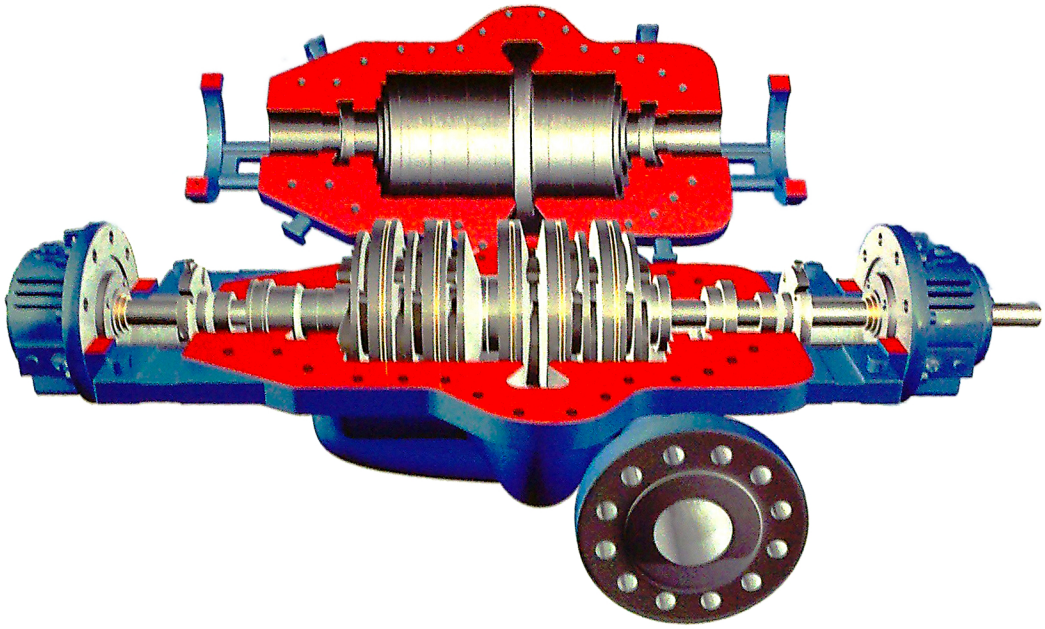
TSMP Series

Multi-Stage Turbine Pump
API 610 - 10th Edition

# Installation, Operation, & Maintenance Manual



TRUFLO™
QUALITY ○ VALUE ○ SERVICE

A New Vision For Quality Pumps

# FOREWORD

The following is the IOM, (Installation, Operation, and Maintenance manual for Truflo pumps, TSMP, process Pump designed to API* Standard 610 10th Edition (ISO13709). We cover the standard product plus common options that are available. For special options, additional instructions are added**.** Please read complete manual before installation and maintenance.

The quality design, materials, and workmanship used in the construction of all TRUFLO Pumps, gives these units long lasting service. The life and satisfactory service of any mechanical unit, however, is enhanced and extended by correct application, proper installation, inspection, monitoring and consistent maintenance. This instruction manual was prepared to assist you in understanding the construction and the correct methods of installing, operating, and maintaining these pumps.

**Warranty is valid only when genuine TRUFLO parts are used.**

Use of the equipment on a service other than stated in the order will nullify the warranty, unless written approval is obtained in advance from Truflo Pumps.

Supervision by an authorized Truflo Pumps representative is recommended to assure proper installation.

Additional manuals can be obtained by contacting your local Industries -Truflo Pumps representative, by calling 1-336-664-9225, or visiting our website at www.truflo.com.

***We, at Truflo, would like to thank you for buying our high quality equipment and want you to know that we are committed to you with this purchase and long term as a satisfied customer. We know that you can buy form any Manufacturer, but we want you convinced that we are the only real true supplier that is on your team.***

**THIS MANUAL EXPLAINS**

- **Installation**
- **Start-up Procedures**
- **Routine Maintenance**
- **Operation Procedures**
- **Pump Overhaul**
- **Troubleshooting**
- **Ordering Spare or Repair Parts**

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Washington, D.C. 20005

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# IMPORTANT SAFETY NOTICE

User safety is a major focus in the design of our products. Following the precautions outlined in this manual will minimize your risk of injury.
Truflo pumps will provide safe, trouble-free service when properly installed, maintained, and operated.

Safe installation, operation, and maintenance of Truflo Pumps equipment are a critical end user responsibility. This Pump Safety Manual identifies specific safety risks that must be considered at all times during product life. Understanding and following these safety warnings is mandatory to ensure people, property, and/or the environment will not be harmed. Following these warnings alone, however, is not sufficient it is anticipated that the end user will also comply with industry and corporate safety standards.

Please take the time to review and understand the safe installation, operation, and maintenance guidelines outlined in this Pump Safety Manual and the Instruction, Operation, and Maintenance (IOM) manual. Current manuals are available at www.truflo.com or by contacting your nearest Truflo Pumps sales representative.

For additional information, contact your nearest Truflo Pumps sales representative or visit our Web site at www.truflo.com, or call us at 336-664-9225.

# SAFETY WARNINGS

**WARNING**

A pump is a pressure vessel with rotating parts that can be hazardous. Any pressure vessel can explode, rupture, or discharge its contents if sufficiently over pressurized causing death, personal injury, property damage, and/or damage to the environment. All necessary measures must be taken to ensure over pressurization does not occur. Please review all pages of this manual.

**WARNING**

Never operate a pump with a blocked suction and discharge, this must be avoided in all cases, even for a brief period under these conditions, this will cause superheating of enclosed pumped fluid and result in a violent explosion. All necessary measures must be taken by the end user to ensure this condition is avoided.

**WARNING**

The pump may handle hazardous and/or toxic fluids. Care must be taken to identify the contents of the pump and eliminate the possibility of exposure, particularly if hazardous and/or toxic. Potential hazards include, but are not limited to, high temperature, flammable, acidic, caustic, explosive, and other risks.

**WARNING**

Pumping equipment Instruction, Operation, and Maintenance manuals identify accepted methods for disassembling pumping units. All these methods must be adhered to. Specifically, applying heat to impellers and/or impeller retaining devices to aid in their removal is strictly forbidden. Trapped liquid can rapidly expand and result in a violent explosion and injury.

**Truflo Pumps will not accept responsibility for physical injury, damage, or delays caused by a failure to observe the instructions for installation, operation, and maintenance contained in this Pump Safety Manual or the current IOM available at www.truflo.com.**

# SAFETY

## DEFINITIONS

Throughout this manual the words **WARNING**, **CAUTION**, **and ELECTRICAL,** are used to indicate where special operator attention is required, please pay caution.

## WARNING

Indicates a hazardous situation, which if not avoided could result in death or serious injury.

Example: Never operate a pump without coupling guard installed correctly. Never run dry.

Never run with no suction are a few examples.

## CAUTION

Indicates a hazardous situation, which if not avoided could result in minor or major injury.

## ELECTRICAL HAZARD

Indicates the possibility of electrical risks if directions are not followed. Example**:** Lock out driver power to prevent electric shock, accidental start-up, and physical injury.

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

# GENERAL PRECAUTIONS

**⚠ WARNING**

A pump is a pressure vessel with rotating parts that can be hazardous. Hazardous fluids may be contained by the pump including high temperature, flammable, acidic, caustic, explosive, and other risks. Operators and maintenance personnel must realize this and follow safety measures. Personal injuries will result if procedures outlined in this manual are not followed. Truflo Pumps will not accept responsibility for physical injury, damage or delays caused by a failure to observe the instructions in this manual and the IOM provided with your equipment.

| General Precautions | | |
|---|---|---|
| **NOTE** | | NEVER HEAT TO REMOVE IMPELLER. It may explode due to trapped liquid. |
| **NOTE** | | NEVER use heat to disassemble pump due to risk of explosion from tapped liquid. |
| **NOTE** | | NEVER operate pump without coupling guard correctly installed. |
| **NOTE** | | NEVER run pump below recommended minimum flow when dry, or without prime. |
| **NOTE** | | ALWAYS lock out power to the driver before performing pump maintenance. |
| **NOTE** | | NEVER operate pump without safety devices installed. |
| **NOTE** | | NEVER operate pump with discharge valve closed. |
| **NOTE** | | NEVER operate pump with suction valve closed. |
| **NOTE** | | DO NOT change service application without approval of an authorized Truflo Pumps representative. |
| **NOTE** | | Safety Apparel**:** Insulated work gloves when handling hot bearings or using bearing heater , Heavy work gloves when handling parts with sharp edges, especially impellers Safety glasses (with side shields) for eye protection Steel-toed shoes for foot protection when handling parts, heavy tools, etc. Other personal protective equipment to protect against hazardous/toxic fluids. |
| **NOTE** | | Receiving: Assembled pumping units and their components are heavy. Lift properly and support equipment, neglect can result in serious physical injury and/or equipment damage. Lift equipment only at specifically identified lifting points or as instructed in the current IOM. Current manuals are available at www.truflo.com or contact your local Truflo Pumps sales representative. Note: Lifting devices (eyebolts, slings, spreaders, etc.) must be rated, selected, and used for the entire load being lifted. |
| **WARNING** | | Alignment: Shaft alignment procedures must be followed to prevent catastrophic failure of drive components or unintended contact of rotating parts. Follow coupling manufacturer's coupling installation and operation procedures. |

| General Precautions | | |
|---|---|---|
| **NOTE** | | Before beginning any alignment procedure, make sure driver power is locked out. Failure to lock out driver power will result in serious physical injury. |
| **NOTE** | | Piping**:** Never pull piping into place by forcing at the flanged connections of the pump. This may impose dangerous strains on the unit and cause misalignment between pump and driver. Pipe strain will adversely affect the operation of the pump resulting in physical injury and damage to the equipment. |
| **NOTE** | | Flanged Connections: Use only fasteners of the proper size and material. |
| **NOTE** | | Replace all corroded fasteners. |
| **NOTE** | | Ensure all fasteners are properly tightened and there are no missing fasteners. |
| **NOTE** | | Startup and Operation**:** When installing in a potentially explosive environment, please ensure that the motor is certified explosion proof. |
| **NOTE** | | Do not operate pumps in reverse rotation may result in contact of metal parts, heat generation, and breach of containment. |
| **NOTE** | | LOCK out Tag out drivers |
| **NOTE** | | The impeller clearance setting procedure must be followed. Improperly setting the clearance or not following any of the proper procedures can result in sparks, unexpected heat generation and equipment damage. |
| **NOTE** | | If using a cartridge mechanical seal, the centering clips must be installed and set screws loosened prior to setting impeller clearance. Failure to do so could result in sparks, heat generation, and mechanical seal damage. |
| **NOTE** | | The coupling used in an ATEX classified environment must be properly certified and must be constructed from a non-sparking material. |
| **NOTE** | | Never operate a pump without coupling guard properly installed. Personal injury will occur if pump is run without coupling guard. |
| **NOTE** | | Properly lubricate the bearings. Failure to do so may result in excess heat generation, sparks, and / or premature failure. |
| **NOTE** | | The mechanical seal used in an ATEX classified environment must be properly certified. Prior to start up; ensure points of potential leakage of process fluid to the work environment are closed. |
| **NOTE** | | Do not operate the pump without liquid supplied to mechanical seal. Running a mechanical seal dry, even for a few seconds, can cause seal damage and must be avoided. Physical injury can occur if mechanical seal fails. |
| **NOTE** | | Never attempt to replace packing until the driver is properly locked out and the coupling spacer is removed. |
| **NOTE** | | Dynamic seals are not allowed in an ATEX classified environment. |
| **NOTE** | | DO NOT operate pump below minimum rated flows or with suction and/or discharge valve closed. These conditions can create an explosive and hazardous to vaporization of pumped fluid and can quickly lead to pump failure and physical injury. |

| General Precautions | | |
|---|---|---|
| **NOTE** | | Ensure pump is isolated from system and pressure is relieved before disassembling pump, removing plugs, opening vent or drain valves, or disconnecting piping. |
| **NOTE** | | Shutdown, Disassembly, and Reassembly**:** Pump components can be heavy. Please lift properly to avoid physical injury and/or equipment damage. Steel toed shoes must be worn at all times. |
| **NOTE** | | The pump may handle hazardous and/or toxic fluids. Observe proper decontamination procedures. Proper personal protective equipment should be worn. Precautions must be taken to prevent physical injury. Pumped fluid must be handled and disposed of in conformance with applicable environmental regulations. |
| **NOTE** | | Operator must be aware of pumped fluid and safety precautions to prevent physical injury. |
| **NOTE** | | Lock Out Tag Out. |
| **NOTE** | | Allow all system and pump components to cool before handling them to prevent physical injury. |
| **NOTE** | | There may be a risk of static electric discharge from plastic parts that are not properly grounded. If pumped fluid is non-conductive, pump should be drained and flushed with a conductive fluid under conditions that will not allow for a spark to be released to the atmosphere. |
| **NOTE** | | Never apply heat to remove an impeller. The use of heat may cause an explosion due to trapped fluid, resulting in severe physical injury and property damage. |
| **NOTE** | | Wear heavy work gloves when handling impellers as sharp edges may cause physical injury. |
| **NOTE** | | Wear insulated gloves when using a bearing heater. Bearings will get hot and can cause physical injury. |

***The use of genuine Truflo parts will provide the safest and most reliable operation of your pump. Truflo Pumps certification and quality control procedures ensure the parts are manufactured to the highest quality and safety levels. Quality parts are extremely important for original, Fit, Form and Function for continued long term, and safe operation. Please do not use non OEM parts as warranties will be voided.***

| Table 1 | | |
|---|---|---|
| **Code** | **Max permissible surface temperature °F (°C)** | **Max permissible liquid temperature °F (°C)** |
| T1 | 842 (450) | 700 (372) |
| T2 | 572 (300) | 530 (277) |
| T3 | 392 (200) | 350 (177) |
| T4 | 275 (135) | 235 (113) |
| T5 | 212 (100) | Option not available |
| T6 | 185 (85) | Option not available |

II = Group 2
2 = Category 2
G/D = Gas and Dust present
T4 = Temperature class, can be T1 to T6 (see Table 1)


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

# Transportation and Storage

## Receive the unit

1 Inspect the package for damaged or missing items upon delivery.
2 Note any damaged or missing items on the receipt and freight bill.
3 File a claim with the shipping company if anything is out of order.

## Unpack the unit

1 Remove packing materials from the unit. Dispose of all packing materials correctly.
2 Inspect the unit to determine if any parts have been damaged or are missing.
3 Contact your TRUFLO representative if anything seems out of order.

## Pump handling

**WARNING:**
Make sure that the pump cannot roll or fall over and injure people or damage property.

**NOTICE:** Use a forklift truck with sufficient capacity to move the pallet with the pump unit on top. Failure to do so may result in equipment damage.

### Lifting methods

**WARNING:**

- Assembled pumping units and their components are heavy. Failure to properly lift and support this equipment can result in serious physical injury and/or equipment damage. Lift equipment only at the specifically identified lifting points. Lifting devices such as eyebolts, slings, and spreaders must be rated, selected, and used for the entire load being lifted.
- The pump and the components are heavy. Use proper lifting methods, and wear steel-toed shoes at all times. Failure to do so can result in physical injury.

**Table 1: Methods**

| Pump type | Lifting method |
|---|---|
| A bare pump without lifting handles | Use a suitable sling attached properly to solid points like the casing, the flanges, or the frames. |
| A bare pump with lifting handles | Lift the pump by the handles. |
| A base-mounted pump | Use slings under the pump casing and the drive unit, or under the base rails. |

**Warning:** Do not attach sling ropes to shaft ends. Doing so may result in equipment damage.

**Examples**

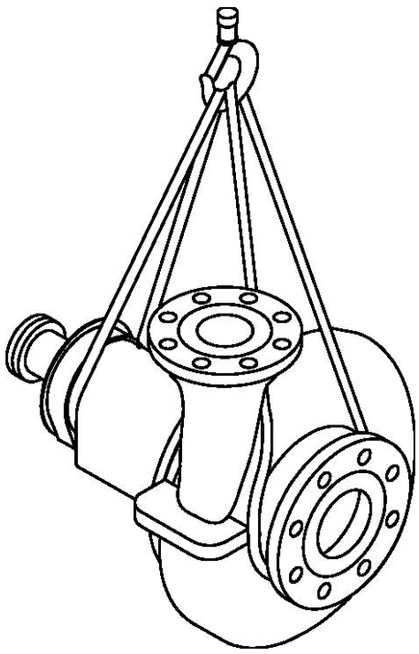


**Figure 1: Proper lifting method**

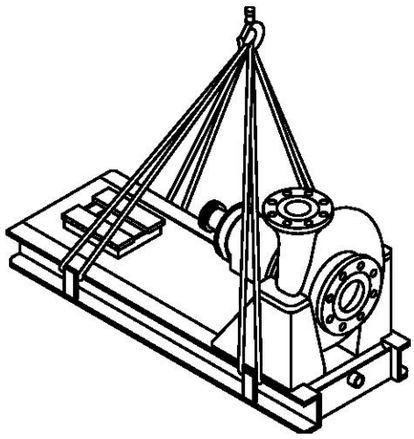


**Figure 2: Proper lifting method**

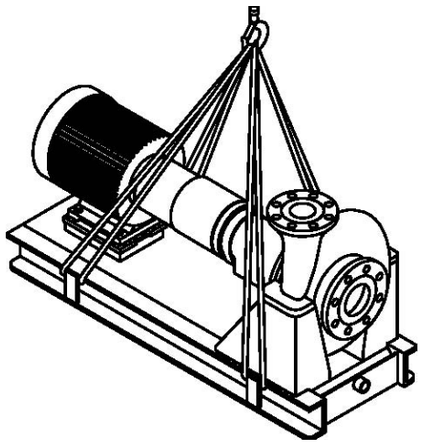


**Figure 3: Proper lifting method**

# Pump storage requirements

Storage requirements are dependent on the amount of time the pump is stored. The normal packaging is designed only to protect the pump during shipping.

| Length of time in storage | Storage requirements |
|---|---|

- Store in a covered and dry location.
- Store the unit free from dirt and vibrations.
- Store in a covered and dry location.
- Store the unit free from heat, dirt, and vibrations.
- Rotate the shaft by hand several times at least every three months.

Treat bearing and machined surfaces so that they are well preserved. Refer to drive unit and coupling manufacturers for their long-term storage procedures. You can purchase long-term storage treatment with the initial pump order or you can purchase it and apply it after the pumps are already in the field. Contact your local TRUFLO sales representative.

# GENERAL INFORMATION





## PUMP DESCRIPTION

The Model TSMP is a high pressure, multi-stage, between the bearings, horizontal centrifugal pump designed to meet the rigorous demands of the petroleum and petrochemical market place. It is in full compliance with API 610 10th Edition (ISO 13709).

**Casing** -The casing is mounted with side suction and side discharge nozzles. ANSI class 900+ (Higher flange options available) pound raised face serrated flanges with a 125-250 rims finish are standard. 600 and 1500 pound and ring type joint (RTJ) flanges are available options.

**Impeller** -The impeller is a fully closed design and is keyed.

**Seal Chamber** -The Model TSMP has a seal chamber designed in accordance with API 682 2nd Edition criteria. Customer selected cartridge mechanical seals are standard.

**Bearing Housings** -Ductile iron bearing housings are standard on non-API services and carbon steel on API services. Oil level is viewed through a sight glass. Constant level oilers and labyrinth seals are standard. No machining is required to convert the standard ring oil lube to either purge or pure mist, although pure mist applications require minor bearing housing modifications. Pressure lubrication is required with hydrodynamic thrust bearings.

**Shaft** -The heavy duty shaft is designed for cartridge mechanical seals, minimal shaft deflection at the seal faces (.002) when run in the worst case condition (typically minimum flow), and a critical speed at least 20% above design operating speed. Fully compliant with API 10th Edition (ISO 13709).

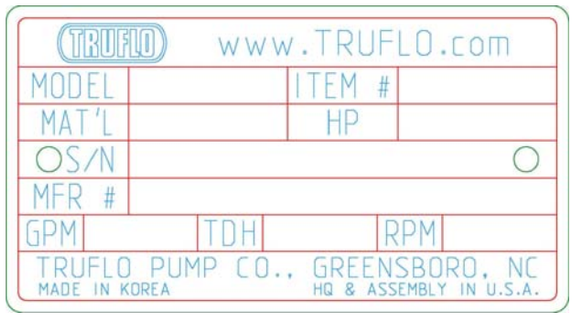
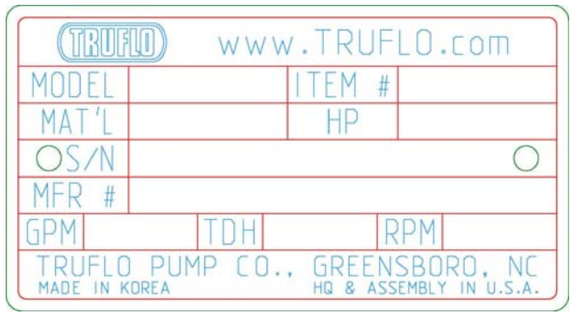
**Bearings** -Radial loads are carried by a single row, deep groove ball bearing (standard) or sleeve bearings (optional). The axial thrust load is handled by a pair of single row angular contact ball bearings mounted back to back (standard), or a hydrodynamic thrust bearing (used with sleeve type journal bearings). When ball bearings are used (standard), the outboard bearing (thrust bearing) is shouldered and locked into place, thus enabling it to carry both radial and axial thrust loads. All fits are precision machined to both the shaft and bearing housing to industry standards. Size 6x8-13 pumps come standard with sleeve/ball bearing arrangement.

**Baseplate** -The fabricated steel baseplate is designed to support the pump, driver and accessories in accordance with API 10th Edition (ISO 13709) requirements.

**Direction of Rotation** -Counterclockwise (left hand) as viewed from the driver, looking at the pump shaft. (Check with the factory for clockwise rotation.)

# NAMEPLATE INFORMATION

Our Pumps have a Truflo nameplate that provides all necessary pump information you will need to identify information about the pump. The nameplate is located on model, size, serial number, and the item number of the pump casing. Required parts. Information can be taken from the pump casing tags. Item numbers can be found later on in this manual.

| Description | Fig. No. | Example |
|---|---|---|
| **Pump Casing Tag** -provides information about the pump's hydraulic characteristics. Note the format of the pump size: Discharge x Suction -Nominal maximum Impeller Diameter in inches. (Example: 2x3-8) (Figs.1&2). | **Fig. 1 English** |  |
| | **Fig. 2 Metric** |  |
| | | |

# RECEIVING THE PUMP

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

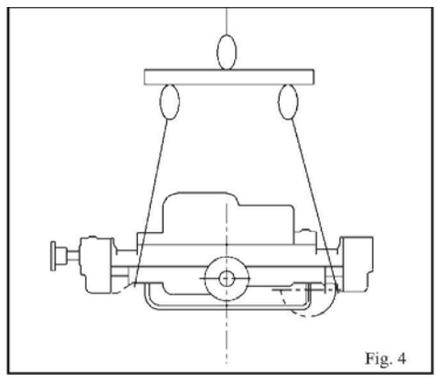


Fig. 4



## STORAGE REQUIREMENTS

**Short Term** (Less than 6 months) Truflo normal packaging procedure is designed to protect pump during shipping. Upon receipt, store in a covered and dry location.

**Long Term** (More than 6 months) Preservative treatment of bearings and machined surfaces will be required. Rotate shaft several times every 3 months. Refer to driver and coupling manufacturers for their long term storage procedures. Store in a covered and dry location.

## HANDLING

**! WARNING**

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

Use care when moving pumps. Lifting equipment must be able to adequately support the entire assembly. Hoist bare pump using suitable slings under the suction flange and discharge flange (Fig. 4). Baseplate mounted units are provided with lifting points for use with proper lifting devices. Refer to (Fig.5&6) for examples of proper lifting procedures.

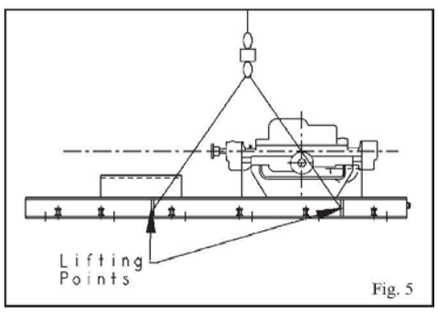


Fig. 5

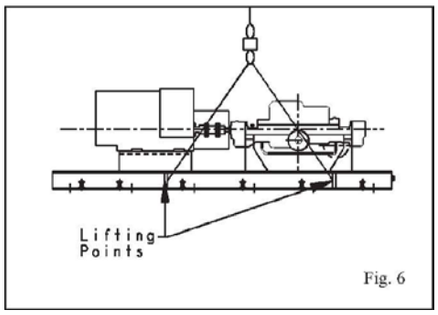


Fig. 6

# INSTALLATION



3

# SITE AND FOUNDATION

## GENERAL INFORMATION

Procedures for installation described in this section are general. More detailed procedures are described in various publications including API Recommended Practice 686/PIP (Process Industry Practices) REIE 686, "Recommended Practices for Machinery Installation and Installation Design." A pump should be located near the liquid supply and have adequate space for operation, maintenance, and inspection. Be sure to allow for crane or hoist service.

Baseplate mounted pumps are normally grouted on a concrete foundation which has been poured on a solid footing. The foundation must be able to absorb any vibration and to form a permanent, rigid support for the pumping unit.

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

The location and size of foundation bolts are shown on the outline assembly drawing provided with the pump data package.

Foundation bolts commonly used are sleeve type (Fig. 7) and J type. If using the sleeve type, the inside diameter of the sleeve should be 2 1/2 -3 times the bolt diameter. A washer should be placed between the bolt and the sleeve. Both foundation bolt types permit movement for final bolt adjustment.

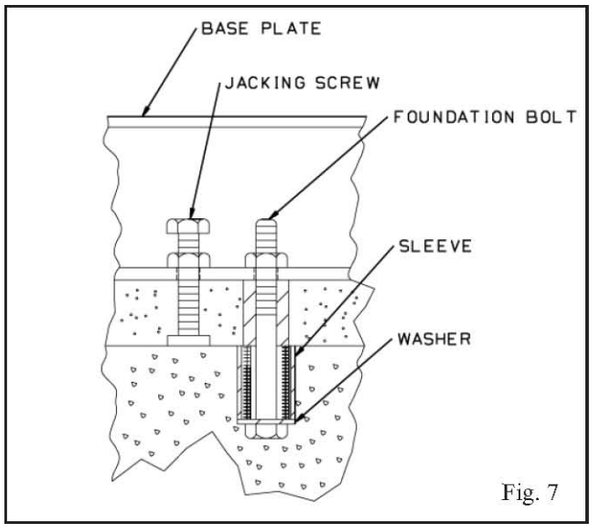


Fig. 7

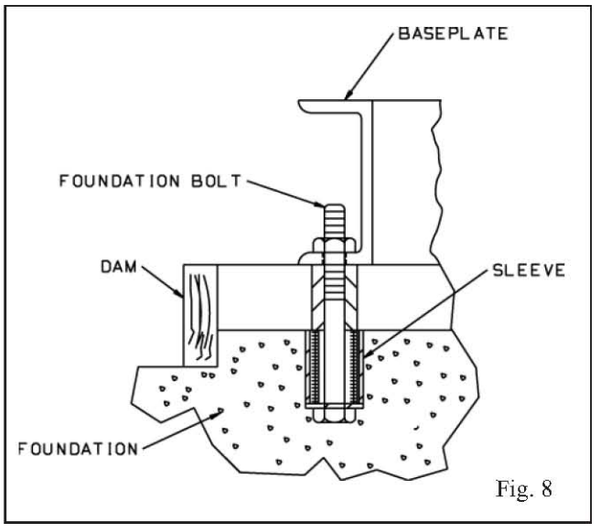


Fig. 8

# BASEPLATE INSTALLATION PROCEDURE

Industry standard procedures, such as API RP 686/ PIP REIE 686, and/or the following procedure should be followed prior to grouting the baseplate. The procedure assumes the installer has a basic knowledge of baseplate and foundation design and installation methods.

## BASEPLATE PREPARATION

1-Inspect all surfaces of baseplate that will contact grout for contamination (e.g. -rust, oil, grime, etc.).

1- Thoroughly clean all surfaces of the baseplate that will contact grout with a cleaner that will **not** leave **any** residue.

2-Inspect all machined surfaces for burrs, rust, paint or any other type of contamination. If necessary, use a honing stone to remove burrs.

3-Coat portions of leveling screws that will contact grout with a non-bonding (anti-seize) compound (such as paste wax) to facilitate their removal after grouting.

4-Thread nuts on foundation bolts and hand tighten.

## FOUNDATION PREPARATION

- Chip top of foundation a minimum of 25 mm) to remove porous or low strength concrete. If using a pneumatic hammer, assure that it is not contaminating the surface with oil, moisture, etc

**CAUTION**

***Do not use heavy tools such as jackhammers, as they could damage the structural integrity of the foundation.***

- Remove water and/or debris from foundation bolt holes/sleeves. If the sleeve type bolts are being used, fill the sleeves with nonbinding moldable material and seal to prevent grout from entering.
- Coat exposed portion of anchor bolts with a non-bonding compound (such as paste wax) to prevent grout from adhering to anchor bolts.
- If recommended by grout manufacturer, coat foundation surface with a compatible primer.

## SETTING AND LEVELING BASEPLATE

- Lower base onto foundation bolts. Base will rest on top of foundation on jackscrews provided on base (Figs. 9 & 10).
- Adjust leveling jack screws, located adjacent to the foundation bolt holes, until the baseplate rests 1-2 in. (25 -50 mm) above foundation to allow for adequate grouting. This will provide even support for the base once it is grouted.
- Level base to within .002 in./ft. (0.20 mm/m) of length or width of the base, respectively, by adjusting leveling screws. Maximum total variation from one end or side of the base to the other is .015 in. (0.38 mm).

Equipment mounting surfaces should be utilized to establish level.

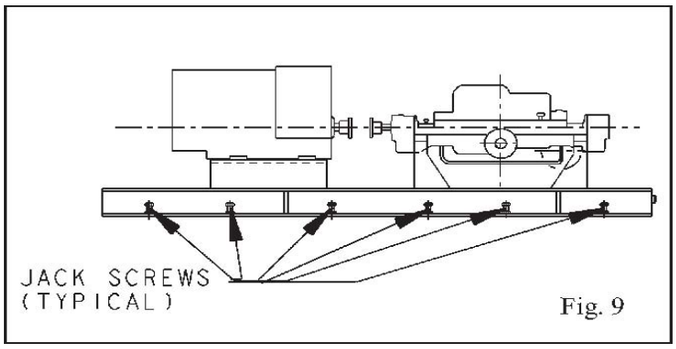
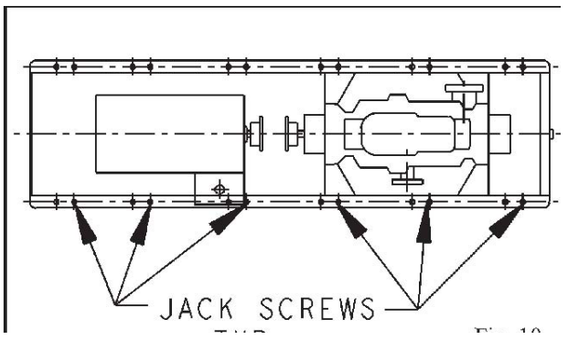


Fig. 9






# ALIGNMENT AND ALIGNMENT CRITERIA

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

## GENERAL CONSIDERATIONS

**WARNING**

***Before beginning any alignment procedure, make sure driver power is locked out. Failure to lock out driver power will result in serious physical injury.***

To remove coupling guard, refer to coupling guard installation and disassembly instructions in *Appendix II*.

**Initial Alignment (Cold Alignment)** is done prior to operation when the pump and the driver are at ambient temperatures.

1-Before Grouting Baseplate -To ensure alignment can be obtained.
2-After Grouting Baseplate -To ensure pipe strains haven't altered alignment. If changes have occurred, alter piping to remove pipe strains on pump flanges.

**Final Alignment (Hot Alignment)** is done after operation when the pump and driver are at operating temperatures.

• After First Run -To obtain correct alignment when both pump and driver are at operating temperature. Thereafter, alignment should be checked periodically in accordance with plant operating procedures.

***NOTE: Alignment check must be made if process temperature changes, piping changes, and/or pump service is performed.***

Alignment is achieved by adding or removing shims from under the driver and/or shifting driver horizontally as needed.

***NOTE: Proper alignment is the responsibility of the installer and user of the unit.***

Accurate alignment of the equipment must be attained. Trouble-free operation can be accomplished by achieving alignment within the levels specified in the following section.

Three common alignment methods are utilized:

1-Reverse Dial Indicator method is most common.
2-Laser method is similar to reverse dial indicator method, but uses a laser to obtain the necessary measurements.
3-Dial Indicator (rim-and-face) method.

Follow alignment equipment manufacturers' procedures when utilizing reverse dial indicator or laser methods. A detailed procedure for alignment using the dial indicator (rim-and-face) method is included as *Appendix III*.

## ALIGNMENT CRITERIA

Good alignment is attained when readings as specified in this section have been achieved with pump and driver at operating temperatures (final alignment).

Maximum allowable Total Indicator Reading (T.I.R.) for parallel and angular misalignment is .002 (0.05mm) for all Model TSMP pumps, regardless of the alignment method used.

# Pump-to-driver alignment

**Precautions**

**WARNING:**

- Follow shaft alignment procedures to prevent catastrophic failure of drive components or unintended contact of rotating parts. Follow the coupling manufacturer's coupling installation and operation procedures.
- ALWAYS lock out power to the driver before performing any installation or maintenance tasks. Failure to lock out driver power will result in serious physical injury.

**NOTICE:** Proper alignment is the responsibility of the installer and the user of the unit. You must check the alignment of frame-mounted units before the unit is operated. Failure to do so may result in equipment damage or decreased performance.

**Alignment methods**

Three common alignment methods are used:

- Dial indicator
- Reverse dial indicator
- Laser

Follow the equipment manufacturer's instructions when using the reverse dial indicator or laser methods. Detailed instructions for using the dial indicator method are contained in this section.

## Alignment checks

**When to perform alignment checks**

Alignment checks must be performed when the following occurs:

- The process temperature changes.
- The piping changes.
- The pump has been serviced.

| Types of alignment checks | Type of check |
|---|---|
| Initial alignment (cold alignment)check | Prior to operation when the pump and the driver are at ambient temperature. |
| Final alignment (hot alignment)check | After operation when the pump and the driver are at operating temperature. |

After grouting the baseplate This ensures that no changes have occurred during the grouting . After connecting the piping This ensures that pipe strains have not altered the alignment.

**Final alignment (hot alignment) checks**

After the first run This ensures correct alignment when both the pump and the driver are at operating temperature.

Periodically This follows the plant operating procedures.

## Indicator values for alignment checks

**NOTICE:** The specified perm reading values are valid at operating temperature only. For cold settings, other values are permTRUFLOed. You must use the correct tolerances. Failure to do so may result in misalignment and reduced pump reliability.

**IMPORTANT**

For electric motors, the motor shaft initial (cold) parallel vertical alignment setting should be 0.002 to 0.004 in. (0.05 to 0.10 mm) lower than the pump shaft.

For other drivers such as turbines and engines, follow the driver manufacturers' recommendations.

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

1-The total indicator runout is a maximum of 0.002 in. (0.05 mm) at operating temperature.
2-The tolerance of the indicator is 0.0005 in./in. (0.0127 mm/mm) of indicator separation at operating temperature.

## Alignment measurement guidelines

Rotate the pump coupling half and the driver's coupling half. This prevents incorrect measurement. together so that the indicator rods have contact with the same points on the driver's coupling half.

Move or shim only the driver to make adjustments. This prevents strain on the piping installations.

Ensure that the hold-down bolts for the driver's feet are tight. This prevents the driver from moving as when you take indicator measurements.

Ensure that the hold-down bolts for the driver's feet are loose This makes it possible to move the driver when correcting before you make alignment corrections.

Check the alignment again after any mechanical adjustments. This corrects any misalignments that an adjustment may have caused.

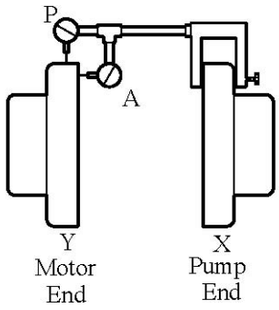
## Attach the dial indicators for alignment

You must have two dial indicators to complete this procedure.

1. Attach two dial indicators on the pump's coupling half:

a) Attach one indicator so that the indicator rod comes into contact with the perimeter of the driver's coupling half. This indicator is used to measure parallel misalignment.

b) Attach the other indicator so that the indicator rod comes into contact with the inner end of the driver's coupling half. This indicator is used to measure angular misalignment.




1 Rotate the pump's coupling half to check that the indicators are in contact with the driver's coupling half but do not bottom out.
2 Adjust the indicators if necessary.

## Pump-to-driver alignment instructions Perform angular alignment (vertical correction)

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

| If your reading value is... | Then... |
|---|---|
| negative | • raise the driver's feet at the shaft end (add shims), or<br>• lower the driver's feet at the other end (remove shims). |
| positive | • lower the driver's feet at the shaft end (remove shims), or<br>• raise the driver's feet at the other end (add shims). |

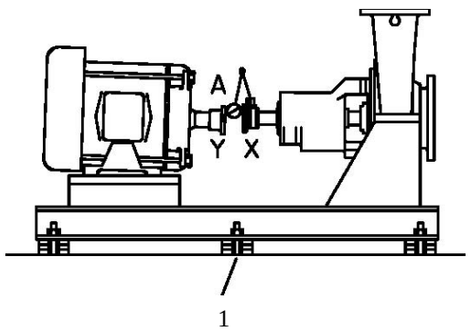



**Figure 5: Example of incorrect vertical alignment (side view)**

5. Repeat the previous steps until the correct reading value is achieved.

### Perform angular alignment (horizontal correction)

1. Set the angular alignment indicator to zero on left side of the driver's coupling half, 90° from the top-center position (9 o’clock).

2. Rotate the indicator through the top-center position to the right side, 180° from the start position (3 oClock)

3. Record the indicator reading.

| When the reading value is... | Then the coupling halves are... |
|---|---|
| negative | farther apart on the right side than the left. |
| positive | closer together on the right side than the left. |

4. Do as follows:

| If your reading value is... | Then slide... |
|---|---|
| negative | • the shaft end of the driver to the left, or<br>• the opposite end to the right. |
| positive | • the shaft end of the driver to the right, or<br>• the opposite end to the left. |

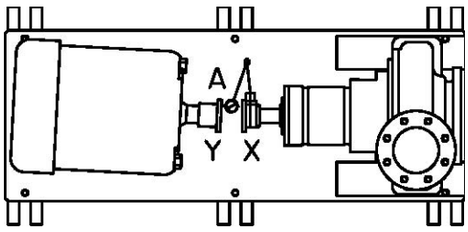



**Figure 6: Example of incorrect horizontal alignment (top view)**

5. Repeat the previous steps until the corrected reading value is achieved.

## Perform parallel alignment (vertical correction)

Before you start this procedure, make sure that the dial indicators are correctly set up. A unit is in parallel alignment when indicator P (parallel indicator) does not vary by more than 0.002 in. (0.05 mm) as measured at four points 90° apart at the operating temperature.

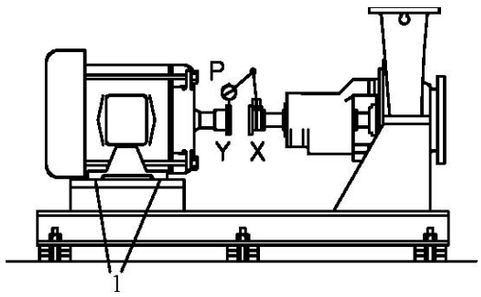
1 Set the parallel alignment indicator to zero at the top-center position (12 o’clock) of the driver's coupling half.
2 Rotate the indicator to the bottom-center position (6 o’clock).
3 Record the indicator reading.

| When the reading value is... | Then the pump's coupling half is... |
|---|---|
| negative positive | lower than the driver's coupling half. |
| | higher than the driver's coupling half. |

4. Do as follows:

| If the reading value is.. | Then... |
|---|---|
| negative | remove shims of a thickness equal to half of the indicator reading value under each driver's foot. |
| positive | add shims of a thickness equal to half of the indicator reading value to each driver's foot. |

**NOTICE:** You must use an equal amount of shims with each driver foot to prevent misalignment. Failure to do so may result in equipment damage or decreased performance.




1. Shims

**Figure 7: Example of incorrect vertical alignment (side view)**

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

## Perform parallel alignment (horizontal correction)

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

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

| When the reading value is... | Then the driver's coupling half is... |
|---|---|
| negative | to the left of the pump's coupling half. |
| positive | to the right of the pump's coupling half. |

4. Do as follows:

| If your reading value is... | Then... |
|---|---|
| negative or positive | slide the driver carefully in the appropriate direction. |

**NOTICE:** Make sure to slide the driver evenly. Failure to do so may negatively affect horizontal angular correction.

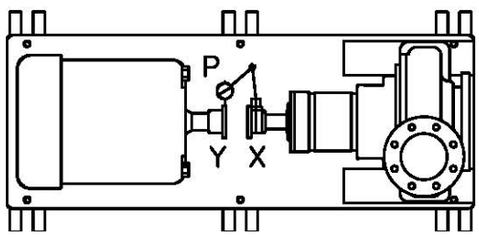



**Figure 8: Example of incorrect horizontal alignment (top view)**

5. Repeat the previous steps until the corrected reading value is achieved.

## Perform complete alignment (vertical correction)

A unit is in complete alignment when both indicators A (angular) and P (parallel) do not vary by more than 0.002 in. (0.05 mm) as measured at four points 90° apart.

1 Set the two dial indicators (angular and parallel) to zero at the top-center position (12 o'clock) of the driver's coupling half.
2 Rotate the indicators to the bottom-center position (6 o'clock).
3 Record the indicator readings.
4 Make corrections according to the separate instructions for angular and parallel alignment until the corrected reading values are obtained.

**Perform complete alignment (horizontal correction)**

A unit is in complete alignment when both indicators A (angular) and P (parallel) do not vary by more than 0.002 in. (0.05 mm) as measured at four points 90° apart.

1 Set the two dial indicators (angular and parallel) to zero at the left side of the driver's coupling half (9 o'clock), 90° from the top-center position.
2 Rotate the indicators through the top-center position to the right side (3 o'clock), 180° from the start position.
3 Record the indicator readings.
4 Make corrections according to the separate instructions for angular and parallel alignment until the TRUFLO permitted reading values are obtained.

# ALIGNMENT TROUBLESHOOTING

| Problem | Probable Cause | Remedy |
|---|---|---|
| Cannot obtain horizontal (Side-to-Side) | Driver feet bolt bound. | Loosen pump hold down bolts and slide pump and driver until horizontal alignment is achieved. |
| alignment, angular or parallel | Baseplate not leveled properly, probably twisted. | Determine which corner(s) of the baseplate are high or low and adjust leveling screws at the appropriate corner(s) and realign. |
| Cannot obtain vertical (Top-to-Bottom) alignment, angular or parallel | Baseplate not leveled properly, probably bowed. | Determine if center of baseplate should be raised or lowered and correct by adjusting leveling screws equally at the center of the baseplate. |

| Maximum Allowable Parallel and Angular Misalignment | | |
|---|---|---|
| **Size** | **Maximum Allowable Misalignment** | |
| | **Parallel** | **Angular** |
| **All** | 0.05 mm (.002 in.) | 0.03 degrees [0.125 mm/cm (.0005 in. /in.) of coupling face diameter] |

***NOTE For electric motors, motor shaft initial (cold)***

***(0.05 -0.10 mm) lower than pump shaft, since thermal expansion will cause the motor shaft on foot mounted motors to "grow" up to the pump shaft centerline.***
***NOTE B: For other drivers (turbines, engines, etc.), follow driver manufacturers' recommendations.***

# BASEPLATE GROUTING PROCEDURE

## GENERAL PROCEDURE

Use of non-shrink epoxy grout is best.

***NOTE: Grout manufacturer's instructions should be consulted and followed.***

The following are general procedures for grouting baseplates. Additional information may be found in API Standard 610, 8th Edition, Appendix L, API RP 686, Chapter 5, and other industry standards.

Baseplate Installation Procedure should be followed prior to grouting baseplate.

1-Build form around foundation to level of bottom of baseplate (Fig. 8).

2-Pour grout through grout hole in baseplate, up to level of dam. Remove air bubbles from grout puddling or by pumping the grout into place (Fig. 11).
3-Strike along top of dam with trowel to give a neat appearance.
4-Allow grout to set.
5-Fill remainder of baseplate with grout, removing air as in Step 2 above (Fig. 12).
6-Allow grout to set at least 48 hours. Leveling screws should be removed when grout has hardened.
7-Tighten foundation bolts.

## ALIGNMENT CHECK

Re-check alignment before continuing, using criteria previously stated.

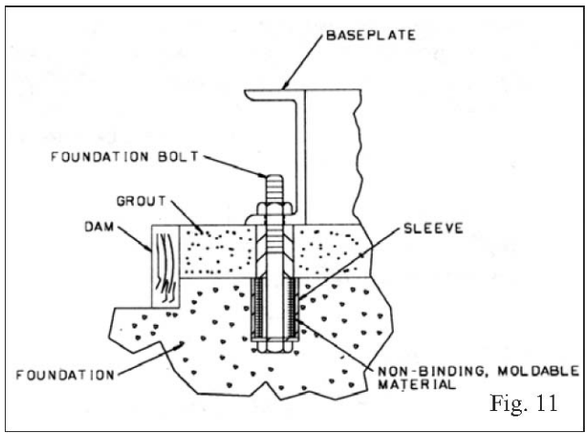


Fig. 11

# PIPING

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

Hydraulic Institute 30200
Detroit Road Cleveland,
OH 44145-1967

and in API RP 686, and must be reviewed prior to pump installation.

**WARNING**

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

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

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

**Table 2 Piping Flange Alignment**

| Type | Criteria |
|---|---|
| Axial | Flange gasket thickness ± 0.8 mm (.03 in.). |
| Parallel | 0.001 mm/mm (.001 in./in.) of flange diameter to a maximum of 0.8 mm (.03 in.). |
| Concentric | Flange bolts should easily install by hand. |

6-Piping must not be connected to the pump until the grout has thoroughly hardened and the foundation bolts, as well as driver and pump hold down bolts, have been tightened.

## SUCTION PIPING

**CAUTION**

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

1-Use of elbows close to the pump suction flange should be avoided. There should be a minimum of two (2) pipe diameters of straight pipe [five (5) pipe diameters is preferred] between the elbow and suction inlet. Where used, elbows should be long radius.
2-Use suction pipe one (1) or two (2) sizes larger than the pump suction, with a reducer at the suction flange. Suction piping should never be of smaller diameter than the pump suction.
3-Reducers, if used, should be eccentric and located at the pump suction flange with sloping side down.

**CAUTION**

***Pump must never be throttled on suction side.***

1-A suction screen should be installed prior to initial start-up and when suction system has been opened for work. The screen should be of the cone type with a net area equal to at least three (3) times the cross sectional area of the suction pipe. The mesh of the screen should be sized to prevent particles larger than 1.6 mm (1/16 in.) from entering the pump and should be installed in a spool piece to allow removal for cleaning. The screen should remain in the system until periodic inspection shows system is clean.
2-Separate suction lines are recommended when more than one pump is operating from the same source of supply.

**Suction Lift Conditions**

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

**Suction Head/Flooded Suction Conditions**

1-An isolation valve should be installed in the suction line at least two (2) pipe diameters from the pump suction to permit closing of the line for pump inspection and maintenance.
2-Keep suction pipe free from air pockets.
3-Piping should be level or slope gradually downward from the source of supply.
4-No portion of the piping should extend below pump suction flange.
5-The size of entrance from supply should be one (1) or two (2) sizes larger than the suction pipe.
6-The suction pipe must be adequately submerged below the liquid surface to prevent vortices and air entrainment at the supply.

## DISCHARGE PIPING

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

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

## BYPASS PIPING

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

A minimum flow orifice can be sized and installed in bypass line to preclude bypassing excessive flows. Consult nearest sales office or factory for assistance in sizing orifice.
An automatic recirculation control valve and/or solenoid operated valve should be considered if a constant bypass is not possible.

## AUXILIARY PIPING

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

Cooling systems such as those for bearing lubrication, mechanical seals, etc., where provided, must be operating properly to prevent excess heat generation, sparks and premature failure.

Sealing systems that are not self purging or self venting, such as plan 23, require manual venting prior to operation. Failure to do so will result in excess heat generation and seal failure.

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

If bearing cooling and/or seal chamber cover cooling is required, follow guidelines listed below.

- Flows of 4 l/min. (1 GPM) will generally satisfy cooling requirements for each component. If both bearing and seal chamber cover cooling are provided, a minimum flow of 8 l/min. (2 GPM) will be necessary.
- Cooling water pressure should not exceed 7.0kg/cm (100PSI)

## FINAL PIPING CHECK

After connecting the piping to pump:

Rotate shaft by hand to ensure it rotates smoothly and there is no rubbing which could lead to excess heat generation and or sparks.

Check alignment, per alignment criteria outlined previously, to determine if pipe strain has affected alignment. If pipe strain exists, correct piping.

# OPERATION





# PREPARATION FOR START-UP

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

## CHECKING ROTATION

***NOTE: Pump is shipped with coupling spacer removed.***

1. Lock out power to driver. Remove coupling spacer if installed.

2. Make sure coupling hub is securely fastened to the driver shaft. (This is a good time to check pump hub also.)
3. Unlock driver power.

**WARNING**

***Do NOT jog a coupled pump.***

1 Make sure everyone is clear. Jog driver just long enough to determine direction of rotation. Rotation must correspond to arrow on bearing housing.
2 Lock out power to driver before proceeding with coupling spacer installation.

## COUPLING PUMP AND DRIVER

**WARNING**

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

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

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

Motors with sleeve bearings may be manufactured with ¼ or ½ inch end movement (float) in the motor rotor. For limited end-float arrangement, the gap between the coupling halves must be set in a different manner. If specific directions are not indicated in the motor instructions, the following is applicable.

***NOTE: If the driver is mounted at Truflo, the setting for the coupling will already have been determined.***

1-Slide the rotor towards the outboard end of the motor as far as it will go and mark the shaft at the motor frame (Fig. 13).
2-Slide the motor rotor towards the inboard end of the motor as far as it will go and mark the shaft again. The distance between marks should be either ½ or ¼ inch if the motor is arranged for limited end-float travel.
3-Scribe a third mark on the shaft half way between scribe marks made in (a.) and (b.) above.
4-Clamp the rotor in place.
5-Move the motor as a unit towards the pump until the end of the motor shaft is the correct coupling "spacer" distance from pump shaft.

1-Install and lubricate coupling per manufacturer's instructions.
2-Check angular and parallel alignment of coupling halves using a dial indicator and a feeler gauge. See *Alignment and Alignment Criteria* in *Operation* Section.

4. Install coupling guard. Refer to coupling guard installation instructions in *Appendix II*.

**WARNING**

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

## LUBRICATING BEARINGS

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

**Ring Oil Lubrication**

Ring oil lubricated ball bearings are standard on Model TSMP units. Sleeve/ball bearings are optional. Bearing housings are supplied with constant level oilers and sight glasses.

**CAUTION**

***The bearings are NOT lubricated at the factory. (See Maintenance of Bearings in*** Preventive Maintenance ***Section.)***

Assure that oil rings are properly located as described in *Disassembly & Reassembly* section.

***NOTE: See Preventive Maintenance section for lubrication recommendations.***

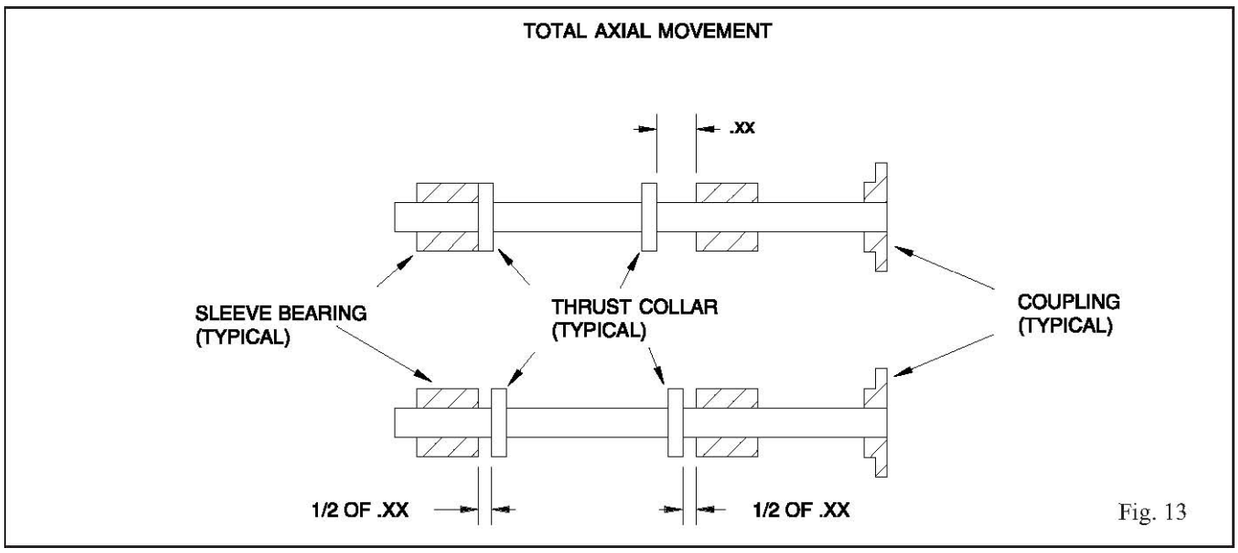


Fig. 13

**Pure or Purge Oil Mist Lubrication**

Pure or purge oil mist are optional features for the Model TSMP pump. Follow oil mist generator manufacturer's instructions. The inlet and drain connections (drain connection required for pure mist only) are located on the top and bottom, of the bearing housing. (See *Appendix I* for conversion from ring oil bearings to purge or pure mist bearings.)

***NOTE: See* Preventive Maintenance *section for lubrication recommendations.***

## SHAFT SEALING

**Mechanical Seal Option**

Pumps may be shipped with or without mechanical seals installed. The seal used with this model is the cartridge type. Cartridge seals are preset at the seal manufacturer's facility and require no field settings. Cartridge seals installed by the user require disengagement of the holding clips prior to operation, allowing the seal to slide into place. If the seal has been installed in the pump by Truflo, these clips have already been disengaged. For other types of mechanical seals, refer to the seal manufacturer's instructions for installation and setting.

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

***Cooling systems such as those for bearing lubrication, mechanical seal systems, etc., where provided, must be operating properly to prevent excess heat generation, sparks and premature failure.***

***Sealing systems that are not self purging or self venting, such as plan 23, require manual venting prior to operation. Failure to do so will result in excess heat generation and seal failure.***

**Connection of Sealing Liquid**

For satisfactory operation, there must be a liquid film between seal faces to lubricate them. Refer to seal manufacturer's drawing for location of taps. Some methods which may be used to flush/cool the seal are:

- Product Flushing -In this arrangement, the pumped fluid is piped from the casing (and cooled in an external heat exchanger when required) then injected into seal chamber.
- External Flush -A clean, cool compatible liquid is injected from an outside source directly into seal chamber. Flushing liquid must be at a pressure 20 to 25 psi (1.4-1.76 kg/cm) greater than seal chamber pressure. Injection rate should generally be 2 GPM (8 LPM) although the mechanical seal instructions indicate proper amounts for given applications.
- Other methods may be used which make use of multiple gland connections. Refer to documentation supplied with the pump, mechanical seal reference drawing, and piping diagrams.

4

## PRIMING PUMP

***Pumps must be fully primed at all times during operation.***

Figure 14 shows the supply above the pump suction.

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

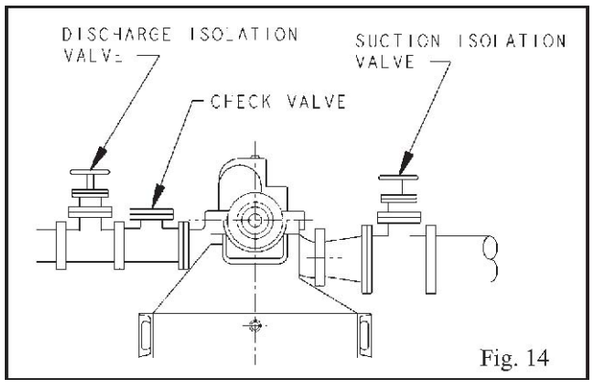


Fig. 14

**CAUTION**

***Ensure that pump and systems are free of foreign objects before operating and that objects cannot enter the pump during operation. Foreign objects in the pumped fluid or piping system can cause blockage of flow which can result in excess heat generation, sparks and premature failure.***

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

1-All equipment and personal safety related devices and controls must be installed and operating properly.
2-To prevent premature pump failure at initial start-up due to dirt or debris in the pipe system, operate the pump continuously at full speed and flow for 2 to 3 hours with suction strainers installed.
3-Variable speed drivers should be brought to rated speed as quickly as possible.
4-Variable speed drivers should not be adjusted or checked for speed governor or overspeed trip settings while coupled to the pump at initial start-up. If settings have not been verified, uncouple the unit and refer to driver manufacturer's instructions

1 Running a new or rebuilt pump at slow speeds may not provide enough flow to adequately flush and cool the wear ring and throat bushing close running surfaces.
2 Pumped fluid temperatures in excess of 200°F (93°C) will require warm-up of pump prior to operation. Circulate a small amount of pumped fluid (typically through the casing drain connections on the TSMP) until the casing temperature at all points monitored is within 50°F to 75°F of pumped fluid temperature. As a guideline, warm up the pump at a rate of 50°F per hour. Average warming stream rates are based on observations at various operating sites and are indicated in *Table 2* for reference only.

**Table 2**

| Pump Discharge Nozzle Size | Operating Temperature vs. Warming Stream Flow Rate (GPM) per Pump 200°F 400°F | |
|---|---|---|
| 3 | 3 | 4 |
| 4-6 | 4 | 5 |

# STARTING PUMP
# Operation

1-Make sure suction valves and any recirculation valves are open.
4. Slowly open discharge valve until the desired flow cooling lines are open. is obtained.
2-Fully close or partially open discharge valve as dictated by system conditions.
3-Start driver.

**CAUTION**

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

**CAUTION**

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

# OPERATION

## GENERAL CONSIDERATIONS AND REVIEWS

### CAUTION

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

***Driver may overload if the pumped fluid specific gravity is greater than orig***

### CAUTION

***The following are minimum operational checks for the pump only. Consult driver and auxiliary equipment manufacturers' literature for additional information.***

- For ball bearings and sleeve radial/ball thrust bearing check oiler to insure proper level.

***Always operate the pump at or near the rated prevent damage resulting from cavitations or recirculation.***

For Fig 15, 113B Oil Ring Inspection Plugs --→ 5C Oil Cap, ; 251 Oiler Bottle --→ 5G Oiler, ; 319 Sight Glass --→ Sight Glass (No number)



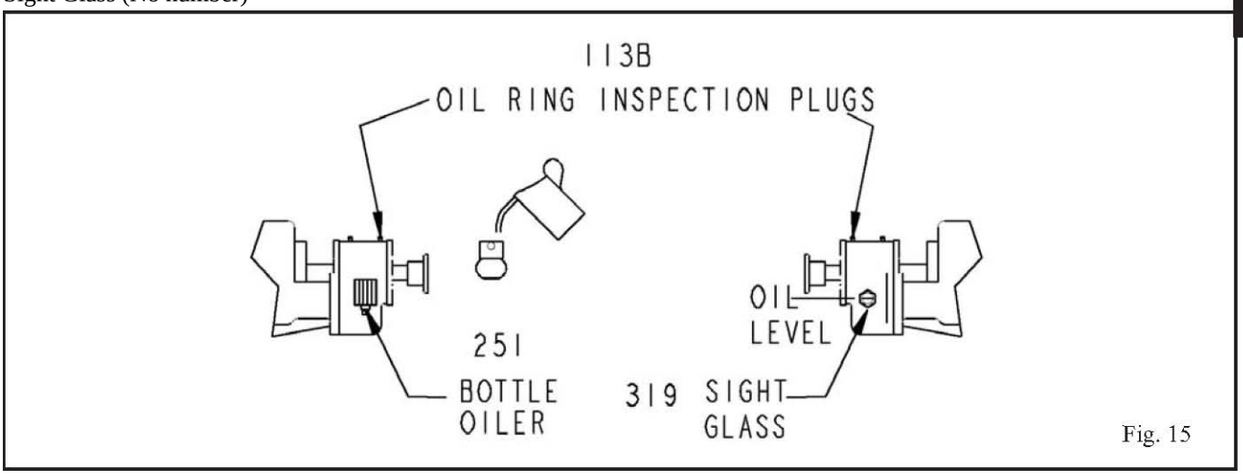



Fig. 15

## OPERATING AT REDUCED CAPACITY

1- Check bearing temperatures using a pyrometer or other accurate temperature measuring device. Monitor bearing temperature frequently during initial operation to determine if a bearing problem exists as well as to establish normal bearing operating temperature.
2- On units equipped with auxiliary piping, assure that proper flows have been established and that equipment is operating properly.
3- Baseline vibration readings should be established to determine normal running conditions. If it is determined that the unit is running rough, consult factory.
4- Monitor all gauges to ensure pump is running at or near rating and that suction screen (when used) is not clogged.

### CAUTION

Damage occurs from:

1- Increased vibration levels -Affects bearings, seal chambers/stuffing boxes, and mechanical seals.

2-Increased radial load -Stresses on shaft and bearings.

3-Heat build up -Vaporization causing rotating parts to score or seize.

4. Cavitation -Damage to internal surfaces of pump.

# OPERATING UNDER FREEZING CONDITIONS

Exposure to freezing conditions while pump is idle could cause liquid to freeze and damage the pump.

Fluid inside pump, if supplied, should also be drained.

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

# SHUTDOWN

# FINAL ALIGNMENT

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

1-Run the unit in actual operating conditions for a sufficient length of time to bring the pump, driver, and associated systems to operating temperature.
2-Shut down the pump and lock out driver.
3-Remove coupling guard. Refer to coupling guard installation and disassembly instructions in *Appendix II*.
4-Check alignment while unit is still hot per alignment criteria in the *Installation* section.
5-Reinstall coupling guard. Refer to coupling guard installation and disassembly instructions in *Appendix II*.
6-Unlock driver power.

# DOWELING PUMP CASING

The pump casing must be doweled to the base plate pedestals to positively maintain position. Two (2) separate methods are used by Truflo, depending on whether the pump is used in a cold application or a hot application (see below).

| Model | Stage Length | Temperature | |
|---|---|---|---|
| | | °F | °C |
| | 4 | N/R | N/R |
| | 5 | N/R | N/R |
| | 6 | 375 | 190 |
| | 7 | 350 | 180 |
| | 8 | 325 | 160 |
| TSMP | 9 | 300 | 150 |
| | 10 | 275 | 135 |
| | 11 | 275 | 135 |
| | 12 | 250 | 120 |
| | 13 | 250 | 120 |
| | 14 | 250 | 120 |

When the driver is mounted at the factory, the pump is doweled for both cold and hot applications. The driver is not doweled to allow for final field alignment. When the driver is mounted in the field, the pump is not doweled. Therefore, the following procedure, typically done at the Truflo manufacturing factory, must be done in the field.

## MOTOR INSTALLATION

1. Center the pump on its pedestal such that the hold down bolts is centered in the tapped holes of the pump pedestal.
2. Place the motor on the base plate with the proper shaft separation (DBASE = Distance Between Shaft Ends).
3. Tighten down on the pump hold down bolts.
4. After correct motor location has been determined on the motor pedestals, transfer the location of the motor onto the pedestals by hole punching the motor pedestal through the hold down bolt holes in the motor feet.
5. Remove the motor, then drill and tap the punched holes on the motor pedestal.
6. Set the motor back onto the baseplate with the shims in the correct location. Tighten hold down bolts.
7. Loosen the pump and motor hold down bolts. Confirm that the pump and motor are not bolt-bound. This step assures that the final drilled holes will be correctly located.

***NOTE: Scribe the motor shims in order to return them to the correct location on the motor pedestal.***

***NOTE: Pump is not doweled prior to this time because the pump cannot be moved on its pedestals after it has been doweled.***

## COLD SERVICE APPLICATION

***NOTE: This procedure must be done only after the pump is properly aligned with the driver on the baseplate.***

1. Drill two (2) holes, using a 21/64 in. or "Q" size drill through the pump foot and pump pedestal. Position the hole between the hold down bolt and the end of the pump foot at the coupling end on both sides.

**CAUTION**

***If water cooled pedestals have been provided do NOT drill through the baseplate pedestal or leakage of cooling water will occur.***

2. Ream the holes with a Number 7 taper pin reamer to the proper fit with the taper dowel pins. Pins should insert to a depth that leaves only the threaded portion exposed when fully seated.
3. Seat taper pins firmly in holes with hardwood block or soft faced hammer.

Should it become necessary to remove the dowel pins, tighten the hex nuts provided on the pins. If the pins are not seated deeply enough, a spacer under the hex nut may be required to lift the pins free when the hex nut is tightened.

## HOT SERVICE APPLICATION

**Refer to Fig. 16 for Steps 1 through 5.**

- Remove the hold-down bolts from the pump feet furthest from the coupling.
- Scribe a mark mid-way between the end of the pump foot and the hold down bolt whole centerline, parallel with the pump axis.
- Re-torque the hold down bolt between the pump foot and the pump pedestal.
- The pump foot and the outside of the pedestal will not be flush. Mill or grind a spot on the pump pedestal to make it flush with the pump foot.
- Drill and ream for a 1.00 inch dowel pin, keeping the pin flush with the pump foot.

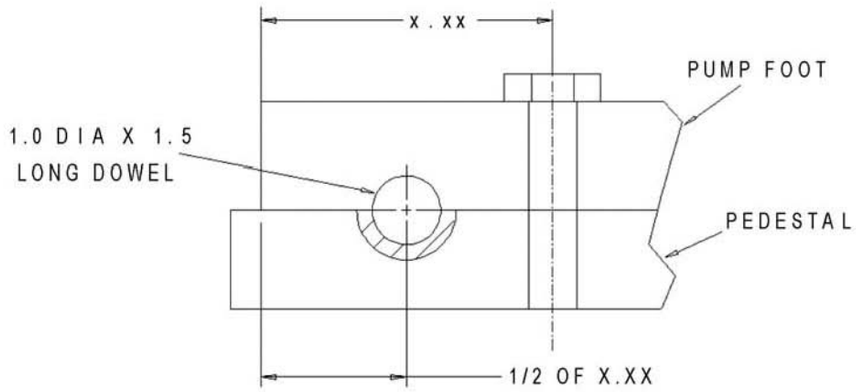



Fig. 16

# PREVENTIVE MAINTENANCE



## GENERAL COMMENTS



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

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

## MAINTENANCE SCHEDULE

### ROUTINE MAINTENANCE

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

### ROUTINE INSPECTIONS

Check for unusual noise, vibration and bearing temperatures.
Inspect pump and piping for leaks.
Verify there is no seal chamber leakage.

### QUARTERLY INSPECTIONS

Check foundation and hold down bolts for tightness.
If pump has packing and has been left idle, check packing. Replace if required.
Oil should be changed at least every 3 months, 2000 Hours or more often if there are any adverse atmospheric conditions or other conditions which might contaminate or break down the oil. Oil should also be changed if it is cloudy or contaminated.

- Check shaft alignment and realign if required.

### ANNUAL INSPECTIONS

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

***Inspection intervals should be shortened appropriately if the pumped fluid is abrasive and/or corrosive, or if the environment is classified as potentially explosive.***

# MAINTENANCE OF BEARINGS

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

## RING OIL LUBRICATED BEARINGS

Ring oil lubricated ball bearings are standard on Model TSMP pumps.

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

Bearing temperatures are generally about 20°F (11°C) higher than the bearing housing outer surface temperature.

Some acceptable oils are:

| | |
|---|---|
| Exxon | Teresstic EP 68 |
| Mobil | Mobil DTE 26 300 SSU @ 100°F (38°C) |
| Sunoco | Sunvis 968 |
| Royal Purple | SYNFILM ISO VG 68 Synthetic Lube |

The oil reservoir in the bearing housing should be filled by filling the oiler bottle with oil and placing it into the oiler housing. Several fillings of the oiler bottle will be required. Do not fill bearing housing oil reservoir through the vent or through the oiler housing without using the bottle.

Oil capacities and oiler information for the various TSMP bearing housings are shown in *Table 4*.

Oil should be changed after 200 hours if bearings are new. Thereafter, change oil every 2000 operating hours or 3 months, whichever first occurs.

Ring oil lubricated pumps are supplied with an oiler which maintains a constant oil level in the bearing housing. The oiler must be adjusted to “0" setting to maintain the oil level in the middle of the sight glass. This is accomplished by either removing the oiler adjusting stem, or screwing it down to the bottom. Refer to Fig. 18 and *Table 3* for proper setting dimensions.

***NOTE: Setting dimension (A) of 0 will be accomplished by removing and discarding the oiler adjusting stem.***

**Table 4 Bearing Housing Oil Capacities**

| Size | Bearing Housing Capacity | | Trico Oiler No. | Oiler Capacity | | |
|---|---|---|---|---|---|---|
| | Ounces | | | Milliliters | Ounces | Milliliters |
| | | | | | | |
| | | | | | | |

## PURE OR PURGE OIL MIST LUBRICATED BEARINGS (OPTIONAL)

***NOTE: Oil mist is recommended for use on ball bearing arrangements only*** **(See Appendix I).**

The same oil requirements applicable to ring oil lubricated bearings also apply to oil mist lubricated bearings.

The steps necessary for oil mist lubrication are as follows:

1 Follow oil mist system supplier's instructions.
2 Connect oil mist supply lines to oil ring inspection plug connections (Fig. 19) (Note that only one of the two connection ports in the radial bearing housing is used [immediately above the single row radial bearing] while both connections on the thrust housing must be connected since there are two rows of bearings.)
3 For pure oil mist, connect drain lines to outlet connections (not required for purge oil mist).

# MAINTENANCE OF SHAFT SEALS

## MECHANICAL SEALS

When mechanical seals are furnished, a manufacturer's reference drawing is supplied with the data package. This drawing should be kept for future use when performing maintenance and adjusting the seal. The seal drawing will also specify required flush liquid and attachment points. The seal and all flush piping must be checked and installed as needed prior to starting the pump.

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

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

***Cooling systems such as those for bearing lubrication, mechanical seal systems, etc., where provided must be operating properly to prevent excess heat generation, sparks, and premature failure.***

***Sealing systems that are not self purging or self venting, such as plan 23, require manual venting prior to operation. Failure to do so will result in excess heat generation and seal failure.***

***NOTE: The standard TSMP is supplied with seal chambers designed for cartridge mechanical seals.***

**WARNING**

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

# TROUBLESHOOTING

| Issue | Probable Cause | Remedy |
|---|---|---|
| | • Pump not primed. | Check that pump and suction line are full of liquid. Reprime pump. |
| | • Suction line clogged/not filled with liquid | Remove obstructions/fill line. |
| | • Impeller clogged with foreign material. | Back flush pump to clean impeller. |
| No liquid delivered | • Foot valve or suction pipe opening not sufficiently submerged. | Consult factory for proper depth. Use baffle to eliminate vortices. |
| | • Suction lift too high. | Reduce suction lift. |
| | • Wrong rotation direction. | Provide correct rotation |
| | • Air or vapor pocket in suction line. | Vent suction line. |
| | • Available NPSH not sufficient. | Increase available NPSH. |
| | • Pump not up to rated speed. | Increase speed. |
| | • System head too high. | Decrease system resistance. |
| | • Air leak thru gasket. | Replace gasket. |
| | • Air leak thru seal chamber | Replace or readjust packing/mechanical seal. |
| | • Impeller partly clogged. | Back flush pump to clean impeller. |
| | • Worn wearing rings. | Replace defective part as required. |
| Pump not producing rated flow or head. | • Insufficient suction head. | Ensure that suction line shutoff valve is fully open and line is unobstructed and filled with liquid. Vent line of vapor or air pockets. Increase suction head. |
| | • Worn or broken impeller. | Inspect and replace if necessary. |
| | • Wrong direction of rotation. | Change rotation to concur with direction indicated by arrow on bearing frame. |
| | • Available NPSH not sufficient. | Increase available NPSH. |
| | • Pump not up to rated speed. | Increase speed. |
| | • Improperly primed pump. | Reprime pump and maintain full suction line. |
| | • Air or vapor pockets in suction line. | Rearrange piping to eliminate air pockets. |
| Pump starts then stops | • Air leak in suction line or seal chamber. | Repair (plug) leak. |
| pumping | • Air or vapor in liquid. | Deareate liquid, maintain pressure to prevent vaporization. |
| | • Available NPSH not sufficient. | Increase available NPSH. |
| | • Improper alignment. | Re-align pump and driver. |
| Bearings run hot | • Improper lubrication. | Check lubricant for suitability, quantity, quality, and pressure. Remove dirt and moisture from oil and bearings. |
| | • Insufficient cooling liquid. | Check cooling system, clean oil cooler. |
| | • Bearings too tight. | Replace bearings. |
| | • Excessive vibration | Correct cause of vibration. |

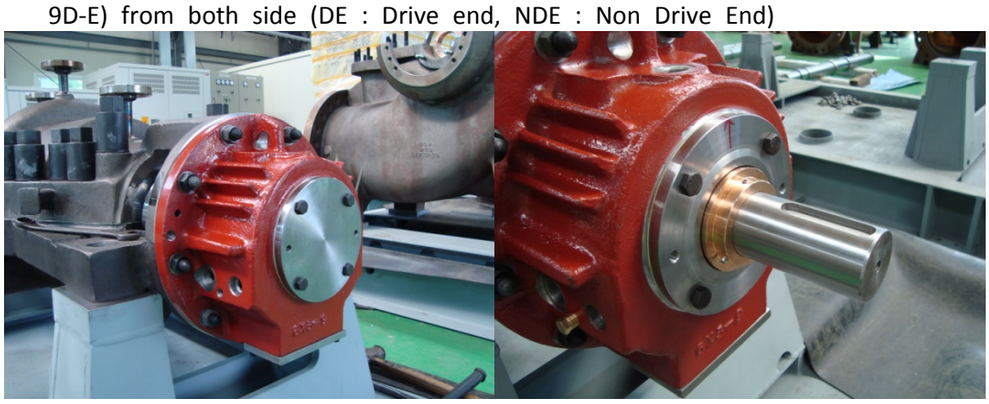
# TROUBLESHOOTING

| Problem | Probable Cause | Remedy |
|---|---|---|
| | • Improper pump/driver alignment. | Align shafts, recheck piping stability. |
| | • Partly clogged impeller causing imbalance. | Backflush pump to clean impeller, remove rotating element to inspect if necessary. |
| | • Broken or bent impeller or shaft. | Replace as required. |
| | • Impeller out of balance. | Balance impeller. |
| | • Foundation not rigid. | Assure uniform contact of pump and/or supports with foundation, confirm bolts are tight. |
| Pump is noisy or vibrates | • Worn bearings. | Replace. |
| | • Suction or discharge piping not anchored or properly supported. | Anchor per Hydraulic Institute Standards recommendations. Check to API Appendix or Piping Loads. |
| | • Pump is cavitating. | Locate and correct system problem. |
| | • Loosen driver or pump hold down bolts | Tighten bolts, check level and alignment, and correct, as required. |
| | • Vibration transmitted from drive to pump | Disconnect coupling and run driver at full speed. If driver vibrates, follow its manufacturer's instructions for corrective action. |
| | | |
| | • Worn mechanical seal parts. | Replace worn parts. |
| Excessive leakage from stuffing box | • Overheating mechanical seal. | Check lubrication and cooling lines. |
| | | |
| | • Shaft sleeve scored. | Remachine or replace as required. |
| | • Head lower than rating. Pumps too much liquid. | Consult factory. Install throttle valve. Cut impeller. Confirm system head curve. |
| | • Liquid heavier than expected. | Check specific gravity and viscosity. |
| Motor requires excessive power | • Rotating parts bind. | Check internal wearing parts for proper clearances. |
| | • Speed too high. | Reduce speed. |
| | • Misalignment. | Align shafts. |
| | • Shaft bent. | Correct or replace shaft. |
| | • Misalignment | Re-align pump and driver. |
| | • Shaft bent. | Correct or replace shaft. |
| | • Vibration | Correct cause of vibration. |
| | • Excessive thrust resulting from mechanical failure or wear inside pump. | Check cause of excessive thrust and reduce. |
| Bearings wear rapidly | • Improper lubrication. | Check lubricant for suitability, quantity, quality and pressure. Remove dirt and moisture from oil and bearings. |
| | • Bearings installed improperly. | Re-install bearings confirming correct dimension. |
| | • Excessive cooling system, monitor temperature to | Check cooling system, monitor temperature to |

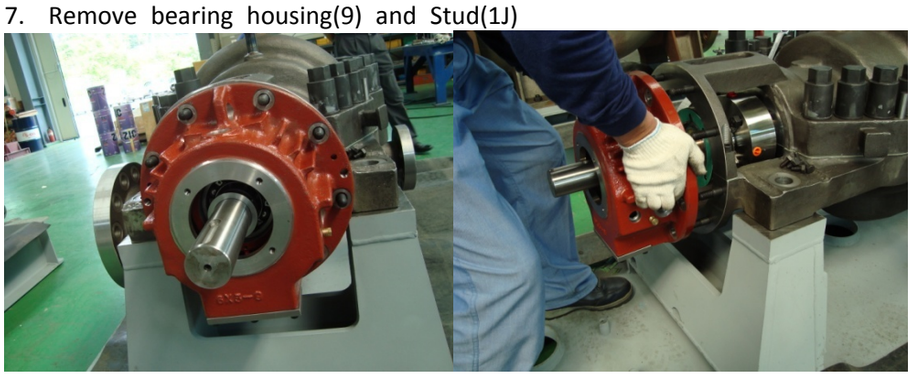
# DISASSEMBLY & REASSEMBLY

## Disassemble / Assemble

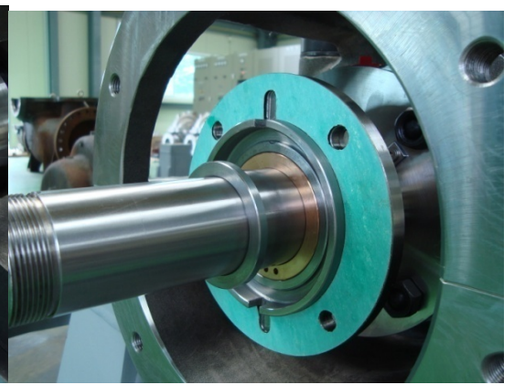
1. Unbolt hexbolt(9A) and remove bearing housing cover(9G-D/N) and bearing housing cover gasket( 9D-E) from both side (DE : Drive end, NDE : Non Drive End)



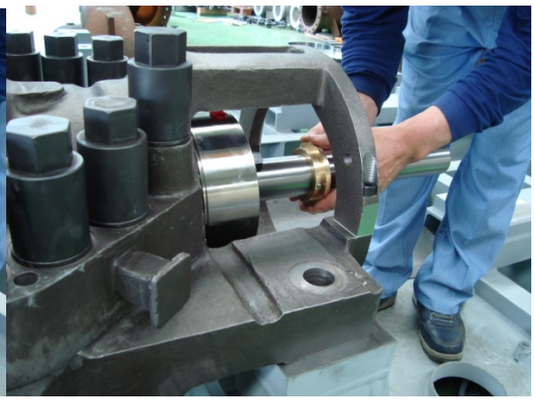
2. For DE side, untighten set screw on deflector (6H2) and then remove deflector before step 1.
3. Remove bearing housing cover from bearing h ousing (9)
4. Remove oiler(5A) from the bearing housing
5. Unbolt hextbolt(9A) from bearing housing cover(9G-D/N)
6. Remove nut from stud(casing) (1J)
7. Remove bearing housing(9) and Stud(1J)



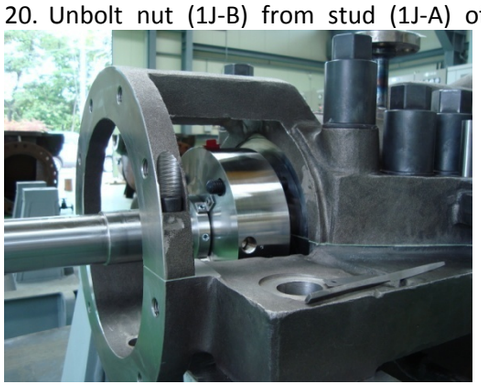
8. Remove Lock nut(6B) and Lock washer(6A)
9. Remove Release Collar (Close/Open, 6U1/6U2)
10. Remove Bearings(B,B1)
11. Remove Bearing Collar (9R-N/D)

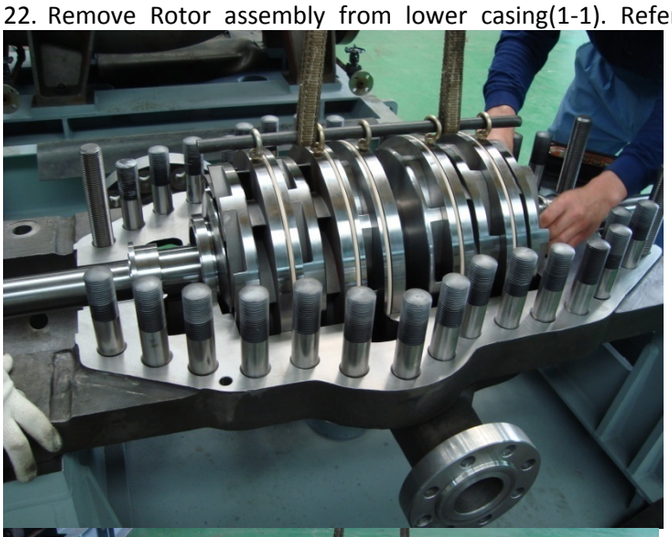
12. Untighten set screw on deflector(6H1)
13. Unbolt hexbolt from bearing housing cover inboard(9F-D/N)
14. Remove bearing housing cover gasket
15. Remove bearing housing cover
16. Remove Delfector(6H1)

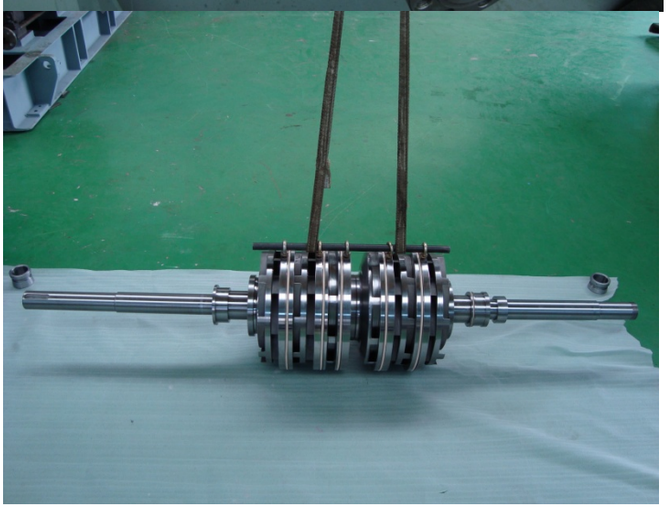



17. Release nut from Stud(Seal Cover) (8E)
18. Remove Mechanical seal.
19. Unbolt wrench bolt(1J-1)
20. Unbolt nut (1J-B) from stud (1J-A) of upper casing

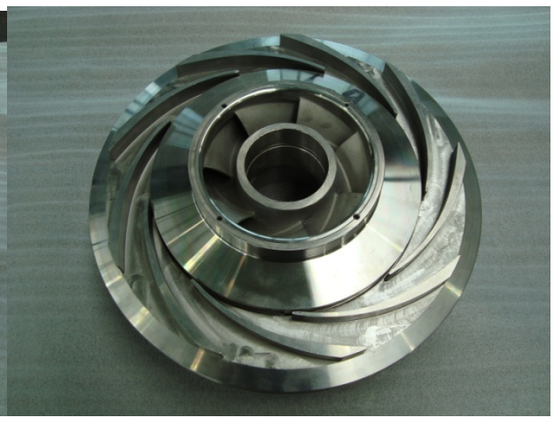
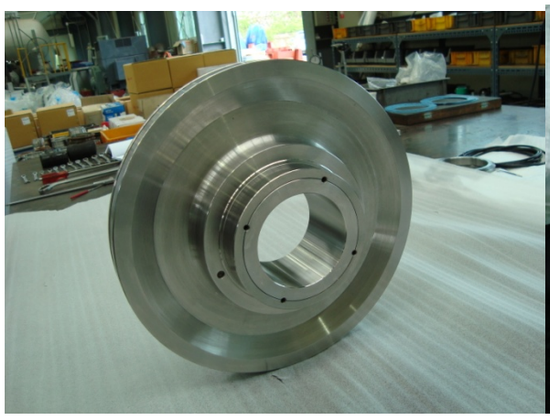
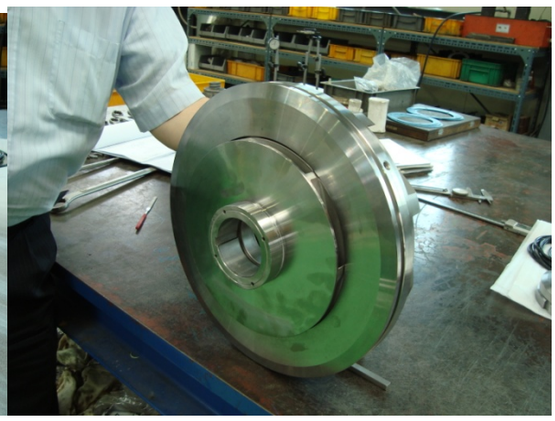


21. Remove upper casing(1-2) by using proper equipment like overhead crane.
22. Remove Rotor assembly from lower casing(1-1). Refer to following picture.





23. Remove Sleeve nut(7A) from the shaft.
24. Remove Throat Bush(2F)
25. Remove Suction Adjust Sleeve(7H).
26. Remove Spacer Ring (3R)
27. Remove Impeller(2), Guide Vane (2G) and Sleeve (Stage 7)
28. Mark number on Impeller, Guide Vane and Sleeve as combination.

Assemble is reverse sequence of disassemble.

# INSPECTIONS

Model TSMP parts must be inspected to the following criteria before they are reassembled to ensure the pump will run properly. Any part not meeting the required criteria should be replaced.

***NOTE: Clean parts to remove oil, grease or dirt. Protect machined surfaces against damage during cleaning.***

## CASING (1-1, 1-2)

The casing should be inspected for excessive wear, corrosion or pitting. Areas most susceptible are indicated by the arrows in Fig. 42. The casing should be repaired or replaced if it exceeds the following criteria.

1. Localized wearing or grooving greater than 3.2mm.
2. Pitting greater than
3. Irregularities in case gasket seat surface which could hinder or prevent sealing.
4. Wear ring clearances exceed values in *Table 6*.

***NOTE: When clearances between the rings become excessive (increase by 50%), hydraulic performance decreases substantially.***

## Table 5 — Diametrical Clearance (in)

| Pump Size | Impeller Wear Ring | | | Pressure Reducing Sleeves | Center Impeller Rings |
|---|---|---|---|---|---|
| | Truflo Standard | API 610 | Ring Diameter | Truflo Standard | Truflo Standard |
| 3x4-8B | 0.010 | 0.015 | 4.00 | 0.010 | 0.030 |
| | | 0.016 | 4.87 | | |
| | | 0.017 | 5.50 | | |
| 3x6-9/10 | 0.010 | 0.015 | 4.01 | 0.010 | 0.030 |
| | | 0.017 | 5.22 | | |
| | | 0.018 | 6.60 | | |
| 4x6-10/D | 0.011 | 0.015 | 4.24 | 0.010 | 0.030 |
| | | 0.017 | 5.97 | | |
| | | 0.018 | 6.52 | | |
| 4x6-11/D | 0.010 | 0.016 | 4.61 | 0.010 | 0.030 |
| | | 0.018 | 6.48 | | |
| | | 0.019 | 7.36 | | |
| 6x8-11A/B | 0.010 | 0.017 | 5.74 | 0.010 | 0.030 |
| | | 0.019 | 7.86 | | |
| | | 0.020 | 8.48 | | |
| 6x8-13D | 0.010 | 0.017 | 5.74 | 0.010 | |

6

## IMPELLER (2)

**Refer to Fig. 43 for Steps 1 thru 4.**

1 Inspect impeller vanes for damage. Replace if grooved deeper than

***NOTE: When clearances between the rings become excessive (increase by 50%), hydraulic performance decreases substantially.***

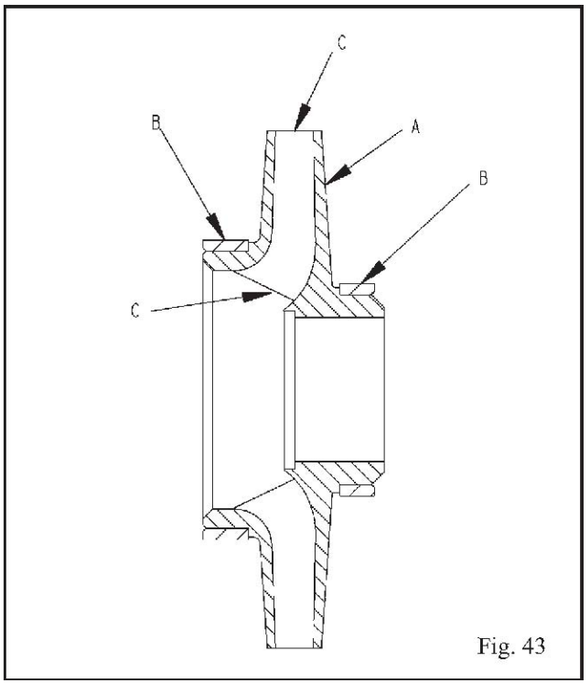


Fig. 43

1 Clean and check impeller bore diameter.
2 Check impeller balance. It should be rebalanced if it exceeds the criteria of ISO G1.0 (4W/N).

***NOTE: Balancing impellers to ISO G1.0 requires extremely accurate tooling and equipment, and should not be attempted unless such tooling and equipment are available.***

***NOTE: After assembly, the rotor should be balanced to ISO G1.0.***

## BEARINGS -BALL (B, B1)

1 Bearings should be inspected for contamination and damage. The condition of the bearings will provide useful information on operating conditions in the bearing housing (B,B1).
2 Lubricant condition and residue should be noted.
3 Bearing damage should be investigated to determine cause. If cause is not normal wear, it should be corrected before pump is returned to service.

***NOTE: Ball bearings that have been removed from their shaft fits must be replaced. Replacement bearings must be of proper size and type.***

4. Replacement bearings must be the same as, or equivalent to, those listed in *Table 6*.

***NOTE A: Thrust bearings must have machined bronze cages (retainers).***

## BEARING HOUSINGS (9)

Make sure bearing housings are very clean -no burrs. Check bearing housing bores to values in *Table 6* for the ball bearing arrangement. Repair or replace as necessary (Fig. 44 shows ball bearing housing).

## OIL RINGS (5K)

Oil rings must be as round as possible to function properly. Replace oil rings if they are worn, distorted and/or damaged beyond reasonable repair.

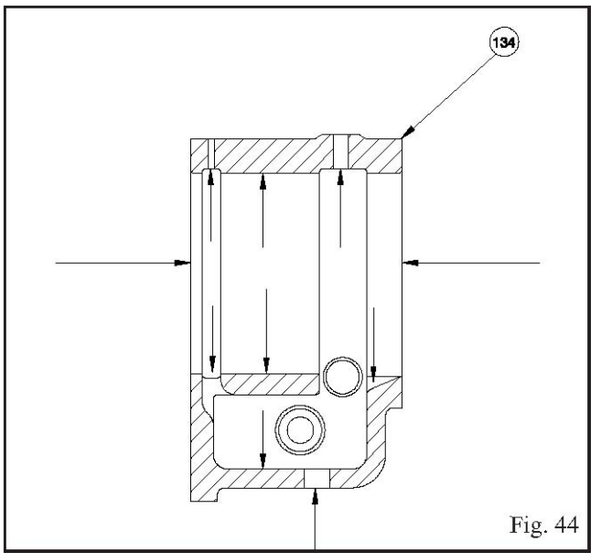


Fig. 44

**Table 6 Model TSMP Ball Bearing Fits**

| Size | Radial Bearing | Thrust Bearing | Bearing Housing Bore | Shaft Turn |
|---|---|---|---|---|
| 3x4-8B | 6311 | 7311/BEGAM | 4.7244<br>4.7253 | 2.1664<br>2.1659 |
| 3x6-9<br>3x6-10 | 6312 | 7312/BEGAM | 5.1181<br>5.1191 | 2.3631<br>2.3626 |
| 4x6-10<br>4x6-10D | 6313 | 7313/BEGAM | 5.5118<br>5.5128 | 2.5597<br>2.5592 |
| 4x6-11<br>4x6-11D | 6314 | 7314/BEGAM | 5.9055<br>5.9065 | 2.7565<br>2.7560 |
| 6x8-11 | 6313 | 7313/BEGAM | 5.5118<br>5.5128 | 2.5597<br>2.5592 |

***NOTE: DO NOT use shaft centers for runout check as they may have been damaged when removing bearings.***

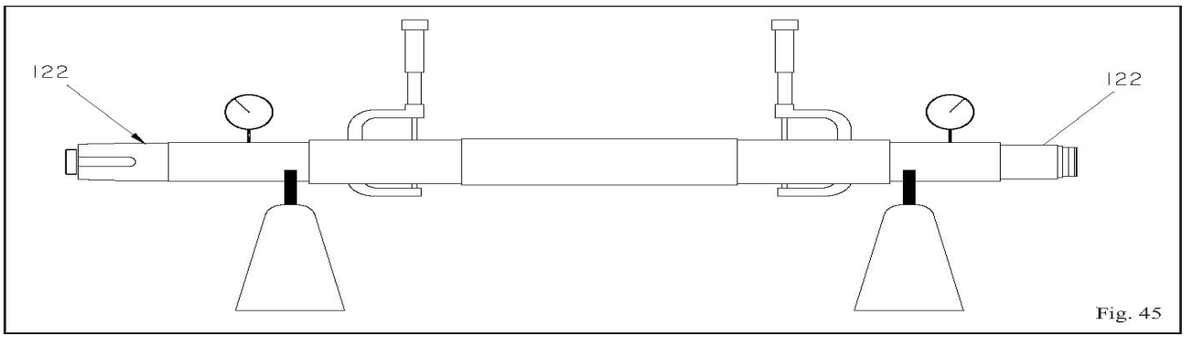


Fig. 45

| Table 7 Shaft and Rotor Runout Requirements (Abstracted from Table 15 in API-610 10th Edition) | |
|---|---|
| Flexibility factor, L/D, mm (in) | >1.9x10$^{9}$ (3.0x10)$^{6}$ |
| Allowable shaft runout, TIR um (in.) | 40 (0.0015) |
| Component fit to shaft | Interference |
| Allowable rotor radial Runout, um (in.) TIR (see NOTE 1) | 60 (0.0025) |

Allowable runouts of the fully assembled rotor are listed in *Table 7* (Fig. 46).

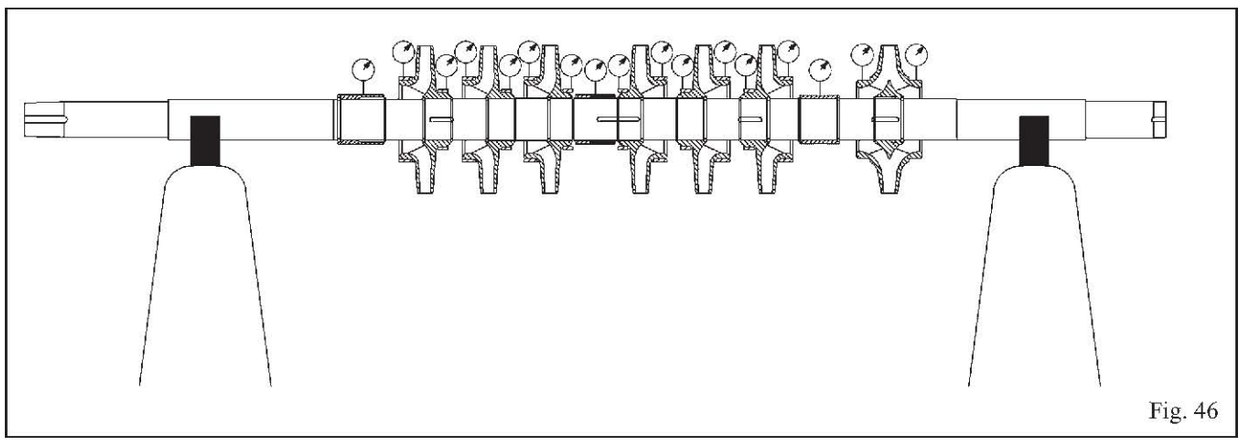


Fig. 46

## MECHANICAL SEAL

Cartridge type mechanical seals are standard in the TSMP and should be serviced by the seal manufacturer.

## COUPLING GUARD

1 Inspect guard for corrosion or other defects.
2 Replace guard or repair.

**⚠ WARNING**

***To avoid physical injury, coupling guard must be installed and must be maintained in first-class condition.***

## GASKETS, O-RINGS, AND SEATS

***NOTE: Spiral wound gaskets should not be reused.***

- Replace all gaskets and o-rings at each overhaul/ disassembly.
- Inspect seats. They must be smooth and free of physical defects. If remachining is necessary to restore surface, contact a Truflo PRO Services Center for service. Dimensional relationships must be maintained with other surfaces. Replace parts if seats are defective beyond reasonable repair.

## GENERAL

All other parts should be inspected and repaired or replaced, as appropriate, if inspection indicates continued use would be harmful to satisfactory and safe pump operation.

Inspection must include, but not be limited to, the following:

- Bearing End Covers (109A) and 360A)
- Labyrinthrinth Seals (332A & 333A)
- Bearing Locknut (136)
- Impeller Key (178) and Coupling Key (400)
- Bearing Lockwasher (382)
- All Nuts, Bolts and Screws

# RENEWAL OF WEAR PARTS

## REPLACEMENT OF IMPELLER WEAR RINGS

**Refer to Fig. 47.**

Impeller wear rings (2C, 2C-1)) are held in place by a press fit and three tack welds.

**Removal of Impeller Wear Rings (2C, 2C-1))**

1 Grind out tack weld.
2 Remove wear rings from impellers (2), using suitable pry or puller tools to force rings from fits. Rings may also be machined for removal.

**⚠ CAUTION**

***Excessive machining can damage ring fits and render parts unusable.***

**Installation of Wear Rings (2C, 2C-1))**

- Clean wear ring seats thoroughly, ensuring they are smooth and free of scratches.

- Heat new impeller wear rings to 180° -200°F (132° -143°C) using a uniform method for heating e.g. -oven) and place on impeller (2) wear ring seats.

a) I

**For the rarely-supplied sleeve/Kingsbury arrangement, refer to the included sleeve/ball arrangement for sleeve bearing assembly and disassembly, and see the included instructions from Kingsbury for specific instructions regarding this tilting pad hydrodynamic bearing.**

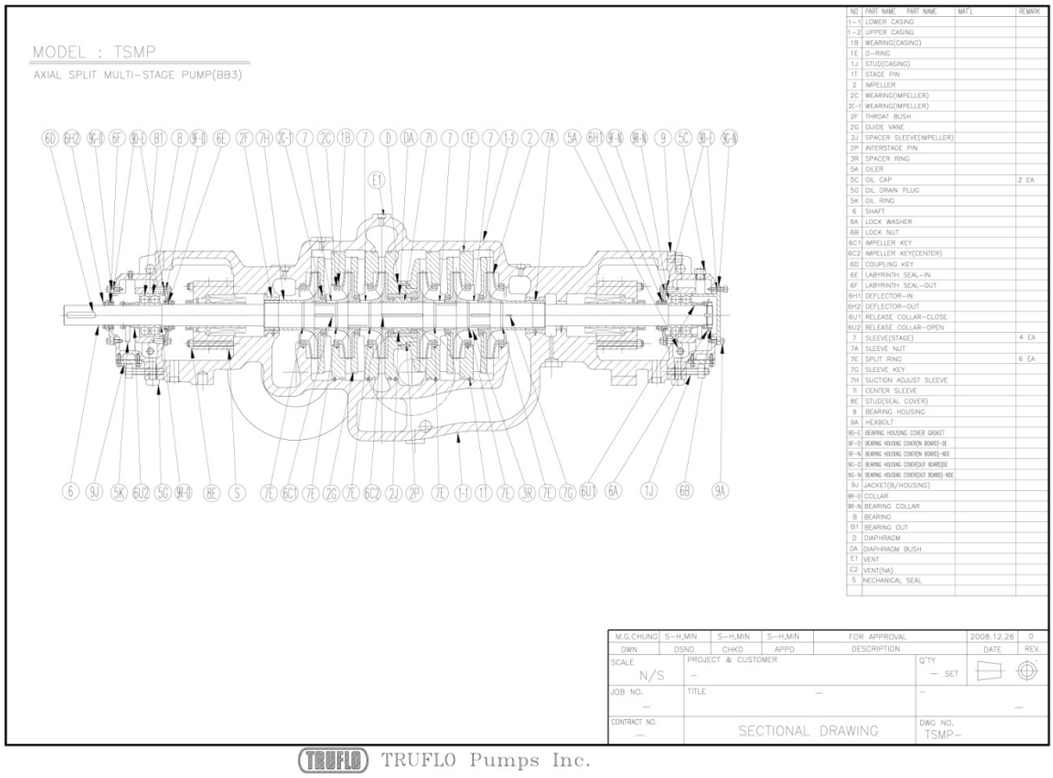


# POST ASSEMBLY CHECKS

***All checks and procedures listed under* Safety, Installation, Operation*, and P*reventive Maintenance *sections must be followed.***

***Rotate shaft by hand to ensure it rotates smoothly and there is no rubbing which could lead to excess heat generation and or sparks.***

# SECTIONAL Drawing of Typical TSMP




TRUFLO Pumps Inc.

# SPARE PARTS



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

## RECOMMENDED SPARE PARTS

It is suggested that the following spare parts be stocked, where applicable: Cartridge Mechanical Seal Impeller Wear Rings (202, 202B, 203) Thrust Bearing (Duplex Pair) (112A) Center Sleeve (205) Oil Rings (114,323) Labyrinthrinth Seal -Outboard (332A) Throttle Bushing, Sleeve (128) Labyrinthrinth Seal -Inboard (333A) Throttle Bushing (129) Casing Gasket (351) Baring Locknut (136) Bearing Lockwasher (382) Stage Ring (144) Bearing End Cover Gasket (360A) Center Bushing (155) Sleeve Bearings -two (117) (Sleeve bearing construction only) Casing Wear Rings (164, 164A) Radial Bearing (168) (Ball bearing construction only

For critical services, the following parts should also be stocked: Impeller (101 thru 101M) Shaft (122) Thrust Bearing End Cover, Outboard (Ball and sleeve Impeller Key (178) bearing construction only) (109A)

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- Bearing Spacer (217)
- Snap Ring (361F)
- Locater Ringer (361H)

An alternative approach is to stock a complete rotating element. This is a group of assembled parts which includes all rotating components except the bearings (and parts), mechanical seals, and coupling. Cross-sectional drawings supplied with the Truflo drawing package indicates commissioning spares, 2 year spares, and the components of the spare rotating assembly.

## TSMP Parts List With Materials Of Construction for Sleeve/Ball Bearing Arrangement

| Item | Part Name | Qty. | Construction -API Designation | | | | |
|---|---|---|---|---|---|---|---|
| | | | S-6 | S-8 | C-6 | A-8 | D-1 |
| 100 | Casing | 1 | Carbon Steel | | 12% Chrome | 316L SS | Duplex (2) |
| 101/101M | Impeller (3) | – | 12% Chrome | 316L SS | 12% Chrome | 316L SS | Duplex (2) |
| 109A | Bearing End Cover (Thrust) - Outboard) | 1 | Carbon Steel | | | | |
| 112A | Bearing -Thrust | 1 | Steel | | | | |
| 114 | Oil Ring -Thrust Bearing | 1 | Brass | | | | |
| 117 | Sleeve Bearing | 2 | Babbitted Tin / Steel | | | | |
| 122 | Shaft | 1 | 17`4PH) | Nitronic 50 | 17-4PH | Nitronic 50 | Duplex |
| 128 | Throttle Bushing Sleeve | 1 | Nitronic 60 | H.F. 316L SS (1) | Nitronic 60 | H.F. 316L SS (1) | H.F. Duplex (1) |
| 129 | Throttle Bushing | 1 | 410SS/ (Hardened) | H.F. 316L SS (1) | 410SS/ (Hardened) | H.F. 316L SS (1) | H.F. Duplex (1) |
| 134 | Housing, Bearing -Radial | 1 | Carbon Steel | | | | |
| 134A | Housing Bearing -Thrust | 1 | Carbon Steel | | | | |
| 136/382 | Bearing Locknut & Lockwasher | 1 | Steel | | | | |
| 144 | Stage Ring (3) | – | 410SS/ (Hardened) | H.F. 316L SS (1) | 410SS/ (Hardened) | H.F. 316L SS (1) | H.F. Duplex (1) |
| 155 | Center Bushing | 1 | 410 SS (Hardened) | H.F. 316L SS (1) | 410 SS (Hardened) | H.F. 316L SS (1) | H.F. Duplex (1) |
| 164,164A | Casing Wear Rings (3) | – | 410 SS (Hardened) | H.F. 316 SS (1) | 410 SS | H.F. 316L SS(1) | H.F. Duplex(1) |
| 178 | Impeller Key (3) | – | 316 SS | 316 SS | 410 SS | 316 SS | Duplex |
| 202, 202B, 203 | Impeller Wear Rings (3) | – | 17-4PH | H.F. 316L SS(1) | 17-4PH | H.F. 316L SS (1) | H.F Duplex (1) |
| 205 | Center Sleeve | 1 | Nitronic 60 | H.F. 316L SS (1) | Nitronic 60 | H.F. 316L SS (1) | H.F Duplex (1) |
| 217 | Bearing Spacer | 1 | Carbon Steel | | | | |
| 323 | Oil Ring, Sleeve | 4 | Brass | | | | |
| 332A | Labyrinthrinth Seal -Outboard | 1 | Bronze | | | | |
| 333A | Labyrinthrinth Seal -Inboard | 2 | Bronze | | | | |
| 351 | Gasket -Casing | 1 | Garlock 3000 | | | | |
| 353/355 | Stud and Nut -Gland | 8 | 4140 | | | | |
| 356A,356 C,3 56K,425 | Stud and Nut -Casing (3) | – | 4140 | | | | |
| 360A | Gasket -Bearing End Cover | 6 | Vellumoid | | | | |
| 361F | Snap Ring (3) | – | 316 SS | | | | Zinc Dichromate on Steel |
| 361H | Lantern Ring (3) | – | 316SS | | | | Duplex |
| 371T/427J | Stud and Nut, Bearing Housing to Casing | 8 | Carbon Steel | | | | |
| | Cap Screw, Bearing Hsg. End | | | | | | |

## TSMP Parts List With Materials Of Construction for Ball Bearing Arrangement

| Item | Part Name | Qty | Construction -API Designation | | | | |
|---|---|---|---|---|---|---|---|
| | | | S-6 | S-8 | C-6 | A-8 | D-1 |
| 100 | Casing | 1 | | | 12% Chrome | 316L SS | Duplex (2) |
| 101-101M | Impeller (3) | 1 | 12% Chrome | 316L SS | 12% Chrome | 316L SS | Duplex (2) |
| 109A | Bearing End Cover (Thrust) - Outboard) | 1 | Carbon Steel | | | | |
| 112A | Bearing -Thrust | 1 | Steel | | | | |
| 114 | Oil Ring | 2 | Brass | | | | |
| 122 | Shaft | 1 | 17-4PH | Nitronic 50 | 17-4PH | Nitronic 50 | Duplex |
| 128 | Throttle Bushing Sleeve | 1 | Nitronic 60 | H.F. 316L SS (1) | Nitronic 60 | H.F. 316L SS (1) | H.F. Duplex(1) |
| 129 | Throttle Bushing | 1 | 410 SS (Hardened) | H.F. 316L SS (1) | 410 SS (Hardened) | H.F. 316L SS (1) | H.F. Duplex(1) |
| 134 | Bearing Housing -Radial and Thrust | 2 | Carbon Steel | | | | |
| 136/382 | Bearing Locknut & Lockwasher | 1 | Steel | | | | |
| 144 | Stage Ring (3) | – | 410 SS (Hardened) | H.F. 316L SS (1) | 410 SS (Hardened) | H.F. 316L SS (1) | H.F. Duplex(1) |
| 155 | Center Bushing | 1 | 410 SS (Hardened) | H.F. 316L SS (1) | 410 SS (Hardened) | H.F. 316L SS (1) | H.F. Duplex(1) |
| 160 | Brg End Cover, Radial (inboard & outboard) and Thrust (inboard) | 3 | Carbon Steel | | | | |
| 164, 164A | Casing Wear Rings (3) | – | 410 SS (Hardened) | H.F. 316L SS (1) | 410 SS (Hardened) | H.F. 316L SS (1) | H.F. Duplex(1) |
| 168 | Bearing -Radial | 1 | Steel | | | | |
| 178 | Impeller Key (3) | – | 316SS | | 410 SS | 316 SS | Duplex |
| 202, 202B, 203 | Impeller Wear Rings (3) | – | 17-4 PH | H.F. 316L SS(1) | 17-4 PH | H.F. 316L SS(1) | H.F. Duplex (1) |
| 205 | Center Sleeve | 1 | Nitronic 60 | H.F. 316L SS(1) | Nitronic 60 | H.F. 316L SS(1) | H.F. Duplex(1) |
| 217 | Bearing Spacer | 1 | Carbon Steel | | | | |
| 324 | Sleeve, Oil Ring (Radial End) | 1 | Carbon Steel | | | | |
| 332A | Labyrinthrinth Seal -Radial Outboard | 1 | Bronze | | | | |
| 333A | Labyrinthrinth Seal -Radial & Thrust Inboard | 2 | Bronze | | | | |
| 351 | Gasket -Casing | 1 | Garlock 3000 | | | | |
| 353/355 | Stud and Nut -Gland | 8 | 4140 | | | | |
| 356A, 356C,356K, 425 | Stud and Nut -Casing (3) | – | 4140 | | | | |
| 360A | Gasket -Brg End Cover (Radial & Thrust) | 9 | Vellumoid | | | | |
| 361F | Snap Ring (3) | – | 316SS | | | | Zinc Dichromate on Steel |
| 361H | Lantern Ring (3) | – | 316SS | | | | Duplex |
| 371C | Cap Screw Brg.Hsg. End Cover | 16 | Carbon Steel | | | | |
| 371T/427J | Stud and Nut, Brg Hsg to Csg/Head | 8 | Carbon Steel | | | | |
| 400 | Coupling Key | 1 | Carbon Steel | | | | |
| 443B | Sleeve Oil Ring, Thrust End | 1 | Carbon Steel | | | | |
| 520 | Shaft Nut | 1 | Carbon Steel | | | | |

| CONSTRUCTION CROSS REFERENCE CHART | |
|---|---|
| **API Designation** | **Materials (Case/Trim)** |
| S-6 | Steel / 12% Chrome |
| S-8 | Steel / SS Impeller & Trim |
| C-6 | 12% Chrome |
| A-8 | 316LSS |
| D-1 | Duplex SS |

| MATERIAL CROSS REFERENCE CHART | | | |
|---|---|---|---|
| **Material** | **Truflo Pumps Material Code** | **ASTM** | **Other** |
| Carbon Steel | 1212 | A216 Grade WCB | |
| 12% Chrome | 1234 | A487 Grade CA-6NM | |
| 316LSS | 1265 | A743 Grade CF-3M | |
| 316LSS | 1296 | A351 Grade CF-3M | |
| Duplex SS | 1362 | A890 Grade 3A | UNS J93771 |
| Carbon Steel | 2210 | A 108 Grade 1211 | |
| 303SS | 2226 | A 582 Type 303 | UNS S30300 |
| 316SS | 2229 | A 276 Type 316 | UNS S31600 |
| 410SS | 2244 | A276 Type 410 | UNS S41000 |
| 420SS | 2222 | A276 Type 420 (hardened to 450-500) | UNS 41200 |
| 17-4 PH | 2255 | A564 Type 630 | UNS S17400 |
| Nitronic 50 | 2351 | A276 Type XM-19 | UNS S20910 |
| Nitronic 60 | 2445 | A276 S21800 | UNS S21800 |
| Duplex SS | 2435 | A276 Type S31803 | UNS S31803 |
| Colmonoy #6 on 1362 | 6737 | | Nickel Base hard surfacing alloy |
| Colmonoy #6 on 1265 | 6983 | | Nickel Base hard surfacing alloy |

| FASTENERS/PLUGS | | |
|---|---|---|
| **Material** | **Truflo Pumps Material Code** | **ASTM** |
| Carbon Steel | 2210 | A307 Grade B |
| 4140 Steel | 2239 | A193 Grade B7 |
| 4140 Steel | 2285 | A194 Grade 2H |

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# APPENDIX I

# BEARING HOUSING LUBRICATION CONVERSION

## Conversion from Ring Oil to Oil Mist Lubrication (Applicable to Ball Bearing Construction Only)

Truflo has designed the TSMP bearing housing to accept oil mist lubrication. The radial and thrust end bearing housings (134) are provided with pre-drilled connections for oil misting — a 1/4" NPT connection on the inboard side of the housing and a 1/2" NPT connection or the outboard side. Both are plugged for shipment (See Fig. IA). The following instructions are written for conversion to oil mist (pure or purge) from the ring oil lubrication method.

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

A. **Purge Mist Lubrication:** Intermittent oil mist in housing. Oil sump in housing is utilized, and oil ring and constant level oiler are required.

**Radial Housing:** Replace the 1/4" NPT plug with an oil mist fitting provided by the oil mist system manufacturer. The 1/2" NPT connection remains plugged since it is not required in the oil mist system.

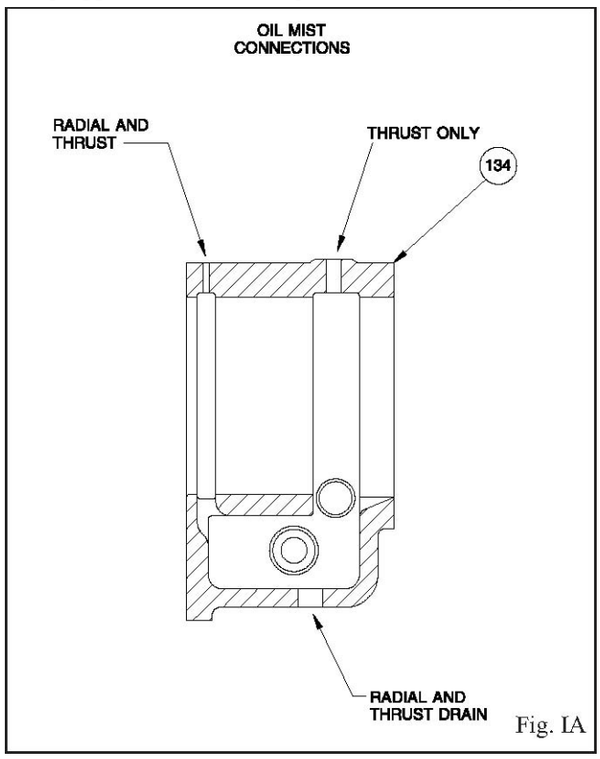

Fig. IA

**Thrust Housing:** Replace the 1/4" NPT plug with an oil mist fitting. Remove the 1/2" NPT plug and replace it with a 1/2" to 1/4" bushing, and insert an oil mist fitting by the oil mist manufacturer.

B. **Pure Mist Lubrication:** Constant oil mist in housing. Oil sump is not utilized, nor is oil ring and constant level oilers. The drain connections in the bearing housing is required as part of oil recirculation system.

**Radial Housing:** Replace 1/4" NPT plug as in the purge mist application. The 1/2" NPT plugged connection is not required.

**Thrust Housing:** Replace both plugs, as instructed for the purge mist application.

***NOTE: In both housings, the inboard channel (channel beneath "Radial and Thrust" Fig. IA) must be 1/4" plug epoxied to prohibit rapid oil drainage. Drill a 1/8" hole for required but restricted drainage.***

# APPENDIX II

## INSTALLATION AND DISASSEMBLY INSTRUCTIONS FOR TRUFLO ANSI B15.1/OSHA COUPLING GUARDS

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

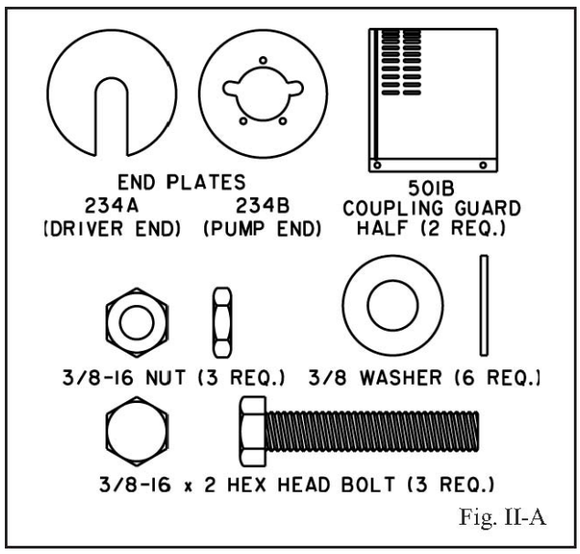

Fig. II-A

## INSTALLATION

***NOTE: If end plate (pump end) is already installed, make any necessary coupling adjustments and then proceed to Step 7.***

1. Remove spacer portion of coupling. Refer to coupling manufacturer's instructions for assistance.

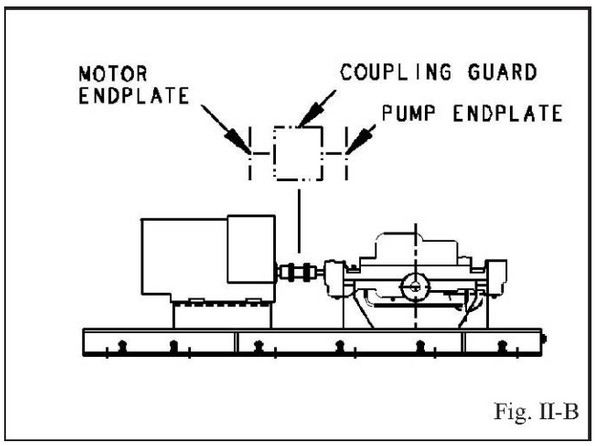

Fig. II-B

2. If the coupling hub diameter is larger than the diameter of the opening in the end plate (234B), remove the coupling hub.

1 Remove thrust bearing end cover screws (371C).
2 Align the end plate (234B) to the thrust bearing end cover (119A) so that the holes in the end plate align with the holes in the end cover.
3 Replace the three thrust bearing end cover screws (371C) and torque to values shown in *Table 9*.
4 Replace coupling hub (if removed) and spacer portion of coupling. Refer to coupling manufacturer's instructions for assistance.

***NOTE: Coupling adjustments should be completed before proceeding with coupling guard assembly.***

7. Spread opening of coupling guard half (501B) slightly and place over pump end plate (234B) as shown in Fig. II-C.

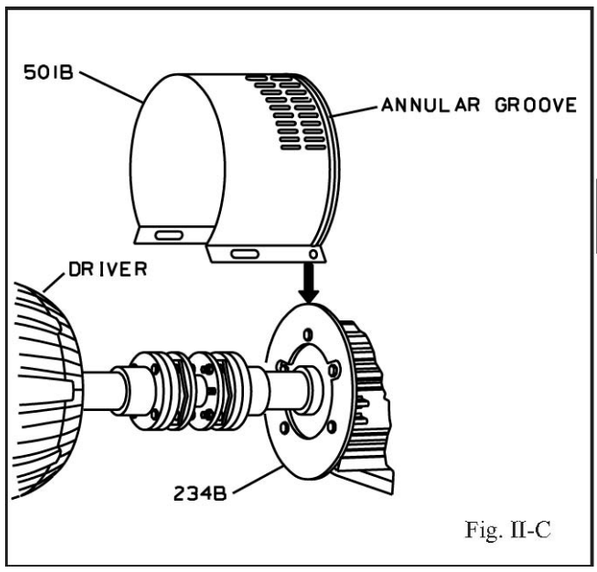

Fig. II-C

8

The annular groove in the guard is located around the end plate as indicated in Fig. II-D.

***NOTE: Locate opening (flange) so that it will not interfere with piping but will allow access for installing bolts (Step 8).***

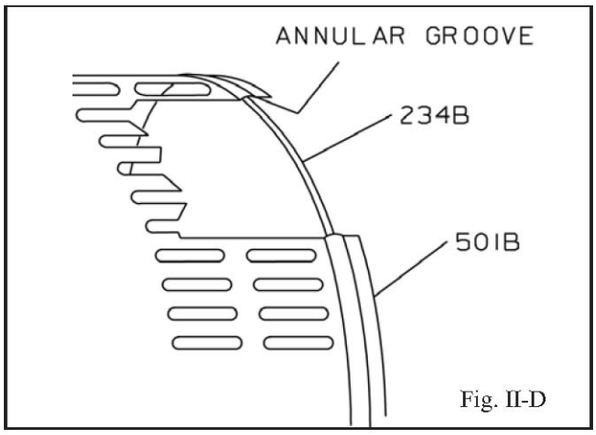

Fig. II-D

8. Place one washer over bolt and insert bolt through round hole at front end of guard half (501B).

9. Place a second washer over exposed end of bolt.

10. Thread nut onto exposed end of bolt and tighten firmly.

The proper sequence of components is shown in Fig. I-A-5; an assembled unit is shown in Fig. II-E.

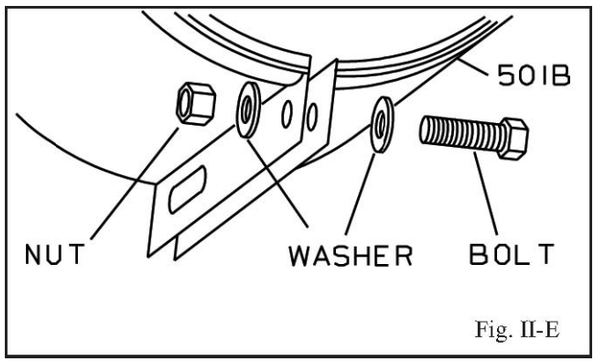

Fig. II-E

11. Spread opening of remaining coupling guard half (501B) slightly and place over installed coupling guard half so that annular groove in remaining coupling guard half faces the driver as indicated in Fig. II-G.

12. Place end plate (234A) over driver shaft as indicated in Fig. II-H. Locate the end plate in the annular groove at the rear of the coupling guard half (501B).

13. Repeat steps 8-10 for rear end of coupling guard half (501B), except that nut should be finger tightened only.

14. Adjust length of coupling guard to completely cover shafts and coupling as shown in Fig. II-H by sliding rear coupling guard half (501B) towards motor.

15. Repeat steps 8-10 for center slots in coupling guard.

16. Tighten all nuts on the guard assembly firmly.

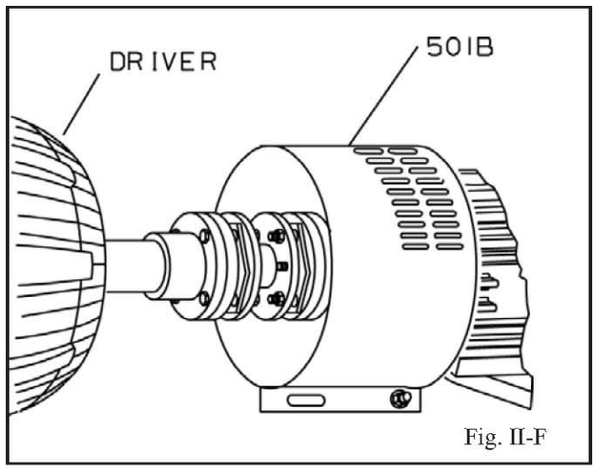

Fig. II-F

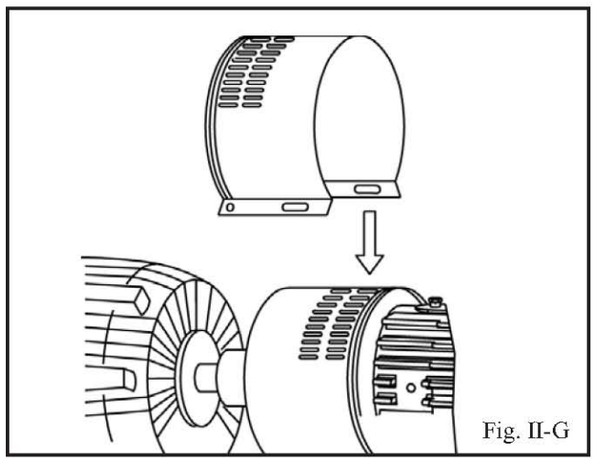
Fig. II-G

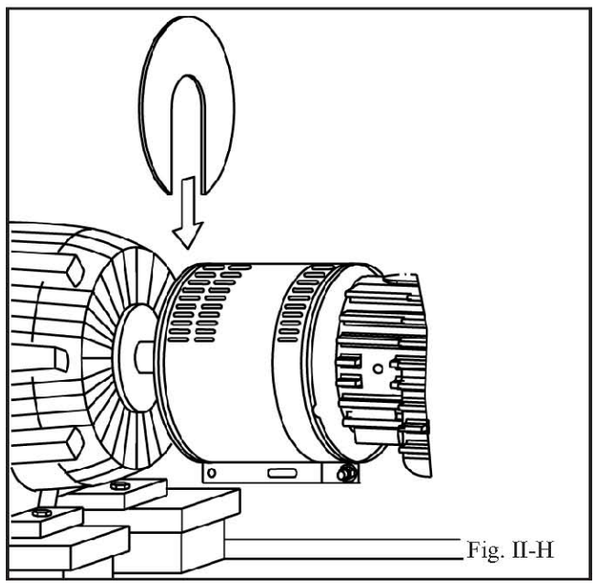
Fig. II-H

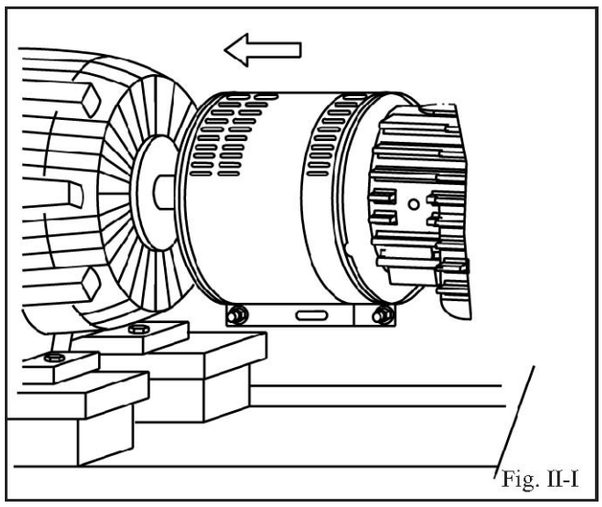

Fig. II-I

1 Remove nut, bolt, and washers from center slotted hole in the coupling guard assembly.
2 Slide driver end coupling guard half (501B) towards pump (Fig. II-I).
3 Remove nut, bolt, and washers from driver coupling guard half (501B).
4 Remove driver end plate (234A) (Fig. II-H).
5 Spread opening of driver coupling guard half (501B) slightly and lift over remaining coupling guard half (Fig. II-G).
6 Remove nut, bolt, and washers from remaining coupling guard half (501B).
7 Spread bottom of coupling guard half slightly and lift off pump end plate (234B) (Fig. II-C).

This completes disassembly of the coupling guard.

***NOTE: It is not necessary to remove the end plate (pump end) from the pump bearing frame. Before removing other components, refer to* Disassembly *section of this manual.***

## DISASSEMBLY

The coupling guard must be removed for certain maintenance and adjustments to the pump, such as adjustment of the coupling. The coupling guard should be replaced after maintenance is completed.

### WARNING

**Before assembly or disassembly of the coupling guard is performed, the driver must be de-energized, the driver controller/starter put in a locked-out position and a caution tag placed at the controller/starter indicating the disconnect. Replace coupling guard before resuming normal operation of the pump. TRUFLO Pumps, Inc., assumes no liability for avoiding this practice.**

### WARNING

**DO NOT resume normal pump operation with the coupling guard removed.**

# APPENDIX III

# DIAL INDICATOR (RIM-AND-FACE) ALIGNMENT PROCEDURE

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

*Appendix III* details the procedure to be followed when using the dial indicator (rim-and-face) method of aligning pump and motor shafts.

Other alignment methods (reverse dial indicator, laser) are acceptable. Maximum allowable misalignment criteria for these methods are shown in *Table III-1*.

Good alignment is achieved when the dial indicator readings as specified in this alignment procedure are equal to 0.05 mm (.002 in.) Total Indicator Reading (T.I.R.) is less when the pump and driver are at operating temperature (Final Alignment).

## SET UP

1 Mount two dial indicators on the pump coupling half X so they contact the driver coupling half Y (Fig. III-A).

2 Check setting of indicators by rotating coupling half X to ensure indicators stay in contact with coupling half Y but do not bottom out. Adjust indicators accordingly.

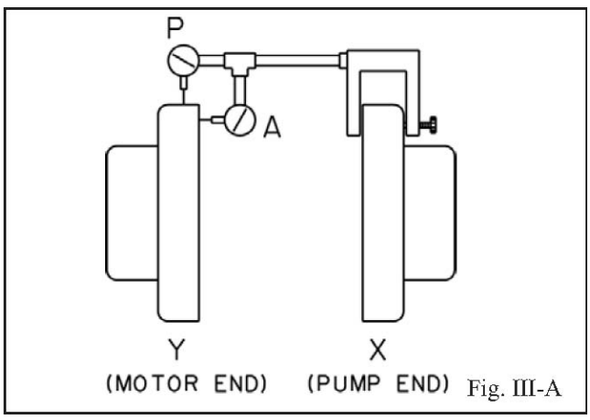

Fig. III-A

## MEASUREMENT

To ensure accuracy of indicator readings:

1. Always rotate both coupling halves together so indicators contact the same point on coupling half Y. This will eliminate any measurement problems due to runout on coupling half Y.

1 Take indicator measurements with driver foot hold down bolts tightened. Loosen hold down bolts prior to making alignment corrections.

2 Take care not to damage indicators when moving driver during alignment corrections.

## ANGULAR ALIGNMENT

A unit is in angular alignment when indicator A (angular indicator) does not vary by more than 0.05 mm (.002 in.) as measured at four points 90° apart at operating temperature.

**Vertical Correction (Top-to-Bottom)**

1 Zero indicator A at top dead center (12 o'clock) of coupling half Y (Fig. III-B).

2 Rotate indicators/coupling halves to bottom dead center (6 o'clock). Observe needle and record reading.

3a. **Negative Reading -**The coupling halves are farther apart at the bottom (6 o'clock) position than at the top (12 o'clock). Correct by adjusting leveling screws near the center foundation bolts in order to raise the center of the baseplate (Fig. III-B). See Notes A and B.

3b. **Positive Reading -**The coupling halves are closer at the bottom (6 o'clock) position than at the top (12 o'clock) position. Correct by adjusting leveling screws near the center foundation bolts in order to lower the center of the baseplate (Fig. III-B). See Notes A and B.

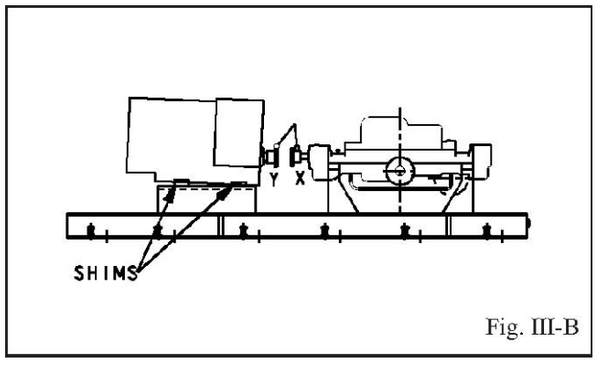

Fig. III-B

***NOTE A: When adjusting leveling screws, nuts on foundation bolts should be tightened only enough to hold firmly. Final tightening is done after the unit is grouted and the grout has set for at least 48 hours.***

4. Repeat steps 1 through 3 until indicator A reads 0.05 mm (.002 in.) or less.

**Horizontal Correction (Side-to-Side)**

1 Zero indicator A on left side of coupling half Y, 90° from top dead center (9 o'clock, Fig. III-C).

2 Rotate indicators/coupling halves through top dead center to the right side, 180° from the start (3 o'clock). Observe needle and record reading.

3a. **Negative Reading** -The coupling halves are farther apart on the right (3 o'clock) side than the left (9 o'clock) side. Correct by sliding the shaft end of the driver to the left or the opposite end to the right (Fig. III-C).

3b. **Positive Reading** -The coupling halves are closer together on the right (3 o'clock) side than the left (9 o'clock) side. Correct by either sliding the shaft end of the driver to the right or the opposite end to the left (Fig. III-C).

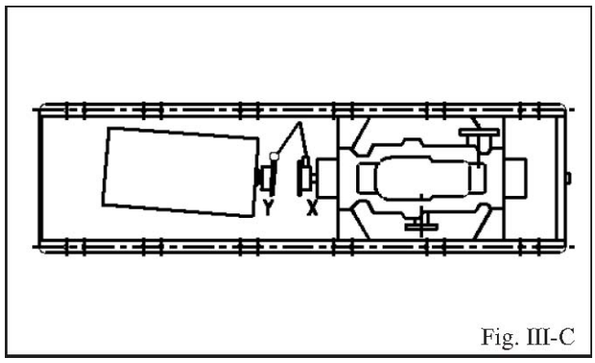

Fig. III-C

***NOTE: Drive trains of over 100 HP are supplied with adjustment provisions fastened to the baseplate which may be used to make all horizontal alignment corrections.***

4. Repeat steps 1 through 3 until indicator A reads 0.05 mm (.002 in.) or less.

5. Re-check both horizontal and vertical readings to ensure adjustment of one did not disturb the other. Correct as necessary.

# PARALLEL ALIGNMENT

A unit is in parallel alignment when indicator P (parallel indicator) does not vary by more than 0.05 mm (.002 in.) as measured at four points 90° apart at operating temperature, or when the shaft centerlines are within the recommended cold setting criteria as shown in *Table III-1*.

***NOTE B: Shims that may be provided under the driver feet should not be used to obtain satisfactory angular alignment until after the grout has been poured and allowed to cure.***

**Table III-1 Cold Setting of Parallel Vertical Alignment**

| Driver Type | Set Driver Shaft |
|---|---|
| Electric Motor | 0.05 -0.10 mm LOW (.002 -.004 in. LOW) |
| Turbine, Engine, etc. | Follow driver manufacturer's recommendations |

**Vertical Correction (Top-to-Bottom)**

1 Zero indicator P at top dead center (12 o'clock) of coupling half Y (Fig. III-D).

2 Rotate indicator/coupling halves to bottom dead center (6 o'clock). Observe needle and record reading.

3a. **Negative Reading** -Coupling half X is lower than coupling half Y. Correct by removing shims of thickness equal to half of the indicator reading from under each driver foot (Fig. III-D).

3b. **Positive Reading** -Coupling half X is higher than coupling half Y. Correct by adding shims of thickness equal to half of the indicator reading under each driver foot (Fig. III-D).

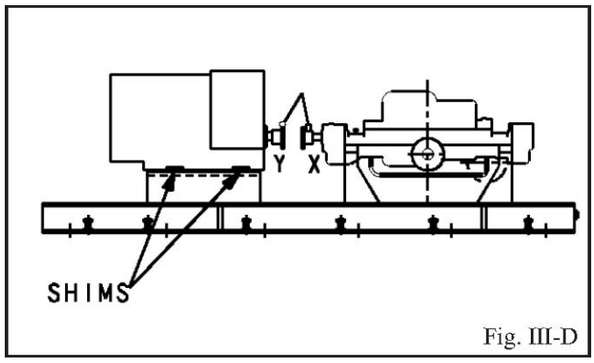

Fig. III-D

***NOTE: Equal amounts of shims must be added to or removed from each driver foot, or the vertical angular alignment will be affected.***

4. Repeat steps 1 through 3 until indicator P reads 0.05 mm (.002 in.) or less when hot, or per *Table III-1* when cold.

**Horizontal Correction (Side-to-Side)**

1 Zero indicator P on left side of coupling half Y, 90° from top dead center (9 o'clock, Fig. III-E).

2 Rotate indicator/coupling hubs through top dead center to the right side, 180° from the start (3 o'clock). Observe needle and record reading.

3a. **Negative Reading** -Coupling half Y is to the left of coupling half X. Correct by sliding driver evenly to the right a distance equal to half of the indicator reading (Fig. III-E).

3b. **Positive Reading** -Coupling half Y is to the right of coupling half X. Correct by sliding driver evenly to the left a distance equal to half of the indicator reading (Fig. III-E).

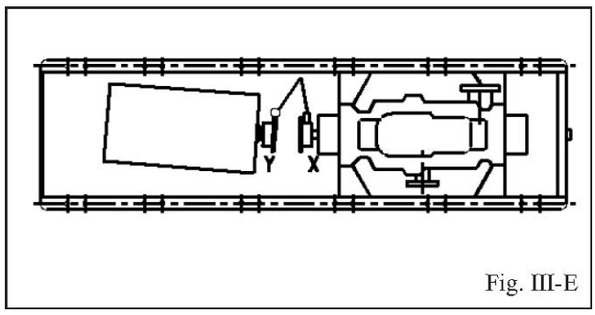


Fig. III-E

***NOTE: Failure to slide driver evenly will affect horizontal angular alignment.***

1 Repeat steps 1 through 3 until indicator P reads 0.05 mm (.002 in.) or less.

2 Re-check both horizontal and vertical readings to ensure adjustment of one did not disturb the other. Correct as necessary.

# COMPLETE ALIGNMENT

A unit is in complete alignment when both indicators A (angular) and P (parallel) do not vary by more than 0.05 mm (.002 in.) as measured at four points 90° apart when pump and driver are at operating temperature.

1 Zero indicators A and P at top dead center (12 o'clock) of coupling half Y.

2 Rotate indicator to the bottom dead center (6 o'clock). Observe the needles and record the readings.

3 Make corrections as outlined previously.

4 Zero indicators A and P on the left side of coupling half Y, 90° from top dead center (9 o'clock).

5 Rotate indicators through top dead center to the right side, 180° from the start (3 o'clock). Observe the needles and record the readings.

6 Make corrections as outlined previously.

7 Recheck both vertical and horizontal readings to ensure adjustment of one did not disturb the other.

8 Correct as necessary.

***NOTE: With experience, the installer will understand the interaction between angular and parallel alignments and will make corrections appropriately.***