Vertical Turbine Pumps
2001299 - VTP- IOM

INSTRUCTION MANUAL FOR INSTALLATION, OPERATION AND MAINTENANCE AND LIST OF PARTS

Revision Page

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1 Introduction

This IOM manual must be read thoroughly before installing or operating the pump. All instructions regarding maintenance must be retained for reference.

The descriptions and instructions included in this manual cover the basic design of the equipment and common deviations when possible. This manual does not cover all design details and variations nor does it provide for every possible contingency which may be encountered. When information cannot be found in this book, contact the nearest representative.

Do not operate this equipment other than in accordance with the instructions contained in this manual. This equipment (or a prototype) has been shop tested and found satisfactory for the conditions for which it was sold.

This equipment is capable of extended trouble-free operation when properly applied, installed and maintained. These instructions present the basic information and methods required for proper installation, operation and maintenance of vertical turbine pumps.

1.1 Scope of the Manual

This manual describes the installation, operation, and maintenance of Vertical Turbine Pumps. The manual must be used as a reference only, in conjunction with any Trillium Pumps USA product-specific information and training.

1.2 Intended Audience

This manual is intended for:

- Trillium Pumps USA service personnel.
- Personnel who have at least a basic level of trade/professional competency.

⚠ WARNING

PERSONNEL INJURY

The pump must be installed, operated, and maintained only by personnel who are trained and have sufficient knowledge about the hazards that may occur during pump operation.

1.3 Disclaimer

Contact your local Trillium Pumps USA representative for any assistance.

- This manual provides basic information about the product. The product purchased may contain equipment variations to this manual.
- Operating conditions specified in the manual may vary to the operating conditions of the product installed on-site.
- Illustrations shown in the manual are for reference only and may not match the specific product.

1.4 Contact Information

Contact your local Trillium Pumps USA representative for any assistance or visit www.trilliumflow.com

1.5 Glossary of Acronyms

Acronym	Description
ATEX	Equipment for Potentially Explosive Atmospheres
EMC	Electromagnetic Compatibility
ID	Inside Diameter
IOM	Installation, Operation, & Maintenance
ISO	International Organization for Standardization
LOTO	Lockout Tagout
MAWP	Maximum Allowable Working Pressure
NPSHR	Net Positive Suction Head Requirement
OD	Outside Diameter
OEM	Original Equipment Manufacturer
PED	Pressure Equipment Directive
PPE	Personal Protective Equipment
RMA	Returned Material Authorization
SDS	Safety Data Sheets
TIR	Total Indicator Reading
TPI	Threads Per Inch
VTP	Vertical Turbine Pump

Table 1-1: Acronyms

2 Safety

DANGER

DANGER

Study this instruction manual carefully. Failure to follow the instructions can cause serious personal injury, death, or property damage.

Legal requirements and local regulations may differ substantially with regard to particular safety requirements and may be regularly modified by relevant authorities without notice. As a consequence, applicable laws and regulations must be consulted to ensure compliance. The following cannot be guaranteed for its completeness or continuing accuracy.

These instructions are intended to facilitate familiarisation with the product and its permitted use. Operating the product in compliance with these instructions is important to help ensure reliability in service and avoid risks. The instructions may not take into account local regulations. It is the responsibility of the purchaser of the product to ensure such regulations are observed by all, including those installing the product. Always coordinate repair activities with operations personnel and follow all plant safety requirements, applicable workplace health and safety laws and regulations.

These instructions must be read prior to installing, operating, using and maintaining the equipment in any region, worldwide. The equipment must not be put into service, until as a minimum, all the conditions relating to workplace health and safety in the instructions, are met.

Information in these user instructions is believed to be reliable. In spite of all the efforts to provide correct and necessary information, the content of this manual may appear insufficient and is not guaranteed as to its completeness or accuracy.

2.1 Safety Symbols

Illustration	Safety Tool	Description
DANGER	DANGER	Indicates a hazard with a high level of risk which, if not avoided, could result in death or catastrophic equipment damage.
WARNING	WARNING	Indicates a hazard with a medium level of risk which, if not avoided, could result in serious or moderate injury, or serious equipment damage.
CAUTION	CAUTION	Indicates a hazard with a low level of risk which, if not avoided, could result in moderate or minor injury, or moderate equipment damage.
NOTICE	NOTICE	Indicates important information for the user.

Table 2-1: Safety Symbols

2.2 Mandatory Personal Protective Equipment

Mandatory Personal Protective Equipment	Description
	Use the following personal protective equipment: • Protecting Gloves • Safety Vest • Safety Shoes • Safety Goggles • Hard Hat • Ear Plugs • Safety Shield

Table 2-2: Personal Protective Equipment

2.3 Important Information

DANGER

PERSONNEL INJURY

The equipment supplied can cause serious personnel injury or death if mishandled or misused. Extreme caution must be exercised during the handling and operation of the equipment.

DANGER

TOXIC VAPOURS FROM PUMPAGE

Appropriate risk assessment must be made regarding the nature of the product in the pump and necessary safety precautions put in place to protect from exposure to product vapours.

DANGER

RISK ASSESSMENT

A comprehensive risk assessment of the installation site, pump equipment, and pumping system must be completed prior to receiving the equipment. The risk assessment should include but is not limited to the following: lifting procedures, pump equipment, system piping, system valving, system operation and readiness, containment of pressurized fluid, intake structures, electrical systems, hazardous materials and conditions, lock-out-tag-out procedures, start-up and shutdown procedures, potential for reverse flow and/or reverse pump rotation, water hammer, safety considerations for all personnel and public, and site security including preventing access to the pump intake structure.

DANGER

PUMP SIGNAGE AND ACCESS

Do not allow anyone near the suction or open discharge of the pump during operation. Pumps can create strong forces that will pin individuals. It is highly recommended to post signage and restrict access to the pump suction and/or intake structure to prevent serious injury or death.

DANGER

LOCKOUT-TAGOUT (LOTO)

- Prior to allowing any checking, maintenance, or other work on the equipment, all hazardous energy sources (for example, electrical, mechanical, hydraulic, pneumatic, etc.) must be isolated using an appropriate lockout-tagout procedure.
- Ensure that the intake and discharge openings are totally isolated from all potentially pressurized connections and that they are, and can only be exposed to atmospheric pressure.
- Drain the pump and isolate pipework before dismantling the pump. The appropriate safety precautions must be taken when the pumped liquids are hazardous.
- Failure to follow appropriate LOTO procedures may result in serious personal injury or death.

DANGER

GUARDS

Contact with rotating equipment can result in serious injury. Appropriate guards must be installed at all times during operation. Any procedures requiring the removal of the equipment guards must be performed by qualified personnel trained to perform such work.

DANGER

PERSONNEL INJURY FROM FALLS

Working at height may be required when working on equipment (for example, when adjusting the impellers with a hollow shaft driver). Always wear appropriate PPE, such as a safety harness and restraint system, when working at heights.

DANGER

VAPORIZATION

- Do not operate the pump at low or zero flow conditions, or under any circumstances that causes the pumped liquid to vaporize.
- Personnel injury and equipment damage could result from the high temperature and pressures created if the pumping liquid vaporizes.
- Low or zero flow conditions must be avoided under any circumstances for any significant period of time (more than 1 minute) due to the risk of heat/vaporisation of pumped fluid in the casing that may cause subsequent explosion.

DANGER

THERMAL SHOCK

Do not feed very hot liquid into a cold pump or very cold liquid into a hot pump. Thermal shock may cause damage to the internal components and rupture the pump casing.

DANGER

LIFTING DEVICE SAFETY

- Lifting devices of adequate capacity must be used whenever they are required.
- Safe workshop practices must be applied during all assembly and maintenance work.
- Personnel must never work under suspended loads.

DANGER

DANGER

Unapproved parts, unapproved pump construction, and misapplication (for example, foot valves, non-OEM parts, worn/damaged/corroded/obsolete parts, mis-assembly, excess pressure, unapproved fluids, etc.) may result in serious personal injury or death. Only use supplied equipment for its intended purpose.

WARNING

SHARP EDGES

- Before handling, identify work parts that could be hazardous due to sharp edges. All metal components must be considered to have sharp edges.
- Pump components can have sharp or jagged edges. Handle parts carefully, to prevent damage to slings or personal injury.

2.4 Intended Use

Vertical turbine pumps are built in a variety of designs and materials and for many applications/services. The manufacturer's IOM manual must be studied carefully and followed.

For the safety of operating personnel, note that the information contained in this manual applies only to the fitting of genuine Floway parts and recommended spares.

DANGER

GENUINE OEM PARTS

- Genuine OEM parts and accessories are designed, tested and incorporated into the products to help ensure they maintain continued product quality and performance in use.
- As Trillium Pumps USA does not test the parts and accessories sourced from other vendors, the installation of such parts and accessories may adversely affect the performance and safety features of the products.
- The failure to properly select, install or use authorized parts and accessories is considered misuse. Damage or failure caused by misuse is not covered by our warranty.
- In addition, any modification of Trillium Pumps USA products or removal of original components may impair the safety of these products in their use.

WARNING

SERIOUS PERSONAL INJURY AND EQUIPMENT DAMAGE

- Pump units must only be used for their intended purpose. Refer to the Certified Outline Drawing and other contract documents for construction and application details.
- The pumps must not be operated beyond their design MAWPs (suction and discharge sides), temperature limits and speed limits specified for the application. These limits are dependent on the pump type, configuration and materials used. If there is any doubt about the suitability of the product for the intended application, contact Trillium Pumps USA, referencing the serial number.

If the conditions of service on the purchase order are going to be changed (for example liquid pumped, temperature or duty), it is requested that the user seek the manufacturer's written agreement before start-up.

2.5 Qualified Workers

All personnel involved in the assembly, installation, operation, maintenance, inspection, and decommissioning of pump equipment must be qualified to carry out the work involved. If the personnel in question do not already possess the necessary knowledge and skill, appropriate training and instruction must be provided.

If required, the operator may engage the manufacturer/supplier to provide applicable training.

Always coordinate repair activities with operations and workplace health and safety personnel, and follow all plant safety requirements and applicable workplace health and safety laws and regulations.

2.6 Markings and Approvals

⚠ WARNING

EXPLOSIVE ATMOSPHERES

Prior to installing any equipment, determine the hazardous area classification and any other requirements applicable to the specific location and confirm all equipment has the required certifications.

It is a legal requirement that machinery and equipment put into service within certain regions of the world must conform to the applicable marking directives and standards such as CE marking directives covering machinery and, where applicable, low-voltage equipment, EMC, PED, and ATEX.

Where applicable, the directives and any additional approvals cover important workplace health and safety aspects relating to machinery and equipment and the satisfactory provision of technical documents and workplace health and safety instructions.

To confirm the applying approvals, and if the product is CE marked, check the serial number plate markings and the certification.

2.7 Safety Equipment for the Pump

Do not operate the pump without properly installed seal and coupling guards in place. If guards are removed during maintenance or gland adjustment, they must be replaced prior to operating the pump.

⚠ WARNING

ROTATING PARTS

Personnel injury or illness may result from contact with rotating parts, seal leakage or spray from the rotating shaft.

⚠ WARNING

GLAND ADJUSTMENT

During gland seal adjustment the fixed guard needs to be removed while the pump is operational. When the guard is removed, the rotating shaft is exposed. Additional safety management measures must be implemented to manage this specific hazard and only suitable trained and qualified personnel must work on gland adjustment. The guard must be replaced when adjustment is complete.

For auxiliary equipment, standard workplace health and safety precautions must be followed and appropriate instruction manuals consulted before and during installation, operation, adjustment, and maintenance.

2.8 Fire Fighting

A number of possible emissions or leakage of hazardous substances may be possible depending on the product being pumped. Ensure you are familiar with site and local procedures and requirements.

2.9 Emergency Procedures

Ensure you are familiar with site and local procedures and requirements. If there is an emergency, follow site and local procedures.

3 General Information and Description

3.1 General Information

Floway Pump's standard practice is to ship close coupled pumps assembled. Where long pump lengths, shipping limitations, handling limitations and headroom limitations prevent complete assembly, we will ship the pump sub-assembled. It is the responsibility of the installer to ask for assistance should it be required to properly assemble and install the pump.

The duration of satisfactory service obtained from the equipment, in part, depends on proper installation and maintenance.

This instruction manual provides basic guidelines for installation, operations and maintenance of the equipment and other safety precautions required for personnel. Due to the many variations and custom designed units it is impossible to cover every design variation or contingency which may arise. However, the basic information contained herein will answer most questions.

3.2 Identification

- Should questions arise concerning the pump equipment, the complete pump serial number will be required for identification. The pump serial number is stamped on metal nameplates affixed to the discharge head and bowl assemblies.
- The driver has a separate nameplate attached to it.
- When requesting information on the driver, both the driver serial number and pump serial number must be provided.

3.3 General Description

The major components of vertical turbine pumps include:

- Driver
- Discharge Head Assembly
- Column Assembly (when used)
- Bowl Assembly (with strainer as applicable)
- Suction Vessel (when used)

Refer to Figure 3-1 for one possible variant. Pumps less than 30 feet in length are typically shipped fully assembled and ready for installation. The drivers, couplings and strainers (when used) are shipped separately to prevent damage.

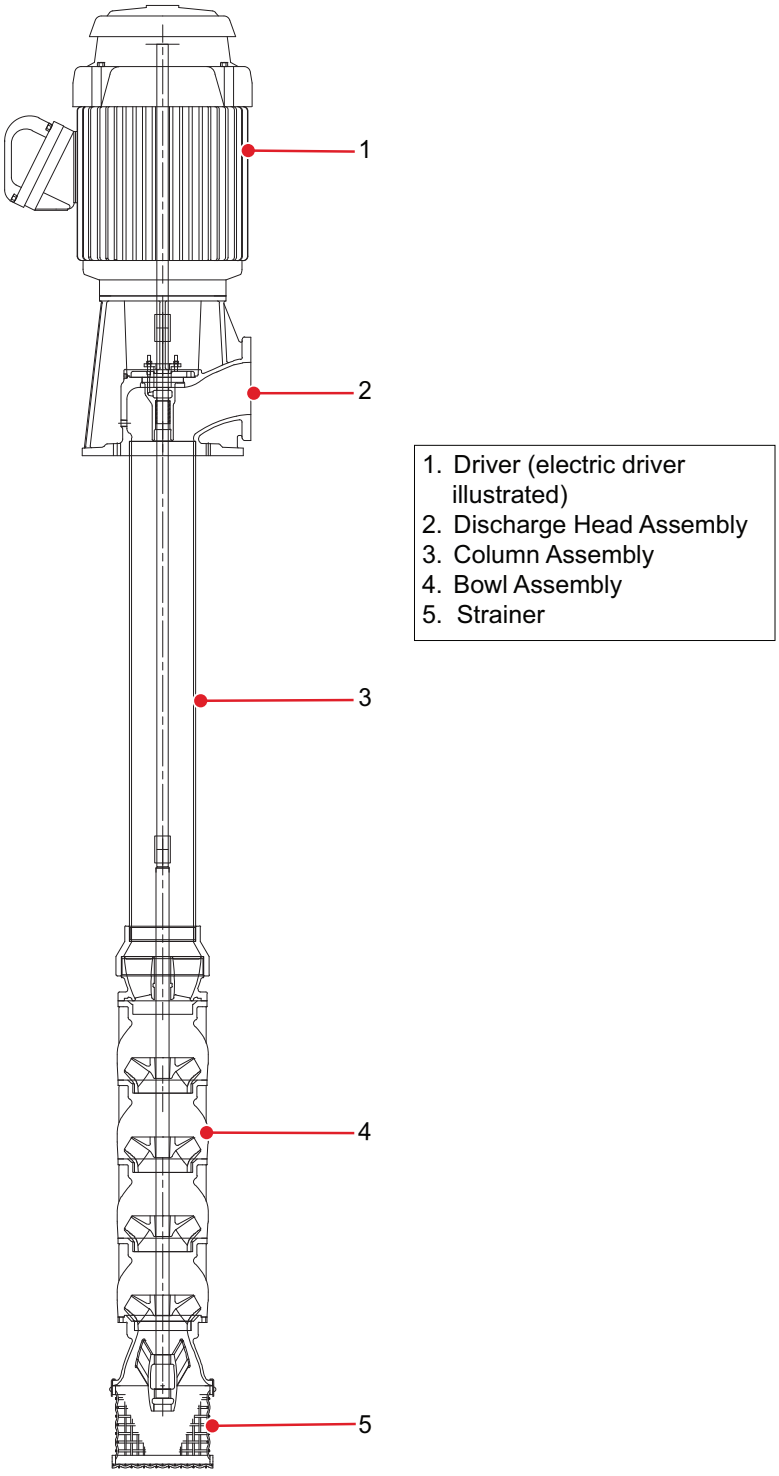


Figure 3-1: Major VTP Components

3.3.1 Drivers

A variety of drivers can be used; however, electric motors are most common. In this manual, electric motor drivers are grouped into two categories:

1. Hollow Shaft Drivers: where the pump shaft extends through a tube in the center of the motor shaft and is connected to the driver by a clutch assembly at the top of the driver.
2. Solid Shaft Drivers: where the motor shaft is solid and projects below the driver mounting base. This type of driver requires an adjustable coupling to connect to the pump.

3.3.2 Discharge Head Assembly

- The discharge head supports the driver, column, and bowl assemblies in addition to providing a discharge connection (the type VU discharge connection is located on one of the column pipe sections below the discharge head).
- A shaft sealing arrangement is located in the discharge head to seal the rotating shaft where it passes from the stationary housing (liquid chamber). Typically, the shaft seal is either a mechanical seal assembly or a packing box.

3.3.3 Column Assemblies

Column assemblies are of two basic types, either of which can be used on vertical turbine pumps:

1. Open Lineshaft Construction: utilizes the liquid being pumped to lubricate the lineshaft bearings.
2. Enclosed Lineshaft Construction: has an enclosing tube around the lineshaft and utilizes oil, grease or injected liquid (usually clean water) to lubricate the lineshaft bearings (not used on barrel pumps).

Column assemblies consist of the following:

- Column Pipe: which connects the bowl assembly to the discharge head and carries the pumped liquid to the discharge head. Column pipe is either threaded or flanged.
- Shaft: which connects the bowl shaft to the driver; and may contain bearings if required for the particular unit.
- Enclosing Tube (if applicable): surrounds the lineshaft to contain the supplied lubrication.

NOTICE

Some units do not require a column assembly, as the bowl assembly is connected directly to the discharge head.

3.3.4 Bowl Assemblies

The bowl assembly consists of the following:

- Impellers rigidly mounted on the bowl shaft which rotate and impart energy to the fluid.
- Bowls to contain the increased pressure and direct the fluid.
- Suction bell or case which directs the fluid into the first stage impeller.
- Bearings located in the suction bell (or case) and each bowl.

A separate instruction manual is available which provides construction details and repair instructions for Floway bowl assemblies.

3.3.5 Suction Vessel

The suction vessel may consist of a barrel with or without suction fitting, to connect to customers piping arrangement, or a storage tank with suitable opening to mount the pump.

Whatever the arrangement may be, it must provide:

- Adequate support for the unit
- A means of supplying the pump with liquid

4 Pre-installation

DANGER

LIFTING DEVICE SAFETY

- Use mechanical lifting devices to lift heavy or awkward components.
- Lifting devices must be in good condition, certified, and tagged.
- Lifting devices of adequate capacity must be used whenever they are required.
- Personnel must never work under suspended loads.

DANGER

LIFTING POINT SAFETY

Check that the lifting lugs are in suitable condition for lifting, before lifting pump parts.

4.1 Receiving and Unloading

When receiving the shipment, extreme care must be taken while unloading.

- Use a forklift or crane to unload the equipment.
- Do not drop the unit, or any parts, as damage can cause trouble in assembly and operation of the units.
- Inspect the unit for signs of transit damage before beginning to uncrate or placing in storage. If damage is evident notify the local transporting company agent before uncrating and file a claim with the agent.

4.2 Storage

NOTICE

These provisions are applicable to Trillium Pumps USA pump components only. For the appropriate storage procedures for non-Trillium items (for example, drivers, mechanical seals, auxiliary equipment, etc.), refer to specific requirements from the manufacturer.

- If the unit is to be stored prior to installation, carefully select a storage space where the unit will not be subjected to excess moisture, extreme weather conditions, corrosive fumes, or other harmful conditions.
- Carefully inspect the unit and clean the rust spots on the machined surfaces with a fine emery cloth.
- Coat machined surfaces with a rust preventative.
- Protect the pump from any dust, dirt, or debris from entering the unit. Wrap all openings with a heavy gauge polyethylene and tape tightly to seal.
- If the unit is stored for a long period of time it should be periodically inspected and cleaned as required.
- Contact the factory for special long term storage (greater than 4 months) requirements for the unit supplied.

4.3 Uncrating and Cleaning

If the unit appears undamaged proceed to uncrate following the instructions given below:

⚠ CAUTION

DEFLECTION OF THE PUMP

To prevent deflection of the pump components, take appropriate precaution to prevent the weight of the pump from resting on the suction bell or case, when lifting to vertical position. Refer to Figure 4-1 on page 15.

- Clean all the parts of any dirt, packing material or other foreign matter.
- Flush the pump inside and outside with clean water or a fluid compatible with pumpage. If the pump is for potable water, a lightly chlorinated flush may be recommended.
- Clean all machined surfaces as these are coated with a rust preventative before shipment, which must be removed.
- Remove any rust spots found on the machined surfaces with a fine emery cloth.
- Clean all threaded connections and any accessory equipment.

NOTICE

Parts and accessories may be placed inside shipping containers or attached to skids in individual packages. Inspect all containers, crates and skids for attached parts before discarding.

4.4 Lifting

⚠ DANGER

LIFTING DEVICE SAFETY

- Use mechanical lifting devices to lift heavy or awkward components.
- Lifting devices must be in good condition, certified, and tagged.
- Lifting devices of adequate capacity must be used whenever they are required.
- Personnel must never work under suspended loads.

⚠ DANGER

LIFTING POINT SAFETY

Check that the lifting lugs are in suitable condition for lifting, before lifting pump parts.

⚠ WARNING

LIFTING EXPERIENCE

All lifting and rigging must be performed by qualified and experienced personnel who are familiar with safe lifting practices and requirements. A lifting plan should be established and followed to ensure safe lifting of all equipment.

⚠ WARNING

PERSONAL INJURY

To avoid personal injury, all components and assemblies greater than 30 lbs. (14 kg) should be lifted using mechanical methods.

⚠ WARNING

LIFTING DRIVERS AND AUXILIARY EQUIPMENT

Refer to the manufacturer's instruction manual for proper lifting techniques of all drivers and auxiliary equipment. Driver lifting locations must only be used to lift the driver. Do not use the driver lifting locations to lift the assembled pump and driver.

4.4.1 Lifting Pump Components and Pump Assemblies

Refer to the certified outline drawing for approximate pump assembly weights.

Pump components and assemblies must only be lifted from the appropriate locations. If there is any doubt regarding proper lifting methods and locations, contact your nearest manufacturer's representative.

⚠ WARNING

PERSONAL INJURY AND EQUIPMENT DAMAGE

Never lift any assemble by the bowl shaft or lineshaft. This can result in damage to the shaft and personal injury.

- Cans/Barrels must be lifted using appropriate lifting devices attached to the mounting plate.
- Discharge heads are fitted with lifting lugs suitable to support the entire weight of the pump. Typically two or more lifting lugs are supplied, a minimum two point lifting method is required (refer to Figure 4-2 on page 16 for fabricated heads and Figure 4-3 on page 16 for cast heads).
- Column and bowl assemblies must be lifted using an appropriate clamping fixture. The fixture must positively lock to the item being lifted and have adequate strength to support the assembly's weight. A common fixture design employs beams and threaded rods that can be fastened around the assembly (refer to Figure 4-4 on page 16). When clamping to threaded column, the upper column coupling must be fully installed to provide a stop for the lifting clamp placed below the coupling. If the column is supplied with optional lifting lugs, those may be used to lift the assembly.

⚠ WARNING

PERSONNEL INJURY

- Clamping fixtures that do not positively lock to the assembly being lifted may come loose and cause personal injury. Always ensure the clamping fixture is of an appropriate design to support the load and has secure means to lock onto the assembly being lifted.
- Do not lift bowl assemblies by placing lifting devices through the flange bolt holes, the cast bowl flange holes may break through and result in dropping the load and personal injury.

Lift devices (straps, chains, etc.) attached to the pump must not exceed a 45 degree angle to the vertical position. Exceeding this angle could overload the lifting location (refer to Figure 4-2 on page 16).

When lifting an assembled pump, it must be supported at minimally two locations. When lifting to the vertical position, use the discharge head lifting lug locations to lift the pump assembly (refer to Figure 4-1 on page 15). For pump units over 40 ft in length, the pump shall be assembled during installation vertically in place over the mounting location.

If the unit is supplied with a separate motor stand (that is, a component bolted between the driver and discharge head), do not lift the entire pump unit from the motor stand. The motor stand lifting lugs are for lifting the motor stand assembly only.

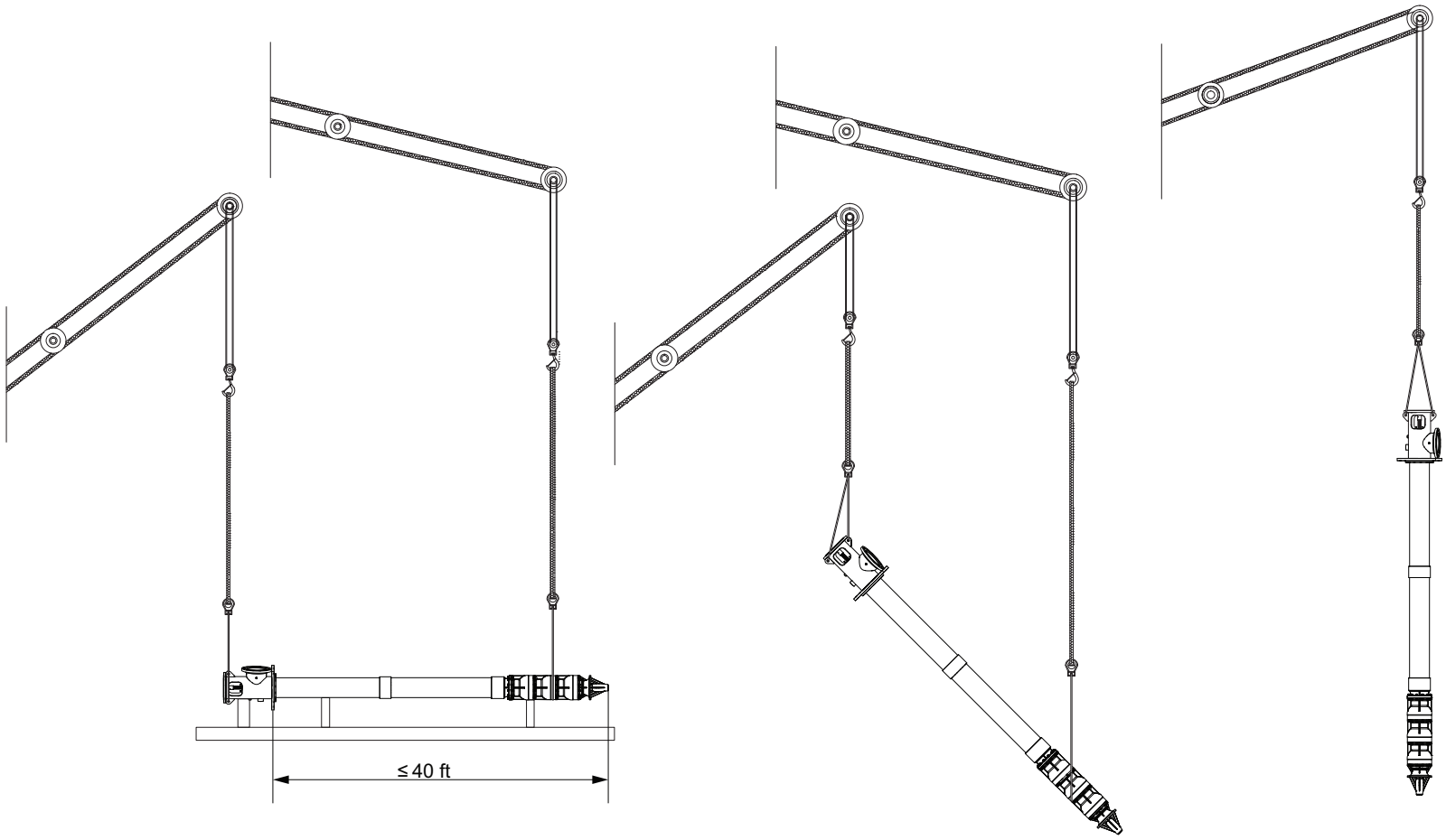


Figure 4-1: Lifting Pumps from Horizontal to Vertical Position

(for pump lengths up to 40 feet)

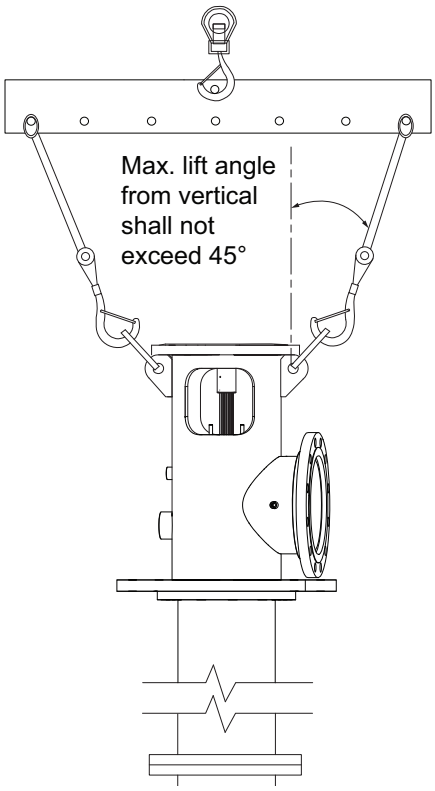


Figure 4-2: Fabricated Head Lifting

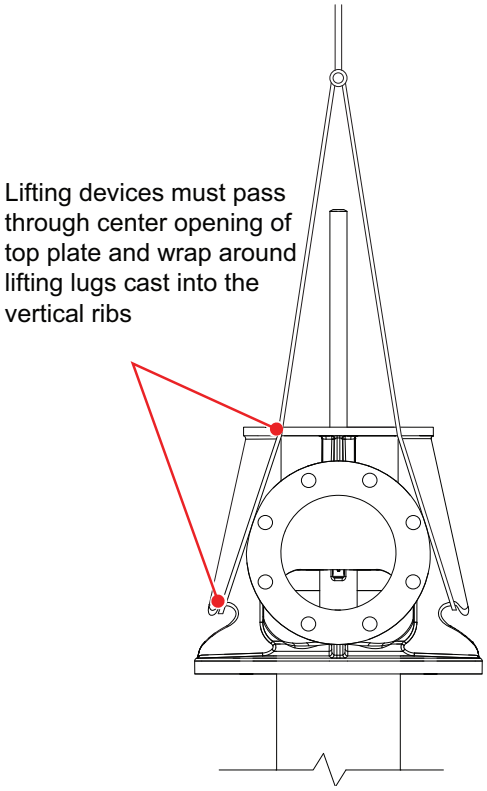


Figure 4-3: Cast Head Lifting

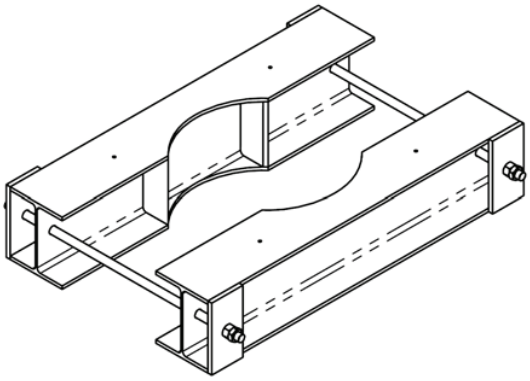


Figure 4-4: Typical Clamping Fixture

4.5 Installation Equipment and Tools

Do not attempt installation without proper equipment. The following list covers the major equipment and tools required for installation:

1. Mobile crane capable of hoisting and lowering the weight of the pump or motor (refer to Figure 4-1 on page 15).
2. Cable sling for attaching to the pump and motor lifting eyes (refer to Figure 4-1 on page 15).
3. Ordinary hand tools such as end wrenches, socket set, screw drivers, allen wrenches, etc.
4. Wire brush, scraper and fine emery cloth.
5. Thread sealing compound, light machinery oil and a thread lubricant.
6. Tank or barrel flange gasket and flange bolts & nuts (Can Pumps).

4.6 Pre-installation Check List

For proper and timely installation, complete the following checks before starting the installation procedure:

1. Check the pump serial number with the number on the packing slip to ensure that the correct unit is installed.
2. Check the driver horsepower and speed indicated on the driver nameplate and the horsepower and speed indicated on the pump nameplate (located on the discharge head) to ensure they agree.

NOTICE

A slight difference between the nominal speeds (RPM) shown on the driver and pump nameplates are permissible. However, the difference must not be more than 1% to 2%.

3. For electric motor driven units, make sure the voltage and frequency on the motor nameplate agree with the service available. Also, ensure the horsepower/voltage rating of the control panel, starter, and/or VFD agree with the horsepower/voltage rating of the motor.
4. Check the depth of the sump or barrel against the pump length to ensure there is no interference.
5. Check bottom of the pump. Sleeve-type mechanical seal units shipped completely assembled are supplied with a shaft locking plate which must be removed and replaced with a pipe plug (plug is required only on grease packed suction bearings) prior to installation (refer to Figure 4-5 on page 18).

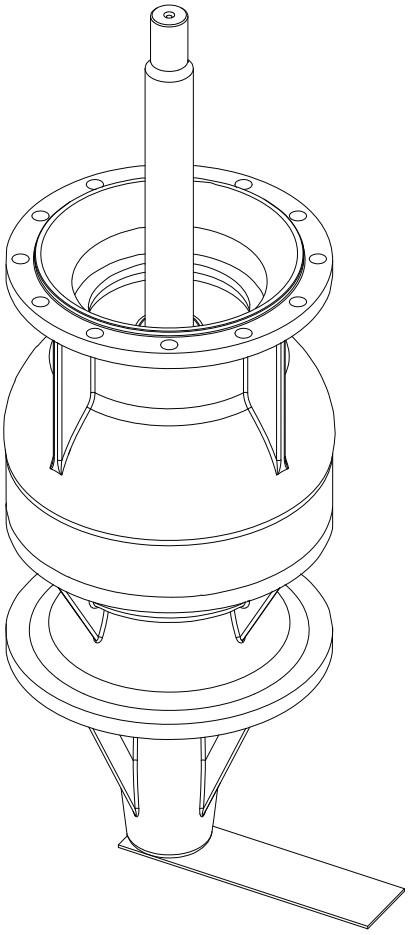


Figure 4-5: Shaft Locking Plate

NOTICE

Shaft type seals are shipped separately and are not installed in the seal housing. A tag is supplied indicating that the seal is not installed. Lock down plate is not supplied for units which have no seals installed.

6. Check the proposed minimum liquid level in the sump against the pump length; the bottom stage of the pump must be submerged at all times and satisfy the minimum required submergence and NPSHR.
7. Clean the sump and piping system before installing the pump.
8. Check the installation equipment to ensure it can safely handle the equipment.
9. Check the pump connections (bolts, nuts, etc.) for tightness. These are properly tightened before leaving the factory. However, some connections can become loose during transit.
10. For hollow shaft drivers, check the clutch size against the shaft size that must pass through the clutch. Sometimes the shaft size coming through the discharge head is different from the shaft size going through the driver (ensure the clutch is checked against to correct shaft).
11. For solid shaft drivers, check the motor shaft size against the driver half coupling bore size. Also check all keys.

5 Installation

⚠ WARNING

PERSONAL INJURY

The pump must be installed, operated and maintained only by personnel who are trained and have sufficient knowledge about the hazards that may occur during such work.

5.1 General

This is a precision piece of equipment and must be treated as such. Proper installation is necessary to obtain maximum service life from the pump. To ensure proper alignment, three items are very important during installation:

1. All machined mating surfaces (such as the mating flanges of the pump and driver) must be clean and free of burrs and nicks. These surfaces must be cleaned thoroughly with scraper, wire brush and emery cloth if necessary, and any nicks or burrs must be removed with a fine file.
2. Exterior strain must not be transmitted to the pump. The most common cause of trouble in this respect is forcing the piping to mate with the pump. It is recommended that flexible connectors are installed in the piping adjacent to the pump when possible. This is especially critical on type VU (underground discharge) units where the discharge could be several feet below the supporting structure and a relatively small strain can cause misalignment.
3. All threads must be checked for damage and repaired if necessary. If filing is required, remove the part from the pump if possible, or arrange a rag to catch all the filings so that they do not fall into other parts of the pump. Clean all threads with wire brush and cleaning solvent. Ends of shafts must be cleaned and any burrs removed since alignment depends on the shaft ends butting squarely. Lubricate all screwed connections with a thread lubricant suitable for steel. Use an anti-galling compound such as “Never- Seez” on stainless and monel mating threads.

⚠ CAUTION

EQUIPMENT DAMAGE

Apply thread lubricant sparingly to male shaft threads only when making up shaft connections. Do not allow excess lubricant to get in between the ends of the shaft.

5.2 Foundation

- The foundation may be constructed out of any material which can afford permanent, rigid support to the discharge head and can absorb the expected stress that may be encountered during service.
- It is recommended that concrete foundations have anchor bolts installed in sleeves twice the diameter of the bolt to allow alignment with the holes in the mounting plate as illustrated in Figure 5-1 on page 20, however, sleeves are not required and anchor bolts may be directly installed in concrete.

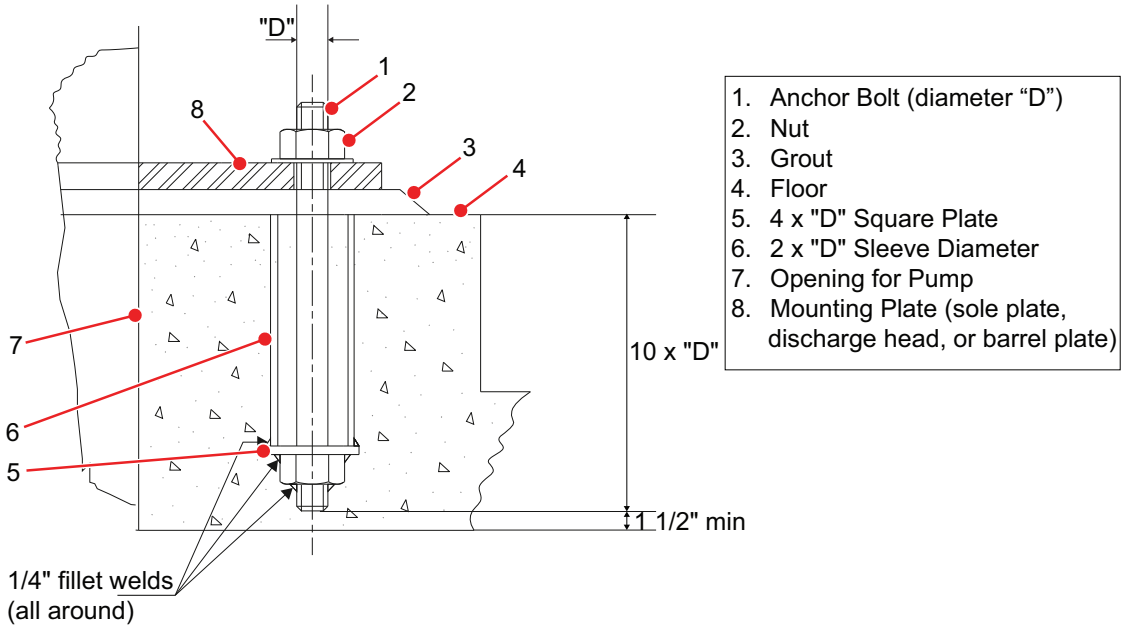


Figure 5-1: Recommended Anchor Bolt Arrangement

5.3 Suction Barrel Installation

If a suction barrel has been furnished with the pump it must be mounted to a firm foundation. The suction vessel must provide permanent, rigid support to the pump and motor. It is recommended that concrete foundations have anchor bolts installed in sleeves twice the diameter of the bolt to allow alignment with the holes in the mounting plate, however, sleeves are not required and anchor bolts may be directly installed in concrete. Level the pump mounting surface, then grout and anchor in place.

5.4 Vertical Turbine Pump Installation for Wet Pit (Type VS1)

DANGER

LIFTING DEVICE SAFETY

- Use mechanical lifting devices to lift heavy or awkward components.
- Lifting devices must be in good condition, certified, and tagged.
- Lifting devices of adequate capacity must be used whenever they are required.
- Personnel must never work under suspended loads.

DANGER

LIFTING POINT SAFETY

Check lifting lugs are in suitable condition for lifting, before lifting pump parts.

CAUTION

DAMAGE TO THE PUMP

Clean the sump and piping of all abrasive particles and loose debris before starting installation, to avoid any damage to the pump.

1. Position the lifting equipment so it will center over the foundation opening.
2. If a soleplate is used, level the mounting surface then grout and anchor in place.

3. Clean the pump discharge flange.

NOTICE

- All machined surfaces are coated with rust preventative prior to shipment. This must be completely removed along with any paint overspray or rust which might be on the machined faces.
- The faces must be scraped and wire brushed first.
- Use fine emery cloth to remove any stubborn spots.

CAUTION

EQUIPMENT DAMAGE

Be particularly careful not to damage any piping which may extend down, along the column and/or bowl assembly. This piping (when used) must not be crushed. If damaged, remove and replace it.

4. Lift the pump, mount the strainer if required and lower slowly into the sump. Guide the pump as it is being lowered and watch for any obstructions or binding of the pump. Stop lowering the unit when still a few inches off the foundation.
5. Rotate the pump until the discharge flange faces the proper direction for alignment with piping. Align the anchor bolt holes.
6. Slowly lower the pump onto the foundation (or sole plate if applicable).
7. Install the mounting bolts or nuts. Do not tighten at this stage.

CAUTION

EQUIPMENT DAMAGE

Excessive nozzle loads must not be imposed on the pump. All piping must be carefully aligned and supported to prevent excessive nozzle loads.

CAUTION

EQUIPMENT DAMAGE

It is strongly recommended that flexible connectors (dresser couplings or equivalent) be installed in the piping immediately adjacent to the pump.

8. Connect the system piping to the pump, if required, shift the pump slightly on the foundation to facilitate alignment.

WARNING

PERSONNEL INJURY

- Always ensure proper tightening of all piping connections to the pump.
- Ensure the required gaskets and/or o-rings are installed.
- Poor connections may result in leakage.
- Leakage of hazardous or high pressure pumpage may result in personnel injury.

9. Tighten the discharge flange bolting. Ensure that the flanges mate face to face without applying excessive force.
10. Tighten the mounting bolts (grout and anchor if no sole plate).

5.5 Vertical Turbine Can Pump Installation (Type VS6)

DANGER

LIFTING DEVICE SAFETY

- Use mechanical lifting devices to lift heavy or awkward components.
- Lifting devices must be in good condition, certified, and tagged.
- Lifting devices of adequate capacity must be used whenever they are required.
- Personnel must never work under suspended loads.

DANGER

LIFTING POINT SAFETY

Check lifting lugs are in suitable condition for lifting, before lifting pump parts.

1. Position the lifting equipment so it will center over the suction vessel mounting flange (refer to “Suction Barrel Installation” on page 20).

CAUTION

DAMAGE TO THE PUMP

Clean the suction vessel and piping of all abrasive particles and loose debris before installation, to avoid any damage to the pump.

2. Clean the suction vessel mounting flange, oil lightly, and position the gasket. Clean the pump mounting flange and oil lightly.

NOTICE

- All machined surfaces are coated with rust preventative prior to shipment. This must be completely removed along with any paint overspray or rust which might be there on the machined faces.
- The faces must be scraped and wire brushed first.
- Use fine emery cloth to remove any stubborn spots.

NOTICE

- Type VC can pumps have the suction nozzle located on the discharge head.
- Type AF, CF, VF and VFR can pumps have the suction nozzle located on the suction vessel.

3. Clean the pump discharge flange (and suction flange wherever applicable).

CAUTION

EQUIPMENT DAMAGE

Be particularly careful not to damage any piping which may extend down along the column and/or bowl assembly. This piping (when used) must not be crushed. If damaged, remove and replace it.

4. Lift the pump, mount the strainer if required and lower slowly into the suction vessel. Guide the pump as it is being lowered and watch for any obstructions or binding of the pump. Stop lowering the unit when still a few inches off the mounting flange.
5. Rotate the pump until the discharge flange faces the proper direction for alignment with piping. Align the mounting flange bolt holes.

NOTICE

- Type VC discharge heads have both suction and discharge flanges. Therefore, it is important to make sure that the suction piping is connected to the suction side of the pump.
- A flow arrow is located on the side of the suction pipe to help identify the correct orientation.
- Figure 5-2 on page 23 is provided to enable field identification in case the flow arrow is not visible.

6. Check the mounting flange gasket to ensure it is in the correct position. Some pumps may be supplied with O-rings in lieu of a gasket.
7. Slowly lower the pump onto the mounting flange.
8. Install the mounting bolts or nuts. Do not tighten at this stage.

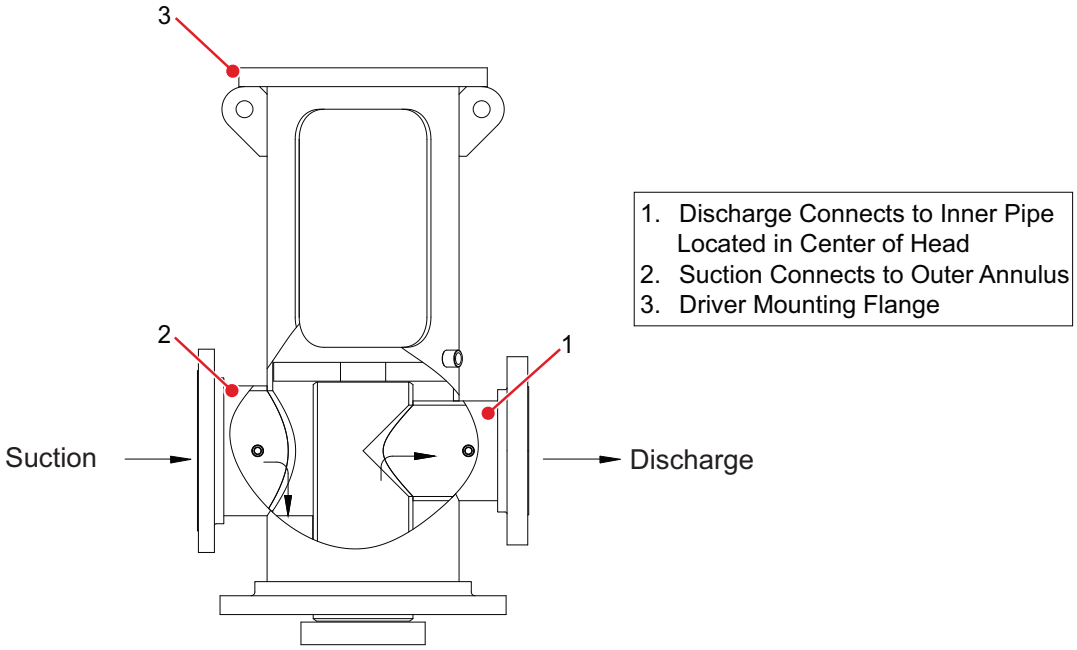


Figure 5-2: Suction and Discharge Identification - Type VC Discharge Head

CAUTION

EQUIPMENT DAMAGE

Excessive nozzle loads must not be imposed on the pump. All piping must be carefully aligned and supported to prevent excessive nozzle loads.

CAUTION

EQUIPMENT DAMAGE

It is strongly recommended that flexible connectors (dresser couplings or equivalent) be installed in the piping immediately adjacent to the pump.

9. Connect the system piping to the pump, if required, shift the pump slightly on the mounting flange to facilitate alignment.

⚠ WARNING

PERSONNEL INJURY

- Always ensure proper tightening of all piping connections to the pump.
- Ensure the required gaskets and/or o-rings are installed.
- Poor connections may result in leakage.
- Leakage of hazardous or high pressure pumpage may result in personnel injury.

10. Tighten the discharge (and suction, if applicable) flange bolting. Ensure that the flanges mate face to face without applying excessive force.
11. Tighten the mounting flange bolting.

5.6 Hollow Shaft Driver Installation

⚠ DANGER

LIFTING DEVICE SAFETY

- Use mechanical lifting devices to lift heavy or awkward components.
- Lifting devices must be in good condition, certified, and tagged.
- Lifting devices of adequate capacity must be used whenever they are required.
- Personnel must never work under suspended loads.

⚠ DANGER

LIFTING POINT SAFETY

Check lifting lugs are in suitable condition for lifting, before lifting pump parts.

⚠ WARNING

CONSULT DRIVER IOM MANUAL

Consult the driver IOM for all safety, installation, operation, maintenance and other product information.

NOTICE

- All machined surfaces are coated with rust preventative prior to shipment. This must be completely removed along with any paint overspray or rust which might be there on the machined faces.
- The faces must be scraped and wire brushed first.
- Use fine emery cloth to remove any stubborn spots.

1. Clean the driver mounting flange on the discharge head and remove any burrs or nicks on the register and mounting face. Oil lightly.
2. Remove the driver clutch.
3. Clean the driver mounting flange and remove any burrs or nicks on the register and mounting flange. Oil lightly.
4. Some electric motors are supplied with a lower guide bushing installed at the bottom of the motor to stabilize the shaft at this point (also called a steady bushing). Some motor manufacturers mount this guide bushing before shipping while others will ship the guide bushing separately with instructions for field mounting. If applicable, mount the guide bushing to the motor (refer Figure 5-3 on page 25).

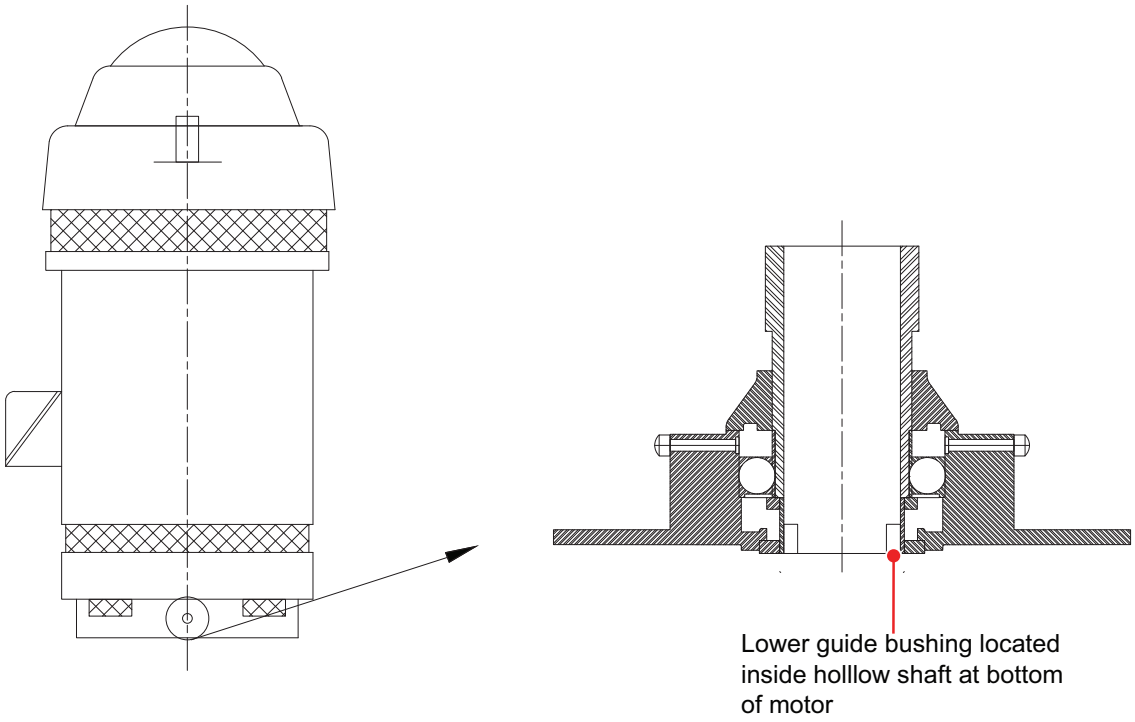


Figure 5-3: Motor Guide Bushing Location

5. Raise and center the driver over the pump.
6. Lower carefully until about 1/4″ above mounting flange.
7. Rotate the driver until the junction box on the motor or the input shaft on the gear drive is in correct position.
8. Align bolt holes and insert bolts.
9. Lower carefully into place ensuring that the driver and pump registers mate correctly.
10. Tighten the mounting bolts.
11. Refer to the driver manufacturer's instruction manual for specific product requirements regarding installation and start-up procedures.

⚠ WARNING

PERSONNEL INJURY

Do not touch the rotating elements with hands to establish the direction of rotation. Visually confirm the direction of rotation.

⚠ CAUTION

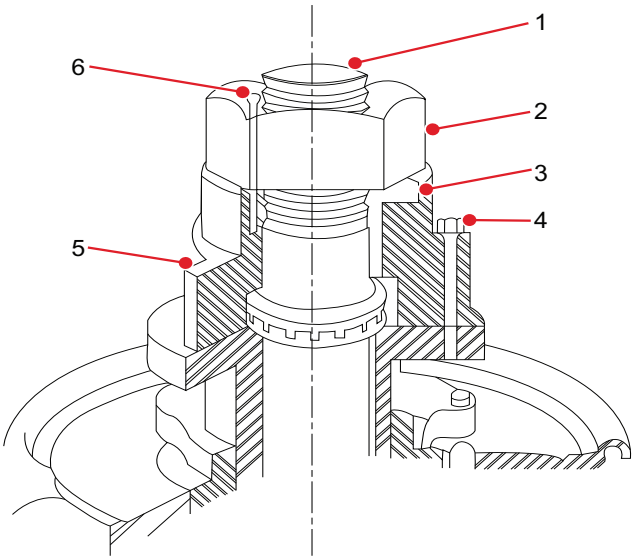
DAMAGE TO THE PUMP

Always check rotation before connecting the driver to the pump as reverse rotation while the pump is connected can cause extensive damage to the pump.

12. Prior to installation of headshaft, check electric drivers for rotation. Establish electrical connections and jog the motor briefly to check the rotation. Driver must rotate in counter clockwise direction when viewed from the top end of the motor.

    To change the direction of rotation on a three phase motor, interchange any two line leads.
13. Install the mechanical seal at this time, if the pump is so equipped and the mechanical seal was shipped uninstalled. Refer to "Mechanical Seal" on page 33 for further details.

14. Clean all the shaft threads (on top shaft and both ends of headshaft). Try the lineshaft coupling and headshaft nut on their respective threads. These must thread on by hand. If not, clean up the threads with a fine three cornered file. Check the ends of the shaft where they butt inside the lineshaft coupling. Ends must be square and clean. Fit the gib key to both motor clutch and headshaft. The key must slide smoothly in both keyways.



1. Headshaft
2. Headshaft Nut (adjusting nut)
3. Gib Key
4. Cap Screw
5. Clutch
6. Headshaft Nut Lock Screw

Figure 5-4: Hollow Shaft Driver Clutch

NOTICE

For units equipped with one piece headshaft (no lineshaft coupling between driver and pump) steps 15 and 16 will not be applicable.

CAUTION

EQUIPMENT DAMAGE

Apply thread lubricant only to male shaft threads sparingly to avoid buildup between ends of shaft which can cause misalignment.

15. Lubricate the top shaft threads and thread (left hand threads) the lineshaft coupling half way onto the top shaft.
16. Lubricate the headshaft threads and lower the headshaft carefully down through the driver, and thread into the lineshaft coupling. Shafts must butt against each other.

NOTICE

Headshaft must stand centered (long shafts may lean slightly from own weight; however, they can be centered without effort) in the driver hollow shaft. If not, check the driver mounting flange for improper mounting and re-clean the shaft ends coupled inside the discharge head.

17. Install the clutch on the driver and ensure that it fits down properly.
18. Install pre-fitted gib key in the clutch and the shaft.
19. Thread adjusting the nut down (right hand threads) on the shaft until it bears against the clutch.
20. Refer to “Impeller Adjustment - General” on page 29 for impeller adjustment.
21. Adjust mechanical seal after adjusting impellers.

5.7 Solid Shaft Driver Installation

DANGER

LIFTING DEVICE SAFETY

- Use mechanical lifting devices to lift heavy or awkward components.
- Lifting devices must be in good condition, certified, and tagged.
- Lifting devices of adequate capacity must be used whenever they are required.
- Personnel must never work under suspended loads.

DANGER

LIFTING POINT SAFETY

Check lifting lugs are in suitable condition for lifting, before lifting pump parts.

WARNING

CONSULT DRIVER IOM MANUAL

Consult the driver IOM for all safety, installation, operation, maintenance and other product information.

NOTICE

- All machined surfaces are coated with rust preventative prior to shipment. This must be completely removed along with any paint overspray or rust which might be there on the machined faces.
- The faces must be scraped and wire brushed first.
- Use fine emery cloth to remove any stubborn spots.

1. Clean the driver mounting flange on the discharge head and remove any burrs or nicks on the register and mounting face. Oil lightly.
2. Clean the headshaft threads. Lubricate the threads and try installing the adjusting nut (it should thread on by hand easily, if not, clean up the threads with a fine three cornered file).
3. Clean the driver mounting flange and remove any burrs or nicks on the register and mounting flange. Oil lightly.
   a. Check the shaft diameter and projection against coupling and schematic provided.
   b. If the dimensions are correct proceed to step 4.
   c. If the dimensions are incorrect contact the nearest manufacturer's representative for assistance.
4. Install the driver half coupling on the driver shaft (refer to Figure 5-5 on page 28 and Figure 12-1 on page 58 for coupling illustrations).
   a. Place the straight key into the keyway. Ensure that the key is up far enough to clear the circular groove cut around the shaft, near the end. Hand press the key into groove.
   b. Slide the driver half coupling onto the motor shaft far enough to insert the split circular thrust ring into the shaft groove. The coupling must be a tight fit to the driver shaft but not interference fit.
   c. Install split circular thrust ring in the shaft groove. When properly positioned the motor half coupling will slide down over the split circular key and hold it in position (refer to Figure 5-5 on page 28).

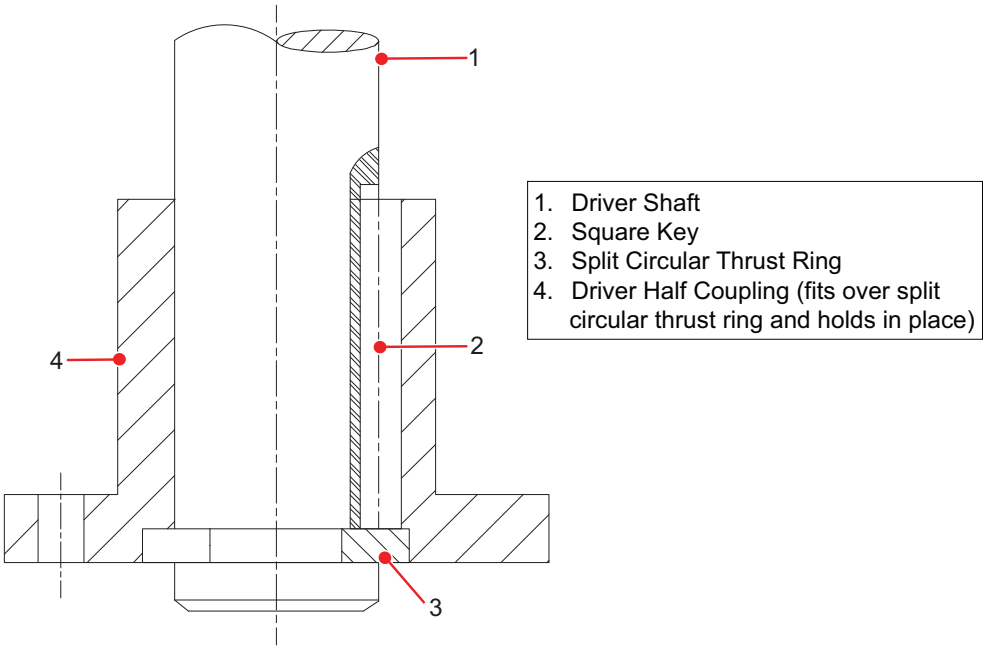


Figure 5-5: Driver Half Coupling Correctly Positioned

5. Install the mechanical seal at this time if the pump is so equipped and the mechanical seal was shipped uninstalled. Refer to "Mechanical Seal" on page 33 for further details.
6. Install the pump half coupling onto the headshaft:
   a. Slide the pump half coupling onto the shaft.
   b. Install the key and push down to clear the threads.
   c. Thread the adjusting nut (right hand threads) onto the shaft until the end of the shaft is even with the top of the adjusting nut.
7. Center the motor over the pump and rotate to align the mounting holes and properly align the power conduit box. For gear drives, rotate the input shaft into desired position.
8. Lower the driver carefully into place ensuring that the driver and pump registers mate correctly. Check the shaft gap between the motor and pump shaft against the schematic provided.

⚠ CAUTION

EQUIPMENT DAMAGE

- If the discharge head or motor stand was supplied with jacking screws, the driver must be manually aligned to the pump shaft prior to bolting it down. Failure to align the driver may result in equipment damage. The driver shaft must be aligned to within 0.002" max. TIR with respect to the precision machined ID on the pump's driver mounting plate.
- If jacking screws are not supplied, manual driver alignment is not required.

9. Bolt the driver to the discharge head.
10. Refer to the driver manufacturer's instruction manual for specific product requirements regarding installation and start-up procedures.

⚠ WARNING

PERSONNEL INJURY

Do not touch the rotating elements with hands to establish the direction of rotation. Visually confirm the direction of rotation.

⚠ CAUTION

DAMAGE TO THE PUMP

- Before jogging the motor make sure the coupling halves are not touching and the motor shaft end is sufficiently clear of the pump shaft and adjusting nut, and the driver can rotate freely without rotating the pump. The driver half coupling must be in proper position as shown in Figure 5-5 on page 28 so that the split circular thrust ring does not come out.
- Always check rotation before connecting the driver to the pump as reverse rotation while the pump is connected can cause extensive damage to the pump.

11. Check the electric driver for rotation at this time. Establish electrical connections and run the motor briefly to check the rotation. Driver must rotate in counter clockwise direction when viewed from the top end of the motor.
    a. To change the direction of rotation on a three phase motor, interchange any two line leads.
    b. To change direction of rotation on a two phase motor, interchange the leads of either phase.
12. For pumps using a spacer type coupling, bolt the spacer to the driver half coupling.
13. Thread the adjusting nut up until there is 1/8″ gap between the nut and the spacer or driver half coupling (refer to Figure 5-7 on page 32).

NOTICE

Adjusting nuts have drilled holes on the outside diameter for inserting handle of hex wrench or round bar to facilitate adjustment.

14. Refer to “Impeller Adjustment - General” on page 29 for impeller adjustment.
15. Adjust mechanical seal after adjusting the impellers (refer to “Mechanical Seal” on page 33).

5.8 Impeller Adjustment - General

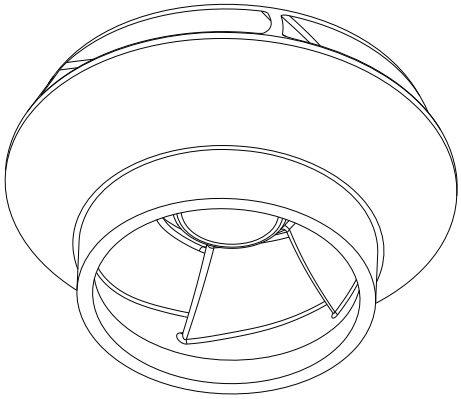
- Proper impeller adjustment positions the impeller inside the bowl assembly for maximum performance.
- The impellers must be raised slightly to prevent dragging on the bowls.

⚠ DANGER

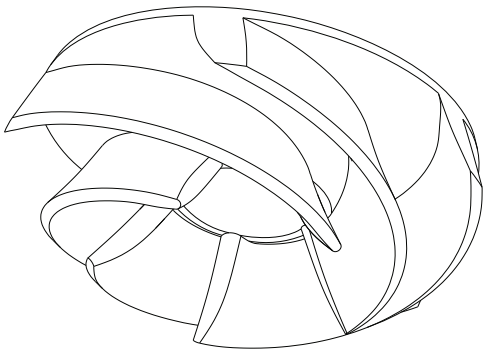
PERSONNEL INJURY AND EQUIPMENT DAMAGE

Never operate the pump without properly adjusting the impellers. Operating the pump without proper adjustment could result in catastrophic damage to the equipment and injury to personnel from projectiles.

Impellers are of two basic types: enclosed and semi-open (also referred to as semi-enclosed). The type and size of impeller, as well as the application, determine what the proper impeller adjustment must be. The type of impellers installed in the pump can be determined from the pump nameplate or packing slip. If the second letter of the pump type is K, it is an enclosed impeller and if the letter is O, then it is a semi-open impeller. Hence DKM indicates enclosed impellers, while DOM indicates semi-open impellers (refer to Figure 5-6 on page 30).



Enclosed Type Impeller



Semi-open Type Impeller

Figure 5-6: Types of Impellers

⚠ CAUTION

EQUIPMENT DAMAGE

The impellers must be completely down against the bowl seat when starting the impeller adjustment. All dimensions and instructions given above are based on the assumption that the impellers are seated. When pumps are subjected to suction pressure, the pressure acting against the shaft tends to raise it. If the suction pressure is great enough it can raise the shaft. Make sure the shaft is down when starting to adjust the impellers.

1. Enclosed Impellers: for proper impeller adjustment refer to the pump nameplate on the discharge head.
2. Semi-open Impellers: the adjustment of semi-open impellers is more critical than that of enclosed impellers. A small change in the impeller setting impacts the pump performance considerably (refer to Figure 7-1 on page 43).

   If after making the below adjustment the pump does not deliver its rated capacity, the impellers can be lowered one step at a time until the lowest possible adjustment is achieved without the impellers dragging.

   On the other hand, if the impellers appear to be dragging after the initial adjustment the unit must be stopped and the impellers raised one step. Dragging the impellers will increase the pump power considerably and can usually be heard and felt as increased vibration.

⚠ CAUTION

EQUIPMENT DAMAGE

Excessively dragging impellers during operation will result in equipment damage. If dragging occurs, stop the pump and increase the impeller setting.

NOTICE

If semi-open impellers are raised and then adjusted down, a slight increase in the power required will be noted due to the increased delivery of the pump. Do not confuse this with the marked power increase when impellers are lowered enough to drag.

- For optimum performance the impeller must run within a few thousandths of an inch of the bowl seat. The exact shaft adjustment varies according to variables of each installation.
- For close coupled units, a general rule of 0.015" plus 0.005" of adjustment for each 100 feet of discharge head produced by the pump, plus 0.005" adjustment for each 10 feet of column assembly will provide close to ideal adjustment.

- Use the highest discharge head that the unit is expected to operate against to calculate the impeller adjustment value.
- For example: a pump designed to operate at 400 feet discharge head but will also be operated against a closed valve for short intervals at which time it will produce 500 feet of pump pressure, therefore 5 x 0.005″ = 0.025″. For a unit with 20 feet of column assembly, the calculation would be: 2 x 0.005 = 0.010". The initial adjustment would be 0.025″ + 0.010″ + 0.015″ = 0.050″.

Refer to Table 5-1 to determine how many turns or fraction of a turn is necessary for the shaft diameter supplied. For example: a 1 11/16 - 10″ TPI shaft will provide 0.100″ adjustment per turn of nut. Therefore 1/2 turn of the nut will provide the required 0.050″ impeller setting in the previous example.

Shaft Diameter	Headshaft Nut (thread/inch)	Inches per Full Turn of Adjusting Nut
3/4″	16 TPI - R.H.	0.063
1″	14 TPI - R.H.	0.071
1 1/4″	12 TPI - R.H.	0.083
1 1/2″	12 TPI - R.H.	0.083
1 11/16″	10 TPI - R.H.	0.100
1 15/16″	12 TPI - R.H.	0.083
2 1/4″	12 TPI - R.H.	0.083
2 7/16″	12 TPI - R.H.	0.083
2 11/16″	12 TPI - R.H.	0.083
2 15/16″	10 TPI - R.H.	0.100
3 3/16″	8 TPI - R.H.	0.125
3 7/16″	8 TPI - R.H.	0.125

Table 5-1: Shaft Diameter Turns

5.9 Impeller Adjustment - Hollow Shaft Driver

Impeller adjustment when using hollow shaft driver is accomplished at the top of the driver by the following procedure.

1. Remove the driver canopy.
2. Install the headshaft as outlined in “Hollow Shaft Driver Installation” on page 24 if not already in place.
3. Install the driver clutch as per the driver instruction manual and bolt into place.
4. Install the gib key, ensuring the top of the gib key pushes down below the top of the clutch. To prevent interference with the headshaft nut, fit the gib key to both the motor clutch and the headshaft. The key must slide in smoothly in the keyway.
5. Check the shaft position; the impellers must be fully seated against the bowls prior to adjusting the impellers.
6. Thread the headshaft nut down (right hand threads) until the impellers are lifted off their seat and the shaft rotates freely. When semi-open impellers are used, the correct determination of the point where the impellers just barely clear their seat is very important for proper adjustment.
7. Adjust the impellers as outlined in “Impeller Adjustment - General” on page 29.
8. Lock the headshaft nut with the lockscrew inserted down through the holes in the headshaft nut and threaded into the driver clutch.

⚠ CAUTION

DAMAGE TO THE PUMP AND THE DRIVER

Always ensure the headshaft nut is locked before starting the driver to avoid damage to the pump and the driver.

5.10 Impeller Adjustment - Solid Shaft Driver (thrust bearing in driver)

Impeller adjustment when using a solid shaft driver (with thrust bearing in driver) is accomplished with the adjustable flanged coupling located below the driver.

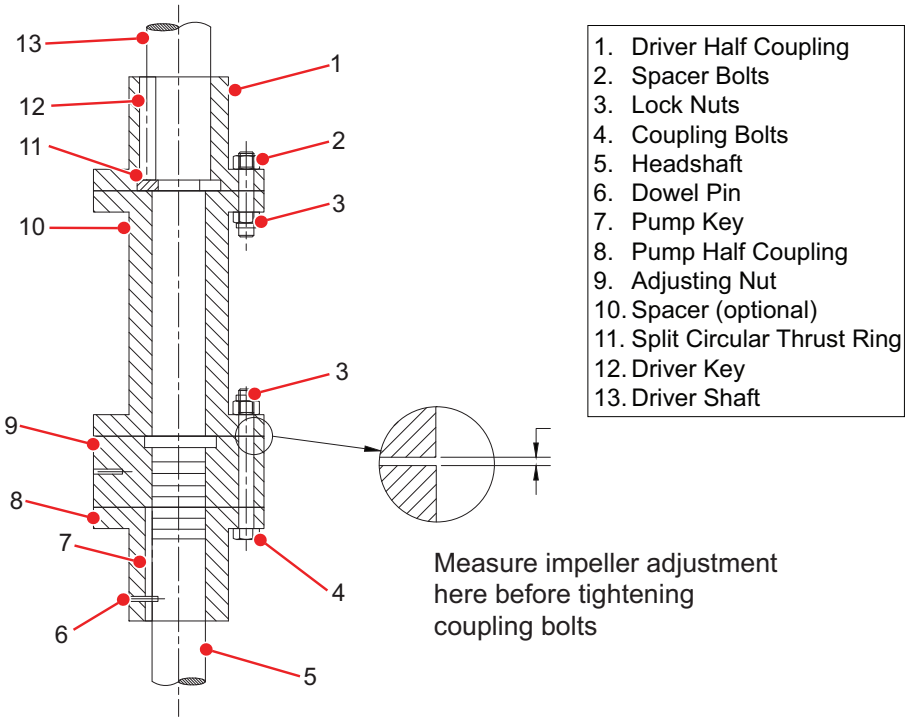


Figure 5-7: Adjustable Flanged Coupling for Solid Shaft Drivers

(illustrated with spacer)

5.10.1 Adjustable Flanged Couplings

1. Assemble the coupling on the pump and the driver as outlined in “Solid Shaft Driver Installation” on page 27.
2. Back off the adjusting nut up the shaft (threads are right hand) until the nut bears firmly against the spacer or driver shaft and the headshaft does not move down. This ensures that the impellers are all the way down against their seat and in proper position for starting the adjustment.
3. Thread the adjusting nut down until proper impeller adjustment as outlined in “Impeller Adjustment - General” on page 29 can be measured between the adjusting nut and spacer or driver half coupling as shown in Figure 5-7 on page 32.
4. Slide the pump half coupling up the shaft and align the adjusting nut bolt holes with those in the pump half coupling. Rotate the driver shaft until bolts can be inserted and tightened.
5. Tighten all the bolts. This will raise the impellers to correct operating position.

5.11 Impeller Adjustment - Solid Shaft Driver (thrust bearing in pump)

Impeller adjustment when using a solid shaft driver (with thrust bearing in pump) is accomplished using the adjusting nut located on top of the pump’s thrust bearing.

1. Install the thrust bearing drive key, ensuring the top of the key pushes down below the top of the thrust bearing clutch. To prevent interference with the adjusting nut, fit the key to both the clutch and the top lineshaft. The key must slide in smoothly in the keyway.
2. Check the shaft position; the impellers must be fully seated against the bowls prior to adjusting the impellers.
3. Thread the adjusting nut down (right hand threads) until the impellers are lifted off their seat and the shaft rotates freely. When semi-open impellers are used, the correct determination of the point where the impellers just barely clear their seat is very important for proper adjustment.
4. Adjust the impellers as outlined in “Impeller Adjustment - General” on page 29.

5. Lock the adjusting nut with the lockscrew(s) inserted down through the holes in the adjusting nut and threaded into the thrust bearing clutch. Use all lockscrews supplied.

⚠ CAUTION

DAMAGE TO THE PUMP AND THE DRIVER

Always ensure the adjusting nut is locked before starting the driver to avoid damage to the pump and the driver.

6. After the impeller adjustment is completed, the flexible driver coupling may be installed.

5.12 Mechanical Seal

⚠ CAUTION

DAMAGE DUE TO MECHANICAL SEAL TABS

- For pumps fitted with mechanical seals always follow the seal manufacturer’s instruction manuals.
- Always remove the mechanical seal setting tabs prior to starting the pump.
- Failure to remove the tabs will result in damage to both the pump and the seal.
- Ensure that the set screws are tight before removing the setting tabs.

Separate instruction manuals are written covering installation and operation for various mechanical seal arrangements. However, the following instructions are common to all seals:

1. Clean the seal cavity before installing the seal.
2. Clean the faces and registers of the seal housing and seal housing cover. Remove any burrs.
3. The shaft seal is a precision product. Treat it with care. Take appropriate care not to scratch or chip the lapped faces of the runner or seat.
4. Leave any circulation lines in place and open, do not remove.
5. Impeller adjustment must be made prior to seal adjustment.

Refer to the seal manufacturer's instruction manual for proper installation, operation, and maintenance.

5.13 Packing Boxes

Packing boxes are pre-packed at the factory and are typically factory installed. Do not tighten the packing gland at this stage. Refer to “Packing Box Adjustment” on page 36 for further information.

5.14 Enclosing Tube Tension

The enclosing tube (enclosed line shaft design) tension is pre-adjusted at the factory before shipping; therefore, additional adjustment is not required. Refer to assembly instructions in “Assembly” on page 51 in case assembly or adjustment is required for any reason.

6 Commissioning and Operation

DANGER

PERSONNEL INJURY DUE TO PROJECTILES

The following items may cause catastrophic pump failure resulting in projectiles. The guarding is only designed to prevent personnel contact with the shaft and may not stop projectiles. Do not stand in the line-of-fire.

- Improperly tightened couplings and coupling fasteners. Always ensure proper shaft coupling installation prior to starting equipment.
- Incorrect driver rotational direction may unscrew coupling or damage pump. Always ensure correct driver rotational direction with the pump uncoupled.
- Starting pump while it is spinning backwards. Never start a pump while it is spinning backwards. A non-reverse ratchet on the driver or special system design must be utilized to protect against this scenario.
- Reverse runaway rotation. For pumps not equipped with a non-reverse ratchet, the system shall be designed and controlled such that the pump unit does not exceed the specified maximum reverse runaway speed for that particular application. This capability is not typically offered on pump units and must be specified by the customer in their pump specification. If a maximum reverse runaway speed is not specified on the pump's Certified Outline Drawing, the operator must assume the unit was not designed for reverse rotation.
- Improperly adjusted impellers could cause the pump to seize and catastrophically fail. Always confirm that the impellers are properly adjusted.
- Overheating of the thrust bearing due to overload, over-speed, poor lubrication, poor cooling or damage may result in seizing of the thrust bearing. Always ensure proper operation of the thrust bearing.

WARNING

SERIOUS PERSONAL INJURY AND EQUIPMENT DAMAGE

- Pump units must only be used for their intended purpose. Refer to the certified outline drawing and other contract documents for construction and application details.
- The pumps must not be operated beyond their design MAWPs (suction and discharge sides), temperature limits and speed limits specified for the application. These limits are dependent on the pump type, configuration and materials used. If there is any doubt about the suitability of the product for the intended application, contact Trillium Pumps USA, referencing the serial number.

WARNING

PERSONNEL INJURY FROM HAZARDOUS PUMPAGE

- Prior to introducing hazardous pumpage to any system, always leak test the system and check for loose fitting and acceptable sealing.
- For applications involving hazardous fluids, degradation of the equipment and resulting leaks may occur over time due to normal corrosion and wear of containment vessels and/or sealing components. Procedures must be utilized to inspect equipment in such applications to detect problems before they cause hazardous leaks and to detect leaks if they occur.

⚠ WARNING

HOT FLUIDS AND SURFACES

Fluids and surfaces may become hot during operation (for example, hot pumpage, pump surfaces, thrust bearing surfaces, thrust bearing oil, driver oil, driver surfaces, packing leakage, etc.). Appropriate safety measures and PPE must be utilized to prevent personnel injury.

6.1 Pre-starting Checks

Do the following checks before starting the pump:

⚠ WARNING

PERSONNEL INJURY

Do not touch the rotating elements with hands to establish the direction of rotation. Visually confirm the direction of rotation.

1. Rotate the pump shaft to make sure the pump is free and impellers are correctly positioned.
2. The shaft adjusting nut is properly locked into position.
3. The driver has been installed and lubricated in accordance with the manufacturer's instructions furnished with the driver.
4. Check the driver for proper rotation. If not, disconnect the pump from the driver before doing further checks. The driver must rotate counter-clockwise when viewed from the top of the driver.
5. All connections to the driver and control equipment are in place.
6. All piping connections are tight, leak free, and have the required gasket or O-ring installed.
7. All anchor bolts are tight.
8. All bolting and tubing connections are tight (driver mounting bolts, flanged coupling bolts, seal housing cover bolts, seal piping, etc.).
9. For pumps equipped with a packing box, make sure the gland nuts are only finger tight. Do not tighten the packing gland before starting the pump.
10. For pumps equipped with mechanical seals, clean fluid must be put into the seal chamber. For pumps under suction pressure this can be accomplished by bleeding all the air and vapor out of the seal chamber and allowing the fluid to enter. For pumps not under suction pressure the seal chamber must be flushed liberally with clean fluid to provide initial lubrication. Make sure the mechanical seal is properly adjusted and locked into place.

NOTICE

After the initial start-up, pre-lubrication of the mechanical seal is usually not required, as enough liquid will remain in the seal chamber for subsequent start-up lubrication.

11. For pumps equipped with enclosed lineshaft, lubricating fluid must be available and allowed to run into the enclosing tube in sufficient quantity to thoroughly lubricate all lineshaft bearings.

6.2 Initial Start-up

⚠ WARNING

PERSONNEL INJURY

Personnel injury or illness may result from contact with rotating parts, seal leakage or spray from the rotating shaft.

1. If the discharge line has a valve in it, it should be partially open for initial starting.
2. Start the lubrication liquid flow on enclosed lineshaft units.
3. Start the pump and observe for excess noise, vibration or any other difficulty. If any malfunctions occur, stop the pump immediately and refer to “Troubleshooting” on page 55 for probable cause.
4. Ensure all air and gases are properly vented from the pump and system.
5. Open the discharge valve as desired.
6. Check the complete pump and driver for leaks, loose connections or improper operation.
7. If possible, leave the pump running for approximately half an hour on the initial start-up; this will allow the bearings, packing or seals, and other parts to “run-in” and reduce the possibility of trouble on future start-ups.

⚠ CAUTION

EQUIPMENT DAMAGE DUE TO PUMP BLOCKAGE

The standard unit is not designed to pump large amounts of abrasives or debris. If any unexpected debris or abrasives are present in the discharge liquid and the pumpage does not clear up, immediately shut down the unit and eliminate the source of abrasives and debris.

6.3 Packing Box Adjustment

⚠ WARNING

RISK OF ENTRAPMENT

During gland adjustment, the guard needs to be removed. When the guard is removed, the rotating shaft is exposed and may cause entrapment. Hence, only qualified personnel must work on gland adjustment.

- It is important that the packing is not tightened too much on initial start-up to prevent overheating and damage.
- New packing must be “run in” properly to prevent damage to the shaft and shortening of the packing life. Refer to “Start-up with New Packing” on page 41 for further information.
- The packing box must be allowed to leak for proper operation. The appropriate quantity of leakage can be determined by checking the temperature of the leakage. The temperature must be cool or lukewarm, not hot. Leakage of 40 to 60 drops per minute is adequate.
- When adjusting the packing gland, bring both the nuts down evenly and gradually until the leakage is reduced to the required quantity. Tighten the nuts only about half a turn at a time, at 20 to 30 minute intervals to allow the packing to “run-in”.
- Under proper operation a set of packing will last a long time. Occasionally a new ring of packing will need to be added to keep the box full. After adding two or three rings of packing, or when proper adjustment cannot be achieved, the packing box should be cleaned completely of all old packing and repacked.

6.4 Lineshaft Lubrication

1. Open Lineshaft Bearings: are lubricated by the pumped fluid. Close coupled units (less than 40 feet long) usually do not require pre or post lubrication.
2. Enclosed Lineshaft Bearings: are lubricated by external liquid (usually oil or clean water) which is fed to the tension nut by either a gravity flow or pressure injection system. The gravity flow system which utilizes oil is the most common arrangement. The oil reservoir must be kept filled with good quality light turbine oil (about 150 S.S.U. at operating temperature) and adjusted to feed 5 to 8 drops per minute.

   Injection lubrication systems are designed for each installation. The injection pressure and quantity of lubricating liquid varies. Refer to Figure 12-8 on page 65 for injection lubrication arrangement.

Refer to the certified outline drawing for requirements when the unit is designed for injection lubrication.

Refer to Table 6-1 for turbine oils, that are recommended for enclosed lineshaft bearing lubrication under normal operating conditions.

Manufacturer	Trade Name of Oil
Amoco	American Industrial 32
Exxon	Teresstic 32
Mobil Oil Company	DTE Light
Conoco	Conoco 32
Shell Oil Company	Tellus 32
Chevron	Chevron GST68
Texaco	Texaco Regal R&O 32
Phillips 66	Magnus 32
Unocal	Unocal Turbine Oil 32

Table 6-1: Recommended Lineshaft Oil

Refer to Table 6-2 for turbine oil that is suitable for use where FDA approved lubricating oil is required for USDA-Classification H1.

Manufacturer	Trade Name of Oil
Chevron	Chevron FM Lubricating Oil 32
Lyondell Petrochemical	ARCO White Oil 32

Table 6-2: Recommended Lineshaft Oil

If none of the above oils are available, procure the oil with following specifications:

- Turbine type oil with rust and oxidation inhibitors added.
- Viscosity 145-175 S.S.U. at 100°F with 90 minimum viscosity index. ISO grade 32.
- Do not use detergent type oils.

Recommended greases for packing boxes and suction bearings are given in Table 6-3.

Union Oil Products	Grades	Other Specs.	ARCO	SHELL	TEXACO	MOBIL	GULF	EXXON	CHEVRON
UNOBA EP Grease	NLGI #1 & 2	Lithium Soap	Litholine H-EP	Alvania EP	Multifak EP	Moloiux EP	Gulfcrown EP	Beacon EP	Dur-Lith
MP Automotive Grease	NLGI #00	GM, Ford, Chrysler Molybde-num Disulfide & Poly-ethylene	EP Moly Grease	Super Duty Grease	Marfak All Purpose	Mobile Grease Special	Gulfex Poly	Multi-Purpose Grease	Multi-Motive Grease

Table 6-3: Recommended Greases

7 Maintenance

DANGER

LOCKOUT-TAGOUT (LOTO)

- Prior to allowing any checking, maintenance, or other work on the equipment, all hazardous energy sources (for example, electrical, mechanical, hydraulic, pneumatic, etc.) must be isolated using an appropriate lockout-tagout procedure.
- Ensure that the intake and discharge openings are totally isolated from all potentially pressurized connections and that they are, and can only be exposed to atmospheric pressure.
- Drain the pump and isolate pipework before dismantling the pump. The appropriate safety precautions must be taken when the pumped liquids are hazardous.
- Failure to follow appropriate LOTO procedures may result in serious personal injury or death.

WARNING

PERSONNEL INJURY

- The pump must be installed, operated and maintained only by the personnel who are trained and have sufficient knowledge about the hazards that may occur during the pump operation and maintenance.
- A comprehensive risk assessment shall be conducted prior to performing any maintenance or repair work on the equipment.
- Refer to the requirements in the driver, seal, and other auxiliary equipment IOMs prior to beginning work.

WARNING

PERSONNEL INJURY DUE TO HAZARDOUS MATERIALS

During disassembly, personnel may come in contact with hazardous materials. These materials must be identified before disassembly, and the correct SDS must be made available and appropriate safety management precautions put in place. Hazardous pumpage must be purged and flushed from the pump prior to disassembly. Always wear appropriate PPE.

WARNING

HOT FLUIDS AND SURFACES

Fluids and surfaces may become hot during operation (for example, hot pumpage, pump surfaces, thrust bearing surfaces, thrust bearing oil, driver oil, driver surfaces, packing leakage, etc.). Appropriate safety measures and PPE must be utilized to prevent personnel injury.

7.1 Periodic Inspection, Condition Monitoring, and Preventative Maintenance

- Periodic inspections (ideally once a month) and preventative maintenance are recommended as the best means of preventing breakdown and keeping maintenance costs at a minimum.
- Maintenance personnel should look over the entire installation with a critical eye, each time the pump is inspected.
- A change in noise level, amplitude of vibration, or performance is an indication of a possible impending trouble and must be investigated for probable causes.
- During inspection the pump and driver should be checked for performance and change in noise or vibration level, loose bolts or piping, dirt and corrosion. It helps to develop a vibration trend analysis based upon periodic vibration reading recordings. This helps determine changes in equipment condition and optimum repair frequency.
- Variances from initial performance are an indication of changing system conditions, wear or impending breakdown of the unit.
- Clean and repaint all areas that are rusted or corroded.

7.2 Packing Box Maintenance

Maintenance of the packing box will consist of greasing the box when required, tightening the packing gland occasionally as the leakage becomes excessive, and installing new packing rings or sets as required.

7.2.1 Packing Box Greasing

- Under normal operation, once a month greasing of the packing box is typically adequate.
- Use good grade multipurpose grease such as Chevron Industrial Grease - Medium or Marfak MULTIPURPOSE #2.

7.2.2 Replacing the Packing

- Remove the gland and old packing. If the box contains a lantern ring remove this and the packing below it.
- Inspect the shaft or sleeve for score marks or rough spots. Ensure that the bypass holes (if required) are not plugged.
- Repair or replace badly worn shaft or sleeve. If the wear is minor dress down until smooth and concentric. Clean the box bore.
- Oil the inside and outside of the replacement rings lightly and install in the box, staggering joints 90°. Be sure to replace lantern ring in proper position when used.

NOTICE

Formed replacement packing rings are recommended and are available from the factory.

- Replace the gland, tighten the nuts and make sure the gland enters the box squarely. Keep the packing under moderate pressure for one minute to allow it to cold flow and adjust itself. Back off on the gland until loose and the gland nuts are hand tight before starting the pump.

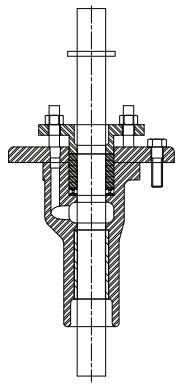
	Shaft Size	# Packing Rings	Packing Ring Size	Depth of Box	O.D. of Packing
	3/4	5	5/16	1 23/32	1 3/8
	1	5	5/16	1 23/32	1 5/8
	1 3/16, 1 1/4	5	3/8	2 1/16	2
	1 1/2	5	3/8	2 1/16	2 1/4
	1 11/16	5	7/16	2 13/16	2 5/8
	1 15/16	6	3/8	2 13/32	2 3/4
	2 1/4	6	3/8	2 3/4	3 1/16
	2 7/16	6	3/8	4 3/4	3 1/4

Table 7-1: Standard Type Box

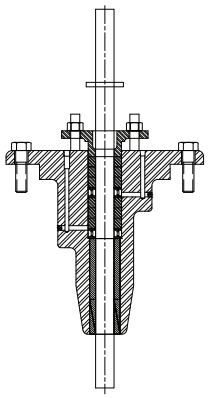
	Shaft Size	# Packing Rings	Packing Ring Size	Depth of Box	O.D. of Packing
	3/4	6	5/16	3 5/8	1 3/8
	1	6	5/16	3 5/8	1 5/8
	1 3/16, 1 1/4	7	3/8	4 5/8	2
	1 1/2	7	3/8	4 5/8	2 1/4
	1 11/16	7	7/16	4 7/8	2 5/8
	1 15/16	8	3/8	4 7/8	2 11/16
	2 1/4	6	1/2	4 3/4	3 1/4
	2 7/16	6	1/2	4 3/4	3 1/2
	2 11/16	7	1/2	4 1/2	3 3/4

Table 7-2: Hi-pressure Type Box

7.3 Start-up with New Packing

- Check that the bypass line (if used) is connected and packing gland is loose.
- Start the pump and allow it to run for 20 to 30 minutes; do not tighten the gland during this “run-in” period even if leakage is excessive. If the leakage continues to be more than normal, adjust as outlined in “Packing Box Adjustment” on page 36.
- If the new packing causes excess heating during run-in, flush the shaft and packing box area with cold water or shut the pump down. Allow to cool if necessary.

7.4 Auxiliary Packing Box Maintenance

- Pumps equipped with mechanical seals may also be provided with an auxiliary packing box to restrict leakage, should the mechanical seal fail.
- This packing gland must be left loose since under regular operation the packing is not cooled or lubricated by the pumpage.
- This packing box arrangement is designed to help contain leakage past the mechanical seal in the event of a seal failure. It is not designed as a primary seal and must not be used as such.

7.5 Mechanical Seal Maintenance

⚠ CAUTION

DAMAGE DUE TO MECHANICAL SEAL TABS

- For pumps fitted with mechanical seals always follow the seal manufacturer's instruction manuals.
- Always remove the mechanical seal setting tabs prior to starting the pump.
- Failure to remove the tabs will result in damage to both the pump and the seal.
- Ensure that the set screws are tight before removing the setting tabs.

Mechanical seals should not be readjusted unless there is a reason. Best results are obtained when the seal is properly set at start-up and left that way. If the seal starts to leak after an extended operating period, some readjusting can be done at that time. However, it is usually best to replace the seal during the next scheduled maintenance cycle.

After impeller readjustment, seal leakage may occur due to improper seal adjustment or improper seating of the seal parts.

If readjustment of the seal does not correct the problem, refer to the manufacturer's instruction manual for further information.

7.6 Impeller Readjustment

Typically, impellers do not require readjustment if properly set at initial installation. Almost no change in performance can be obtained by minor adjustment of enclosed impellers; however, the positioning of semi-open impellers has a definite effect on the performance of the pump. This characteristic is sometimes used to adjust the output of the pump without valving. Figure 7-1 on page 43 illustrates the general effect of raising semi-open impellers.

After extended operation, the sealing faces between the semi-open impellers and the bowl will wear causing a reduction in performance. The pump performance can be brought back up to almost "as new" by proper readjustment of the impellers. Refer to "Impeller Adjustment - General" on page 29 for proper adjustment procedure.

NOTICE

Adjusting the impellers will change the mechanical seal setting unless the seal is loosened from the shaft. It is recommended to first loosen the seal from the shaft, perform the impeller adjustment, then reset the mechanical seal.

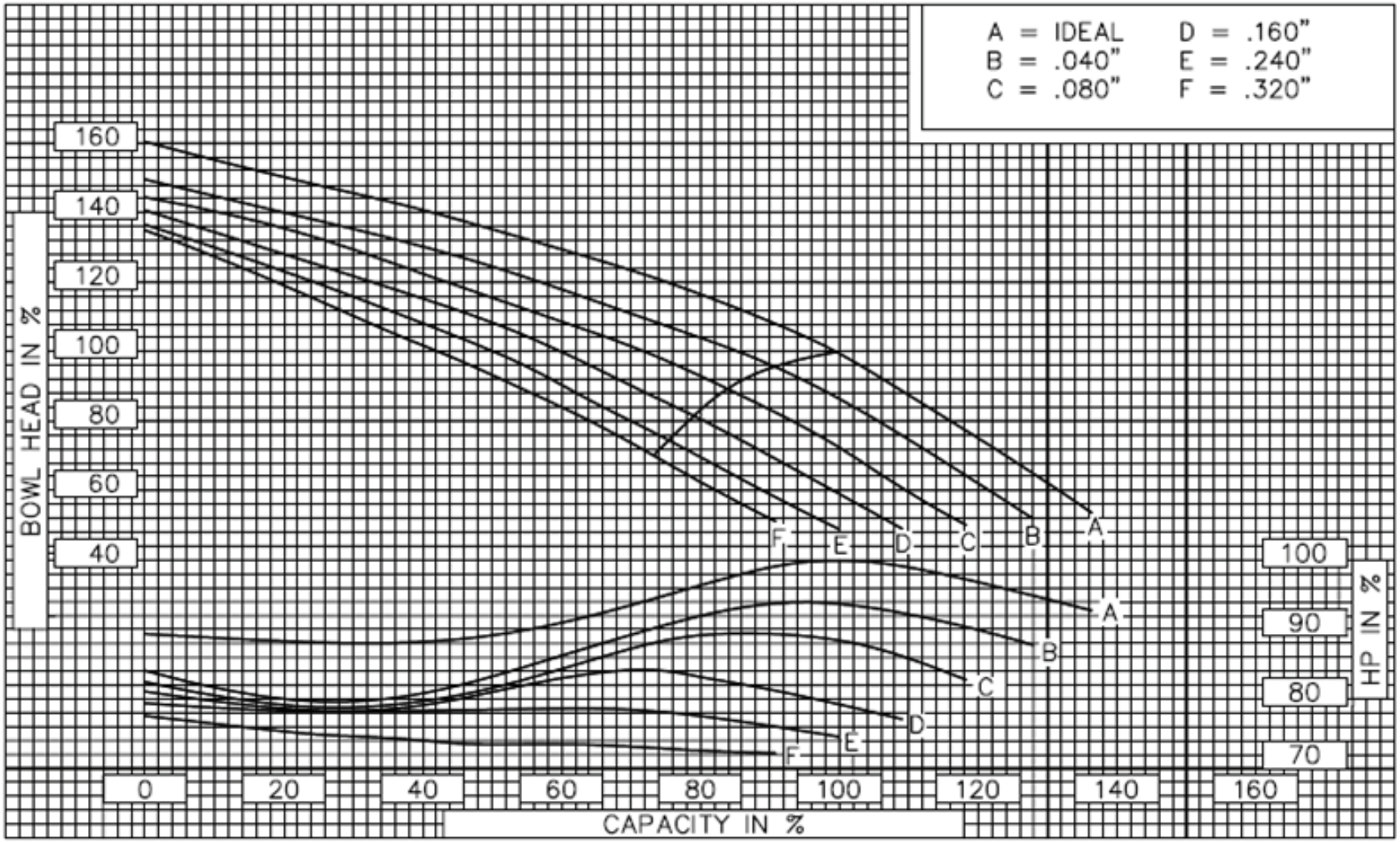


Figure 7-1: Effect of Adjusting Semi-open Impellers

Figure 7-1 on page 43 indicates the approximate effect of raising semi-open impellers from their ideal (a) operating position. Raising the impellers increases the clearance between the impeller and the bowl seat and reduces the performance accordingly. The chart is generic and not exact for any particular pump model since each model reacts differently. 100% head and capacity are to be taken as the head and capacity of the pump at the best efficiency point (BEP).

For example, if a particular pump delivers 250 gpm and 50' head at BEP, when impellers are properly adjusted, raising the impellers 0.080" will reduce the capacity to approximately 181 gpm (72.5% of 250 gpm) while maintaining 50' head or conversely, the pump will deliver 250 gpm at 37.5' head (75% of 50'). The horsepower will be about 91.50% of the previous horsepower.

7.7 Pump Lubrication

Other than the packing box lubrication outlined in “Packing Box Greasing” on page 40 and lineshaft lubrication outlined in “Lineshaft Lubrication” on page 37 the pump does not require further periodic lubrication. The suction bearing should be repacked with grease when repairs are done on the bowl assembly (it is not necessary to repack the suction bearing before bowl assembly repairs are required). Special pump construction may allow for more lubrication options, reference the pump’s Certified Outline Drawing for such features and details.

7.8 Driver and Auxiliary Equipment Maintenance

Drivers and auxiliary equipment require periodic maintenance.

	Refer to the manufacturer’s instruction manual for proper installation, operation, and maintenance.

8 Repairs

DANGER

LOCKOUT-TAGOUT (LOTO)

- Prior to allowing any checking, maintenance, or other work on the equipment, all hazardous energy sources (for example, electrical, mechanical, hydraulic, pneumatic, etc.) must be isolated using an appropriate lockout-tagout procedure.
- Ensure that the intake and discharge openings are totally isolated from all potentially pressurized connections and that they are, and can only be exposed to atmospheric pressure.
- Drain the pump and isolate pipework before dismantling the pump. The appropriate safety precautions must be taken when the pumped liquids are hazardous.
- Failure to follow appropriate LOTO procedures may result in serious personal injury or death.

DANGER

LIFTING POINTS GIVING AWAY

Lifting points may be corroded and may not be fit for use. Always check for suitable condition of lifting points and rigging prior to lifting equipment.

WARNING

PERSONNEL INJURY

- The pump must be installed, operated and maintained only by the personnel who are trained and have sufficient knowledge about the hazards that may occur during the pump operation and maintenance.
- A comprehensive risk assessment shall be conducted prior to performing any maintenance or repair work on the equipment.
- Refer to the requirements in the driver, seal, and other auxiliary equipment IOMs prior to beginning work.

8.1 General

- The repair of vertical turbine pumping units is best handled by an experienced pump service center.
- Trillium Pumps USA has a worldwide network of service centers where skilled machinists and mechanics can repair and rebuild any pump unit to “as-new” condition. For information regarding the nearest service center, contact Trillium Pumps USA by email at, floway@trilliumflow.com.
- Eventually repairs will be required for the pump equipment. When maintenance checks, condition monitoring, or other indications show that an overhaul is required, the necessary repairs should not be delayed. Delay of repairs could lead to catastrophic failure, safety risks, and system down time.
- Major repairs typically consist of removal of the unit and disassembly to the point necessary for replacement of worn out parts.
- Disassembly must be performed in a clean area with sufficient space to lay out the parts in order of disassembly. Cleanliness during repairs is important as this is a close tolerance, high speed machine and must be handled as such.

8.2 Equipment and Tools

If bowl assembly repairs are anticipated, a separate manual is available giving detailed instructions for disassembly and repair. Read this manual thoroughly before attempting repairs of the bowl assembly. When requesting this manual from the factory the pump model must be given.

Required equipment and tools are as listed in “Pre-installation” on page 12 of this manual and in the appropriate Pump Bowl Instruction Manual.

8.3 Packing Box Repairs

Packing box repairs can be done without removing the complete unit. Packing replacement as outlined in “Replacing the Packing” on page 40 can be accomplished without disturbing the pump or driver. The packing box bearing can be replaced if necessary by removing the driver and sliding the packing box off the shaft.

8.4 Mechanical Seal Repairs

- Mechanical seal repairs can be done without removing the complete unit.
- The mechanical seal assembly can be replaced by removing the spacer and pump half coupling on solid shaft units (remove the thrust bearing if it is located in the pump). For hollow shaft units, remove the headshaft and shaft coupling inside the discharge head.
- Replacement of the bearing located at the bottom of the seal housing requires removal of the driver in order to get enough headroom.

8.5 Disassembly

Refer to “Parts List” on page 58 for part drawings and identification.

⚠ WARNING

PERSONNEL INJURY DUE TO HAZARDOUS MATERIALS

During disassembly, personnel may come in contact with hazardous materials. These materials must be identified before disassembly, and the correct SDS must be made available and appropriate safety management precautions put in place. Hazardous pumpage must be purged and flushed from the pump prior to disassembly. Always wear appropriate PPE.

⚠ WARNING

PERSONNEL INJURY

Threaded components typically require application of very high torques to disassemble (for example, shaft couplings, threaded bowls, threaded columns, etc.). Always ensure the tools and methods used for disassembly are appropriate for the forces/torques required.

⚠ CAUTION

MACHINED SURFACES

Protect all machined surfaces from burrs and scrapes as this can cause misalignment upon reassembly.

1. Disconnect the electrical leads from the motor.
2. Loosen the mechanical seal from the shaft.
3. Disconnect the pump shaft from the driver:
   a. Hollow Shaft Driver: remove the headshaft nut lockscrew, headshaft nut, gib key and the driver clutch. Unscrew and remove the headshaft from the shaft coupling inside the discharge head.

b. Solid Shaft Driver: Unbolt the driver coupling to lower the pump shaft. Remove coupling components (driver half coupling may be left in place, ensure it is safely secured to the driver shaft).

4. Remove the bolts which attach the driver to the discharge head.
5. Lift the driver off the pump and set it on wooden supports. For solid shaft drivers ensure the supports are high enough to clear the shaft and coupling half, which project beneath the motor mounting plate.
6. Disconnect the discharge (and suction, if applicable) piping from the pump.
7. Remove the anchor bolt nuts, or bolts from the mounting flange.
8. Lift the pump vertically until the pump suction clears the foundation, or the mounting flange. Remove the mounting flange gasket if required.
9. Cover the opening in the foundation.
10. Lower the pump and position horizontally on a stable support in a suitable area for disassembly.

	For any major repairs it is recommended to take the unit to a shop or any other clean area which has smooth flooring and overhead lifting equipment.

11. For packing box, mechanical seal and enclosed lineshaft construction do the following:
    a. Packing Box Construction: remove the slinger and the packing gland.
    b. Mechanical Seal Construction: loosen seal cover fasteners and remove the seal housing cover.

	For sleeve mounted mechanical seals, remove the seal and sleeve assembly along with the cover.

	Refer to the manufacturer's instruction manual for further mechanical seal details.

c. Enclosed Lineshaft Construction: remove the lockscrew and lubrication line and unscrew the tension nut assembly. Threads are left hand.

12. Remove the fasteners which attach the packing box, tension plate or seal housing to the discharge head.
13. Remove the packing box, tension plate or seal housing.

	If type FF-2 or FF-9 mechanical seal is used, loosen the set screws which lock the seal assembly to the shaft before removing the seal housing.

	Before proceeding further, make sure the discharge head and the bowl/column assembly are supported independently of each other.

14. Disconnect the bowl assembly or top column from the discharge head. This connection may be flanged or threaded. If threaded, the thread will be right hand.
15. Remove the discharge head being careful not to damage the shaft.
16. Disconnect the column pipe (if present) at first joint below the top and remove from the shaft.

17. For open lineshaft and enclosed lineshaft construction do the following:
    a. Open Lineshaft Construction: each time a lineshaft coupling is exposed by removing a length of the column pipe, the lineshaft and the coupling must be removed by holding the coupling and turning the upper lineshaft in right hand direction (line shaft threads are left hand).

⚠ CAUTION

EQUIPMENT DAMAGE

- When using wrenches on shafting, always place the wrenches on the same side of the shaft as illustrated in Figure 8-1 on page 48 to avoid excess side strain on shafting.
- Always position the wrench that will grip the shaft above the shaft coupling (that is, on the upper shaft as viewed when the pump is in the vertical installed position). This must be done to prevent scoring and burrs on the top ends of the shafting to allow bearings to slide on/off freely.

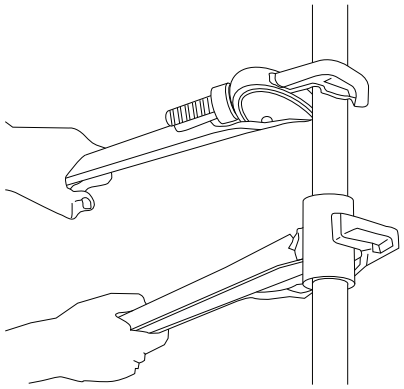


Figure 8-1: Correct Positioning of Wrenches on Shafting

    b. Enclosed Lineshaft Construction: each time a length of column pipe is removed the enclosing tube and lineshaft must also be disassembled. Locate the joint (refer to Figure 8-2) and unscrew (left hand threads) the enclosing tube from the lineshaft bearing (which acts as a bearing for the shaft and also as an enclosing tube coupling). Leave the lineshaft bearing threaded into the enclosing tube not being removed (to support the lineshaft). Slide the enclosing tube up to expose the lineshaft coupling and uncouple as outlined in step 17(a) above.

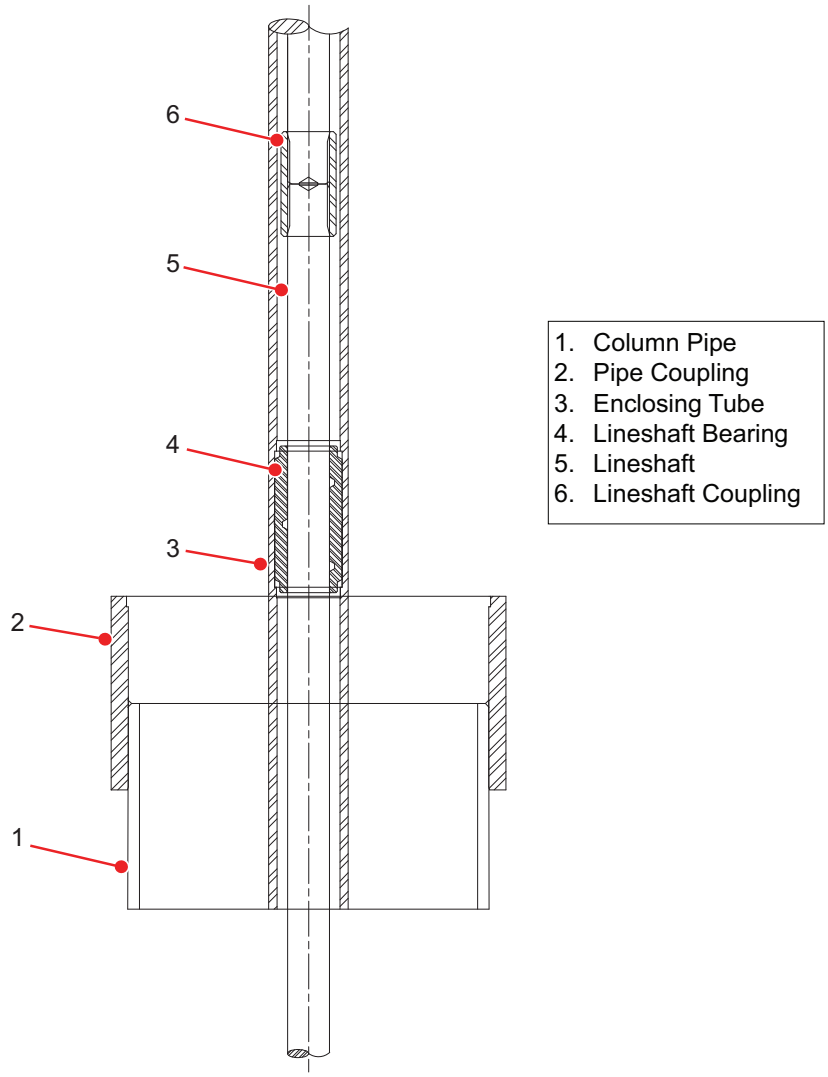


Figure 8-2: Enclosing Tube and Lineshaft

18. Disconnect each section of the column pipe one at a time and remove along with the shaft and enclosing tube as applicable until all are removed.
19. Remove and place the bowl assembly in a clear area.

	Continue disassembly as outlined in separate Pump Bowl Instruction Manual.

8.6 Inspection and Cleaning

- After disassembly, clean all components and examine thoroughly for physical defects, wear, corrosion and damage.
- Check all bearing bores for total clearance over the shaft diameter. Replace all lineshaft bearings indicating wear. The following indicates the maximum allowable diametrical clearance over existing shaft diameter, in which case bearing must be replaced.
  - 3/4″ through 1 11/16″ shaft - 0.020″ clearance
  - 1 15/16″ through 2 7/16″ shaft - 0.025″ clearance
  - 2 11/16″ through 3 15/16″ shaft - 0.030″ clearance

- It is recommended that bowl assembly bearings be replaced when pump bowl assembly is disassembled, and measured diametrical clearance exceeds standard clearance indicated in bowl repair manual (new bearings) by 0.004 maximum.
- Inspect shaft straightness. Each shaft should be straight to within 0.0005" TIR per foot of shaft length (for example, 0.005" TIR over a 10ft shaft length).

  To measure shaft straightness:

  i Support the shaft on two precision rollers, each placed 1/4 of the shaft length in from both shaft ends.

  ii Rigidly mount a dial indicator to contact the shaft.

  iii Slowly rotate the shaft on the rollers and record the TIR from the dial indicator.

  iv Measure and record TIR readings at 1 ft increments along the shaft length.

  If the shaft is not straight, it must be either straightened or replaced with a new shaft.
- Check all enclosed impeller to bowl running clearances. If the clearance exceeds the quantity of (Imp. Ring OD in inches +12) thousandths of an inch, renewing the clearance should be considered to achieve optimum pump efficiency. For example, if the impeller wear ring OD is 13 inches, the clearance should be renewed if the impeller to bowl clearance is greater than 0.025" (13+12 = 25 thousands of an inch).

8.7 Replacement Parts

Replace parts showing signs of damage, cracks or excessive wear. Use only genuine Floway parts for replacements.

DANGER

GENUINE OEM PARTS

- Genuine OEM parts and accessories are designed, tested and incorporated into the products to help ensure they maintain continued product quality and performance in use.
- As Trillium Pumps USA does not test the parts and accessories sourced from other vendors, the installation of such parts and accessories may adversely affect the performance and safety features of the products.
- The failure to properly select, install or use authorized parts and accessories is considered misuse. Damage or failure caused by misuse is not covered by our warranty.
- In addition, any modification of Trillium Pumps USA products or removal of original components may impair the safety of these products in their use.

Order replacement parts as indicated in “Parts” on page 57.

CAUTION

INSPECT PARTS

When repairing a pump which has been in service, it is important to inspect the physical condition or strength of all parts such as fasteners, bowls, threads, pressure casings, etc., to ensure all parts that will be reused are in good condition and fit to perform in the specific application.

8.8 Lubrication

Repack the suction bearing as outlined in Pump Bowl Instruction Manual.

Lubricate all bearings and impeller skirts with clean grease or oil acceptable for the application. Thoroughly clean all threaded connections and flanges and coat with thread lubricant, oil, or pipe joint compound.

8.9 Assembly

Before proceeding with assembly, thoroughly clean and check all the threads, registers and mating faces for burrs. Deburr with file and emery cloth where required. Lubricate as given in “Lubrication” on page 50. Oil the shafts lightly.

Proceed with assembly in reverse order of disassembly as outlined in “Disassembly” on page 46.

⚠ CAUTION

EQUIPMENT DAMAGE

Cleanliness and proper lubrication are extremely important as one small chip, burr or dry bearing can result in equipment damage and require further repair.

Refer to Table 8-1 for recommended torque values of typical fasteners.

	Typical Fastener Materials						
	A307 Gr. A; A193 B8M Cl. 1, B8MA Cl. 1A	F593 S304/S316 CW2 (3/4 - 1 1/2) SH4(1 3/8 - 1 1/2); A193 B8M Cl.2 (1 1/4-1 1/2)	F593 S304/S316 CW1 (1/4 - 5/8), SH3(1 1/8 - 1 1/4); A193 B8M Cl.2 (1-1 1/4)	A193 Gr. B7M, B8M Cl. 2 (3/4-1), B8 Cl. 2B; A325 (Gr. 5 equivalent) (1 1/8 - 1 1/2); F593 S304/S316 SH2 (3/4 - 1)	A325 (Gr. 5 equivalent) (1/2 - 1); F468 Monel K-500	F593 S304/S316 SH1 (1/4 - 5/8); A193 B7, B8M Cl.2 (<3/4)	A354 Gr.BD (Gr. 8 equivalent) Carbon steel
	Floway Material code						
	084, 223, 232	106, 107, 179, 225	106, 107, 179, 225	233, 225, 235 330, 179	330, 042	179, 224, 225	085
	Approximate Fastener Material Min. Yield Strength (psi)						
	30000	45000	65000	80000	90000	100000	130000
Bolt size-threads/in	Torque Value (lbf-ft)						
1/4 - 20	2	3	4	5	5	6	8
5/16 - 18	4	6	8	10	11	12	16
3/8 - 16	7	10	14	17	20	22	28
7/16 - 14	10	16	23	28	31	35	45
1/2 - 13	16	24	35	43	48	53	69
9/16 - 12	23	35	50	61	69	77	100
5/8 - 11	32	48	69	85	95	106	138
3/4 - 10	56	85	122	151	169	188	245
7/8 - 9	91	136	197	242	273	303	394
1 - 8	136	204	295	363	409	454	591
1 1/8 - 7	193	290	419	515	580	644	837
1 1/4 - 7	273	409	591	727	818	909	1181
1 3/8 - 6	357	536	774	953	1072	1191	1548
1 1/2 - 6	474	711	1028	1265	1423	1581	2055
1 5/8 - 8	649	973	1406	1730	1947	2163	2812
1 3/4 - 5	748	1122	1620	1994	2244	2493	3241
1 7/8 - 8	1018	1528	2207	2716	3055	3395	4413
2 - 4.5	1124	1686	2436	2998	3373	3747	4872

Based on UNC threads lubricated with oil.
Fasteners with intermediate yield stess values may be linearly interpolated from table.
Table contains general torque values for pump components based on a 60% preload to the material's yield strength.
For applications requiring a higher preload, the ratio of (desired preload% / 60%) can be multiplied by table values to detemine torque.
Torque values assume adequate thread strength and engagement to prevent stripping the threads.
For tightening anchor bolts embedded in concrete, do not exceed 500 lbf-ft.

Table 8-1: Recommended Torque Values for Typical Fasteners

8.10 Tension Nut Assembly and Adjustment

Enclosed lineshaft units use a tension nut which is at the top of the enclosing tube and must be tightened for proper operation. Refer to Figure 8-3 for general construction.

1. Clean all O-ring sealing surfaces including the groove in the tension plate and oil lightly.
2. After assembling the discharge head to the column, install the tension plate (ensure that both O-rings are in place), and allow the O-ring to slide down outside of tube adjusting nipple. Lightly oil the outside of the tube adjusting nipple prior to installation of tension plate.
3. Bolt the tension plate into place.
4. Slide the tension nut over the shaft and thread into inside of the tube adjusting nipple (left hand threads) until the tension nut is snug against the tension plate. Continue to tighten the tension nut until the lockscrew slot lines up with the “first” tapped hole in tension plate (1/4 turn maximum).

⚠ CAUTION

DO NOT OVER TIGHTEN THE TENSION NUT

It is necessary that the enclosing tube have tension on it which is accomplished by tightening the tension nut. However, excess tightening can distort or break the tension nut. Do not tighten more than 1/4 turn on close coupled pumps.

5. Install the lockscrew and tighten.
6. Proceed to complete the installation.

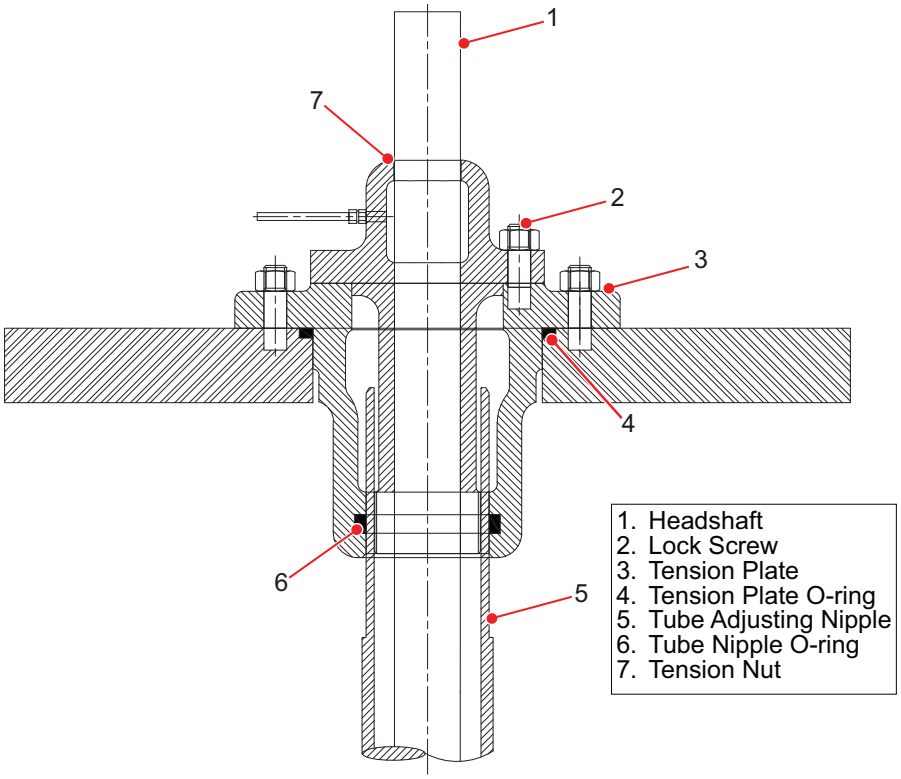


Figure 8-3: Tension Nut Assembly

9 Decommissioning and Disposal

This section describes decommissioning and disposal of the complete pump unit.

DANGER

LOCKOUT-TAGOUT (LOTO)

- Prior to allowing any checking, maintenance, or other work on the equipment, all hazardous energy sources (for example, electrical, mechanical, hydraulic, pneumatic, etc.) must be isolated using an appropriate lockout-tagout procedure.
- Ensure that the intake and discharge openings are totally isolated from all potentially pressurized connections and that they are, and can only be exposed to atmospheric pressure.
- Drain the pump and isolate pipework before dismantling the pump. The appropriate safety precautions must be taken when the pumped liquids are hazardous.
- Failure to follow appropriate LOTO procedures may result in serious personal injury or death.

DANGER

LIFTING DEVICE SAFETY

- Lifting devices of adequate capacity must be used whenever they are required.
- Safe workshop practices must be applied during all assembly and maintenance work.
- Personnel must never work under suspended loads.

DANGER

LIFTING POINTS GIVING AWAY

Lifting points may be corroded and may not be fit for use. Always check for suitable condition of lifting points and rigging prior to lifting equipment.

WARNING

PERSONNEL INJURY DUE TO HAZARDOUS MATERIALS

During disassembly, personnel may come in contact with hazardous materials. These materials must be identified before disassembly, and the correct SDS must be made available and appropriate safety management precautions put in place. Hazardous pumpage must be purged and flushed from the pump prior to disassembly. Always wear appropriate PPE.

WARNING

SHARP EDGES

- Before handling, identify work parts that could be hazardous due to sharp edges. All metal components must be considered to have sharp edges.
- Pump components can have sharp or jagged edges. Handle parts carefully, to prevent damage to slings or personal injury.

⚠ WARNING

RESALE OF PUMPS AND PARTS

Due to the highly engineered nature of vertical turbine pumps, Trillium Pumps USA does not recommend reselling used pumps or pump parts. Potentially unsafe conditions could be created by using pumps and pump parts in applications for which they are not intended for. Furthermore, used parts may be unsafe and not fit for any use due to corrosion, wear, or other damage.

To decommission and dispose of a pump unit, Trillium Pumps USA recommends the following steps:

NOTICE

For drivers, mechanical seals, and other auxiliary equipment, refer to the respective manufacturer's IOM for further details regarding decommissioning and disposal.

1. Flush the pump of all hazardous pumpage using the necessary safety precautions.
2. Isolate the pump electrically, hydraulically, and mechanically (reference LOTO warning).
3. Drain all equipment fluids such as driver oil, thrust bearing oil, etc.
4. Disconnect the pump electrically, hydraulically, and mechanically.
5. Remove the driver, seal, and all other auxiliary equipment.
6. Remove the pump unit.
7. Disassemble the pump unit as required for disposal.
8. Follow all applicable environmental, health, and safety regulations, laws, and requirements to dispose of the equipment and any hazardous materials.

10 Troubleshooting

Refer to Table 10-1 for troubleshooting instructions.

Condition	Probable Cause	Remedy
Pump not running.	1 Motor overload protection contacts open. a Incorrect control box. b Incorrect connections. c Faulty overloads. d Low Voltage. e Ambient temperature of control box or starter too high. 6 Blown fuse, broken or loose electric connections. 7 Defective Motor. 8 Faulty control equipment. 9 Faulty switch. 10Pump binding.	1 Do the following: a Check nameplate for HP and voltage. b Check wiring diagram furnished with starter. c Replace. d Check voltage at pump side of control box. e Use ambient compensated relays. 6 Check fuses, relays or heater elements for correct size and all electrical connection. 7 Repair or replace. 8 Check all circuits and repair. 9 Repair or replace. 10Pull master switch, rotate pump by hand to check. Check impeller adjustment or disassemble the unit to determine the cause.
Pump is running but no fluid delivered.	1 Line check valve backward. 2 Line check valve stuck. 3 Unit running backwards. 4 Lift too high for pump. 5 Pump not submerged. 6 Excessive amounts of air or gas. 7 Intake strainer or impeller plugged, or pump in mud or sand. 8 Impeller(s) loose on shaft.	1 Reverse check valve. 2 Free the valve. 3 Refer to “Hollow Shaft Driver Installation” on page 24, step 12. 4 Check with performance curve. 5 Lower pump if possible or add fluid to system. 6 Correct conditions. 7 Start & stop pump several times or use line pressure if available to back flush. Pull pump and clean. 8 Pull unit and repair.
Reduced capacity.	1 Bypass open. 2 Lift too high for pump. 3 Motor not coming up to speed. 4 Strainer or impellers partly plugged. 5 Scaled or corroded discharge pipe or leaks anywhere in system. 6 Excessive amounts of air or gas. 7 Excess wear due to abrasives. 8 Impellers not properly adjusted. 9 Impeller(s) loose on shaft.	1 Check bypass valving. 2 Check performance curve. 3 Check voltage while unit is running. 4 Start & stop pump several times or use line pressure if available to back flush. Pull pump and clean. 5 Replace pipe or repair leaks. 6 Suitable conditions. 7 Replace worn parts. 8 Refer to “Impeller Adjustment - General” on page 29. 9 Pull the unit and repair.

Table 10-1: Troubleshooting Chart

Condition	Probable Cause	Remedy
Motor overloaded.	1 Line voltage not correct. 2 Faulty equipment used to check. 3 Specific gravity higher than design. 4 Operation at point on pump curve other than design. 5 Motor speed too high. 6 Impellers dragging. 7 Pump in bind.	1 Check and correct. 2 Check equipment. 3 Correct specific gravity or re-evaluate system. 4 Check performance curve. 5 Line voltage too high or incorrect frequency. 6 Readjust. 7 Pull master switch, rotate pump by hand to check. Disassemble the unit to determine the cause.
Pump vibrating excessively and making noise.	1 Unit running backwards. 2 Pump breaking suction and pumping air. 3 Loose fasteners. 4 Badly worn motor or pump bearings. 5 Impeller(s) loose on shaft. 6 Pump & motor shafts misaligned. 7 Stress due to piping misalignment.	1 Refer to “Hollow Shaft Driver Installation” on page 24, step 12. 2 Lower pump or reduce capacity or increase fluid level. 3 Check all bolts, nuts, and re-tighten. 4 Pull unit and repair. 5 Pull unit and repair. 6 Pull unit and repair. 7 Correct.
Excess wear	1 Abrasives. 2 Pump in bind. 3 Vibration.	1 Clean system. 2 Pull master switch, rotate pump by hand to check. Disassemble the unit to determine the cause. 3 Determine cause and correct.
Corrosion	1 Impurities. 2 Corrosive liquid.	1 Analyze the fluid. 2 Change to corrosion resistant materials.

Table 10-1: Troubleshooting Chart (Continued)

11 Parts

DANGER

GENUINE OEM PARTS

- Genuine OEM parts and accessories are designed, tested and incorporated into the products to help ensure they maintain continued product quality and performance in use.
- As Trillium Pumps USA does not test the parts and accessories sourced from other vendors, the installation of such parts and accessories may adversely affect the performance and safety features of the products.
- The failure to properly select, install or use authorized parts and accessories is considered misuse. Damage or failure caused by misuse is not covered by our warranty.
- In addition, any modification of Trillium Pumps USA products or removal of original components may impair the safety of these products in their use.

11.1 Ordering Parts

When ordering spare parts or replacement parts give the following details:

- Pump serial number (available on the nameplate of the unit)
- Pump model (available on the nameplate of the unit)
- Part descriptions with complete part numbers
- Quantity required for each part

11.2 Stocking Spare Parts

Spare parts to be stocked in inventory depend on the following:

- Service type
- Anticipated maintenance cycles
- Allowable down time
- Number of units

It is recommended to maintain a minimum inventory of the following components:

- One complete set of bearings
- Gaskets
- O-rings
- Packing (or Mechanical Seal)
- One spare of each moving part.

11.3 Returning Parts

The following points are to be kept in mind when returning any materials:

- All materials returned to the factory must be accompanied by a RMA number.
- An RMA number can be obtained directly from the factory or by contacting a local Dealer/District Manager.
- The RMA form must be filled in completely and forwarded as instructed.
- Parts being returned under warranty claim must be submitted with a complete written report along with the RMA form.

CAUTION

PREVENT TRANSIT DAMAGE TO THE EQUIPMENT

Material returned must be carefully packaged to prevent transit damage. Trillium Pumps USA cannot be held responsible for parts damaged in transit.

For information regarding service and spare parts:

1. Contact your local Trillium Pumps USA Pumps representative.

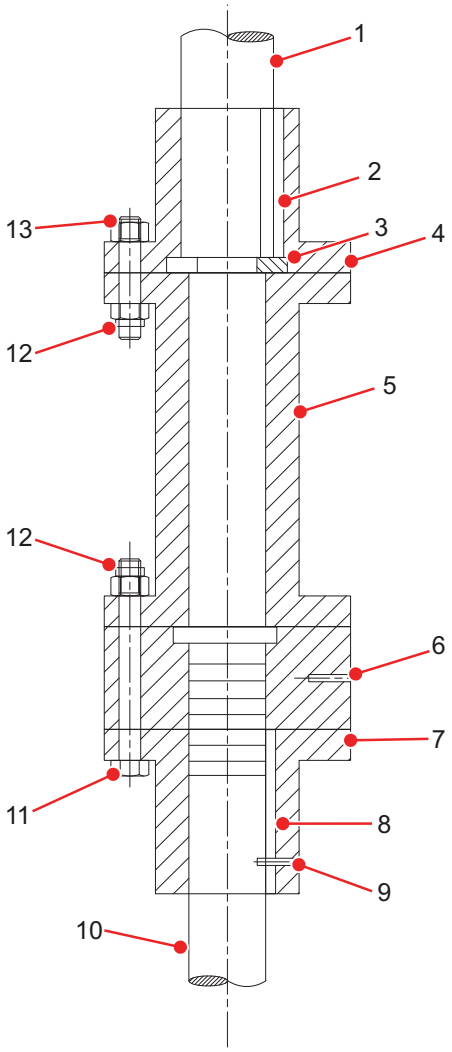
   OR

2. Contact us through email at floway@trilliumflow.com or visit www.trilliumflow.com

12 Parts List

NOTICE

- Separate instruction manual available covering bowl assembly construction and parts list.
- Separate instruction manual available covering mechanical seal construction and parts list.
- Construction of unit supplied may vary considerably from drawings.



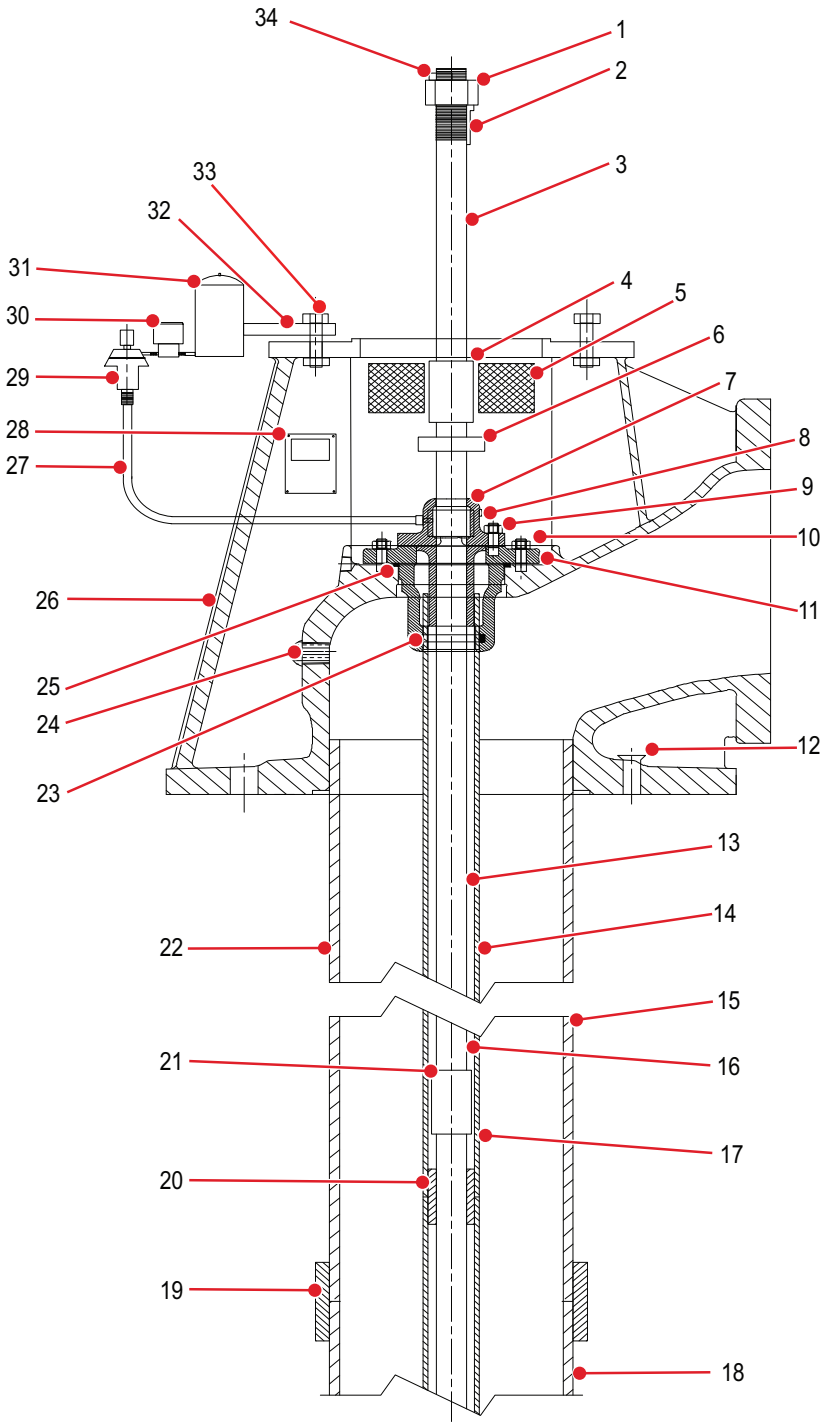
1. Driver Shaft
2. Driver Key
3. Split Thrust Ring
4. Driver Half Coupling
5. Spacer
6. Adjusting Nut
7. Pump Half Coupling
8. Pump Key
9. Dowel Pin
10. Pump Shaft
11. Coupling Bolt
12. Lock Nut
13. Spacer Bolt

Figure 12-1: Adjustable Flanged Coupling

(illustrated with spacer)

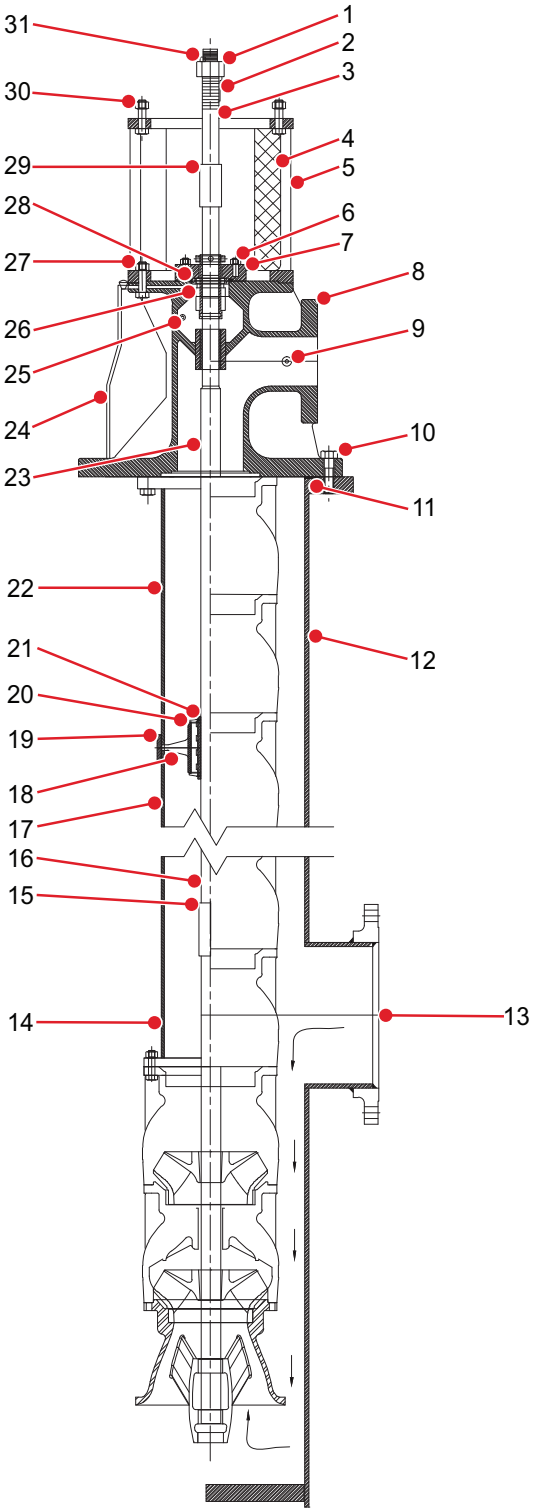
NOTICE

Construction for coupling assembly less spacer is identical to that shown except that the spacer, spacer bolts, and lock nuts are omitted.



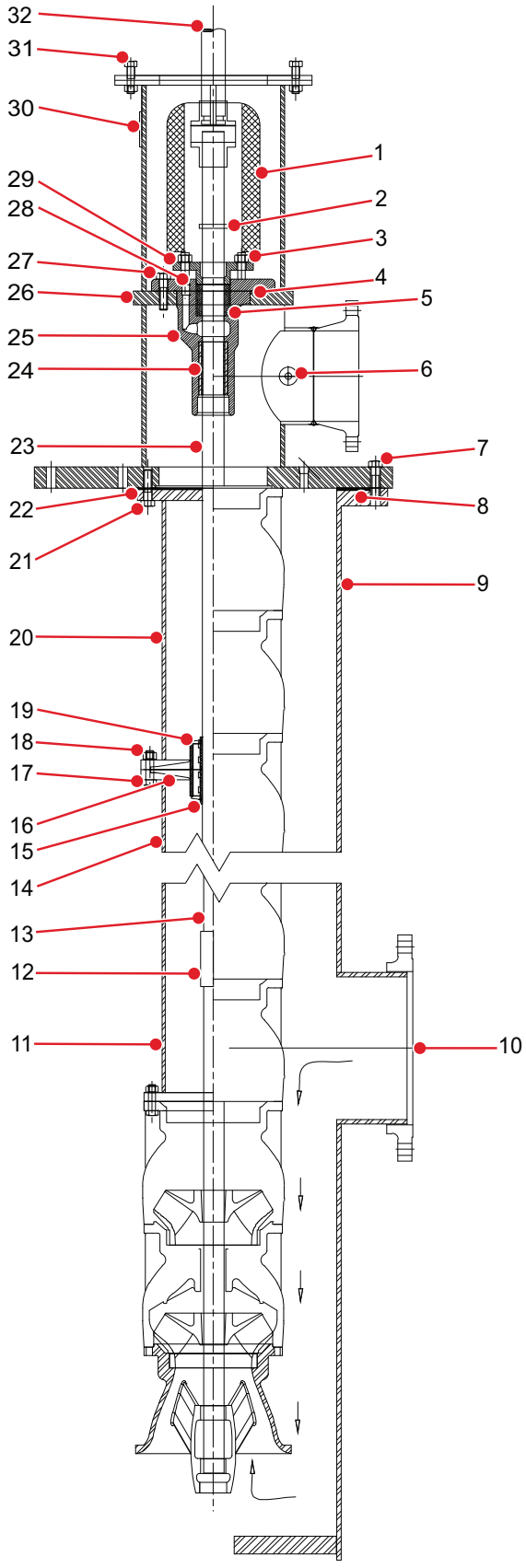
1. Headshaft Nut
2. Gib Key
3. Head Shaft
4. Shaft Coupling
5. Coupling Guard Assembly
6. Slinger
7. Tension Nut
8. Tension Nut Plug
9. Tension Nut Lockscrew
10. Stuffing Box Cap Screws
11. Tension Plate
12. Snap Button Hole Plug
13. Top Lineshaft
14. Top Adjusting Tube
15. Intermediate Column Pipe
16. Intermediate Line Shaft
17. 5 feet Enclosing Tube
18. Bottom Column Pipe
19. Column Pipe Coupling
20. Line Shaft Bearing
21. Shaft Coupling
22. Top Column Pipe
23. Tube Nipple O-ring
24. Pipe Plug
25. Stuffing Box O-ring
26. Discharge Head
27. Oil Line with Fittings
28. Nameplate with Drive Screws
29. Sight Feed Valve (Auto)
30. Solenoid Valve (O.L)
31. Oil Pot with Cover
32. Oil Pot Mounting Bracket
33. Driver Bolts and Nuts
34. Headshaft Nut Lockscrew

Figure 12-2: Type A - Enclosed Lineshaft



1. Headshaft Nut
2. Gib Key
3. Headshaft
4. Coupling Guard Assembly
5. Motor Stand
6. Seal Cover Cap Screws
7. Seal Housing Cover
8. Discharge Head
9. Pipe Plug
10. Mounting Flange Bolts or Studs
11. Mounting Flange Gasket
12. Suction Barrel
13. Suction Barrel Inlet
14. Bottom Column Pipe
15. Shaft Coupling
16. Intermediate Lineshaft
17. Intermediate Column Pipe
18. Bearing Retainer
19. Column Pipe Coupling
20. Lineshaft Bearing
21. Lineshaft Sleeve
22. Top Column Pipe
23. Top Lineshaft
24. By-pass with Fittings
25. Seal Housing Plug
26. Mechanical Seal Assembly
27. Motor Stand Bolts and Nuts
28. Seal Cover Gasket or O-ring
29. Shaft Coupling
30. Driver Nuts and Bolts
31. Headshaft Nut Lockscrew

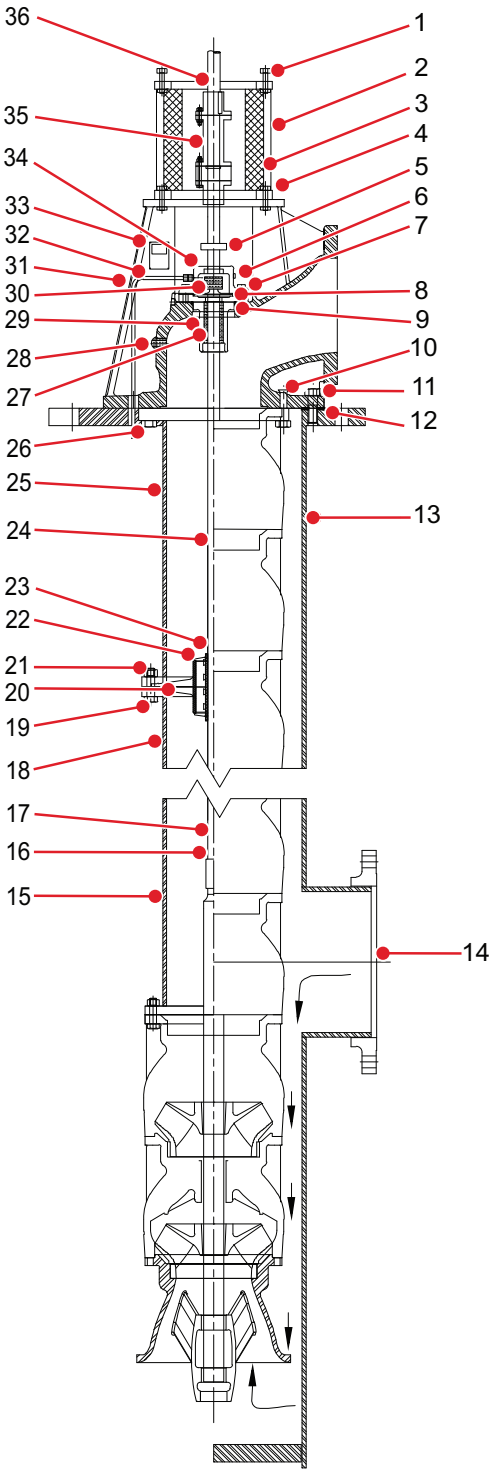
Figure 12-3: Type CF - Open Lineshaft



1. Coupling Guard Assembly
2. Slinger
3. Packing Glands Studs and Nuts
4. Stuffing Box O-ring
5. Packing Rings
6. Pipe Plug
7. Mounting Flange Bolts or Studs
8. Mounting Flange Gasket
9. Suction Barrel
10. Suction Barrel Inlet (VF only)
11. Bottom Column Pipe
12. Shaft Coupling
13. Intermediate Lineshaft
14. Intermediate Column Pipe
15. Lineshaft Sleeve
16. Bearing Retainer
17. Column Flange Bolts
18. Column Flange Nuts
19. Lineshaft Bearing
20. Top Column Pipe
21. Top Column Flange Cap Screws
22. Stop Column Flange Gasket
23. Top Lineshaft
24. Stuffing Box Bearing
25. Stuffing Box
26. Discharge Head
27. Stuffing Box Cap Screws
28. Grease Zerk with Cover
29. Packing Gland
30. Nameplate with Driver Screws
31. Driver Nuts and Bolts
32. Driver Shaft

Figure 12-4: Type F and VF - Open Lineshaft

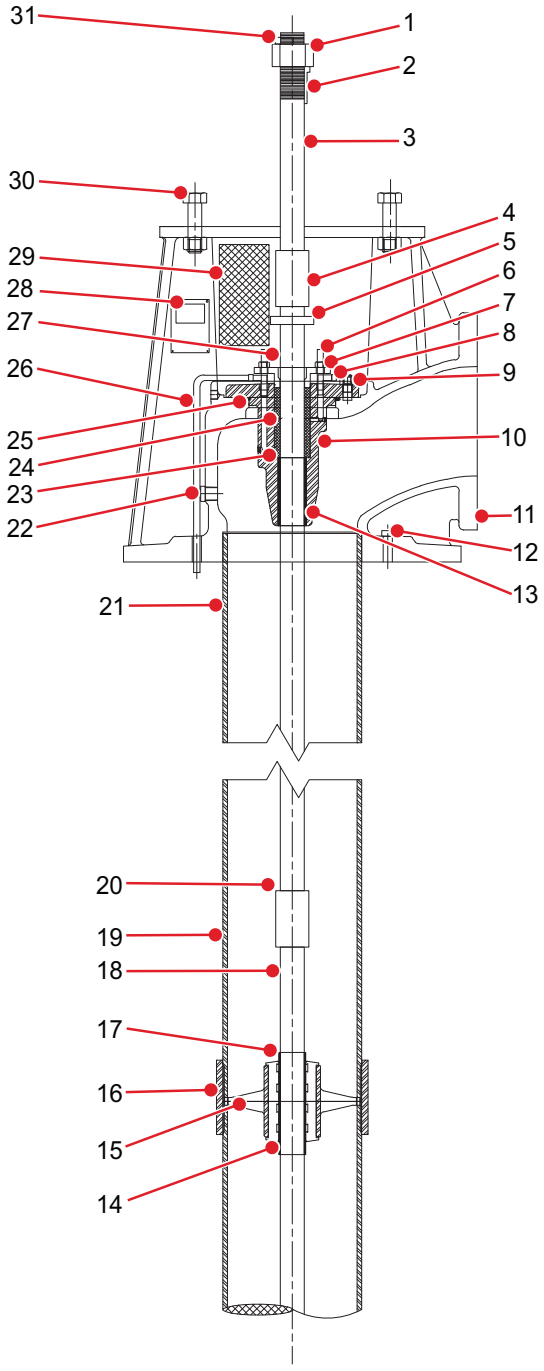
(illustrated with adjustable flange coupling without spacer and standard packing box)



1. Driver Bolts and Nuts
2. Motor Stand
3. Coupling Guard Assembly
4. Motor Stand Bolts and Nuts
5. Slinger
6. Seal Housing Plug
7. Seal Cover Cap Screws
8. Seal Cover Gasket or O-ring
9. Seal Housing O-ring
10. Snap Bottom Hole Plug
11. Mounting Flange Bolts or Studs
12. Mounting Flange Gasket
13. Suction Barrel
14. Suction Barrel Inlet (AF only)
15. Bottom Column Pipe
16. Shaft Coupling
17. Intermediate Lineshaft
18. Intermediate Column Pipe
19. Column Flange Bolts
20. Bearing Retainer
21. Column Flange Nuts
22. Lineshaft Bearing
23. Lineshaft Sleeve
24. Top Lineshaft
25. Top Column Pipe
26. Top Column Flange Cap Screws
27. Throttle Bushing Seal
28. Pipe Plug
29. Seal Housing
30. Mechanical Seal Assembly
31. Discharge Head
32. By-pass with Fittings
33. Nameplate with Driver Screws
34. Seal Housing Cover
35. Adjustable Flanged Spacer Coupling Assembly
36. Driver Shaft

Figure 12-5: Type AF - Open Lineshaft

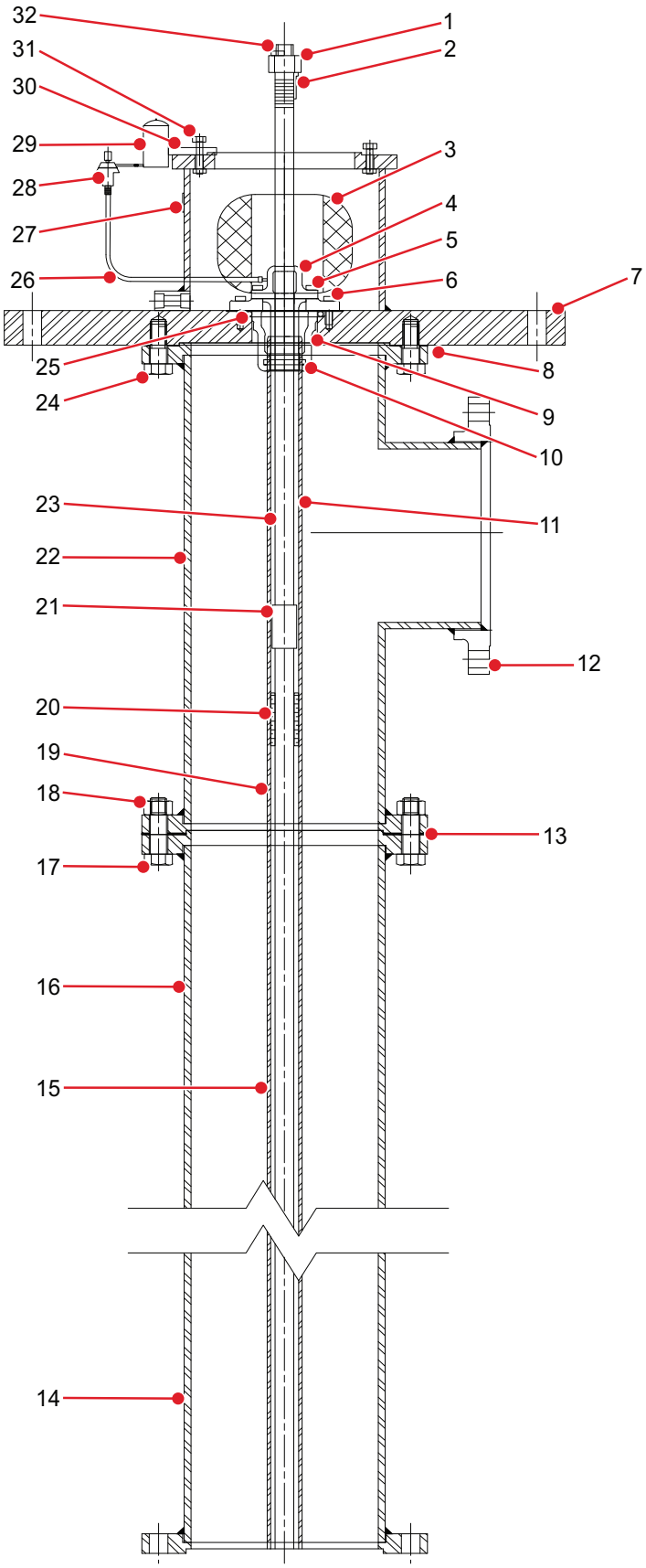
(illustrated with motor stand, spacer coupling, FF-2 seal and seal housing)



1. Headshaft Nut
2. Gib Key
3. Headshaft
4. Shaft Coupling
5. Slinger
6. Packing Gland Studs and Nuts
7. Packing Gland
8. Grease Zerk (with Cover)
9. Stuffing Box Cap Screws
10. Stuffing Box
11. Discharge Head
12. Snap Button Hole Plug
13. Stuffing Box Bearing
14. Lineshaft Sleeve
15. Bearing Retainer
16. Column Pipe Coupling
17. Lineshaft Bearing
18. Intermediate Lineshaft
19. Intermediate Column Pipe
20. Shaft Coupling
21. Top Column Pipe
22. Pipe Plug
23. Packing Rings
24. Lantern Ring
25. Stuffing Box O-rings
26. By-pass with Fittings
27. Top Lineshaft
28. Nameplate with Driver Screws
29. Coupling Guard Assembly
30. Driver Bolts and Nuts
31. Headshaft Nut Lockscrew

Figure 12-6: Type A - Open Lineshaft

(illustrated with column and hi-pressure packing box)



1. Headshaft Nut
2. Gib Key
3. Coupling Guard Assembly
4. Tension Nut
5. Tension Nut Lockscrew
6 Stuffing Box Cap Screws
7. Discharge Head
8. Top Column Flange Gasket
9. Tension Plate
10. Tube Nipple O-ring
11. Top Adjusting Tube
12. Underground Discharge Assembly
13. Column Gasket or O-ring
14. Bottom Column Pipe
15. 5 feet Enclosing Tube
16. Intermediate Column Pipe
17. Column Flange Bolts
18. Column Flange Nuts
19. Shaft Enclosing Tube
20. Lineshaft Bearing
21. Shaft Coupling
22. Top Column Pipe
23. Top Lineshaft
24. Top Column Flange Screws
25. Stuffing Box O-ring
26. Oil Line with Fittings
27. Nameplate with Drive Screws
28. Sight Feed Valve
29. Oil Pot with Cover
30. Oil Pot Mounting Bracket
31. Driver Bolts and Nuts
32. Headshaft Nut Lock Screw

Figure 12-7: Type VU - Enclosed Lineshaft

(illustrated with manually operated lubrication assembly)

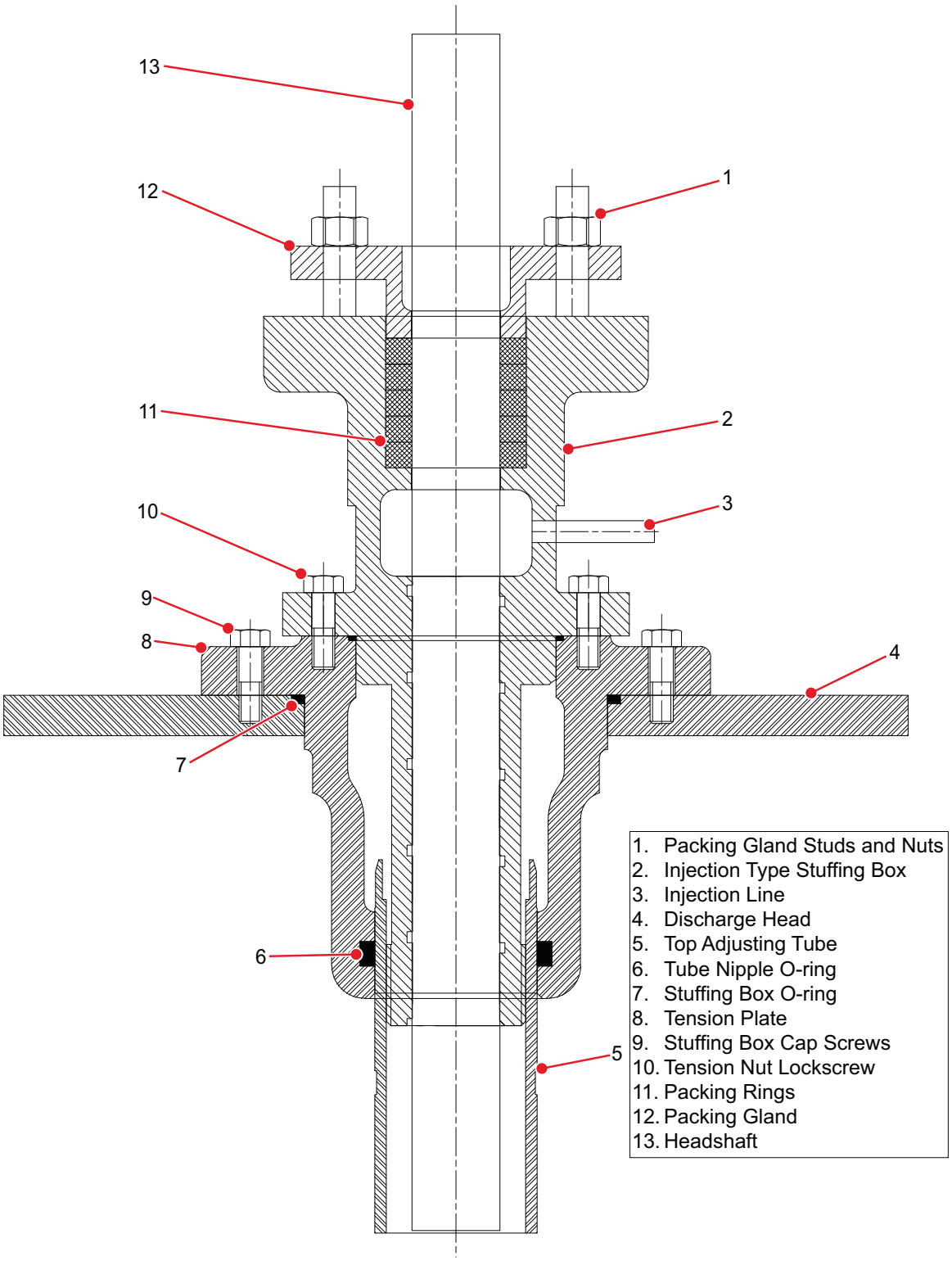
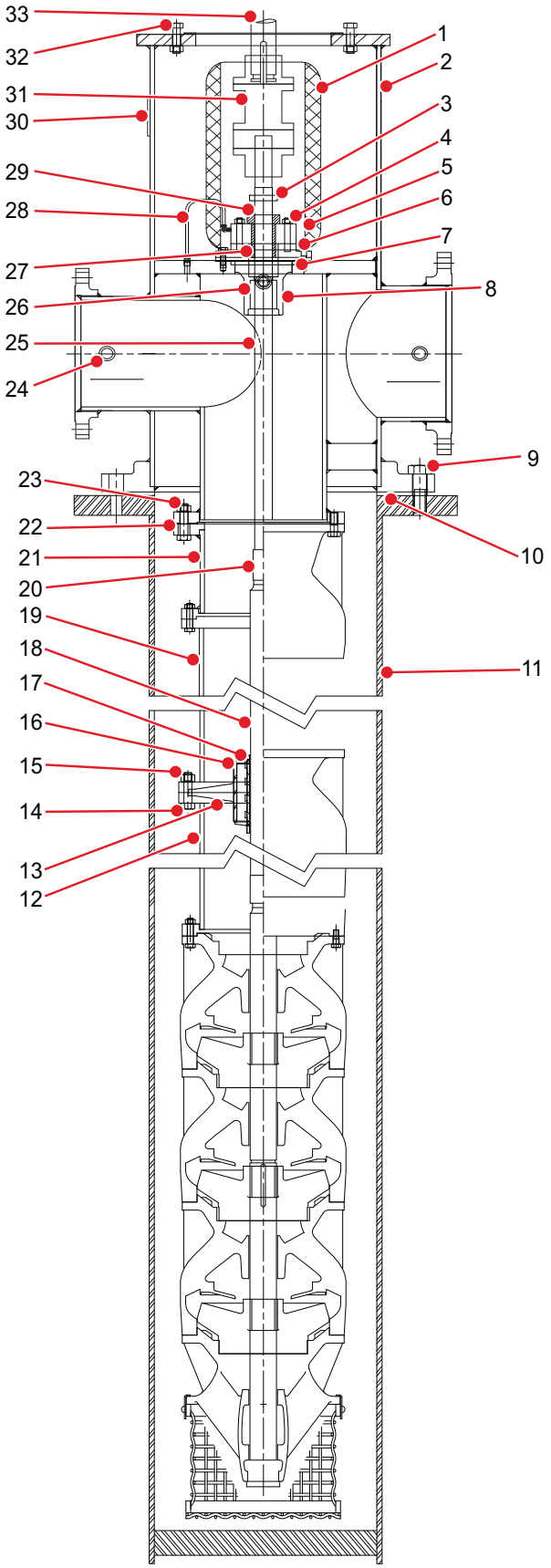


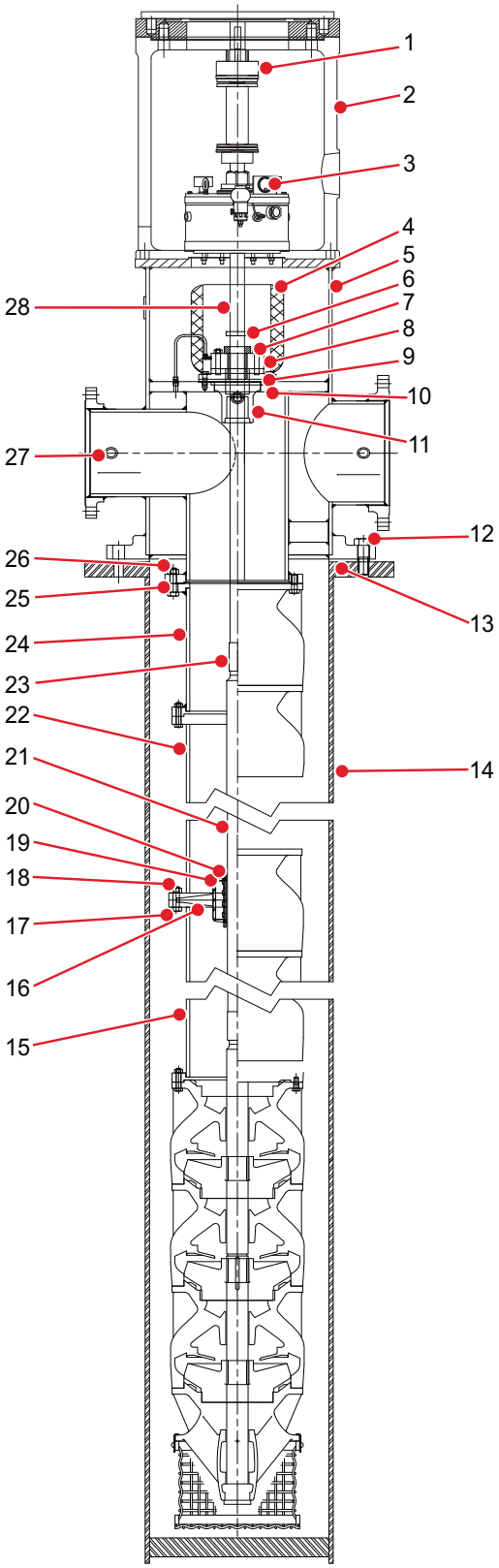
Figure 12-8: Injection Lubrication Arrangement



1. Coupling Guard Assembly
2. Discharge Head
3. Slinger
4. Seal Cover Cap Screws
5. Seal Housing Cover
6. Seal Cover Gasket or O-ring
7. Seal Housing O-ring
8. Seal Housing
9. Mounting Flange Bolts or Studs
10. Mounting Flange Gasket
11. Suction Barrel
12. Bottom Column Pipe
13. Bearing Retainer
14. Column Flange Bolts
15. Column Flange Nuts
16. Lineshaft Bearing
17. Lineshaft Sleeve
18. Intermediate Lineshaft
19. Intermediate Column Pipe
20. Shaft Coupling
21. Top Column Pipe
22. Top Column Flange Gasket
23. Top Column Bolts and Nuts
24. Pipe Plug
25. Top Lineshaft
26. Seal Housing Bearing
27. Mechanical Seal Assembly
28. By-pass with Fittings
29. Seal Lock Collar with Set Screws
30. Nameplate with Drive Screws
31. Adjustable Flanged Spacer Coupling Assembly
32. Driver Bolts and Nuts
33. Driver Shaft

Figure 12-9: Type VC

(illustrated with adjustable flanged coupling with spacer and mechanical seal)



1. Motor Shaft Coupling
2. Thrust Stand
3. Thrust Bearing Assembly
4. Coupling Guard Assembly
5. Discharge Head
6. Slinger
7. Seal Cover Cap Screws
8. Seal Housing Cover
9. Seal Cover Gasket or O-ring
10. Seal Housing O-ring
11. Seal Housing
12. Mounting Flange Bolts or Studs
13. Mounting Flange Gasket
14. Suction Barrel
15. Bottom Column Pipe
16. Bearing Retainer
17. Column Flange Bolts
18. Column Flange Nuts
19. Lineshaft Bearing
20. Lineshaft Sleeve
21. Intermediate Lineshaft
22. Intermediate Column Pipe
23. Shaft Coupling
24. Top Column Pipe
25. Top Column Flange Gasket
26. Top Column Bolts and Nuts
27. Pipe Plug
28. Top Lineshaft

Figure 12-10: Type VC

(illustrated with TSO thrust bearing, motor stand, and flexible driver coupling)

TRILLIUM
FLOW TECHNOLOGIES™

Trillium Pumps USA
Fresno California 93706

Tel: (559) 442 - 4000
Fax: (559) 442 - 3098

www.trilliumflow.com