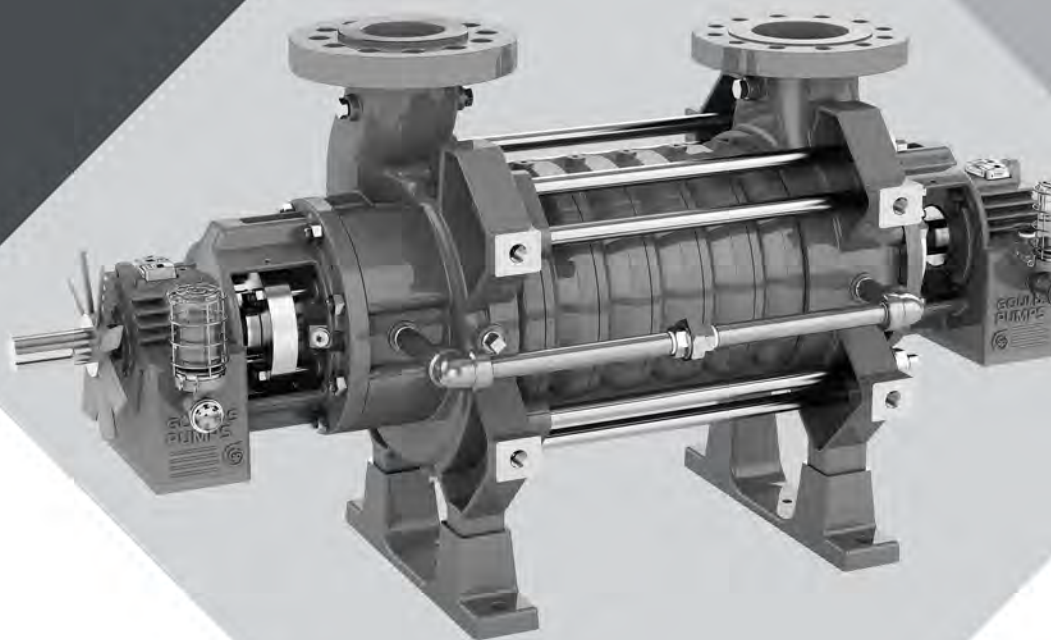




# Installation, Operation, and Maintenance Manual

Model 3393



**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



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### 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.

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### NOTICE:

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

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### 1.1.1 Requesting other information

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

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

## 1.2 Safety



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### 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.



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#### **WARNING:**

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

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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.



## 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



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**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.

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### Temperature



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**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.

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

### Description of Ex

The Ex directives are a specification enforced in Europe for electrical and non-electrical equipment. Ex deals 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. You can apply these guidelines to equipment installed in any potentially explosive atmosphere.

### Guidelines for compliance



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#### **WARNING:**

This manual clearly identifies accepted methods for disassembling units. These methods must be adhered to. Trapped liquid can rapidly expand and result in a violent explosion and injury. Never apply heat to impellers, propellers, or their retaining devices to aid in their removal. If there are any questions regarding these requirements, the intended use, or if the equipment requires modification, contact an ITT representative before you proceed.

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Compliance is only fulfilled when the pump is operated within its intended use, for example within its intended hydraulic range. The conditions of the service must not be changed without approval of an authorized ITT representative. When installing or maintaining explosion-proof pumps, follow these guidelines:

- Always install Ex-approved equipment in compliance with the directive and applicable standards (IEC/EN 60079–14).
- Do not install explosion proof products in locations that are classified as hazardous in the national electric code, ANSI/NFPA 70–2005.

### **Personnel requirements**

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

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 and/or vapor present in hazardous areas.
- Any maintenance for Ex-approved products must conform to international and national standards (for example IEC/EN 60079-17).

### **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 stated on the nameplates.
- The Ex-approved product must never run dry during normal operation. Dry running during service and inspection is only permitted outside the classified area.
- Never start a pump without the proper priming.
- Before you start working with 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.
- 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 have been provided by an authorized ITT representative.

### **Equipment for monitoring**

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

- Pressure gauges
- Flow meters
- Level indicators
- Motor load readings
- Temperature detectors
- Bearing monitors

- Leak detectors
- PumpSmart control system

## 1.4 Product warranty

### Coverage

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

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

### Limitations

The warranty does not cover faults caused by these situations:

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

ITT assumes no liability for these situations:

- Bodily injuries
- Material damages
- Economic losses

### Warranty claim

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

## 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.



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**WARNING:**

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

---



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**CAUTION:**

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

---

##### Precautions for lifting the pump



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**WARNING:**

- Dropping, rolling or tipping units, or applying other shock loads, can cause property damage and/or personal injury. Ensure that the unit is properly supported and secure during lifting and handling.
- Risk of serious personal injury or equipment damage. Proper lifting practices are critical to safe transport of heavy equipment. Ensure that practices used are in compliance with all applicable regulations and standards.

- Lifting and handling heavy equipment poses a crush hazard. Use caution during lifting and handling and wear appropriate Personal Protective Equipment (PPE, such as steel-toed shoes, gloves, etc.) at all times. Seek assistance if necessary.
  - Safe lifting points are specifically identified in this manual. It is critical to lift the equipment only at these points. Integral lifting eyes or eye bolts on pump and motor components are intended for use in lifting the individual components only.
- 

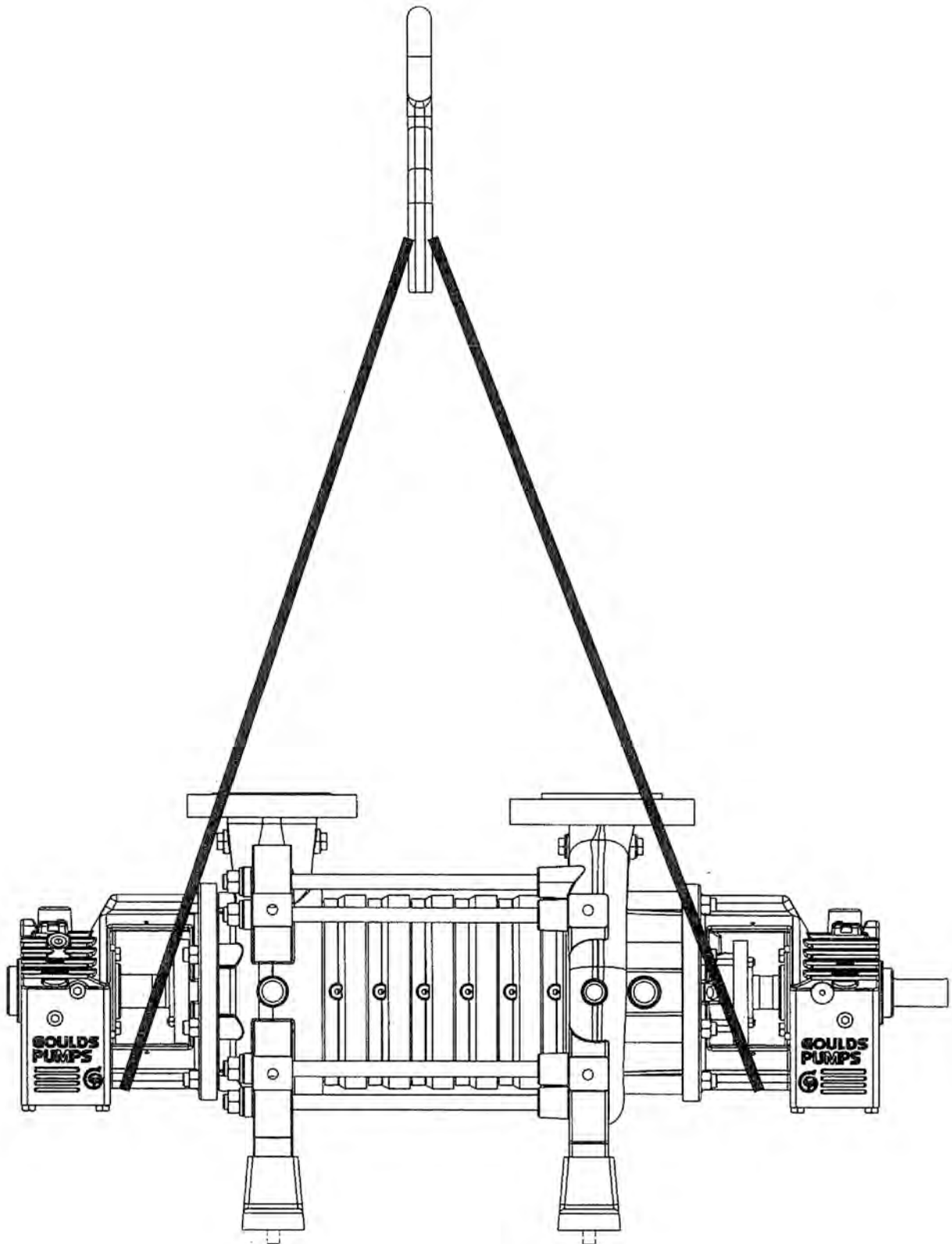
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### **NOTICE:**

- 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.
- 

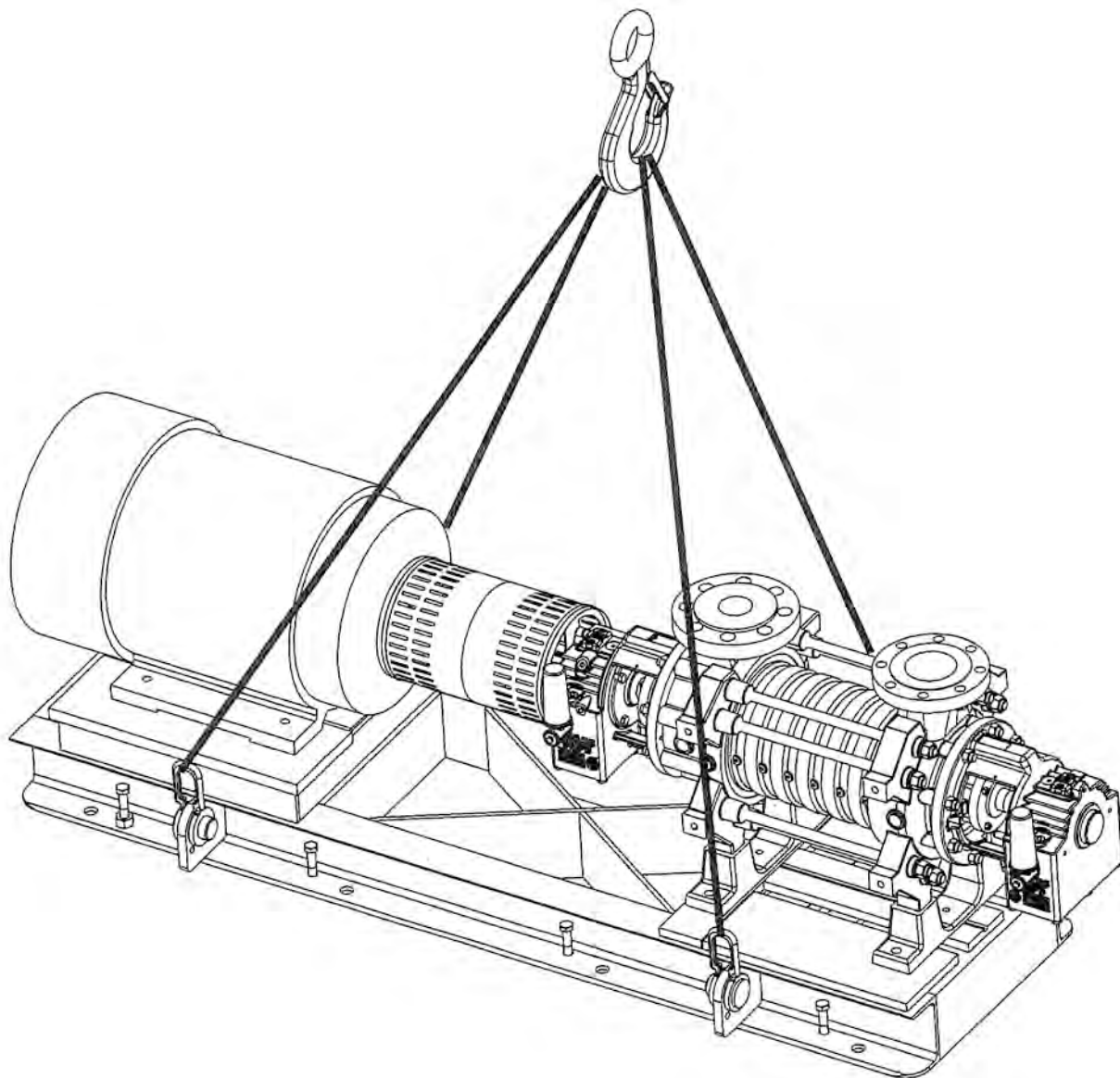
### **Lifting the pump**

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



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

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



**Figure 2: Example of the proper lifting method for baseplate-mounted units**

## 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.

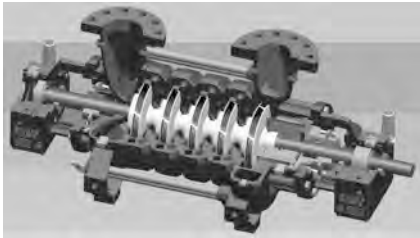
## 3 Product Description

### 3.1 General description

The Model 3393 is a radially split, segmented casing, multistage pump with these characteristics:

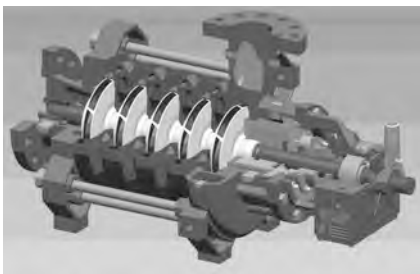
- Modular interstage components
- Varying numbers of stages, hydraulics, materials, and configurations
- Multiple suction nozzle and discharge nozzle orientations.
- Multiple hydraulics for each pump size

Radial suction configuration features radial suction and discharge nozzles. The suction and discharge nozzles can be positioned either vertical or horizontally at 90° to either side. This design consists of two robust, finned bearing housings with traditional anti-friction bearings and mechanical seals on each end of the pump.



**Figure 3: Radial suction design**

End suction configuration features an end suction nozzle in conjunction with a radial discharge nozzle. The suction end of the pump utilizes a product-lubricated bearing eliminating the need for a second bearing housing and mechanical seal. Because of the positioning of the sleeve bearing in the end suction casing, the suction flange size is one size larger than the size for the radial suction arrangement. The discharge nozzle can be positioned either vertically or horizontally at 90° to either side.



**Figure 4: End suction design**

#### Casing

The pressure boundary consists of three basic casings and a mechanical seal chamber.

- The suction casing is available in an end or radial suction arrangement and is rated to a lower pressure than the interstage or discharge casings.
- The interstage casings are combined with the diffuser into a single piece and are rated to the full discharge pressure.
- The discharge casing is of dual volute construction.

### Flange ratings

Flange Options
<b>Suction</b>
ANSI B16.5 150 lb RF / ISO 7005-1 PN 20
ANSI B16.5 300 lb RF / ISO 7005-1 PN 50
EN 1092-1 PN 40
<b>Discharge</b>
EN 1092-1 PN 63
ANSI B16.5 600 lb RF / ISO 7005-1 PN 110
EN 1092-1 PN 100
ANSI B16.5 900 lb RF / ISO 7005-1 PN 150 (12 Chrome casing only)

### Impeller

The impeller is a single suction, enclosed impeller. It is keyed to the shaft.

### Seal chamber

The seal chamber accepts single or double cartridge seals and various piping plans. It is dimensioned based on DIN 24960.

### Bearing frame and bearings

The bearing frame is cast iron, finned for additional cooling and oil lubricated. Bearings are as noted in the following table.

Pump Size	2.5x4-8	4x5-10	5x6-11	6x8-13
Bearing - driver end (thrust)	7408-B-MP-UA	7409-B-MP-UA	7311 BECBM	7214 BECBM
Bearing - outboard (ES) (radial)	SiC/SiC	SiC/SiC	SiC/SiC	SiC/SiC
Bearing - outboard (RS) (radial)	6408	6409	6311	6214

### Shaft

The shaft is of heavy-duty construction of 17-4 pH or super duplex depending on the casing material. It is designed for cartridge mechanical seals to limit shaft deflection to .002 in. (0.051 mm) at worst case condition.

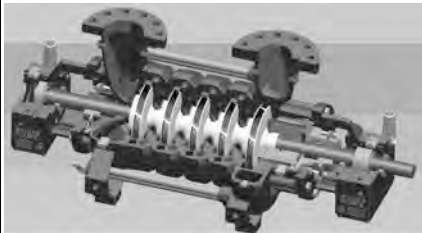
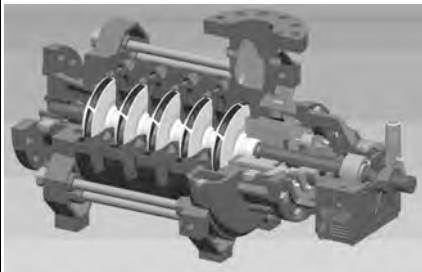
### Baseplate

The baseplate is of fabricated steel and supports the pump, driver, and any accessories.

## 3.2 Pump description

The **Goulds Model 3393** is a radially split, segmented casing, multistage pump designed with modular interstage components. These identical components can be assembled to produce pumps of varying numbers of stages, hydraulics, materials, and configurations to meet the customer's specific requirements. Its multiple suction nozzle and discharge nozzle orientations allow the 3393 to adapt to multiple piping installations and provide the piping designer with flexibility in plant layout. Multiple hydraulics for each pump size optimize efficiency across a vast range of applications. All intermediate stage components are identical which reduces spare parts inventory.

The 3393 is designed as a two-pole speed pump. There will be times when the pump will be operated at variable speed. The 3393 can be operated between 2700 and 3600 rpm without reference to the factory. At speeds above 3600 rpm and below 2700 rpm, a lateral critical speed analysis must be conducted by the factory. Contact your local representative for pricing. In all cases it is imperative that the pump be brought up to its minimum operating speed as quickly as possible. This ramp up time should not exceed 5 seconds.

<p><b>RS</b> - Radial Suction configuration features radial suction and discharge nozzles. The suction and discharge nozzles can be positioned either vertically or horizontally at 90° to either side. This design consists of two robust, finned bearing housings with traditional anti-friction bearings and mechanical seals on each end of the pump.</p>	
<p><b>ES</b> - End Suction configuration features an end suction nozzle in conjunction with a radial discharge nozzle. The suction end of the pump utilizes a product-lubricated bearing eliminating the need for a second bearing housing and mechanical seal. Because of the positioning of the sleeve bearing in the end suction casing, the suction flange size is one size larger than the size for the radial suction arrangement. The discharge nozzle can be positioned either vertically or horizontally at 90° to either side.</p>	

## 3.3 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/ 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 1: 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

## 3.4 Nameplate information

### Important information for ordering

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

When you order spare parts, identify this pump information:

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

Item numbers can be found in the spare parts list.

### 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)
Bearing frame	Provides information about the lubrication system used.
Ex	If applicable, your pump unit might have an Ex nameplate affixed to the pump, the baseplate, or the discharge head. The nameplate provides information about the Ex specifications of this pump.
IECEEx	If applicable, your pump unit might have the following IECEEx nameplate affixed to the pump and/or baseplate. The nameplate provides information about the IECEEx specifications of this pump.
Other	If applicable, additional information, warnings or cautions may be noted.

### Nameplate on the pump casing using English units

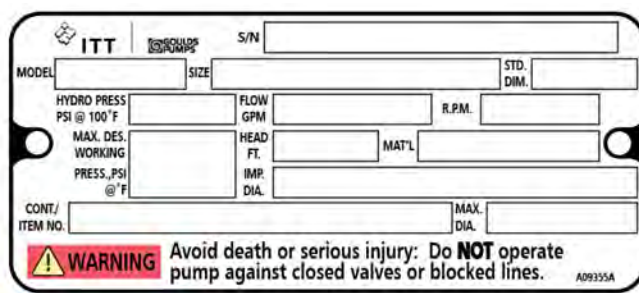


Figure 5: Nameplate on the pump casing using English units

### Nameplate on the bearing frame



**Figure 6: Nameplate on the bearing frame**

**Table 2: Explanation of the nameplate on the bearing frame**

Nameplate field	Explanation
Assembled in	Country in which final unit built
Year built	Year in which final unit built
S/N	Serial number
Bearing O.B.	Outboard bearing number/designation
Bearing I.B.	Inboard bearing number/designation
Lubrication	Type of lubrication of pump

### Ex nameplate



**Figure 7: Ex nameplate**

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

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.

### Warning nameplate



**Figure 8: Warning nameplate**

The nameplate shown is the standard warning and is applicable for most pumps. You must refer to the startup procedures in the IOM for any specific instructions that may be different. The instructions in the IOM will take precedence.

# 4 Installation

## 4.1 Pre-installation


**WARNING:**

Equipment that will operate in a potentially explosive environment must be installed in accordance with the following instructions.

**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
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.

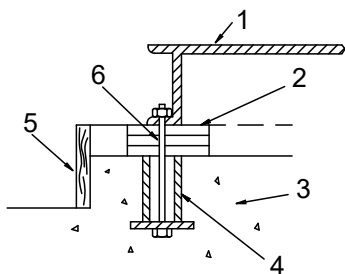


## 4.1.2 Foundation requirements

### Requirements

- Provide a flat, substantial concrete foundation in order to prevent strain and distortion when you tighten the foundation bolts.

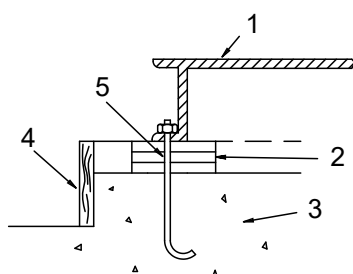
### Sleeve-type bolts



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

**Figure 9: Sleeve type bolts**

### J-type bolts



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

**Figure 10: J-type bolts**

## 4.2 Baseplate-mounting procedures

### 4.2.1 Prepare the baseplate for mounting

1. Remove all the attached equipment from the baseplate.
2. Clean the underside of the baseplate completely.
3. If applicable, coat the underside of the baseplate with an epoxy primer.  
Use an epoxy primer only if using an epoxy-based grout.
4. Remove the rust-proofing coat from the machined mounting pads using an appropriate solvent.
5. Remove water and debris from the foundation-bolt holes.

### 4.2.2 Install the baseplate using shims or wedges

Required tools:

- Two sets of shims or wedges for each foundation bolt
  - Two machinist's levels
  - Baseplate-leveling worksheet
1. If you use sleeve-type bolts, fill the bolt sleeves with packing material or rags to prevent grout from entering the bolt holes.
  2. Put the sets of wedges or shims on each side of each foundation bolt.
  3. Lower the baseplate carefully onto the foundation bolts.
  4. Put the machinist's levels across the mounting pads of the driver and the mounting pads of the pump.

---

#### **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.

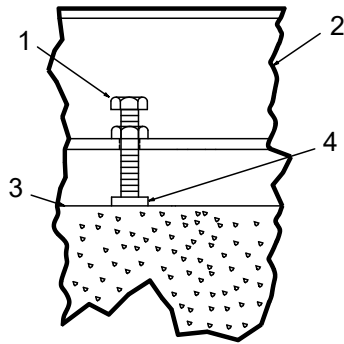
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5. Level the baseplate both lengthwise and across by adding or removing shims or moving the wedges.  
You can use the baseplate-leveling worksheet when you take the readings.
6. Hand-tighten the nuts for the foundation.

### 4.2.3 Install the baseplate using jackscrews

Tools required:

- Anti-seize compound
  - Jackscrews
  - Bar stock
  - Two machinist's levels
1. Apply an anti-seize compound on the jackscrews.  
The compound makes it easier to remove the screws after you grout.
  2. Lower the baseplate carefully onto the foundation bolts and perform these steps:
    - a) Cut the plates from the bar stock and chamfer the edges of the plates in order to reduce stress concentrations.
    - b) Put the plates between the jackscrews and the foundation surface.
    - c) Use the four jackscrews in the corners in order to raise the baseplate above the foundation.
    - d) Make sure that the center jackscrews do not touch the foundation surface yet.



Item	Description
1.	Jackscrew
2.	Baseplate
3.	Foundation
4.	Plate

**Figure 11: Jackscrews**

3. Level the driver mounting pads:

---

**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.

---

- a) Put one machinist's level lengthwise on one of the two pads.
- b) Put the other machinist's level across the ends of the two pads.
- c) Level the pads by adjusting the four jackscrews in the corners. Make sure that the machinist's level readings are as close to zero as possible, both lengthwise and across.
4. Turn the center jackscrews down so that they rest on their plates on the foundation surface.
5. Level the pump mounting pads:

---

**NOTICE:**

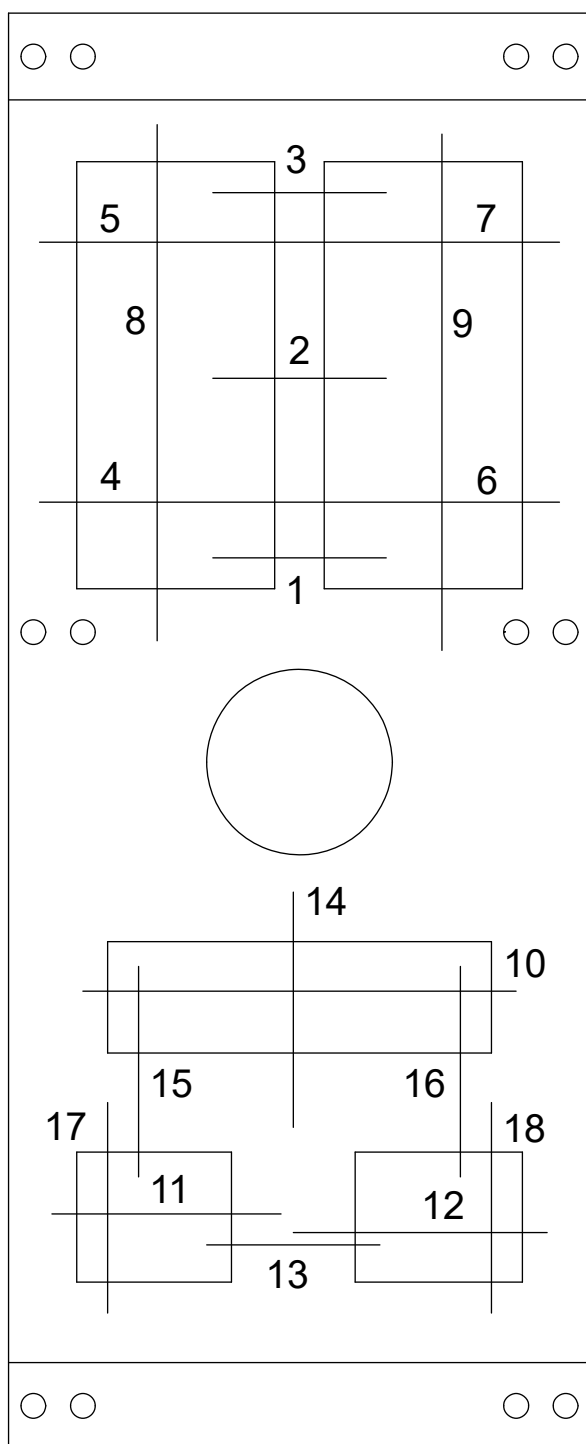
Remove all dirt from the mounting pads in order to ensure that the correct leveling is achieved. Failure to do so can result in equipment damage or decreased performance.

---

- a) Put one machinist's level lengthwise on one of the two pads.
- b) Put the other level across the center of the two pads.
- c) Level the pads by adjusting the four jackscrews in the corners. Make sure that the machinist's level readings are as close to zero as possible, both lengthwise and across.
6. Hand-tighten the nuts for the foundation bolts.
7. Check that the driver's mounting pads are level and adjust the jackscrews and the foundation bolts if necessary.

## 4.2.4 Baseplate-leveling worksheet

### Level measurements



- 1) \_\_\_\_\_
- 2) \_\_\_\_\_
- 3) \_\_\_\_\_
- 4) \_\_\_\_\_
- 5) \_\_\_\_\_
- 6) \_\_\_\_\_
- 7) \_\_\_\_\_
- 8) \_\_\_\_\_
- 9) \_\_\_\_\_
- 10) \_\_\_\_\_
- 11) \_\_\_\_\_
- 12) \_\_\_\_\_
- 13) \_\_\_\_\_
- 14) \_\_\_\_\_
- 15) \_\_\_\_\_
- 16) \_\_\_\_\_
- 17) \_\_\_\_\_
- 18) \_\_\_\_\_

## 4.3 Install the pump, driver and coupling

1. Mount and fasten the pump on the baseplate. Use applicable bolts.

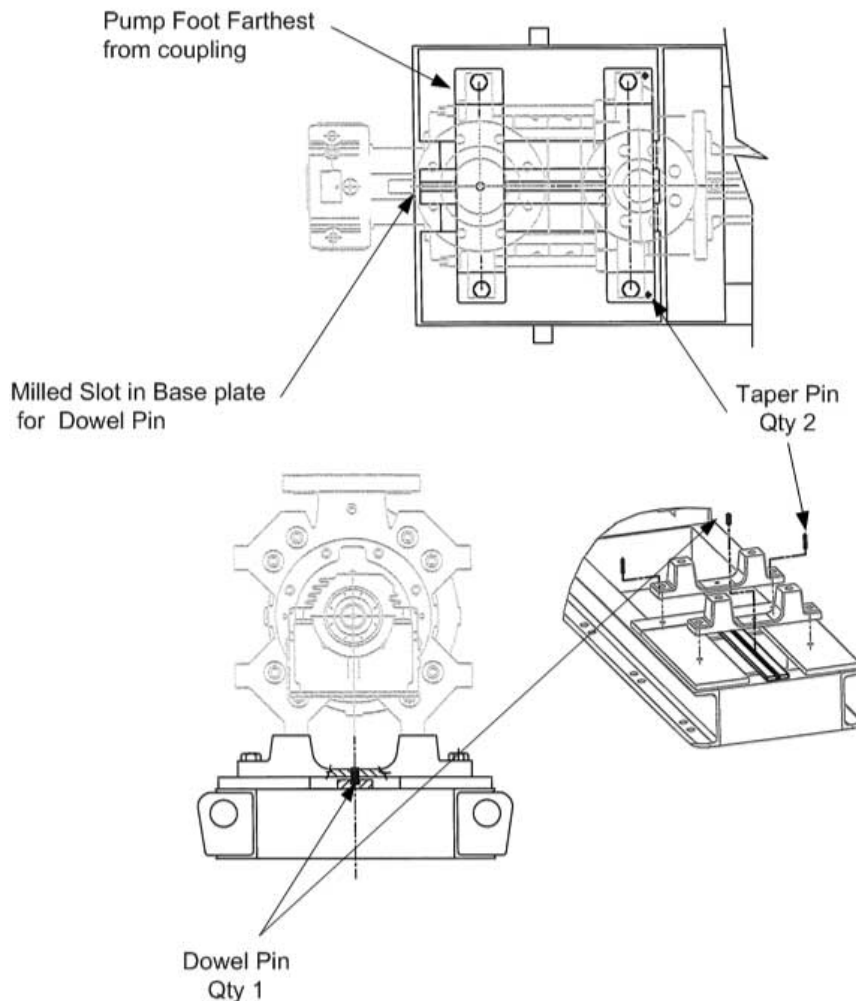
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**NOTICE:**

Two tapered dowel pins are provided in case there is a need to provide repeatable location between the pump and base plate. Installation of the dowel pins is not mandatory.

---

2. Mount the driver on the baseplate.
3. Install the coupling. See the installation instructions from the coupling manufacturer.
4. If the pump baseplate has a slot for high temperature dowelling the following must be performed after final alignment.
  - a) Verify that the parallel dowel has been installed in the center of the pump foot furthest from the drive end. It should locate fully in a slot parallel to the shaft that has been machined in the base plate.
  - b) Torque the bolts closest to the driver to the standard values.
  - c) Torque the bolts on the outboard end to 15% of the standard value. This will allow the pump to expand axially with increasing temperature while maintaining pump to driver alignment.
5. If repeatable location of the pump to base plate is desired perform either 5.a. or 5.b.
  - a) For pumps without high temperature doweling, drill through each pump foot (drive end and non drive end), into the base plate then taper ream to suit the supplied taper dowel pins.
  - b) For pumps fitted with high temperature doweling, drill through the drive end pump foot into the base plate then taper ream to suit the supplied taper dowel pin. Discard the unused taper dowel pin.



## 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 shown in the tables are valid only for motors with the temperature rise noted. For other drivers such as steam turbines, engines or motors with a different temperature rise, the correct settings must be recalculated. If the pump is driven through a speed reduction or speed increasing gear, contact the factory. You must use the correct tolerances. Failure to do so can result in misalignment and reduced pump reliability.

#### Alignment Criteria: Cold parallel vertical alignment setting

#### NOTICE:

A positive value indicates that the pump shaft should be set higher than the motor shaft; a negative value indicates that the pump shaft should be set lower than the motor shaft.

**Table 3: Pump operating temperature for 2.5x4-8 and 2.5x5-8**

Motor Temperature Rise	Metric units (mm)				English units (inches)			
	<38°C	38-93°C	94-149°C	150-204°C	<100°F	100-200°F	201-300°F	301-400°F
40°C   104°F	0.11	0.00	-0.23	-0.46	0.004	0.000	-0.009	-0.018
50°C   122°F	0.15	0.04	-0.19	-0.42	0.006	0.001	-0.007	-0.017

**Table 4: Pump operating temperature for 4x5-10 and 4x6-10**

Motor Temperature Rise	Metric units (mm)				English units (inches)			
	<38°C	38-93°C	94-149°C	150-204°C	<100°F	100-200°F	201-300°F	301-400°F
40°C   104°F	0.13	0.00	-0.26	-0.53	0.005	0.000	-0.010	-0.021
50°C   122°F	0.17	0.04	-0.22	-0.48	0.007	0.002	-0.009	-0.019

**Table 5: Pump operating temperature for 5x6-11 and 5x8-11**

Motor Temperature Rise	Metric units (mm)				English units (inches)			
	<38°C	38-93°C	94-149°C	150-204°C	<100°F	100-200°F	201-300°F	301-400°F
40°C   104°F	0.14	-0.01	-0.30	-0.59	0.006	0.000	-0.012	-0.023
50°C   122°F	0.20	0.05	-0.24	-0.54	0.008	0.002	-0.010	-0.021

**Table 6: Pump operating temperature for 6x8-13 and 6x10-13**

Motor Temperature Rise	Metric units (mm)				English units (inches)			
	<38°C	38-93°C	94-149°C	150-204°C	<100°F	100-200°F	201-300°F	301-400°F
104°F (40°C)	0.16	-0.01	-0.34	-0.68	0.006	0.000	-0.013	-0.027
122°F (50°C)	0.22	0.05	-0.28	-0.62	0.009	0.002	-0.011	-0.024

### 4.4.3 Alignment measurement guidelines

Guideline	Explanation
Rotate the pump coupling half and the driver coupling half together so that the indicator rods have contact with the same points on the driver coupling half.	This prevents incorrect measurement.
Move or shim only the driver in order to make adjustments.	This prevents strain on the piping installations.
Make sure that the hold-down bolts for the driver are tight when you take indicator measurements.	This keeps the driver stationary since movement causes incorrect measurement.
Make sure that the hold-down bolts for the driver are loose before you make alignment corrections.	This makes it possible to move the driver when you make alignment corrections.
Check the alignment again after any mechanical adjustments.	This corrects any misalignments that an adjustment may have caused.

### 4.4.4 Attach the dial indicators for alignment

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

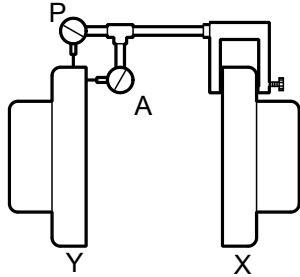
1. Attach two dial indicators on the pump coupling half (X):
  - a) Attach one indicator (P) so that the indicator rod comes into contact with the perimeter of the driver coupling half (Y).



This indicator is used to measure parallel misalignment.

- b) Attach the other indicator (A) so that the indicator rod comes into contact with the inner end of the driver coupling half.

This indicator is used to measure angular misalignment.



**Figure 12: Dial indicator attachment**

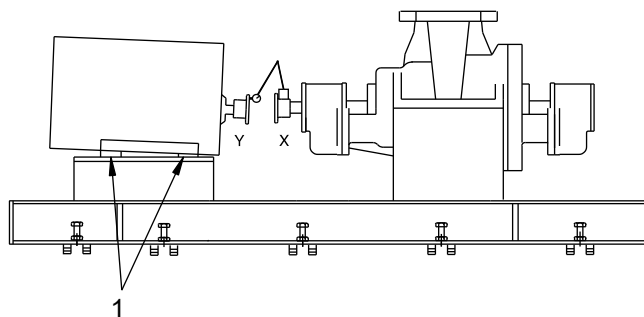
2. Rotate the pump coupling half (X) in order to check that the indicators are in contact with the driver coupling half (Y) but do not bottom out.
3. Adjust the indicators if necessary.

#### 4.4.5 Perform angular alignment for a vertical correction

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

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	<p>The coupling halves are farther apart at the bottom than at the top. Perform one of these steps:</p> <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	<p>The coupling halves are closer at the bottom than at the top. Perform one of these steps:</p> <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

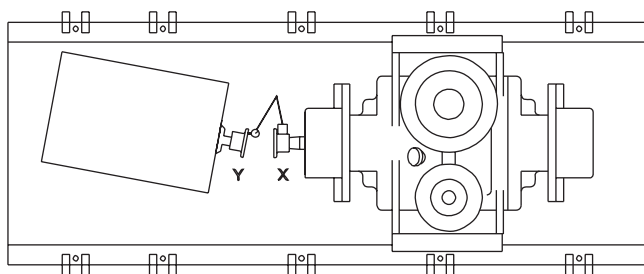
**Figure 13: Example of incorrect vertical alignment (side view)**

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 14: 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

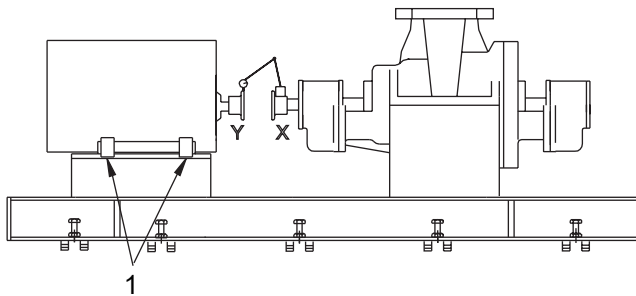
Refer to the alignment table in "Permitted indicator values for alignment checks" (see Table of Contents for location of table) for the proper cold alignment value based on the motor temperature rise and the pump operating temperature.

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

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

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

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



Item	Description
1.	Shims

**Figure 15: Example of incorrect vertical alignment (side view)**

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

#### NOTICE:

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

### 4.4.8 Perform parallel alignment for a horizontal correction

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

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

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

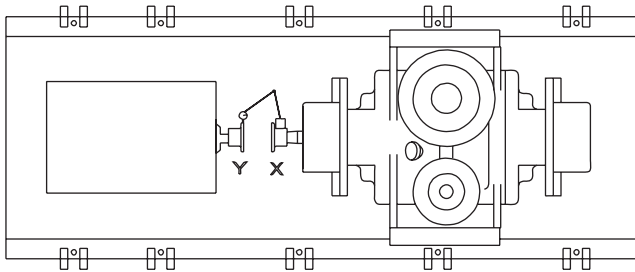
When the reading value is...	Then...
Negative	The driver coupling half (Y) is to the left of the pump coupling half (X).

When the reading value is...	Then...
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 16: Example of incorrect horizontal alignment (top view)**

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

## 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.

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

- 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).
- Rotate the indicators through the top-center position to the right side, 180° from the start position (3 o'clock).
- Record the indicator readings.
- Make corrections according to the separate instructions for angular and parallel alignment until you obtain the permitted reading values.

## 4.5 Grout the baseplate

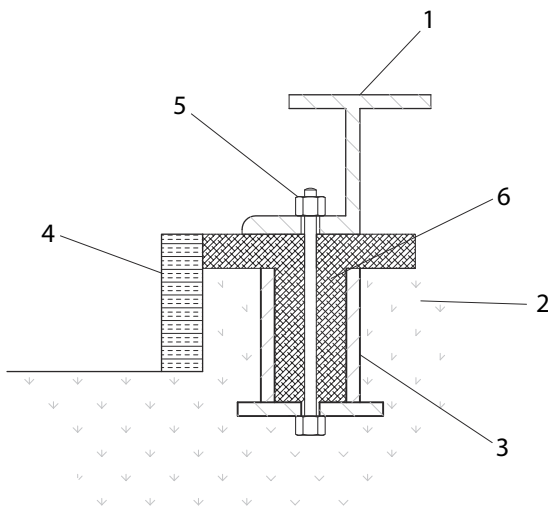
Required equipment:

- 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.

**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.

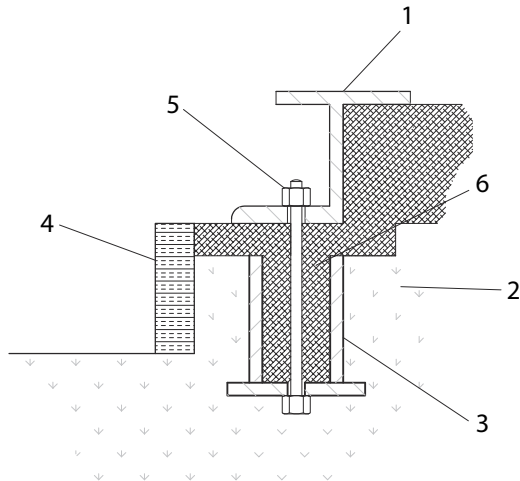
1. Clean all the areas of the baseplate that will come into contact with the grout.
2. Build a dam around the foundation.
3. Thoroughly wet the foundation that will come into contact with the grout.
4. Pour grout through the grout hole into the baseplate up to the level of the dam.  
When you pour the 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 17: 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 18: 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



#### **WARNING:**

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

**CAUTION:**

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

**CAUTION:**

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



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

**NOTICE:**

- The pump must be protected from debris and weld slag that may accumulate in the piping during construction. A start up strainer of 80 mesh should be installed upstream of the pump suction and the system should be flushed for a minimum of 24 hours to be sure the piping is clear of foreign material. It is important that the pressure differential across the strainer be monitored and not exceed 0.34 bar | 5 psi. When system flushing is complete the start up strainer can be removed.
- The pump must be protected from debris that may accumulate in the piping over time. Install a strainer / filter of 40 - 60 mesh upstream of the pump suction. It is important that the pressure differential across the strainer / filter be monitored and not exceed 0.34 bar | 5 psi.

**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	This helps to minimize friction losses.	

Check	Explanation/comment	Checked
45° or long radius 90° fittings where necessary.		
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 grout for the pit cover 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.		
If the pump handles corrosive fluids, make sure that the piping allows you to flush out the liquid before you remove the pump.	The 3393 interstage casings cannot be completely drained. Use caution in disassembly.	
	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	Flange face separation should be the gasket thickness $\pm 1.5$ mm   0.06 in.
Parallel	For flanges with an outside diameter 250 mm   10 in. or less align the flanges to be parallel within 0.25 mm   0.010 in.  Larger flanges should be parallel to 0.001 mm/mm   0.001 in./in. up to a maximum allowable misalignment of 0.75 mm   0.030 in.
Concentric	You can easily install the flange bolts by hand.



## 4.6.2 Suction-piping checklist

### Performance curve reference



#### CAUTION:

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.

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.

#### NOTICE:

For optimum life a suction strainer must be permanently installed in the suction piping to prevent debris from entering the pump and causing it to seize. See below.

### Suction-piping checks

Check	Explanation/comment	Checked
Check that piping is free of dirt and foreign objects.	Dirt or debris can damage the pump on startup.	
Check that the distance between the inlet flange of the pump and the closest elbow is at least two 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.	This minimizes the risk of cavitation in the suction inlet of the pump due to turbulence. —	
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>	—	
Suggested suction strainers are used. Check that they are at least three times the area of the suction piping. Monitor the pressure drop across the suction strainer. An increased pressure drop across the strainer of 34.5 kPa   5 psi indicates that the strainer should be removed and cleaned. After a period of time (24 hours minimum) system flushing should be complete and the suction strainer can be removed.	Suction strainers help to prevent debris from entering the pump.  The strainer should be no coarser than 40 mesh – 60 mesh or higher is preferred. Strainers must have a minimum free open area of 300% of nominal pipe diameter. Velocities should be limited to 6-7 ft/s to keep the pressure drop across the strainer to a minimum.  The pressure drop across the strainer should be monitored and the strainer cleaned if the pressure drop exceeds 0.34 bar   5 psi or NPSHR is not adequate.  Liquids with specific gravity less than 0.60 a pressure drop across the suction strainer may be due to ice buildup. Ice buildup can cause turbulence, low pressure areas and pumpage vaporization.	

Check	Explanation/comment	Checked
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.	—	
	—	
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 Auxiliary-piping checklist

#### Precautions

##### 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 mechanical seal flush or other special features supplied with the pump. Consult the pump data sheet for specific auxiliary piping recommendations.

#### Warm Up Piping

If temperatures of the pumped fluid will exceed 93°C | 200°F, then warm up the pump prior to operation. Circulate a small amount of fluid through the pump until the average casing temperature is within 17°C | 30°F of the fluid temperature. The average casing temperature is the average of the temperatures measured at the top and bottom of the casing. Accomplish this by flowing fluid from the pump discharge drain to the pump suction nozzle. No other method is acceptable. Additionally, the pump casing temperature differential between the top of any stage casing and the bottom of the same stage casing must be less than 17°C | 30°F. Failure to observe this can result in casing distortion due to uneven thermal expansion, which, in turn, may result in rotor seizure on startup.

The warm up flow shall be as follows:

- 2.5x4-8 and 2.5x5-8: 0.2 m3/hr | 1 gpm
- 4x5-10 and 4x6-10: 0.3 m3/hr | 1.3 gpm
- 5x6-11 and 5x8-11: 0.8 m3/hr | 3.5 gpm

- 6x8-13 and 6x10-13: 1.6 m<sup>3</sup>/hr | 7 gpm

Make sure that the temperature change during warm up does not exceed 5°C | 9°F per minute.

#### Checklist

Check	Explanation/comment	Checked
Check that cooling flows and pressures are in accordance with heat exchanger manufacturer recommendations.	—	
Check that the cooling water pressure does not exceed 7.0 kg/cm <sup>2</sup>   100 psig .	—	

#### 4.6.5 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


 When installing in a potentially explosive environment, ensure that the motor is properly certified.



### 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.



-  When installing in a potentially explosive environment, make sure that the motor is properly certified and that all equipment is installed in accordance with instructions for that environment.
- Do not operate the pump dry.
- Do not operate the pump below the hydraulic or thermal minimum rated flows or with the suction or discharge valves closed. These conditions can create an explosive hazard due to vaporization of pumped fluid and can quickly lead to pump failure and physical injury.
- 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.
- Avoid death or serious injury. Leaking fluid can cause fire and/or burns. Speed of pump must reach 2700 rpm within 5 seconds or an increase in vibration and rotor deflection and decrease in rotor stability leading to mechanical seal and/or shaft failure and/or pump seizure can occur.



### 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.



- Service temperature in an Ex classified environment is limited to the area classification specified on the Ex tag to the pump.
  - Risk of seizure, breach of containment, or explosion. Ensure balance line is installed and piped back to either the pump suction or suction vessel. This prevents rapid vaporization of the pumped fluid.
- 

### Precautions



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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.

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#### **NOTICE:**

- Verify the driver settings before you start any pump. Refer to the applicable drive equipment IOMs and operating procedures.
  - Make sure that the temperature change does not exceed 5°C | 9°F per minute.
  - The maximum allowable temperature change for an abnormal transient event such as thermal shock is 103°C | 185°F.
- 

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#### **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 within 5 seconds.
  - If temperatures of the pumped fluid will exceed 93°C | 200°F, then warm up the pump prior to operation. Refer to Warm Up Piping in the Auxiliary-piping checklist.
- 

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.

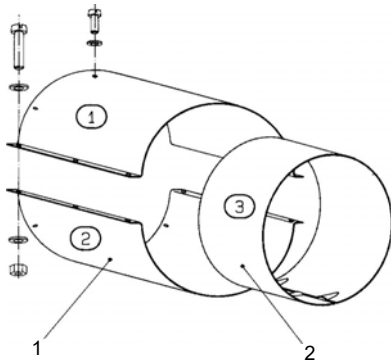
### Variable Speed Operation

If the 3393 is to be run with a variable speed drive, please confirm that the application has been approved by the factory. Variable speed operation is limited to 2700 to 3600 rpm unless a lateral critical speed analysis has been conducted by the factory and the speed range has been approved for operation. In all cases it is imperative that the pump be brought up to its minimum operating speed as quickly as possible. This ramp up time should not exceed 5 seconds.

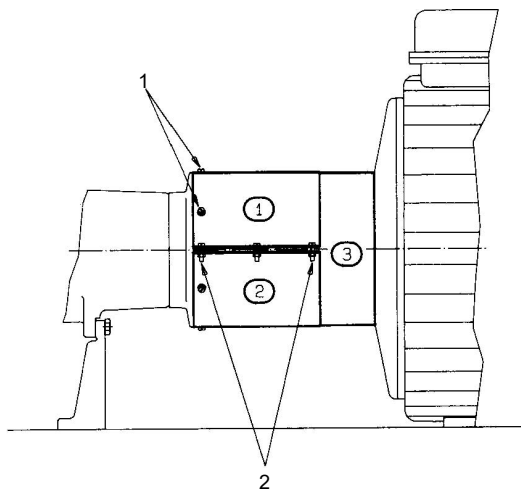
## 5.2 Remove the coupling guard

1. Identify the parts of the coupling guard.

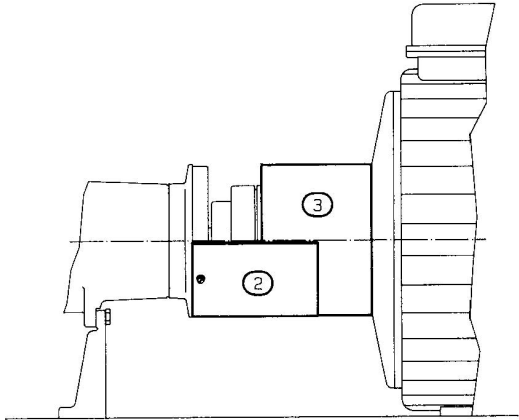
**IMPORTANT:** For pumps with CE conformance, the coupling guard fasteners have devices that keep them from completely detaching from the guard or the pump. Do not remove these devices or separate the fasteners from the guard or the pump.



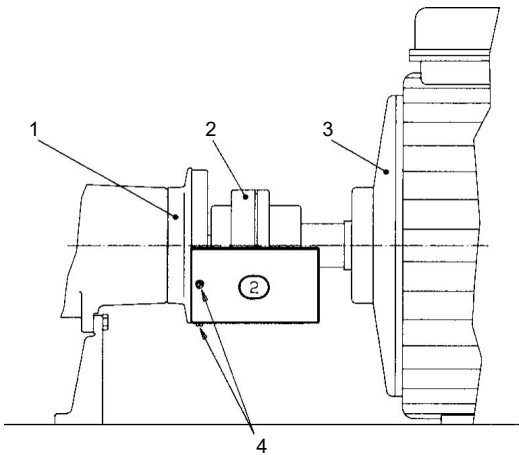
1. Coupling guard – two equal halves (parts 1 and 2)
  2. Adjusting piece (part 3)
2. Remove the screws (2) that attach the two halves (parts 1 and 2) of the coupling guard.



3. Remove the screws (1) that attach the top half (part 1) of the coupling guard to the bearing cover.
4. Remove the top half (part 1) of the coupling guard.
5. Remove the adjusting piece (part 3).



6. Remove the screws (4) that attach the bottom half (part 2) of the coupling guard to the bearing cover (1).



- 1. Bearing cover
- 2. Coupling
- 3. Motor
- 4. Screws

7. Remove the bottom half (part 2) of the coupling guard.

## 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

 When installing in a potentially explosive environment, ensure that the motor is properly certified.



### 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.
- The coupling used in an ATEX or Ex-classified environment must be properly certified and must be constructed from a non-sparking material.

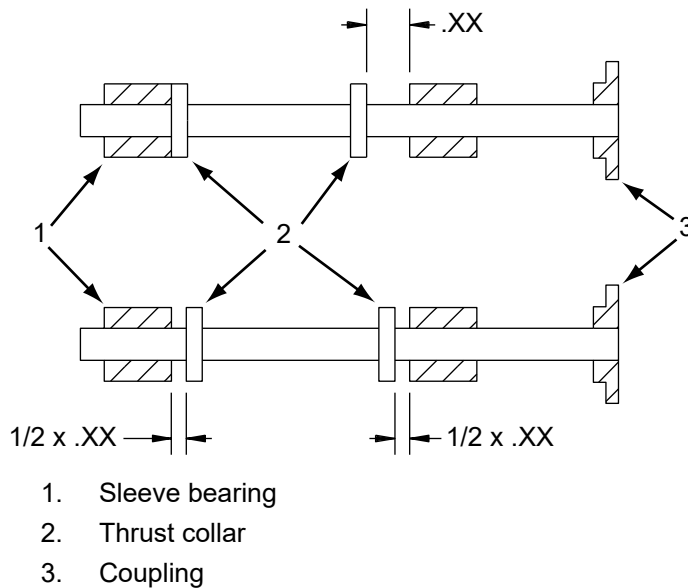
1. Check the gap between the coupling hubs against the dimensions shown on the general arrangement drawing or as stamped on the coupling hub. For any necessary adjustment, move the driver not the pump.

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 19: 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

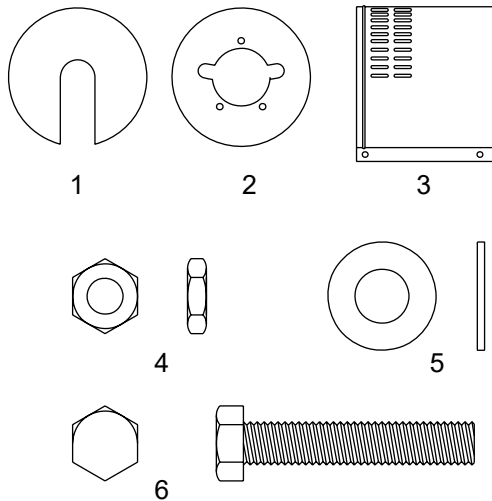


#### **WARNING:**

- 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.

#### Required parts

These parts are required:



Item	Description	Item	Description
1.	End plate, drive end	4	3/8-16 nut, 3 required
2.	End plate, pump end	5	3/8 in. washer
3.	Guard half, 2 required	6	3/8-16 x 2 in. hex head bolt, 3 required

Figure 20: Required parts

### 5.4.1.1 Install the coupling guard



#### 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.



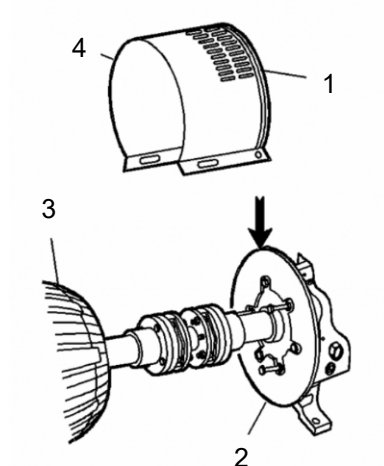
#### WARNING:

The coupling guard used in an Ex classified environment must be properly certified and constructed from a spark resistant material.

#### Required parts:

- De-energize the motor, place the motor in a locked-out position, and place a caution tag at the starter that indicates the disconnect.
- Put the pump-side end plate in place.  
If the pump-side end plate is already in place, make any necessary coupling adjustments and then proceed to the next step.
- Put the pump-half of the coupling guard in place:
  - Slightly spread the bottom apart.

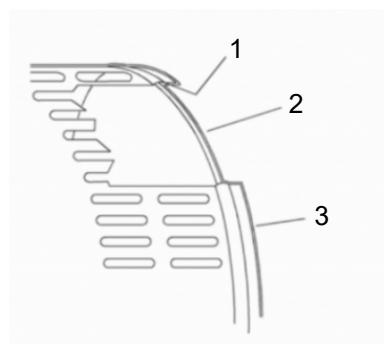
- b) Place the coupling guard half over the pump-side end plate.



Item	Description
1.	Annular groove
2.	Pump-side end plate
3.	Driver
4.	Pump half of the coupling guard

**Figure 21: Guard half installation**

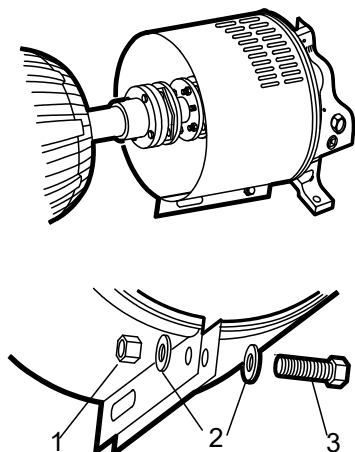
The annular groove in the coupling guard half must fit around the end plate.



Item	Description
1.	Annular groove
2.	End plate (pump end)
2.	Guard half

**Figure 22: Annular groove in coupling guard**

4. Use a bolt, a nut, and two washers to secure the coupling guard half to the end plate. Tighten securely.



Item	Description
1.	Nut
2.	Washer
3.	Bolt

**Figure 23: Secure coupling guard half to end plate**

5. Put the driver half of the coupling guard in place:
  - a) Slightly spread the bottom apart.
  - b) Place the driver half of the coupling guard over the pump half of the coupling guard. The annular groove in the coupling guard half must face the motor.
6. Place the driver-side end plate over the motor shaft.
7. Place the driver-side end plate in the annular groove of the driver-half of the coupling guard.
8. Use a bolt, a nut, and two washers to secure the coupling guard half to the end plate. Hand-tighten only.  
The hole is located on the driver-side of the coupling guard half.
9. Slide the driver-half of the coupling guard towards the motor so that the coupling guard completely covers the shafts and coupling.
10. Use a nut, a bolt, and two washers to secure the coupling guard halves together.
11. Tighten all nuts 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.

### Flood oil lubrication

Flood oil-lubricated bearings are standard. Bearing housings are supplied with constant-level oilers and sight glasses. If the oiler can be accessed easily from either side of the bearing frame, the recommendation is to install it on the side of the bearing frame that the rotation of the shaft would push the oil toward. That is if, when facing the shaft, the rotation is clockwise the oiler would be on the left and when counter clockwise the oiler would be on the right. However, the oiler can be installed on either side of the bearing housing so it should be put where it is most easily accessible.

## 5.5.1 Oil volumes

## 5.5.2 Lubricating oil requirements

Use a high quality turbine oil with rust and oxidation inhibitors.

See Lubricating Oil Requirements in "Maintenance of Bearings" for common names of some acceptable lubricating oils.

3393 Ball Bearings				
Pump size	2.5x4-8	4x5-10	5x6-11	6x8-13
	2.5x5-8	4x6-10	5x8-11	6x10-13
Initial Fill per Bearing Housing - Oil (US pt, l)	3.4 / 1.6	3.4 / 1.6	5.3 / 2.5	5.3 / 2.5
Bearing - Driver End	7408-B-MP-UA	7409-B-MP-UA	7311 BECBM	7214 BECBM
Bearing - Outboard (ES) *1	SiC/SiC	SiC/SiC	SiC/SiC	SiC/SiC
Bearing - Outboard (RS)	6408	6409	6311	6214
Maximum permissible surface temperature measured at the 12 o'clock (top of bearing housing) position. (°F, °C)	180 / 82	180 / 82	180 / 82	180 / 82

\*1 Product lubricated bearing

## 5.5.3 Lubricate the bearings with oil

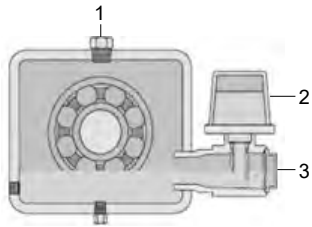
Flood oil-lubricated pumps are supplied with an oiler that maintains a constant oil level in the bearing housing.

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

**NOTICE:**

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

2. Check that the oil level is correct. The correct oil level is centered in the bullseye sight glass, when the pump is not in operation. During operation, bullseye sight gives a false oil level reading.



1. Plug
2. Reservoir
3. Main body

### 5.5.4 Purge Oil Mist

The 3393 can be modified for purge oil mist lubrication. Consult a factory representative for details.

### 5.5.5 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 ATEX or Ex-classified environment must be properly certified. Prior to startup, make sure that all areas that could leak pumped fluid to the work environment are closed.

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**NOTICE:**

- Follow seal manufacturer's guidelines for proper seal installation procedures.
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### 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.

## 5.7 Connection of sealing liquid for mechanical seals

⚠ The mechanical seal must have an appropriate seal flush system. Failure to do so will result in excess heat generation and seal failure.

**Seal lubrication is required**

Mechanical seals must have an appropriate seal flush system to avoid excessive heat generation and premature seal failure.

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

**Seal flushing methods**

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

Method	Description
Product flush	Run the piping so that the pump pushes the pumped fluid from the casing and injects it into the seal gland. If necessary, an external heat exchanger cools the pumped fluid before it enters the seal gland.
External flush	Run the piping so that the pump injects a clean, cool, compatible liquid directly into the seal gland. The pressure of the flushing liquid must be 0.35 to 1.01 kg/cm <sup>2</sup>   5 to 15 psi greater than the seal chamber pressure. The injection rate must be 2 to 8 lpm   0.5 to 2 gpm.
Other	You can use other methods that employ multiple gland or seal chamber connections. Refer to the mechanical seal reference drawing and piping diagrams.

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

---

**NOTICE:**

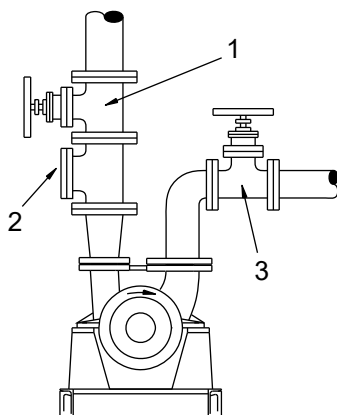
If temperatures of the pumped fluid will exceed 200°F (93°C), then warm up the pump prior to operation. Refer to Warm Up Piping in the Auxiliary-piping checklist.

---

⚠ Pumps that are not self-priming must be fully primed at all times during operation.

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 24: 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.
- On frame mounted units, ensure that the oil level is correct prior to starting pump. Close coupled pumps do not have oil lubricated bearings.

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.  
If the pump is to be run with a variable speed device, it should be brought up to 2700 rpm within 5 seconds. If a lateral critical speed analysis has been done, it must be brought up to the minimum allowable operating speed within 5 seconds.
  3. Slowly open the discharge valve until the pump reaches the desired flow.
  4. Immediately check the pressure gauge to ensure that the pump quickly reaches the correct discharge pressure.
  5. If the pump fails to reach the correct pressure, perform these steps:
    - a) Stop the driver.
    - b) Prime the pump again.
    - c) Restart the driver.

6. Monitor the pump while it is operating:
  - a) Check the pump for bearing temperature, excessive vibration, and noise.
  - b) If the pump exceeds normal levels, then shut down the pump immediately and correct the problem.
7. Repeat steps 5 and 6 until the pump runs properly.

## 5.10 i-ALERT® Equipment Health Monitor

---



### **WARNING:**

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

---

For all information refer to the i-ALERT® Equipment Health Monitor Installation, Operation and Maintenance manual. <https://www.i-alert.com/support/>

## 5.11 Pump operation precautions

### General considerations



### **WARNING:**

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

### **NOTICE:**

- Vary the capacity with the regulating valve in the discharge line. Never throttle the flow from the suction side. This action can result in decreased performance, unexpected heat generation, and equipment damage.
- Risk of equipment damage from unexpected heat generation. Do not overload the driver. Ensure that the pump operating conditions are suitable for the driver. The driver can overload in these circumstances:
  - The specific gravity or viscosity of the fluid is greater than expected
  - The pumped fluid exceeds the rated flow rate.
- Make sure the oil level has remained steady by checking the oiler.
- Check the bearing temperatures using a pyrometer or other temperature-measuring device. Monitor the bearing temperature frequently during initial operation in order to determine if a bearing problem exists, as well as to establish normal bearing operating temperature.
- For pumps with auxiliary piping, make sure that proper flows have been established and that the equipment is operating properly.
- Establish baseline vibration readings in order to determine normal running conditions. If the unit is running roughly, then consult the factory.

- Monitor all gauges to ensure that the pump is running at or near rating and that the suction screen (when used) is not clogged.
- 

#### Operation at reduced capacity

---



##### **WARNING:**

- Risk of breach of containment and equipment damage. Excessive vibration levels can cause damage to bearings, stuffing box, seal chamber, and/or mechanical seal. Observe pump for vibration levels, bearing temperature, and excessive noise. If normal levels are exceeded, shut down and resolve.
  - Risk of explosion and serious physical injury. Do not operate pump with blocked system piping or with suction or discharge valves closed. This can result in rapid heating and vaporization of pumpage.
  - Risk of equipment damage and serious physical injury. Heat build-up can cause rotating parts to score or seize. Observe pump for excessive heat build-up. If normal levels are exceeded, shut down and resolve.
- 

##### **NOTICE:**

Cavitation can cause damage to the internal surfaces of the pump. Ensure net positive suction head available (NPSH<sub>A</sub>) always exceeds NPSH required (NPSH<sub>3</sub>) as shown on the published performance curve of the pump.

---

#### Operation under freezing conditions

---

##### **NOTICE:**

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

---

## 5.12 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.
  3. Bring the pump to a complete stop within 5 seconds.
- 

## 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 25: 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

⚠ Alignment procedures must be followed to prevent unintended contact of rotating parts. Follow coupling manufacturer's installation and operation procedures.



### **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. Lock out power to the driver.

4. Remove the coupling guard.  
See Remove the coupling guard in the Maintenance chapter.
5. Check the alignment while the unit is still hot.  
Refer to [4.4 Pump-to-driver alignment on page 28](#) in the Installation chapter.
6. Reinstall the coupling guard .
7. Restart the pump and driver.

# 6 Maintenance

## 6.1 Maintenance precautions

---

**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.
  - 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.
  - 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.
  - 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.
- 

## 6.2 Maintenance schedule

---

**NOTICE:**

The preventive maintenance section must be adhered to in order to keep the applicable Ex classification of the equipment. Failure to follow these procedures will void the Ex classification for the equipment.

---

**Maintenance inspections**

A maintenance schedule includes these types of inspections:

- 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 inspections**

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

- Check for unusual noise vibration, and bearing temperatures.

- Check the pump and piping for leaks.
- Analyze the vibration.\*
- Check the seal chamber and stuffing box for leaks.
  - Ensure that there are no leaks from the mechanical seal.
  - Adjust or replace the packing in the stuffing box if you notice excessive leaking.
- 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.

**Three-month inspections**

Perform these tasks every three months:

- Check that the foundation and the hold-down bolts are tight.
- 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.

## 6.3 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.

## 6.4 Bearing replacement

- The end suction arrangement uses a silicon carbide sleeve bearing which is retained in a holder integral with the end suction casing.
- The radial suction arrangement uses a bearing housing identical to the bearing housing on the discharge side but with a single row ball bearing for radial loads.
- The discharge side bearing housing has back to back angular contact thrust bearings and a cooling fan mounted on the pump shaft..
- Clean and check condition of all parts that have been removed. When in doubt, components should be replaced. Wearing parts (ball bearings) and seals must always be replaced.

- If parts or half-open pumps are to be stored for any length of time, they must be protected from dirt and corrosion.

## 6.4.1 Maintenance of Bearings

### OIL LUBRICATED BEARINGS



#### 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.

After the pump has been installed, flush the housing to remove dirt, grit, and other impurities that may have entered the bearing housing during shipment or installation; then refill the housing with proper lubricant.

**Note:** *Do not fill the oil reservoir of the bearing frame through the vent or through the oiler housing without using the oiler bottle. The oil level will be maintained by the Trico oiler.*

#### Acceptable Lubricants

The table below lists some commonly available oils that meet this specification.

Brand	Lubricant Type
Chevron	GST Oil 68
Exxon Mobile	Teresstic EP 68
	DTE Heavy Medium
Shell	Tellus Oil 68
Sunoco	Sunvis 968
Royal Purple	SYNFILM ISO VG 68 Synthetic lube

3393 Ball Bearings				
Pump size	2.5x4-8 2.5x5-8	4x5-10 4x6-10	5x6-11 5x8-11	6x8-13 5x10-13
Initial Fill per Bearing Housing - Oil (US pt, l)	3.4 / 1.6	3.4 / 1.6	5.3 / 2.5	5.3 / 2.5
Bearing - Driver End	7408-B-MP-UA	7409-B-MP-UA	7311 BECBM	7214 BECBM
Bearing - Outboard (ES)*1	SiC/SiC	SiC/SiC	SiC/SiC	SiC/SiC
Bearing - Outboard (RS)	6408	6409	6311	6214
Maximum permissible surface temperature measured at the 12 o'clock (top of bearing housing) position (°F, °C)	180 / 82	180 / 82	180 / 82	180 / 82

\*1 Product lubricated bearing



## 6.4.2 Mechanical-seal maintenance


**WARNING:**

The mechanical seal used in an ATEX or Ex-classified environment must be properly certified. Prior to startup, make sure that all areas that could leak pumped fluid to the work environment are closed.


**WARNING:**


The mechanical seal must have an appropriate seal flush system. Failure to do so will result in excess heat generation and seal failure.


**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.

### Before you start the pump

Check the seal and all flush piping.

## 6.5 Disassembly

### 6.5.1 Introduction

The section on disassembly will address the bearings, mechanical seal, balance drum and balance drum stator as well as the complete pump. Where the disassembly is the same for end and radial suction pumps, no distinction will be made. When the disassembly is different, it will be identified for either end or radial suction configuration.

### 6.5.2 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.

### NOTICE:

- Always wear the proper Personal Protective Equipment (PPE).
- Make sure that no damage occurs to any part during disassembly that will impede the removal of other parts. For example, damage to the shaft that makes it difficult to remove a part that must slide over that part of the shaft.

## 6.5.3 Required Tools

Metric Wrenches (Hex and Open Ended)	Torque Wrench with Metric Socket
Screwdriver	Dial Indicator
Lifting Slings	Metric Micrometers (Inside and Outside)
Soft Faced Hammer	Cleaning Agents and Solvents
Induction Bearing Heater	Feeler Gauges
Brass Drift Punch	Metric Allen Wrenches
Brass Drift Punch	Files
Spanner Wrench	Emery Cloth

## 6.5.4 Disassembly



### 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.

1. Shut off all valves controlling flow to and from pump.
2. Drain liquid from piping. Flush pump if necessary.
3. Lock out power to the driver.
4. Disconnect all auxiliary piping and tubing.
5. Remove coupling guard.

6. Disconnect coupling.
7. Unbolt the pump from the piping system and baseplate and remove pump from baseplate.
8. Drain oil from the bearing housing(s) before inverting the pump.

## 6.5.5 Disassembly of suction end bearing

### 6.5.5.1 End suction pump - item 117 (sleeve bearing)

See relevant sectional drawing

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**NOTICE:**

It is not recommended to remove the product lube bearing (197A) unless it is worn or damaged.

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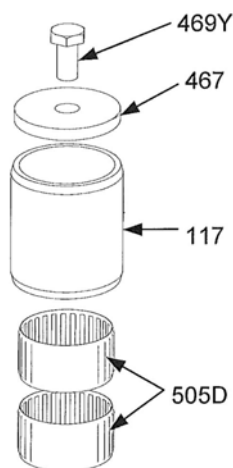
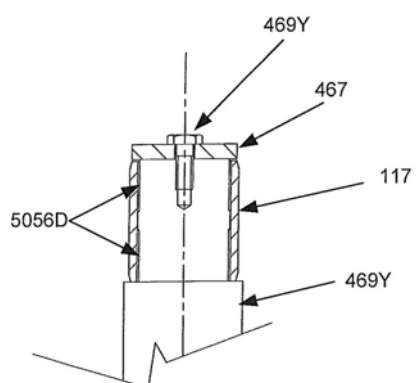
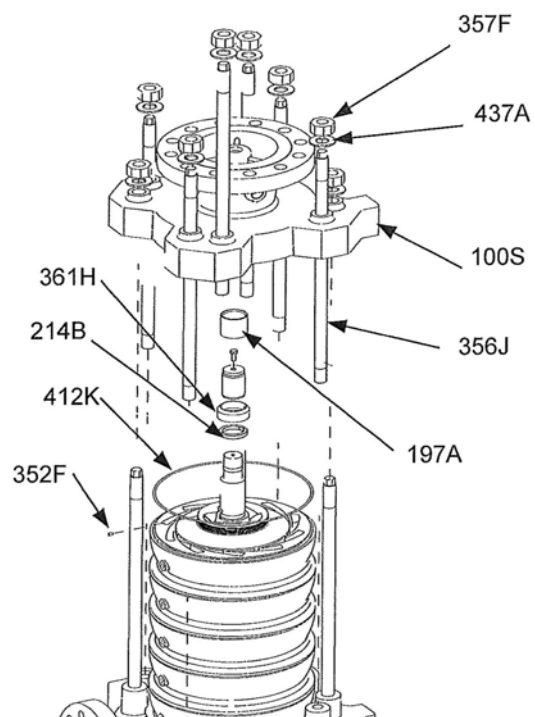
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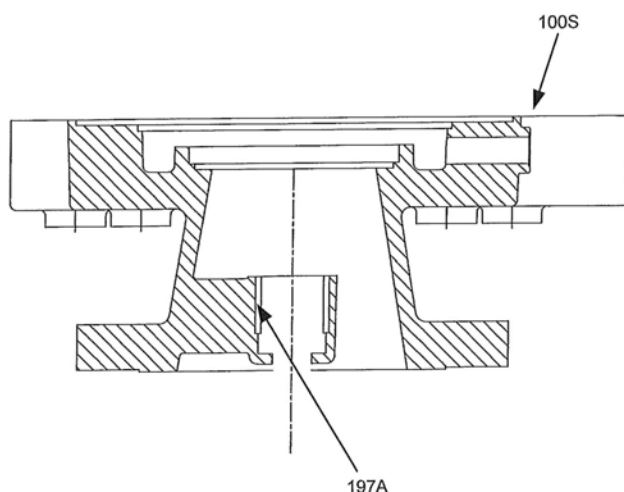
**NOTICE:**

Replacement of this bearing requires removal of the pump from the pipework and baseplate.

---

1. Unbolt the pump from the piping system and baseplate.
2. Support the pump vertically with the suction casing uppermost.
3. Remove the balance line and any seal flush piping.
4. Remove the tie rod nuts (357F) and tie rod washers (437A) on the suction end of pump.
5. Remove suction casing (100S). Bearing 197A will be in the suction casing. Remove the o-ring (412K).
6. Remove capscrew (469Y) and retaining plate (467).
7. Remove sleeve bearing (117) and tolerance rings (505D) from the end of the shaft.
8. Inspect the bearing sleeve for damage and check the clearance between the sleeve bearing and the stationary bearing.
9. Unless the stationary bearing (197A) is worn or damaged it should not be removed from the suction casing.
10. If necessary, remove stationary bearing (197A) from the suction casing being careful to avoid damage to the casing..





### 6.5.5.2 Radial suction pump - item 112 (ball bearing)

See relevant sectional drawing.

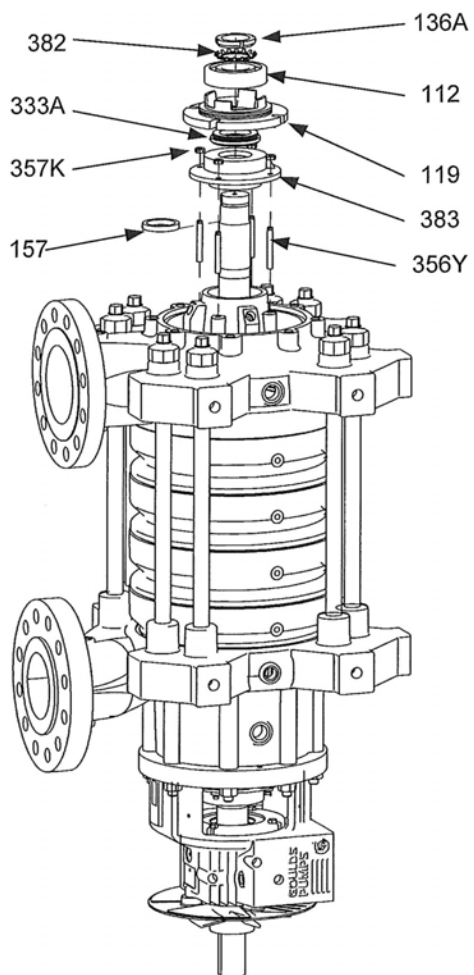
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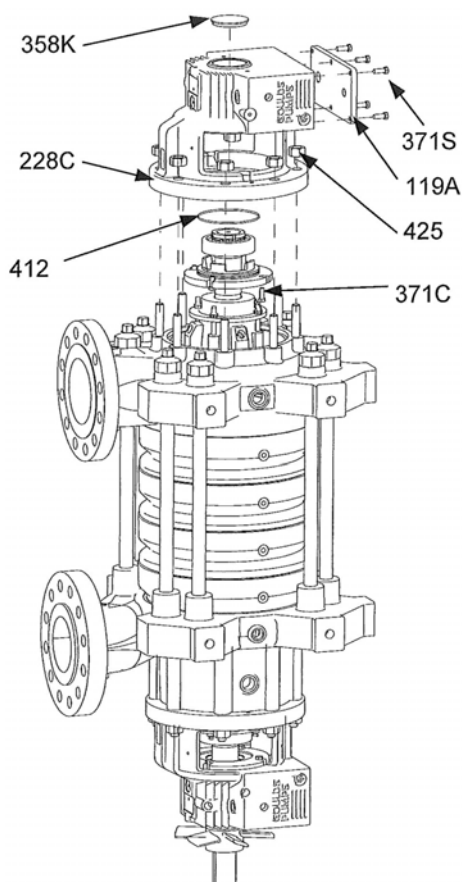
#### NOTICE:

The sump cover (119A) is generally not removed. If it must be removed, remove screws 371S and remove cover. The cover has a sealant between it and the bearing housing. Clean this off carefully. When reinstalling the sump cover (119A) use a uniform bead of Loctite® 5699 between the sump cover and the bearing housing. Be careful to avoid getting sealant in the holes for the cap screws (371S).

---

1. Make sure that there is adequate access around the pump for inspection and maintenance. Pump must be properly secured and stable before working on it.
2. Remove seal guards (499). These are not shown but cover the openings in the bearing housing.
3. Disconnect any flush piping from the mechanical seal gland and lock the mechanical seal in accordance with manufacturer's recommendation.
4. Unscrew nuts (425) and back off the bearing bracket (228C) using the jacking screw (418).
5. Unscrew cap screws (371C) and confirm that the bearing housing cover (119) is free to move.
6. Remove bearing housing (228C).
7. Remove the bearing housing cover o-ring (412). Do not reuse the o-ring.
8. Bend back the lock washer tab (382) and remove bearing nut (136A) and lock washer (382).
9. Remove bearing (112) with a suitable bearing puller.

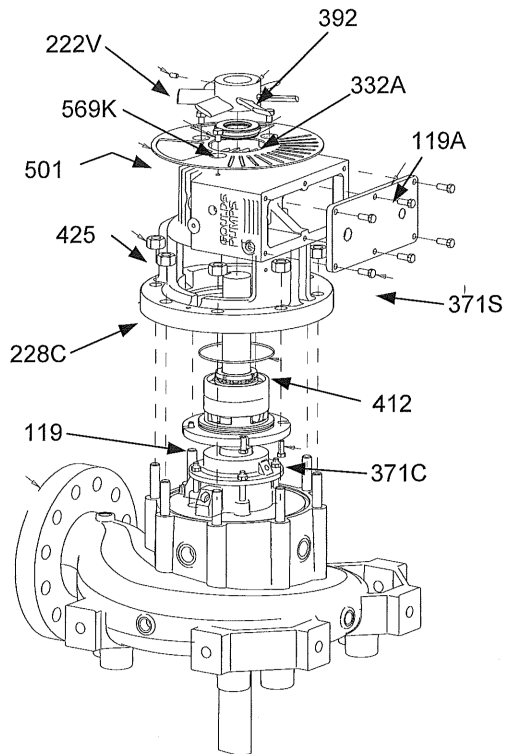




## 6.5.6 Disassembly of discharge end bearing

### 6.5.6.1 End and radial suction pumps - item 409 (ball bearing)

1. Make sure that there is adequate access around the pump for inspection and maintenance. Pump must be properly secured and stable before working on it.
2. Remove coupling halves.
3. Remove seal guards (499).
4. Remove cooling fan (392), by loosening set screw (222V).
5. Disconnect any flush piping from the mechanical seal gland.
6. Unscrew nuts (425) and back off the bearing bracket (228C) using the jacking screw (418).
7. Unscrew cap screws (371C) and confirm that the bearing housing cover (119) is free to move.
8. Remove bearing housing (228C).
9. After the bearing bracket (228C) has been removed the shaft can be moved freely in an axial direction (approx. 1/8"). Standard shaft seals can absorb this adjustment without their function being impaired. In the case of special shaft seals, please follow the Operating Instructions of the seal.
10. Remove the bearing housing cover o-ring (412). Do not reuse the o-ring.
11. Bend back the lock washer tab (382) and remove bearing nut (136A) and lock washer (382).
12. Remove ball bearings (409) with the bearing puller.



### 6.5.7 Disassembly of the mechanical seal - end and radial suction pumps

Mechanical seals are located on the suction side (RS configuration) and discharge side (RS and ES configurations). Mechanical seals are cartridge type seals and these instructions refer to cartridge seals. If other seals are used, refer to the seal manufacturer's instructions.



#### WARNING:



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



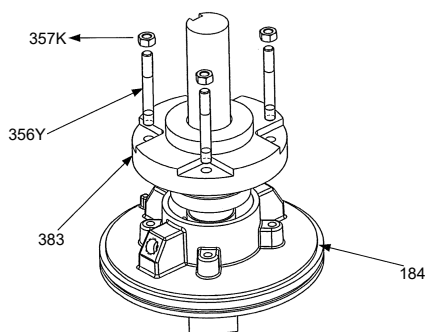
#### CAUTION:

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.

See relevant sectional drawing and mechanical seal vendor's installation instructions.

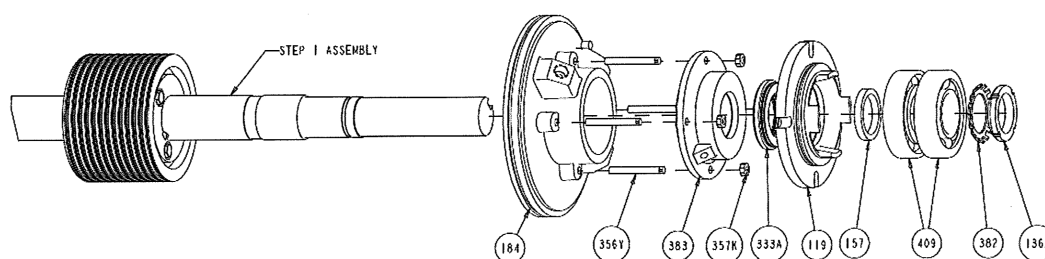
1. Remove the seal guards (499). These are not shown but cover the openings in the bearing frame.
2. Disconnect any seal flush piping connected to the gland.
3. Locate and reinstall setting clips and clip screws from initial installation if seal is to be reinstalled. This is necessary to properly install seal.
4. Remove the bearings, following appropriate bearing removal instructions above depending on seal location and pump configuration (item 409 and/or item 112).
5. Loosen the set screws holding the seal to the shaft.
6. Remove nuts (357K) holding the mechanical seal (383) to the seal chamber housing (184).
7. Slide entire cartridge seal assembly over the shaft to remove it from the pump.

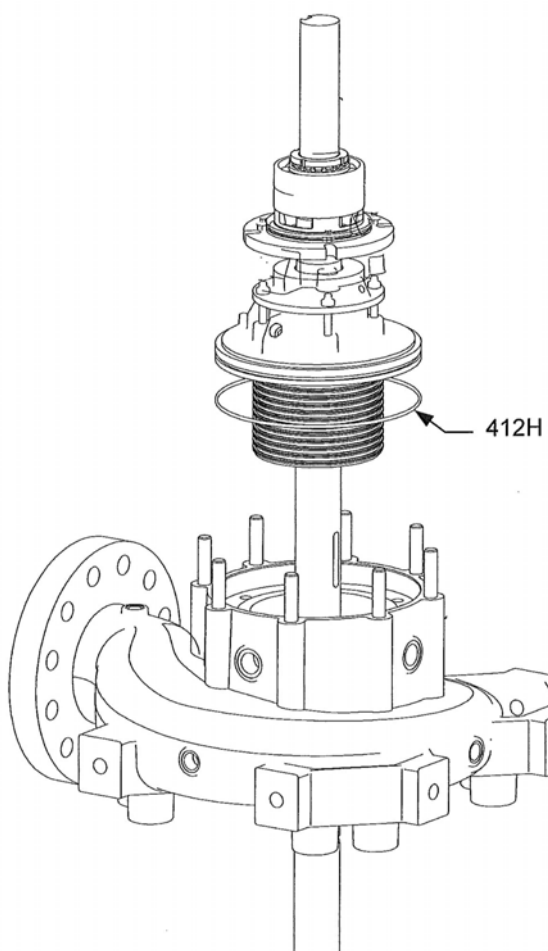
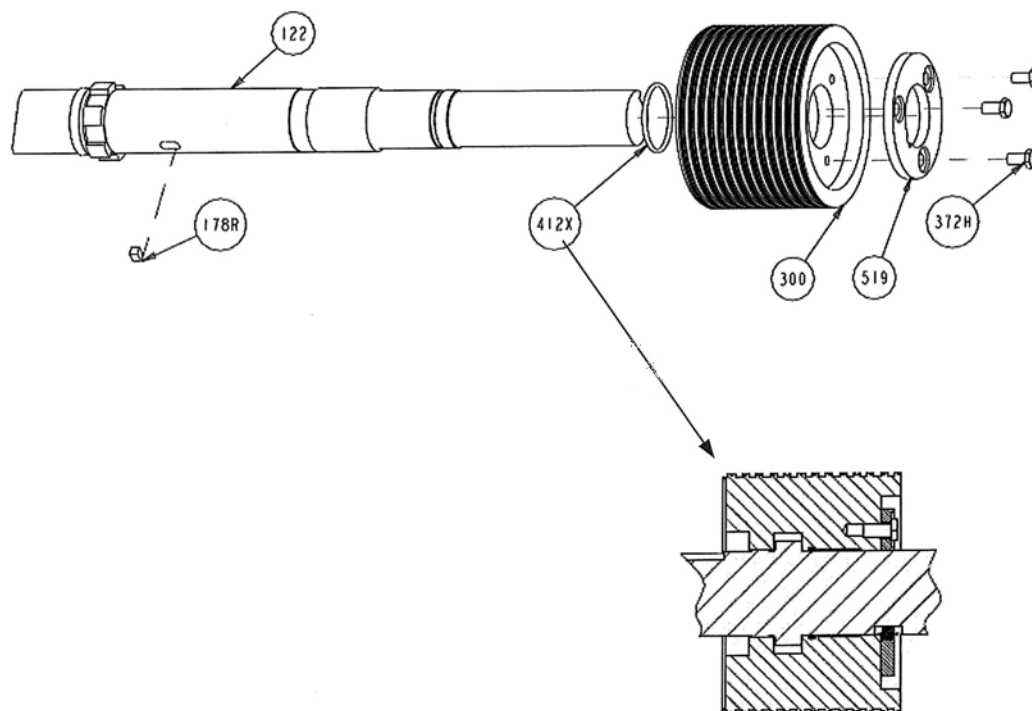


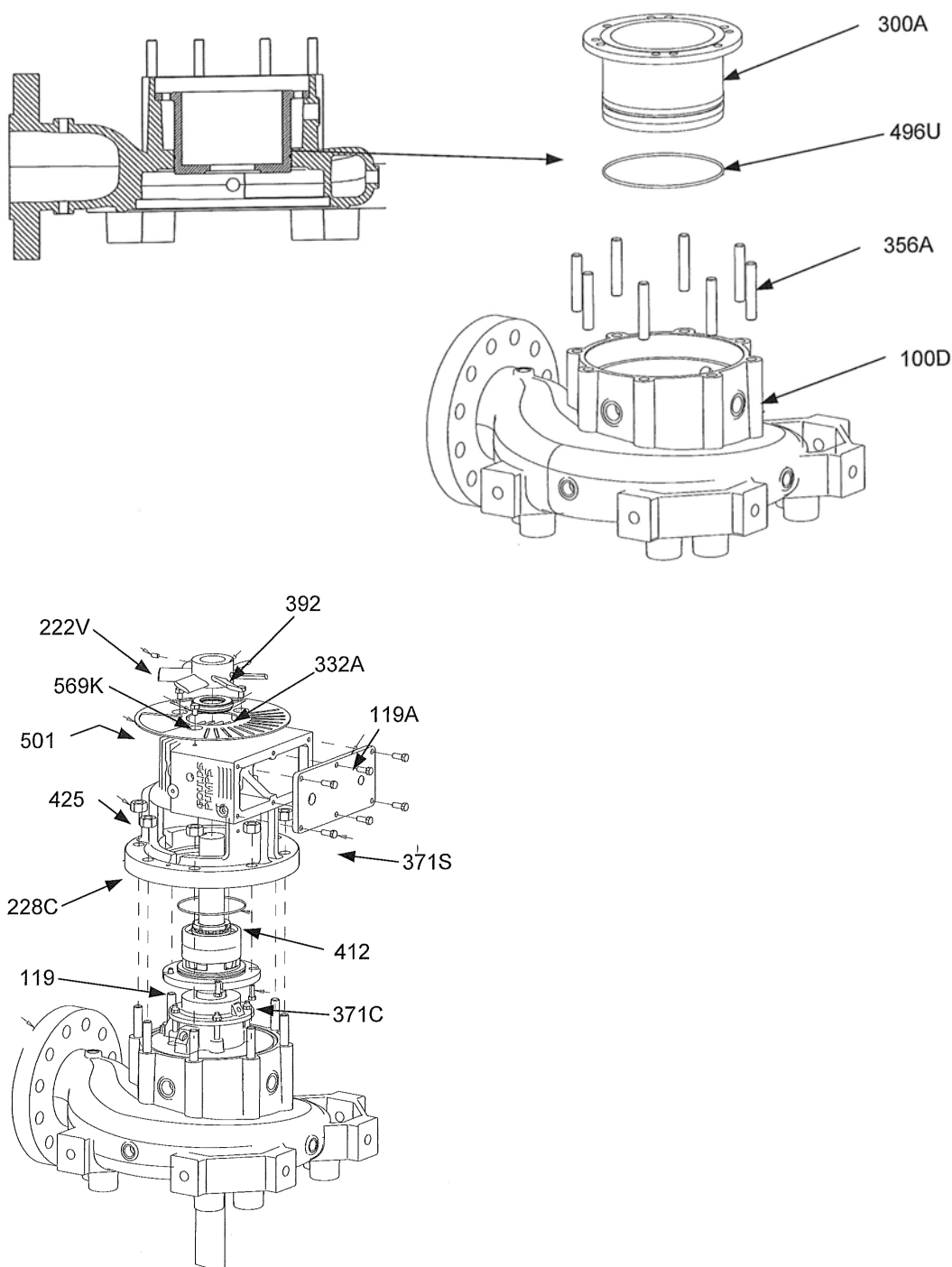


### 6.5.8 Disassembly of the balance drum rotor and stator - end and radial suction pumps

1. Make sure that there is adequate access around the pump for inspection and maintenance. Pump must be properly secured and stable before working on it.
2. Remove the thrust end bearing housing as noted in instructions for removal of the thrust bearing (item 409).
3. Remove the mechanical seal and gland as noted in instructions for removal of the mechanical seal.
4. Seal chamber (184) and seal chamber o-ring (412H) can now be removed from the discharge casing (100D). Pull the housing toward the shaft end axially.
5. Remove the capscrews (372H) holding balance drum locking plate (519) to the balance drum (300).
6. Remove balance drum locking plate (519) and balance drum locking plate key (178R).
7. Use a permanent marker to place an alignment mark on the shaft and balance drum.
8. Brace the shaft to prevent it from rotating. Insert threaded rods in the balance drum holes and rotate the balance drum by 30° to clear the locking tabs on the shaft.
9. Remove balance drum and balance drum o-ring (412X) using the threaded rod. Do not reuse balance drum o-ring.
10. Insert threaded rods into the balance drum stator and remove axially. Remove balance drum stator (300A) and balance drum stator o-ring (496U). Do not reuse balance drum stator o-ring.
11. Inspect visible portion of the shaft and remove any burrs or scratches with a file and emery cloth.







## 6.5.9 Disassembly of complete pump

### 6.5.9.1 End suction pump

See relevant sectional drawing.

To dismantle the whole pump for maintenance work, place it in a vertical position with the suction nozzle facing upwards. It is important that the pump is secured and stable and supported without damaging the bearing housing. A workbench with a hole approximately 1/2" larger than the shaft is helpful in such cases. A hoist or a second person is required for a safe disassembly.

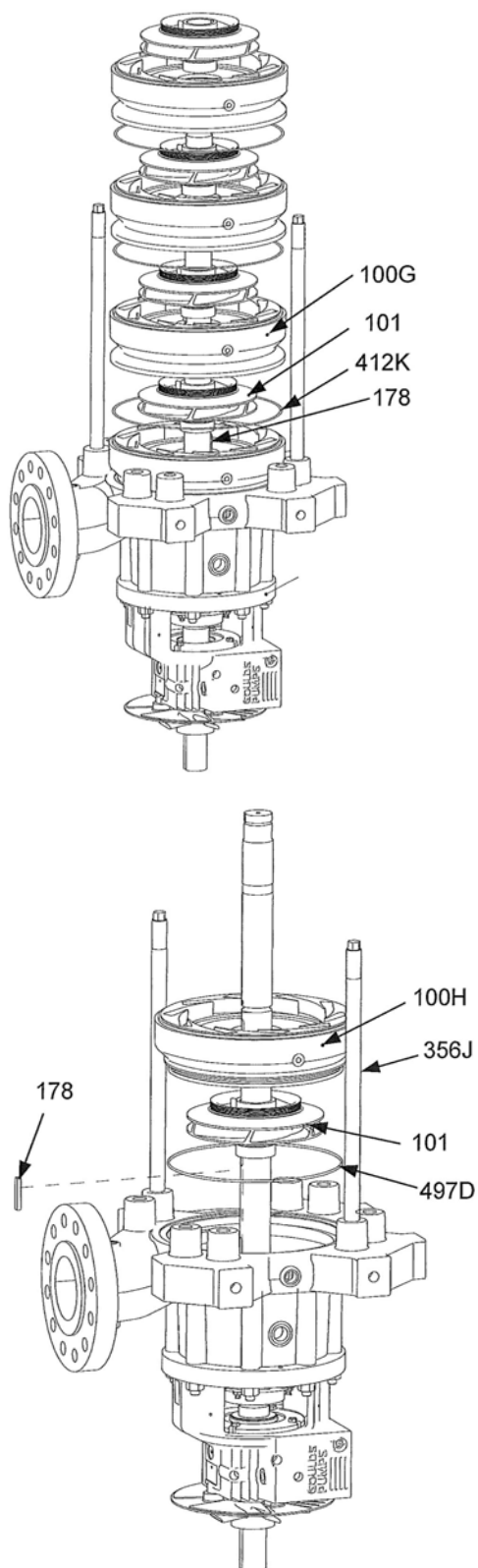
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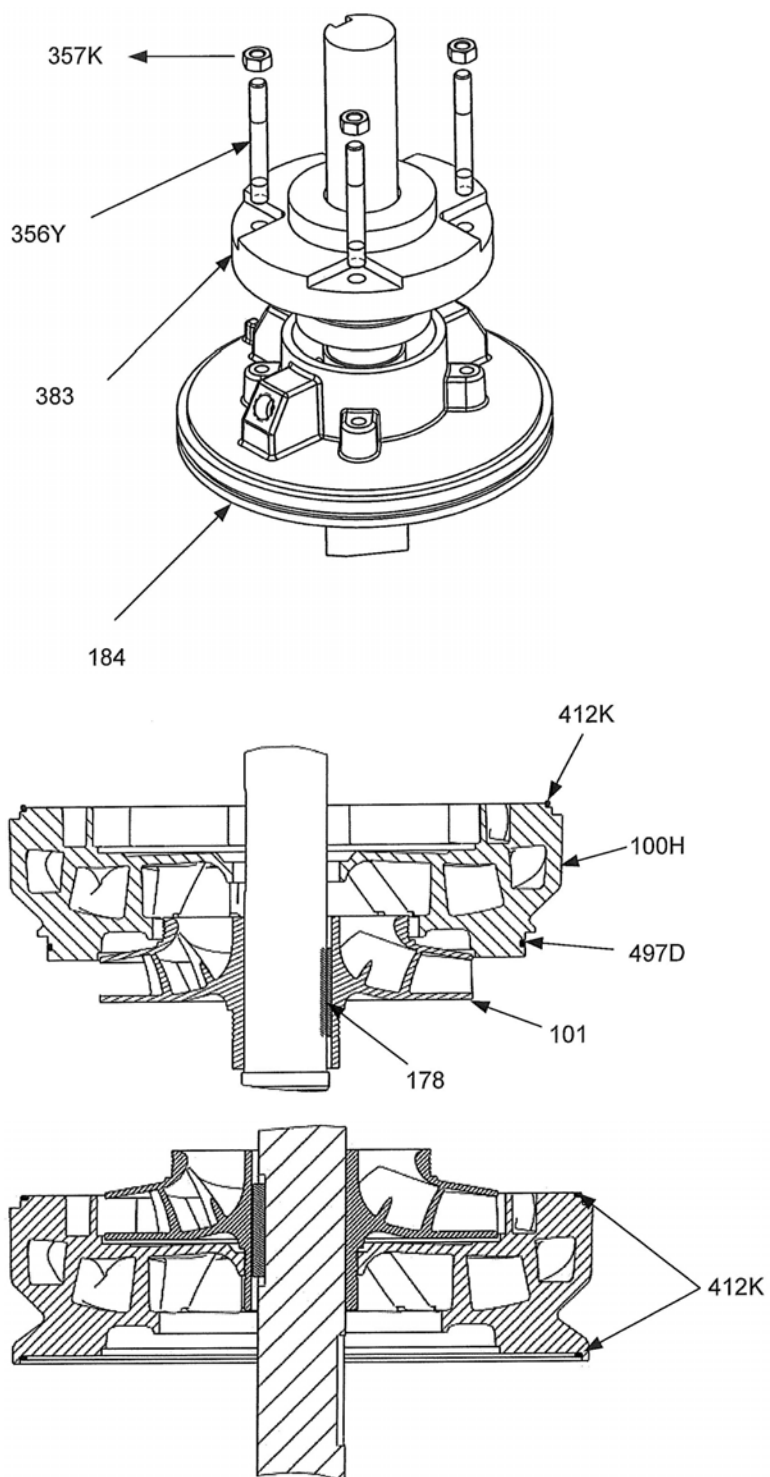
Dropping, rolling or tipping units, or applying other shock loads, can cause property damage and/or personal injury. Ensure that the unit is properly supported and secure during lifting and handling.

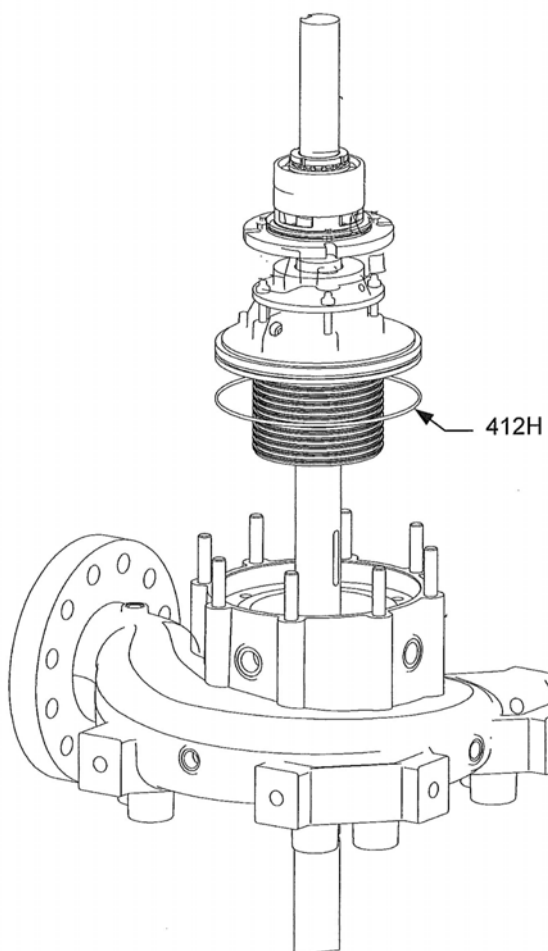
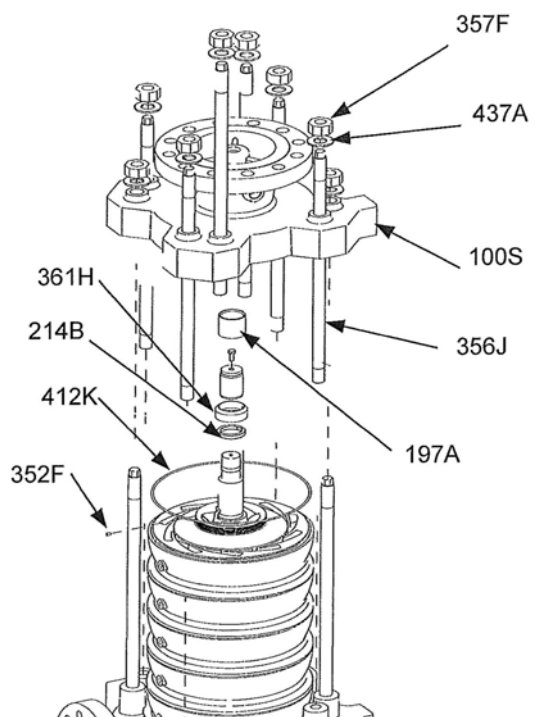
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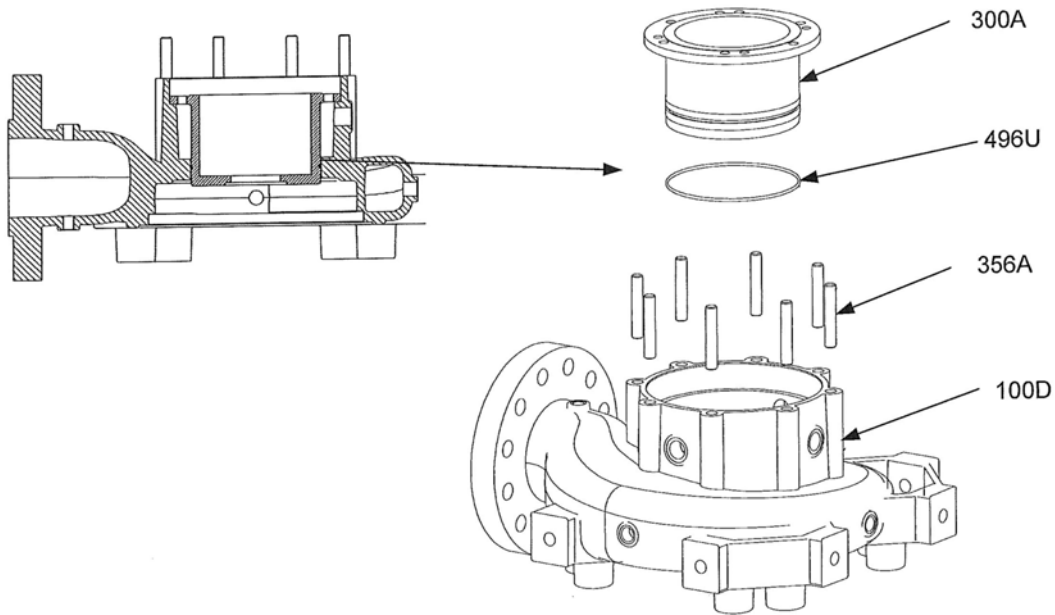
The pump must be dismantled and assembled in the vertical position.

1. Loosen tie rod nuts (357F) at both ends and remove tie rods (356J). Note: the tie rods are threaded into the discharge casing and must be removed by unscrewing the tie rods using the flats machined into their surface.
2. Remove suction casing (100S) and remove o-ring (412K).  
It is not recommended to remove the product lube bearing unless worn or damaged.
3. Loosen retaining ring set screw (352F) and remove the retaining ring (361H) and split ring (214B).
4. Remove impeller (101), impeller key (178), stage casings (100G) and final stage casing (100H) along with stage casing o-rings (412K) and discharge casing o-ring (497D). This step must be done stage by stage down to the discharge casing (100D). Do not reuse o-rings.
5. Invert the pump so the bearing housing (228C) faces upward position.
6. Remove seal guards (499).
7. Remove cooling fan (392) by loosening set screw (222V).
8. Disconnect any flush piping from the mechanical seal gland.
9. Unscrew nuts (425) and back off the bearing bracket (228C) using the jacking screw (418).
10. Unscrew capscrews (371C) and confirm that the bearing housing cover (119) is free to move.
11. Remove bearing bracket (228C).  
**IMPORTANT:** After the bearing bracket (228C) has been removed, the shaft can be moved freely in an axial direction approximately 1/8". Standard shaft seals can absorb this adjustment without their function being impaired. For special shaft seals, follow the Operating Instructions of the seal.
12. Remove the bearing housing cover o-ring (412). Do not reuse the o-ring.
13. Bend back the lock washer tab (382) and remove the bearing nut (136A) and the lock washer (382).
14. Remove ball bearings (409) with the bearing puller.
15. Remove the mechanical seal and gland as noted in the instructions for removal of the mechanical seal.
16. Remove the seal chamber (184) and seal chamber o-ring (412H) from the discharge casing (100D). Pull the housing toward the shaft end axially.
17. Remove cap screws (372H) that hold the balance drum locking plate (519) to the balance drum (300).
18. Remove balance drum locking plate and balance drum locking plate key (178R).
19. Use a permanent marker to place an alignment mark on the shaft and balance drum.
20. Brace the shaft to prevent it from rotating. Insert threaded rods in the balance drum holes and rotate the balance drum by 30° to clear the locking tabs on the shaft.
21. Remove balance drum and balance drum o-ring (412X) using the threaded rod. Do not reuse balance drum o-ring.
22. Insert threaded rods into the balance drum stator and remove axially. Remove balance drum stator (300A) and balance drum stator o-ring (496U). Do not reuse balance drum stator o-ring.









### 6.5.9.2 Radial suction pump

See relevant sectional drawing.

To dismantle the whole pump for maintenance work, place it in a vertical position with the suction nozzle facing upwards. It is important that the pump is secured and stable and supported without damaging the bearing housing. A workbench with a hole approximately 1/2" larger than the shaft is helpful in such cases. A hoist or a second person is required for a safe disassembly.



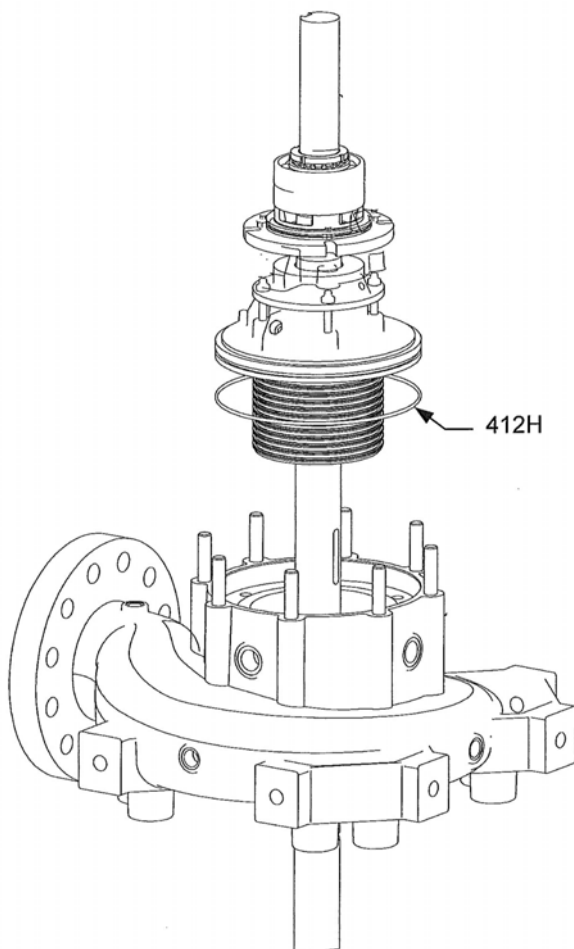
#### **WARNING:**

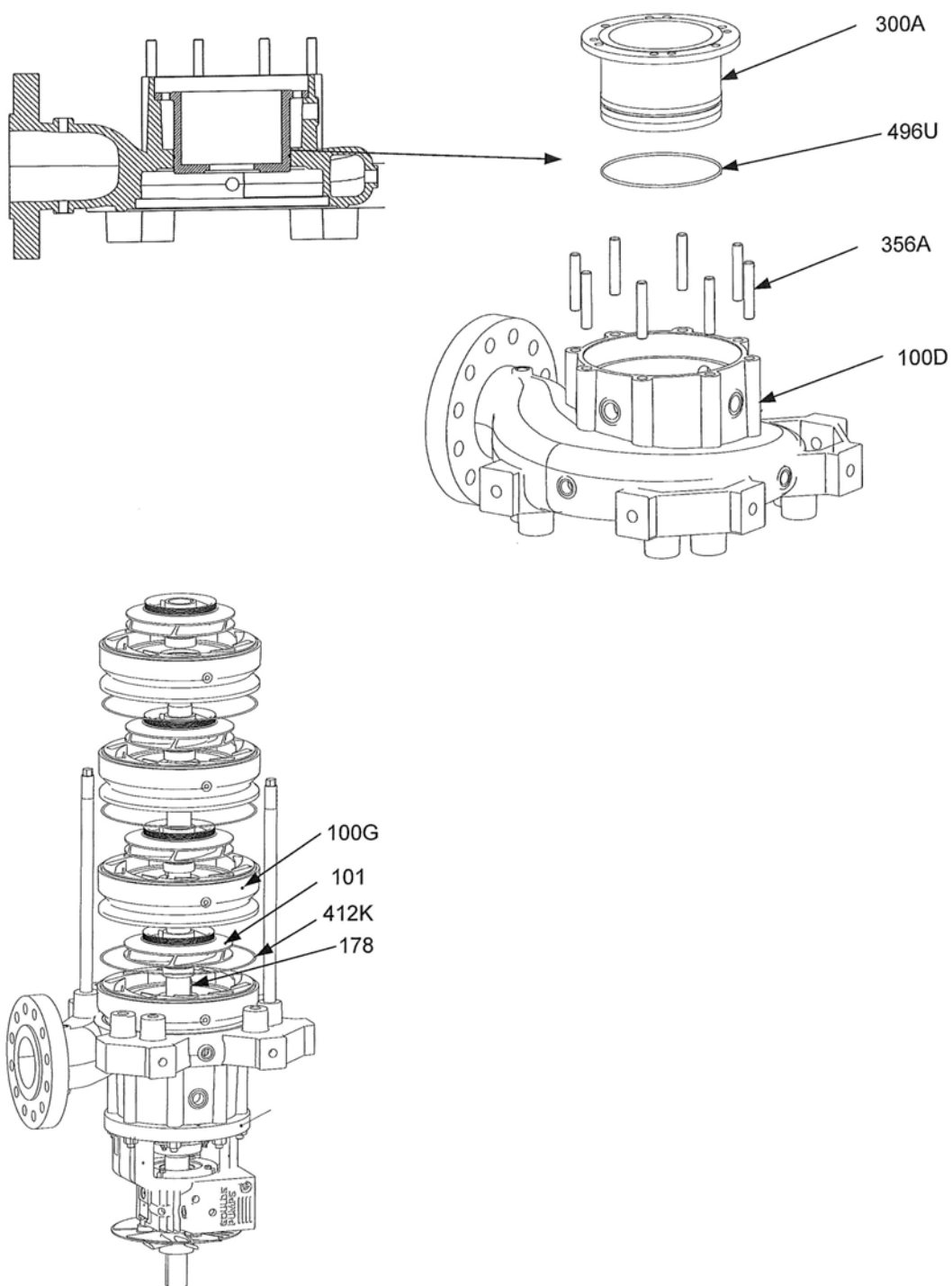
Dropping, rolling or tipping units, or applying other shock loads, can cause property damage and/or personal injury. Ensure that the unit is properly supported and secure during lifting and handling.

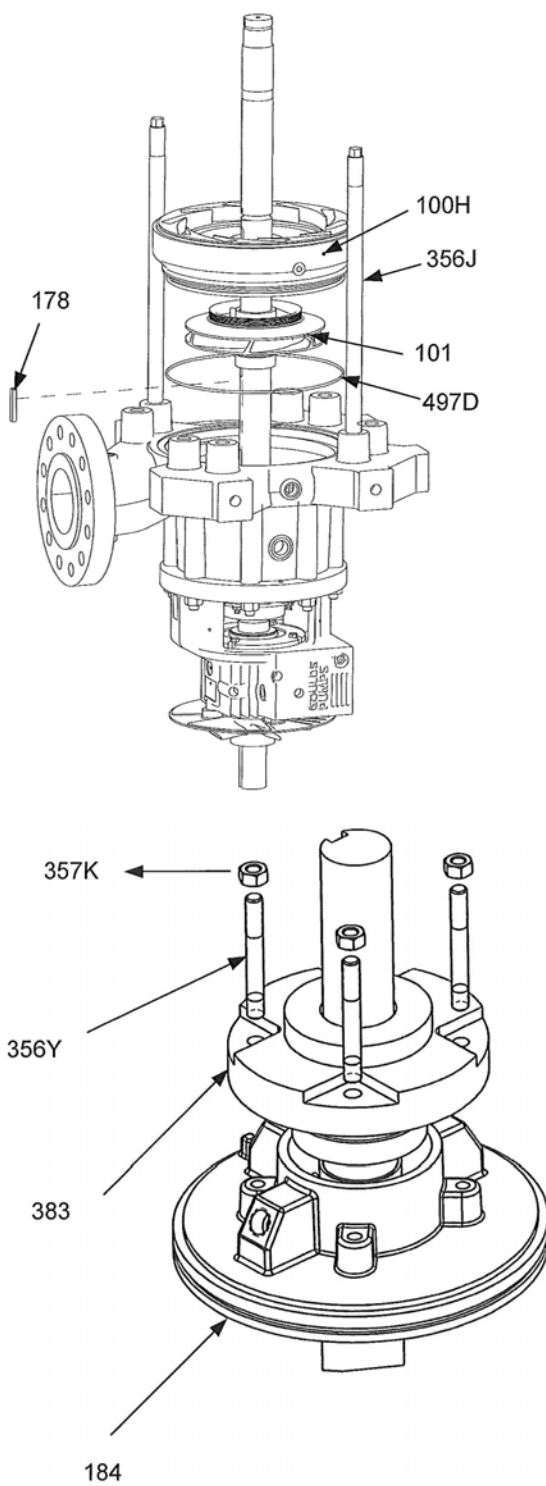
1. Unscrew nuts (425) and back off the bearing bracket (228C) using the jacking screw (418).
2. Unscrew cap screws (371C) and confirm that the bearing housing cover (119) is free to move.
3. Remove bearing housing (228C)
4. Remove the bearing housing cover o-ring (412). Do not reuse the o-ring.
5. Bend back the lock washer tab (382) and remove bearing nut (136A) and lock washer (382).
6. Remove ball bearings (112) with the bearing puller.
7. Remove the mechanical seal and gland as noted in the instructions for removal of the mechanical seal.
8. Loosen tie rod nuts (357F) and remove tie rods (356J). Note: the tie rods are threaded into the discharge casing and must be removed by unscrewing the tie rods using the flats machined into their surface.
9. Remove suction casing (100S) and remove O-ring (412K).
10. Loosen retaining ring set screw ((352F) and remove retaining ring (361H) and split ring (214B).
11. Remove impeller (101), impeller key (178), stage casings (100G) and final stage casing (100H) along with stage casing o-rings (412K) and discharge casing o-ring (497D). This must be done stage by stage down to the discharge casing (100D). Do not reuse o-rings.
12. Invert the pump so the discharge side bearing housing (228C) faces upward position.
13. Remove seal guards (499).
14. Remove cooling fan (392) by loosening set screw (222V).
15. Disconnect any flush piping from the mechanical seal gland.
16. Unscrew nuts (425) and back off the bearing housing (228C) using the jacking screw (418).

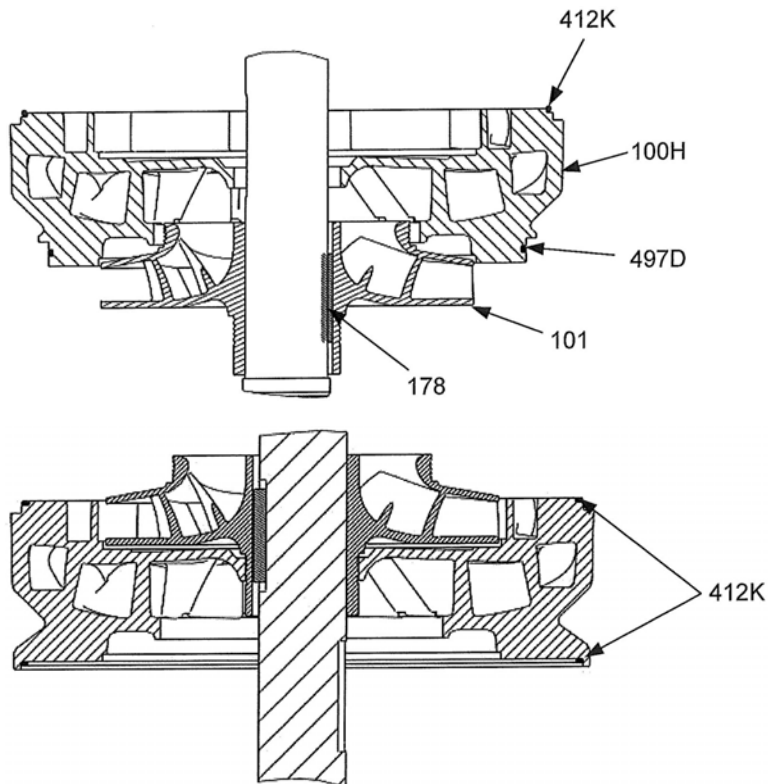


17. Unscrew cap screws (371C) and confirm that the bearing housing cover (119) is free to move.
18. Remove bearing housing (228C).
19. Remove the bearing housing cover o-ring (412). Do not reuse the o-ring.
20. Bend back the lock washer tab (382) and remove bearing nut (136A) and lock washer (382).
21. Remove ball bearings (409) with the bearing puller.
22. Remove the mechanical seal and gland as noted in the instructions for removal of the mechanical seal.
23. Seal chamber (184) and seal chamber o-ring (412H) can now be removed from the discharge casing (100D). Pull the housing toward the shaft end axially.
24. Remove cap screws (372H) holding balance drum locking plate (519) to balance drum (300).
25. Remove balance drum locking plate and balance drum locking plate key (178R).
26. Using a permanent marker, place an alignment mark on the shaft and balance drum.
27. Brace the shaft to prevent it rotating, insert threaded rods in the balance drum holes and rotate the balance drum by 30° to clear the locking tabs on the shaft.
28. Remove balance drum and balance drum o-ring (412X) using the threaded rod. Do not reuse balance drum o-ring.
29. Insert threaded rods into the balance drum stator and remove axially. Remove balance drum stator (300A) and balance drum stator o-ring (496U). Do not reuse balance drum stator o-ring.









### 6.5.10 Guidelines for i-ALERT® 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.

## 6.6 Pre-assembly inspections

#### Guidelines

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

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

**NOTICE:**

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

## 6.6.1 Preassembly inspections

### Replacement guidelines

#### Casing check and replacement

Inspect the casing and diffusers for cracks and excessive wear or pitting. Thoroughly clean o-ring surfaces and alignment fits to remove corrosion and debris.

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

- Localized wear or grooving that is greater than 1/8 in. (3.2 mm) deep
- Pitting that is greater than 1/8 in. (3.2 mm) deep
- Irregularities in the casing-gasket seat surface
- Wear ring and balance drum clearances that exceed the values in the running clearances table

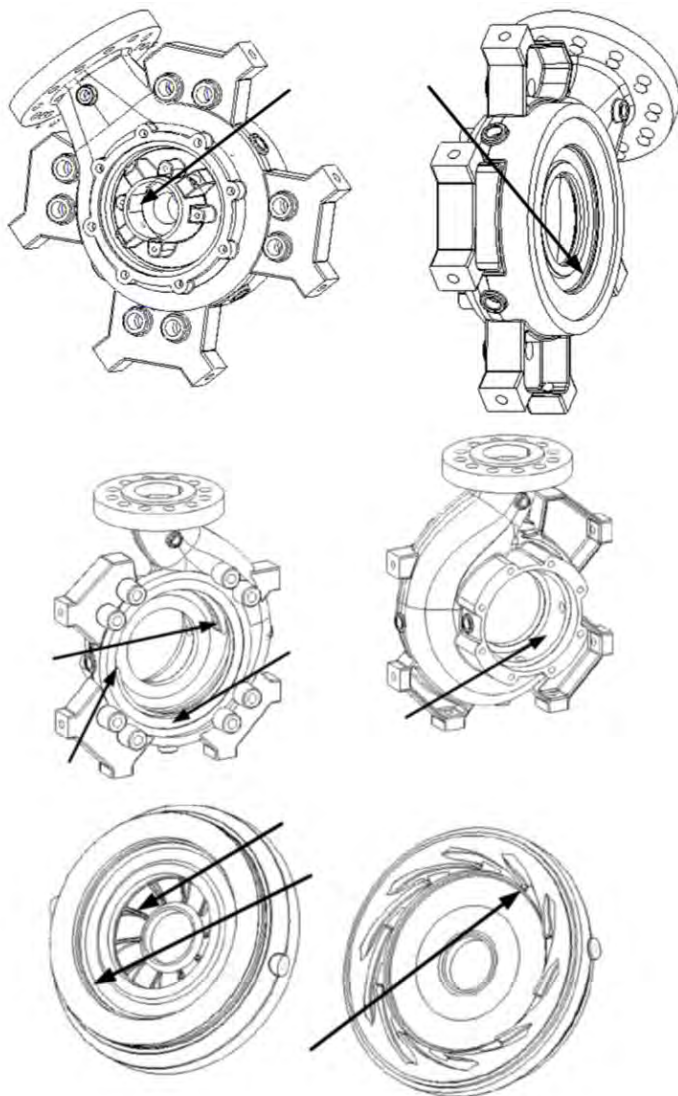
**NOTICE:**

When clearances between the rings become excessive (increase by 100%), hydraulic performance decreases substantially.

#### Casing areas to inspect

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

Casing Parts	When to Replace
Cutwaters on casings, inlet and outlet vanes on diffusers	<ul style="list-style-type: none"> <li>• When grooved deeper than 1/16 in. (1.6 mm), or</li> <li>• When worn evenly more than 1/32 in. (0.8 mm)</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 100% over the values in the running clearances table



### 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 1/16 in. (1.6 mm),</li> <li>or</li> <li>• When worn evenly more than 1/32 in. (0.8 mm)</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 100% over the values in the running clearances table

### Impeller checks

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

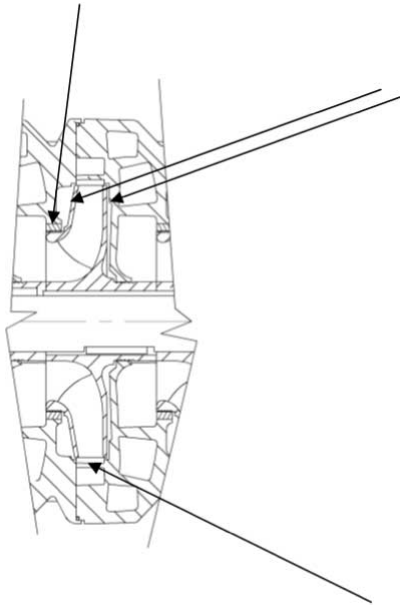
#### NOTICE:

You must have accurate tooling equipment to balance impellers to the ISO 1940 G2.5 criteria.

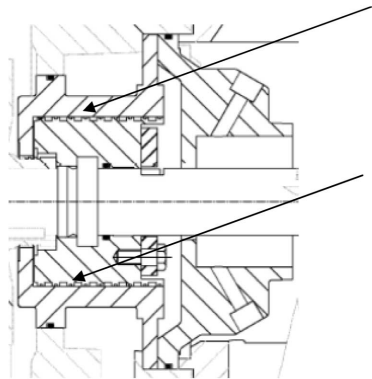
Do not attempt to balance impellers to this criteria unless this type of tooling and equipment is available.

**Impeller areas to inspect**

- A. Shroud
- B. Wear Ring (if supplied)
- C. Vane

**Balance drum areas to inspect**

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

**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.

**O-rings, and seats replacement**

- Replace all gaskets and O-rings at each overhaul and disassembly.

- Inspect the seats. They must be smooth and free of physical defects
- Replace parts if the seats are defective.

### 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 (119)
- Labyrinth seals (332A and 333A)
- Bearing locknut (136A)
- Impeller key (178), coupling key (400) and balance drum key (178R)
- Bearing lockwasher (382)
- All nuts, bolts, and screws

### Shaft replacement guidelines

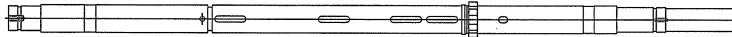
#### Shaft measurement check

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 straightness check

Check the shaft straightness. Use "V" blocks or balance rollers to support the shaft on the bearing fit areas. Replace the shaft if runout exceeds the values in the Shaft and rotor runout requirements table.

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



#### Shaft surface check

Check the shaft surface for damage. Remove any burrs. Replace the shaft if it shows fretting or gouging or is damaged beyond reasonable repair.

#### Rotor

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

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

Characteristic	Requirement
Allowable shaft runout, TIR*	0.05 mm (0.0020 in.)
Component fit to shaft	Clearance
Allowable rotor radial runout, TIR*	0.10 mm (0.0040 in.)
*Total indicated runout of impeller hubs and sleeves	

### Bearings inspection

#### Condition of bearings

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

#### Checklist



Perform these checks when you inspect the old 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 3: Model 3393 ball bearing fits**

Pump Size	Radial Bearing	Thrust Bearing	Bearing Housing Bore	Shaft turn
2.5x4-8	6408	7408-B-MP-UA	4.3321 in. / 4.3307 in. 110.035 mm / 110.00 mm	1.5755 in. / 1.5749 in. 40.018 mm / 40.002 mm
4x5-10	6409	7409-B-MP-UA	1.7258 in. / 4.7244 in. 120.035 mm / 120.00 mm	1.7724 in. / 1.7717 in. 45.018 mm / 45.002 mm
5x6-11	6311	7311 BECBM	4.7258 in. / 4.7244 in. 120.035 mm / 120.00 mm	2.1662 in. / 2.1654 in. 55.021 mm / 55.002 mm
6x8-13	6214	7214 BECBM	4.9228 in. / 4.9213 in. 125.040 mm / 125.006 mm	2.7567 in. / 2.7560 in. 70.020 mm / 70.002 mm

### 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.

### Replace the casing and diffuser wear rings

Check for obvious damage and excessive clearance and if necessary replace the casing and diffuser wear rings. The casing and diffuser wear rings (103) are held in place by a press fit and Loctite® 635.

1. Remove the wear rings from the suction casing (100S) and the diffusers (100H). Use suitable pry or puller tools to force the rings from the fits. You can also machine the rings for removal.

#### NOTICE:

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.



2. Install the wear rings:

- a. Thoroughly clean the wear ring seats and make sure they are smooth and free of scratches.
- b. Chill the new wear rings (103) using dry ice or other suitable chilling substance and install the rings into the fit of the suction casing (100S) and the diffusers (100H). Use Loctite 635 between the casing and casing wear ring. Be prepared to tap the ring in place with a hardwood block or a soft-faced hammer.

---

**NOTICE:**

The impeller and wear ring clearance setting procedure must be followed. Improperly setting the clearance or not following any of the proper procedures can result in sparks, unexpected heat generation and equipment damage.

---

3. Check the suction casing and diffuser wear rings (103) runout and distortion by measuring the bore at three (3) locations 120° apart with inside micrometers or vernier calipers.

**Replace the impeller wear rings (Optional - may not be on all pumps)**

Impeller wear rings are an option. A press fit and three tack welds hold the impeller wear rings (142) in place.

1. Remove the impeller wear rings (142) by grinding out the tack welds and using suitable pry or puller tools to force the wear rings from the impeller. If this is impractical, the wear rings may be ground off.
2. Clean the impeller hubs thoroughly to make sure they are smooth and free of scratches
3. Heat the new impeller wear rings to between 180°F (82°C) and 200°F (93°C) using a uniform method for heating, such as an oven, and place them on the impeller (101) hub in the correct location..
4. Tack weld each ring in three places 120° apart.

*Note: It may be necessary to replace the impellers.*

## 6.7 Reassembly

### 6.7.1 Preliminary work



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**WARNING:**

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

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Ensure that there is adequate space to safely work on the pump. Make sure pump is stable and secured from tipping over. Insure all parts are available and that any parts being reused are clean and dry.

### 6.7.2 Assembly of suction end bearing

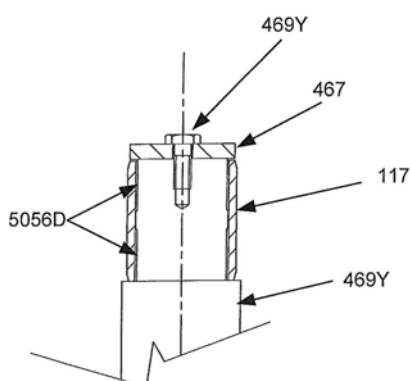
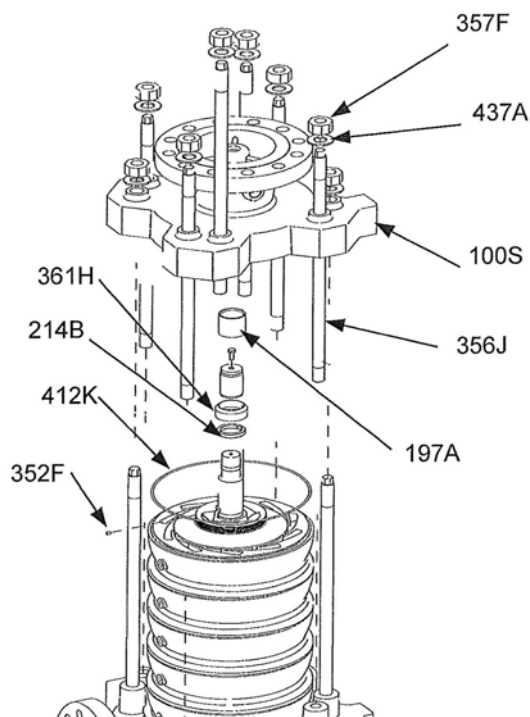
#### 6.7.2.1 End suction pump - item 117 (sleeve bearing)

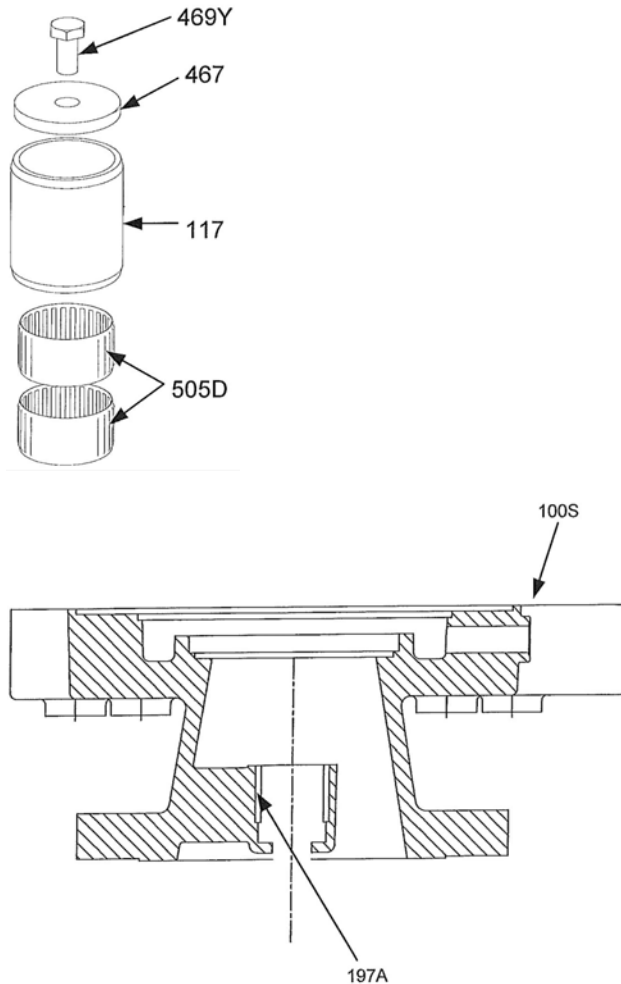
Do not reuse 505D (tolerance ring) or 412K (o-ring).

1. Clean the fitting surfaces between the bearing sleeve (197A) and suction casing (100S).
2. Coat the casing bearing bore and the outside of the stationary bearing (197A) with Loctite 635
3. Insert bearing sleeve (197A) into the casing. This can be facilitated by placing the bearing sleeve in a freezer for approximately one hour and heating the suction casing with hot water. When the casing has been heated, insert the bearing sleeve into the casing bore. The greater the temperature difference between the bore and the sleeve, the easier it will be to insert the bearing sleeve. An

assembly fixture that can aid in this portion of the assembly can be made or can be purchased from Goulds.

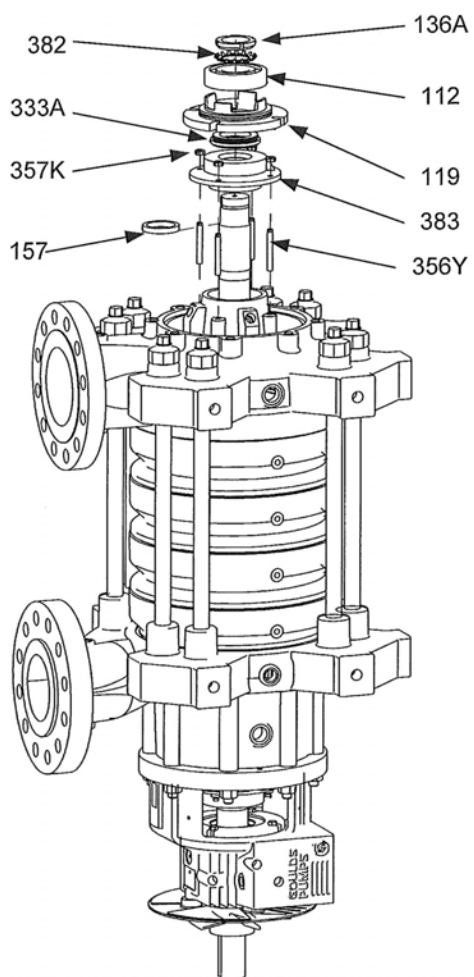
4. Replace tolerance rings (505D) and sleeve bearing (117) on the end of the shaft
5. Replace cap screw (469Y) and retaining plate (467) on the end of the shaft.
6. Place o-ring (412K) in position on the diffuser.
7. Replace suction casing (100S) and align with the shaft.
8. Reinstall tie rod nuts (357F) and tie rod washers (437A) on tie rods and tighten to correct torque values as noted in Appendix A. Tighten in sequence and increments as noted in Appendix D.

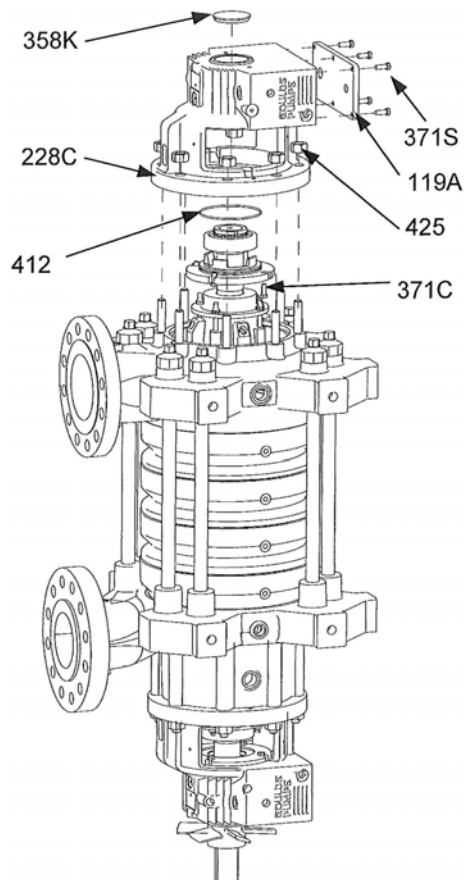




### 6.7.2.2 Radial suction pump - item 112 (ball bearing)

1. Clean and lubricate the fitting surfaces between the bearing bracket (228C) and discharge casing (110D).
2. Position the bearing cover (119) with the bearing isolator (333A) over the shaft.
3. Verify that the bearing spacer (157) is in place against the shaft shoulder.
4. Preheat the new bearing (112) (max. 230°F) and slide onto the shaft (122).
5. Replace bearing lockwasher (382) and bearing nut (136A).
6. Allow the bearing (112) to cool to room temperature.
7. Tighten the bearing locknut (136A) until resistance is felt.
8. Replace the bearing housing (228C) and align with the shaft (122) and seal chamber (184).
9. Reinstall and tighten nuts (425) to proper torque values.
10. Install the bearing cover (119) to the bearing housing with cap screws (371C) and tighten to correct torque values. NOTE: the drain hole in the isolator must be at bottom dead center when the pump is in the horizontal position.
11. Connect flush piping to gland.
12. Refit the seal guards (499).





### 6.7.3 Assembly of discharge end bearing

#### 6.7.3.1 End and radial suction pump - item 409 (ball bearing)

1. Clean and lubricate the fitting surfaces between the bearing bracket (228C) and discharge casing (110D).
2. Position the bearing cover (119) with the bearing isolator (333A) over the shaft.
3. Verify that the bearing spacer (157) is in place against the shaft shoulder.
4. Preheat the new bearing (409) (max. 230°F) and slide onto the shaft (122) in a back to back arrangement.
5. Replace bearing lockwasher (382) and bearing nut (136A).
6. Allow the bearings (409) to cool to room temperature.
7. Tighten the bearing locknut (136A) until resistance is felt when rotating the bearing outer races in opposite directions by hand.
8. Replace the bearing bracket (228C) and align with the shaft (122) and seal chamber (184).
9. Reinstall and tighten nuts (425) to proper torque values.
10. Install the bearing cover (119) to the bearing housing with cap screws (371C) and tighten to correct torque values.
11. Install or confirm that the bearing isolator (332A) is properly installed in the bearing housing.

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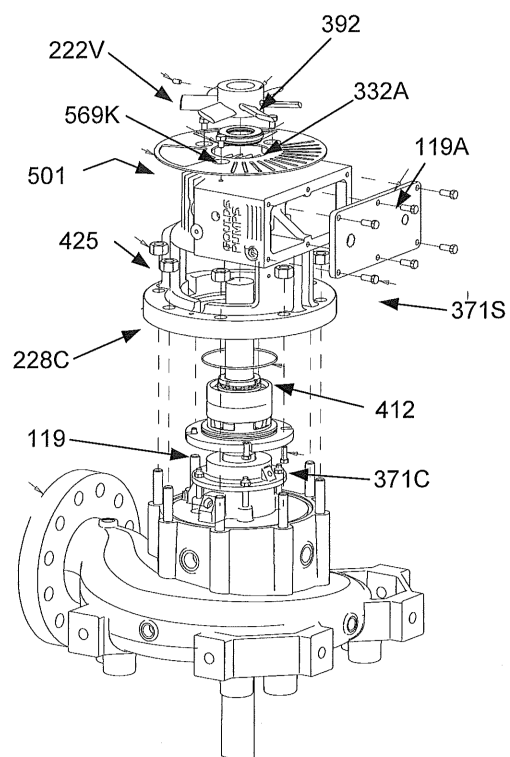
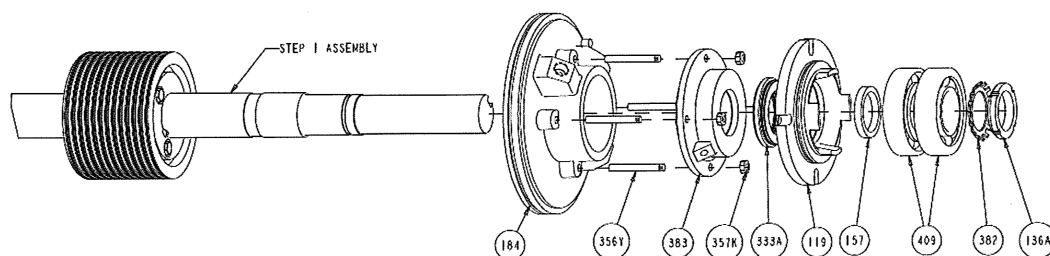
**NOTICE:**

The drain hole in the isolator must be at bottom dead center when the pump is in the horizontal position.

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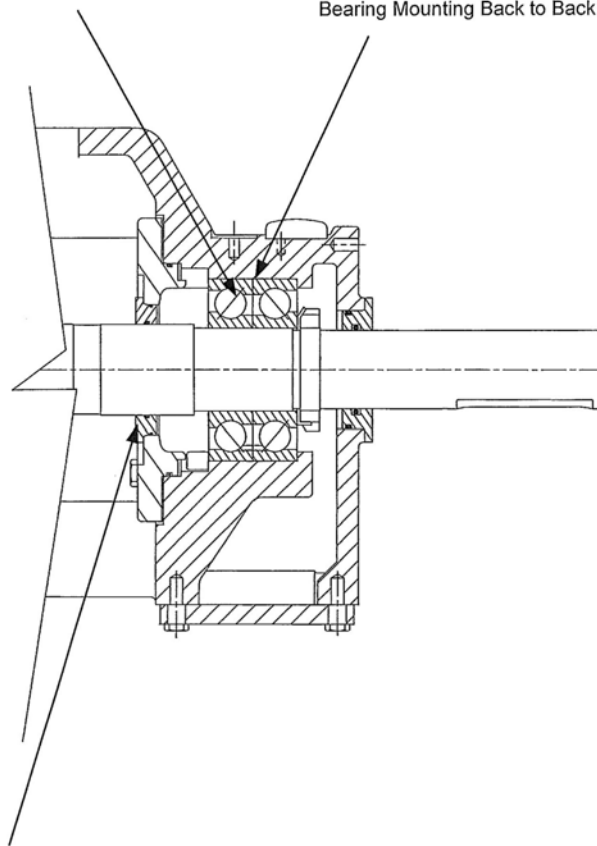
12. Replace cooling fan (392).
13. Mount coupling half (may preheat to max. 230°F).

14. Connect flush piping to gland.
15. Refit the seal guards (499).



Outer races have resistance when turned  
in opposite rotations by hand

Bearing Mounting Back to Back



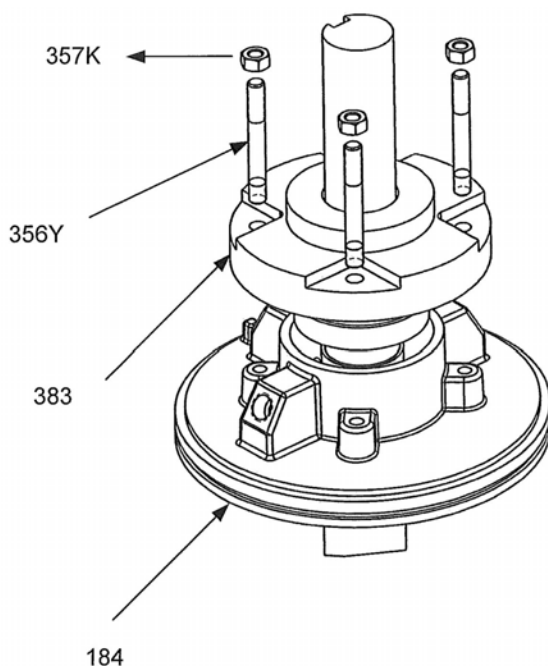
Install Isolator (333A) so that drain hole is at the bottom.

### 6.7.4 Assembly of mechanical seal - end and radial suction pumps

Mechanical seals are cartridge type seals and these instructions refer to cartridge seals. If other seals are used, refer to the seal manufacturer's instructions.

1. Lubricate the shaft with the assembly lubricant provided with the mechanical seal (383).
2. Slide seal over shaft and into position. Make sure gland connections are orientated properly for required flush piping.
3. Reinstall the bearings following appropriate bearing assembly instructions above depending on seal location and pump configuration.
4. Install and tighten seal chamber nuts (357K).
5. Tighten the set screws holding the seal to the shaft.
6. Remove setting clips and retain for future use.
7. Rotate the shaft to see that it turns smoothly.
8. Install flush piping to seal gland.
9. Install the seal guard (499). These are not shown but cover the openings in the bearing frame.





### 6.7.5 Assembly of the balance drum rotor and stator - end and radial suction pumps

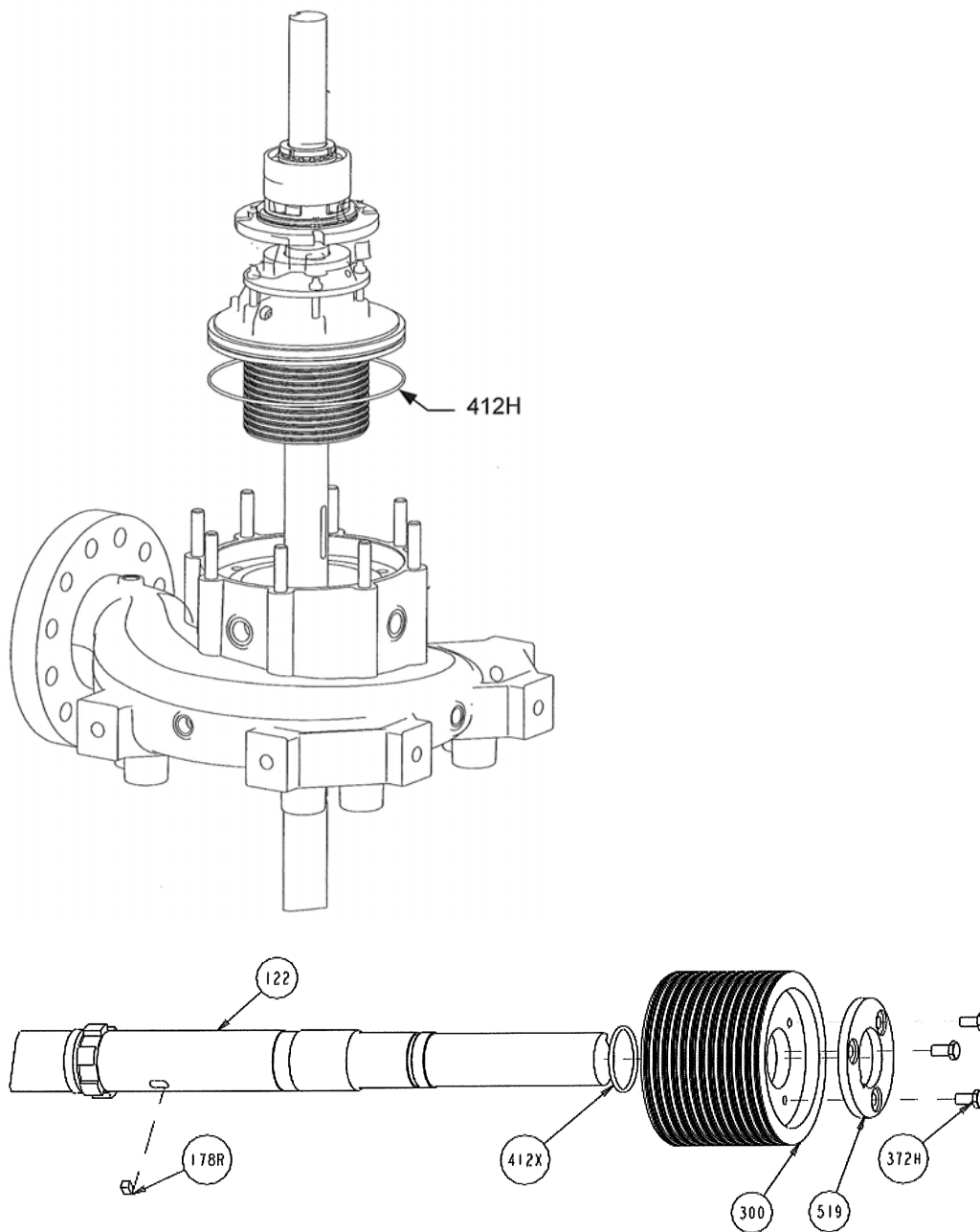
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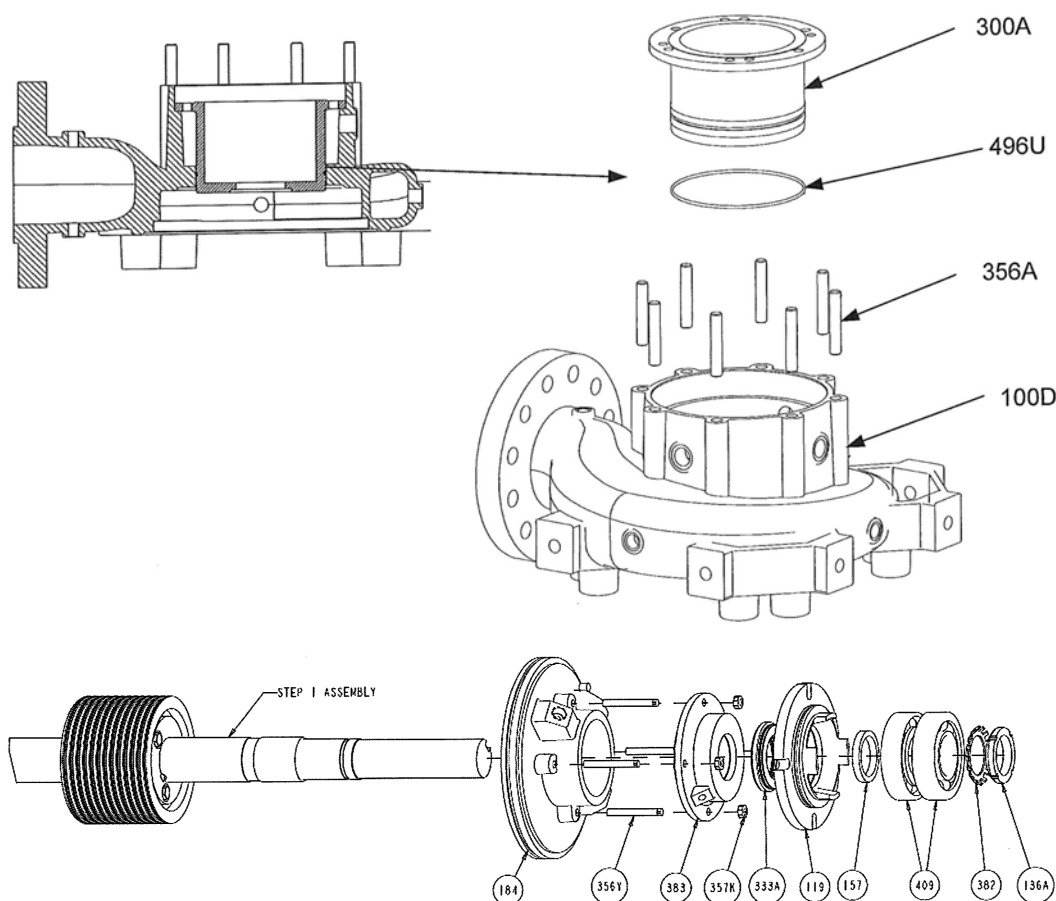
**NOTICE:**

Take care not to damage the shaft (122) during reassembly.

---

1. Replace balance drum stator (300A) and balance drum stator o-ring (496U).
2. Replace balance drum rotor (300) and balance drum rotor o-ring (4112X). Balance drum rotor must be rotated approximately 30° to lock it into place. Use the alignment marks placed during disassembly as a guide.
3. Insert balance drum locking plate key (178R) in shaft and slide balance drum locking plate (519) over key and secure it to balance drum with capscrews (372H).
4. Replace seal chamber (184) by inserting the lip on the flat surface of the seal chamber into the positioning groove in the balance drum stator.
5. Replace mechanical seal and gland as noted in instructions for assembly of mechanical seal.
6. Replace thrust end bearing housing as noted in instructions for assembly of thrust bearing (item 409).





## 6.7.6 Assembly of complete pump

### 6.7.6.1 End and radial suction configuration common assembly procedures

See "End Suction Configuration" or "Radial Suction Configuration" below for steps specific to end or radial suction configuration.

See **Appendix B** for running clearances

See relevant sectional drawing.

If the whole pump is to be assembled, it should be assembled in a vertical position. Start with the discharge casing facing down so that the side that mounts against the bearing housing is facing up. It is important that the pump be secured, stable and supported during assembly. A workbench with a hole (approximately W' larger than the shaft) is very helpful in such cases. A hoist or a second person is required for safe assembly.



#### **WARNING:**

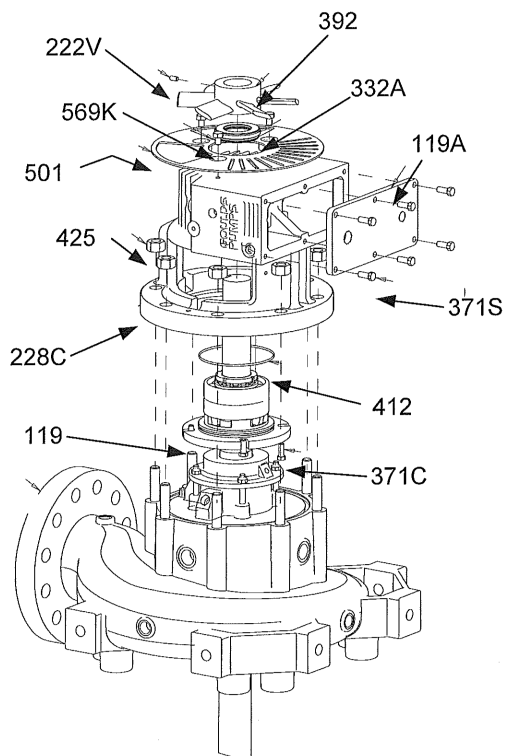
Make sure that the unit cannot roll or fall over and injure people or damage property.

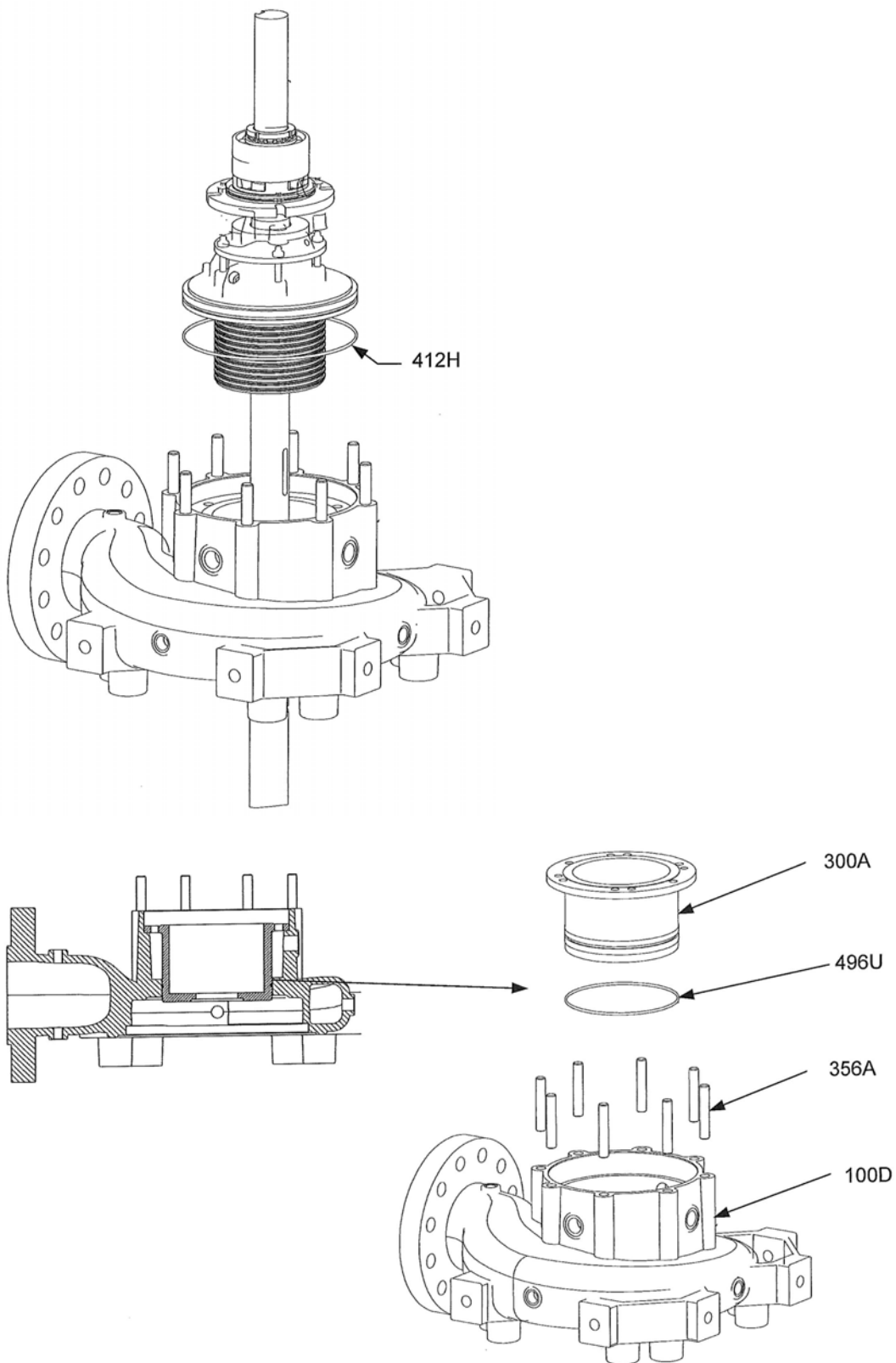
#### **NOTICE:**

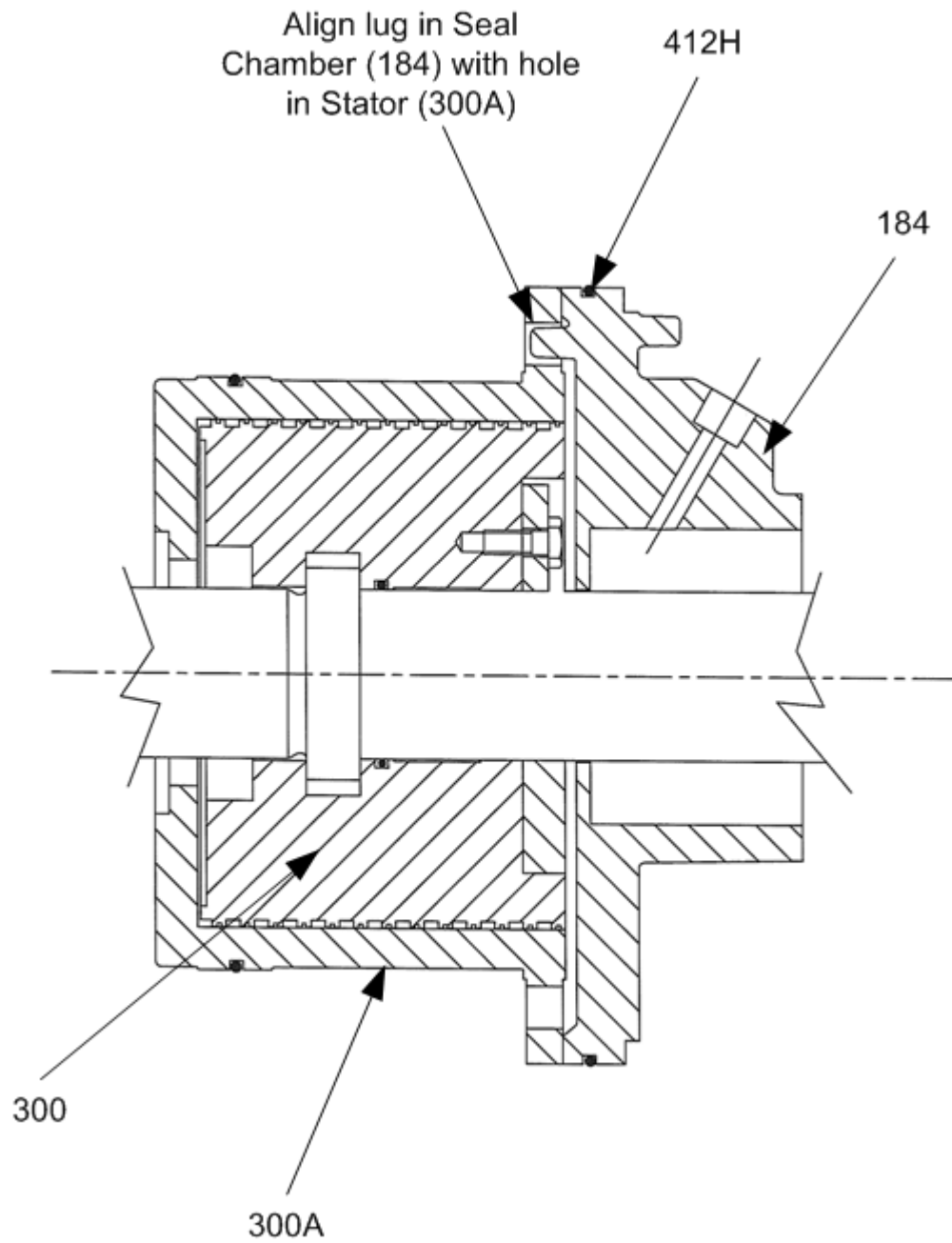
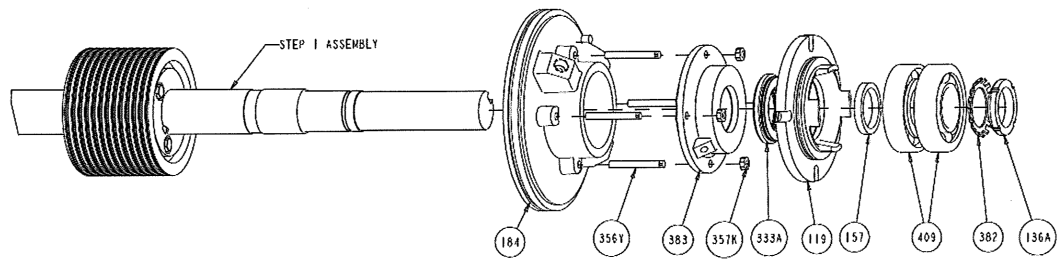
- Take care not to damage the shaft (122) during reassembly.
- Final stage diffuser is machined differently to fit into the discharge casing

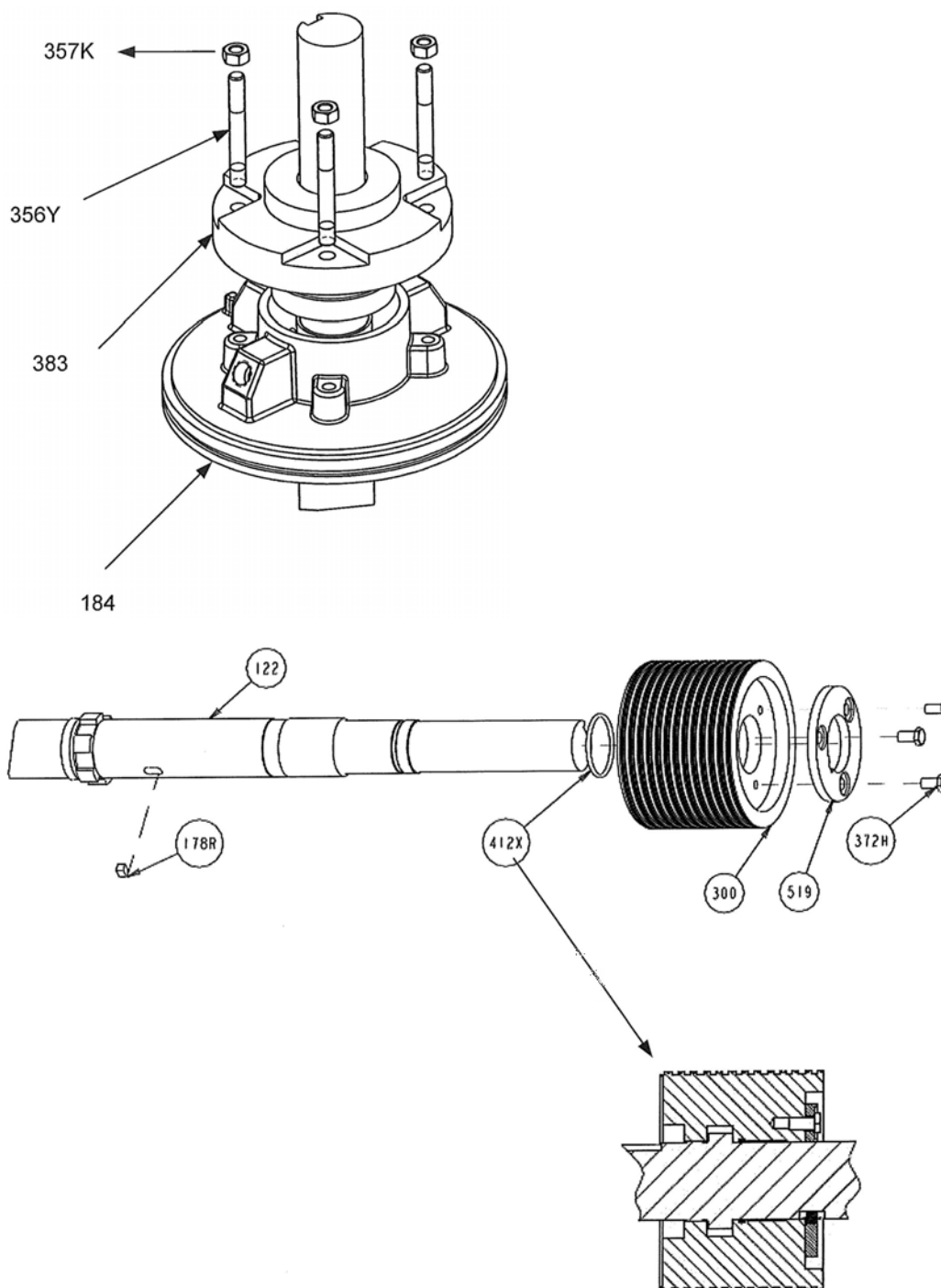
- First stage impeller may be different than remaining impellers
- Any trimmed impellers are to be located at the discharge end of the pump
- Ensure suction and discharge casings are in the proper orientation
- Follow torquing instructions and sequence and assembly checks in Appendix D.

1. Place balance drum stator (300A) and balance drum stator o-ring (496U) in the discharge casing.
2. Replace balance drum rotor (300) and balance drum rotor o-ring (412X) on the shaft. Balance drum rotor must be rotated approximately 30 degrees to lock it into place on the shaft. Use the alignment marks placed during disassembly as a guide. Make sure that shaft is braced to prevent it from rotating.
3. Insert balance drum locking plate key (178R) in shaft and slide balance drum locking plate (519) over key and secure it to balance drum with cap screws (372H).
4. Locate shaft approximately in the center of the discharge casing with the coupling end up.
5. Replace seal chamber (184) by inserting the lip on the flat surface of the seal chamber into the positioning hole in the balance drum stator.
6. Replace mechanical seal and gland as noted in instructions for assembly of mechanical seal.
7. Clean and lubricate the fitting surfaces between the bearing housing (228C) and discharge casing (110D).
8. Position the bearing cover (119) with the bearing isolator (333A) over the shaft.
9. Verify that the bearing spacer (157) is in place against the shaft shoulder.





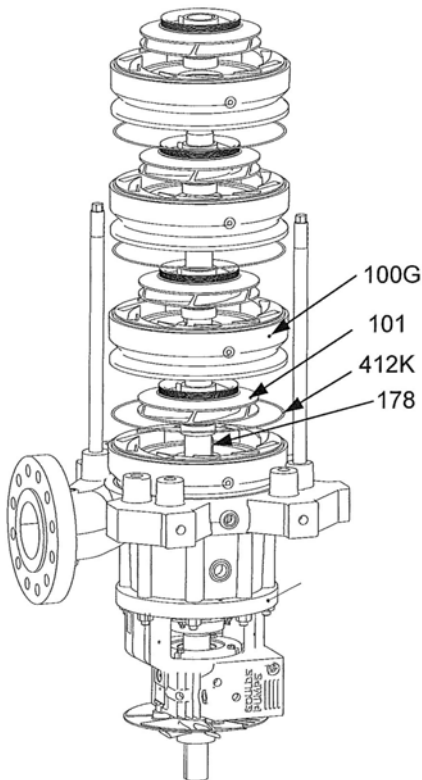




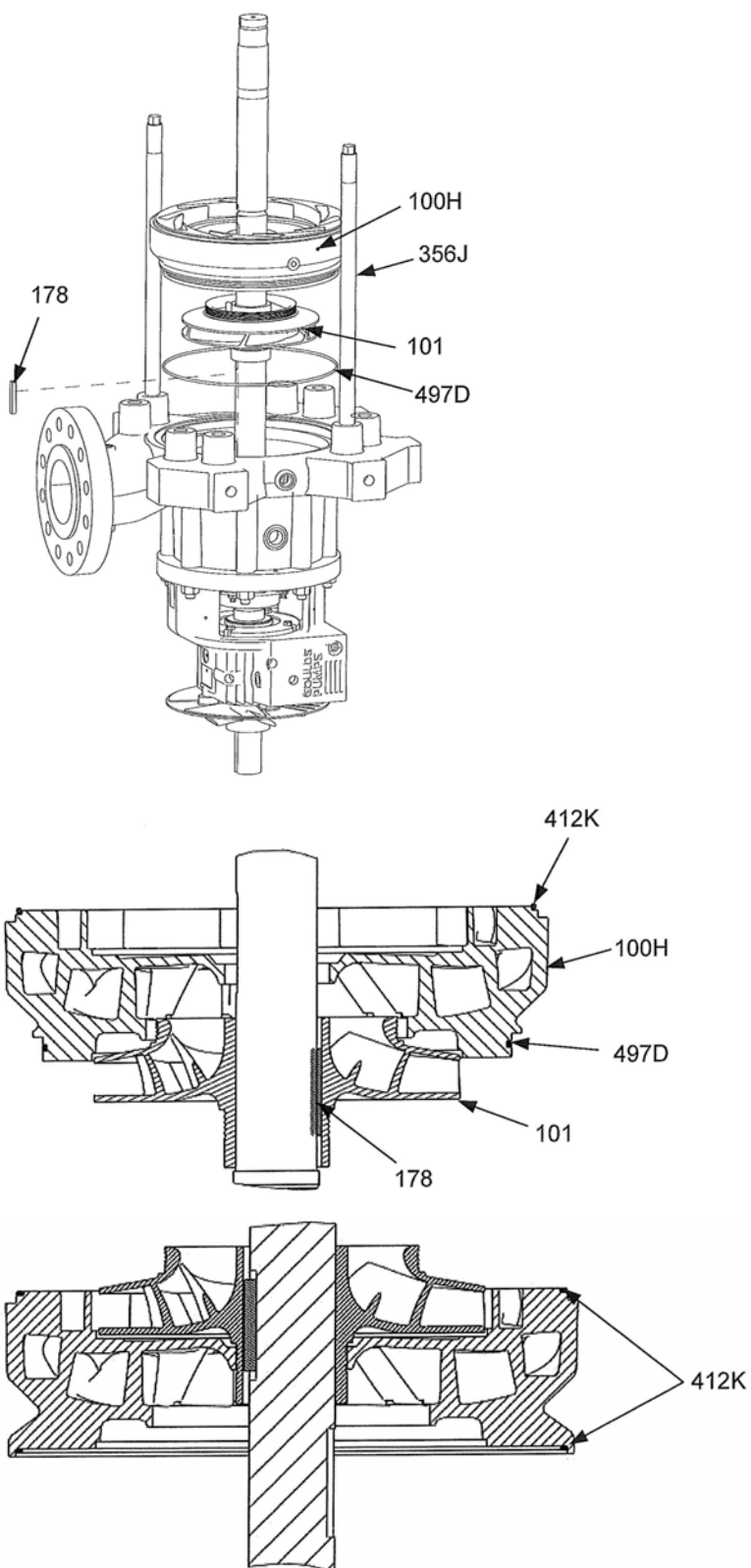
10. Preheat the new bearing (409) (max. 230°F) and slide onto the shaft (122) in a back to back arrangement.
11. Replace bearing lock washer (382) and bearing nut (136A).
12. Allow the bearings (409) to cool to room temperature.
13. Tighten the bearing locknut (136A) until resistance is felt when rotating the bearing outer races in opposite directions by hand. See illustration.
14. Replace the bearing bracket (228C) and align with the shaft (122) and seal chamber (184).
15. Reinstall and tighten nuts (425) to proper torque values.
16. Position bearing housing o-ring (412) and reinstall bearing housing cover (119) with cap screws (371C) and tighten to correct torque values.

The drain hole in the isolator must be at bottom dead center when the pump is in the horizontal position. Use Loctite® thread sealant 5699 or equal when installing the cap screws.

17. Replace cooling fan (392).
18. Refit the seal guards.
19. Rotate shaft (122) to see that it turns smoothly.
20. Reorient the assembly 180° so that the discharge casing is down and the shaft extends up.
21. Install last stage impeller (101) and key (178) into discharge casing (100D). Any impeller wear rings should have been installed first.
22. Install final stage piece (100H) and discharge casing o-ring (497D) and secure against discharge casing. Casing and stage piece wear rings should be installed prior to this step
23. Install remaining impellers (101), impeller keys (178), stage casings (100G) and stage casing o-rings (412K). Impellers should all butt up against one another.



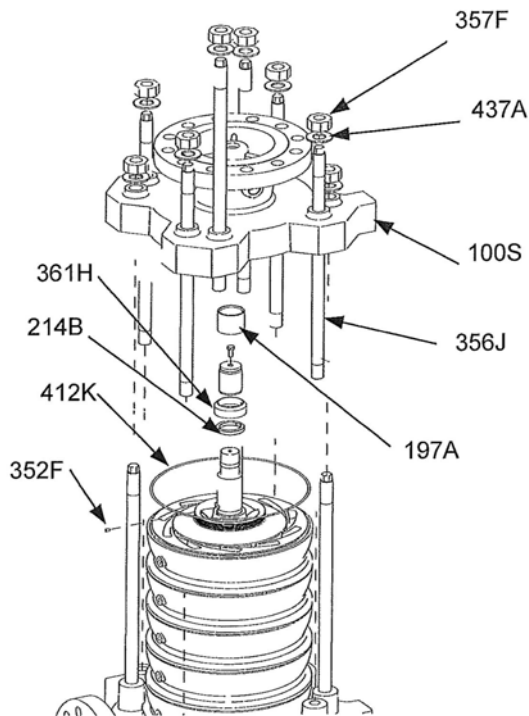


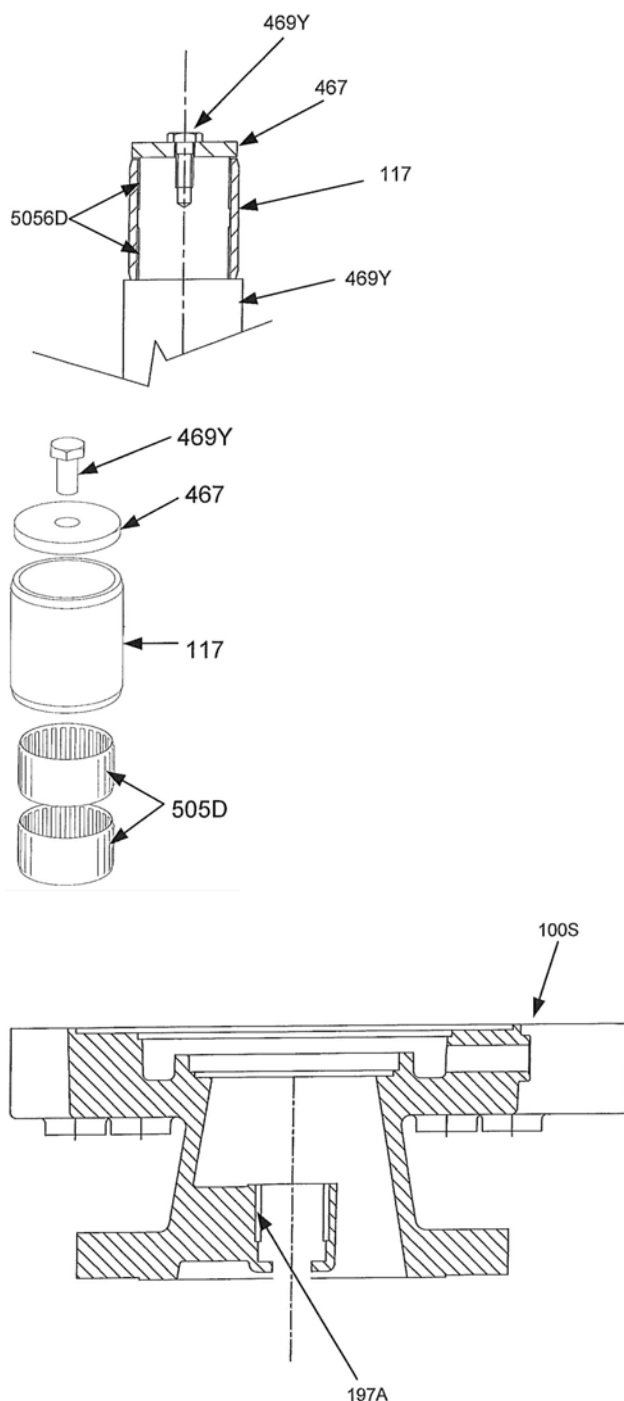


### 6.7.6.2 End Suction Configuration

First, complete the steps in "End and radial suction configuration common assembly procedures" before completing the steps below.

1. Clean the fitting surfaces between the bearing sleeve (197A) and suction casing (100S).
2. Coat the casing bearing bore and the outside of the stationary bearing (197A) with Loctite 635.
3. Insert bearing sleeve (197A) and tolerance ring (505D) into the casing sleeve retainer. Use care. This can be facilitated by placing the bearing sleeve in a freezer for approximately one hour and heating the suction casing with hot water. When the casing has been heated, insert the bearing sleeve into the casing bore. The greater the temperature difference between the bore and the sleeve, the easier it will be to insert the bearing sleeve. An assembly fixture that can aid in this portion of the assembly can be made or can be purchased from Goulds.
4. Replace tolerance rings (505D) and sleeve bearing (117) on the end of the shaft.
5. Replace cap screw (469Y) and retaining plate (467) on end of shaft.
6. Replace suction casing (100S) and align with shaft.
7. Install tie rods through the tie rod holes in the suction casing and secure them to the discharge casing by threading them into the casing using the flats on the tie rods to screw them into the discharge casing or by using the tie rod nuts (357F) and tie rod washers (437A).
8. Install tie rod nuts (357F) and tie rod washers (437A) on tie rods and tighten to correct torque values.  
See Appendix A for correct torque values and Appendix D for correct torqueing sequence.
9. Slide seal and gland into position over seal chamber studs (356Y) and install and tighten seal chamber nuts (357K).
10. Remove setting clips and retain for future use.
11. Spin shaft by hand to check for any binding or other potential problems.
12. Install flush piping to seal gland.





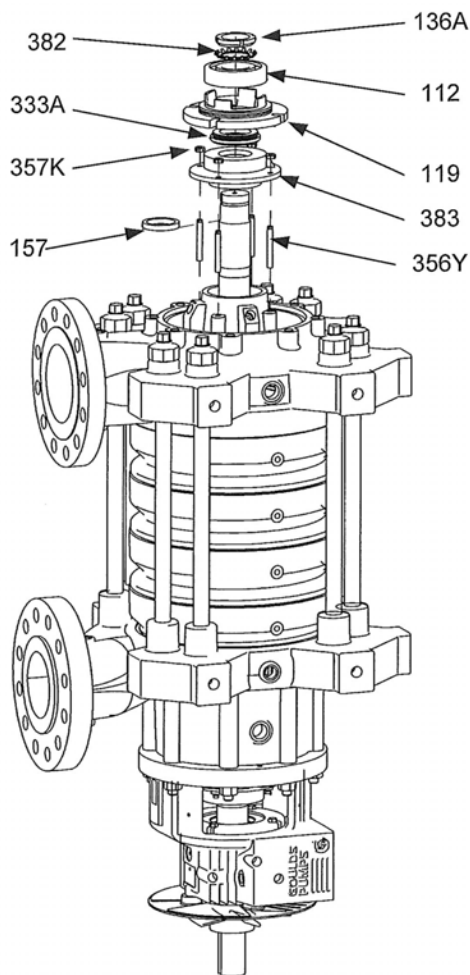
### 6.7.6.3 Radial Suction Configuration

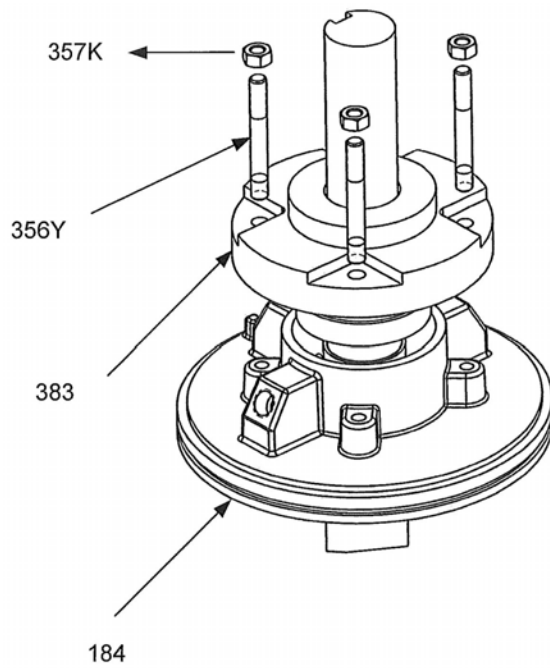
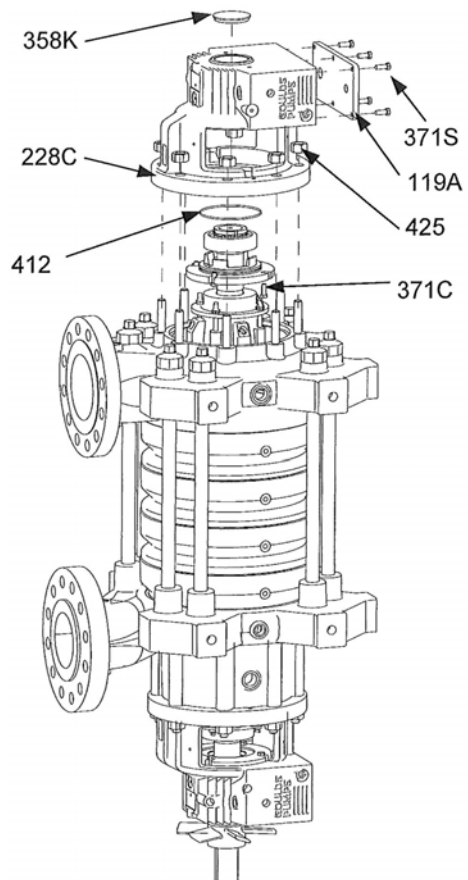
First, complete the steps in "End and radial suction configuration common assembly procedures" before completing the steps below.

1. Replace suction casing (100S) and align with shaft.
2. Install tie rods through the tie rod holes in the suction casing and secure them to the discharge casing by threading them into the casing using the flats on the tie rods to screw them into the discharge casing or by using the tie rod nuts (357F) and tie rod washers (437A).
3. Install tie rod nuts (357F) and tie rod washers (437A) on tie rods and tighten to correct torque values.

See Appendix A for correct torque values and Appendix D for correct torqueing sequence.

4. Install seal chamber studs (356Y) in radial suction casing.
5. Replace mechanical seal and gland as noted in instructions for assembly of mechanical seal.
6. Preheat the new bearing (112) (max. 230°F) and slide onto the shaft (122). Make sure bearing housing cover (119), inboard bearing isolator (333A) and bearing housing cover o-ring (412) are in place on the shaft before installing the bearing.
7. Install bearing nut (136A).
8. Install the bearing bracket (228C) and align with the shaft (122) and radial suction casing (100S).
9. Install bearing housing to casing studs (356J) and tighten nuts (425) to proper torque values.
10. Position bearing housing o-ring (412) and install bearing housing cover (119) using cap screws (371C).
11. Replace mechanical seal and gland as noted in instructions for assembly of mechanical seal.
12. Slide suction side mechanical seal (383) over shaft end and over the seal chamber studs. Install seal chamber nuts (357K) and tighten.
13. Slide discharge side mechanical seal (383) over shaft end and over the seal chamber studs. Install seal chamber nuts (357K) and tighten.
14. Remove setting clips on both seals and retain for future use.
15. Spin shaft by hand to check for any binding or other potential problems.
16. Connect flush piping to glands.





# 7 Troubleshooting

## 7.1 Alignment troubleshooting

Symptom	Cause	Remedy
Horizontal (side-to-side) alignment cannot be obtained (angular or parallel).	The driver feet are bolt-bound.	Loosen the pump's hold-down bolts, and slide the pump and driver until you achieve horizontal alignment.
	The baseplate is not leveled properly and is probably twisted.	<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>

## 7.2 Operation troubleshooting

Symptom	Cause	Remedy
The flow rate is too low.	The back pressure is too high.	Open the discharge valve a little further.
		Reduce the resistance in the discharge pipe. Clean the filter if necessary.
		Use a larger impeller. Make sure to take note of the available motor power.
	The speed is too low.	Increase the speed. Check the available motor power.
		Compare the speed of the motor with the specified pump speed. See the rating place.
		When you adjust the speed (frequency transformer), check the reference value settings.
	The impeller diameter is too small.	Use a larger impeller. Check the available motor power.
	The pump and/or pipes are not completely filled with liquid.	Fill the pump and/or pipes with liquid.
		Vent the pump and/or pipes.
	The pump or suction/intake pipe is blocked.	Clean the pipes.
	There is an air pocket in the pipeline.	Vent the pipes.
		Improve the pathway of the pipes.
	The NPSH is too low.	Increase the liquid level.
		Increase the suction pressure.
		Reduce the resistance in the intake/suction pipe. Change the course and pipe size, open the shutoff valves, and clean the filters.
	Air is being sucked into the pipes.	Increase the liquid level.
		Check that the suction pipe is vacuum-tight.
		Provide valves and fittings in the suction pipe with water seal.
	The direction of rotation is wrong.	Change the motor rotation.

Symptom	Cause	Remedy
	The inner components are suffering from wear.	Replace the worn parts.
	Density and/or viscosity of the pumped liquid is too high.	Seek assistance
The flow rate stops after a period of time.	The pump or suction/intake pipe is blocked.	Clean the pipes.
	The NPSH is too low.	Increase the liquid level.
		Increase the suction pressure.
		Reduce the resistance in the intake/suction pipe. Change the course and pipe size, open the shutoff valves, and clean the filters.
	Air is being sucked into the pipes.	Increase the liquid level.
		Check that the suction pipe is vacuum-tight.
		Provide valves and fittings in the suction pipe with water seal.
	The inner components are suffering from wear.	Replace any worn parts.
The head is too low.	The density and/or viscosity of the pumped liquid is too high.	Seek assistance.
	The back pressure and discharge pressure are too low.	Throttle the discharge valve.
	The speed is too low.	Increase the speed. Check the available motor power.
		Compare the speed of the motor with the specified pump speed. See the rating plate.
		When you adjust the speed (frequency transformet), check the reference value settings.
	The impeller diameter is too small.	Use a larger impeller. Make sure to check the available motor power.
	The pump and/or pipes are not completely filled with liquid.	Fill the pump and/or pipes with liquid.
		Vent the pump and/or pipes.
	The pump or suction/intake pipe are blocked.	Clean the pipes.
	There is an air pocked in the pipeline.	Vent the pipeline.
		Improve the path of the pipes.
	The NPSH of the system is too low.	Increase the liquid level.
		Increase the suction pressure.
		Reduce the resistance in the intake/suction pipe. Change the course and pipe size, open the shutoff valves, and clean the filters.
	Air is being sucked into the pipes.	Increase the liquid level.
		Check that the suction pipe is vacuum-tight.
		Provide valves and fittings in the suction pipe with water seal.
	The direction of rotation is wrong.	Change the motor rotation.

Symptom	Cause	Remedy
	The inner components are suffering from wear.	Replace the worn parts.
	The density and/or viscosity of the pumped liquid is too high.	Seek assistance.
The head is too high.	The speed is too high.	Reduce the speed.
		Compare the speed of the motor with the specified pump speed. See the rating plate.
		When you adjust the speed (frequency transformer), check the reference value setting.
	The impeller diameter is too large.	Use a smaller impeller.
The drive mechanism is overloaded	The back pressure and discharge pressure are too low.	Throttle the discharge valve.
	The speed is too high.	Reduce the speed.
		Compare the speed of the motor with the specified pump speed. See the rating plate.
		When you adjust the speed (frequency transformer), check the reference value setting.
	The impeller diameter is too large.	Use a smaller impeller.
	The density and/or viscosity of the pumped liquid is too high.	Seek assistance.
	The shaft seal is worn.	Replace the mechanical seal.
		Check the sealing, flushing, and cooling pipe (pressure).
		Avoid running the pump dry.
	There is not enough sealing.	Tighten the screws.
		Replace the mechanical seal.
	The discharge pressure is too low.	Increase the minimum amount being carried. Open the control valves and bypass piping.
	There is not enough hydraulic thrust balance.	Clean the relief holes in the impeller.
		Replace the worn impeller and wear rings.
The pump is not running quietly.	The pump and/or pipes are not completely filled with liquid.	Fill with liquid
		Vent the pump and/or pipes.
	The NPSH is too low.	Increase the liquid level.
		Increase the suction pressure.
		Reduce the resistance in the intake/suction pipe. Change the course and pipe size, open the shutoff valves, and clean the filters.
	The inner components are suffering from wear.	Replace the worn parts.
	Forces in the pipeline are too high and the pump is under strain.	Change the position of the support pipes and use compensators.
		Check that the foundation plate and frame are properly cast and in place.



Symptom	Cause	Remedy
	There is too much, not enough, or the wrong type of lubricant.	Change the lubricant.
	The electrical supply is incorrect.	Check the voltage of all phases (2-phase running).
		Check the cable connections.
		Check the fuses.
	The sealing is insufficient.	Tighten the screws.
		Replace the mechanical seal.
	There is not enough hydraulic thrust balance.	Clean the relief holes in the impeller.
		Replace the worn impeller and wear rings.
	There is system-related vibration (resonance).	Seek assistance.
	The pump casing becomes warm during operation.	The pump or suction/intake pipe is blocked
The NPSH is too low.		Increase the liquid level.
		Increase the suction pressure.
		Reduce the resistance in the intake/suction pipe. Change the path and pipe size, open the shutoff valves, and clean the filters.
The inner components are suffering from wear.		Replace the worn parts.
There is system-related vibration (resonance).		Seek assistance.
The temperature in the shaft sealing area is too high.	The shaft seal is worn.	Replace the mechanical seal.
		Check the sealing, flushing, and cooling pipe (pressure).
		Do not run the pump dry.
	There are lines and rough spots on the shaft or shaft sleeve.	Replace the worn parts.
	There are deposits on the mechanical seal.	Clean the mechanical seal.
		Replace the mechanical seal if necessary.
		Provide additional rinsing or quench.
	The coupling is not aligned.	Align the pump.
The temperature at the bearing is too high.	The back pressure is too high.	Open the discharge valve more.
		Reduce resistance in the discharge pipe. Clean the filter if necessary.
		Use a larger impeller. Make sure to note the available motor power.
	The back pressure and the discharge pressure are too low.	Throttle the discharge valve.
	The speed is too high.	Reduce the speed.
		Compare the speed of the motor with the specified pump speed. See the rating plate.
When you adjust the speed (frequency transformer), check the reference value setting.		

Symptom	Cause	Remedy
	The inner components are suffering from wear.	Replace the worn parts.
	The forces in the pipeline are too high and the pump is under strain.	Change the position of the support pipes and use compensators.
		Check that the foundation plate and frame are properly cast and in place.
	There is either too much, too little, or the wrong type of lubricant.	Change the lubricant.
	The electrical supply is not correct.	Check the voltage of all phases (2-phase running).
		Check the cable connections.
		Check the fuses.
	There is not enough sealing.	Tighten the screws.
		Replace the mechanical seal.
	The bearing is damaged.	Replace the bearing.
		Check the lubricant and bearing space for pollutants. Rinse the oil area.
The pump is leaking.	There is not enough sealing.	Clean the relief holes in the impeller.
		Replace the worn impeller and wear rings.
	There is system-related vibration (resonance).	Seek assistance.
	There is not enough sealing.	Tighten the screws.
		Replace the mechanical seal.
There are leaks at the shaft seal.	The discharge pressure is too high.	Reduce the amount of pressure that is carried. Throttle the control valve.
	The shaft seal is worn.	Replace the mechanical seal.
		Check the sealing, flushing, and cooling pipes (pressure).
		Do not run the pump dry.
	There are deposits on the mechanical seal.	Clean the mechanical seal.
		Replace the mechanical seal if necessary.
		Provide additional rinsing or quench if necessary.
	The impeller is out of balance.	Remove any blocks or deposits.
		Replace the impeller if it is broken or unevenly worn.
		Check the shafts to make sure that they are running true.
	The coupling is not aligned.	Align the pump.
	The coupling distance is too small.	Correct this.
	Forces in the pipeline are too high and the pump unit is under strain.	Change the position of the support pipes and use compensators.
		Check that the foundation plate and frame are properly cast and in place.
	There is not enough sealing.	Tighten the screws.
		Replace the mechanical seal.



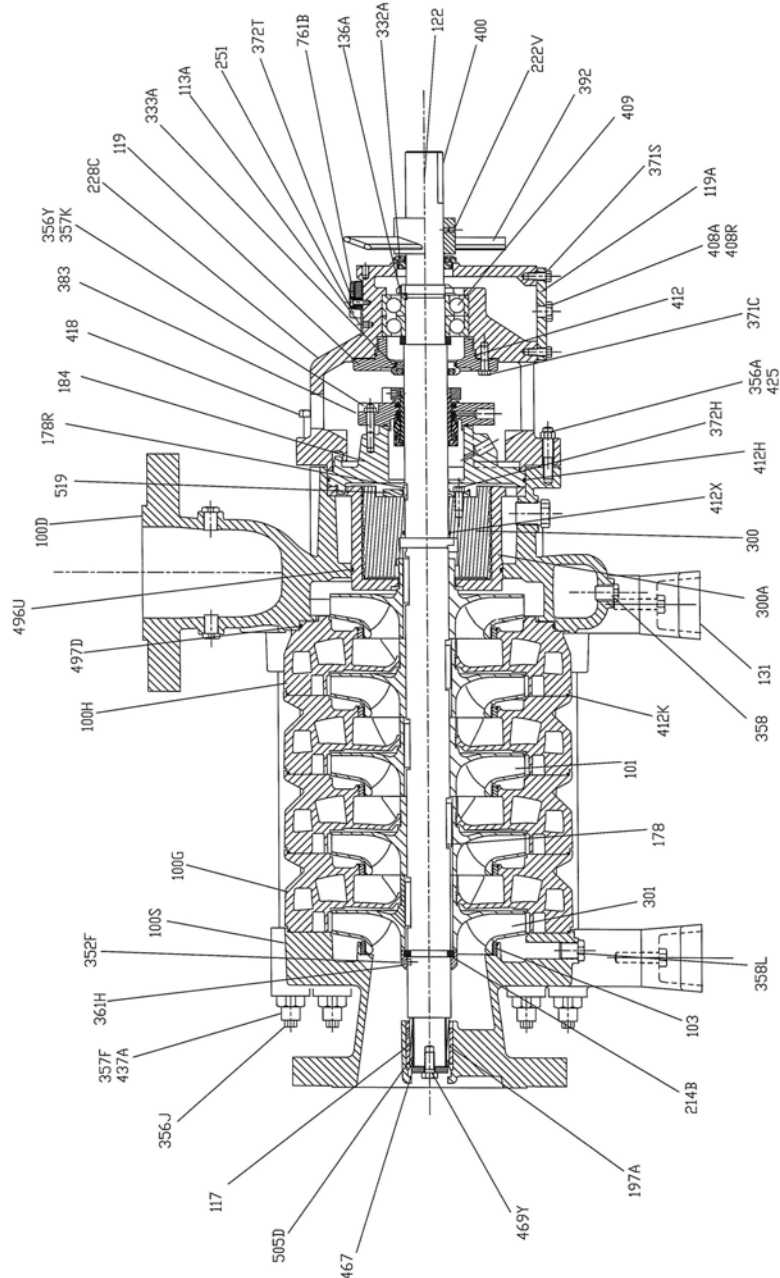


Figure 27: End Suction Pump

Table 8: Parts List

Item Number	Description	Quantity
100B	1st Stage Remachine for Plan 11 takeoff (optional)	1
100D	Casing (Discharge)	1
100G	Diffuser Stage Casing	stage dependent
100H	Diffuser Final Stage Casing	1
100S	Casing (Suction)	1
100X	Casing (Destaging and Takeoff - Optional)	stage dependent
101	Impeller (Series)	stage dependent
103	Case Wear Ring (Standard Clearance)	stage dependent

Item Number	Description	Quantity
112	Ball Bearing (Radial)	1
113A	Breather	1 ES / 2 RS
117	Bearing Sleeve (End Suction Only)	1
119	Cover (Bearing Housing)	1 ES / 2 RS
119A	Cover (Bearing Housing Sump)	1 ES / 2 RS
122	Shaft	1
131	Foot	2
136A	Bearing Lock Nut	1
142	Impeller Wear Ring (Optional)	stage dependent
157	Bearing Spacer	2
178	Key (Impeller)	stage dependent
178R	Key (Balance Drum)	1
184	Seal Chamber	1
197A	Bearing Bushing (End Suction Only)	1
214B	Split Ring	1
222V	Set Screw (Fan) On 5"(125) and 6"(150) pumps only	1
228C	Bearing Housing	1 ES / 2 RS
251	Oiler (Constant Level)	1 ES / 2 RS
300	Balance Drum	1
300A	Balance Drum Stator	1
332A	Bearing Isolator (Outboard)	1
333A	Bearing Isolator (Inboard)	1 ES / 2 RS
352F	Set Screw (Retaining Ring)	1
356A	Stud (Bearing Housing to Suction/Discharge Casing)	8 ES / 16 RS
356J	Tie Rod	8
356Y	Stud (Seal Chamber)	8
357F	Nut (Tie Rod)	8
357K	Nut (Seal Chamber)	8
358	Drain Plug (Casing)	3
358A	Plug (Seal Chamber Flush)	2
358C	Plug (Destage Casing - optional)	stage dependent
358K	Plug (Bearing Housing Opening)	1 ES / 2 RS
358L	Plug (Balance Return)	4
358M	Plug (Casing Branch Tapping)	4
361H	Retaining Ring	1
371C	Cap Screw (Bearing Housing Cover)	8
371S	Cap Screw (Bearing Housing Sump Cover)	12
372H	Cap Screw (Balance Drum Locking Plate)	3
372T	Cap Screw (i-ALERT to Bearing Housing)	2
382	Bearing Lock Washer	2
383	Mechanical Seal	1 ES / 2 RS
392	Fan (Brg. Cooling)	1
400	Key (Coupling)	1
409	Ball Bearing (Thrust)	1
412	O Ring (Bearing Housing Cover)	2
412H	O Ring (Seal Chamber)	1

Item Number	Description	Quantity
412K	O Ring (Diffuser Stage Casing)	stage dependent
412X	O Ring (Balance Drum)	1
418	Cap Screw (Bearing Housing Jacking)	4
424	Screw (Shaft Guard - Optional)	2 ES / 4 RS
425	Nut (Bearing Housing to Suction/Discharge Casing)	8 ES / 16 RS
437A	Washer (Tie Rod)	8
467	Retaining Plate (Bearing Bushing) End Suction Only	1
469Y	Cap Screw (Retaining Plate to Shaft) End Suction Only	1
477	Sleeve (Destaging and Takeoff - optional)	stage dependent
496Y	O Ring (Balance Drum Stator)	1
497D	O Ring (Discharge Casing)	1
499	Guard (Shaft - Optional)	2 ES / 4 RS
505D	Tolerance Ring (Bearing Sleeve) End Suction Only	2
519	Locking Plate (Balance Drum)	1
534C	Bolt Retainer (Guard to Bearing Housing)	3
569F	Cap Screw (Guard to Bearing Housing)	3
761B	<i>i-ALERT</i> <sup>TM</sup>	1 ES / 2 RS

### SPARE AND REPAIR PARTS

Spare parts stock should be based on customer's operating experience, risk assessment, cost of down-time and part lead times. In the absence of this information, the following is offered as a guideline. The quantities shown are on a per pump basis. Items with an asterisk should be multiplied by the number of stages. For multiple pump installations, the total quantity can be reduced.

Part Name	Start Up Spares	1 year operation	2 year operation	Export
Mechanical Seal	1	1	1	1
Impeller*	1	1	1	1
Case Wear Ring*	1	1	1	2
Stage Piece*	-	-	(# stages -2) / 3	(# stages -2) / 2
Final Stage Piece	-	-	1	1
Radial Bearing	1	1	1	1
Thrust Bearing	1	1	2	2
Balance Drum	1	1	1	1
Sleeve Bearing (ES)	1	1	1	1

# 9 Appendix

## 9.1 Torque Values

### Appendix A

Item #	Part Description	Fastener Size	Carbon Steel Class 8.8 Torque		Stainless Steel Class 70 Torque		Pump Size			
			ft-lbs	N-m	ft-lbs	N-m	2.5x4.8	4x5-10	5x6-11	6x8-13
							2.5x5-8	4x6-10	5x8-11	6x10-13
356A 425	Stud / Nut Bearing Housing to Casings	M16x2	81	110			X	X		
		M20x2.5	163	221					X	
		M24x3	281	381						X
356Y 357K	Stud / Nut Seal Chamber	M8x1			6.6	9	X			
		M12x1.7 5			24	32		X	X	X
372H	Cap Screw Balance Drum to Locking Plate	M10x1.5			14.0	19	X	X	X	X
371C	Cap Screw Bearing Housing Cover	M10x1.5			14.0	19	X	X		
		M12x1.7 5			24	32			X	X
371S	Cap Screw Bearing Housing Sump	M10x1.5			14.0	19	X	X		
		M12x1.7 5			24	32			X	X
469Y	Cap Screw Retain- ing Plate to Shaft	M10x1.5			14.0	19	X	X	X	X
569F	Cap Screw Guard to Bearing Housing	M6x1			3.0	4	X	X	X	X
136A	Locknut Bearing	M40x1.5	65	88			X			
		M45x1.5	75	101				X		
		M55x2	105	142					X	
		M70x2	175	237						X
356J 357F	Tie-Rod / Tie Rod Nut	20x2.5	163	221			X			
		24x3	281	381				X		
		30x3.5	559	758					X	
		36x4	976	1324						X

Item #	Part Description	Fastener Size	A108		Pump Size			
			ft-lbs	N-m	2.5x4.8	4x5-10	5x6-11	6x8-13
					2.5x5-8	4x6-10	5x8-11	6x10-13
372V	Pump hold down bolts	5/8-11	81	110	X	X		
		1-8	163	221			X	X

## 9.2 Running clearances

### Appendix B

Table 9:

		English Units (inches)				Metric Units (mm)			
	Diametric Clearance	2.5x4-8	4x5-10	5x6-11	6x8-13	2.5x4-8	4x5-10	5x6-11	6x8-13
Impeller or Wear Ring to Casing Wear Ring Normal Clearance	Normal	0.012	0.013	0.014	0.015	0.30	0.33	0.35	0.38
	Replace	0.024	0.026	0.028	0.030	0.60	0.66	0.70	0.76
Impeller Hub to Diffuser	Normal	0.020	0.020	0.020	0.020	0.50	0.50	0.50	0.50
	Replace	0.040	0.040	0.040	0.040	1.00	1.00	1.00	1.00
Balance Drum to Stator	Normal	0.016	0.016	0.016	0.016	0.40	0.40	0.40	0.40
	Replace	0.032	0.032	0.032	0.032	0.80	0.80	0.80	0.80
Suction Bearing Bushing to Sleeve (ES)	Normal	0.004	0.004	0.004	0.004	0.10	0.10	0.10	0.10
	Replace	0.008	0.008	0.008	0.008	0.20	0.20	0.20	0.20

## 9.3 Maximum allowable forces and moments

### Appendix C

Table 10: Suction Nozzle Configuration (English units)

		Forces (lbf)				Moments (ft-lbs)			
	Flange Size (in)	Fx	Fy	Fz	Σ F	Mx	My	Mz	Σ M
Horizontal nozzle parallel to the shaft (ES)	5	550	440	360	790	1340	685	1020	1820
	6	700	560	460	1010	1700	870	1300	2310
	8	1100	850	700	1560	2600	1300	1900	3500
	10	1500	1200	1000	2200	3700	1800	2800	5000
Vertical nozzle perpendicular to the shaft (RS)	4	320	260	400	570	980	500	740	1330
	5	440	360	550	790	1340	685	1020	1820
	6	560	460	700	1010	1700	870	1300	2310
	8	850	700	1100	1560	2600	1300	1900	3500
Horizontal nozzle perpendicular to the shaft (RS)	4	320	400	260	570	980	500	740	1330
	5	550	440	360	790	1340	685	1020	1820
	6	560	700	460	1010	1700	870	1300	2310
	8	850	1100	700	1560	2600	1300	1900	3500

Table 11: Suction Nozzle Configuration (Metric units)

		Forces (N)				Moments (Nm)			
	Flange Size (in)	Fx	Fy	Fz	Σ F	Mx	My	Mz	Σ M
Horizontal nozzle parallel to the shaft (ES)	5	2446	1957	1601	35140	1816	928	1382	2466
	6	3114	2491	2046	4492	2304	1179	1762	3130
	8	4893	3781	3114	6939	3523	1762	2575	4743
	10	6672	5338	4448	9786	5014	2439	3794	6775



		Forces (N)				Moments (Nm)			
Vertical nozzle perpendicular to the shaft (RS)	4	1423	1156	1779	2535	1328	678	1003	1802
	5	1957	1601	2446	3514	1816	928	1382	2466
	6	2491	2046	3114	4492	2304	1179	1762	3130
	8	3781	3114	4893	6939	3523	1762	2575	4743
Horizontal nozzle perpendicular to the shaft (RS)	4	1423	1779	1156	2535	1328	678	1003	1802
	5	2446	1957	1601	3514	1816	928	1382	2466
	6	2491	3114	2046	4492	2304	1179	1762	3130
	8	3781	4893	3114	6939	3523	1762	2575	4743

**Table 12: Discharge Nozzle Configuration (English units)**

		Forces (lbf)				Moments (ft-lbs)			
	Flange Size (in)	Fx	Fy	Fz	Σ F	Mx	My	Mz	Σ M
Vertical nozzle perpendicular to the shaft (ES and RS)	2.5	200	165	250	360	520	260	395	705
	4	320	260	400	570	980	500	740	1330
	5	440	360	550	790	1340	685	1020	1820
	6	560	460	700	1010	1700	870	1300	2310
Horizontal nozzle perpendicular to the shaft (ES and RS)	2.5	200	165	250	360	520	260	395	705
	4	320	400	260	570	980	500	740	1330
	5	440	550	360	790	1340	685	1020	1820
	6	560	700	460	1010	1700	870	1300	2310

**Table 13: Discharge Nozzle Configuration (Metric units)**

		Forces (N)				Moments (Nm)			
	Flange Size (in)	Fx	Fy	Fz	Σ F	Mx	My	Mz	Σ M
Vertical nozzle perpendicular to the shaft (ES and RS)	2.5	890	734	1112	1601	705	352	535	955
	4	1423	1156	1779	2535	1328	678	1003	1802
	5	1957	1601	2446	3514	1816	928	1382	2466
	6	2491	2046	3114	4492	2304	1179	1762	3130
Horizontal nozzle perpendicular to the shaft (ES and RS)	2.5	890	734	1112	1601	705	352	535	955
	4	1423	1779	1156	2535	1328	678	1003	1802
	5	1957	2446	1601	3514	1816	928	1382	2466
	6	2491	3114	2046	4492	2304	1179	1762	3130

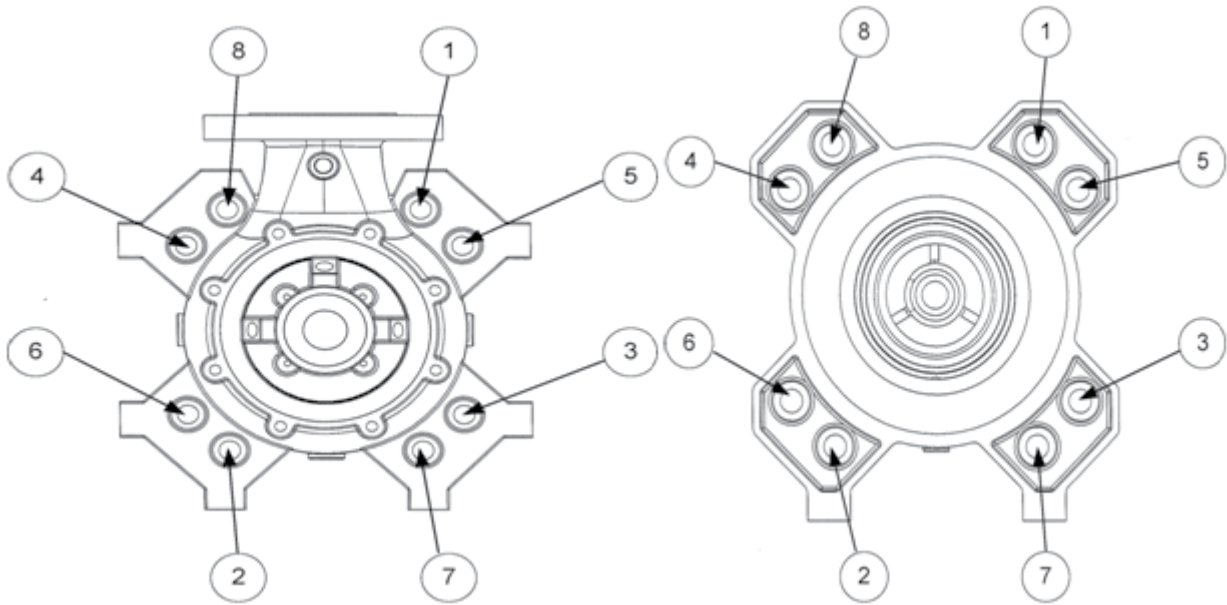
## 9.4 Tie-Rod Torque Specifications and Procedure

### Appendix D

Model	Size (mm)	English units		Metric units	
		50% ft-lb	100% ft-lb	50% N-m	100% N-m
2.5x4-8 (65)	20x2.5	N/A	163	N/A	221
4x5-10 (100)	24x3	140	281	191	381

Model	Size (mm)	English units		Metric units	
5x6-11 (125)	30x3.5	280	559	379	758
6x8-13 (150)	36x4	488	976	662	1324

Mark casings as shown below and apply torque values in this sequence or as noted in the instructions below.



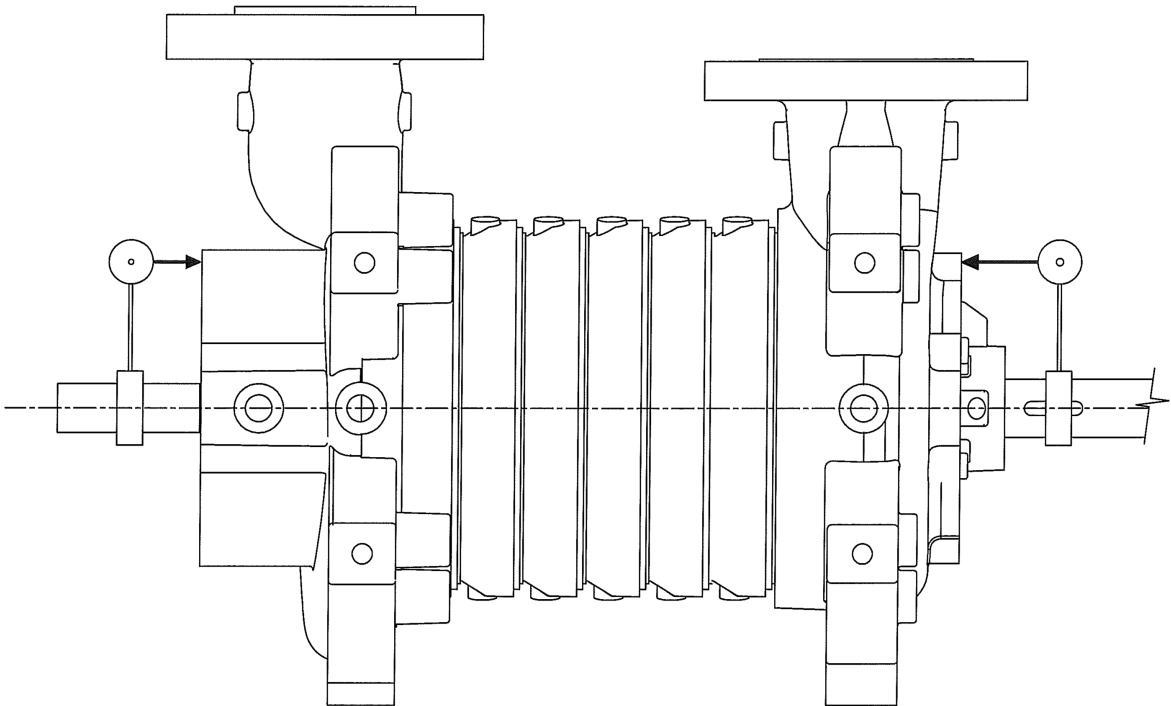
### NOTICE:

Check torquing tools to ensure the calibration dates are current; the use of an impact wrench is not allowed for torquing hardware.

- Using a cross bolt pattern as noted in the figures above, carefully mate the components in the liquid end stack to ensure proper metal to metal contact of the assembly.
- Use tie bolts nuts 1 thru 4 as shown.
- Bring nuts up evenly by hand with a wrench
- Snug nuts with wrench by hand to approx. 20 to 30 ft-lb.
- Mount suction and discharge casing feet in final location.
- Place liquid end assembly horizontally on a milled surface (the baseplate supplied with the pump can be used).
- Check flatness of casing feet against the milled surface with a feeler gauge. If not flat, carefully and evenly loosen the four tie bolt nuts just enough to allow the casing feet to be moved so they are flat on the milled surface of the table. Variation is to be  $\leq 0.003$  in. If greater than 0.003 in, reface to meet requirements or replace casing feet.
- Once the feet are flat on the table, retighten tie rod nuts 1 thru 4 in the manner defined above.
- Tighten tie rod nuts 5 thru 8 in the same manner.
- Tighten all eight tie rod nuts in sequence shown in Figure above by hand with torque wrench to approximately 50 ft-lb.
- Mount dial indicators to shaft, measure and record the bearing housing face run-out on the suction and discharge casings (see sketch below). If any readings exceed 0.005 in, stop and address the issue. Note: Because there are no bearings mounted at this time, the shaft will need to be pushed inward from the discharge end until it stops. Set the gauges to zero and record the readings every 90°.

**NOTICE:**

End suction pumps will only have a reading on the discharge side.



12. Using a torque wrench, torque the tie rod nuts in the following three increments using the sequence shown in Figure above: a. 100 ft-lb. b. 50% of full torque (if applicable). c. 100% of full torque.

**Table 14:**

Model	Size (mm)	English Units		Metric Units	
		50% ft-lb	100% ft-lb	50% N-m	100% N-m
2.5x4-8 (65)	20x2.5	N/A	163	N/A	221
4x5-10 (100)	24x3	140	281	191	381
5x6-11 (125)	30x3.5	280	559	379	758
6x8-13 (150)	36x4	488	976	662	1324

13. Re-check flatness of casing feet against the milled surface with a feeler gauge. Max variation is to be  $\leq 0.003$  in.
14. Re-mount dial indicators to shaft and measure and record the bearing housing face on the suction and discharge casings again. If any readings exceed 0.005 in, stop the build and address the issue.

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