reactive hazardous waste. Use these guidelines when disposing of the condition monitor.

- The condition monitor is safe for disposal in the normal municipal waste stream.
- Adhere to local laws when you dispose of the condition monitor.

## 6.4.11 Remove the rotating element

[6.6.4 Assemble the casing on page 106](#)



**Figure 59: Disassembly of the upper half casing**

\* 164A for 4x6-10 and 4x6-11 pumps. 165B for all other pump sizes.

1. Loosen and remove the casing nuts (425) and taper pins.
2. Use the jacking bolts (provided with the pump) to loosen the upper half from the lower half of 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.

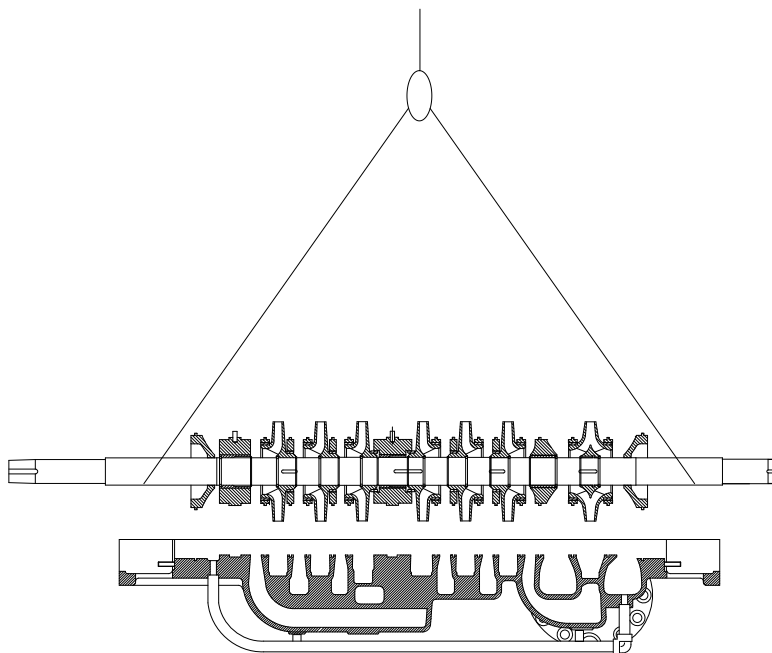
3. Insert eyebolts (not supplied) in the pre-drilled threaded holes in the perimeter of the upper half of the casing. Remove the upper half to the work area.



**WARNING:**

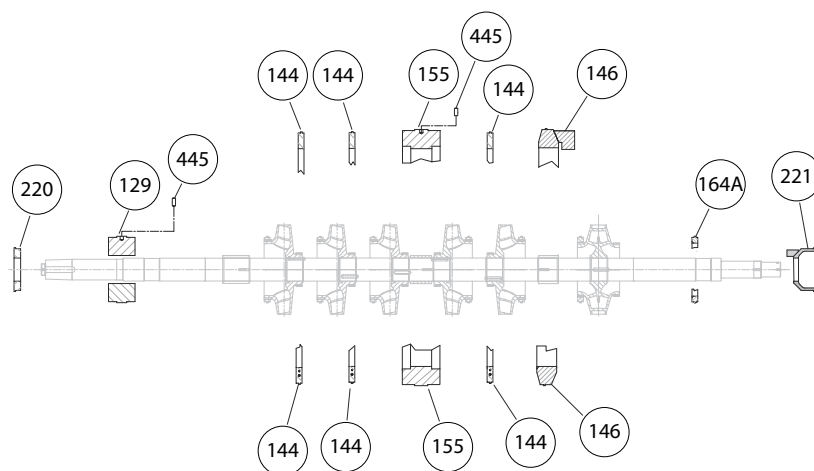
Use the eyebolts to lift only the upper half of the casing. They will not support the weight of the entire pump.





**Figure 60: Removal of the rotating element**

4. Position slings around the mechanical seal mounting area of the shaft on each side. Lift the rotating assembly slightly to remove contact with the wear parts.
5. Remove the socket head capscrews from the center bushing (155).



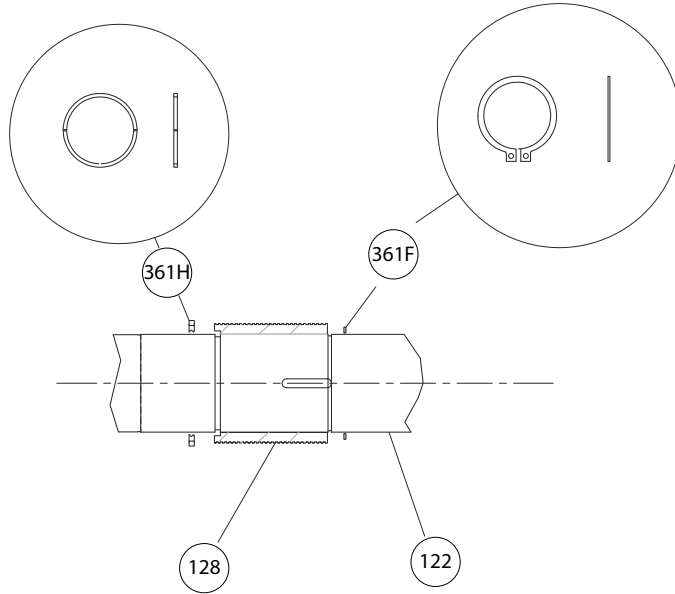
**Figure 61: Disassembly of the stationary components**

6. Remove the center bushing (155), all stage rings (144), and the diaphragm (146), if supplied.
  - a) Remove the upper half of all components.
  - b) Rotate the lower half of all components out of the lower half of the casing.
7. Lift the rotating assembly further to disengage the stationary locks.
8. Remove the seal chambers (220, 221), the throttle bushing (129), the first-stage casing ring (164A), and the series casing ring (164) on the opposite side.
9. Lift the rotating assembly out of the lower half of the casing.
10. Remove the casing studs (356A, 356C, 356K) and the casing gasket (351).

### 6.4.12 Disassemble the rotating element

1. Remove throttle bushing sleeve (128):

- a) Remove the snap ring (361F) from the groove and slide onto the adjacent larger shaft diameter toward the center of the rotor.
- b) Slide the sleeve towards the center of the rotor, exposing the locating ring (361H).
- c) Remove the locating ring (two halves) and the throttle bushing sleeve.
- d) Remove the snap ring (361F).



**Figure 62: Remove the throttle bushing sleeve**

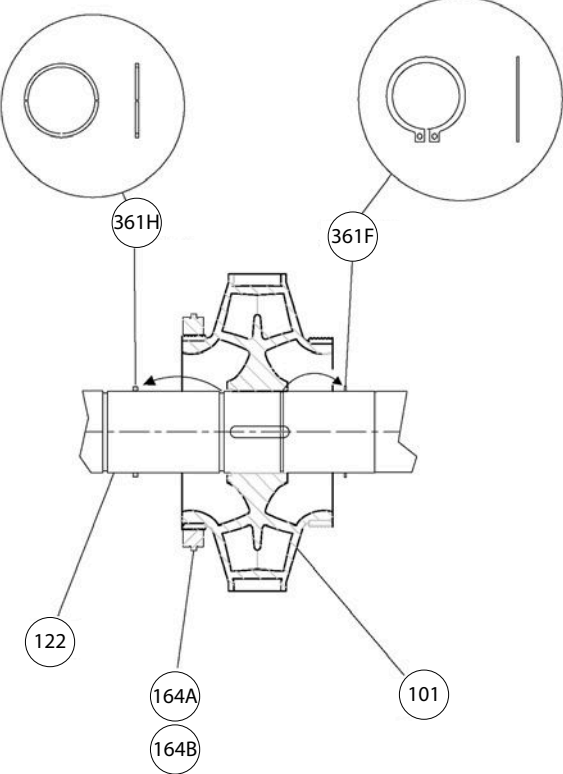
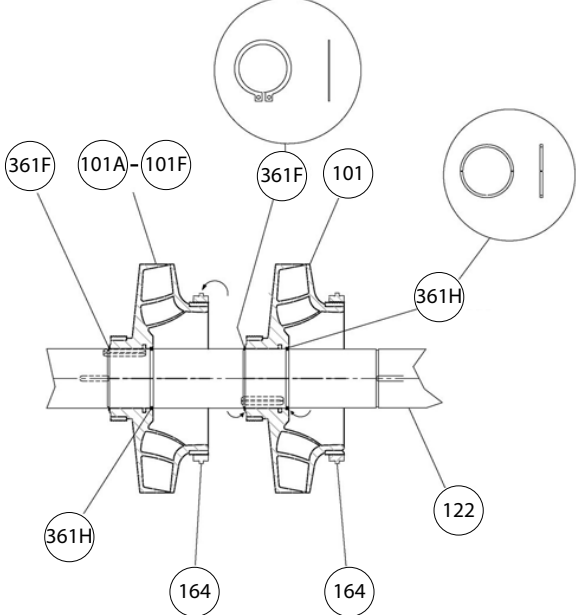
2. The following method should be used to remove the first-stage impeller:
  - a) Using snap ring pliers remove the snap ring (361F) from the groove and move aside on the larger diameter of the shaft.
  - b) Heat the impeller using a rosebud torch and applying flame through the volutes of the impeller, at the same time continuously rotating the shaft. The temperature should be 150°C to 200°C | 300°F to 400°F to be able to remove the impeller. Quickly slide the impeller toward the center of the rotor in order to expose the locating ring (361H).
  - c) Quickly remove the locating ring and then the impeller.
  - d) Remove the 1st stage casing ring (164A\*, 164B\*), the snap ring (361F) and if the pump is single suction the subsequent stage casing ring (164).



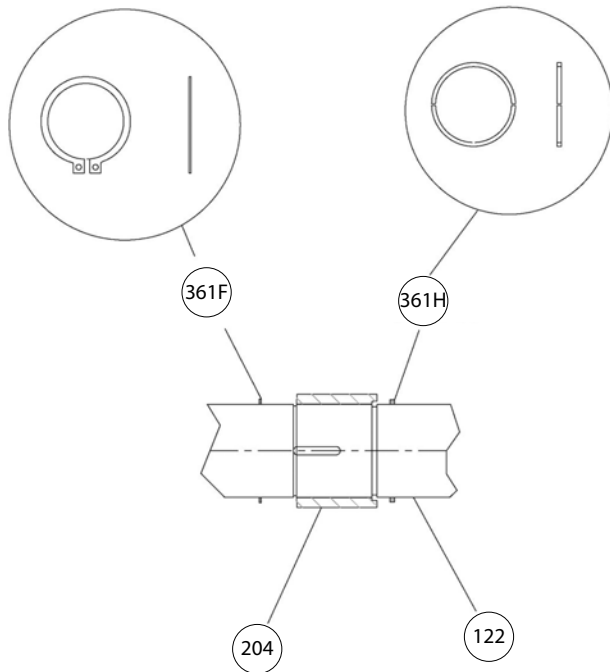
**CAUTION:**

Burn hazard. The impeller will get hot. Wear insulated gloves when handling the impeller.

Option	Description
If the impeller is...	Then reference...

Option	Description
Double Suction	
Single Suction	

3. If the pump has a double suction impeller design, do the following to remove the diaphragm sleeve (204):
  - a) Using snap ring pliers remove the snap ring (361F) from the groove and move aside on the shaft toward the center of the rotor.
  - b) Slide the sleeve towards the center of the rotor, exposing the locating ring (361H). The diaphragm sleeve is clearance fit, no heat is necessary.



**Figure 63: Remove the diaphragm sleeve**

4. Repeat step 2 for the remaining impellers.

---

**NOTICE:**

Allow the shaft and impeller to cool to ambient temperature before assembling the next impeller.

5. After all the impellers are removed, remove the center sleeve (205).

## 6.5 Preassembly inspections

### 6.5.1 Replacement guidelines

#### Casing check and replacement



**WARNING:**

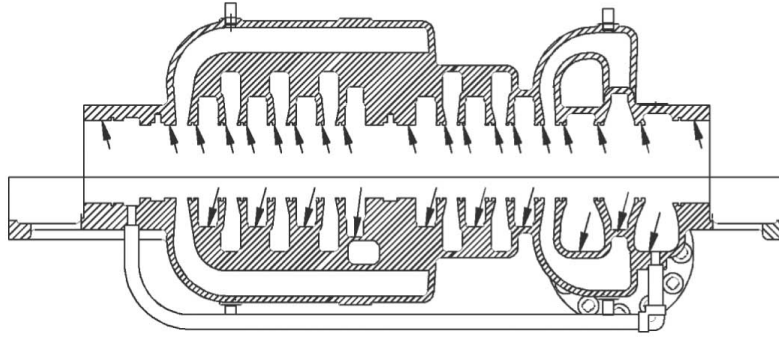
Risk of death or serious injury. Leaking fluid can cause fire and/or burns. Inspect and ensure gasket sealing surfaces are not damaged and repair or replace as necessary.

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

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

#### Casing areas to inspect

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



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

**Figure 64: Casing inspection critical locations**

### 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>
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.

---

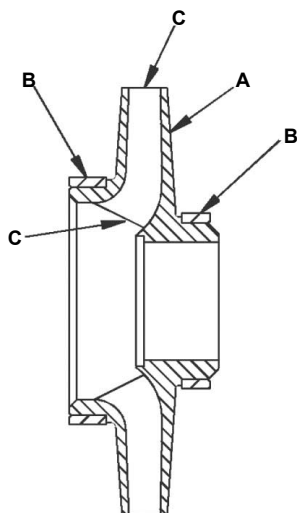
- Check and clean the impeller bore diameter.
  - Check the impeller balance. Rebalance the impeller if it exceeds ISO 1940-1, grade G1.0.
- 

#### **NOTICE:**

You must have extremely accurate tooling equipment to balance impellers to ISO 1940-1, grade G1.0. 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 65: 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.

**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.



**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.

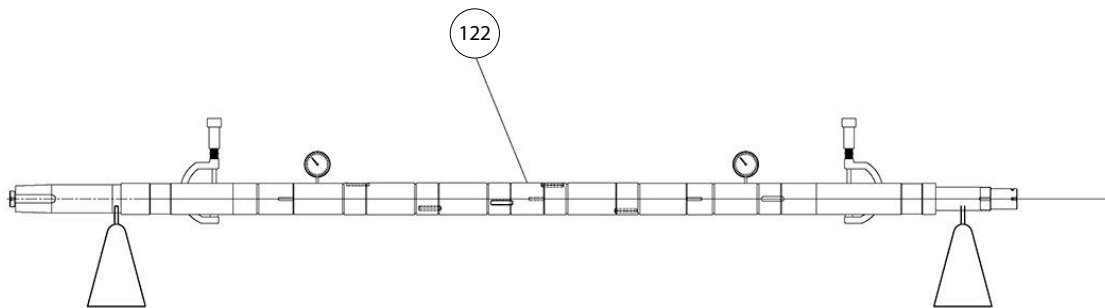


Figure 66: Shaft inspection

### 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 4: 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.

Characteristic	Requirement
Allowable shaft runout, TIR	40 µm (0.0015 in.)
Component fit to shaft	Interference
Allowable rotor radial runout, TIR*	60 µm (0.0025 in.)
*Total indicated runout of impeller hubs and sleeves	

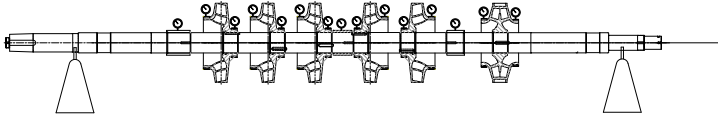


Figure 67: Fully assembled rotor

### 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).

Table 5:

Pump size	Radial Bearing	Thrust bearing	Bearing housing bore mm   in.	Shaft turn mm   in.
24F	6311	7311	120.033   4.7257	55.016   2.1660
			120.012   4.7249	55.004   2.1655
25G	6312	7314	130.038   5.1196	60.015   2.3628
			130.014   5.1187	60.003   2.3623
34H	6313	7313	140.038   5.5133	65.016   2.5597
			140.014   5.5124	65.004   2.5592
35J	6314	7314	150.038   5.9070	70.015   2.7565
			150.014   5.9061	70.002   2.7560
36H	6216	7313	140.038   5.5133	65.016   2.5597
			140.014   5.5124	65.004   2.5592



## 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 rings

A press fit and three setscrews hold the impeller wear rings (202, 202A, 202B, 203) in place.

1. Remove the wear rings:
  - a) Remove the setscrews.
  - b) Remove the wear rings from the impellers (101, (101A–101M), using suitable pry or puller tools to force the rings from the fits.

You may also machine the rings in order to remove them.

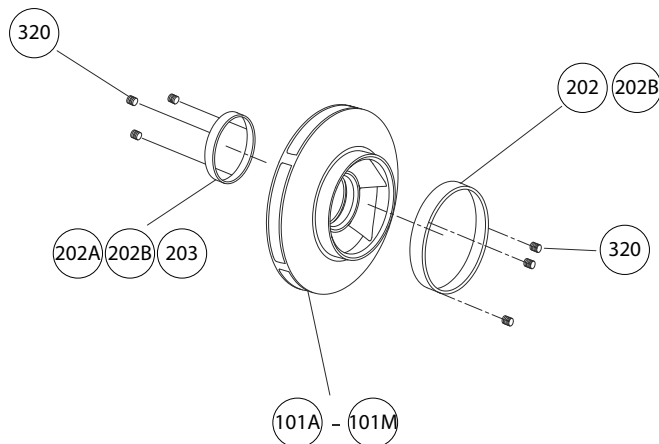



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### CAUTION:

Excessive machining can damage ring fits and render parts unusable.

---



**Figure 68: Wear ring replacement**

2. Install new wear rings (202, 202A, 202B, 203):
  - a) Clean the wear-ring seats thoroughly to make sure that they are smooth and free of scratches.
  - b) Heat the new impeller wear rings to 132°C to 143°C | 180°F to 200°F using a uniform method for heating, such as an oven, and place them on the impeller (101-101M) wear-ring seats.




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### CAUTION:

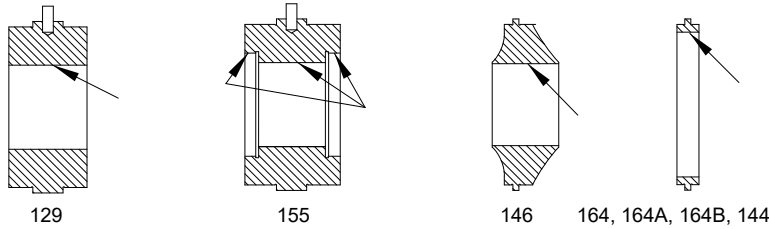
Wear insulated gloves when you handle rings. Rings will be hot and can cause physical injury.

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- 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 set screws (320) and upset the threads.

3. Check the throttle bushing (129), the center bushing (155), the diaphragm (146), the case ring (164, 164A, 164B), and the stage ring (144) runout/distortion by measuring the bore at three locations with inside micrometers or vernier calipers. Correct any distortion in excess of 0.076 mm | 0.003 in. by machining prior to trimming new impeller wear rings, if supplied.

The arrows point to wear surfaces on these parts.



**Figure 69: Bushing inspection critical locations**

Part number	Part name
129	Throttle bushing
155	Center bushing
146	Diaphragm
164, 164A, 164B, 144	Case and stage ring

4. Confirm the bore of the throttle bushing (129), the center bushing (155), the diaphragm (146), the casing ring (164, 164A, 164B), and the stage ring (144).
5. Turn the impeller wear rings (202, 202A, 202B, 203) to size after mounting on the impeller (101-101M).



**CAUTION:**



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 are supplied 0.508 mm to 0.762 mm | 0.020 in. to 0.030 in. oversize. See Minimum running clearances for final running clearances. Machine the impeller rings accordingly.

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

### 6.5.5 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	
in.	mm	in.	mm
<2.000	<50.00	0.010	0.25
2.000 to 2.4999	50.00 to 64.99	0.011	0.28

Diameter of rotating member at clearance		Minimum diametrical clearance	
in.	mm	in.	mm
2.500 to 2.999	65.00 to 79.99	0.012	0.30
3.000 to 3.499	80.00 to 89.99	0.013	0.33
3.500 to 3.999	90.00 to 99.99	0.014	0.36
4.000 to 4.499	100.00 to 114.99	0.015	0.38
4.500 to 4.999	115.00 to 124.99	0.016	0.41
5.000 to 5.999	125.00 to 149.99	0.017	0.43
6.000 to 6.999	150.00 to 174.99	0.018	0.46
7.000 to 7.999	175.00 to 199.99	0.019	0.48
8.000 to 8.999	200.00 to 224.99	0.020	0.51
9.000 to 9.999	225.00 to 249.99	0.021	0.53
10.000 to 10.999	250.00 to 274.99	0.022	0.56
11.000 to 11.999	275.00 to 299.99	0.023	0.58
12.000 to 12.999	300.00 to 324.99	0.024	0.61
13.000 to 13.999	325.00 to 349.99	0.025	0.63
14.000 to 14.999	350.00 to 374.99	0.026	0.66
15.000 to 15.999	375.00 to 399.99	0.027	0.69
16.000 to 16.999	400.00 to 424.99	0.028	0.71
17.000 to 17.999	425.00 to 449.99	0.029	0.74
18.000 to 18.999	450.00 to 474.99	0.030	0.76
19.000 to 19.999	475.00 to 499.99	0.031	0.79
20.000 to 20.999	500.00 to 524.99	0.032	0.81
21.000 to 21.999	525.00 to 549.99	0.033	0.84
22.000 to 22.999	550.00 to 574.99	0.034	0.86
23.000 to 23.999	575.00 to 599.99	0.035	0.89
24.000 to 24.999	600.00 to 624.99	0.036	0.91
25.000 to 25.999	625.00 to 649.99	0.037	0.94

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

### NOTICE:

The impeller hub side wear rings will have a much higher clearance for impellers 101F and 101M, as the close clearance is driven by the center bushing to center sleeve. The minimum clearance for these rings should be as indicated in the table below:

Case rings (Center Only) (Item 164)	0.76/0.81mm   0.030/0.032in
-------------------------------------	-----------------------------

### Bushings

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

Bushing	Temperature	
	<260°C   500°F	260°C   ≥500°F
Throttle (Item 129)	0.25/0.30mm   0.010/0.012in	0.38/0.43mm   0.015/0.017in
Center (Item 155)	0.25/0.30mm   0.010/0.012in	0.38/0.43mm   0.015/0.017in
Diaphragm (Item 146)	0.25/0.30mm   0.010/0.012in	0.38/0.43mm   0.015/0.017in

## 6.6 Reassembly

### 6.6.1 Assemble the rotating element

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**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.

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**NOTICE:**

Make sure that all parts and threads are clean and that you have followed all directions under the Preassembly inspections section.

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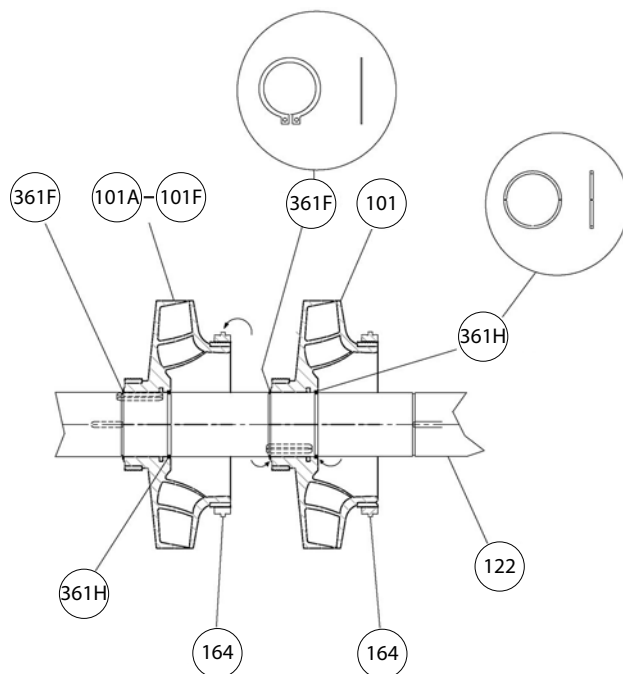
1. Assemble the center impeller (101M) onto the shaft. The impeller is interference fit.
    - a) Install the snap ring on the shaft diameter adjacent to the ring groove, but out of the way of the sleeve.
    - b) Use an electric induction heater to preheat the impeller to 150°C–200°C | 300°F–400°F.
    - c) Slide the impeller past the locating ring groove, put the locating rings (361H) in place, and slide the impeller back so that it is snug against the locating ring.
    - d) Install the snap ring (361F) in the groove.
- 



**CAUTION:**

- Burn hazard. The impeller will get hot. Wear insulated gloves when handling the impeller.
  - Risk of physical injury from sharp edges. Wear heavy work gloves when handling impellers.
- 

2. Install the center sleeve (205).
3. Repeat step 1 for all subsequent impellers making sure to install the casing ring (164, 164A, 164B) on each previous impeller.

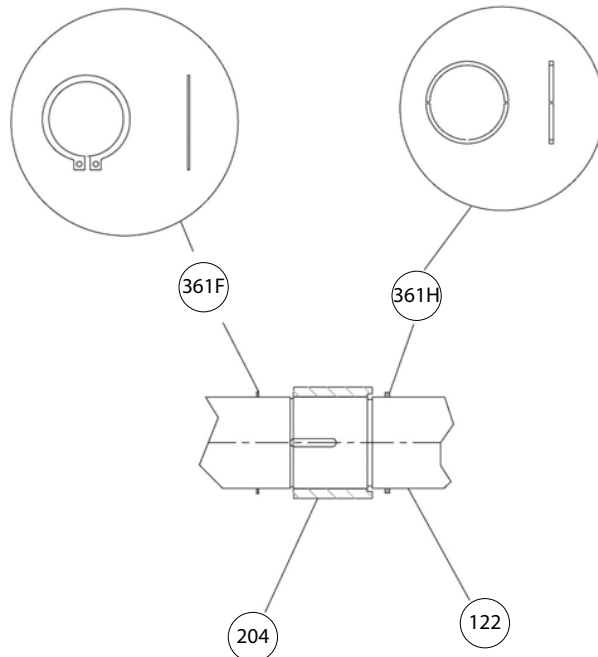


**Figure 70: Impeller assembly**

**NOTICE:**

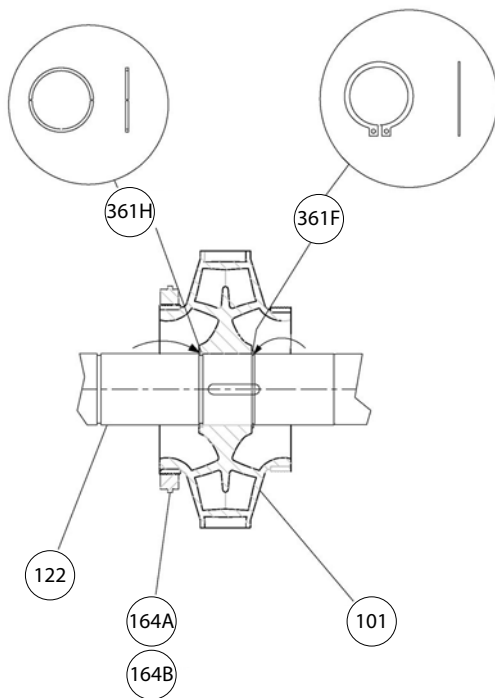
Allow the shaft and impeller to cool to ambient temperature before assembling the next impeller.

4. On double-suction pumps only, prior to assembling the first-stage impeller (101), assemble the diaphragm sleeve (204):
  - a) Install the snap ring on the shaft diameter adjacent to the ring groove, but out of the way of the sleeve.
  - b) Slide the diaphragm sleeve onto the shaft past the locating ring groove, put the locating ring (361H) in place, and slide the sleeve back so that it is snug against the locating ring.



**Figure 71: Diaphragm sleeve reassembly**

- c) Install the snap ring (361F) into the groove.
5. Assemble the first-stage impeller (101) as in Step 1.
6. On double-suction pumps only install the locating ring (361H), then slide on the first-stage impeller and install the snap ring (361F).



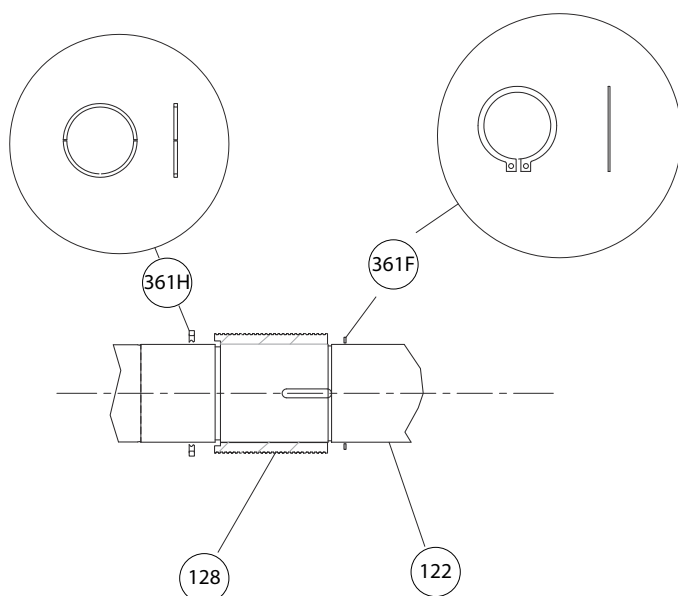
**Figure 72: Double suction 1st stage impeller reassembly**

7. Assemble the throttle bushing sleeve (128).
  - a) Install the snap ring on the shaft diameter adjacent to the ring groove, but out of the way of the sleeve.

- b) Slide the sleeve onto the shaft past the locating ring groove, put the locating ring (361H) in place, and slide the sleeve back until snug.
- c) Install the snap ring (361F) into the groove.

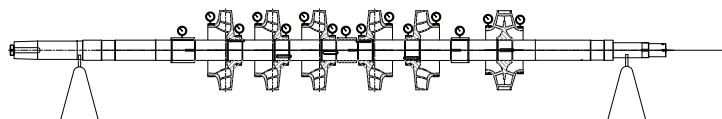
**CAUTION:**

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.



**Figure 73: Throttle bushing sleeve reassembly**

8. Measure the total indicated runout (TIR) on the impeller wear rings, center sleeve, throttle sleeve, diaphragm sleeve, 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 74: Rotor runout check**

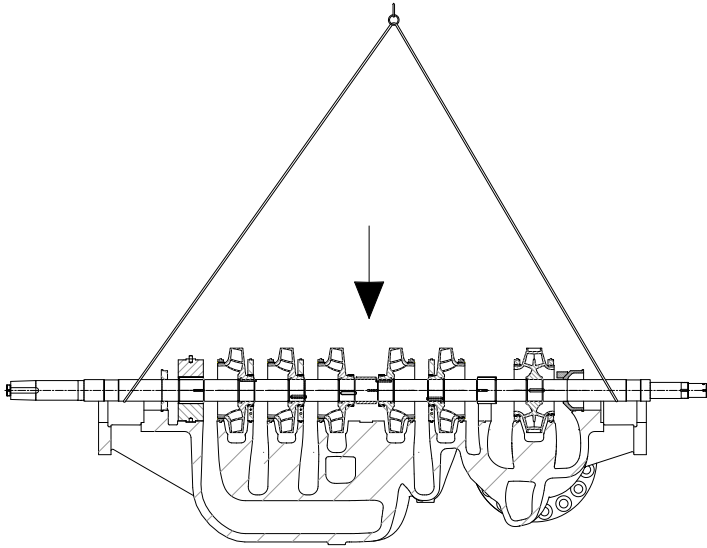
## 6.6.2 Install the rotating element

1. Fit the casing gasket (351) around all the hydraulics, bores, and through holes using the upper half as a template.

Pay particular attention to the area around the seal chamber face. This is a critical area for proper sealing. Make sure that the gasket extends all the way to the face but does not protrude past this face. Use a file to make the face clean and flush.

2. Assemble all casing studs (356A, 356C, 356K).
3. Assemble the first-stage impeller casing ring\* (164A), the final-series casing ring (164), the throttle bushing (129), and both seal chambers (220, 221).

\* 164A for 4x6-10D and 4x6-11BD pumps. 165B for all other pump sizes.



**Figure 75: Installing the rotor**

4. Position the sling so that both loops around the shaft fall approximately at the seal diameter and in front of the seal chambers (220, 221).
5. Lower the rotating assembly, making sure all stationary parts fit into the groove locks.
6. While maintaining tension on the rotating assembly, slide the lower half of all stage rings (144), the center bushing (155), and the diaphragm (146), if applicable, into the lower half of the casing.
7. Assemble the upper half of each component and tighten the socket head capscrews.
8. You must center the rotating element inside the casing whenever the bearings are replaced:
  - a) Push the rotating element towards the coupling end until it stops.
  - b) Measure the distance from the thrust bearing shoulder on the shaft to the bearing housing face on the casing.
  - c) Pull the rotating element towards the thrust end until it stops.
  - d) Again, measure the distance from the thrust bearing shoulder on the shaft to the bearing housing face on the casing.

The difference between the two measurements is the total travel of the rotating element.

  - e) Calculate the average of these dimensions.
  - f) Measure the shoulder depth on the inboard cover (160) and subtract the calculated average dimension.

The result is the spacer (217) thickness required to properly center the rotating element.

- g) Remachine the spacer as necessary making sure that both faces are parallel within 0.025 mm | 0.001 in.

### 6.6.3 Confirm the seal chamber runout

The bearing housings are doweled to the casing (100) during the original build. However, to assure the correct running position of the shaft, use the following procedure to confirm the seal chamber runout before installing the cartridge mechanical seals:

1. Install the old bearings on the shaft and bolt the bearing housings to the casing.
2. Mount the dial indicator on the shaft (122). Rotate the shaft (122) so that the indicator rides along the seal chamber bore for 180°.
3. If the total indicator reading exceeds 0.127 mm | 0.005 in., determine the cause and make corrections. The bottom reading must be 0.0635 mm | 0.0025 in. or less.



- For further instructions see Align the rotor.
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 180°.
    - b) If the total indicator reading exceeds the allowable runout as shown in the following table, determine the cause and make corrections.

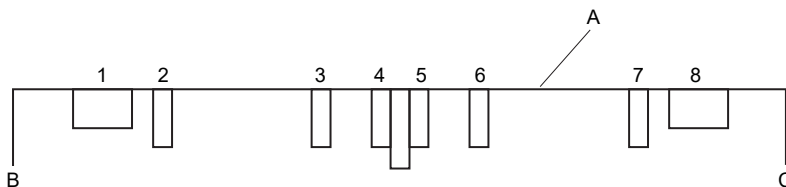
Size	Pump	Seal chamber bore mm   in.	Maximum allowable total indicator reading mm   in.
24F	3x4-8E 3x4-9A/B	160.00   6.300	0.0813   0.0032
25G	3x6-9/10	160.00   6.300	0.0813   0.0032
34H	4x6-10/10D 3x4-12.5A/B/C	160.00   6.300	0.0813   0.0032
35J	4x6-11A/AD/B/BD 4x6-12A/B 6x8-11A/AD/B/BD	160.00   6.300	0.0813   0.0032
36H	6x8-14AD/BD 8x10-13D	160.00   6.300	0.0813   0.0032
36H	10x12-14.5D	170.00   6.693	0.0838   0.0033
36H	10x12-15.5D	180.00   7.087	0.0889   0.0035
57Q	8x10-13D	190.00   7.481	0.0940   0.0037
57Q	14-18-22D	200.00   7.875	0.0991   0.0039

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

### 6.6.3.1 Qualify the casing bores

Three casing bores are used as datums during the centering procedure: the two seal chamber bores and the center case bushing bore. If these bores are not in alignment or are of different sizes, then compensation is required in order to accommodate the deviation(s). Qualification of these three bores must occur before you align the rotor.

1. Measure the ring bores with a plug gauge and correct any conditions that are out of tolerance.
2. Measure the depth of the ring bores noted in the figure and record the measurements in the table row "Actual depth."



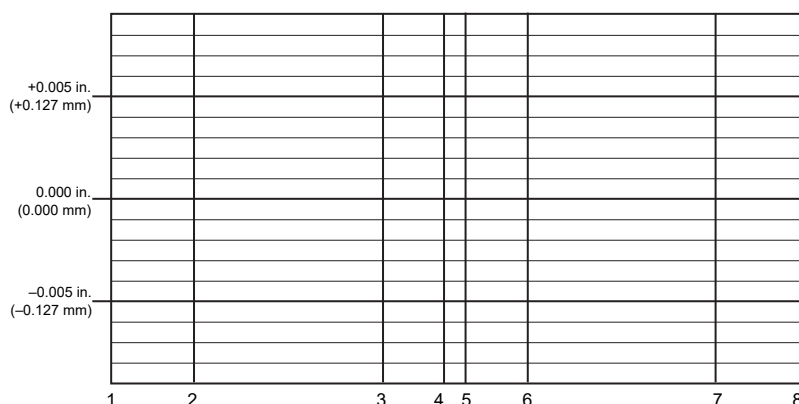
1. Inboard seal chamber
2. Last ring bore
3. First ring, inboard side
4. Inboard center bushing bore
5. Outboard center bushing bore
6. Last ring, outboard side
7. First ring bore
8. Outboard seal chamber

- A. Lower half casing flange
- 
- B. Inboard end
- 
- C. Outboard end

Location	1	2	3	4	5	6	7	8
Design depth								
Actual depth								
Difference								

Pump size	Design depth in inches		
	1 and 8	7	2 through 6
3x4-9 A/B	3.145	3.145	3.145
3x6-9/10/10B	3.145	3.120	3.620
3x4-12.5 A/B/C	3.145	3.745	3.370
4x6-12 A/B	3.145	3.745	3.370
4x6-10	3.145	3.745	3.308
4x6-10D	3.145	3.308	3.308
4x6-11A	3.145	3.995	3.995
4x6-11B	3.139	3.995	3.558
4x6-11AD	3.145	3.995	3.995
6x8-11BD	3.145	3.558	3.558
6x8-11 A/B/AD/BD	3.145	4.433	4.433
6x8-14 AD/BD	3.145	4.620	4.620
8x10-13D	3.145	4.870	4.870
10x12-14.5D	3.342	5.275	5.275

3. For each bore, subtract the actual depth from the design depth and record the difference in the table.
4. Plot the "Difference" points on the chart.



5. Draw a straight line from point 1 to point 8.  
This is the seal chamber centerline.
6. Draw a trend line through points 2 through 7 and investigate any deviations greater than 0.051 mm | 0.002 in.  
This is the casing ring centerline.
7. Adjust the nominal 0.127 mm | 0.005 in. thickness of the center case shim by the difference between the seal chamber centerline and the ring bore centerline at points 4 and 5.
  - If the seal chamber centerline is above the ring bore centerline, then increase the shim thickness.
  - If the seal chamber centerline is below the ring bore centerline, then decrease the shim thickness.
8. Check and confirm that the separation between the seal chamber center and the rotor center is 0.127 mm | 0.005 in. or less.  
If the separation is greater than 0.127 mm | 0.005 in., then contact your ITT representative for assistance.

### 6.6.3.2 Align the rotor

Before you align the rotor, you must qualify the casing bores. See Qualify the casing bores.

The purpose of this procedure is to align the center of the bearing housing bores with the center of the casing bore. This ensures that the rotor is straight through all the bores during operation.

1. Temporarily place two one-inch square shims in the bottom of each center case bushing bore. The thickness of the shim must be determined during the casing bore qualification procedure. These shims remove the sag, or bend, from the rotor by compensating for the misalignment between the center bushing clearance and the casing bore.
2. Place the rotor in the lower half of the casing. Make sure that the dowel in the center case bushing is at the 12 o'clock position.
3. Mount the tool bearings on the shaft.  
Tool bearings are used for rotor alignment purposes only. The bore diameter of the inner race has been increased so that it is a slip fit onto the shaft.
4. Mount the bearing housings. Hand-tighten the mounting nuts to allow for adjustment.
5. Install two dial indicators on the shaft, one in each seal chamber bore.
6. Set each indicator to zero on the same side of the casing. Adjust the bearing housings vertically and horizontally to achieve a TIR less than 0.0381 mm | 0.0015 in.  
Make sure that the indicator is reading on a machined surface and not on a hand-filed surface, which is sometimes necessary near the parting flange.
7. Keep the bearing housing level from side to side during the bearing housing adjustment in order to ensure the correct oil level setting.
8. Double-check the centering of the rotor with a feeler gauge between the casing rings and impeller rings and confirm the clearance around the circumference.

- For standard clearance use a 0.076 mm | 0.003 in. feeler gauge. For API clearance use a 0.152 mm | 0.006 in. feeler gauge. Make minor adjustments to the bearing housings accordingly.
9. Recheck the shaft-to-seal chamber bore TIR after this adjustment. Side-to-side readings must be 0.127 mm | 0.005 in. or less. The bottom reading must be 0.0635 mm | 0.0025 in. or less.
  10. Tighten the mounting screws on the bearing housing. Confirm that the shaft-to-seal chamber TIR has not changed. Adjust the bearing housings until the TIR criteria is met with the mounting screws firmly tightened.
  11. Mount a magnetic base dial indicator on the thrust end of the shaft and indicate the housing face of the thrust bearing. Readings must be within 0.076 mm | 0.003 in. TIR. If this value is exceeded, inspect the bearing housing and the casing face, and correct any condition that is out of tolerance.
  12. Drill pilot holes, taper-ream holes for the dowel pins, and install the dowels.
  13. Remove the temporary shims from under the center case bushing either by removing the bushing or by removing the rotor.

### 6.6.4 Assemble the casing

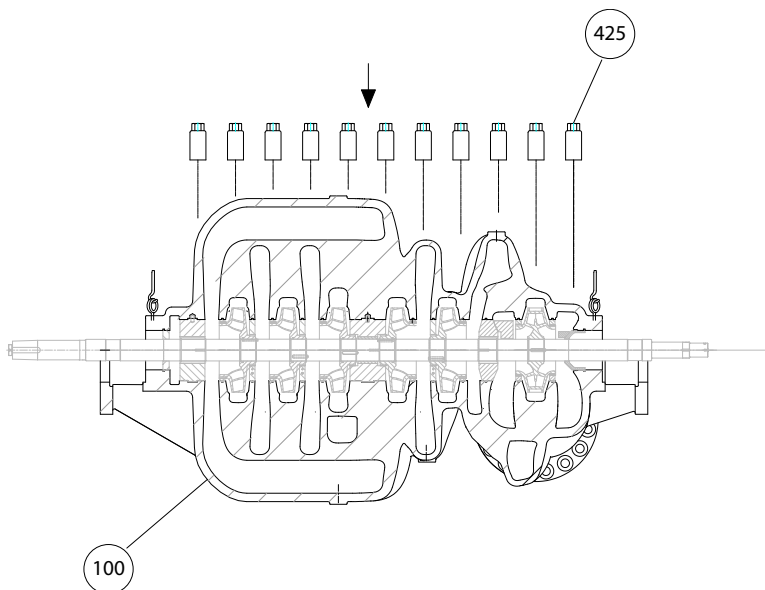
1. Lower the upper half of the casing, using taper pins to correctly align to the lower half.

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#### NOTICE:

Apply an anti-seize compound to the studs and to the face of the casing where the nuts make contact.

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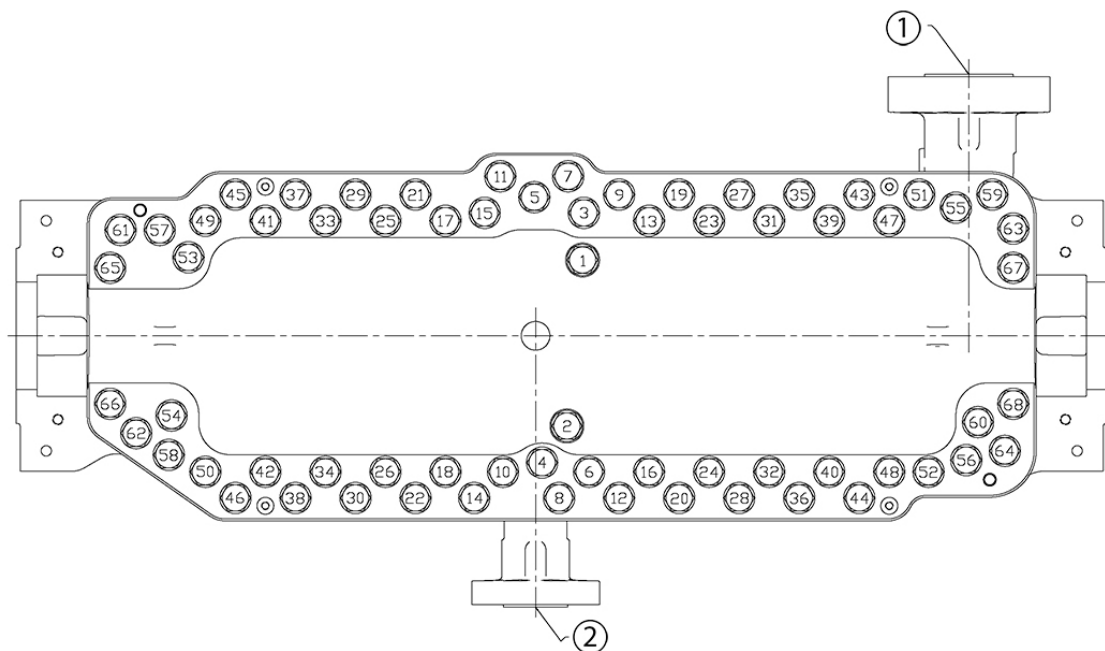


**Figure 76: Installing the casing upper half**

2. Torque the casing nuts (425) to the values found in the Maximum torque values for fasteners table in Assembly references.
  - a) Apply LPS (or equivalent) nickel or moly based anti-seize compound to the studs (356A, 356C, 356K) and to the counterbore surface in the casing where the nuts (425) make contact.
  - b) Install a nut (425) on each stud (356A, 356C, 356K).
  - c) Install a nut (425) on each stud (356A, 356C, 356K)

**NOTICE:**

- Use nickel or MOLY anti-seize on threads
- For bolting sequence start from center go side to side from center to outside
- Torque studs following numbered sequence shown using 3 passes
- First pass torque: 30% ft-lb
- Second pass torque: 60% ft-lb
- Final pass torque: 100% ft-lb (see chart for fasteners torque values 2239 material)

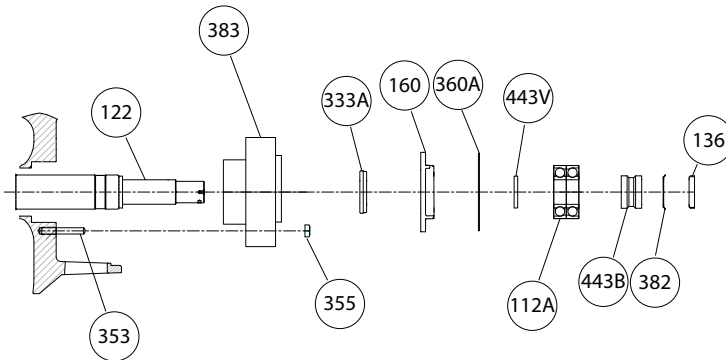


Item	Description
1.	Suction
2.	Discharge

**Figure 77: Casing parting flange hardware torquing sequence**

- Casing parting flange hardware torquing sequence
- Tighten the nuts (425) to 60% full torque using the torquing sequence shown starting with the casing center stud (356C) no. 1.
- Tighten the nuts (425) to 100% full torque using the torquing sequence shown starting with the casing center stud (356C) no. 1.
- Tighten the nuts (425) to 100% full torque using a clockwise sequential process starting with the casing center stud (356C) no. 1.

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



**Figure 78: Thrust 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).

---

**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 bearing spacer (443V) and 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.

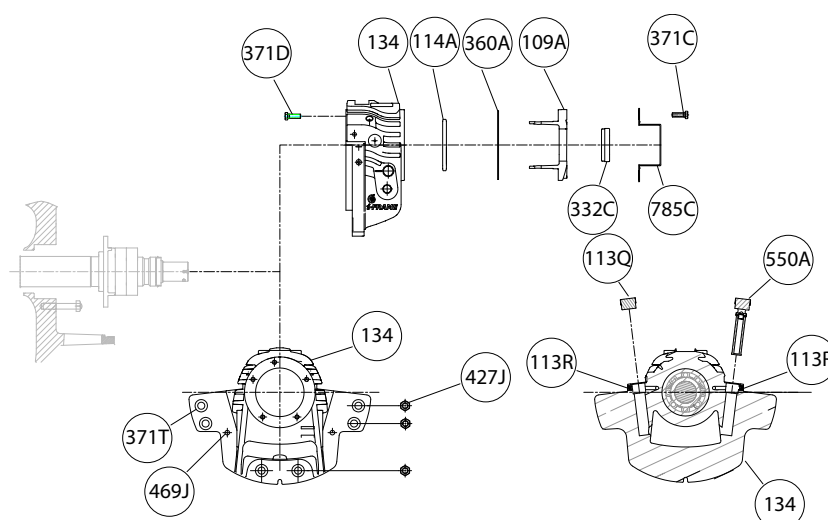
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**NOTICE:**

Do not use a torch and do not force.

- 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: 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 .
7. Install the oil ring (114).
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 (109A).

---

**NOTICE:**

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

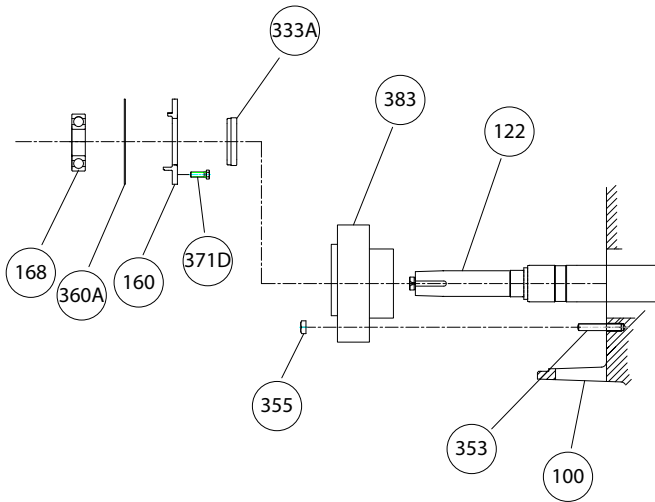
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9. Install the bearing end cover (109A) and the bearing end-cover gasket (360A) with the end-cover capscrews (371C).
10. Install a new oil filter (550A) and filter plug (113Q).
11. When new bearings are installed, you must measure the axial end play:
  - 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	0.254-0.381   0.010-0.015

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



**Figure 80: 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).

---

**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.

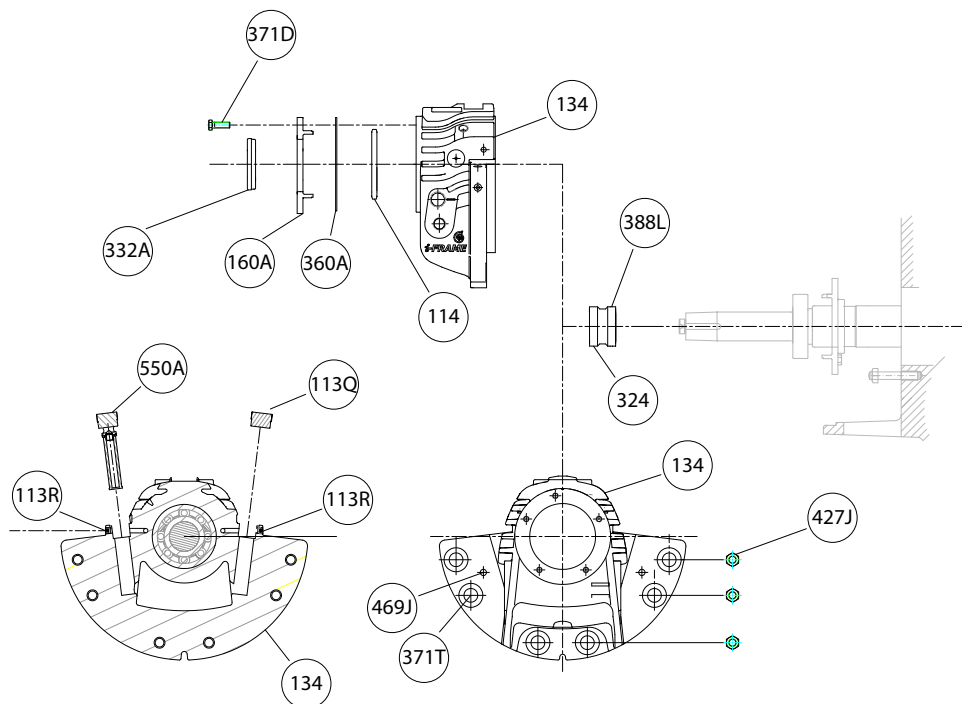
**CAUTION:**

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 81: 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).

### 6.6.7 Assemble the thrust end (sleeve/ball bearing pumps)

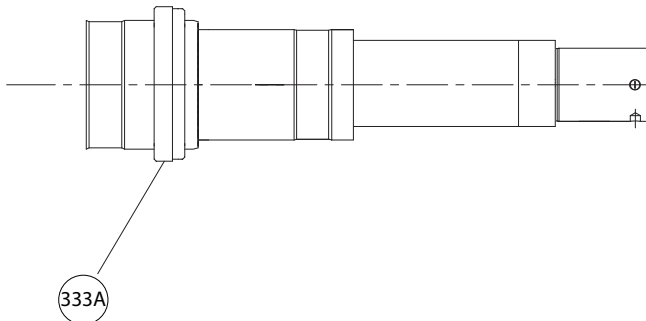
1. Prior to beginning assembly, push the rotor assembly towards the thrust end until it stops.
  2. Install the cartridge mechanical seal (383) on the shaft (122) and align the mechanical seal pilot with the seal chamber bore of the casing. Install the mechanical seal studs (353) and hex nuts (355).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

**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 82: Inboard labyrinth seal installation**

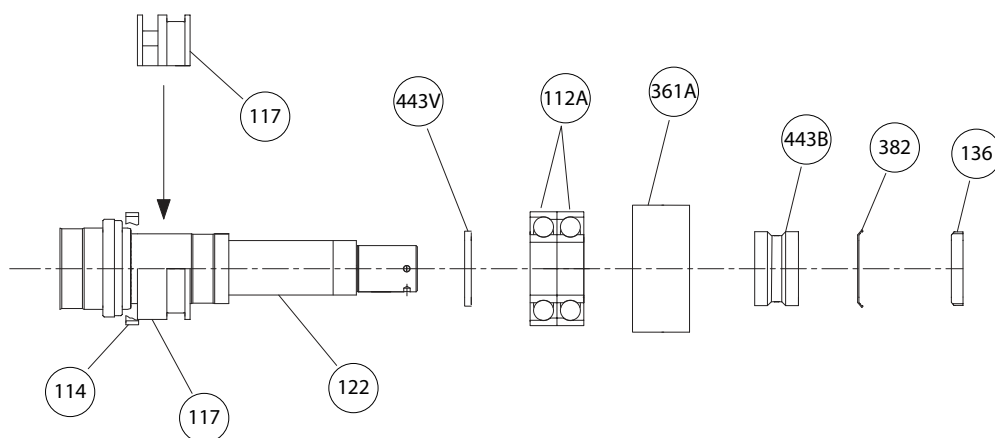
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**NOTICE:**

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 83: 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.



**CAUTION:**

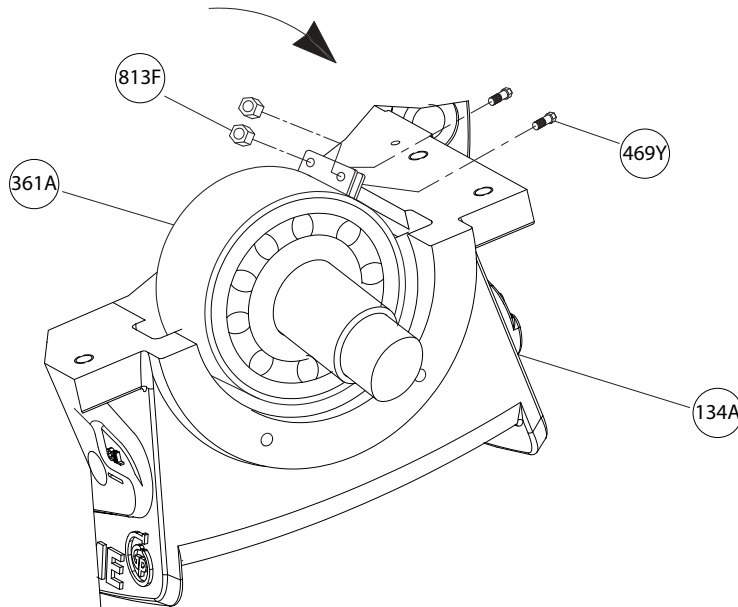
- Risk of physical injury from hot bearings. Wear insulated gloves when using a bearing heater.

**NOTICE:**

Do not use a torch and do not force.

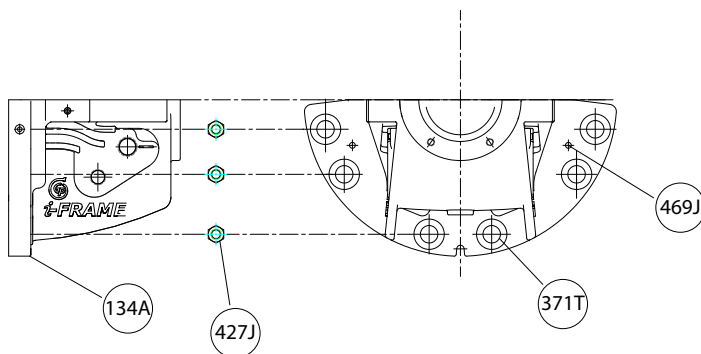
- b) Install the bearings (112A), the oil ring sleeve (443B), and the bearing locknut (136) onto the shaft.
- c) While the bearings are hot, tighten the locknut by hand with a spanner wrench until the bearing is snug against the shaft shoulder.
- d) Allow the bearing assembly to cool slowly to room temperature.  
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 84: Installation of bearing retainer**

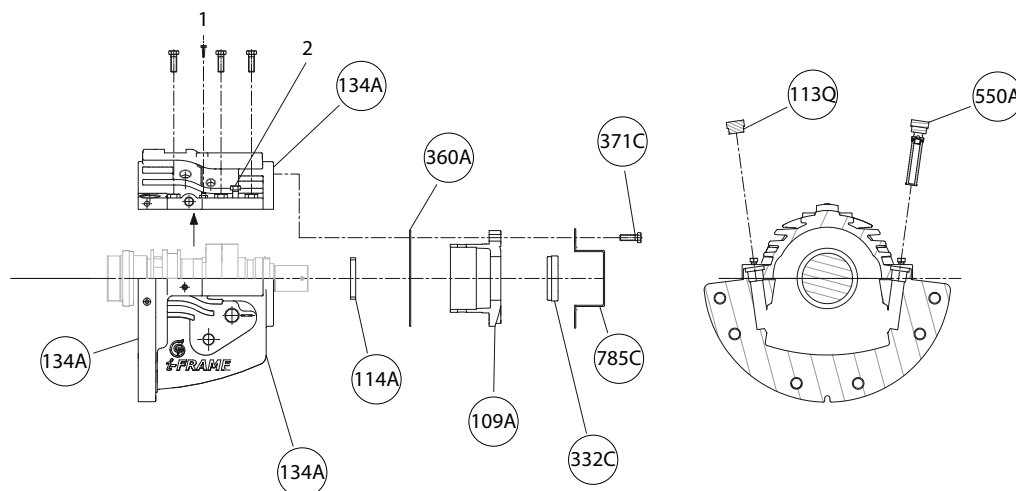
7. Install the thrust bearing retainer (361A). Secure the retainer with the screws (469Y) and nuts (813F). Position the retainer tab into the lower bearing frame (134A) slot.
8. Lift the lower half of the bearing housing (134A) into place, positioning the sleeve bearing oil ring (114) in the bearing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



**Figure 85: 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 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 86: 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 capscrews (371C).
18. Install a new oil filter (550A) and filter plug (113Q).

### 6.6.8 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).

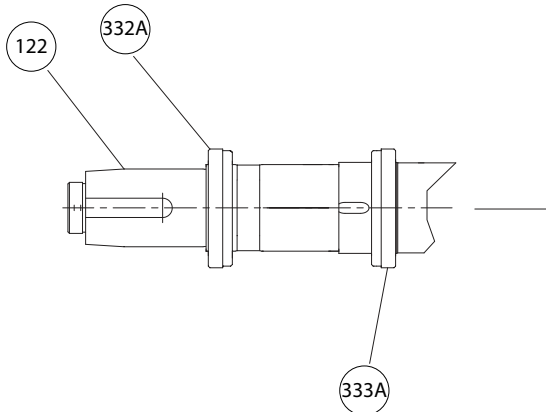
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#### NOTICE:

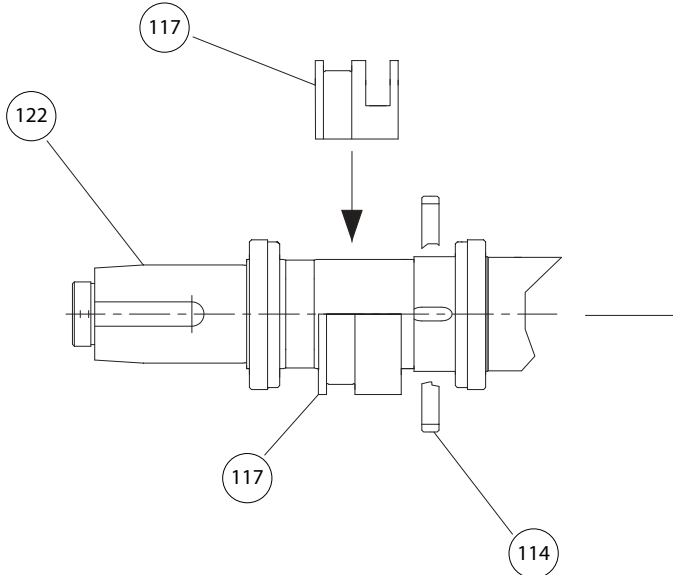
Do not set the mechanical seal sleeve set screws at this time; endplay must be checked first or damage to the seal faces could occur.

---

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



**Figure 87: Inboard labyrinth seal installation**



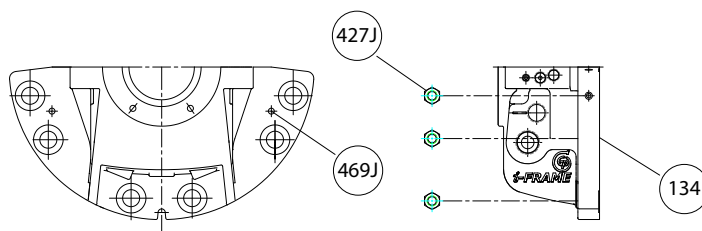
**Figure 88: Radial sleeve bearing assembly**

3. Place the oil ring (114) on the shaft.
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.
6. Place the installed inboard labyrinth seals (332A and 333A) in the lower housing.

**NOTICE:**

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

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 upper 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 rings accordingly. Position the inboard oil rings in the groove on the sleeve bearings.
  - b) Install the dowel pins (469J) in the pre-drilled dowel pin holes between the housing flange and the case bearing flange.



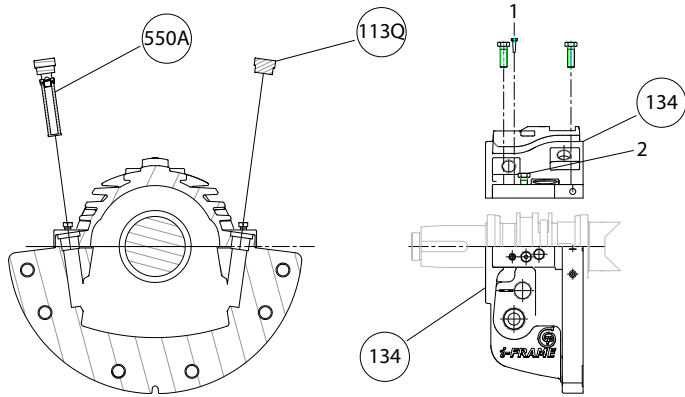
**Figure 89: Radial bearing housing installation**

- 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 rings aside. When the bearing top half is in place, move the oil rings 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 90: 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).

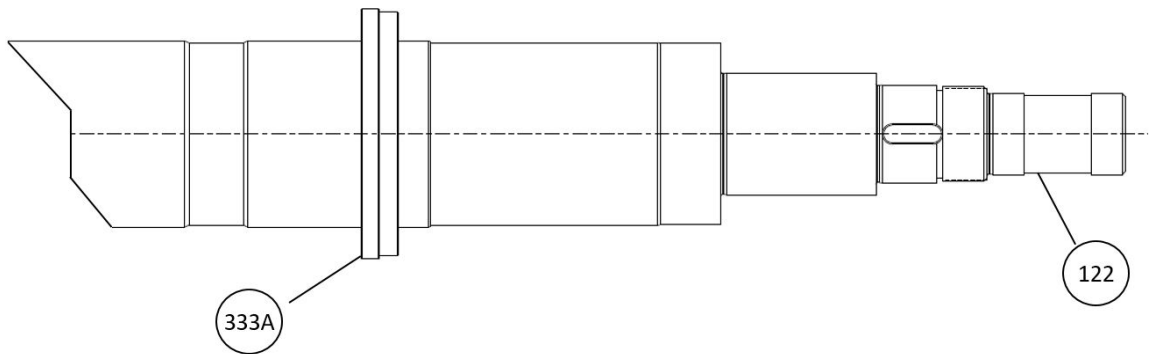
### 6.6.9 Assemble the thrust end (sleeve/tilt pumps)

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 91: Thrust inboard labyrinth seal installation**

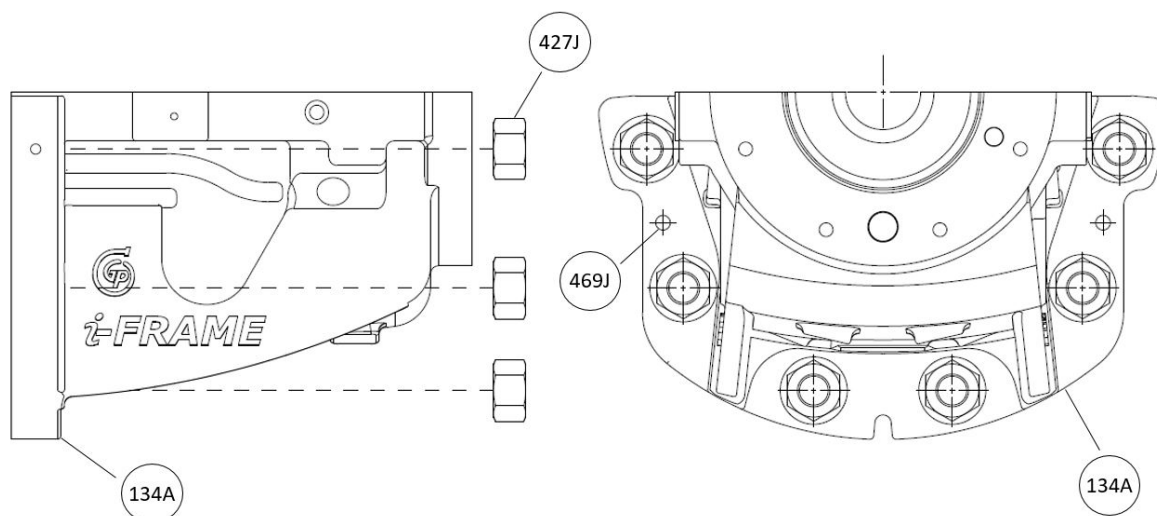
**NOTICE:**

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 92: 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).

### 6.6.10 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).

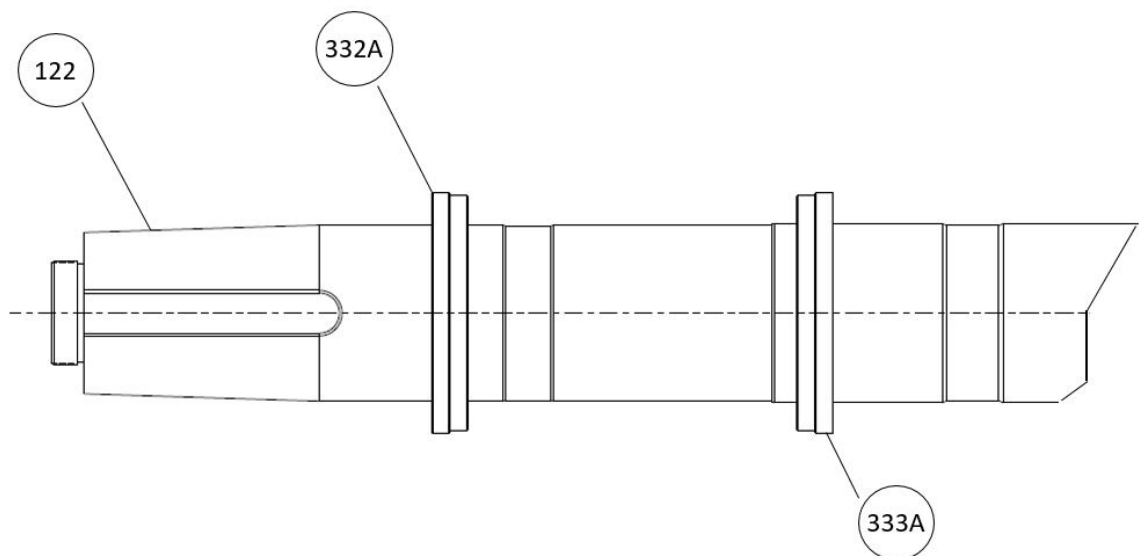
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**NOTICE:**

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.

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

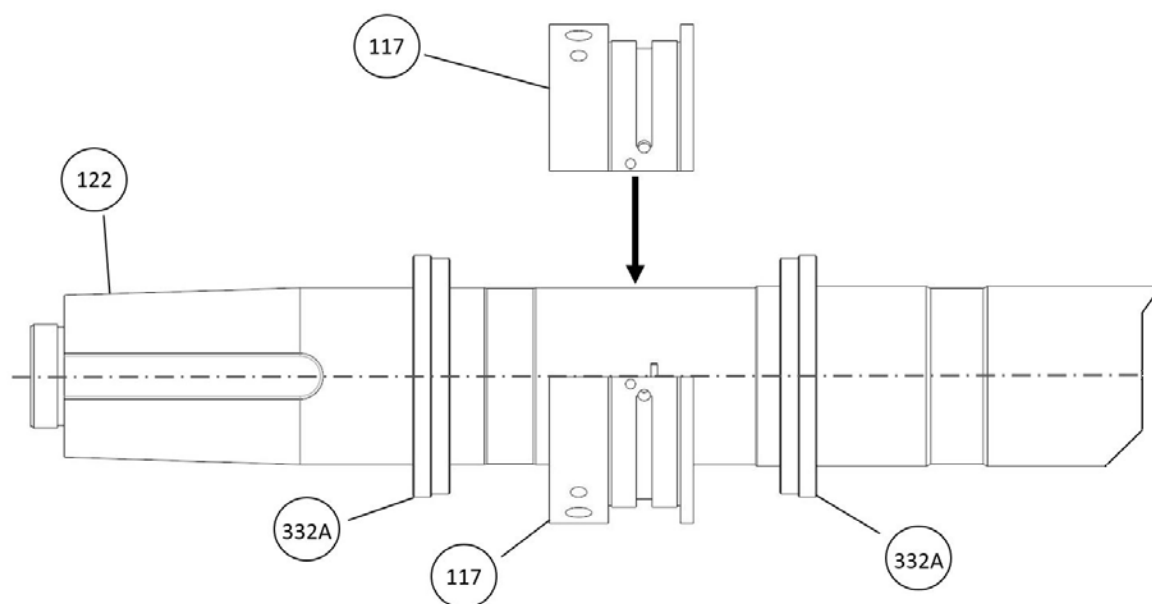


**Figure 93: Radial inboard labyrinth seal installation**

**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 94: 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).

### 6.6.11 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.

## 6.6.12 Assembly references

### 6.6.12.1 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 6: 300 Series Stainless Steel Fasteners

Bolt Dia. (D) (in.– threads/ inch)	Tensile Stress Area (Ab), (sq.– in.)	2226, 2228: 303, 304SS, SAE F593 Group 1 2229: 316SS, SAE F593 Group 2 Yield strength:  65000 psi for 0.25 ≤ dia ≤ 0.625 45000 psi for 0.75 ≤ dia ≤ 1.5		A193 B8, B8M Cl 1, A276 Tp 304, A582 Tp 303  Yield strength=30000 psi  Ultimate tensile=75000 psi	
		Max. preload (lbs)	Torque N-m   ft-lb Nickel or Moly Anti- seize K=0.15	Max. preload (lbs)	Torque N-m   ft-lb Nickel or Moly Anti- 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

Bolt Dia. (D) (in.– threads/ inch)	Tensile Stress Area (Ab), (sq.– in.)	2226, 2228: 303, 304SS, SAE F593 Group 1 2229: 316SS, SAE F593 Group 2 Yield strength:  65000 psi for 0.25 <=dia<=0.625  45000 psi for 0.75<=dia<=1.5		A193 B8, B8M Cl 1, A276 Tp 304, A582 Tp 303  Yield strength=30000 psi  Ultimate tensile=75000 psi	
		Max. preload (lbs)	Torque N-m   ft-lb Nickel or Moly Anti- seize K=0.15	Max. preload (lbs)	Torque N-m   ft-lb Nickel or Moly Anti- seize K=0.15
2.5-4	3.999	125969	5338   3937	83979	3558   2624
2.5-8	4.442	139923	5929   4373	93282	3952   2915
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

### 6.6.12.2 Maximum torque values for fasteners

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

Table 7: High strength steel fasteners

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 Nickel or Moly Anti- seize K=0.15	Torque N-m   ft-lb Nickel or Moly Anti- 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	

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 Nickel or Moly Anti-seize K=0.15	Torque N-m   ft-lb Nickel or Moly Anti-seize K=0.15
1.75-8	2.082	153027	4538   3347	4538   3347
1.875-8	2.414	177429	5637   4158	5637   4158
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	

### 6.6.12.3 Maximum torque values for fasteners

Table 8: Carbon steel fasteners - Goulds 2210, 2294, ASTM A307 Gr B, SAE Gr 2

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

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
1.75-5	1.899	47855	1420   1047
1.75-8	2.082	52466	1556   1148
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

## 6.6.12.4 Spare parts

### Critical service spare parts

For critical services, stock these parts, where applicable:

- Impellers (101 through 101M)
- 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)
- Bearing spacer (217)
- Snap ring (361F)
- Locating ring (361H)

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 (383)
- Filter Assembly (550A)
- Thrust bearing (duplex pair) (112A)
- Oil rings (114, 114A)
- Sleeve bearings, two (117) (sleeve bearing construction only)
- Throttle bushing, sleeve (128)

- Throttle bushing (129)
- Bearing locknut (136)
- Stage ring (144)
- Center bushing (155)
- Casing wear rings (164, 164A, 164B)
- Impeller wear rings (202, 202A, 202B, 203)
- Center sleeve (205)
- Bearing Spacer (443V)
- Labyrinth seal, outboard (332A)
- Labyrinth seal, outboard (332C)
- Labyrinth seal, inboard (333A)
- Casing gasket (351)
- 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.
	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.	Replace the gasket or O-ring.
	The stuffing box has an air leak.	Replace or readjust the mechanical seal.
	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.	Re-prime the pump and check that the pump and suction line are full of liquid.
	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.
	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.

## 7.2 Alignment troubleshooting

Symptom	Cause	Remedy
	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>1. Determine which corners of the baseplate are high or low.</li> <li>2. Remove or add shims at the appropriate corners.</li> <li>3. Realign the pump and driver.</li> </ol>

# 8 Parts List and Cross-Sectionals

## 8.1 Parts list

Item	Part Name	S-6	S-8	C-6	A-8	D-1	D-2	S-8N	A-8N
100	Casing	9734/1212	9734/1212	9495/1234	9497/1296	9523/1362	9089/1361	9734/1212	9497/1296
101 101A-M	Impeller	9168/1234	9436/1265	9168/1234	9436/1265	9524/1362	9011/1361	9365/1265	9365/1265
108F	Coupling, Threaded (Watchdog)	-							
109A	Bearing End Cover, Thrust	1212							
112A	Ball Bearing, Thrust	-							
114, 114A	Oil Ring	1618							
117	Sleeve Bearing	-							
122	Shaft	2255	2351	2255	2351	2435	3280	2351	2351
123	Inpro Seal, VBXX-DB45-U, with flinger	-							
128	Sleeve, Throttle Bushing	2445	6983	2445	6983	6186	6170	2445	2445
129	Throttle Bushing	2222	6983	2222	6983	6187	6171	1265	1265
132	Eye Bolt	-							
133A	Pipe Nipple, Watchdog	6501							
134, 134A	Bearing Housing	1212							
136	Locknut, Thrust Bearing	-							
144	Stage Ring	2222	6983	2222	6983	6187	6171	1265	1265
146	Diaphragm	2222	6983	2222	6983	6187	6171	1265	1265
155	Center Bushing	2222	6983	2222	6983	6187	6171	2229	2229
160	Bearing End Cover, Inboard	2210							
160A	Bearing End	2210							

8.1 Parts list

Item	Part Name	S-6	S-8	C-6	A-8	D-1	D-2	S-8N	A-8N
	Cover, Coupling End								
164, 164A, 164B	Wear Ring, Casing	2222	6983	2222	6983	6187	6171	1265	1265
168	Radial Bearing	-							
178, 178A, 178B	Impeller/ Sleeve Key	2226	2226	2244	2226	2435	3280	2226	2226
178Y	Aux. Pump Coupling Key	2213							
195G	Flange Cover – Suction	3201							
195H	Flange Cover – Discharge	3201							
202, 202A, 202B	Wear Ring, Impeller – Suction	2255	6983	2255	6983	6186	6170	1071	1071
203	Wear ring, Impeller – Hub	2255	6983	2255	6983	6186	6170	1071	1071
203A	Wear Ring, Impeller – Center	2255	6983	2255	6983	6186	6170	1071	1071
204	Sleeve, Diaphragm	2445	6983	2445	6983	6186	6170	2445	2445
205	Sleeve, Center Bushing	2445	6983	2445	6983	6186	6170	2445	2445
219	Auxiliary Oil Pump	-							
220	Seal Chamber, Radial	2210	2210	2244	2229	2435	3280	2210	2229
221	Seal Chamber, Thrust	3201 OR 1212	3201 OR 1212	3220 OR 1234	2229 OR 1296	2435 OR 1362	3280 OR 1361	3201 OR 1212	2229 OR 1296
222B	Set Screw, Thrust Collar Nut	2229							
222S	Set Screw, Coupling Nut	2229							

Item	Part Name	S-6	S-8	C-6	A-8	D-1	D-2	S-8N	A-8N	
222V	Set Screw, Cooling Fan	2229								
234D	Pump Endplate, Thrust Fan Guard	3201								
234E	Outboard Endplate, Thrust Fan Guard	3201								
251	Oiler – Watchdog	-								
280	Tilt Pad Bearing Assembly	-								
282	Thrust Collar Key	2213								
283	Thrust Collar Nut	2210								
318A	Oil Pump Adapter	1212								
319A	Pipe Plug, Oiler	-								
320	Set Screw, Impeller Wear Ring	2229			2435		3280		2229	
324	Oil Ring Sleeve (Radial)	2210								
332A	Inpro Seal, VB45-U, (Radial Outboard)	-								
333A	Inpro Seal, VB45-U (Inboard)	-								
332C	Inpro Seal, VB45-U, (Thrust Outboard)	-								
351	Gasket, Casing	5108								
351E	Gasket, Flange Cover (Suction)	5107								
351F	Gasket, Flange Cover	5107								

8.1 Parts list

Item	Part Name	S-6	S-8	C-6	A-8	D-1	D-2	S-8N	A-8N
	(Dis-charge)								
353	Stud, Mechanical Seal					2239			
355	Hex Nut, Mechanical Seal					2285			
356A, 356C, 356K	Stud, Casing					2239			
357P	Flg Hex Nut, Hsg. To Casing					2341			
358M	Pipe Plug					2210			
358Z	Pipe Plug, Cover					2210			
360A	Gasket, Bearing End Cover					5130			
361A	Bearing Retainer					3211			
361F	Snap Ring					-			
361H	Locating Ring		2229			2435	3280	2229	
370L	Cap Screw, Oil Pump To adapter					2210			
370V	Cap Screw, Adapter To Housing					2210			
371C	Cap Screw, Thrust Bearing End Cover To Housing					2210			
371D	Cap Screw, Radial Bearing End Cover To Housing					2210			
371T	Stud, Housing To Casing					2210			
372T	Cap Screw, i-ALERT2					2367			

Item	Part Name	S-6	S-8	C-6	A-8	D-1	D-2	S-8N	A-8N
382	Lockwasher, Thrust Bearing					-			
383	Mechanical Seal					-			
388L	Set Screw, Oil Ring Sleeve (Radial)					2229			
390C	Shim Pack, Tilt Pad Bearing					2229			
392B	Cooling Fan, CW					1425			
394	Roll Pin, Filler Plate					-			
400	Coupling Key					2213			
408A	Pipe Plug, Drain					-			
408L	Pipe Plug, Bearing Cooling					-			
408M	Pipe Plug, Bearing Cooling					-			
408R	Pipe Plug, RTD					2210			
412M	O-Ring, Filler Plate					5304			
418	Cap Screw, Jack Bolt					2210			
424	Name-plate Pin					-			
425	Cap Nut, Casing					2239			
441A	Filler Plate					2210			
443B	Oil Ring Sleeve (Thrust)					2210			
443V	Bearing Spacer					2228			
445A	Pin, Anti-Rotation Rings & Seal Chamber			2435			3280		2435
469D	Roll Pin, Sleeve Bearing					-			

8.1 Parts list

Item	Part Name	S-6	S-8	C-6	A-8	D-1	D-2	S-8N	A-8N
469J	Taper Pin, Casing					2210			
469Y	Cap Screw, Bearing Retainer					2229			
492V	Pipe Plug, Vibration Connections					2210			
494	Tubing, Finned Cooler					-			
494A	Connector, Thermocouple					-			
494B	Elbow, 90°					-			
494C	Bushing, Hex Head Reducing					-			
497G	O-Ring, Baffle					5304			
520	Coupling Nut					2210			
533	Washer, Casing Parting					-			
534D	Washer, Plain – Fan Cooling					2229			
534E	Bolt Retainer – Fan Cooling					-			
549	Nameplate Tag					-			
549K	Lubrication Notice Tag					-			
569A	Cap Screw, Flange Cover (Suction)					5429			
569B	Cap Screw, Flange Cover (Discharge)					5429			
569F	Hex Tap Bolt, Cooling Fan					2228			



Item	Part Name	S-6	S-8	C-6	A-8	D-1	D-2	S-8N	A-8N
570A	Hex Nut, Flange Cover (Suction)						5429		
570B	Hex Nut, Flange Cover (Dis-charge)						5429		
570F	Nut, Cooling Fan					-			
761B	i-ALERT2 Condition monitor					-			
785B	Guard, Cooling Fan						3201		
785C	Guard, Shaft						3201		
785D	Cowling						3201		
813F	Hex Nut, Bearing Retainer						2229		

### Materials of Construction

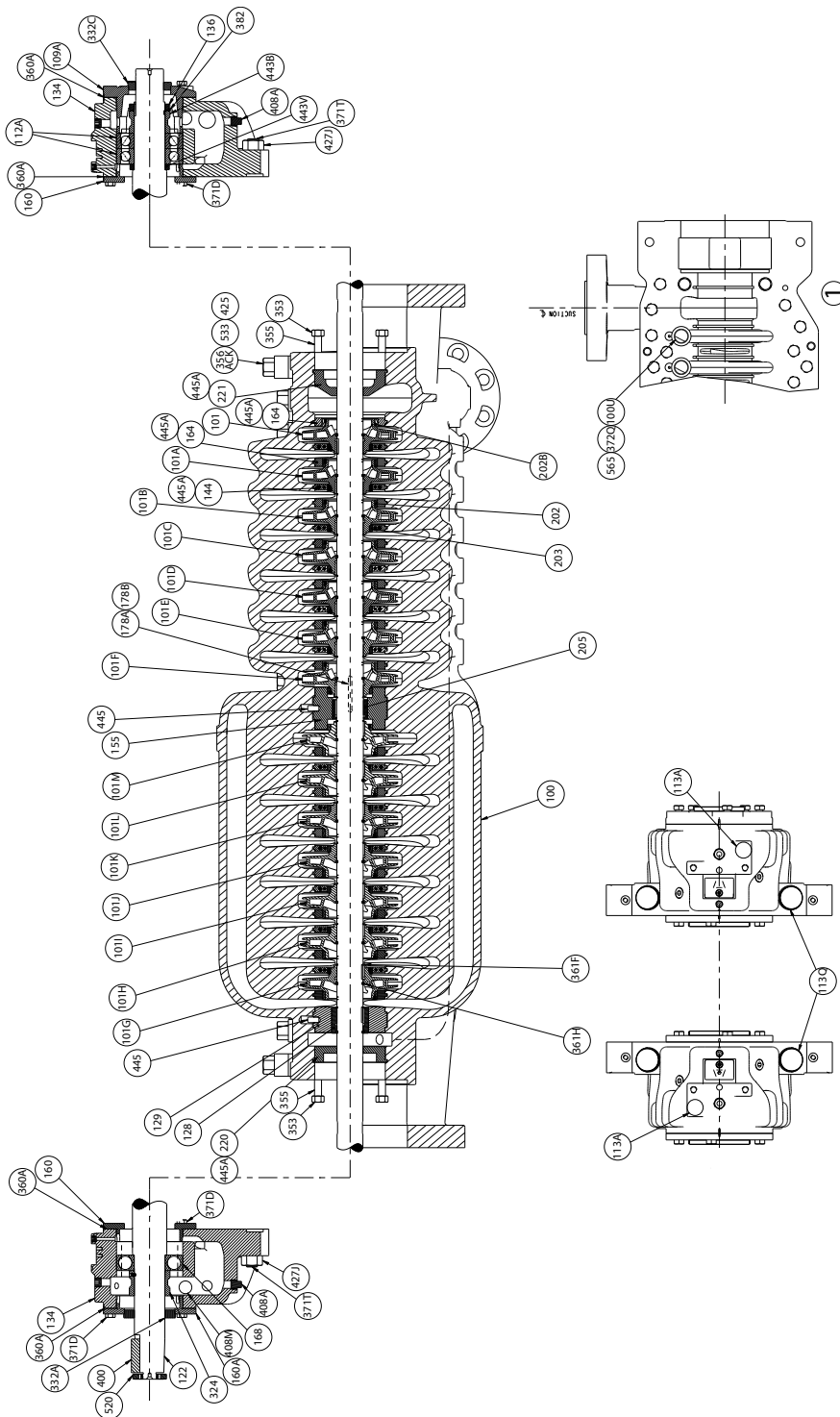
Material	Description	Form	ASTM	UNS
1071	Nitronic 60	Casting	A743 Grade CF10SMnN	J92972
1212	Carbon Steel	Casting	A216 Grade WCB	J03002
1222	12% Chrome	Casting	A743 Grade CA6NM	J91540
1234	12% Chrome	Casting	A487 Grade CA6NM	J91540
1265	316LSS	Casting	A743 Grade CF3M	J92800
1296	316LSS	Casting	A351 Grade CF3M	J92800
1361	Super Duplex SS	Casting	A890 Grade 5A	J93404
1362	Duplex SS	Casting	A890 Grade 3A	J93371
1401	Super Duplex SS	Casting	A995 Grade 5A	J93404
1402	Duplex SS	Casting	A995 Grade 3A	J93371
1618	Bismuth Bronze	Casting	B505 C89320	C89320
2210	Carbon Steel	Wrought	A108 Grade 1213	G12130
2210	Carbon Steel	Fastener	A307 Grade B	-
2213	Carbon Steel	Wrought	A108 Grade 1020	G10200
2222	420SS Hardened (450-500 BHN)	Wrought	A276 Type 420	S42000
2229	316SS	Wrought	A276 Type 316	S31600
2229	316SS	Fastener	F593 Alloy Group 2	S31600
2238	Alloy Steel	Wrought	A434 Grade 4140 Class BC	G41400
2239	Alloy Steel	Fastener	A193 Grade B7	G41400
2244	410SS	Wrought	A276 Type 410	S41000
2245	410SS Hardened (350-400 BHN)	Wrought	A276 Type 410	S41000

8.1 Parts list

Material	Description	Form	ASTM	UNS
2252	410SS	Wrought	A479 Type 410 Cond. 2	S41000
2255	17-4PH	Wrought	A564 Type 630 Cond. H1150D	S17400
2285	Alloy Steel	Fastener	A194 Grade 2H	K04002
2341	Carbon Steel	Fastener	A563 Grade A	K05802
2351	Nitronic 50	Wrought	A276 Grade XM-19	S20910
2435	Duplex SS	Wrought	A276 Type S31803	S31803
2445	Nitronic 60	Wrought	A276 Type S21800 Cond. A	S21800
3207	Carbon Steel	Wrought	A516 Grade 70	K02700
3211	316SS	Wrought	A240 Type 316	S31600
3266	Super Duplex SS	Wrought	A240 Type S32750	S32750
3270	Duplex SS	Wrought	A240 Type S31803	S31803
3280	Super Duplex SS	Wrought	A479 Type S32750	S32750
6170	Duplex SS Stellite 6 Hard-faced	Coating	N/A	N/A
6171	Duplex SS Stellite 12 Hard-faced	Coating	N/A	N/A
6186	Super Duplex SS Stellite 6 Hardfaced	Coating	N/A	N/A
6187	Super Duplex SS Stellite 12 Hardfaced	Coating	N/A	N/A
5107	Rubber	Sheet	N/A	N/A
5108	Garlock Blue Guard 3000	Sheet	N/A	N/A
5130	Vellumoid	Sheet	N/A	N/A
Hardened Steel	Hardened Steel Washer	Wrought	A352 Type 1	N/A

## 8.2 Cross-sectional diagrams

### Model 3600 i-FRAME Single and Double Suction – Ball/Ball



1. Casing Insert Detail Sizes 3x4-8E & 3x4-12.5A/B only

**Figure 95: Single Suction - ball/ball**

8.2 Cross-sectional diagrams

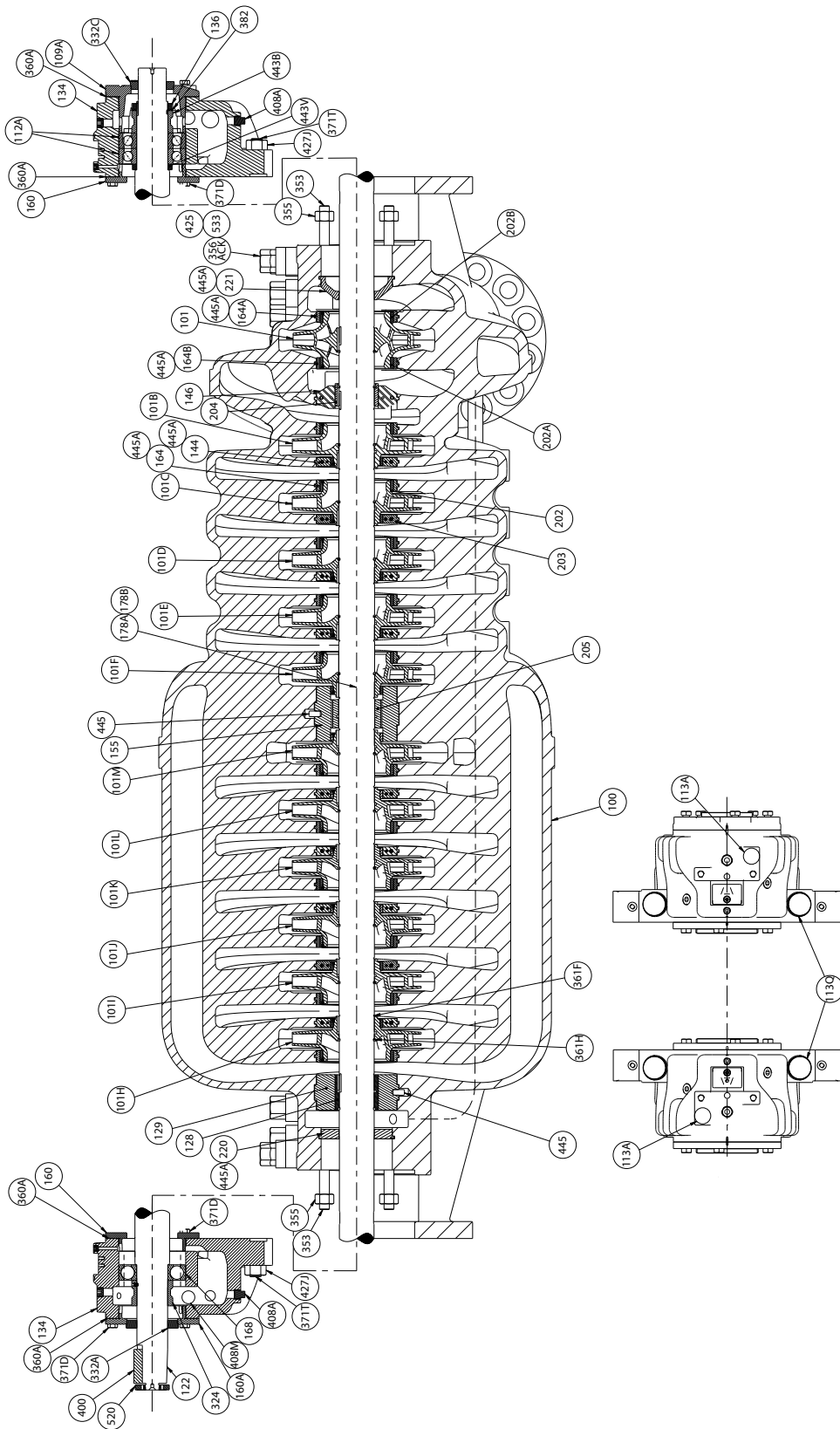
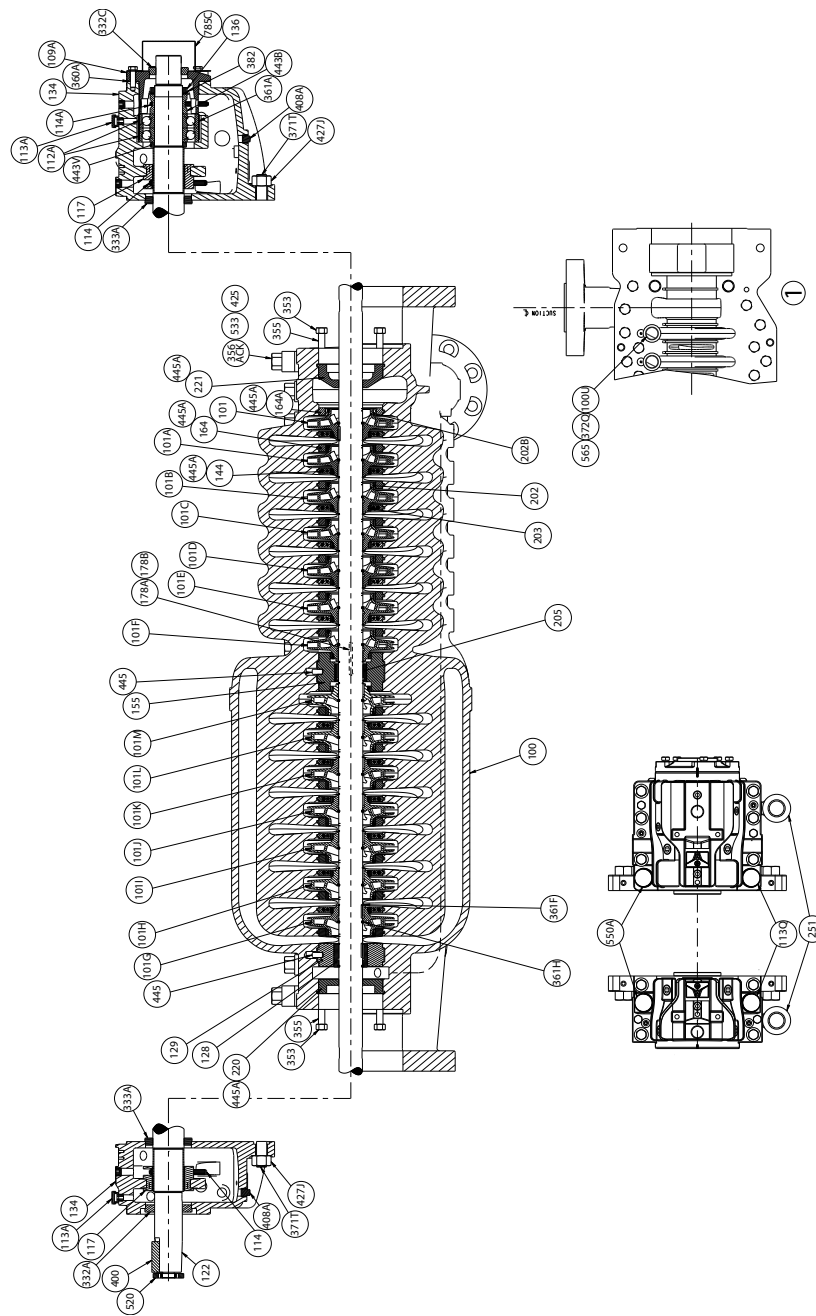


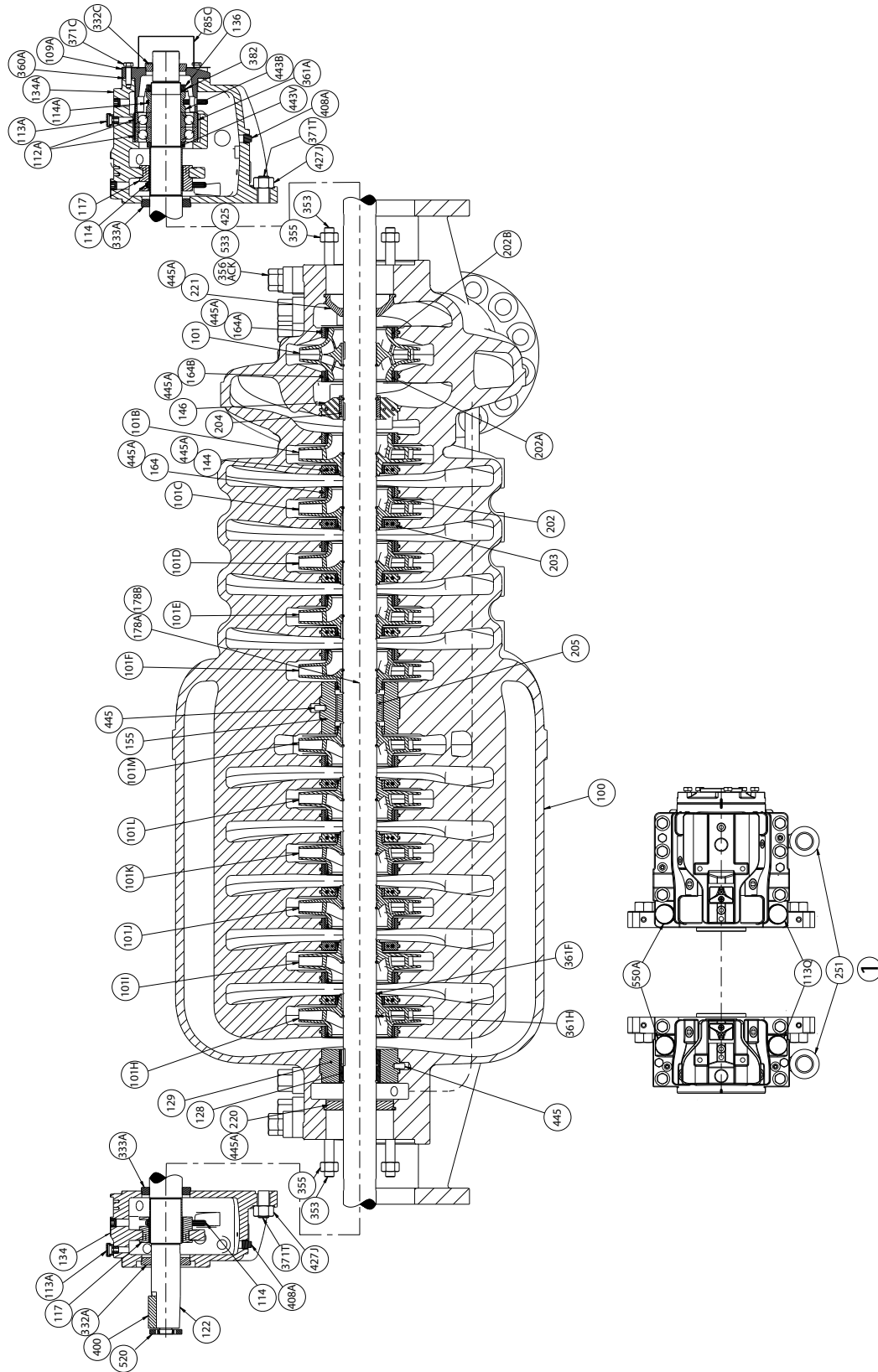
Figure 96: Double suction - ball/ball

**Model 3600 i-FRAME Single and Double Suction – Sleeve/Ball**



1. Casing Insert Detail Sizes 3x4-8E & 3x4-12.5A/B only

**Figure 97: Single suction - sleeve/ball**



1. Oil filter and oiler detail

Figure 98: Double suction - sleeve/ball

Single suction sleeve/tilt

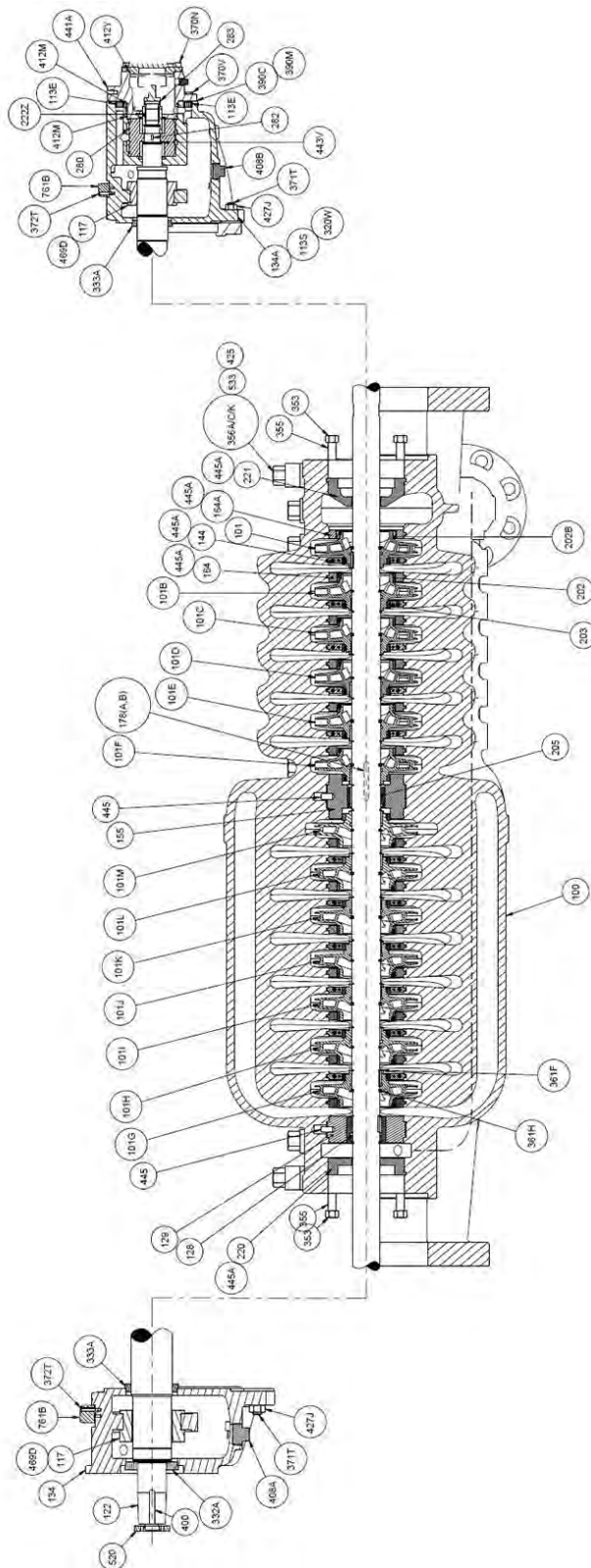
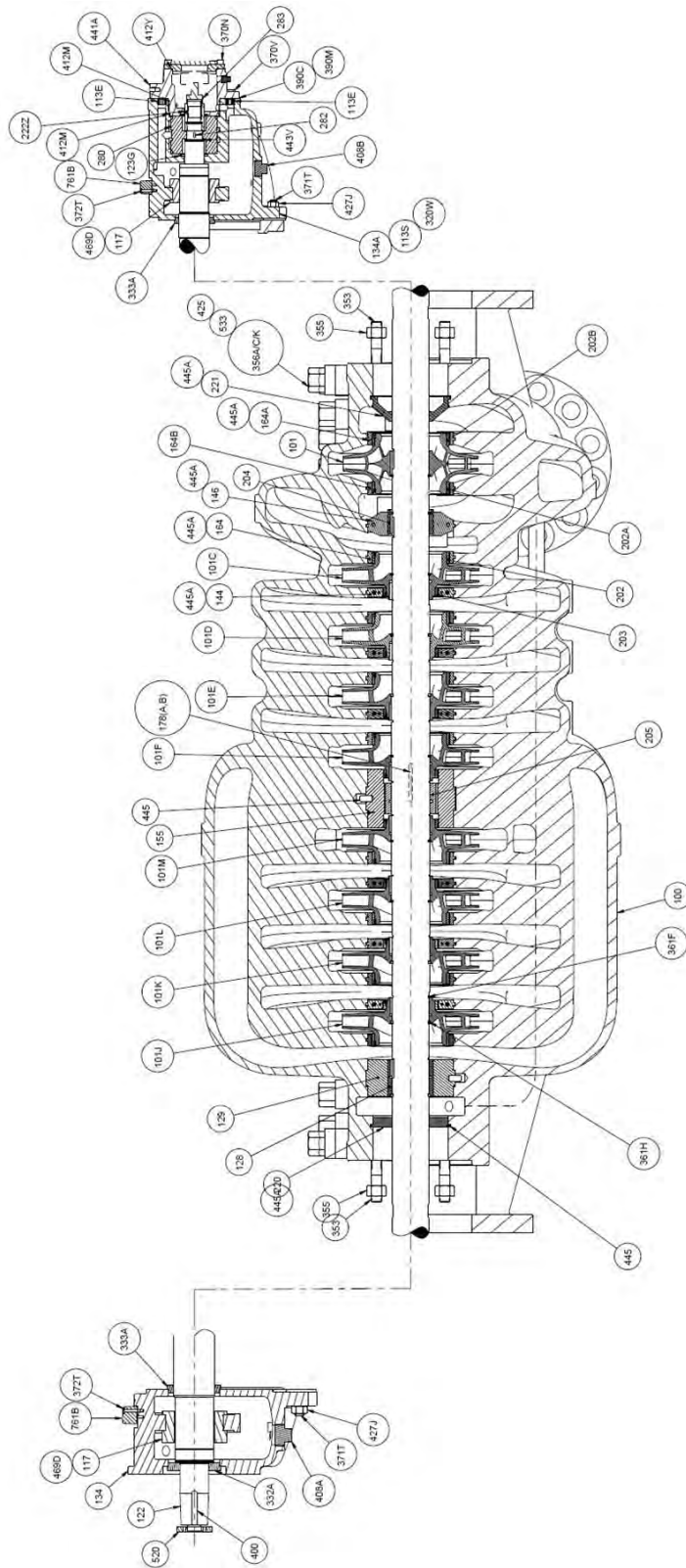


Figure 99: Single suction sleeve/tilt

**Double suction sleeve/tilt**



**Figure 100: Double suction 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 240 Fall Street Seneca Falls, NY 13148 USA	+1 315-568-2811	+1 315-568-2418
Houston office	12510 Sugar Ridge Boulevard Stafford, TX 77477 USA	+1 281-504-6300	+1 281-504-6399
Los Angeles	Vertical Products Operation 3951 Capitol Avenue City of Industry, CA 90601-1734 USA	+1 562-949-2113	+1 562-695-8523
Asia Pacific	ITT Fluid Technology Asia Pte Ltd 1 Jalan Kilang Timor #04-06 Singapore 159303	+65 627-63693	+65 627-63685
Asia Pacific	ITT Goulds Pumps Ltd 35, Oksansandan-ro Oksan-myeon, Heungdeok-gu, Cheongju-si, Chungcheongbuk-do 28101, Rep. of KOREA	+82 234444202	
Europe	ITT - Goulds Pumps Millwey Rise Industrial Estate Axminster, Devon, England EX13 5HU	+44 1297-639100	+44 1297-630476
Latin America	ITT - Goulds Pumps Camino La Colina # 1448 Condominio Industrial El Rosal Huechuraba Santiago 8580000 Chile	+562 544-7000	+562 544-7001
Middle East and Africa	ITT - Goulds Pumps Achileos Kyrou 4 Neo Psychiko 115 25 Athens Greece	+30 210-677-0770	+30 210-677-5642

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ITT Goulds Pumps, Inc.  
240 Fall Street  
Seneca Falls, NY 13148  
USA

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