

 **GOULDS PUMPS**

Installation, Operation and Maintenance Instructions

3996



ITT

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1 Introduction and Safety

1.1 Introduction

Purpose of this manual

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

- Installation
- Operation
- Maintenance



CAUTION:

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

NOTICE:

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

1.1.1 Requesting other information

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

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

1.2 Safety



WARNING:

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

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



CAUTION:

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



WARNING:

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

1.2.1 Safety terminology and symbols

About safety messages

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

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

Hazard levels

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

Hazard categories

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

Electrical hazards are indicated by the following specific symbol:



ELECTRICAL HAZARD:

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

- Crush hazard
- Cutting hazard
- Arc flash hazard

1.2.1.1 The Ex symbol

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



1.2.2 Environmental safety

The work area

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

Waste and emissions regulations

Observe these safety regulations regarding waste and emissions:

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



WARNING:

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

Electrical installation

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

1.2.2.1 Recycling guidelines

Always follow local laws and regulations regarding recycling.

1.2.3 User safety

General safety rules

These safety rules apply:

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

Safety equipment

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

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

Electrical connections

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

Noise



WARNING:

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

Temperature



WARNING:

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

1.2.3.1 Precautions before work

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

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

1.2.3.2 Precautions during work

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



CAUTION:

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

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

1.2.3.3 Hazardous liquids

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

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

1.2.3.4 Wash the skin and eyes

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

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

1.2.4 Ex-approved products

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

Personnel requirements

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

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

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



Product and product handling requirements

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

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

1.3 Product warranty

Coverage

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

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

Limitations

The warranty does not cover faults caused by these situations:

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

ITT assumes no liability for these situations:

- Bodily injuries
- Material damages
- Economic losses

Warranty claim

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

1.4 Ex Considerations and Intended Use

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



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

Personnel requirements

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

- All work on the product must be carried out by certified electricians and ITT-authorized mechanics. Special rules apply to installations in explosive atmospheres.
- All users must know about the risks of electric current and the chemical and physical characteristics of the gas, the vapor, or both present in hazardous areas.

- Any maintenance for Ex-approved products must conform to international and national standards (for example, EN 60079-17).

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

Product and product handling requirements

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

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

Description of Ex-Directives

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

Guidelines for compliance

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

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

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

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

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

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

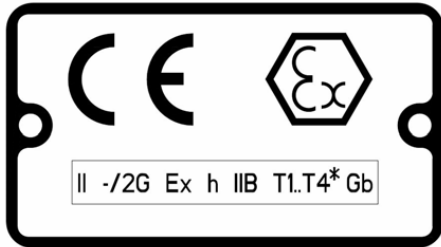


Figure 1: Typical Ex nameplate



Figure 2: Typical UKCA Ex nameplate

Table 1: Temperature class definitions

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

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

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

ISO 80079-37:2016 Section 5.7

Recommended bearing replacement interval (based on L10 life) = 17,520 hours of operation.

2 General Information

2.1 Introduction

This instruction manual is intended to assist those involved with the installation, operation, and maintenance of Goulds Model 3996 pumps. It is recommended that this manual be thoroughly reviewed prior to installing or performing any work on the pump or motor.

2.1.1 Importance of Instructions

The design, material and workmanship incorporated in the construction of Goulds pumps makes them capable of giving long, trouble-free service. The life and satisfactory service of any mechanical unit, however, is enhanced and extended by correct application, proper installation, periodic inspection and careful maintenance. This instruction manual was prepared to assist operators in understanding the construction and correct methods of installing, operating and maintaining these pumps.

Study thoroughly the following sections and carefully follow the instructions for installation and operation. Keep this instruction manual handy for reference. Further information can be obtained by contacting the Engineering Application Division, Goulds Pumps, Inc., Seneca Falls, New York 13148, or your local branch office.

NOTICE:

Goulds Pumps will not be liable for any damages or delay caused by failure to comply with the provisions of this instruction manual. This pump is not to be operated at speeds, working pressures, discharge pressures or temperatures higher than, nor used with liquids other than stated in the original order acknowledgement without written permission of Goulds Pumps.

2.1.2 Receiving Inspection

Care should be taken when unloading pumps. If shipment is not delivered in good order and in accordance with the Bill-of-Lading, note the damage or shortage on both receipt and freight bill. Make any claims to the transportation company promptly.

Instruction sheets on various components as well as the Installation, Operation and Maintenance (IOM) Manual for the pump are included in the shipment. Do not discard!

2.1.3 Preservation and Storage

Goulds' normal domestic storage preparation is suitable for protecting the pump during shipment in covered trucks. It also provides protection during covered storage at the jobsite, and for a short period between installation and start-up.

If the pump is to be idle and exposed to the elements for an extended period, either before or after installation, special precautions are required. One approach is to provide special preservatives and wrapping before shipment. However, after installation, the protective wrappings will have been removed. Therefore, application of preservatives after installation is considered a good practice. Information about various long-term preservation and storage options available can be obtained from your local Goulds representative.

The driver, coupling, and mechanical seal manufacturers should be contacted for their recommendations on preservations and protection procedures.

2.1.4 Handling Techniques

Care should be used in moving pumps. Where required by size of units, slings should be put under both pump and motor, as shown in [2.2.2 Handling on page 13](#).

2.2 Receiving the Pump

Inspect the pump as soon as it is received. Carefully check that everything is in good order. Make notes of damaged or missing items on the receipt and freight bill. File any claims with the transportation company as soon as possible.

2.2.1 Storage Requirements

Short Term (Less than 6 months)

Goulds normal packaging procedure is designed to protect pump during shipping. Upon receipt, store in a covered and dry location.

Long Term (More than 6 months)

Preservative treatment of bearings and machined surfaces will be required. Rotate shaft several times every 3 months. Refer to driver and coupling manufacturers for their long term storage procedures. Store in a covered and dry location.

NOTICE:

Long term storage treatment may be purchased with initial pump order.

Units with drivers mounted are moved with slings under the pump casing and driver.

2.2.2 Handling



WARNING:

Pump and components are heavy. Failure to properly lift and support equipment could result in serious physical injury, or damage to pumps.

Use care when moving pumps. Lifting equipment must be able to adequately support the entire assembly. Hoist bare pump using suitable hooks through the holes in the frame mounted support or suitable slings through the large openings in the casing mounted support.

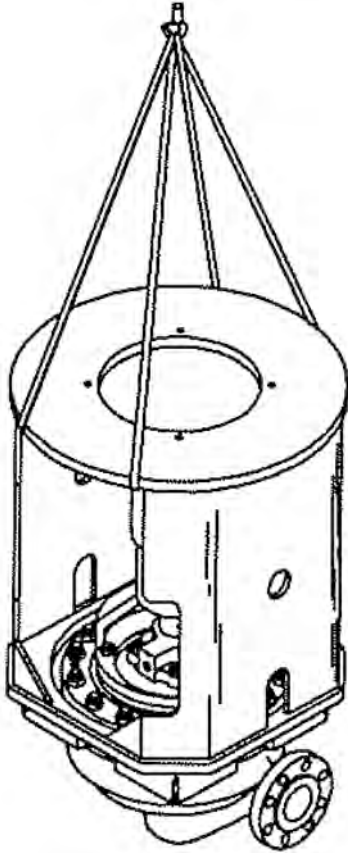


Figure 3: Casing Mounted Support

Units with drivers mounted are moved with slings under the pump casing and driver.

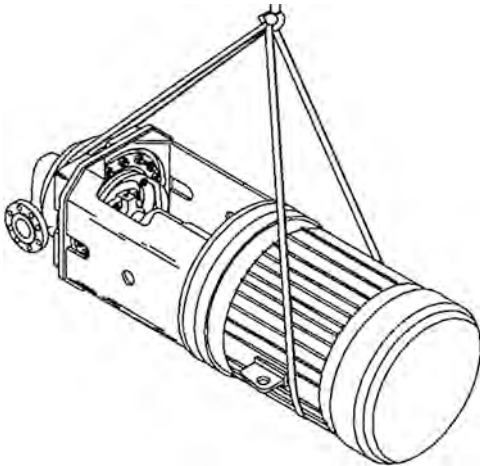


Figure 4: Sling under Pump Casing

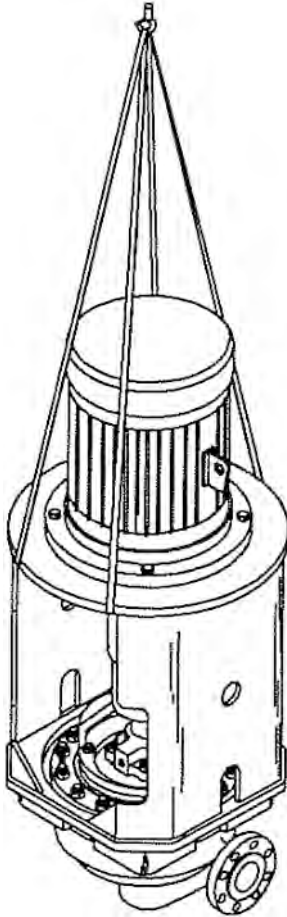


Figure 5: Sling under Driver

Or with hooks through the holes in the frame mounted support or with slings through the large openings in the casing mounted support.



WARNING:



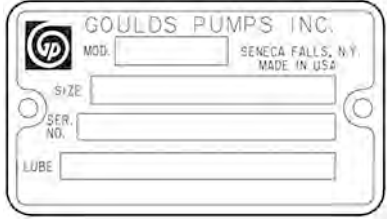
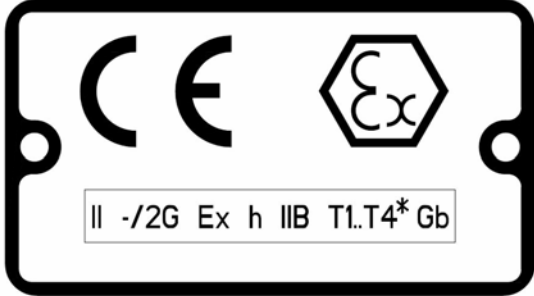

Units with drivers mounted can be top heavy. Driver weight could cause the assembled unit to overturn and could result in serious physical injury, or damage to pumps.

2.3 Nameplate Information

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

When ordering spare parts, you will need to identify pump model, size, serial number, and the item number of required parts. Information can be taken from the pump casing tag. Item numbers can be found in this manual.

2.3 Nameplate Information

Description	Example
<p>Pump Casing Tag - provides information about the pump's hydraulic characteristics. Note the format of the pump size: Discharge x Suction - Nominal maximum impeller diameter in inches. (Example: 2x3-8)</p>	 <p>Figure 6:</p>  <p>Figure 7:</p>
<p>Bearing Frame Tag - provides information on the lubrication system used</p>	 <p>Figure 8:</p>
<p>Ex Tag - if applicable, your pump unit may have the Ex tag affixed to the pump and/or baseplate. See the safety section for a description of the symbols and codes</p>	 <p>Figure 9:</p>
<p>Ex Tag - if applicable, your pump unit may have the UKCA Ex tag affixed to the pump and/or baseplate. See the safety section for a description of the symbols and codes</p>	

3 Installation

**WARNING:**

When pumping unit is installed in a potentially explosive atmosphere, the instructions after the Ex symbol must be followed. Personal injury and/or equipment damage may occur if these instructions are not followed. If there is any question regarding these requirements or if the equipment is to be modified, please contact a Goulds representative before proceeding.

3.1 Site/Foundation

3.1.1 Location

Pumping unit should be placed as close as practical to the source of supply. Floor space and head room allotted to the unit must be sufficient for inspection and maintenance. Be sure to allow for crane or hoist service.

**WARNING:**

All equipment being installed must be properly grounded to prevent unexpected static electric discharge.

3.1.2 Foundation and Baseplate

Model 3996 In-Line pumps are designed to be mounted directly in, and supported by the piping. No supports under the pump are required. Pipe supports should be located close to the pump and be designed to support the weight of the complete unit (pump and motor).

3.2 Piping

Guidelines for piping are given in the "Hydraulic Institute Standards," available from:

Hydraulic Institute 30200 Detroit Road

Cleveland, OH 44145-1967

and must be reviewed prior to pump installation.

**WARNING:**

Never draw piping into place by forcing at the flanged connections of the pump. This may impose dangerous strains on the unit and cause misalignment between pump and driver. Pipe strain will adversely affect the operation of the pump resulting in physical injury and damage to the equipment.

1. Piping runs should be as short as possible to minimize friction losses.
2. It is suggested that expansion loops be properly designed and installed in suction and/or discharge lines when handling liquids at elevated temperatures, so thermal expansion of piping will not draw pump out of alignment.
3. The piping should be arranged to allow pump flushing prior to removal of the unit on services handling hazardous liquids.
4. Carefully clean all pipe parts, valves and fittings, and pump branches prior to assembly.
5. All piping must be supported independently of, and line up naturally with, the pump flanges. Table below shows piping flange alignment criteria.

Table 2: Piping Flange Alignment

Type	Criteria
Axial	Flange gasket thickness \pm 0.8 mm 0.03 in.
Parallel	0.001 mm/mm 0.001 in./in. of flange diameter to a maximum of 0.8 mm 0.03 in.
Concentric	Flange bolts should easily install by hand.

- Bottom of casing should be supported by a solid foundation or casing feet should be used.

3.2.1 Suction Piping



WARNING:

NPSHA must always exceed NPSHR as shown on Goulds performance curves received with order. (Reference Hydraulic Institute for NPSH and pipe friction values needed to evaluate suction piping).

NOTICE:



Pump must never be throttled from suction side.

Properly designed and installed suction piping is a necessity for trouble-free pump operation. Suction piping should be flushed BEFORE connection to the pump.

- Use of elbows close to the pump suction flange should be avoided. There should be a minimum of two (2) pipe diameters of straight pipe [five (5) pipe diameters is preferred] between the elbow and suction inlet. Where used, elbows should be long radius.
- Use suction pipe one (1) or two (2) sizes larger than the pump suction, with a reducer at the suction flange. Suction piping should never be of smaller diameter than the pump suction.
- Reducers, if used, should be eccentric and located at the pump suction flange with sloping side down.
- A suction screen should be installed prior to initial start-up and when suction system has been opened for work. The screen should be of the cone type with a net area equal to at least three (3) times the cross sectional area of the suction pipe. The mesh of the screen should be sized to prevent particles larger than 1.6 mm (1/16 in.) from entering the pump and should be installed in a spool piece to allow removal for cleaning. The screen should remain in the system until periodic inspection shows system is clean.
- Separate suction lines are recommended when more than one pump is operating from the same source of supply.

Suction Lift Conditions

- Suction pipe must be free from air pockets.
- Suction piping must slope upwards to pump.
- All joints must be air tight.
- A means of priming the pump must be provided.

Suction Head/Flooded Suction Conditions

- An isolation valve should be installed in the suction line at least two (2) pipe diameters from the pump suction to permit closing of the line for pump inspection and maintenance.

2. Keep suction pipe free from air pockets.
3. Piping should be level or slope gradually downward from the source of supply.
4. No portion of the piping should extend below pump suction flange.
5. The size of entrance from supply should be one (1) or two (2) sizes larger than the suction pipe.
6. The suction pipe must be adequately submerged below the liquid surface to prevent vortices and air entrainment at the supply.

3.3 Discharge Piping

Properly designed and installed discharge piping is a necessity for trouble-free pump operation. Discharge piping should be flushed BEFORE connection to the pump.

1. Isolation and check valves should be installed in discharge line. Locate the check valve between isolation valve and pump; this will permit inspection of the check valve. The isolation valve is required for priming, regulation of flow, and for inspection and maintenance of pump. The check valve prevents pump or seal damage due to reverse flow through the pump when the driver is turned off.
2. Increasesers, if used, should be placed between pump and check valves.
3. Cushioning devices should be used to protect the pump from surges and water hammer if quick-closing valves are installed in system.

3.3.1 Bypass Piping

Systems that require operation at reduced flows for prolonged periods should be provided with a bypass line connected from the discharge side (before any valves) to the source of suction.

A minimum flow orifice can be sized and installed in bypass line to preclude bypassing excessive flows. Consult nearest sales office or factory for assistance in sizing orifice.

An automatic recirculation control valve and/or solenoid operated valve should be considered if a constant bypass (i.e. orifice) is not possible.

3.3.2 Auxiliary Piping

Auxiliary piping may be required for seal chamber cover cooling, mechanical seal flush or other special features supplied with the pump. Consult pump data sheet for specific auxiliary piping recommendations.

If seal chamber cover cooling is required, follow guidelines listed below.

1. Flows of 4 l/min. (1 GPM) will generally satisfy cooling requirements.
2. Cooling water pressure should not exceed 7.0 kg/cm² (100 psig).

3.3.3 Final piping check

After connecting the piping to pump:

1. Rotate shaft several times by hand to be sure that there is no binding and all parts are free.
2. Check alignment, per alignment criteria outlined previously, to determine if pipe strain has affected alignment. If pipe strain exists, correct piping.

3.4 Alignment

Alignment between pump and motor is built in by use of machined lock fit between the C-face motor and motor support. No further alignment is normally required.

There is one exception to this. The Model 3196 horizontal ANSI pump bearing frame can be used in the Model 3996. This frame may be used in emergencies or when it is desired to minimize inventory. The

Model 3196 frame will not give built-in alignment, and normal alignment procedures must be performed. The Model 3196 frame can be identified by the foot and cooling jacket on the side.

3.4.1 Shaft Alignment

Many users now require a 0.002" T.I.R. alignment to gain a greater mean time between failure (MTBF). All 3996's that have been shipped after 1/9/90 have been aligned at the factory to .002" T.I.R.

Assembly procedures have been developed to align the pump shaft and the driver shaft to .002" T.I.R. Each pump is assembled using a torque range of +10% of the recommended torque value of the bolts. If .002" T.I.R. alignment is required by the customer, a final alignment must be done in the field.

The following is the procedure that has been developed for the use in the field and on our assembly floor to obtain 0.002" shaft to shaft alignment.

3.5 3996 Shaft Alignment Procedure

1. Inspect all machined fits for signs of contamination or damage. All fits must be clean. If the pump is new this step is not necessary.
2. Loosen all motor, motorsupport, and casing bolts, but do not remove.

NOTICE:

Make sure jack bolts on the casing are backed off.

3. Move shaft assembly (shaft, housing, and impeller) away from casing angle face, by adjusting the bearing housing. A 1/4 turn of bearing housing jack bolts is sufficient to ensure the impeller does not ride on the casing angle face. Proper indication cannot be done with the impeller touching the angle face.
4. Tighten motor hold down bolts in a criss cross pattern to the recommended torque. (Refer to the Fastener Size and Recommended Torque Values)
5. Tighten the motor support bolts in a criss cross pattern to 90% of the recommended torque value of the bolts. For example, if the recommended torque value for the bolts is 60 ft.-lbs., tighten bolts to 54 ft.-lbs.
6. Tighten casing bolts in a criss cross pattern to 90% of the recommended torque value.
7. Attach a dial indicator to the driver shaft and mark the pump shaft so the indicator always contacts the same location on the pump shaft.
8. Rotate both shafts in the same direction and record the indicator readings every 90 degrees (4 places).
- 9.

Incrementally increase the torque value and begin to tighten the necessary bolts to bring the shafts into alignment. Do not exceed 110% of the recommended torque values. After each series of tightening, repeat Step #5 until the desired alignment is achieved.

NOTICE:

Indicate off the hub to the motor lock I.D., in the motor support, when supplying the pump less motor.

10. Reset the clearance between the impeller and casing angle face to .008 (.015 if using the high temperature option). Ensure the bearing housing jack bolts are secured.

NOTICE:

Tighten coupling bolts and hub set screw onto shaft. Torquing of these components is not done at the factory, yet is required at the site. Please reference the coupling manufacturers instructions for correct torque levels.

Table 3: Fastener Size and Recommended Torque Values

Fastener Standard	Fastner Nominal Size	Recommended Torque* ¹ lb.-ft.
SAE	5/16	6
	3/8	10
	7/16	18
	1/2	27
	5/8	53
	3/4	94
	7/8	152
	1	228

For lubricated, plated, or PFTE-coated threads, use 75% of torque values shown.

4 Operation

4.1 Preparation for Startup

4.1.1 Checklist



WARNING:

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

1. Checking Rotation



CAUTION:

Serious damage may result if pump is run in the wrong rotation.

1. Lock out power to driver.



WARNING:

Lock out driver power to prevent accidental start-up and physical injury.

2. Make sure coupling hubs are securely fastened to the shafts and the coupling spacer has been removed.

NOTICE:

Pump is shipped with coupling spacer removed.

3. Unlock driver power.
 4. Make sure everyone is clear. Jog driver just long enough to determine the direction of rotation. Rotation must correspond to arrow on bearing housing.
 5. Lock out power to driver.
2. Lubrication



WARNING:

Bearings must be lubricated properly in order to prevent excess heat generation, sparks and premature failure.

Grease Lubrication

- Greased lubricated ball bearings are standard on the Model 3996 units.
- The bearings are greased at the factory.
- See Preventive Maintenance section for lubrication recommendations.

Pure Oil Mist Lubrication

- Pure oil mist is an optional feature for the Model 3996. Follow oil mist generator manufacturer's instructions. The inlet and outlet connections are located on the side of the bearing frame.

- See Preventive Maintenance section for lubrication recommendations and connection locations.

**WARNING:**

Operation of the unit without proper lubrication will cause bearing failure and pump seizure.

3. Alignment - As described in the Alignment section, alignment is normally built-in and need not be rechecked.
4. Stuffing Box - Pumps are shipped without packing, lantern ring or split gland installed. These are included with the box of fittings shipped with the pump and must be installed before start-up.

**WARNING:**

Packed stuffing boxes are not allowed in an ATEX classified environment.

**WARNING:**

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

1. Packing - Stuffing box packing, lantern ring and gland are in the box of fittings supplied with the pump. Install 3 rings of packing, the two piece lantern ring (notched sides facing), 2 more rings of packing and the gland. Twist rings sideways instead of straight out when putting them on the shaft to avoid damaging them. Seat each ring firmly as it is installed, and stagger the joints 90°. Gland should be drawn up only finger tight.

Packing must not run dry. If the pumped liquid is clean, gland leakage of 40-60 drops per minute is satisfactory. If the liquid is dirty, connect a clean liquid flush to the lantern ring connection to keep solids out of the packing.

Occasionally, the stuffing box is below atmospheric pressure (suction under vacuum, etc.). Under these conditions, supply sealing liquid through a line from the discharge of the pump to the lantern ring connection. Leakage from the box can be piped away through the ½ inch drain connection in the casing.

2. Mechanical Seals - When mechanical seals are supplied, they are installed in the pump. Mechanical seals must not run dry, or in abrasives. Connect recirculation, flush and/or cooling flows as required, following instructions on the seal print supplied for the order.
5. Stuffing Box Lubrication/Cooling - Check to be sure that any required auxiliary piping is installed and functioning. If cooling and/or flushing from an outside source is being used, establish these flows.
6. Check Impeller Clearance -

**WARNING:**

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

Prior to starting the pump, the impeller clearance must be checked. The pump efficiency is maintained when the proper impeller clearance is set. The optimum hydraulic performance is attained by setting the impeller front clearance at the factory to predetermined limits which are consistent with service conditions.

The maximum impeller setting should not be set more than .005 inch | 0.13 above values in the table below or significant performance degradation will result.



WARNING:

Service temperature in an ATEX classified environment is limited to the area classification specified on the ATEX tag affixed to the pump (reference Fastener Size and Recommended Torque Values in 3.5 3996 Shaft Alignment Procedure on page 20 for ATEX classifications).

Also, for pumpage temperatures above 200° F | 93°C the cold (ambient) setting must be increased per table below. This is necessary to prevent the impeller from contacting the casing due to differential expansion from the higher operating temperatures.

Table 4: Impeller Clearances - Cold Temperature Clearances for Various Service Temperatures

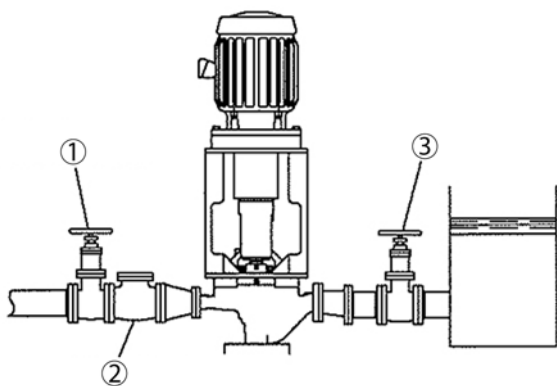
Service Temperature	ST		MT	
	inches	mm	inches	mm
From -20 to 150°F (-29 to 66°C)	0.005	0.13	0.008	0.20
Up to 175°F (79°C)	0.005	0.13	0.008	0.20
Up to 200°F (93°C)	0.005	0.13	0.008	0.20
Up to 250°F (121°C)	0.006	0.16	0.009	0.23
Up to 300°F (149°C)	0.007	0.19	0.010	0.26
Up to 350°F (177°C)	0.009	0.22	0.012	0.29
Up to 400°F (204°C)	0.010	0.25	0.013	0.32
Up to 450°F (232°C)	0.011	0.28	0.014	0.35
Up to 500°F (260°C)	0.012	0.30	0.015	0.38

7. Couple Pump and Driver



WARNING:

Lock out driver power to prevent accidental rotation and physical injury.



- 1. Discharge isolation valve
- 2. Check valve
- 3. Suction isolation valve

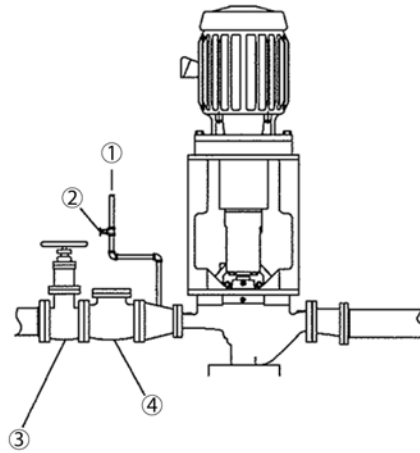
Figure 10:



WARNING:

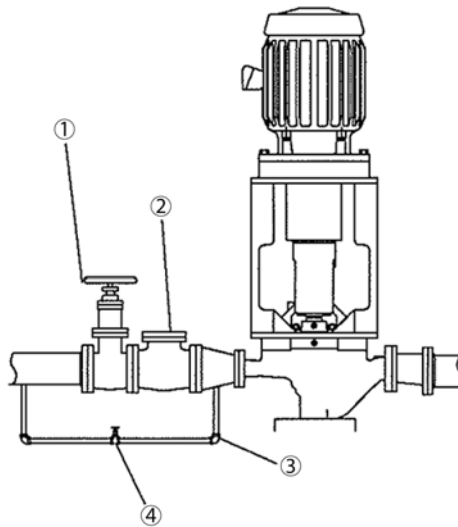
The coupling used in an ATEX classified environment must be properly certified.

1. Install and lubricate coupling per manufacturer's instructions.



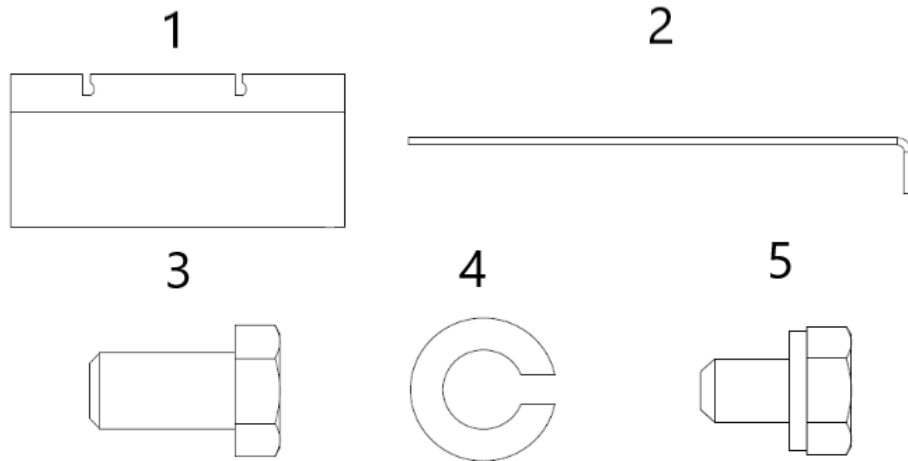
1. From outside supply
2. Shutoff valve
3. Discharge isolation valve
4. Check valve

Figure 11:



1. Discharge isolation valve
2. Check valve
3. By-pass line
4. Shutoff valve

Figure 12:



Item	Description	Qty
1	Guard	2
2	Guard bracket	2
3	Hex head bolt	2
4	Lockwasher	2
5	Hex washer head screw	4

Figure 13: Required parts

2. De-energize the motor, place the motor in a locked-out position, and place a caution tag at the starter that indicates the disconnect.
3. Align the round hole on the bottom of each bracket with the outermost threaded round holes on the ceiling of the motor support.
4. Place one lockwasher over the bolt and insert the bolt through the round hole on the foot of the bracket. Repeat for the other bracket and tighten all bolts firmly.

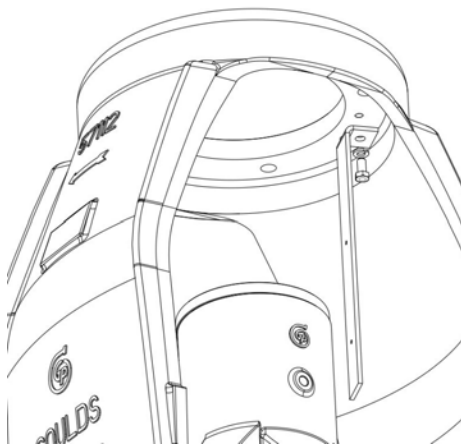


Figure 14: Coupling bracket mounting

5. Insert hex washer head screws into the threaded holes on each bracket, making sure that there is enough room on the screws for the coupling guard halves.
6. Slide coupling guard halves' slots over the bracket's two screws.
Repeat for the other bracket and tighten all screws firmly.

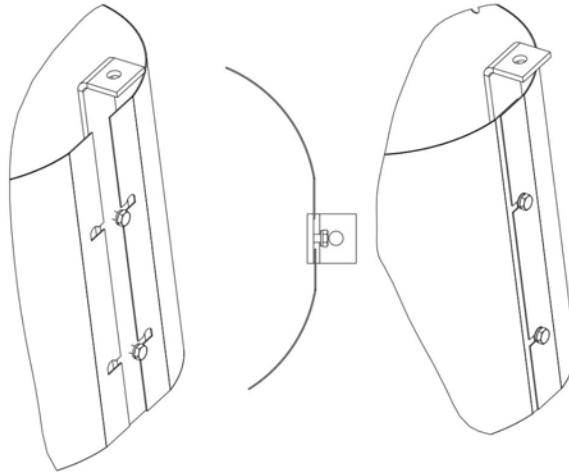


Figure 15: Mounting coupling guard halves to bracket

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



WARNING:

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



WARNING:

Never operate a pump without coupling guard properly installed. Refer to Appendix II for coupling guard installation instructions. Personal injury will occur if pump is run without coupling guard.



WARNING:

Pumps must be fully primed at all times during operation.

Suction Supply Above Pump

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

Suction Supply Below Pump

A foot valve and outside source of liquid may be used to prime the pump. Outside source of liquid can come from a priming pump, pressurized discharge line, or other supply.

1. Close discharge valve and open air vents in suction and discharge piping, casing, seal chamber and seal piping, if provided.
2. Open valve in outside supply line until all air is vented and only liquid flows out.



WARNING:

When handling hazardous and/or toxic fluids, proper personal protective equipment is required. If pump is being drained, precautions must be taken to prevent physical injury. Pumpage must be handled and disposed of in conformance with applicable regulations.

3. Close the vents and then the outside supply line.

Other Methods of Priming Pump

- Priming by ejector.
- Priming by automatic priming pump.

4.2 Start-Up Precautions

1. All equipment and personal safety related devices and controls must be installed and operating properly.
2. To prevent premature pump failure at initial start-up due to dirt or debris in the pipe system, ensure the pump can be run continuously at full speed and flow for 2 to 3 hours.
3. Variable speed drivers should be brought to rated speed as quickly as possible.
4. Variable speed drivers should not be adjusted or checked for speed governor or overspeed trip settings while coupled to the pump at initial start-up. If settings have not been verified, uncouple the unit and refer to driver manufacturer's instructions for assistance.
5. Pumpage temperatures in excess of 93° C (200° F) will require warm-up of pump prior to operation. Circulate a small amount of pumpage through the pump until the casing temperature is within 38° C (100° F) of the pumpage temperature and evenly heated.

NOTICE:

Warm-up rate should not exceed 1.4° C (2.5° F) per minute.

4.3 Starting Pump

1. Make sure suction valve and any recirculation or cooling lines are open.
2. Fully close or partially open discharge valve as dictated by system conditions.
3. Start Driver.

NOTICE:



Immediately observe pressure gauges. If discharge pressure is not quickly attained - stop driver, reprime and attempt to restart.

4. Slowly open discharge valve until the desired flow is obtained.
-

NOTICE:



Observe pump for vibration levels, bearing temperature and excessive noise. If normal levels are exceeded, shut down and resolve.

4.4 Operation

4.4.1 General Considerations

NOTICE:



Always vary capacity with regulating valve in the discharge line. NEVER throttle flow from the suction side.

NOTICE:



Driver may overload if the pumpage specific gravity (density) is greater than originally assumed, or the rated flow rate is exceeded.

NOTICE:



Always operate the pump at or near the rated conditions to prevent damage resulting from cavitation or recirculation.

4.5 Operating at Reduced Capacity



WARNING:

DO NOT operate pump below minimum rated flows or with suction and/or discharge valve closed. These conditions may create an explosive hazard due to vaporization of pumpage and can quickly lead to pump failure and physical injury.

NOTICE:



Damage occurs from:

1. Increased vibration levels - Affects bearings, stuffing box or seal chamber, and mechanical seal.
2. Increased radial loads - Stresses on shaft and bearings.
3. Heat build up - Vaporization causing rotating parts to score or seize.
4. Cavitation - Damage to internal surfaces of pump.

4.6 Operating Under Freezing Conditions

Exposure to freezing conditions, while pump is idle, could cause liquid to freeze and damage the pump. Liquid inside pump should be drained. Liquid inside cooling coils, if supplied, should also be drained.

4.7 Shutdown

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



WARNING:

When handling hazardous and/or toxic fluids, proper personal protective equipment should be worn. If pump is being drained, precautions must be taken to prevent physical injury. Pumpage must be handled and disposed of in conformance with applicable environmental regulations.

4.8 Final Alignment



WARNING:

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

1. Run the unit under actual operating conditions for a sufficient length of time to bring the pump and driver and associated system up to operating temperature.
2. Remove coupling guard. Refer to coupling guard installation and disassembly instructions in Appendix II.
3. Check alignment while unit is still hot per alignment procedure in the Installation Section.
4. Reinstall coupling guard.

5 Preventive Maintenance

5.1 General Comments

A routine maintenance program can extend the life of your pump. Well maintained equipment will last longer and require fewer repairs. You should keep maintenance records, this will help pinpoint potential causes of problems.



WARNING:

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

5.2 Maintenance Schedule

5.2.1 Routine Maintenance

- Bearing lubrication
- Seal monitoring
- Vibration analysis
- Discharge pressure
- Temperature monitoring

5.2.2 Routine Inspections

- Check level and condition of oil through sight glass on bearing frame.
- Check for unusual noise, vibration and bearing temperatures.
- Inspect pump and piping for leaks.
- Check seal chamber/stuffing box leakage. Mechanical Seal: Should be no leakage.

Packing: Excessive leakage requires adjustment or possible packing replacement. Refer to [4.1.1 Checklist on page 22](#) for packing gland adjustment.

5.2.3 3 Month Inspections

- Check the foundation and the hold-down bolts for tightness.
- If the pump has been left idle, check the packing. Replace if required.
- Oil should be changed at least every 3 months (2000 hours) or more often if there are any adverse atmospheric conditions or other conditions which might contaminate or break down the oil. If it is cloudy or contaminated as seen by inspection through the sight glass, it should be changed immediately.
- Check the shaft alignment. Realign if required.

5.2.4 Annual Inspections

- Check the pump capacity, pressure and power. If pump performance does not satisfy your process requirements, and the process requirements have not changed, the pump should be disassembled, inspected, and worn parts should be replaced. Otherwise, a system inspection should be done.

5.2.5 Inspection Intervals

Inspection intervals should be shortened appropriately if the pumpage is abrasive and/or corrosive,



WARNING:

or if the environment is classified as potentially explosive.

5.3 Lubrication

Pump bearings are normally grease lubricated and are lubricated at the factory. Regrease at approximately 3-6 month intervals, until grease comes out the oil caps which serve as grease relief fittings. Use a sodium or lithium base grease, NLGI #2 consistency. Follow motor and coupling manufacturer's lubrication instructions.

5.4 Maintenance of Bearings



Do not insulate bearing housings as this can result in excess heat generation, sparks, and premature failure.



Service temperature in an ATEX classified environment is limited to the area classification specified on the ATEX tag affixed to the pump, refer to [Table 1: Temperature class definitions on page 11](#).



For Ex applications bearing replacement (all) is recommended after 17,500 hours of operation.

5.5 Grease Lubricated Bearings

Grease lubricated bearings are pre-lubricated at the factory. Regrease bearings every 2000 operating hours or 3 months, whichever occurs first.

Regrease Procedure

NOTICE:

When regreasing there is danger of impurities entering the bearing housing. The grease container, the greasing device, and fittings must be clean.

1. Wipe dirt from both grease fittings.

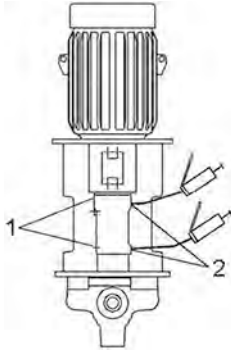


Figure 16:

Table 5:

Item	Description
1	Grease relief plugs
2	Grease fittings

2. Remove two grease relief plugs from side of frame opposite grease fittings.
3. Fill both grease cavities through grease fittings with recommended grease until fresh grease comes out of the relief holes. Reinstall grease relief plugs until immediately prior to starting pump.

NOTICE:

The bearing temperature usually rises after regreasing due to an excess supply of grease. Temperatures will return to normal after pump has run and purged the excess from the bearings, usually two to four hours. Grease relief plugs should be removed during this period, and replaced when temperature has stabilized.

For most operating conditions a lithium based mineral oil grease of NLGI consistency number 2 is recommended. This grease is acceptable for bearing temperatures of -15°C to 110°C (5°F to 230°F).

Bearing temperatures are generally about 20°F (18°C) higher than bearing housing outer surface temperature.

Some acceptable greases are:

NLGI Consistency	2
Exxon	Unirex N2
Mobil	Mobilux EP2
Sunoco	Multipurpose EP
SKF	LGMT 2



CAUTION:

Never mix greases of different consistency (NLGI 1 or 3 with NLGI 2) or different thickener. For example, never mix a lithium base grease with a polyurea base grease.

NOTICE:

If it is necessary to change grease type or consistency, the pump must be disassembled and the old grease removed from the bearings.

5.6 Pure Oil Mist Lubricated Bearings (Optional)



WARNING:

Pumps are shipped without oil. Oil mist lubricated bearings must be lubricated at the job site.

1. Follow oil mist system supplier's instructions.
2. Connect oil mist supply lines to upper and center tapped connection.
3. Connect drain line to bottom tapped connection.

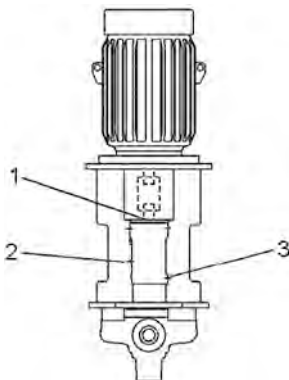


Figure 17:

Table 6:

Item	Description
1	Oil mist vent
2	Oil mist inlet
3	Oil mist vent / drain

Oil mist lubrication is required above pumpage temperature of 232°C | 450° F, but may be used at lower temperatures.

A high quality turbine oil with rust and oxidation inhibitors should be used. For the majority of operational conditions, bearing temperatures will run between 50°C | 120°F and 82°C | 180°F. In this range, an oil of ISO viscosity grade 68 at 40°C | 100°F is recommended. If bearing temperatures exceed 82°C | 180°F, use ISO viscosity grade 100.

Some acceptable oils are:

Table 7:

Exxon	Teresstic EP68
Mobil	Mobil DTE 26 300 SSU @ 40°C 100°F)
Sunoco	Sunvis 968
Royal Purpal	SYNFILM ISO VG 68 Synthetic Lube

5.7 Stuffing Box

5.7.1 Packed Stuffing Box

Periodically inspect stuffing box to see that there is sufficient leakage to lubricate the packing and maintain a cool box. Never draw up packing so that the stuffing box heats, as this will cause damage to both packing and sleeve. Draw up gland nuts slowly and evenly and only when pump is running.

After pump has been in operation for some time and the packing has been completely “run-in”, at least 40 to 60 drops per minute of the liquid should be allowed to trickle from the stuffing box at all times for cooling and lubricating the packing and shaft sleeve.

5.8 Maintenance of Shaft Seals



WARNING:

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



WARNING:

The mechanical seal must be properly flushed. Failure to do so will result in excess heat generation and seal failure.

5.9 Mechanical Seals

When mechanical seals are furnished, a manufacturer’s reference drawing is supplied with the data package. This

drawing should be kept for future use when performing maintenance and adjusting the seal. The seal drawing will also specify required flush liquid and attachment points. The seal and all flush piping must be checked and installed as needed prior to starting the pump.

The life of a mechanical seal depends on various factors such as cleanliness of the liquid handled and its lubricating properties. Due to the diversity of operating conditions it is, however, not possible to give definite indications as to its life.



WARNING:

Never operate the pump without liquid supplied to mechanical seal. Running a mechanical seal dry, even for a few seconds, can cause seal damage and must be avoided. Physical injury can occur if mechanical seal fails.

5.10 Packed Stuffing Box



WARNING:

Packed stuffing boxes are not allowed in an ATEX classified environment.

Packing operation can be inspected without shutting down or disassembling the pump. During normal operation the packing should leak approximately one drop per minute. If the drip rate is higher or lower than one drop per minute then an adjustment of the gland may be required. To slow down the leakage

rate, the two gland bolts should be tightened evenly one-quarter ($\frac{1}{4}$) turn each until the desired leakage rate is obtained. NEVER over-tighten packing to the point where less than one drop per minute is observed. Over-tightening can cause excessive wear and power consumption during operation. If the packing cannot be tightened to obtain less than two drops per minute, then the packing may need to be replaced and the packing installation procedures under Operation should be followed.

**WARNING:**

Never attempt to replace packing until the driver is properly locked out and the coupling spacer is removed.

5.11 Dynamic Seal

**WARNING:**

Dynamic seals are not allowed in an ATEX classified environment.

Dynamic Seal Components

Repeller - The dynamic repeller effectively prevents leakage of pumpage through the stuffing box when the pump is operating under published acceptable conditions. Dynamic seal parts do not wear substantially to affect operation unless the service is particularly abrasive or corrosive. Refer to Disassembly and Reassembly Section for maintenance, disassembly, and repair.

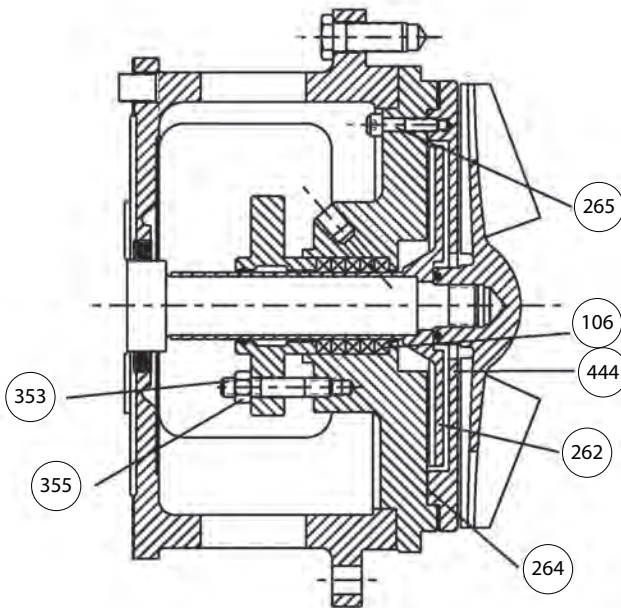


Figure 18: Dynamic Seal with Packing

Static Seal - A static seal is used to prevent leakage when the pump is shut down. This is either a lip seal, elastomeric face seal, or graphite packing. The lip and elastomeric face seal require no maintenance other than replacement when leakage becomes excessive. The packing should be installed as stuffing box packing. It is a special type designed to run dry, so it does not require an external flush.

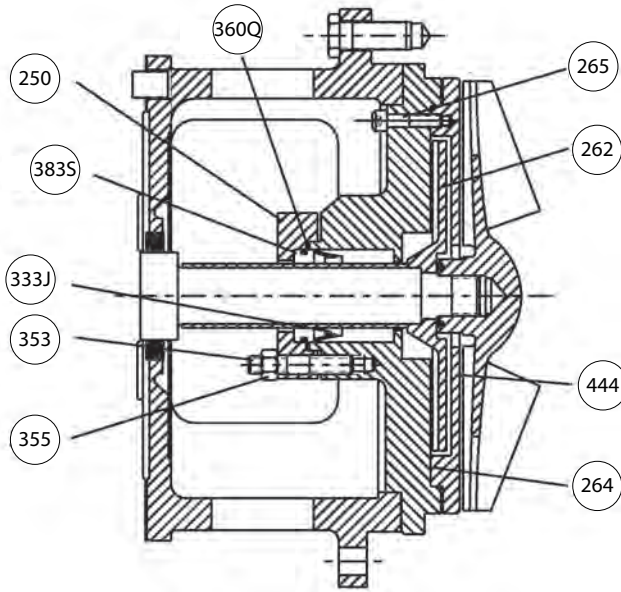


Figure 19: Dynamic Seal with Chekseal™

5.12 Impeller Clearance Setting



WARNING:

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



WARNING:

Lock out driver power to prevent accidental startup and physical injury.

A change in pump performance may be noted over time by a drop in head or flow or an increase in power required. Performance can usually be renewed by adjusting the impeller clearance. Two techniques are given to set the impeller clearance, the dial indicator method and the feeler gauge method.

5.13 Dial Indicator Method

1. Remove coupling guard.
2. Remove coupling.
3. Set indicator so that button contacts either the shaft end or against face of coupling.
4. Loosen jam nuts (423) on jack bolts (370D) and back bolts out about two turns.
5. Tighten each locking bolt (370C) evenly, drawing the bearing housing (134A) towards the bearing frame (228) until impeller contacts the casing. Turn the shaft to ensure contact is made.

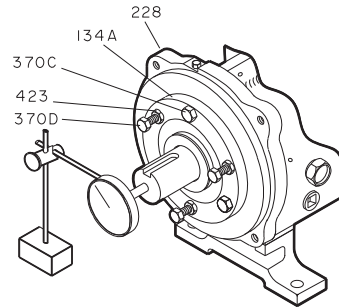


Figure 20: Dial Indicator Method

6. Set indicator to zero and back locking bolt (370C) out about one turn.
7. Thread jack bolts (370D) in until they evenly contact the bearing frame. Tighten the jack bolts evenly (about one flat at a time) backing the bearing housing (134A) away from the bearing frame until the indicator shows the proper clearance per [Table 4: Impeller Clearances - Cold Temperature Clearances for Various Service Temperatures on page 24](#).
8. Evenly tighten locking bolts (370C), then jack bolts (370D) keeping indicator reading at proper setting.
9. Check shaft for free turning.
10. Replace coupling guard.

5.14 Feeler Gauge Method

1. Remove coupling guard.
2. Loosen jam nuts (423) on jack bolts (370D) and back bolts out about two turns.
3. Tighten locking bolts (370C) evenly, drawing bearing housing (134A) towards frame (228) until impeller contacts the casing. Turn shaft to ensure contact is made.
4. Using a feeler gauge, set the gap between the three locking bolts (370C) and bearing housing (134A) per impeller clearances per [Table 4: Impeller Clearances - Cold Temperature Clearances for Various Service Temperatures on page 24](#).
5. Evenly back out bearing housing (134A) using the three jack bolts (370D) until it contacts the locking bolts (370C). Evenly tighten jam nuts (423B).
6. Check shaft for free turning.
7. Replace coupling guard.

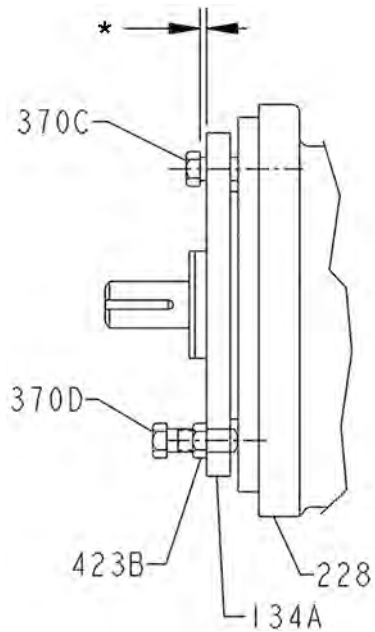


Figure 21:

* Per [Table 4: Impeller Clearances - Cold Temperature Clearances for Various Service Temperatures](#) on page 24

5.15 Vibration

It is good practice to periodically monitor vibration of the pump. Normally, vibration level will be well below accepted standards. Of equal importance is that the vibration level not increase. If a problem with vibration is encountered, refer to [7.1 Troubleshooting](#) on page 53.

6 Disassembly and Reassembly

6.1 Required Tools

- Wrenches
- Screwdriver
- Lifting Sling
- Rubber Mallet
- Induction Bearing Heater
- Bearing Puller
- Brass Drift Punch
- Snap-Ring Pliers
- Torque Wrench with Sockets
- Allen Wrenches
- Dial Indicator
- Micrometer
- Cleaning Agents
- Feeler Gauges
- Hydraulic Press
- Leveling Blocks

6.2 Disassembly

The Model 3996 is designed to permit the complete pullout assembly to be removed without disturbing the casing or motor. The sectional drawing, parts list and construction details should be used in conjunction with the disassembly instructions.



WARNING:

Lifting must be employed to avoid physical injury and/or equipment damage. Steel toed shoes must be worn at all times.



WARNING:

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

NOTICE:

Before disassembling the pump for overhaul, ensure all replacement parts are available.

1. Lock out motor



WARNING:

Lock out power supply to driver motor to prevent accidental startup and physical injury.

2. Shut off all valves controlling flow to and from pump.

**WARNING:**

Operator must be aware of pumpage and safety precautions to prevent physical injury.

3. Drain liquid from piping, flush pump if necessary.
4. Remove auxiliary piping.
5. Unbolt and remove spacer member of coupling.
6. Remove the bolts (370) that hold the frame (228) to the casing. Jacking bolts (418) are provided to assist disassembly. Tighten the bolts evenly, a flat at a time, to jack assembly from casing.
7. Remove casing gasket (351).
8. Unscrew impeller (101) from shaft (122). The threads are right-hand. Prevent the shaft turning by using a wrench on coupling "flats". Do not lose or damage the O-ring (412A) which seals between the impeller (101) and shaft (122) or shaft sleeve (126).
9. Remove shaft guard (if provided).

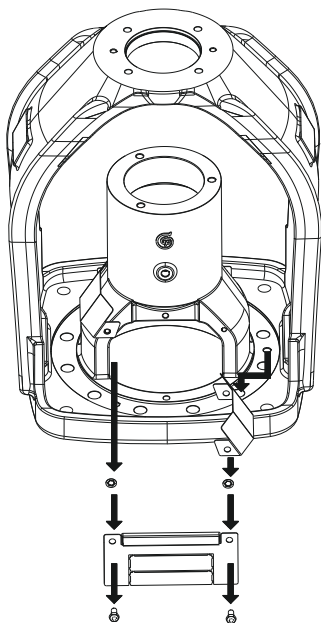


Figure 22: Shaft guard removal

10. On units with mechanical seal (383).
 - a) Inside single or double seal – remove gland stud nuts (355) and carefully slide gland (250) off studs. Do not damage seal faces.
 - b) Outside seal – loosen set screws which position rotary portion of seal and slide seal toward bearing frame (228). Remove gland stud nuts (355) and carefully slide gland (250) off studs. Do not damage seal faces.
11. Remove stud nuts (370H) which hold stuffing box cover (184) from frame. Do not allow stuffing box to contact shaft (122), sleeve (126), shaft threads or any mechanical seal parts. Slide sleeve (126), if any, off shaft (122).
12. On units with mechanical seal, loosen set screws which position rotary portion of seal to shaft (122) and carefully slide seal and gland (250) assembly off shaft. On units which have a shaft sleeve, (126), it is not necessary to remove rotary portion of seal from the sleeve unless replacement of seal is required.
13. Slide deflector (123) off shaft (122).
14. Scribe shaft (122) at coupling hub for proper positioning of hub during reassembly and remove hub.
15. Remove bearing housing bolts (370C). Impeller adjustment bolts (370D) with jam nuts can be used to assist in the removal of the shaft (122) and bearing assembly from the bearing frame (228).

16. Slide complete shaft assembly from bearing frame. This will include the shaft (122), both bearings (112 and 168), and bearing housing (134). Do not lose or damage O-ring (496). Do not damage in-board grease seal (333).
17. Pull inboard bearing (168).
18. Remove bearing retaining ring (361A) and slide bearing housing off ball bearing. Do not damage bearing housing grease seal (332).
19. Straighten "tang" in lockwasher (382) and remove bearing locknut (136) and lockwasher. Pull ball bearing (112).
20. On units with stuffing box packing, remove packing (106) and lantern ring (105) from stuffing box cover (184).

6.3 Inspection and Replacement

1. Impeller (101) – Replace if impeller shows excessive erosion (especially on ejector vanes on back side of impeller), corrosion, extreme wear or vane breakage. O-ring groove and impeller hub must be in good condition. Check impeller balance.
2. Shaft (122) – Check for runout to see that shaft has not been bent. On pumps without shaft sleeves, shaft surface in stuffing box area must be smooth and free of grooves. Bearing seats and oil seal areas must be smooth and free of scratches or grooves. Shaft threads must be in good condition. Replace shaft if necessary.
3. Shaft Sleeve (126) – Surface in stuffing box must be smooth and free of grooves. If grooved, replace.
4. Mechanical Seal (383) – Seal faces, gaskets, and shaft sealing members must be in perfect condition or excessive leakage may result. Replace worn or damaged parts.
5. Ball bearings (112 and 168) – Replace if worn, loose or rough and noisy when rotated. New bearings should not be unwrapped until ready for use. Replacement bearings must be of the proper size and type as specified in the Construction Details (Section VI). Where possible, avoid reusing bearings that have been pulled.
6. Grease Seals (332 and 333) – Replace if torn or otherwise damaged. For seal sizes, see Vendor Identification Number table below.

Seals are held by press fit. Lips on seals should face outward (away from bearings).
7. General – All parts should be clean before assembly. This is especially important at retaining ring and O-ring grooves, threads, lock fits, gasket surfaces and bearing and bearing lubricated areas. Any burrs should be removed with crocus cloth.

Table 8: Vendor Identification Number

	Seal	Chicago Rawhide	Crane	Garlock	Johns - Mansville	Nat'l	Victor
ST	Inboard	13541			9080LPD	330663	6444BK3
	Outboard	8626	137-187-8	76x6133			63647K5
			STD	92x6133			
MT	Inboard	-	175-287-12	63X922	-	-	63333
			STD	65X922			
	Outboard	-	112-200-8	-			64324K3
			STD		-	-	

6.4 Reassembly

This procedure covers reassembly of pump after complete disassembly. Make sure all directions in Inspection and Replacement section have been followed. Refer to Sectional Views for applicable item number.

1. Oil bearing seat on coupling end of shaft (122). Slide coupling end bearing (112) (double row) on shaft as far as possibly by hand. Place pipe or driving sleeve over shaft, making sure it rests against inner race only. Make sure bearing is “square” on shaft, especially where it contacts the grease seal.
2. Place lockwasher (382) and bearing locknut (136) on shaft and tighten firmly. Bend “tang” of lockwasher into slot in locknut.
3. Slide bearing housing (134) with O-ring (496) in place, on shaft and over bearing as far as possible. Do not damage grease seal (332).
4. Insert retaining ring (361) into groove in bearing housing (134). Flat side of retaining ring must be against bearing.
5. Oil inboard bearing seat on shaft (122). Slide inboard ball bearing (168) on shaft as far as possible by hand. Place pipe or driving sleeve over shaft, making sure it rests against inner race only. Make sure bearing is “square” on shaft. Tap or press evenly until bearing is seated firmly against the shaft shoulder. Do not mar the shaft, especially where it contacts the grease seal.
6. Place a small amount of O-ring lubricant on inside of bearing frame (228) at bearing housing (134) and inboard bearing seats, on O-ring, and on inboard grease seal (333). Carefully slide shaft assembly into the bearing frame as far as possible. Do not damage inboard grease seal. Be sure O-ring (496) is in place in groove on housing. Screw bearing housing bolts (370C) about 1/2 in. (12 mm) into bearing frame.
7. Slide deflector (123) on shaft (122).
8. If unit has stuffing box packing: Place stuffing box cover (184) against frame making sure that the studs (370H) align with proper holes in frame. Replace nuts and firmly tighten. Slide sleeve if any, on shaft (122). Make sure groove in end of sleeve engages drive pin (496D) on shaft.
9. If unit has mechanical seal (383):

The following instructions refer to pumps equipped with mechanical seals, either with or without sleeves.

On units with sleeves, the rotary portion of the seal may be mounted on the sleeve, and the seal-sleeve assembly mounted on the shaft as a unit.

Before mounting any seals, wipe the seal faces carefully with a clean soft cloth and lubricate with clean oil.

A preliminary impeller adjustment must be performed to assure proper positioning of the mechanical seal.

- a) Position sleeve (126) if any, on shaft (122) and engage groove in sleeve with drive pin (469) on shaft. Place stuffing box cover (184) against frame (228). Make sure studs (370H) align with proper holes in frame. Firmly tighten nuts or bolts.
- b) Screw impeller (101) with O-ring (412A) in place on shaft. Make sure that shaft assembly extends through stuffing box cover (184) so that the impeller will NOT contact face of stuffing box cover.
- c) Using impeller adjusting bolts (370C & 370D), adjust the impeller clearance until a .020” (0.51 mm) feeler gauge can be inserted between the back of the impeller and the face of the stuffing box cover.
- d) Remove impeller (101) and stuffing box cover (184).

The following instructions are for three basic seal types: Inside, Outside, and Double Seals. Refer to seal manufacturer’s drawing to determine seal type and positioning dimension. Follow the pertinent procedures.

10. Single Inside Seal
 - a) Assemble the gland (250), gaskets and stationary seat. If unit has sleeve (126), position sleeve on shaft (122). Slide gland assembly on shaft or sleeve.
 - b) Refer to Section V-D for instructions on proper positioning of mechanical seals.

- c) Place stuffing box cover (184) against frame making sure that studs (370H) align with proper holes in frame. Replace nuts and firmly tighten. Do not allow stuffing box cover to contact shaft, sleeves, if any, or mechanical seal.
 - d) Refer to Step 13 for further instructions.
11. Outside Seal
- a) If unit has shaft sleeve (126), slide on shaft (122).
 - b) Lubricate rotary portion of seal and slide on shaft or sleeve. Do not tighten set screws.
 - c) Assemble gland (250), gaskets, and stationary seat and slide assembly on shaft or sleeve.
 - d) Place stuffing box cover (184) against frame making sure that the studs (370H) align with the proper holes in frame. Firmly tighten nuts.
 - e) Place gland assembly against face of stuffing box and firmly tighten stud nuts.
 - f) Slide rotary portion toward gland until it contacts stationary seat. Compress the rotary. Tighten screws.
12. Double Seal
- a) Assemble the gland (250), gaskets and stationary seat. If unit has shaft sleeve (126), position sleeve on shaft (122) and engage groove in sleeve with drive pin (469) on shaft. Slide gland assembly on shaft or sleeve.
 - b) Refer to the [6.5.1 Positioning of Mechanical Seals on page 45](#) for instructions on proper positioning of mechanical seals.
 - c) Place inboard stationary seat and gaskets into bottom of stuffing box.
 - d) Place stuffing box cover (184) against frame making sure that studs (370H), align with proper holes in frame. Firmly tighten nuts.
 - e) Refer to Step 13 for further instructions.
13. Install the shaft guard - if provided.

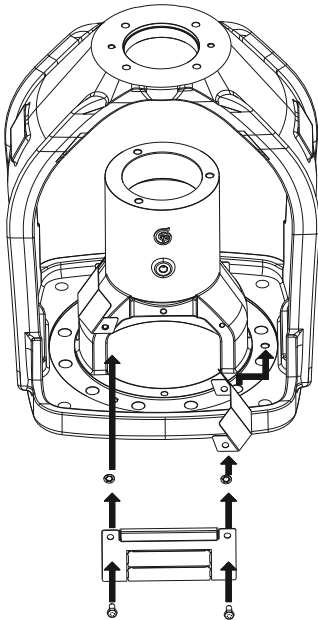


Figure 23: Shaft guard installation

14. Screw impeller (101) with O-ring (412A) in place, on the shaft (122).
15. On units with stuffing box packing (106), repack stuffing box as outlined in the Foundation and Baseplate Section. Assemble gland stud nuts finger tight.
16. Install and position coupling hub at scribe mark on shaft.

17. Place casing gasket (351) against shoulder in casing.
18. Slide the pullout assembly into the casing (100). Drain slot in stuffing box cover (184) should line up with drain connection in casing. Install and tighten the frame-to-casing. Install and tighten the frame-to-casing. Install and tighten the frame-to-casing. Make sure pump turns freely. If not, adjust the impeller adjusting bolts (370C & 370D). Install and tighten the frame to casing bolts evenly while turning the pump by hand. Do not jam the impeller into the casing.
19. Reset impeller clearances.
 - a) Loosen bolts (370–C& D).
 - b) Tighten bolts (370C) while turning shaft until impeller starts to rub against casing.
 - c) Loosen bolts (370C) until a 0.015 inch (0.375 mm) feeler guage can be placed between the bolt head and the bearing housing.
 - d) Tighten bolts (370D) evenly. Bearing housing, shaft and impeller will be jacked to proper clearance from casing. Tighten bolts (370D) and jam nuts on bolts (370D).
 - e) If desired, a dial indicator can be used instead of a feeler gauge to check that the bearing housing has been moved the correct 0.015 inch (0.375 mm) distance.

6.5 Additional Details

6.5.1 Positioning of Mechanical Seals

1. Place stuffing box cover (184) against frame (228), making sure that the studs (370H) align with the proper holes in frame. Firmly tighten nuts.
2. Correct location of the rotary portion of a mechanical seal can be determined by two methods.

Scribe Method

1. Scribe the shaft (122) or sleeve (126) lightly at the face of the stuffing box.
2. Remove the nuts or bolts and slide stuffing box cover (184) away from the frame.
3. Lubricate rotary portion of seal and slide on shaft or sleeve.
4. Compress rotary portion of seal to correct dimension as shown on seal manufacturer's drawing and tighten set screws.

Modified Visegrip Method

1. Slide the gland assembly (250) against the stuffing box. Do not damage seal face. Do not bolt gland to stuffing box.
2. Clamp modified visegrip on the shaft (122) or sleeve (126) directly against the gland.
3. Leaving visegrip in position, remove nuts or bolts and slide stuffing box cover away from frame adapter.
4. Lubricate rotary portion of seal and slide on shaft (122) or sleeve (126).
5. Compress rotary portion of seal to correct dimension as shown on seal manufacturer's drawing and tighten set screws.
6. Remove visegrip and refer to Step 9 for further instructions.

6.6 Engineering Data Construction Details

Table 9: Power End

Power End	Model 3996 ST	Model 3996 MT
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6.7 Pump End

Shaft Diameters	At Impeller	3/4" (19)	1" (25)
	In Stuffing Box (Less Sleeve)	1 3/8" (35)	1 3/4" (44)
	In Stuffing Box (With Sleeve)	1 1/8" (29)	1 1/1" (38)
	Sleeve Outside Diameter	1 3/8" (35)	1 3/4" (44)
	Between Bearings	1 1/2" (38)	2 1/8" (54)
	At Coupling	7/8" (22)	1 1/8" (29)
Bearings	Radial	6207	6309
	Coupling End (Double Row)	3306	3309
	Bearing Span	4 1/8" (105)	6 3/4" (171)
	Shaft Overhang	6 1/8" (156)	8 3/8" (213)
Stuffing Box	Bore	2" (51)	2 1/2" (64)
	Depth	2 1/8" (54)	2 5/8" (67)
	Packing Size	5/16" x 5/16" (8 x 8)	3/8" x 3/8" (10 x 10)
	No. of Rings	5	5
	Width of Lantern Ring	7/16" (11)	5/8" (16)
	Distance - End of Box to Nearest Obstruction	2 3/16" (55)	3" (76)

6.7 Pump End

Table 10:

Pump End	3996ST						3996MT							
	1-1/2 x 2-6	1-1/2 x 3-6	2 x 3-6	1-1/2 x 2-8	1-1/2 x 3-8	1-1/2 x 2-10	1-1/2 x 3-10	2 x 3-10	3 x 4-10	1-1/2 x 3-13	2 x 3-13	3 x 4-13	4 x 6-13	
Max Diameter solids	11/32"	7/13"	3/8"	11/32"	7/16"	7/16"	7/32"	3/8"	5/8"	7/32"	3/8"	5/8"	1"	
	8.7	11.1	9.5	8.7	11.1	11.1	5.6	9.5	15.9	5.6	9.5	15.9	25	
Shaft Deflection	3500 RPM	3	6.2	7	6	7.8	7.2	8.6	9.8	15	10	15.7	35.5	-
	1750 RPM	0.8	1.6	1.8	1.5	2.0	1.9	2.2	2.5	4.1	2.6	4.6	11.5	16.5
Load Factor (M)	1150 RPM	0.3	0.7	0.8	0.7	0.9	0.8	1	1.1	1.7	1.2	1.9	5	6.8
Min Casing Thickness	3/8" (9.5)					1/2" (12.7)					9/16" (14.3)	5/8" (15.9)		
Casing Corrosion Allowance	1/8" (3)					1/8" (3)								
Working Pressure	See charts in High Pressure Capability													
Test Pressure	150% of Working Pressure at 100°F (38°C)													
Max Liquid Temp. (without cooling)	250°F (120°C)													
Max Liquid Temp. (with Cooling and Grease Lube)	350°F (175°C)													
Max Liquid Temp. (with)	500°F (260°C)													

	3996ST					3996MT							
Pump End	1-1/2 x 2-6	1-1/2 x 3-6	2 x 3-6	1-1/2 x 2-8	1-1/2 x 3-8	1-1/2 x 2-10	1-1/2 x 3-10	2 x 3-10	3 x 4-10	1-1/2 x 3-13	2 x 3-13	3 x 4-13	4 x 6-13
Cooling and Oil Mist													
Unit Weight	See Dimensions												

6.8 Sectional view

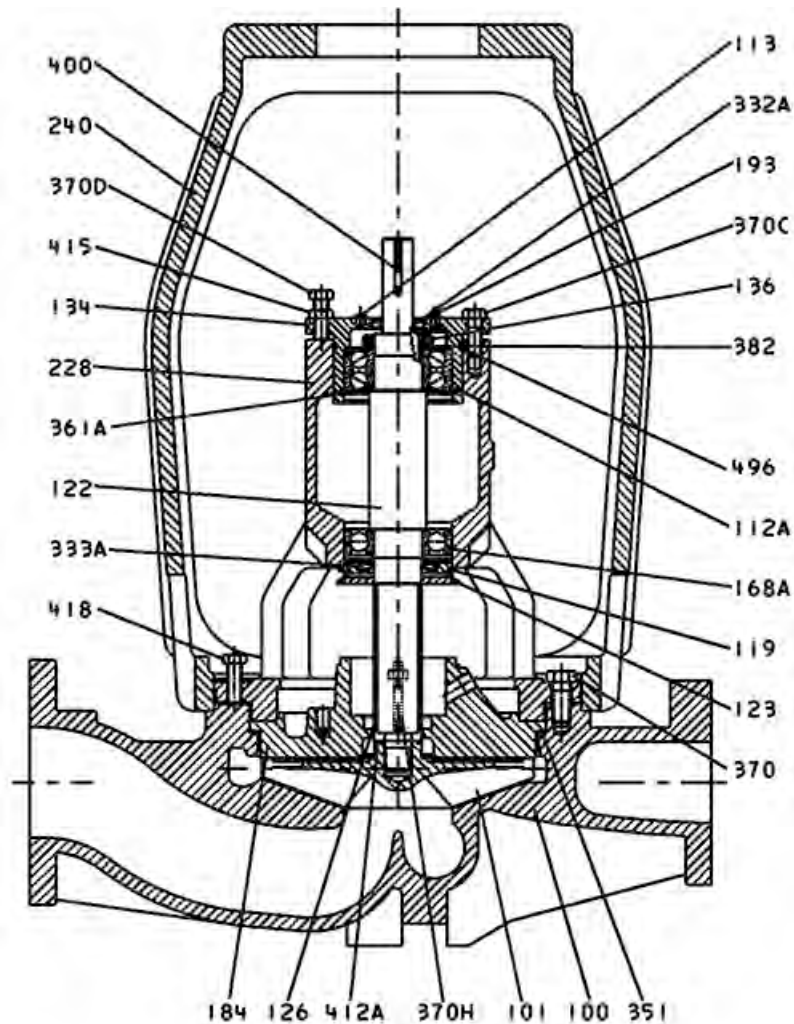


Figure 24:

6.9 Spare and Repair Parts

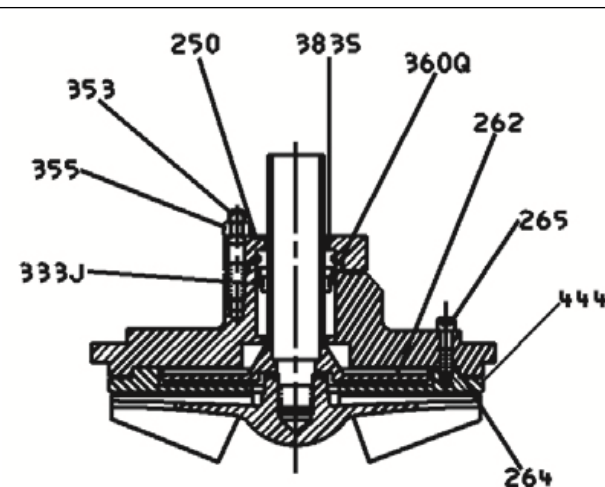
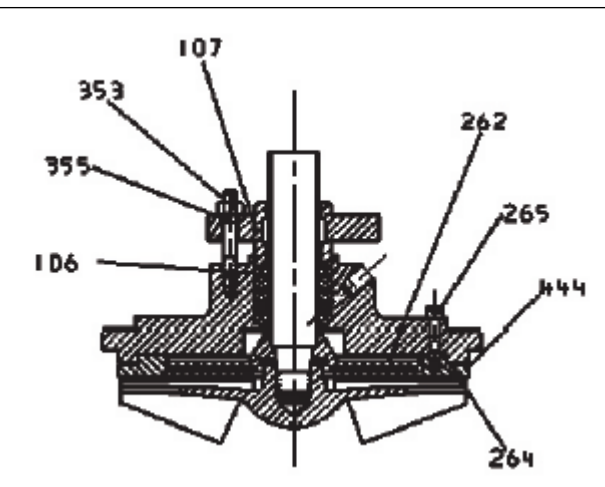
Table 11:

Item No.	Qty / Pump	Part Name
100	1	Casing
101	1	Impeller w/o RG
112	1*	Ball bearing OB

6.9 Spare and Repair Parts

Item No.	Qty / Pump	Part Name
113	2	GRS RLF FTG
119	1	Bearing end cover
122	1*	Shaft assy
123	1	Deflector
126	1*	Shaft sleeve
134	1	Bearing housing
136	1*	Bearing locknut
168	1*	Ball bearing 1B
184	1	SB cover SA
193	2	Grease fitting
228	1	Frame
240	1	Motor support
250	1*	GLD mech seal
332	1	Oil seal
333	1	Oil seal
351	1	Gasket case
353	4	Gland stud
355	4	Hex nut
360Q	1	Gasket - MS
361A	1	Retaining ring
370	4-24	H cap screw
370C	3	H cap screw
370D	3	H tap bolt
370H	2	Stud
372J	4	H cap screw
382	1*	Bearing lockwasher
383	1*	Mech seal
412A	1	O-ring, impeller
415	3	Hex nut (370D)
418	2	Jacking bolt
469D	1	Roll pin
496	1	O-ring

6.10 Dynamic Seal / Self Draining Covers Options Sectional Views

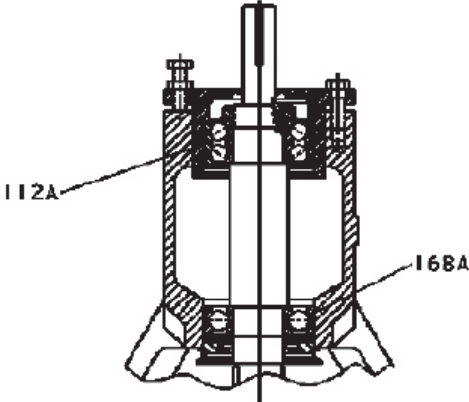
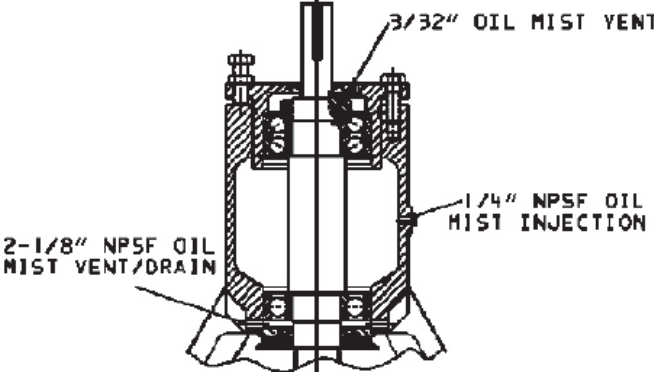
Dynamic Seal CHEKSEAL®				Dynamic Seal Packed box			
							
Item No.	No. Req'd	Part Name	Mat'l	Item No.	No. Req'd	Part Name	Mat'l
250	1	Gland		106	1 x	Stuffing box packing	GRAFOIL
262	1*	Repeller/Sleeve		107	1	Gland	
264	1*	Gasket, CVR, BKPL	PTFE	262	1 x	Repleller/Sleeve	
265	4	Screw, ST, Box, BKPL	316SS	264	1 x	Gasket, CVR, BKPL	PTFE
333J	1*	CHEKSEAL®	FLURAZ®	265	4	Screw, ST, Box, BKPL	316SS
353	4	Stud, gland	316SS	353	2	Stud, gland	316SS
355	4	Nut gland stud	304SS	355	2	Nut gland stud	304SS
360Q	1	Gasket, gland, box	EPDM-RBR	444	1	Backplate	
383S	1	Stationary seat	Ceramic				
444	1	Backplate					

* Recommended spare parts

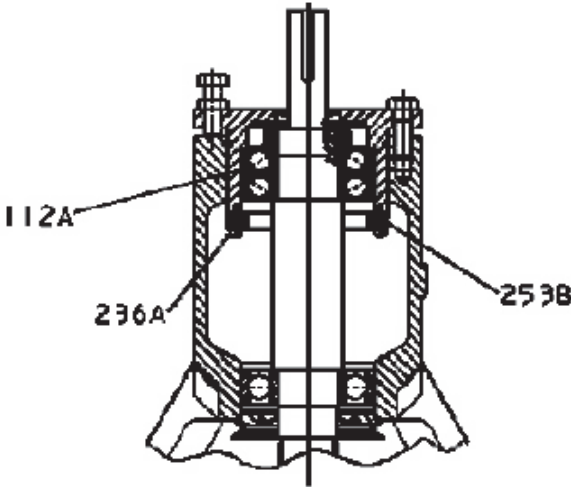
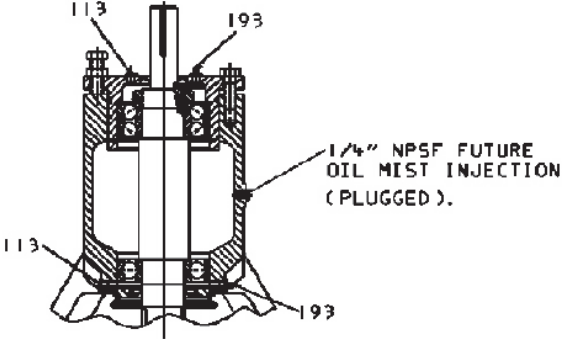
Dynamic Seal Lip Seal				Self Draining Stuffing Box Cover/Seal Chamber
Item No.	No Req'd	Part Name	Mat'l	
250	1	Gland		
262	1*	Repeller/Sleeve		
264	1*	Gasket, CVR, BXPL	PTFE	
265	4	Screw, ST, Box, BKPL	316SS	
333A	1*	Lip Seal	Viton	
353	4	Stud, Gland	316SS	
355	4	Nut Gland Stud	304SS	
360Q	1	Gasket Gland Box	EPDM-RBR	
444	1	Backplate		

* Recommended spare parts

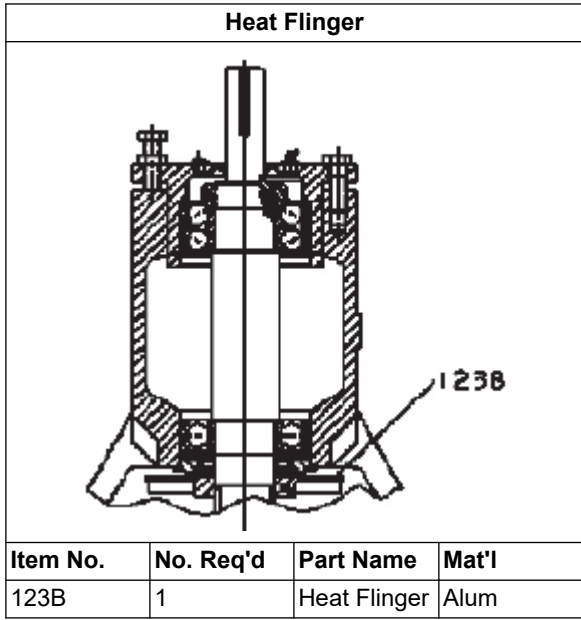
6.11 Bearing Options - Sectional View

Greased for Life Bearings				Pure Oil Mist			
							
Item No.	No. Req'd	Part Name	Mat'l				
112A	1*	Ball Bearing OTBD	Steel				
168A	1*	Ball Bearing INBD	Steel				

* Recommended spare parts

Duplex Thrust Bearings				Grease Lube with Provisions for Pure Oil Mist			
							
Item No.	No. Req'd	Part Name	Mat'l	<ul style="list-style-type: none"> Vents for future oil mist achieved by removing fitting 113 and 193. Remove shields from bearings for pure oil mist. Remove all grease from bearing areas for pure oil mist. 			
112A	1*	Ball Bearing OTBD	Steel				
236A	10	Screw, Clamp Ring	Steel				
253B	1	Clamp ring	Steel				

* Recommended spare parts



* Recommended spare parts

7 Troubleshooting

7.1 Troubleshooting

Problem	Possible Causes and Corrections
A. No liquid delivered, not enough liquid delivered, or not enough pressure.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 18, 19, 20.
B. Pump works a while and then quits.	4, 5, 7, 8, 9, 11, 12, 20.
C. Pump takes too much power.	6, 13, 14, 15, 16, 21, 22, 23, 24, 31.
D. Pump is noisy or vibrates.	15, 16, 17, 28, 31.
E. Pump leaks excessively at stuffing box	8, 24, 25, 26, 27.
F. High bearing temperature	15, 16, 17, 29, 30, 31.
G. Stuffing box overheating	8, 24, 25, 26, 27.

7.1.1 Causes and Corrective Measures

	Cause	Remedy
1	Pump not primed or properly vented.	Check that casing and suction pipe are completely filled with liquid.
2	Speed too low.	Check whether motor wiring is correct and receives full voltage or turbine receives full steam pressure.
3	System discharge head too high.	Check system head (particularly friction losses).
4	Suction lift too high.	Check NPSH available (suction piping too narrow or long may cause excessive friction losses). Check with vacuum or compound gauge.
5	Impeller or piping obstructed.	Check for obstructions.
6	Wrong direction of rotation.	Check rotation.
7	Air pocket or leak in suction line.	Check suction piping for air pockets and/or air leaks.
8	Stuffing box packing or seal worn allowing leakage of air into pump casing.	Check packing or seal and replace as required. Check for proper lubrication.
9	Not enough suction head for hot or volatile liquids.	Increase suction head, consult factory.
10	Foot valve too small.	Install correct size foot valve.
11	Foot valve or suction pipe not immersed deep enough.	Consult factory for proper depth. Use baffle to eliminate vortices.
12	Entrained air or gases in liquid.	Consult factory.
13	Impeller clearance too great.	Check for proper clearance.
14	Impeller damaged.	Inspect and replace as required.
15	Rotating parts bind.	Check internal wearing parts for proper clearance.
16	Shaft bent.	Straighten or replace as required.
17	Coupling or pump and driver misaligned	Check alignment and realign if required.
18	Impeller diameter too small	Consult factory for proper impeller diameter.
19	Improper pressure gauge location	Check correct position and discharge nozzle or pipe.
20	Casing gasket damaged	Check gaskets and replace as required.
21	Speed too high	Check motor winding voltage or steam pressure received by turbine.
22	Head lower than rating; pumps too much liquid	Consult factory. Install throttle valve, cut impeller.
23	Liquid heavier than anticipated	Check specific gravity and viscosity.

7.1 Troubleshooting

	Cause	Remedy
24	Stuffing box not properly packed (insufficient packing, not properly inserted or run in, packing too tight)	Check packing and repack stuffing box.
25	Incorrect packing or mechanical seal	Consult factory.
26	Damaged mechanical seal	Inspect and replace as required. Consult factory.
27	Shaft sleeve scored	Remachine or replace as required.
28	Cavitation	Increase NPSH available. Consult factory.
29	Pump capacity too low	Consult factory for minimum continuous flow.
30	Excessive vibration	See Preventive Maintenance / Vibration.
31	Improper bearing lubrication or bearings worn out	Inspect and replace as required.

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The original instruction is in English. All non-English instructions are translations of the original instruction.