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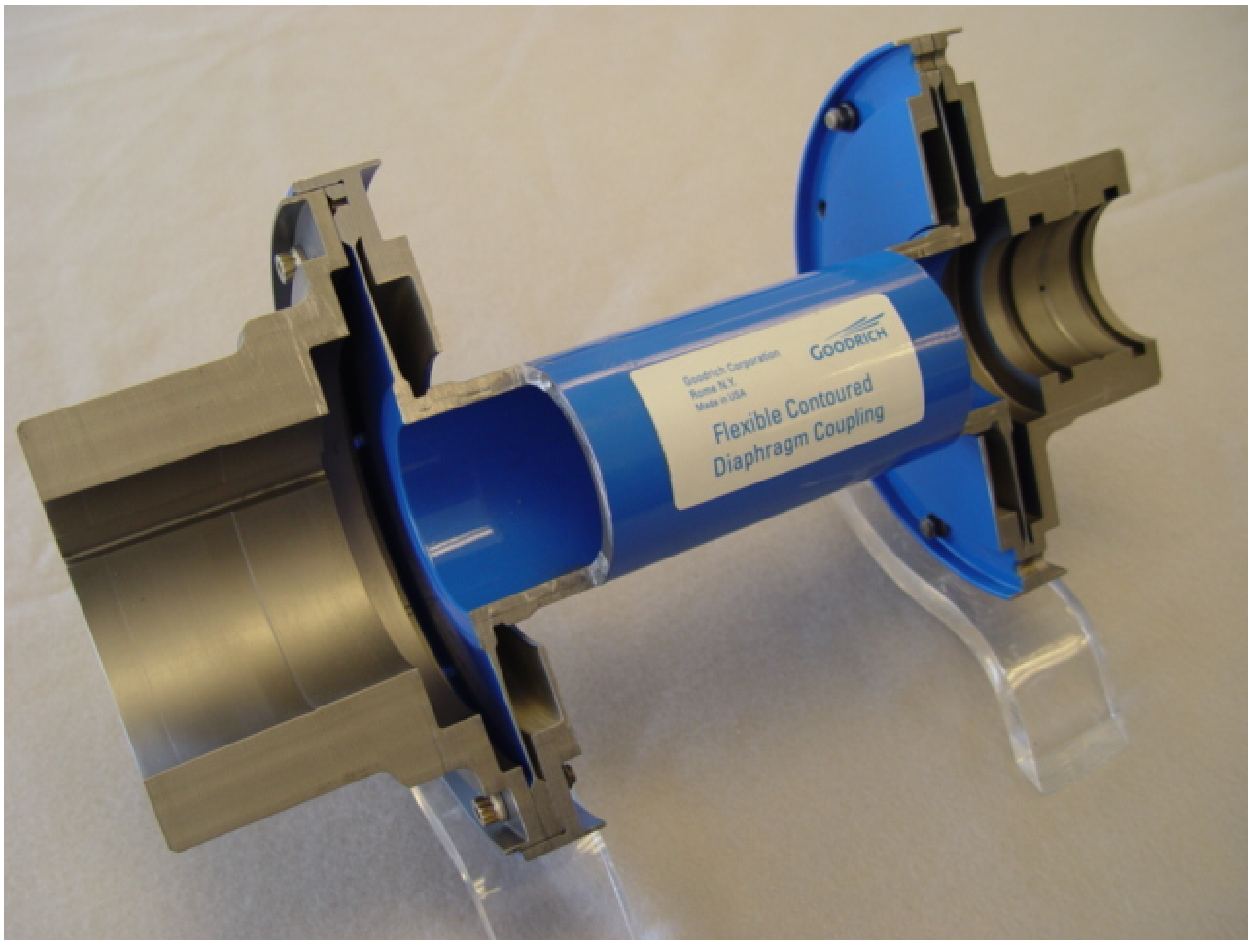
INSTALLATION AND MAINTENANCE MANUAL

Power Transmission Couplings



Foreword

Effective October 2, 2002 the successor corporate entity of TRW Aeronautical Systems-Lucas Aerospace-became Goodrich. All product lines formerly manufactured and sold under the **TRW, Lucas** and **Bendix** name continue as Goodrich products, designed and manufactured to the same standards as before. “The Bendix” coupling is now “The Goodrich" coupling.

This *Installation and Maintenance Manual* is intended to supplement the equipment manufacturer’s Assembly Manual and is to be used in conjunction with the Goodrich assembly drawing of the specific coupling to be installed. Assembly should not be attempted unless this information is available on site.

Copies of all necessary documents may usually be obtained through the equipment manufacturer.

The instruction manual has been prepared by the Engineering Department of Goodrich Corporation, Rome, NY.

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NOTE: GOODRICH SUPPLIES HUBS WITH DRY FILM CORROSION PROTECTION. PRIOR TO INSTALLATION, REMOVE COATING FROM HUB BORES WITH VARSOL OR WD-40. WIPE CLEAN WITH ACETONE.

1.0 Definition Of Terminology

This manual is specific to the Goodrich Power Transmission Coupling. To assist anyone, who may not be familiar with this coupling, this section is included to define terms used for the individual components of the Goodrich couplings.

Included in this section are Cross-sectional drawings of four basic assembly configurations. The Fitted Bolt Pilot (non-piloted guard) **(See Figure 1-1),** Flanged Machinery Shaft **(See Figure 1-2),** Piloted Guard **(See Figure 1-3)**, and Low Moment **(See Figure 1-6)**. Individual components in the drawings have been numbered.

All numbering corresponds to the written descriptions, which follow. When necessary to further clarify configuration, sketches are included with the written description.

1.1 Fitted Bolt Pilot

This coupling employs bolts, which have a close tolerance shank that is closely fitted to the mating holes in the two flanges to be joined. Upon assembly the bolts will always pilot the flanges. This joint is often referred to as a body-bound bolted joint. **(See Figure 1-1)**

Note: Matchmarks across the joints are always used, and must be observed when using this method of piloting.

Flex Unit (1)

The Flex Unit is the spacer tube with flexible diaphragms welded to each end. The flex unit has two guards permanently attached by rivets for the Fitted Piloted Bolt couplings or by interference fit for the Piloted Guard couplings.

Actual Flex Unit Free Length

This is the actual length of the flex unit between the diaphragm faces when it is in a free state. This dimension is measured at the factory and is scribed either on the guard or diaphragm outside diameter. This is the dimension to be referenced when installing the coupling.

NOTE: Numbers in () reference the part(s) shown in the figure(s)

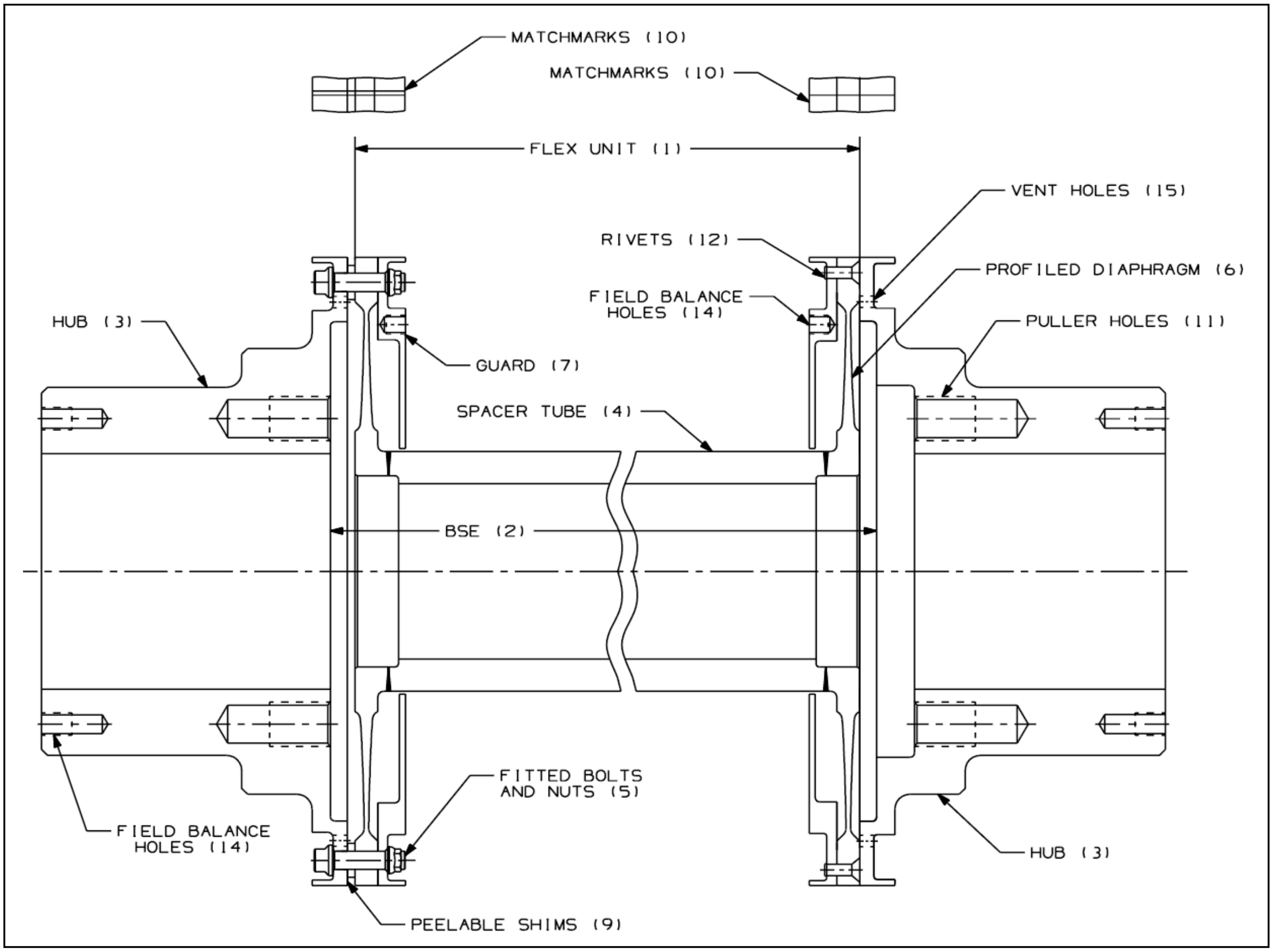


Figure 1-1 Fitted Bolt Pilot Configuration

BSE (2) or DBSE
Between Shaft Ends (BSE) or Distance Between Shaft Ends (DBSE) is the distance between the very ends of the machine shafts to be coupled. For the coupling designer it establishes the length of the coupling. **(See Figure 3-1)**

Hubs (3) or Adapters
Designed to attach to the machine shaft on one end, and to the coupling flex unit on the other. All hubs are made of forged AISI steel material. Shaft end details vary with the manufacturer involved and hub bores are designed to suit these variations.

Spacer Tube (4)
This is a tube in which the length is sized to accommodate the Between Shaft End dimension. The center tube can take various forms with regard to outside and inside diameter. This is done to provide lateral stiffness, adjust weight, or alter torsional spring rate. The spacer is an important torque carrying member of the coupling assembly, and should not be damaged or have any modifications done without consulting Goodrich Engineering,

Fitted Bolts and Nuts (5)
Bolts supplied on Goodrich couplings are body-fitted bolts. The nuts are self-locking and should be reusable for up to 20 assemblies and disassemblies.

The bolts and nuts of all coupling assemblies come in weight-balanced sets. Any bolt may be used in any hole, and any nut assembled on any bolt within a given set. Bolt and nut replacement sets are also weight matched, and are intended to be replaced in sets to maintain tolerances on coupling unbalance.

Profiled Diaphragm (6)
This contoured flexible member, located at each end of the spacer tube, permits the coupling to simultaneously accommodate both axial and parallel offset misalignment. The limits of misalignment are defined on the Goodrich assembly drawing, and should be referred to at the time of installation. These limits should not be exceeded. A tight interference fit controls the guard position on the outside of the diaphragm.

Guard (7)
The guard is machined from an alloy disc, and is riveted to the diaphragm outer rim. The purpose of a guard is to protect the diaphragm profile from being damaged, and to prevent the spacer tube from flailing in the event of diaphragm failure.

Piloted Guard (8)
Same as the standard guard, except the outer rim is extended to form a retractable pilot. The guard pilot slides over the outside diameter of the diaphragm, and the hub or adapter flange. Jacking tap holes are provided in the guard to retract it away from the hub to allow removal of the flex unit. **(See Figure 1-5)**

Peelable Shims (9)
These are spacers of specific thickness. Two stainless steel peelable shim packs are provided on most couplings. Their purpose is to

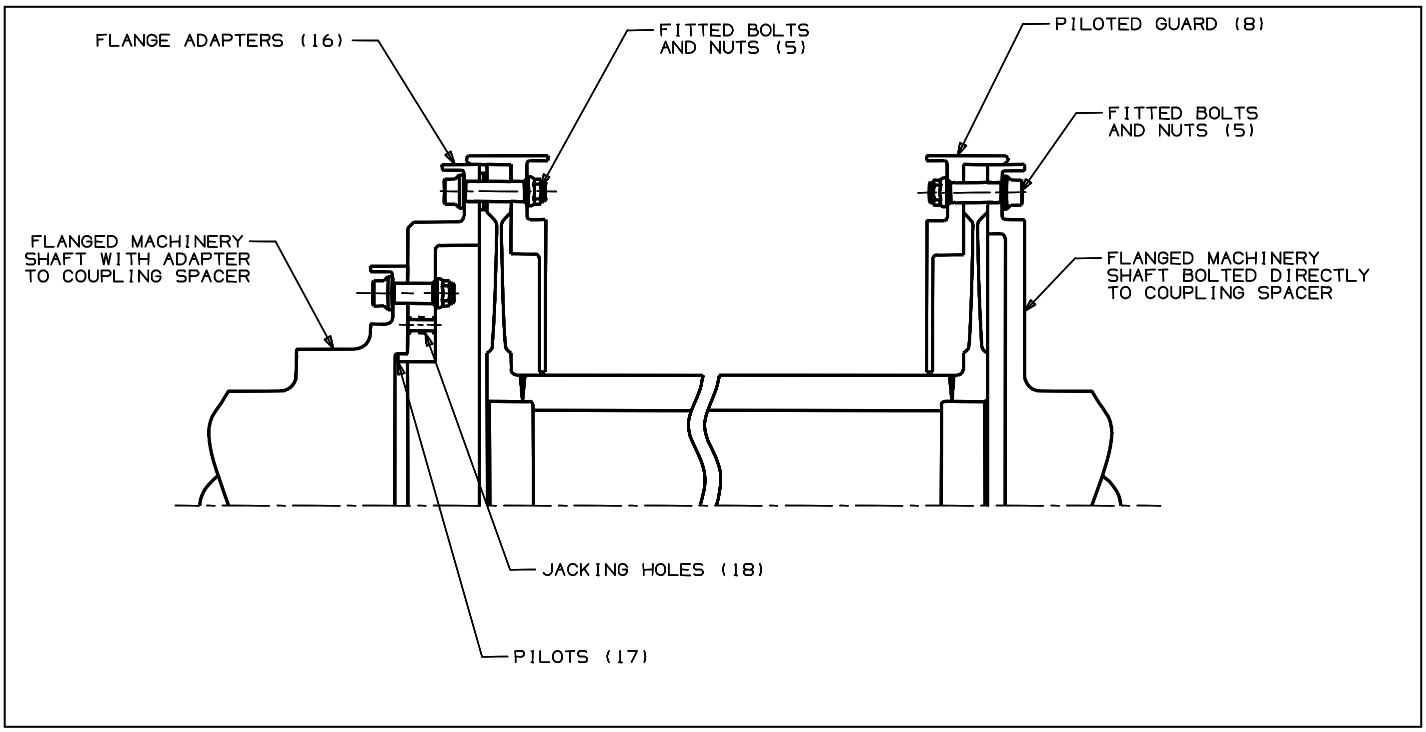


Figure 1-2 Flanged Machinery Shaft Configuration

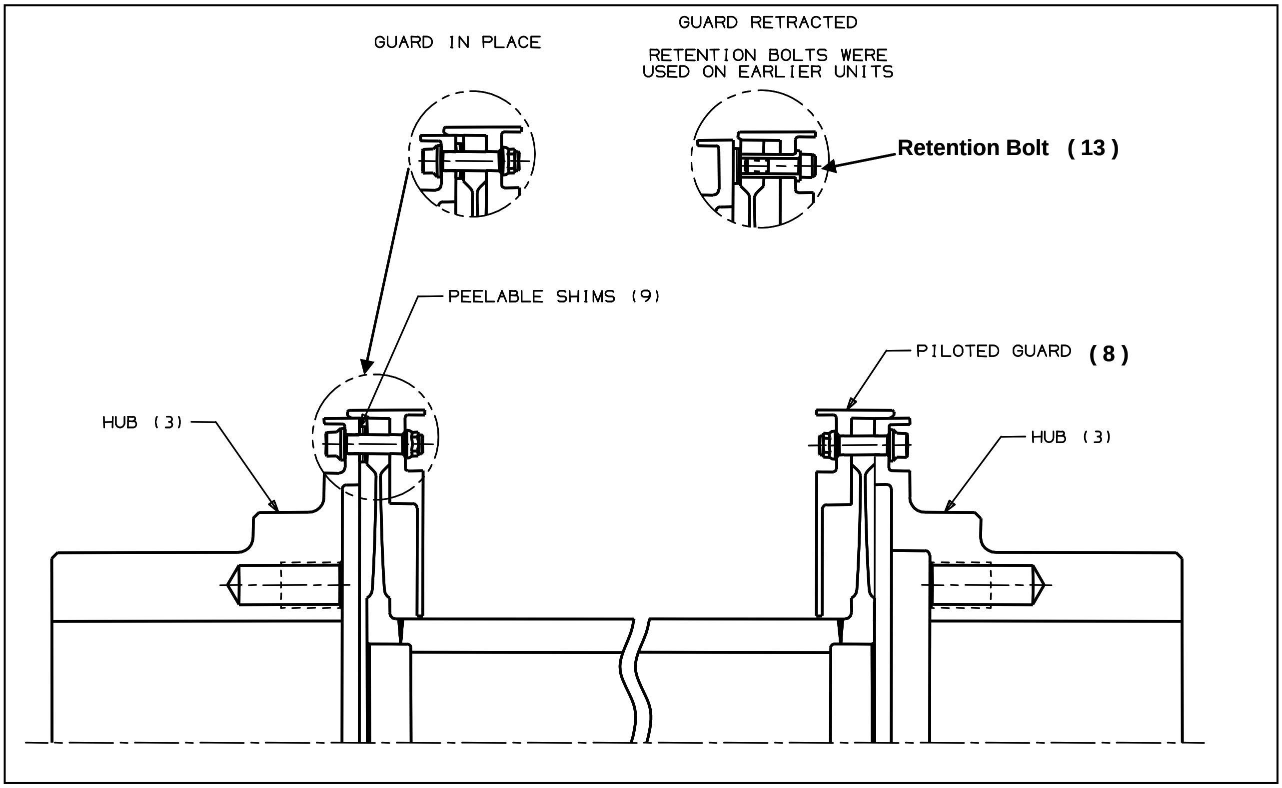


Figure 1-3 Piloted Guard Configuration

accommodate variations in machine position. A Goodrich peelable shim pack is comprised of six stainless steel spacers that are edge bonded around their perimeter, for ease of separating. The shim pack incorporates one 0.060-inch shim, one 0.030-inch shim, and four 0.010-inch thick shims **(See Figure 1-4)**. Use of the provided shim packs can result in installation tolerances as small as plus or minus 0.010 inch.

Any excess shims are removed from the installation, and may be kept as a spare part for future use. Two shim packs are supplied with each flex unit, one to be installed with the coupling, and one spare, to be used if it is necessary. This allows a plus or minus 0.130 inch total installation tolerance.

Prior to October 1985 the standard Goodrich shim pack was comprised of a single 0.125-inch shim installed, and two 0.062 inch shims in a stored position. When not in use, (stored) shims were kept on the inactive face of the hub. These shims were split into 180-degree segments, to facilitate this storage. Use of these split shims has been superseded by the incorporation of the one-piece peelable shim.

Manufacturing tolerances, and the fact that the peelable shims are continuous uniform disks of material, eliminates the requirement for the peelable shims to be matchmarked and balanced with the coupling. This facilitates interchangeability and ease of installation and removal.

Matchmarks (10)
These are lines scribed across each flanged joint (hub to flex unit) when the unit is balanced. This is done to ensure that when the components are reassembled to these matchmarks, they will be in the same circumferential position as when they were balanced. When two or more flanged interfaces are used on one coupling, different matchmarks are used on each.

Puller Holes (11)
Two or more tapped holes are located on the flex unit side of the hub to provide a means of pulling the hub off the shaft.

Note: No puller holes are furnished on hydraulically installed hubs.

Rivets (12)
Used to position and retain the diaphragm guard to the diaphragm (Model 67, 87or 99 Fitted Bolt). These rivets should not be routinely removed in the field. Removal of the rivets should be performed at a Goodrich facility or by Goodrich Customer Support personnel.

Retention Bolts (13)
Retention bolts were used on earlier units to keep the piloted guard from being fully retracted off the diaphragm. New units do not have this because guards can be fully removed from the diaphragm for inspection purposes. NOTE: guard must go back in the same position it was prior to removing.

Field Balance Holes (Optional) (14)
A series of holes drilled and tapped in an axial direction in the hub, flange adapter face or the guard. These holes provide a location for field trim balance weights and are provided only on request.

Vent Holes (15)
Drilled into the hubs, flange adapters, and guards to permit condensate and dirt to escape from the cavity formed by the diaphragm and adjacent part.

Flange Adapters (16)
When a machine shaft end is flanged, a flanged adapter is used to connect the machinery flange to the coupling. These adapters are generally made of hardened alloy steel, and are meant to be maintained as part of the coupling.

A pilot is provided at the machine flange interface. The pilot fit is usually left to the discretion of the coupling designer. The tolerance may range from line-to-line, to several mils of interference, depending on the diametral size and application.

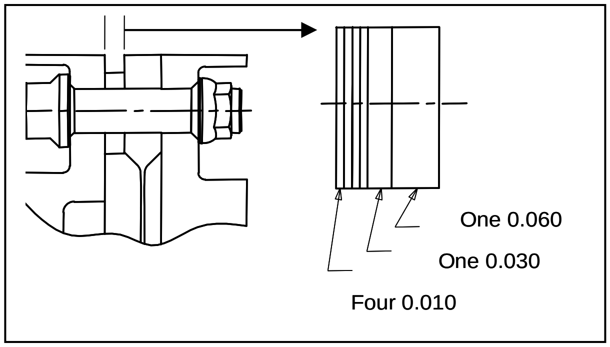


Figure 1-4 Peelable Shim

Pilots (17)
Sometimes called rabbets or spigots, pilot configurations consist of:

1. Male Pilot- A diametral land protruding from the flange face which is closely toleranced for size and concentricity.

2. Female Pilot- A diametral recess extending into the flange face which is closely toleranced for size and concentricity.

Jacking Holes (18)
Tapped holes (usually three) in the flange adapter or part, which are used for uniformly disengaging the pilot. Thread sizes have been selected so that common American National Standard threaded bolts, readily available on site, can be utilized.

The following terms refer specifically to the Goodrich Low Moment Coupling:

In certain rotating equipment trains the coupled machinery is very sensitive to the coupling's overhung weight (moment force due to coupling half-weight) applied at the shaft end. The Low Moment Coupling **(See Figure 1-6)** reduces these values by suspending the weight of the spacer section of the coupling farther back towards the machinery bearing than a standard coupling. The center of gravity of the half-coupling is moved away from the shaft end towards the machinery. The moment arm from the machine bearing is shorter, thus the overhung weight is decreased.

Wavy Diaphragm Profile (19)
The wavy contoured diaphragm profile has all of the design advantages of the straight contoured profile. The wavy profile has the additional advantages of a linear axial spring rate, and lower centrifugal and radial stresses within the profile. The sinusoid wavy shape is imposed over the same hyperbolic profile as our straight contour, adding additional material from the inner to outer rim. This added material maintains a linear spring rate over the range of axial movement, resulting in lower applied forces for a given displacement. In addition the wavy profile allows the inner and outer rim more radial freedom, without causing additional stresses on the profile. This is accomplished by the curling and uncurling of the wave shape, absorbing radial movement within the profile.

Low Moment Hub (20)
Used on the Low Moment Coupling design, the hub and diaphragm are machined from a single forging of AMS 6414 material. The one-piece construction requires the use of the wavy contoured profile. The wavy profile accommodates radial hub expansion experienced when mounting or removing the hub.

Antiflail Ring Guard (21)
Used on the Low Moment Coupling design, the purpose of these guards is to prevent the center spacer tube from flailing in the event of diaphragm failure.

Conical Flange (22)
Used on the Low Moment Coupling design, the conical flange is the member in which torque is transmitted from the diaphragm rim to the center tube section.

Self-Locking Plate Nuts (23)
Used on the Low Moment Coupling, these fasteners are attached to the conical flange with rivets.

Note: Do not use impact wrench tools to remove or install bolt hardware where floating lock nuts are used.

2.0 General Installation

Caution: Do not scratch, dent or otherwise damage the diaphragm profile.

To have trouble-free operation from any coupling, the installation of the coupling must reflect its intended use. Engineers have transmitted information about the equipment to Goodrich, where analysis of the coupling design takes place. In turn, a drawing is submitted for approval. This drawing not only contains engineering data necessary for the system analysis, it presents a dimensional picture of the complete coupling installation.

A coupling installation should not be attempted unless the following are available:

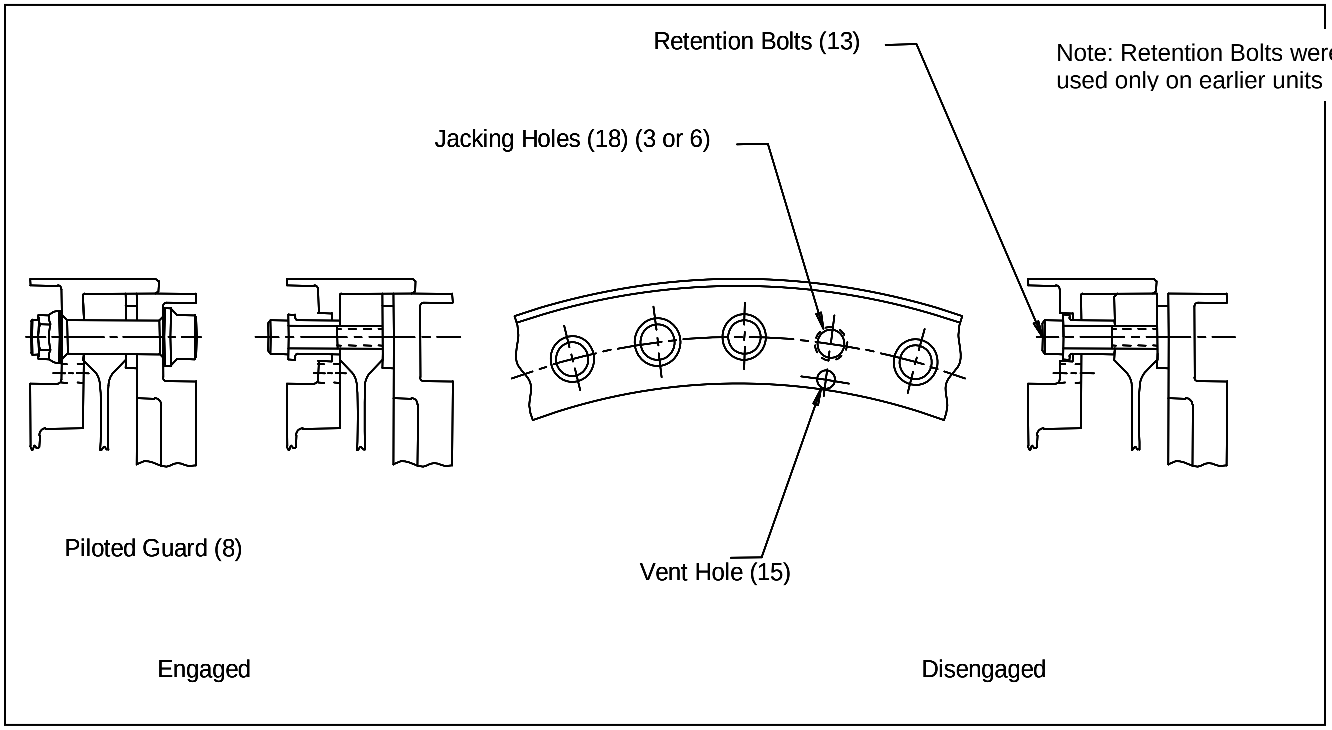


Figure 1-5 Piloted Guard Assembly

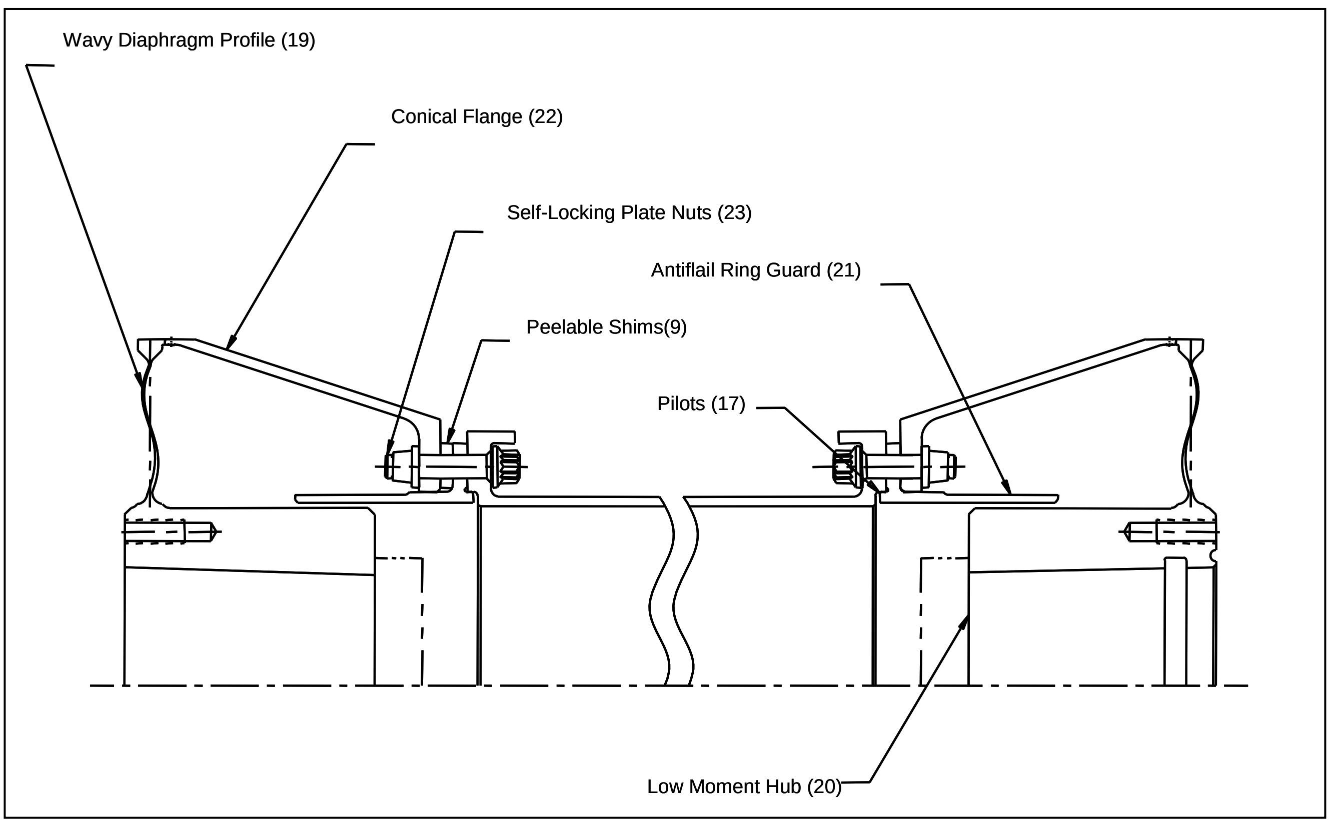


Figure 1-6 Low Moment Configuration

- Drawing of coupling installation
- Driving and load machinery manufacturers' installation instructions
- All coupling components:
  Hubs/Adapters
  Keys (if required)
  Flex Unit
  Set of Hardware
  Shims (If required)
- Hub installation tools and position plates
  See Figures 3-2 and 3-3
- Hydraulic installation tools (If required, refer to machinery manufacturer's manual for instructions)
- Suitable means of heating hubs such as electric oven or oil bath (if required)
- Alignment fixtures and measuring instruments in accordance with your standard practice
- Wrenches to fit bolts as called out on coupling drawing. Torque wrenches are required.

The following are major steps to be performed whenever any coupling is to be installed:

1. Check distance **B**etween **S**haft **E**nds (BSE) **See Figure 3-1**
2. Install hubs
3. Check flange runout
4. Check distance between flanges
5. Perform machine alignment
6. Install flex unit & shims as needed
7. Install coupling housings / guards
8. Final safety check

The installation of a coupling may be considered to fall under one of two categories: New Machinery Installations and Existing Machinery (Retrofit) Installations. This manual treats each category separately.

2.1 New Machinery Installation
If you are making an original installation of new machinery, perform the installation in the following order:

1. Install hubs on the driving and load machinery shafts per **Section 3.2.**
2. Align the machine in accordance with the machinery manufacturers' instructions and your own standard practice.
3. Space the machines axially to achieve the flange-to-flange gap as described in **Section 3.4.**
4. Install the coupling flex unit as described in **Section 3.7**

2.2 Existing Machinery (Retrofit/Changeout) Installations
If you **can move** the machines on their foundations to make axial space adjustments follow the instructions of **Section 2.1.**

If you **cannot move** the machines enough to make axial space adjustment, perform the installation in the following order

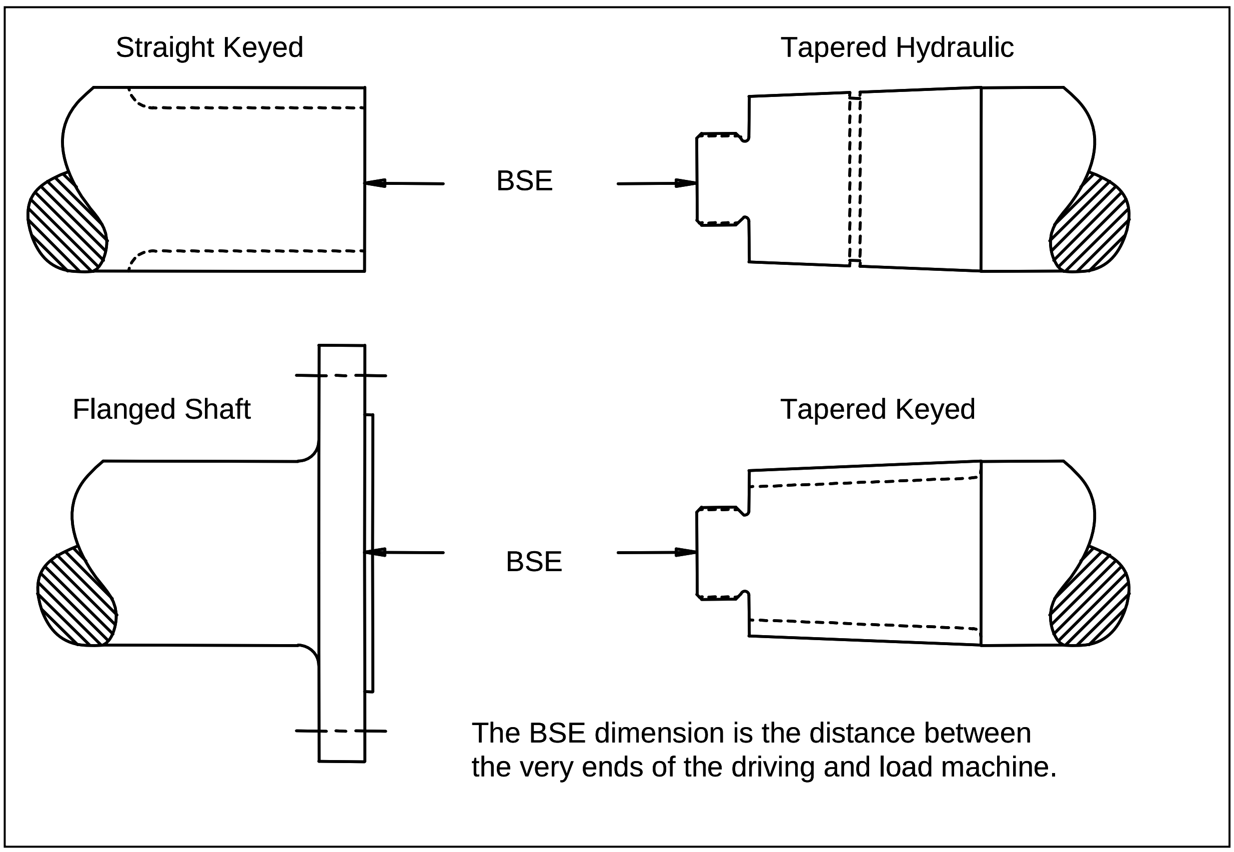


Figure 3-1 Typical Shaft End Combinations

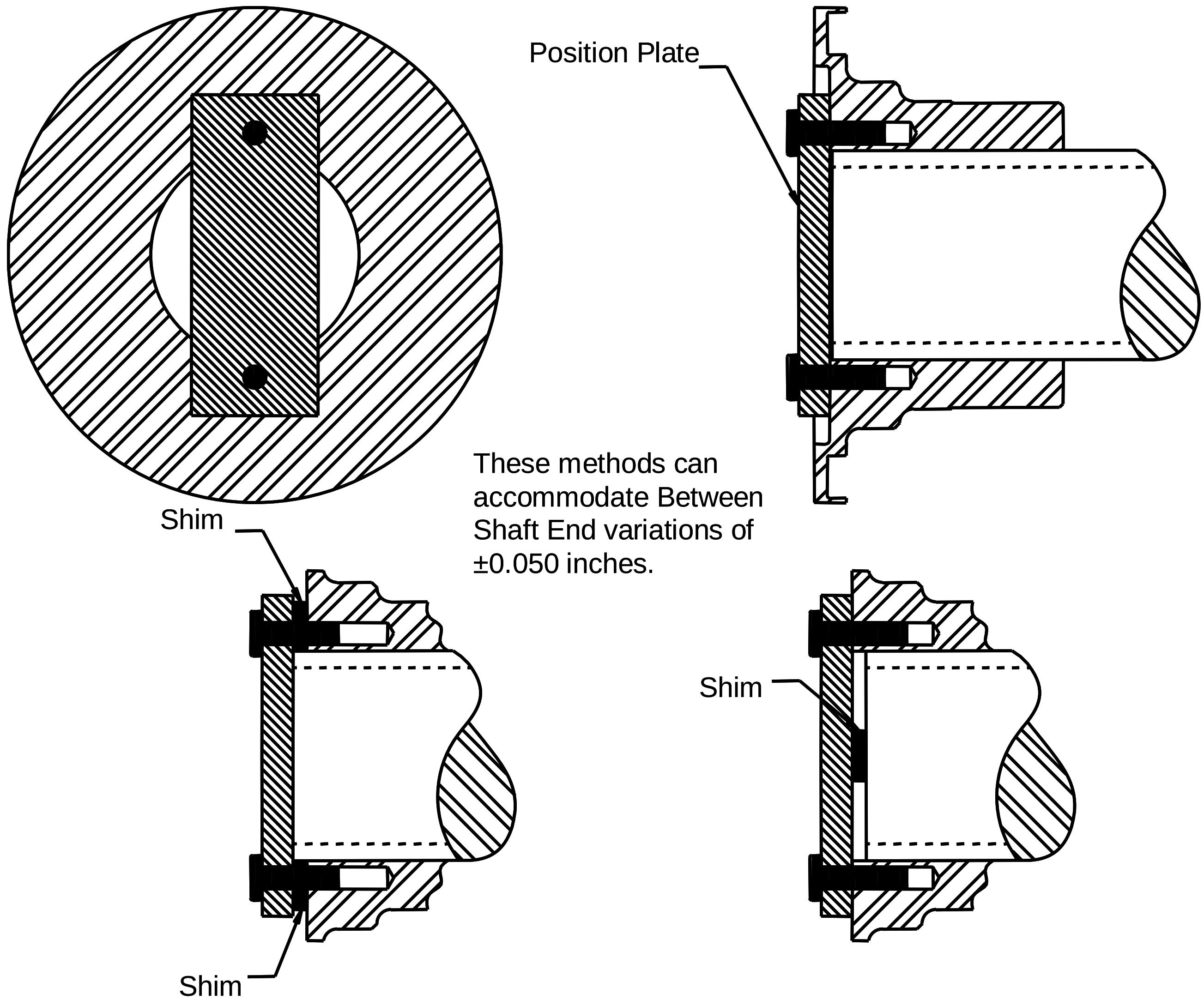


Figure 3-2 Hub Installation Straight Bore

1. Install and position the hubs as described in **Section 3.2.** Hub positioning and shimming, as described in **Section 3.4.2.,** is employed to achieve the proper flange-to-flange gap described in **Section 3.4.**
2. Align the machine in accordance with the machinery manufacturers' instructions and your own standard practice.
3. Install the coupling flex unit as described in **Section 3.7.**

3.0 Installation Detail

3.1 Check Distance Between Shaft Ends- BSE

As an initial step in determining the BSE dimension be certain to position the machinery rotors in their running position **(See Figure 3-1).** For example:

- Put thrust collars against the thrust bearing faces they will bear against during operation.
- Put double helical (herringbone) gears in the axial center of their mesh.
- Put motor rotors at their magnetic center.

3.2 Hub Installation

3.2.1 General Hub Installation

Hub installation is one of the most important steps to successful coupling operation. Care must be taken to ensure a proper fit.

Make sure that both the hub bore and shaft end are clean and free of burrs. Even a small particle trapped between the shaft and bore can cock the hub enough to make it unacceptable for use.

Most importantly, the use of positioning plates will ensure proper axial location on the shaft **(See Figure 3-2 and 3-3).**

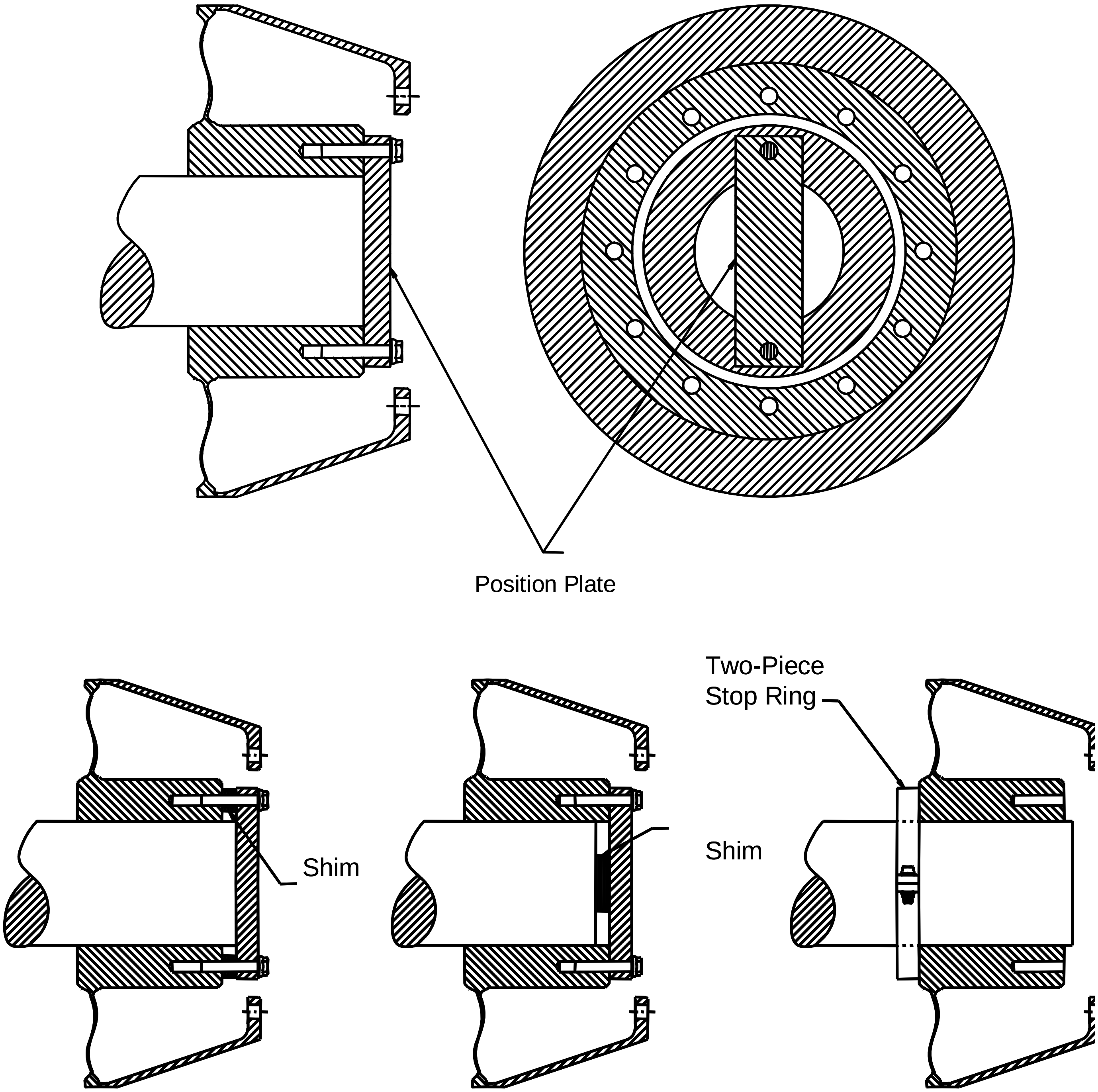


Figure 3-3 Hub Installation Straight Bore Low Moment Configuration

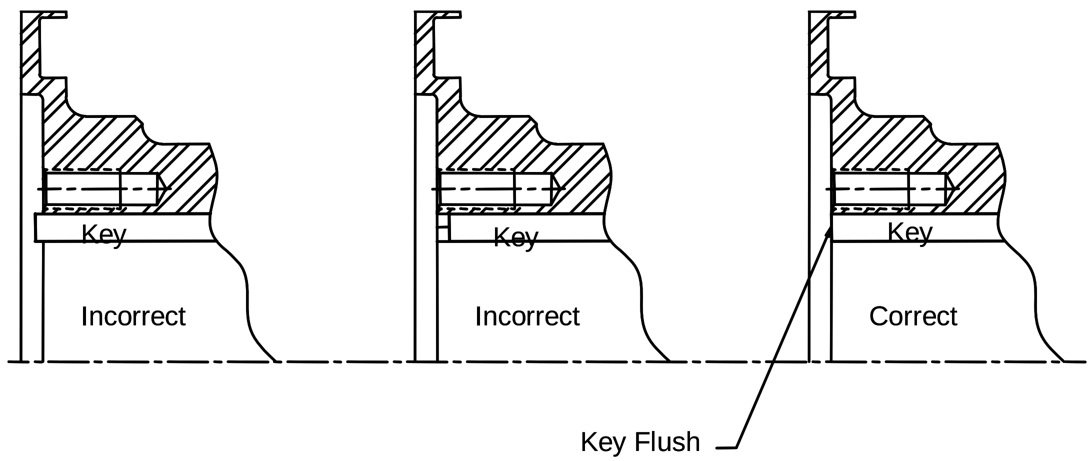


Figure 3-4 Keyway Installation

3.2.2 Straight Bore Hub- Keyed
A straight bore hub should have a stop positioned such that the end of the shaft will align with the proper reference face of the hub. A blocking bar, bolted to the hub using the puller holes, is most convenient. This will prevent protrusion of the shaft end during hub installation. **See Figures 3-2, 3-3, and 3-4.**

To minimize thermal distortion before installation, expand the hub by heating it evenly and thoroughly in an oven heater.

Insert the keys in the shaft to assist the hub in proper relative positioning. It is good practice to check key fit first. The key must exactly fill the keyway. There should be no key extension or recess.

If preliminary indications of BSE measurements show that there is a small variation between actual and theoretical distances, the positioning stop can be shimmed as shown in Figure 3-2, to reduce the amount of machinery relocation by ± 0.050 inch.

3.2.3 Tapered Bore Hub- Keyed
Installation of tapered bore hubs should also make use of a position plate and stop. **See Figures 3-5, 3-6 and 3-7**. The installation of tapered hubs requires them to be advanced up the shaft a short distance from an initial reference point. This is commonly referred to as pullup. A recommended pullup value is shown on the coupling drawing.

With the cold hub placed on the shaft, and a bar bolted across the flange face, an adjustable stop (perhaps a clearance hole with a bolt trapped by a nut on each side) should be set so that the distance between the end of the stop and the shaft end, is equal to the recommended hub pullup. In this manner, the hub may be expanded by gentle heating at 300°F and placed on the shaft end in a hot condition. Push the hub up the shaft until the position stop contacts the shaft end. This will assure proper pullup.

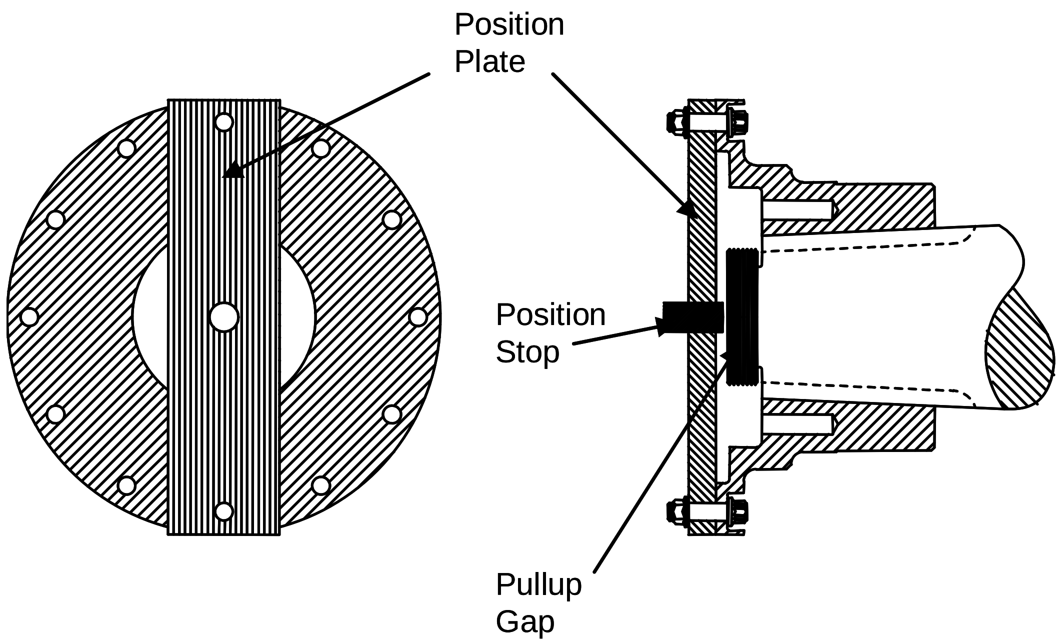
It is important that a correct hub pullup be maintained. Hub pullup tolerance as discussed in Section 3.2.5 may be used to accommodate minor variations of BSE/ flange-to-flange distance.

It is good practice to first try a cold hub, without keys inserted, to establish the pullup dimension. Also make certain that keys exactly fill keyway. There should be no key protrusion or recess. **See Figure 3-4**.

3.2.4 Tapered Bore Hub Hydraulically Fitted
The number of methods used to hydraulically mount hubs on shaft ends is as numerous as the equipment manufacturers in the industry. Each OEM has their own design philosophy regarding placement of o-rings, type of hydraulic fittings, and installation equipment. However, there are general guidelines that should be followed for proper installation.

- Set up hub, without 0-ring or backup ring, on the end of shaft and push it up hand tight.
- Measure the distance between the end of the hub and some stationary reference point on the machinery housing and set an axial position stop at a gap distance that corresponds to the correct pullup. Lock shaft in fixed position if necessary. **See Figures 3-8 and 3-9.**
- Remove hub and insert proper 0-ring and backup ring.
- Clean the o-rings and lubricate with the hydraulic fluid to be used. **Do not use vaseline, glycerine or other viscous lubricant.**
- Place hub back on shaft. Make certain that 0-rings and backup rings are properly seated.
- Attach all mounting equipment as called out in the machinery manufacturer's assembly manual. Measure the distance between the hub and the reference point on the machinery housing. Advance the hub to the same position that it was in when pushed hand tight without 0-rings. It is from this position that the hub must be pulled up the amount specified.

An initial advancing force must be applied to the hub before pressurizing the bore area. This will prevent the flexible o-rings from extruding between the hub and shaft. As the hub is moved further up the shaft, increase the dilation pressure accordingly 20,000 psi should be sufficient to achieve full advancement in most cases, but 40,000 psi may be applied to the hub with no adverse effects.



Position stop-to-shaft-end gap should be set to equal hub pullup at cold installation

Figure 3-5 Hub Installation Tapered Bore

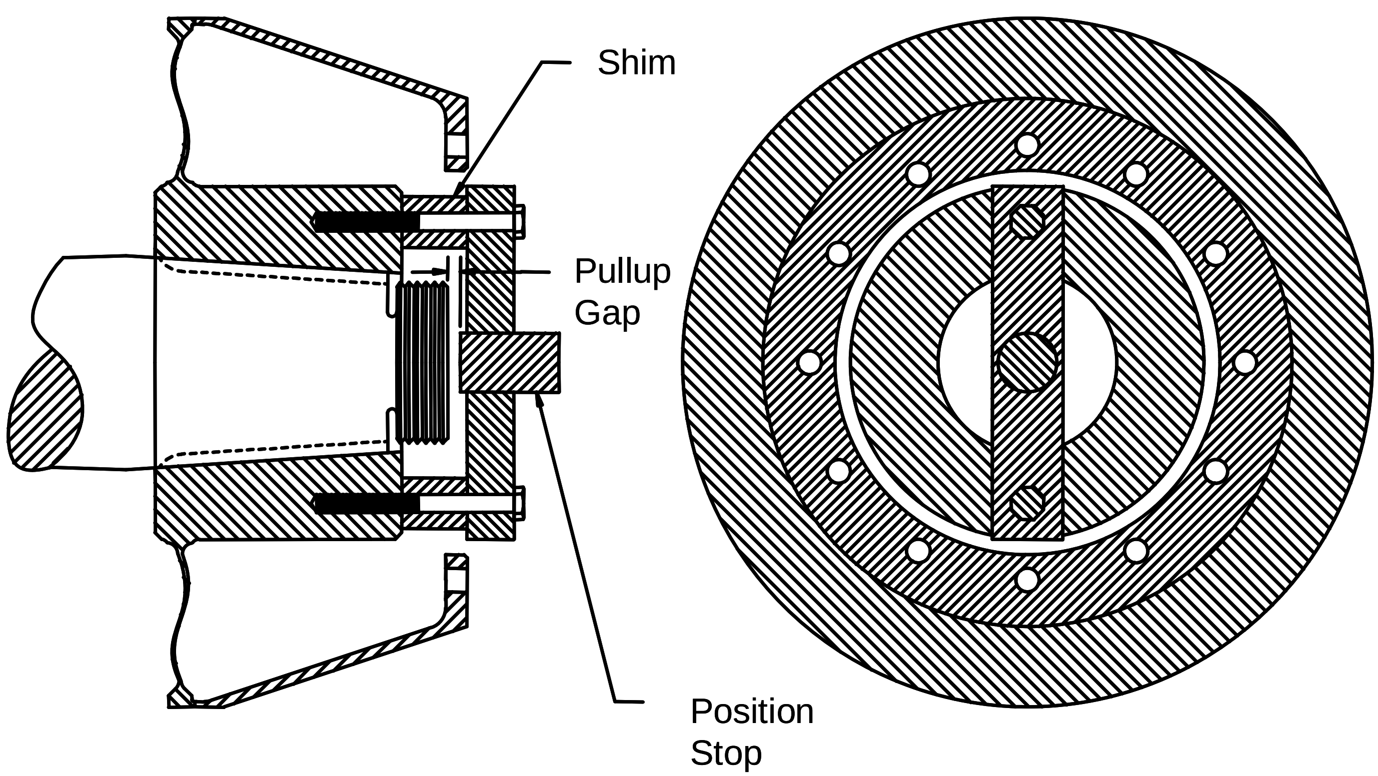


Figure 3-6 Hub Installation Tapered Bore Low Moment Configuration

When the proper pullup has been obtained, release the dilation pressure and continue to hold the hub on with the advancing equipment. After a minimum waiting period of 1/2 hour, remove the equipment.

It is important that a correct hub pullup be maintained. Hub pullup tolerance as discussed in **Section 3.2.5** may be used to accommodate minor variations of BSE/flange distance.

3.2.5 Hub Pullup

Correct hub pullup is critical to proper coupling installation. In the previous sections it has been noted that pullup maybe used to accommodate minor variations in BSE and/or flange-to-flange distance. This is the least preferred way of accomplishing this variation and should be employed only after attempts to move machinery or shimming **(See Section 3.5**) have been exhausted.

Caution: Under no circumstances shall pullup be less than the required amount.

The following criterion may be used when pullup other than that specified on the drawing is required. It must be recognized, however, that this is a Goodrich criterion based on a maximum interference which will still result in a safe hub stress. **It is not necessarily a value which will be approved by the machinery manufacturer.** It is therefore recommended that the machinery manufacturer be contacted prior to excercising this option.

The pullup criterion for Goodrich hubs which may be used to accommodate variations in BSE and flange-to-flange distance is 0.001 inch/inch of interference greater than that resulting from the recommended pullup listed on the drawing. **This value must be treated as an absolute maximum.** Always use a reference stop as shown in **Figures 3-8 and 3-9.**

Pullup Example

Shaft: 4 inch hydraulic, taper 0.750 inch/foot
Pullup recommended by drawing: 0.128 inch
Resulting interference: For 0.750 inch/foot taper, 0.016 of axial movement increases interference by 0.001 (a ratio of 16/1).
Therefore, 0.128 inch of pullup ÷ 16 = 0.008 inch of interference or 0.008 inch of interference ÷ 4 inch shaft diameter = 0.002 inch interference/inch shaft diameter.

This then is the machine manufacturer recommended interference fit.

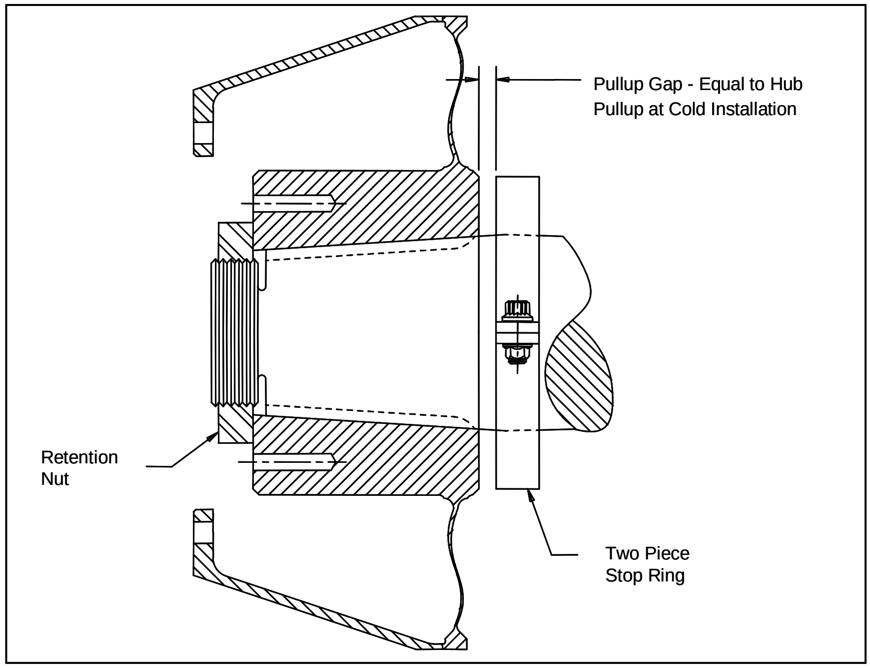


Figure 3-7 Hub Installation Tapered Bore Low Moment Configuration

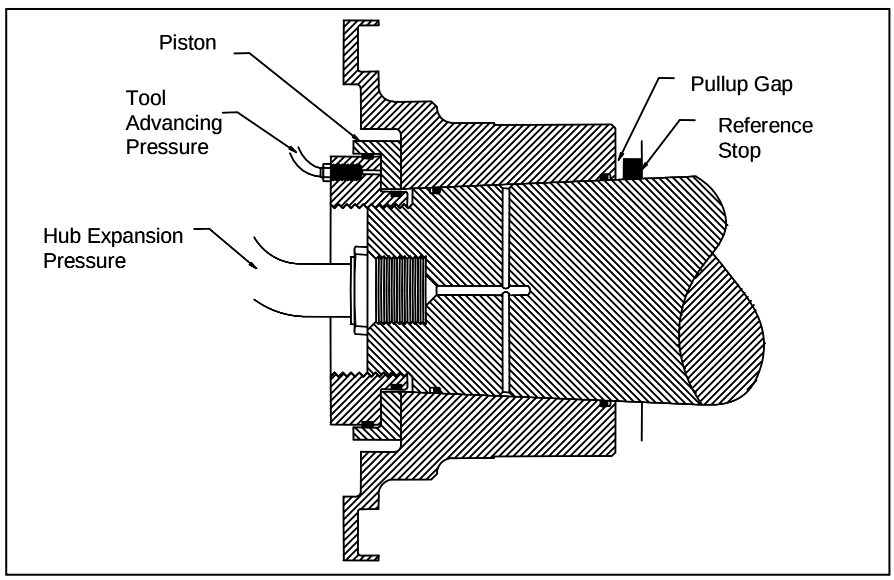


Figure 3-8 Typical Hydraulic Hub Installation Using Shaft Pressure Port

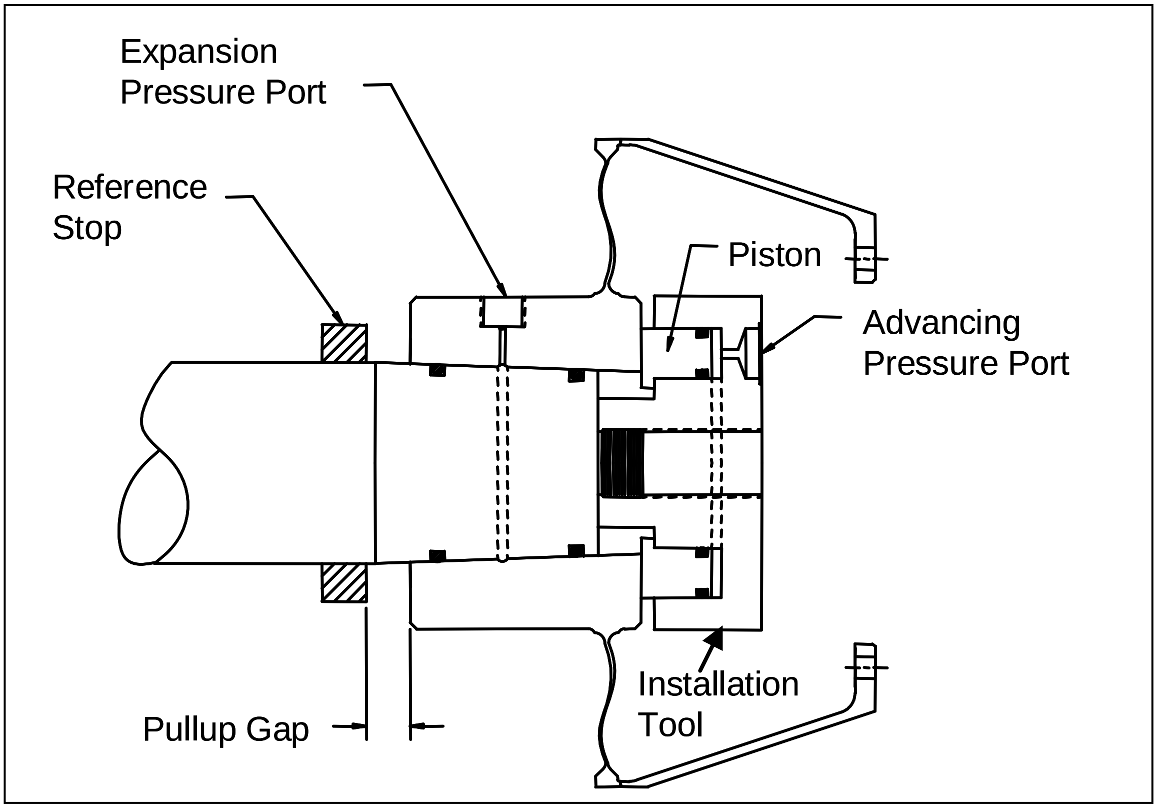


Figure 3-9 Typical Hydraulic Hub Installation Low Moment Configuration Using Hub Pressure Port

When shaft pullup is not specified; the following formula may be used to calculate this value:

$$\frac{\text{Shaft Diameter (Inch)} \times \text{Desired Interference}^* \times 12}{\text{Shaft Taper (Inch Per Foot)}}$$

Goodrich Corporation Criterion
The stated Goodrich Corporation criterion permits increase of this interference fit from 0.002 to 0.003.

The resultant maximum pullup for accomodation then becomes:

0.003 x 4 x 16 = 0.192

3.3 Check Flange Runout
In order to ensure proper hub fit, the relationship between the rotating flange faces and ground should be established. Using a dial indicator, measure the runout of both the bolting face and external flange of the hub. The eccentricity should not be greater than 0.002 inches TIR, but for couplings greater than 16 inches in diameter, this tolerance should be relaxed to 0.004 inches TIR. **See Figure 3-10.**

*** Inch per inch of shaft diameter**

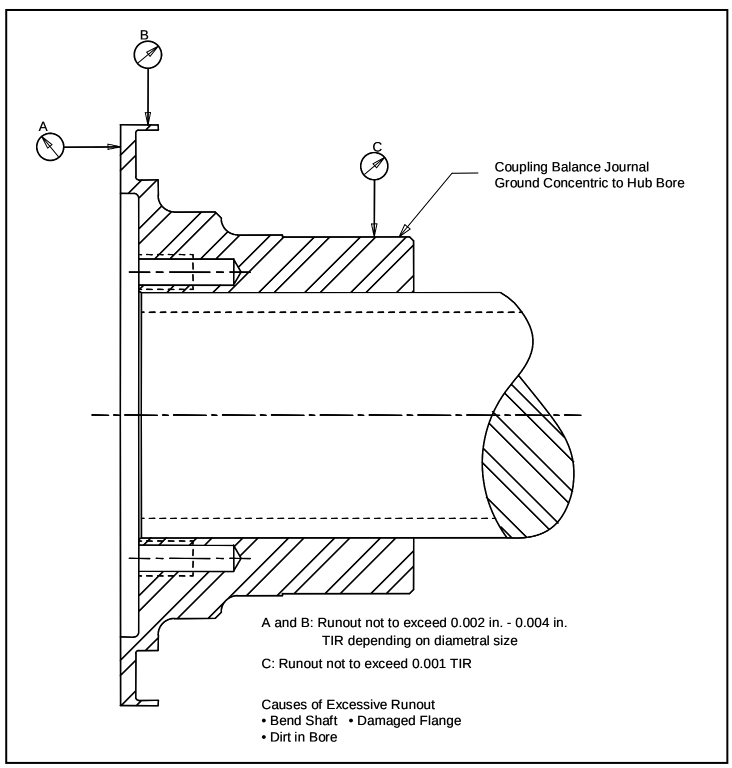


Figure 3-10 Measurement of Runout

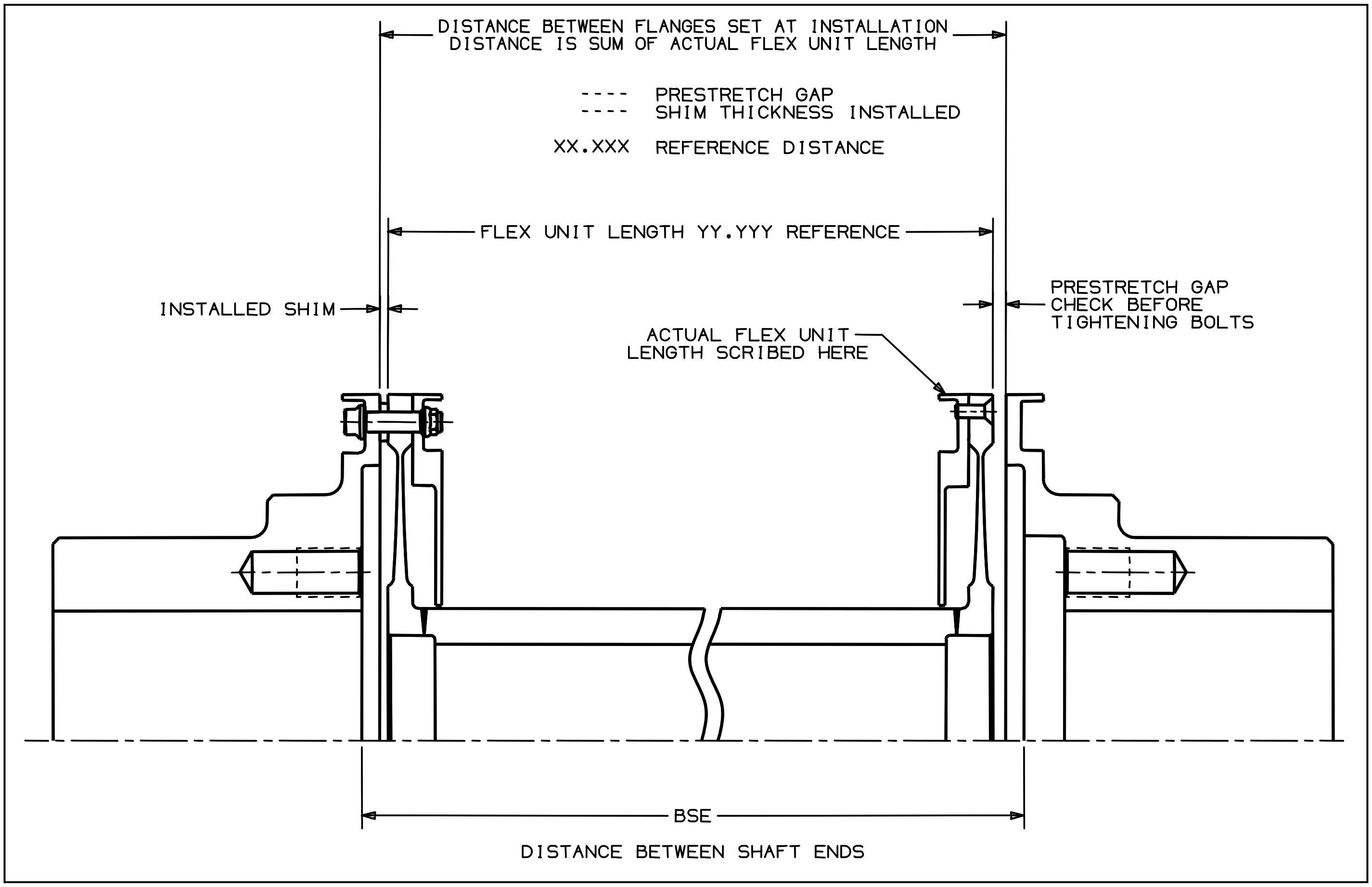


Figure 3-11 Installation Drawing

If the hub runout is excessive, installation of the hub may be the cause. Dismount the hub **(See Section 6.1.3)** and inspect the bore, keys and keyways. Remount and establish new data. If the problem still exists, there are two other possible causes. The hub flange may have been damaged or the shaft may be slightly skewed. If there are indications that there is damage to the hub, return the entire coupling to Goodrich Corporation.

3.4 Check Distance Between Flanges

With both hubs properly installed on the shafts, the distance between the two bolting faces on the hubs must be recorded. Several readings should be taken in different areas around the flanges and a mean dimension established. This dimension should correspond to the installation gap shown on the drawing within ± 0.015. **See Figures 3-11 and 3-12.**

It is important that this dimension be established with the shafting set in their continuous operating positions. All thrust bearings must be set on their active faces, motor and generator rotors should be on magnetic center, and double helical gears on center mesh. Otherwise, the coupling will not be operating at the axial deflection position determined by the manufacturer.

3.4.1 New Machinery Installation

For new machinery installations, with all shafting in proper position, adjust machinery location to achieve the designated flange-to-flange dimension.

Note: Do not alter arrangement of shims from that shown on the coupling drawing. Shims are intended for use on future rotor changeouts and retrofit installations.

The proper use of shims is discussed in **Section 3.5.**

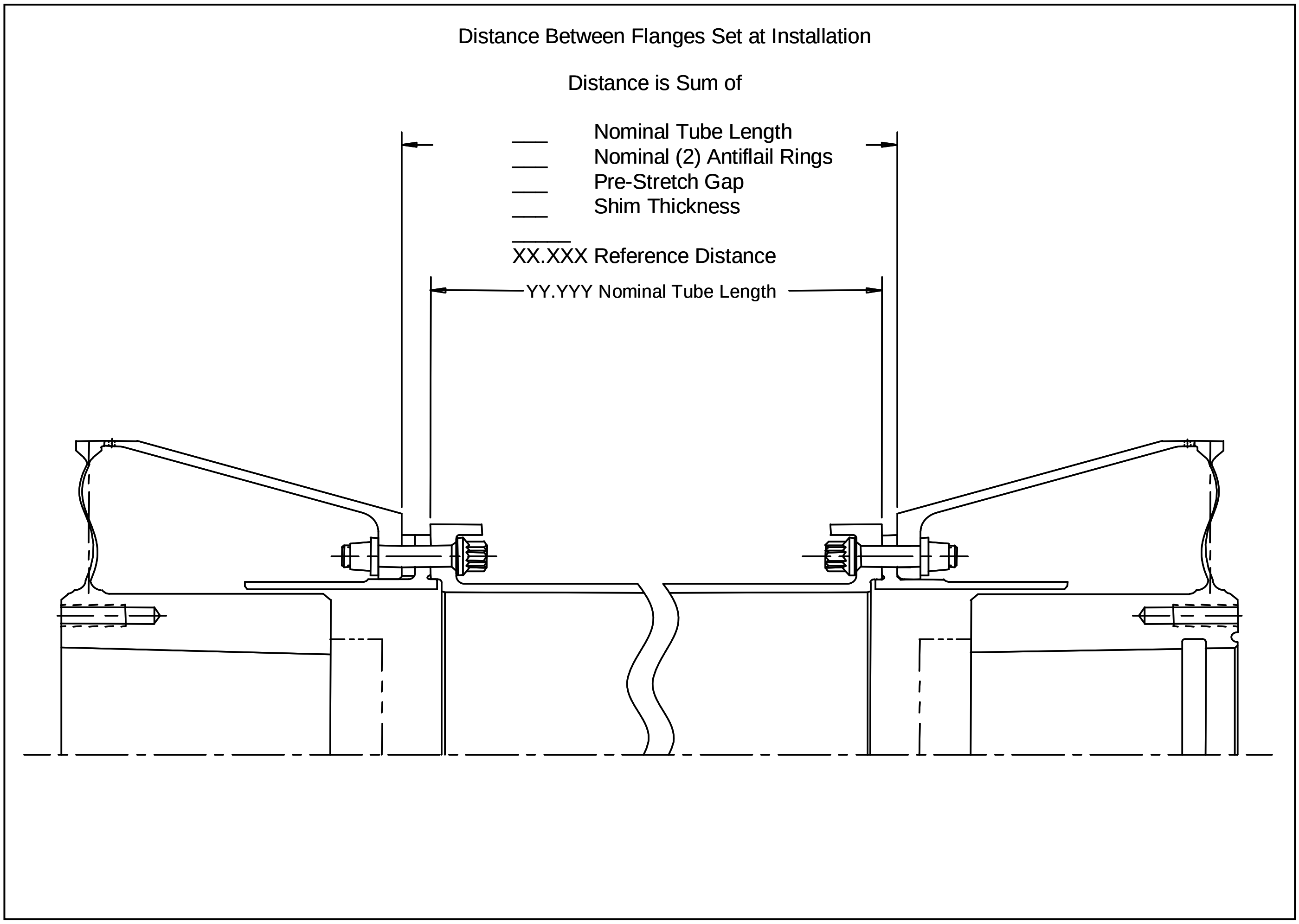


Figure 3-12 Installation Drawing Low Moment Configuration

3.4.2 Existing Machinery (Retrofit/Changeout) Installations
These installations are classified as those where the machinery cannot be moved to make axial space adjustments.

3.4.2.1 Straight Keyed Shafts
For couplings involving one or more straight-keyed shafts you may adjust hub position on the shaft to set the flange-to-flange gap. For this reason shims are not provided with couplings having hubs with straight-keyed bores at both ends (unless requested). Installation of straight bore hubs is discussed in Section 3.2.2.

3.4.2.2 Tapered Shafts-Keyed or Hydraulic
For couplings involving tapered shafts shims are provided to accommodate variations in flange-to-flange distance.

Note: When dealing with a combination of tapered and straight shafts, always install hub on tapered shaft first with correct pullup. Then position hub on straight shaft to achieve desired distance between flanges.

3.5 Shims
The intent of shims is to provide a means of making axial adjustments within the coupling assembly. They are primarily intended for adjustments required after the machines are in place. These axial adjustments are more likely to occur in retrofit/changeout installations. Tolerance variations can cause difficulties in maintaining the proper BSE. Shims can be used to obtain the correct adapter-to-adapter spacing dimensions, even though the BSE is not to specifications.

A typical Goodrich shim set installation is comprised of one 0.060-inch shim, one 0.030-inch thick shim, and four 0.010-inch thick shims. A total adjustment capacity of plus or minus 0.130 inches is provided for by the removal of active shims or the addition of spare shims on the opposite end of the flex unit

The opposite end of the flex unit is specified, because the shim thickness affects the bolt thread length. Adding the spare shims on the active side, instead of the opposite end of the flex unit, can cause the self-locking feature of the nut hardware to be compromised. This may eventually cause the nut to become disengaged from the bolt threads.

DO NOT:

- **Grind shims to achieve thickness variations**
- **Store peelable shims on the hub, or guard side of the coupling**
- **Install spare shims to decrease prestretch gap on the same side of the coupling as the active shims**

3.5.1 Shimming Technique
Figures 3-13A and 3-13B and Figures 3-14A and 3-14B depict two typical examples of manipulating shims. **Figures 3-13A and 3-13B** cover a situation where the mounted adapters for the coupling flex unit are too close together to ensure the proper pre-stretch gap. **Figures 3-14A and 3-14B** exemplify an installation where the mounted adapters are too far apart to maintain the pre-stretch gap shown on the coupling drawing. **See Figures 3-11 and 3-12**.

Do not stack additionally added shims at one end of the coupling.

Installation of shims to maintain prestretch, as in **Figures 3-14A and 3-14B** should be done on the end of the coupling opposite to the location of the 0.130 inch active shim pack.

3.6 Perform Machine Alignment
The first step in system installation is to align the machinery shafts. The alignment goal should be to provide the best possible alignment at the continous operating condition. Data should be provided by the various equipment manufacturers in order that the proper alignment compensations may be made to accommodate the difference between the cold state position and the stabilized position following thermal shift.

An alignment check should be performed in accordance with the machinery manufacturer's instructions or your own standard practice. It is important that this check of alignment be 3-dimensional and includes the vertical, horizontal, and axial planes.

During initial installation always move the machinery to achieve desired positions.

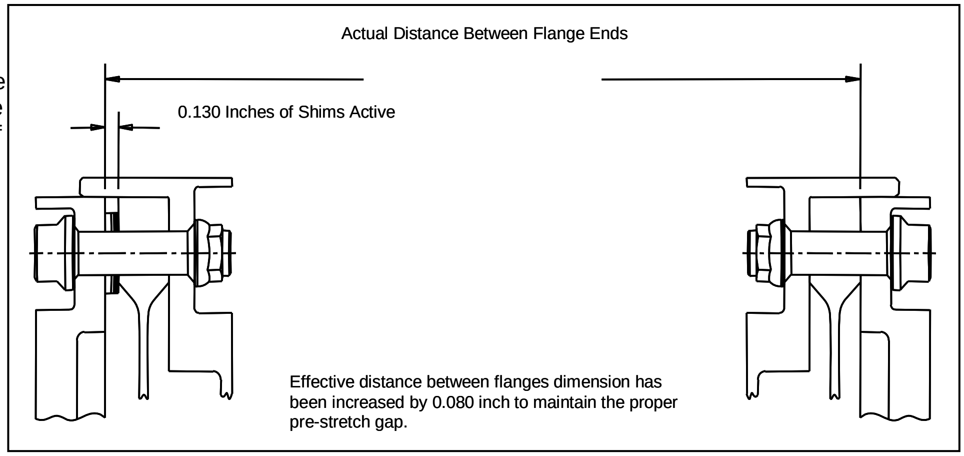


Figure 3-13A Active shim thickness has to be decreased by 0.080 inch to maintain the proper pre-stretch gap. The actual distance between flanges (hub faces) set at installation was less than the value referenced on the coupling drawing.

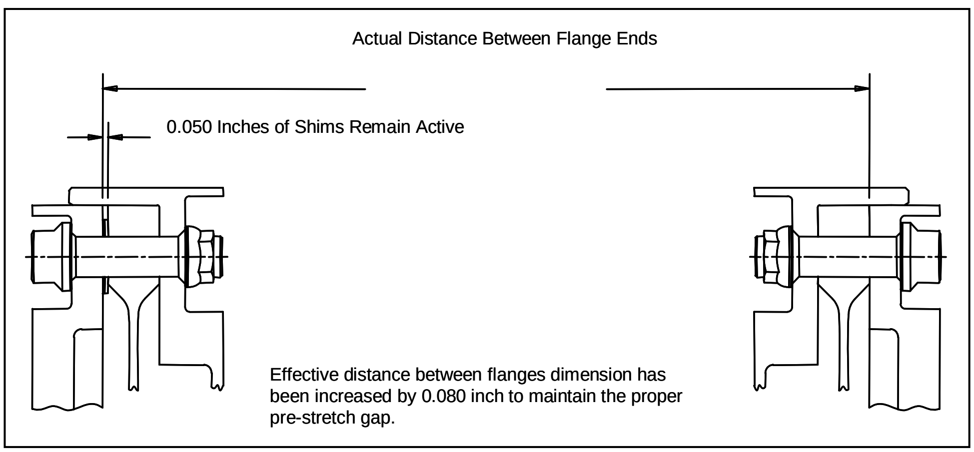


Figure 3-13B shim Manipulation – Remove one 0.060-inch shim and two 0.010-inch shims, which were previously active and store as spare parts for future use. (0.050 inch of peelable shims remains active, one 0.030-inch shim and two 0.010-inch shims.)

3.7 Install Flex Unit of the Coupling

With the machinery set in the proper location, the flex unit can be installed. The following sections explain installation procedures peculiar to the different models called out.

3.7.1 Pre-Stretch

Proper prestretch is critical to satisfactory coupling performance, and must not be overlooked when installing a coupling. Prestretch is established by Goodrich based on data compiled and submitted by the equipment manufacturer. It is the result of the axial thermal growth studies performed by the machinery manufacturers for the equipment located on either end of the coupling. Ideally the prestretch gap is set to accommodate the thermal growth which occurs during steady state continuous operation. This is done so that the coupling diaphragm will run in a null position when the equipment has stabilized. Of course, diaphragm sizing and development of pre-stretch gap dimensions must give consideration to worst case transient conditions as well.

3.7.2 Measurement of Pre-Sretch

The Goodrich drawing will call out dimensional information for the flex unit installation. **See Figures 3-11 and 3-12.** The difference between the flange-to-flange dimensions set at installation and the sum of the actual flex unit length and the active shim thickness is labeled **Pre-Stretch. See Figure 3-15.** With one end of the coupling bolted tight and the other loose, the pre-stretch gap should be measured using feeler gages. With everything properly positioned, the average of four measurements (12, 3, 6, 9 o'clock) of pre-stretch gap should be within +/- 0.015 inch of that shown on the drawing.

If there is a difference in gap dimensions, use the provided shims, or move the machinery axially to adjust. Otherwise, bolt up the other end of the coupling using a couple of turns at a time on the rim bolts in sequence. **Check: Are the matchmarks aligned?**

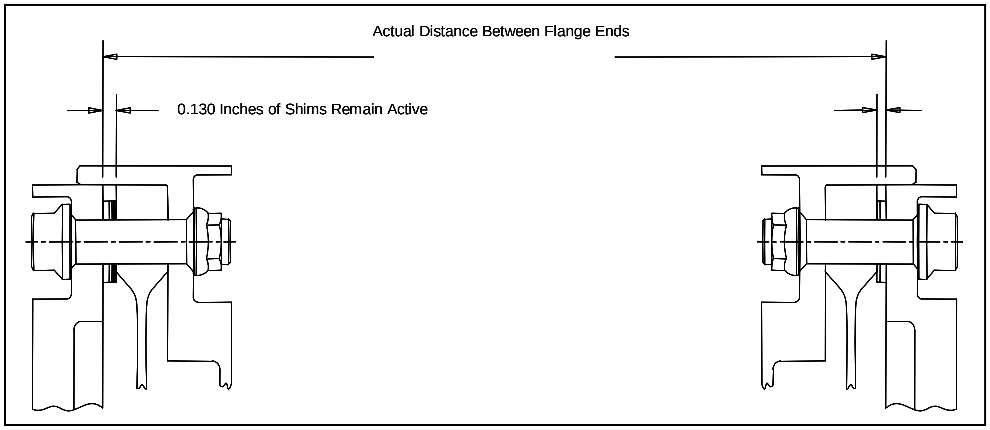


Figure 3-14A Active shim thickness has to be increased by 0.090 inch to maintain the proper pre-stretch gap. The actual distance between flanges (hub faces) set at installation was greater than that stated on the coupling drawing.

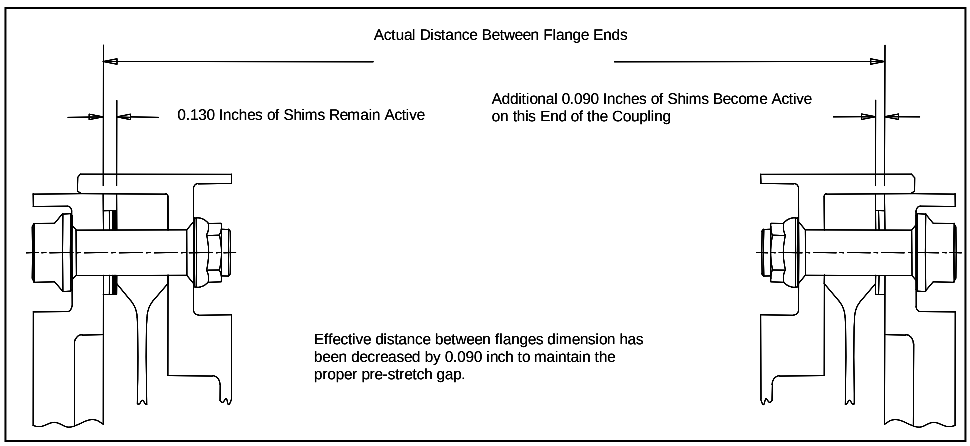


Figure 3-14B Shim Manipulation – Install one 0.060 inch and one 0.030-inch shim from the spare peelable shim pack. Install these on the end of the flex unit opposite to the location of the active shim pack.

(One 0.130 inch shim pack is active on one end of the coupling and 0.090 inch of shims are active on the other end of the coupling. Remove any unused shims from the installation and store for future use as spare parts).

3.7.3 Proper Installation of Bolt Hardware

For standard configuration couplings as covered by this manual, always install bolts from the hub side of the assembly. **See Figure 3-16**. Installing the bolts from the hub side, with the nut against the guard ensures a proper fitted bolt pilot between all members. Remember, the fitted bolt pilot controls balance repeatability of the assembled coupling.

3.8 Model 67/87/99 Fitted Bolt

Making sure that the matchmarks are aligned, bolt up one end of the coupling using the provided hardware. The remaining bolts should be used to position the other end of the coupling. Check the prestretch gap. See Section 3.7.1 and Section 3.7.2. If the measured dimension is within limits, bolt up the other end of the coupling by performing a couple of turns at a time on the rim bolts in sequence.

3.9 Model 74/88/100 Piloted Guard

Align the matchmarks of the coupling and bolt up one end of the flex unit using the provided hardware. To engage the pilot over the hub of the coupling, it may be necessary to use slave bolts in a minimum of six equally spaced positions around the rim of the coupling hub.

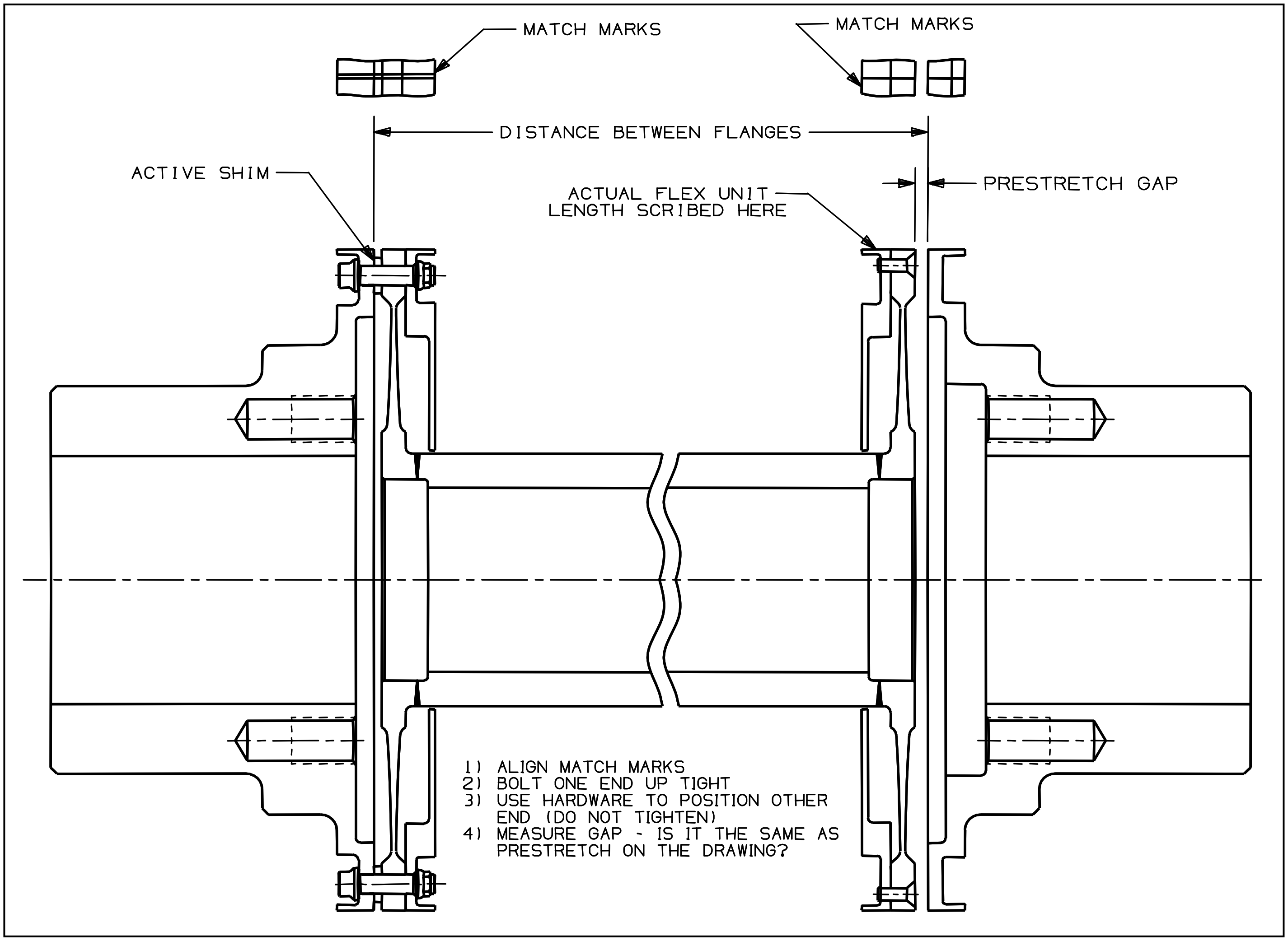


Figure 3-15 Coupling Installation Pre-Stretch

By making a couple of turns at a time on each slave bolt in sequence, the piloted guard will become engaged on the hub. The remaining standard hardware should now engage the piloted guard. The standard bolts should be used in the same manner, to draw the piloted guard to its final position. Once the standard hardware is utilized the slave bolts should be removed and replaced by the provided coupling bolts. The remaining bolts should be used to position the other end of the coupling.

Once the bolts are fully tightened, check the prestretch gap. **See Section 3.7.1 and Section 3.7.2.** If the measured value is within limits, bolt up the other end of the flex unit using the previously outlined procedures.

3.10 Model 70 Low Moment (Conical Flange Design)

Because of the unique features associated with the conical Low Moment Coupling, certain aspects of installation are expanded upon in this section.

3.10.1 Diaphragm/Hub Installation

For the Low Moment Coupling, the diaphragm/hub is one piece of continuous wrought material. Installation of the diaphragm/hubs is critical to achieving the proper coupling prestretch, and shaft-to-hub interference.

Procedures outlined in **Section 3.2** should be referred to for installation of the diaphragm/hub adapters.

3.10.1.1 Diaphragm/Hub- Conical Flange Assembly

The diaphragm/hub assembly of the Model 70 Conical Low Moment is actually comprised of two separate parts. These are the one-piece diaphragm hub and the conical flange. The conical flange is electron beam welded to the rim of the diaphragm hub. Goodrich Corporation' expertise in this type of rim welding enabled the elimination of a weld between the profile flexing element and rigid hub. The design criteria employed favored the transmission of torque along a smoothly transitioned path at the diaphragm to hub juncture to avoid any possibility of increased stress concentrations.

3.10.2 Coupling Assembly

Once the diaphragm/hubs are installed, and the distance between the bolting faces checked, the remaining antiflail ring guards, shims and center tube can be installed.

3.10.2.1 Antiflail Ring Guards

These guards serve the purpose of antiflail protection in the remote event of diaphragm failure. If the diaphragm completely fails, the torque path through the coupling is compromised. The antiflail ring guard is designed to allow the damaged shaft/hub juncture to remain in horizontal and vertical relation to the tube and other diaphragm/hub. Vibration, trip or other failure sensors should cause the driver equipment to shut down. The damaged coupling will then coast down with the antiflail ring guard maintaining the remainder of the coupling in radial location

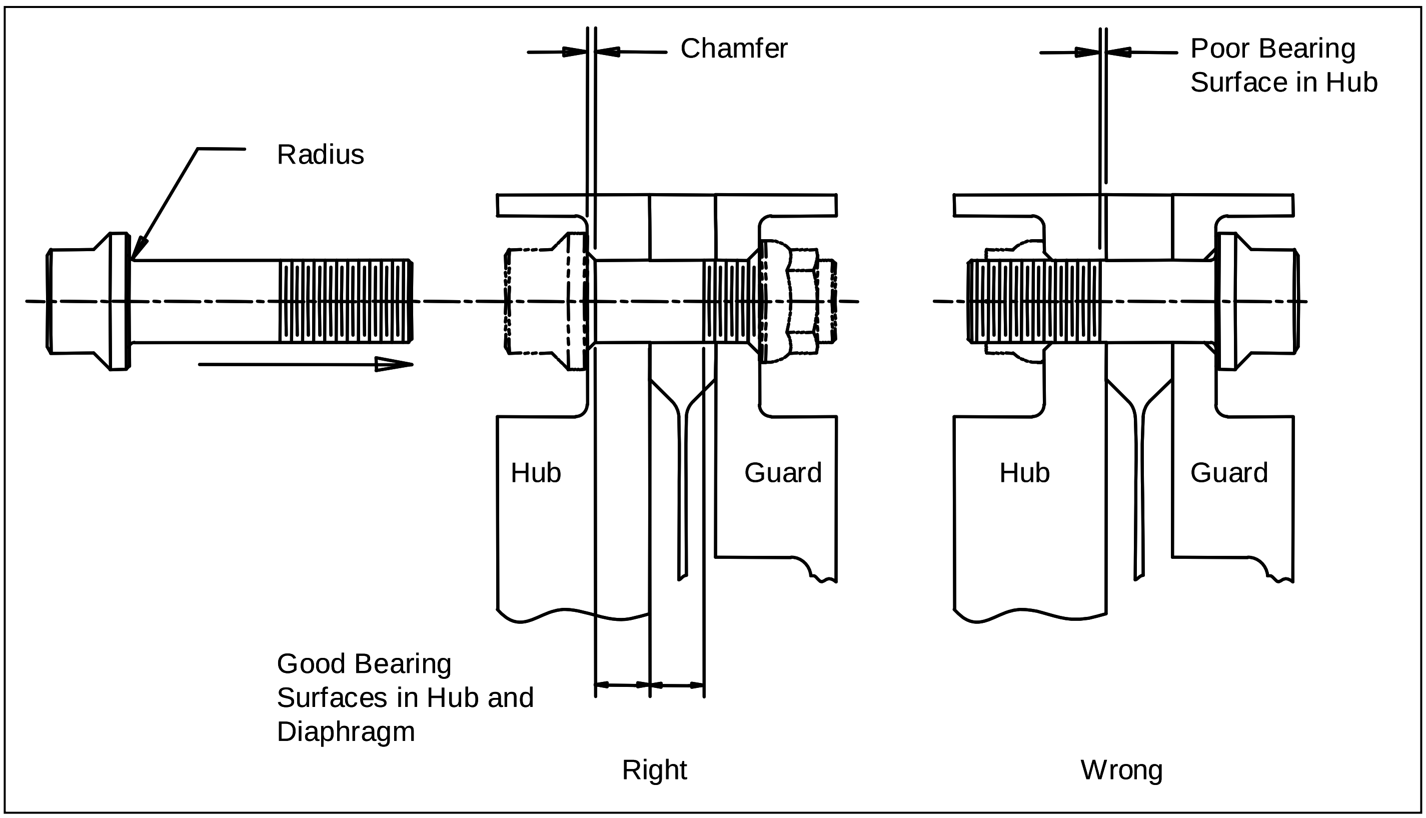


Figure 3-16 Proper Installation of Bolt Hardware

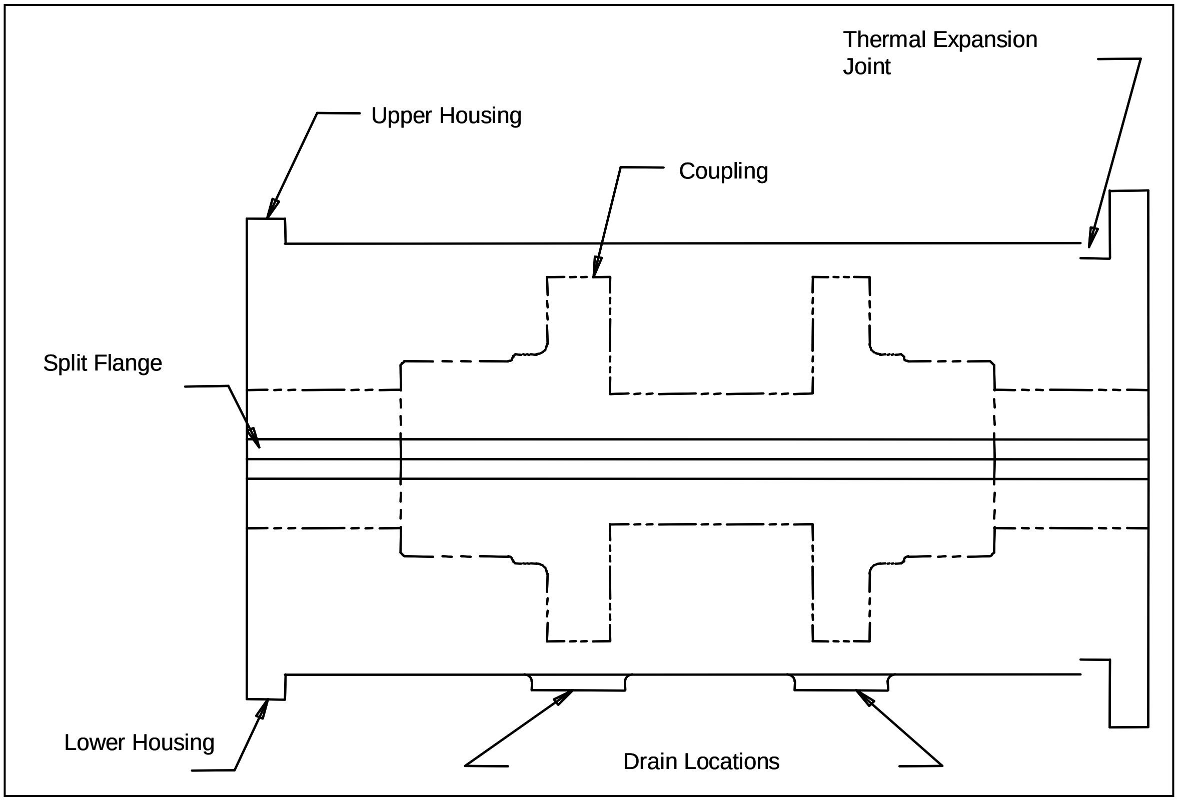


Figure 4-1 Typical Coupling Guard

3.10.2.2 Peelable Shims

The shims provided with the Model 70 Low Moment Coupling are similar to those previously described in Section 1.11 and Section 3.5. They are utilized in the same manner. The different feature is that the peelable shims are split into 180-degree segments for installation between the antiflail ring guard and the conical flange at assembly. The installation procedure for the Low Moment Coupling requires the split peelable shims for adjusting the prestretch gap of the coupling.

3.10.2.3 Center Spacer Tube

The center tube section of the Low Moment Coupling is connected to the diaphragm/hub, antiflail ring assembly by means of a bolted joint. The tube-to-hub juncture incorporates a male pilot on the antiflail ring and a female pilot on the center tube. The use of the pilots ensures correct positioning of the tube upon successive assemblies and disassemblies.

3.10.3 Antiflail Ring Guard, Shim, and Center Tube Installation

The antiflail ring guards, shims, and center tube for the conical Low Moment Coupling are installed in the following manner:

- Position the antiflail ring guards in the diaphragm/hubs using the supplied hardware as a guide. On one end of the coupling, tap the guard lightly around the outer rim with a soft mallet to completely engage the hub-guard pilot. Position the other guard loosely within the hub pilot.
- The combination of prestretch and uninstalled active shims should provide enough clearance to allow the center tube to be inserted between the guards, and located against the fully piloted antiflail ring guard.

Bolt up this end of the coupling using a couple of turns in sequence on the provided hardware. This is done to gradually engage the antiflail ring tube pilot.

- The other loose antiflail ring guard can then be positioned against the center tube section, and the tube-to-guard pilot engaged on this end of the coupling.
- It should now be possible to insert the split peelable shims between the coupling diaphragm/hub and antiflail ring guard. To install the complete split shim pack, it may be necessary to push back uniformly on the conical section, to provide clearance. **See Section 3.10.4. Be careful not to overstress the diaphragms by using too much axial deflection.**

3.10.4 Installation Tooling

In some coupling designs, the use of special diaphragm deflection tooling is called out on the coupling drawing. This tooling is used to uniformly spread the diaphragms apart to accomplish two procedures. The first is to provide clearance for the center tube and shims when installing the coupling. The second is to provide space to disengage the center tube pilots when disassembling the coupling. Once this is done the center tube can be installed or removed easily.

4.0 Coupling Housing

Installation of the coupling housing is the final physical step in coupling installation. The design of the coupling housing is the responsibility of the prime equipment contractor. Basically a housing is a split flange barrel-like assembly comprising a lower and upper section. A thermal expansion joint is provided to accommodate axial movement between machines. Ideally drains will be placed in the vicinity of the coupling hub flanges to preclude the accumulation of oil at these locations should machine leakage occur.

When the envelope surrounding the coupling is limited and housing size is restricted, the inside surface of the housing may be in close proximity to the coupling hub flanges. For certain applications where coupling rotation speed is relatively high, heat may be generated due to windage. This temperature rise should be of no concern to the user for it will in no way affect coupling performance.

The graph depicted below is offered as a guide in predicting the equilibrium temperature within the coupling housing. These data assume that all horsepower loss converts to heat, which must be convected and radiated from the coupling housing outside diameter surface only.

Certain equipment manufacturers and users prefer to preclude any appreciable temperature rise due to windage and elect to continuously spray the inside of the housing with an oil mist. This is perfectly acceptable.

As a last measure before bolting the upper half of the housing in place always check for running clearance over all areas of the coupling

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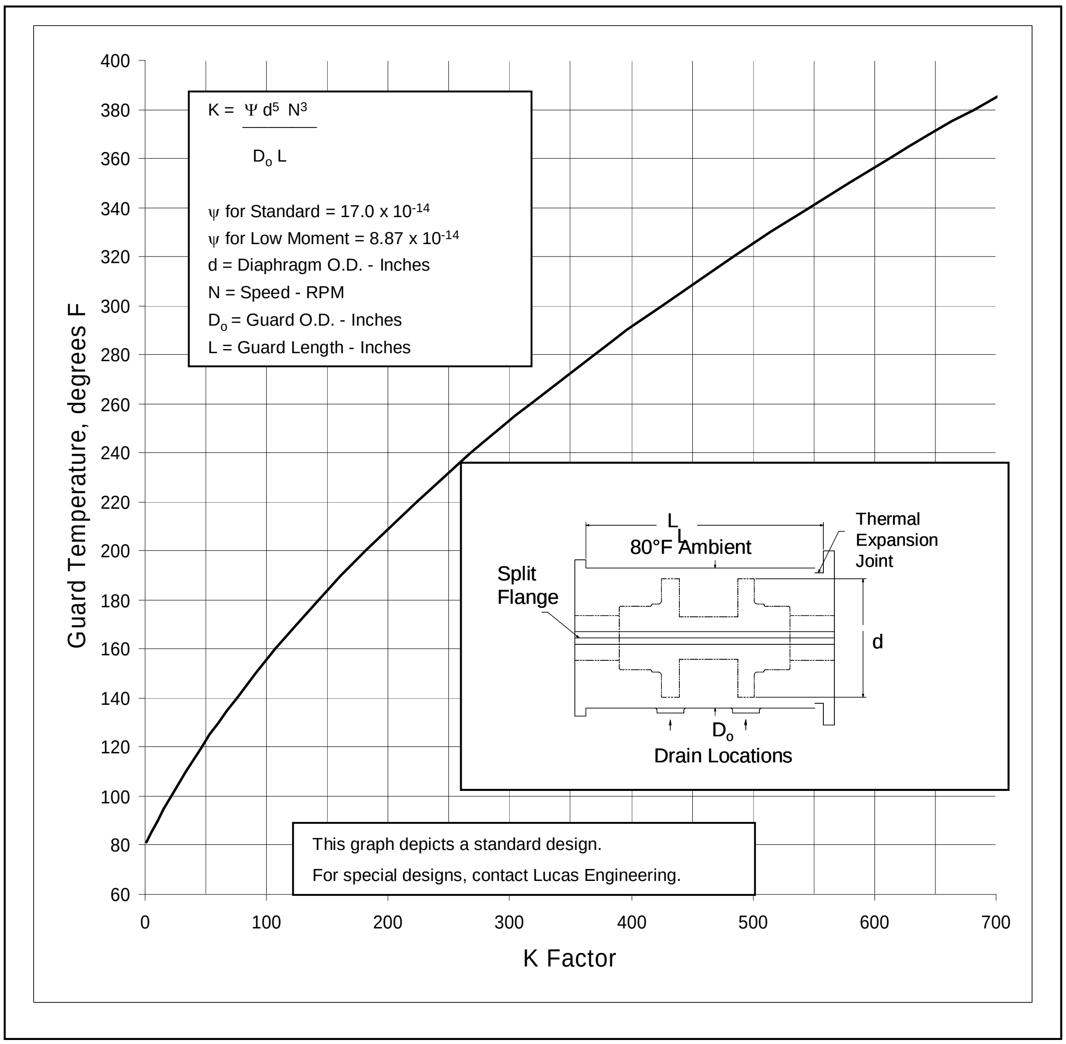

Figure 4-2 Temperature Calculations for Coupling

This graph is offered as a guide in predicating the equilibrium temperature within the coupling housing. These data assume that all horsepower loss converts to heat which must be converted and radiated from the coupling housing outside diameter surface only.

Temperatures over 300°F will degrade the paint of the coupling. Contact Goodrich Corporation Engineering for assistance.

5.0 Final Safety Check

Prior to starting the equipment, review all installation records to be satisfied that everything is correct. If there are any doubts regarding the installation, remove the coupling housing and inspect the coupling.

6.0 Inspection, Maintenance and Disassembly Procedures

Because there are no moving parts to wear out, Goodrich couplings will operate satisfactorily throughout the life of the machinery. However, if the coupling is operated beyond the misalignment ratings, the service life will decrease. In addition to damage due to misalignment fatigue, there are other criteria that also limit the service life.

High overload torques (exceeding the limit torque of the couplings) can cause permanent damage, if not complete failure of the coupling. Likewise, abusive handling, especially dents in the profile area, can limit the coupling's life.

Although the coupling diaphragm profile is protected by a chemically resistant paint, operation in a highly corrosive atmosphere, (e.g., wet chlorine) is not recommended. When it is known that the environment will be highly corrosive the coupling should be operated in a sealed and purged coupling housing.

6.1 Inspection and Maintenance

For routine coupling applications, inspection during equipment overhaul periods is sufficient. In processes that are essential to the operation or production of an entire facility the frequency of inspection periods should be increased to every time the equipment is shut down. In this manner, the probability that damage can be found prior to coupling failure will be maximized. This is also true for noncritical applications that operate in a highly corrosive atmosphere.

Even in the most demanding applications, shutdown for maintenance of Goodrich Corporation couplings is not required.

6.1.1 In-Place Inspection

In-place inspection of the Goodrich Corporation coupling is a simple process. Remove the coupling housing from around the coupling so that all surfaces and connections are available. Inspection steps are as follows:

- Check all bolts and nuts for tightness.
- Check center tube for looseness or side play in all directions. Looseness or noise would indicate possible damage and would necessitate removal for further inspection.
- Using a soft probe (piece of wood), clear all drain holes. Do not use metal probes.

Machinery alignment plays an important role in coupling performance. Time permitting, perform an alignment check as follows:

- Position all machinery on operating thrust faces and centers.
- Loosen a set of rim bolts at one end of the coupling.
- Measure and record gap between diaphragm and hub flange. This is the prestretch gap set at initial installation and should check closely with original value shown on coupling drawing. Differences may be caused by thrust bearing clearances or shaft position tolerances remember to allow for these. Machinery must be cool to perform this check.
- Retorque all hardware and check all alignment in accordance with machinery manufacturers' instructions or your own standard practices.

6.1.2 Removal Inspection and Procedures

Disassembly will provide a more detailed inspection of the coupling and readily permit the accomplishment of any required maintenance. The following procedures are categorized as those general in nature, as well as those pertinent to a specific coupling configuration.

Removal of hubs is treated separately in Section 6.1.3.

6.1.2.1 General Practices

The following procedures are those that pertain to all couplings and should be performed whenever a coupling is disassembled:

Repeat in-place procedures as defined in Section 6.1.1 including a check and recording of prestretch gap.

- Match mark hubs or flanges to their respective machinery shafts.
- Identify shims and record their installed positions.
- Remove all but two bolts from each end of coupling. Securely support flex unit and remove remaining bolts. Remove flex unit take care not to damage unguarded diaphragm profiles.
- With flex unit removed check diaphragm for: serious chipping, crazing, discoloration or blistering of paint; scratches or dents. If profile is obviously damaged, the coupling is unserviceable and must be returned to Goodrich Corporation for evaluation.
- Examine all nuts and bolts. Some scoring of bolt shanks is expected because of tight fit. Bolts and nuts are all weight matched and must be replaced in complete sets for each coupling end or replaced with one of its identical weight.
- Check all nuts for damage to the wrenching flats and deterioration of the threads self-locking feature.
- Check all bolt holes in diaphragms and hubs for serious scoring or elongation.

6.1.2.2 Piloted Guard Coupling

In addition to all of the general procedures defined in Section 6.1.2.1 the removal of a Piloted Guard Coupling requires the following special handling:

- Remove all nuts and bolts-engaged pilot will hold flex unit in place.
- Securely support flex unit.

Caution: Never thread in jacking bolts more than a couple of turns at a time in sequence. Threading in a single jacking bolt will cause serious cocking and bring about undue deformation and stress in the diaphragm.

- Insert jacking bolts into the jacking taps in the face of the piloted guard. By making a couple of turns at a time on each jacking bolt in sequence, disengage the piloted guard from the hub. The guard retention bolts are built in stops, which will prevent the guard from being jacked free *of* the diaphragm **(See Figure 1-5)**

6.1.2.3 Low Moment Coupling (Bolted Flange Design)

For a description of this coupling see Section 7.1 and Figure 7.1. In addition to all of the general procedures defined in Section 6.1.2.1, the removal of the bolted flange Low Moment Coupling requires the following procedures and special removal tools:

- Do not remove the bolts and nuts at the diaphragm rim bolt circle.
- Loosen and remove all but two of the nuts and bolts at each end of the flanged joints at either end of the center tube.
- Securely support the center tube.
- Back off the two remaining bolts at each end to permit disengagement of the center tube pilot.
- Install diaphragm deflection tooling if required, as defined on the coupling drawing. The purpose of this tooling is to uniformly spread the diaphragms apart to permit full disengagement of the center tube pilot. Once disengage, remove the center tube section.
- The center tube-to-diaphragm adapter flanges may now be removed from the diaphragm.

6.1.2.4 Low Moment Coupling (Conical Flange Design)

For a description of this coupling **see Section 7.2** and **Figure 7.2.** Refer to the general procedures of **Section 6.1.2.1.** The following additional procedures should be used for the conical flange design Low Moment Coupling:

- Loosen and remove all but two of the bolts at each end of the center tube.
- Securely support the center tube.
- Back off the two remaining bolts to permit disengagement of the center tube pilot.
- If the interference on the center tube pilot remains large enough to prevent removal of the center tube, perform the following sequence:

  Remove the installed split shims from their active location. Reinstall the bolt hardware in a minimum of three equally spaced locations on the side the shims were removed from.

  Bolt up the hardware using a few turns at a time in sequence to fully engage the antiflail guard pilot. Remove the hardware from the supported center tube and disengage the center tube pilot. The center tube should now have enough clearance to be removed.
- If special diaphragm deflection tooling is called out on the drawing, it should be utilized to remove the center tube from the coupling.
- Use the coupling hardware or other onsite bolts in the three provided equally spaced locations (Jacking Taps) to back the antiflail ring guards away from the diaphragm/hub.

6.1.3 Hub Removal Procedures and Inspection

If for any reason a hub must be removed, always allow both hub and shaft to cool to ambient temperature before proceeding.

Procedures particular to each hub to shaft configuration are defined in the following sections.

6.1.3.1 Straight and Tapered Bore Hubs with Keyways

Puller holes are always provided in the face of the hub to assist in extracting the hub from the shaft after heat has been applied. Puller hole size and location are defined on the coupling drawing. In many instances size and location are in accordance with the machinery manufacturer's standard.

After the hub and shaft are stabilized at ambient temperature, reheat the hub using one or two torches with flame spreading tips. Concentrating heat in the areas over the keyways will help to speed up the process; the slight air gap over the key helps to insulate the shaft, causing a greater temperature differential between the two members.

Caution: The torches should always be kept in motion spreading heat as evenly as possible. Do not permit flame to concentrate in one area for periods greater than 5-10 seconds.

On tapered shafts, puller tool advancement need only be sufficient to free the taper. This movement should approximate the pullup distance employed during assembly as spelled out on the coupling drawing.

For straight bores continuous puller tool advancement will be required until the hub is completely free of the shaft.

6.1.3.2 Tapered Bore Hub Hydraulically Fitted

To remove a hydraulically fitted hub the hydraulic installation tools must be reinstalled. The hub must be redilated to free it from the shaft.

Caution: Very large forces are at play during this procedure, therefore, axial retention elements of sufficient strength must be used to limit and stop axial movement of the hub once it is broken free.

6.1.4 Storage of Parts

Ideally, parts should be stored in their original shipping containers. If this is not possible the following steps should be taken:

- Store flex unit in a strong box with protective covers over the flex unit to protect the diaphragm profile. Pieces of heavy cardboard or plywood with bolt holes to mate with diaphragm bolt hole circle usually make excellent covers.
- Always coat hubs with oil, particularly the bore, to prevent rust. Store in sheltered environment.
- Wire shims together and store with flex unit.
- Bag nuts and bolts and store with flex unit.

Caution: Misplaced or lost hardware is the most common cause of lost time.

7.0 Couplings Incorporating Special Features

7.1 Low Moment Coupling (Bolted Flange Design)

The Low Moment Coupling shown in **Figure 7.1** is designed for applications where low shaft end weight is required. This older design uses bolted-piloted L flanges to enable the placement of the wavy diaphragms further back on the coupling hub. This places the coupling center of gravity closer to the machine bearing. This Low Moment design has been superseded by the conical flange design.

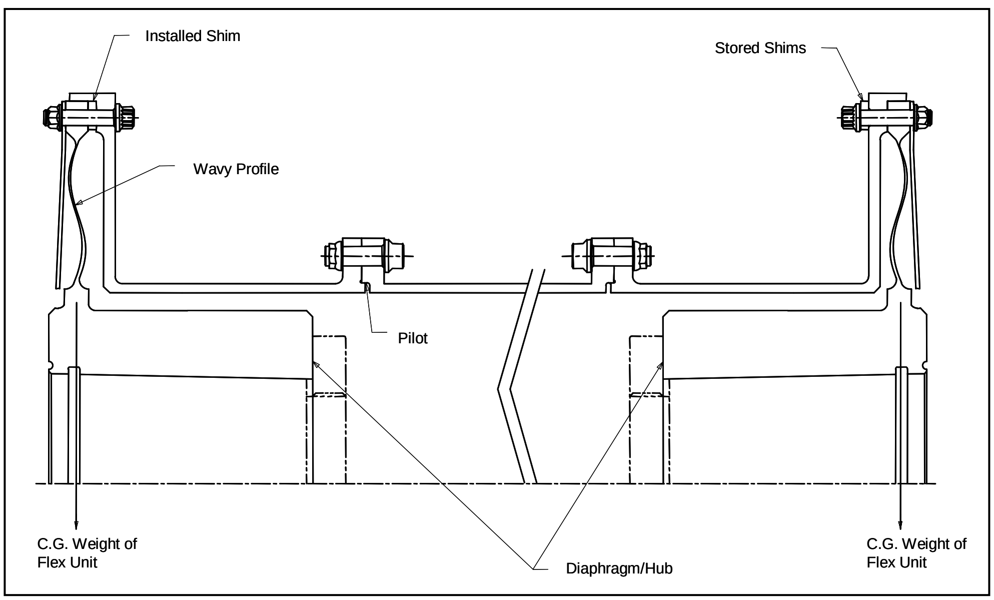

Figure 7-1 Low Moment Coupling Bolted Flange Design

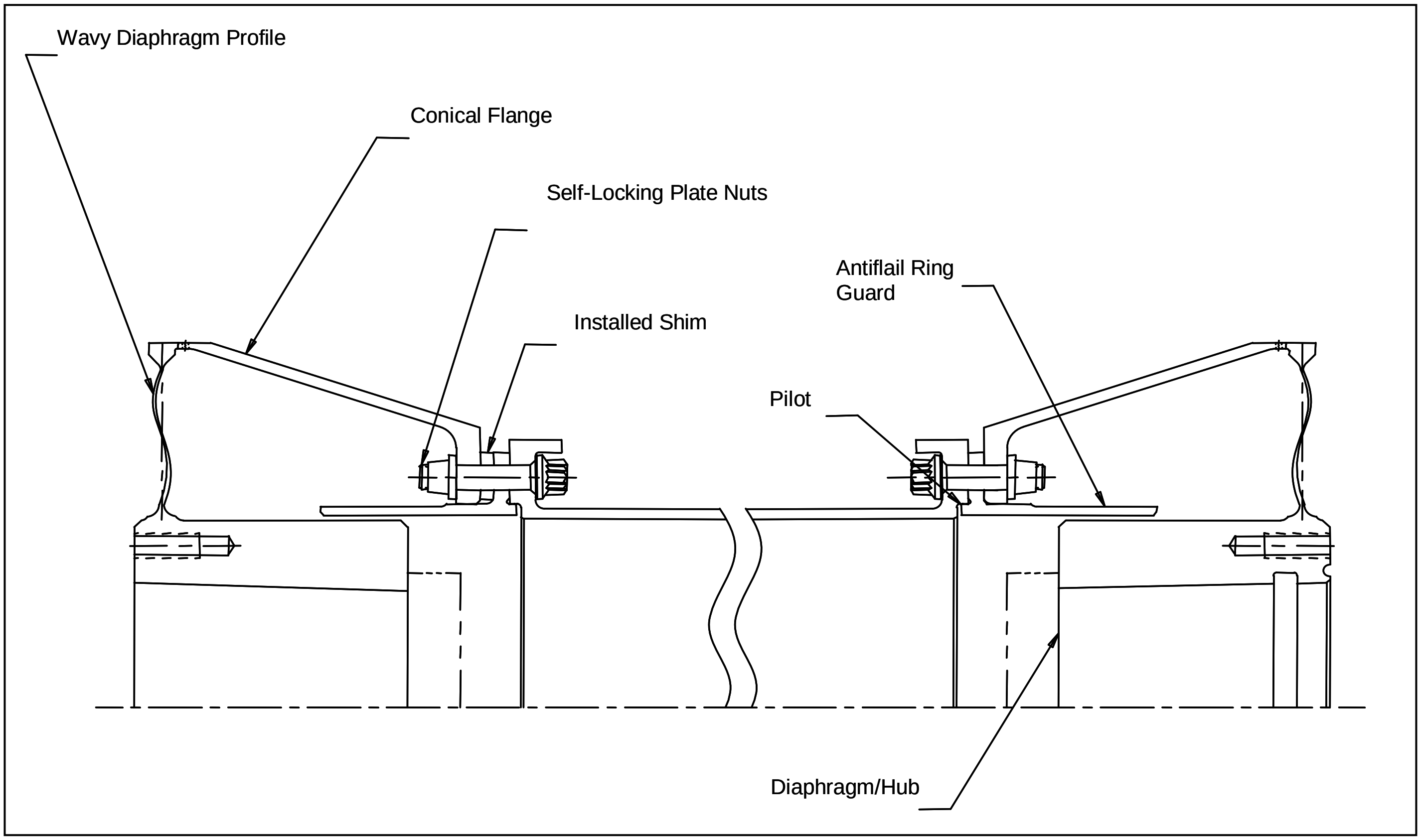

Figure 7-2 Low Moment Coupling Conical Flange Design

7.2 Model 70 Low Moment Coupling (Conical Flange Design)

The Low Moment Coupling shown in Figure 7.2 developed to further reduce the amount of overhung weight of the Goodrich Low Moment design. The diaphragm rim bolt circle of the past design was eliminated in favor of an electron beam weld. The incorporation of the conical flange not only reduces the complexity and weight of the coupling but also has a large effect in reducing the windage (heat generation) of the coupling. **See Figure 4-2**.

The conical flange Low Moment Coupling utilizes the wavy diaphragm hub for the same benefits as the previous Low Moment design. By using the capability of the wavy profile diaphragm to absorb radial expansion of the inner hub, the diaphragm/hub combination places the coupling center of gravity closer to the machine bearing. The conical flange, antiflail ring guard, and tube of the conical Model 70 incorporate pilots to eliminate eccentricity errors which could be caused upon successive assemblies and disassemblies. The Goodrich Corporation conical Low Moment coupling conforms to API 671, and features the same uncluttered design, low force, no lubrication, no scheduled maintenance and balance repeatability found in all of our contoured diaphragm couplings.

7.3 Model 75 Hybrid Coupling

The Model 75 Hybrid Coupling shown in Figure 7-3 is a combination of the Model 70 Low Moment Coupling and the Model 74 Piloted Guard Coupling. In some rotating equipment trains, either the driver or driven machinery is sensitive to overhung weight or moment force. This coupling allows the use of a reduced moment design on the weight sensitive machine, while the less sensitive machine uses a more standard coupling design. The advantages of this arrangement are primarily reduced cost and a less complicated assembly/removal procedure on the standard end as compared to the Model 70 Coupling. The Model 75 Coupling meets all API 671 requirements.

7.4 Coupling with Backup Gear Drive

The backup drive is only incorporated on couplings connected to drivers, which would overspeed and destroy themselves if the coupling diaphragm were to fail abruptly. The backup drive in such an instance would carry the load while simultaneously emitting severe warning vibrations calling for manual shutdown. The backup gears are a completely redundant mechanism, and are in no way intended to enhance coupling reliability.

Figure 7-4 depicts typical backup systems incorporated into fitted bolt and reduced moment type couplings. In each instance, non-contacting gears are machined into beefed-up sections of adjacent components such that the drive train is maintained in the event that the diaphragm should fail. Under normal operation gear clearance is sufficient to permit full working diaphragm misalignment to take place without causing the mesh to contact.

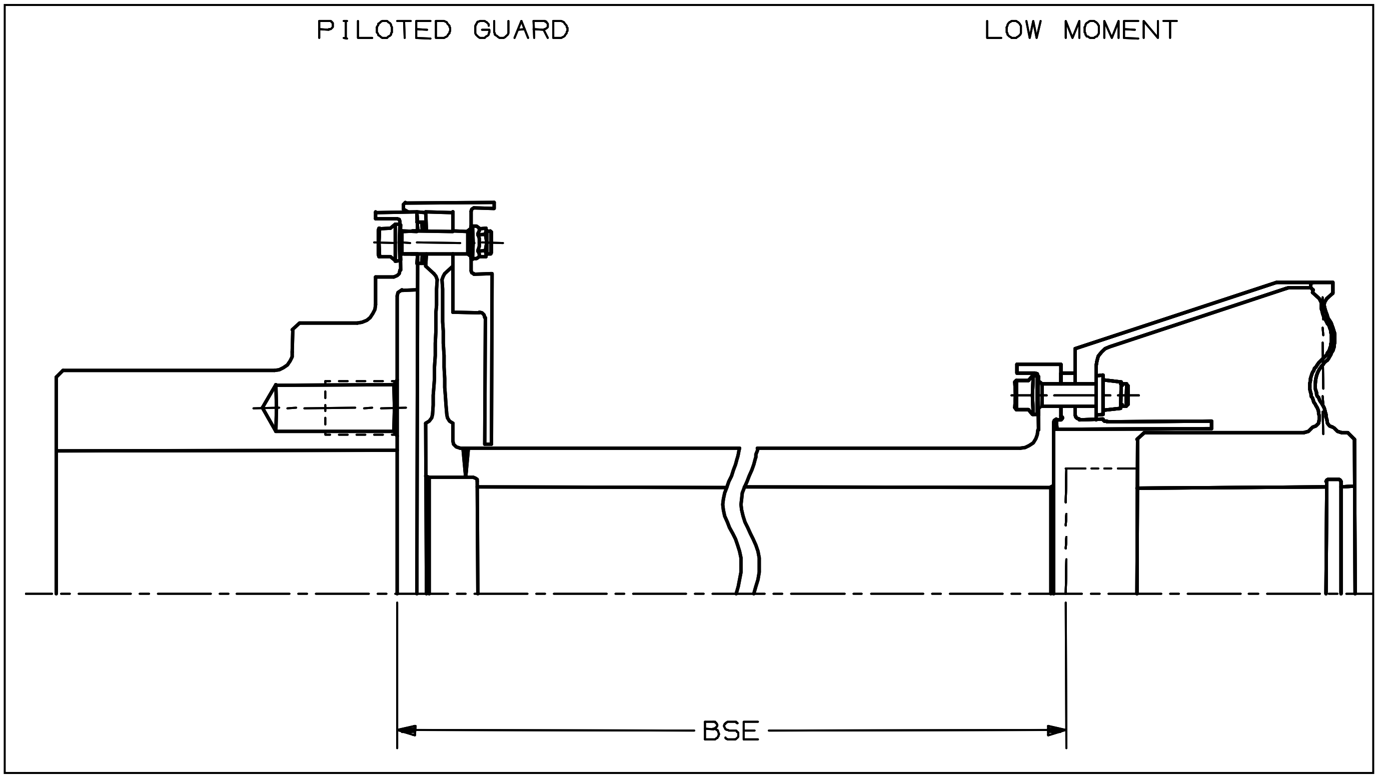

Figure 7-3 Model 75 Hybrid Configuration

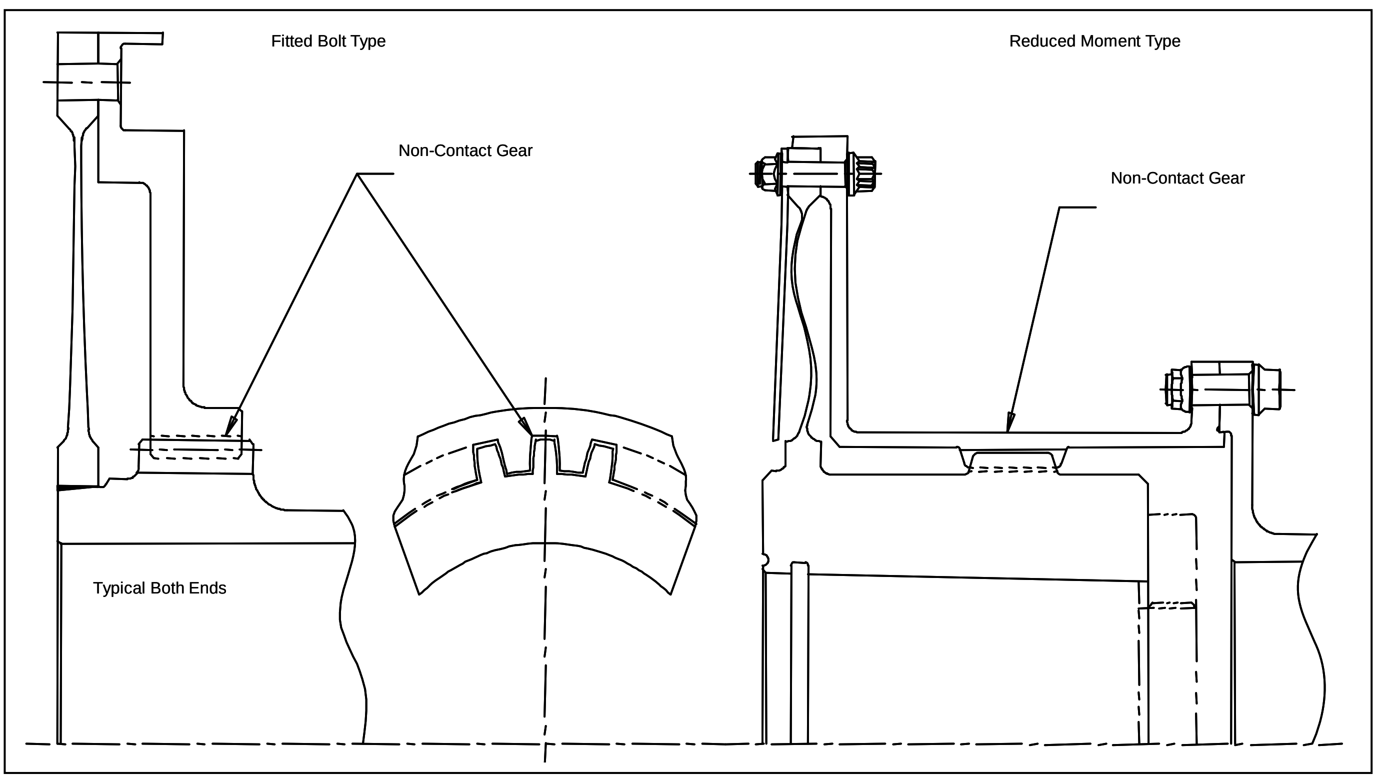

Figure 7-4 Typical Backup Gear Drive Configuration

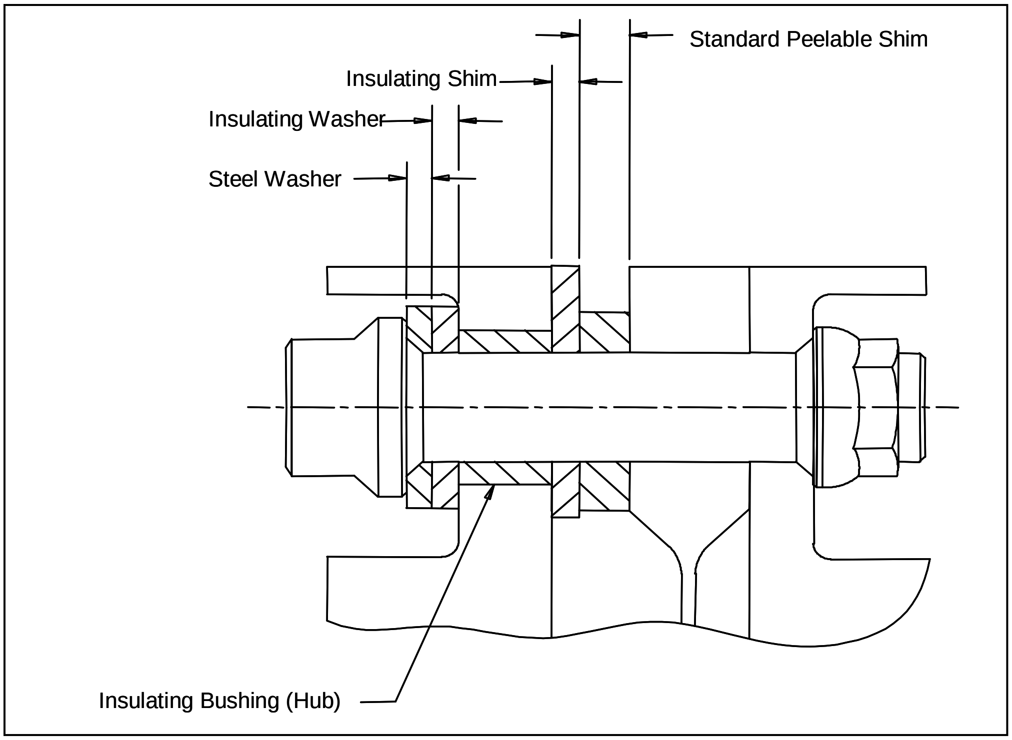

Figure 7-5 Fitted Bolt Electrically Insulated Coupling

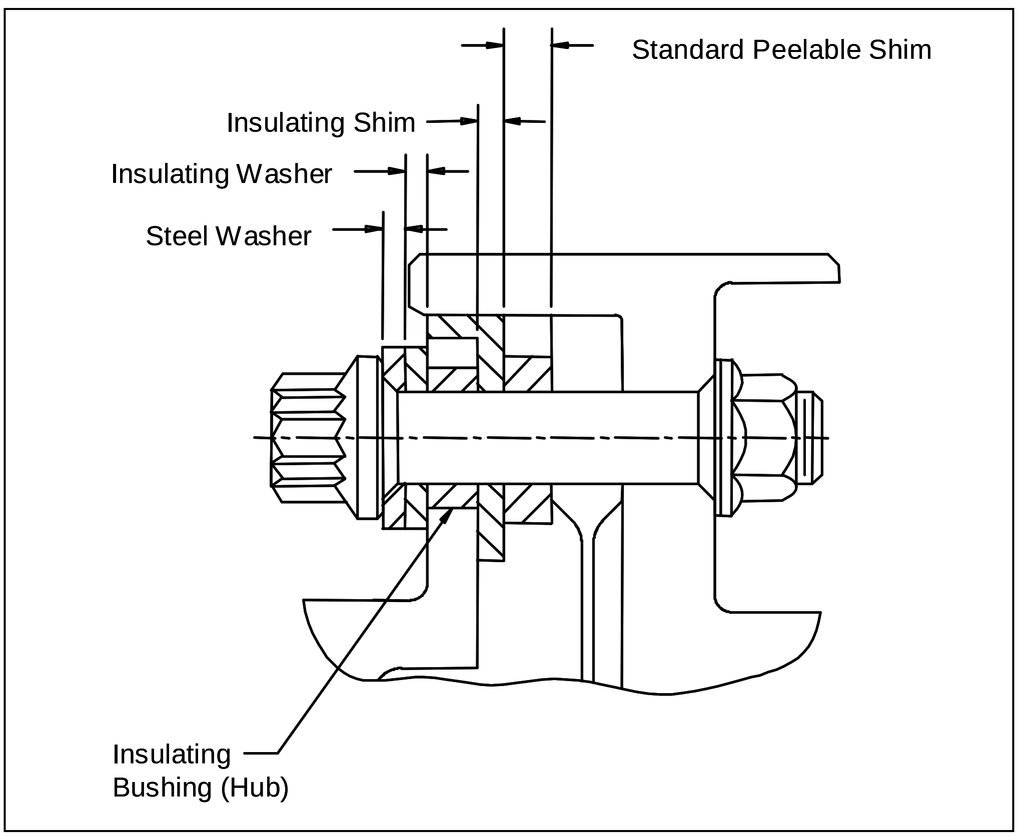

Figure 7-6 Piloted Guard Electrically Insulated Coupling

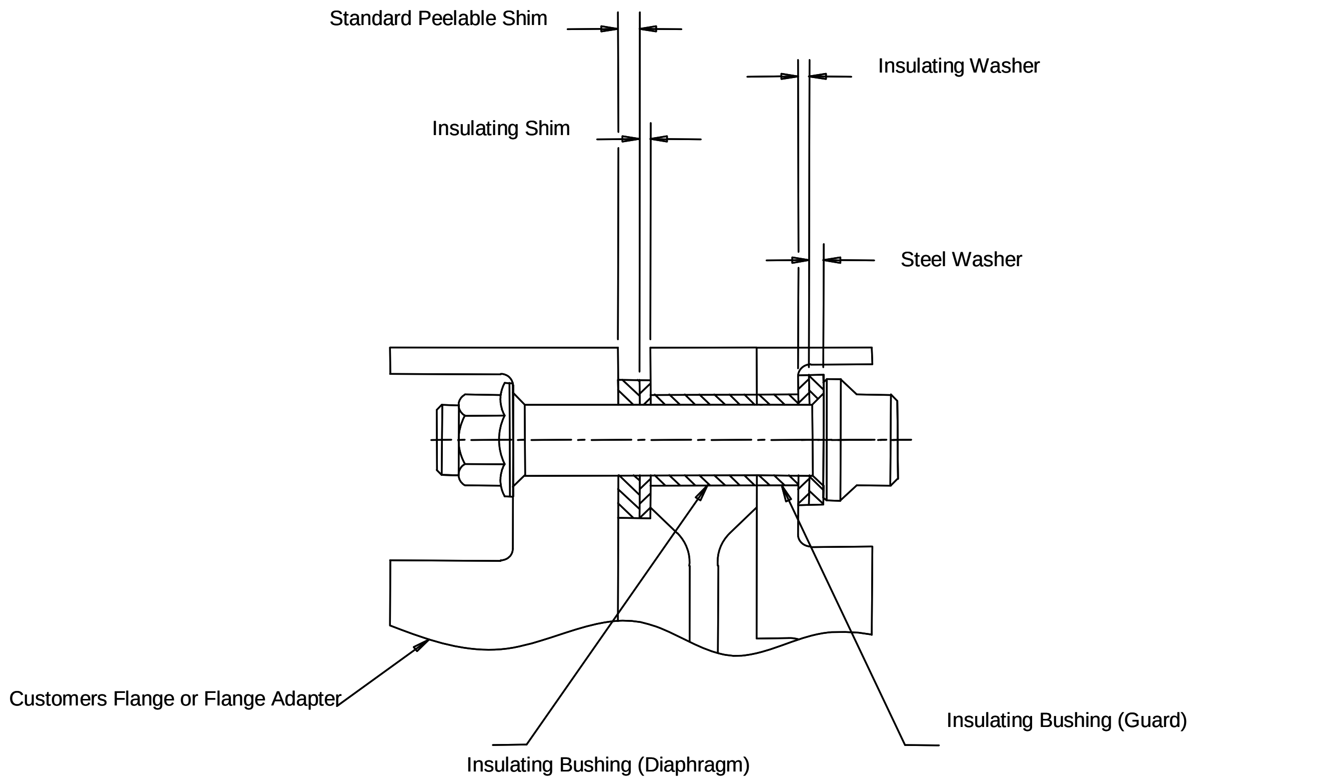

Figure 7-7 Flange Adapter Electrically Insulated Coupling

7.5 Electrically Insulated Couplings

To prevent stray electric current from traveling across the coupling interface on generator and some motor applications, machinery manufacturers may specify that the coupling incorporate electrical insulation.

Figures 7-5, 7-6 and 7-7 depict the typical manner in which electrical isolation is accomplished on fitted bolt, piloted guard, and flange adapter type couplings. The insulating material, a fiberglass epoxy compound, is usually applied to only one end of the coupling. The insulating bushings and insulating L ring (Piloted Design) are epoxy bonded into place on the coupling diaphragm, guard, or hub. **These insulation materials are not intended for field removal or replacement.** Complete repair of the insulating material requires the return of the coupling to the Goodrich facility.

8.0 Spare Parts

A standard Goodrich power transmission coupling is comprised of the three basic components listed below plus hardware:

- Driver Hub
- Driven Hub
- Flex Unit (Spacer)

It is always wise to provision for spare parts when the coupling is first ordered. Goodrich recommends that as a minimum a spare flex unit be ordered. This will automatically include a spare set of hardware and shim pack. The major advantage of ordering the spare flex unit initially is that it will be balanced with the original set of hubs and be ready for immediate field replacement. A spare flex unit ordered after the fact will require that hubs be returned to Goodrich for assembly balance purposes. This can be a time consuming function, which may delay facility startup.

In applications that are extremely critical to plant operation, the user may wish to order a complete spare coupling. This will provide maximum insurance against delays, especially if hubs are damaged as well.

A spare set of hardware may be ordered at any time. As noted previously, bolts and nuts are all weight matched and must be replaced in complete sets for each coupling end.

Power Transmission Coupling Warranty

Goodrich Corporation Rome, New York, USA, warrants each new product sold by Goodrich herein to be free from defects in material and workmanship under normal use and service, and to be in conformance with applicable specifications and drawings. The obligation and liability of Goodrich under this warranty is limited to the repair or replacement at its factory, at the option of Goodrich, of any such product which proves defective or nonconforming within twelve (12) months after delivery to the first end user.

Goodrich shall not be obligated nor liable under this warranty for any defective products which Goodrich, in its sole discretion, determines are defective due to tampering, neglect, improper storage, improper assembly or disassembly, normal wear, misuse, or corrosion caused by unprotected operation of said products in hostile environments which include, but are not limited to, moist chlorine. In addition, Goodrich shall not be obligated or liable under this warranty unless the date of delivery to the first end user shall be within forty-eight (48) months from date of delivery to the original purchaser, if different from the first end user, and provided that written notice of any defect or nonconformity shall be given to Goodrich within thirty (30) days from the date such defect is first discovered.

Products for warranty consideration shall be returned (with all transportation charges prepaid) to Goodrich, either directly or through an authorized service station or distributor, in shipping containers which are adequate to prevent loss or damage in shipment. Goodrich will pay return trip surface transportation charges within the Continental United States for a product which Goodrich determines to be defective or nonconforming within the terms of this warranty. Should a product be returned for warranty consideration which Goodrich determines to be free of defects and in conformance to applicable specifications and drawings, or to be defective because of misuse, etc. subsequent to delivery to the first end user, charges for inspection, testing, repair (or replacement if repair is not practicable) and return transportation may be applicable. Products repaired or replaced under this warranty are warranted for the unexpired portion of the original warranty.

This warranty is in lieu of all other warranties, express or implied, including the implied warranties of merchantability and fitness for a particular purpose, which are herewith expressly excluded. Other than the liability set forth in the express warranty above, seller shall not be liable for consequential, incidental or other types of damages, and expressly excludes and disclaims such damages resulting from or caused by the use, operation, failure, malfunction or defect of any article sold to the purchaser under this order, it being understood that the articles sold to the purchaser are not consumer goods.

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