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BEST PRACTICES FOR CARTRIDGE MECHANICAL SEAL INSTALLATIONS

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ABSTRACT

The reliability of a mechanical seal depends on more than the design of the seal itself. It also depends heavily on the practices used to install the mechanical seal into the centrifugal pump or other equipment. The actual installation may occur in a controlled environment such as a factory or repair shop or it may occur out in the field in an installed pump. The people performing the installation range from skilled workers with significant experience with seals to general mechanics who have had little exposure to seals. Regardless of the situation, the steps taken during the installation process set the foundation for the ultimate success of the seal in operation.

Different pump and seal designs may require different installation procedures but there are several key elements that are common across all installations. These include inspection of the equipment, general requirements for equipment condition, preparation for installation, installing the seal, setting the seal drive, removal of setting/shipping fixtures, and connecting the piping plan. While each of the steps is deceptively simple, the ability to identify and correct problems during the installation is critical.

INTRODUCTION

Mechanical seals provide one of the most common solutions for sealing the rotating shaft in a centrifugal pump and other types of rotating, fluid handling equipment. Purchasers and end users can find information on mechanical seals from a wide range of sources. There is a large body of literature discussing different seal designs and the benefits and limitations of each of these options. There are also industry standards defining seal piping plans along with guidance from industry on the best practices for selection and operation of these sealing systems. There is however one critical step in the life cycle of mechanical seals that has evaded users' attention - installation.

The activities that take place between opening a shipping container with a seal and tightening the final screws or bolts is often loosely identified as the seal installation. In reality, the seal installation extends both before and after these activities. In many cases, the events that occur outside of the commonly considered seal installation steps are the most impactful for the success of the seal. Understanding the requirements of the entire sealing system will improve the chances that the seal will be installed correctly and have the highest reliability in operation.

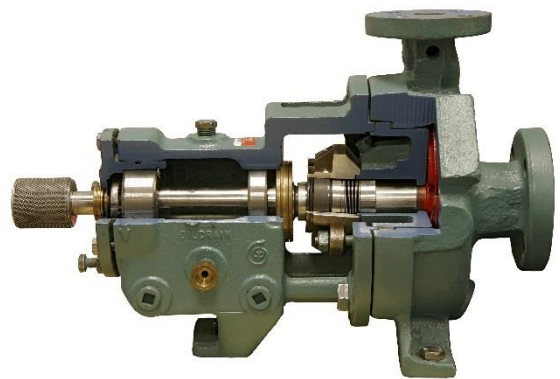


Figure 1 OH1 style centrifugal pump

BASIC SEAL DESIGN

Component Seals

Seal installation is often categorized by the basic design of the seal: a component seal or a cartridge seal. A component seal is a seal design where many of the components are provided as loose, individual parts. These seals are often supplied by the seal OEM with all of the parts provided in one box. This makes the job of identifying the required components easier for the end user. In other cases, however, the end user may stock the components for multiple seals as individual components which allows for greater flexibility in changing materials or for only replacing specific components during a seal repair.

A component seal was the most commonly supplied seal design when mechanical seals were first adopted by industry. Mechanical seals were seen as a direct replacement for packing. Most pump OEMs considered the mechanical seal as only a sealing device that would simply install into the stuffing box and be mounted onto a pump sleeve and into a pump gland. The loose components would arrive at the pump OEMs facility and be installed as part of the pump assembly.

One of the greatest challenges with component seals is that the success of the installation is greatly impacted by the skill of the installer and processes used during installation. In a pump OEM environment, there is a higher likelihood that there will be skilled technicians and a clean environment during installation. To install a component seal, the pump often had to be partially assembled, lines scribed on sleeves, offsets measured, components tightened, gaskets installed, and glands bolts tightened. During the process, the seals, especially the seal faces, must have been kept clean and free from contamination. While this process was largely successful at the OEMs facility, there were significantly greater challenges and a lower success rate at end user's facilities or in the field.

Component seals continue to be a very large market segment for many seal OEMs although they are primarily used in lower duty services and often in less critical applications. Some highly engineered component seals are still used in equipment where the physical constraints of the equipment design require an extremely small seal or the seals must be integrated into the pump design.

Cartridge Seals

Cartridge seals were introduced to reduce the complexity of the seal installation process and to improve the reliability of the seals in service. A cartridge seal is a design where all of the critical seal components are pre-assembled at the factory. This provides the most controlled environment for the seals during assembly. Rather than receiving a box of loose components, the end user would receive a fully assembled seal. By making the adaptive components part of the cartridge assembly, the location of the seal parts, the size and location of the required porting, the mating surfaces for gaskets, and the general design of the seal could be optimized for seal performance. As a further benefit, the cartridge seal assembly could be tested to ensure that a defined level of quality was provided to the purchaser.

The cartridge seal is designed to mate with the pump seal chamber and shaft and, in theory, should be a simple bolt-on component. This is, in fact, the way many end users view seal installations. This is often reinforced by the industry when people discuss how easy it is to install a mechanical seal – “pull out the old seal, stick in the new seal.” Unfortunately, this statement often turns out to be true. Some end user mechanics have become very adept at quickly changing out seals that fail frequently. What is not considered is that seals can fail frequently because they are changed out too quickly. More specifically, the end users may not follow the best practices for installing a mechanical seal and therefore compromise the performance of the seal before it is even put into service.



Figure 2 Typical cartridge seal

DEFINITION

A seal installation is a series of steps required to properly install a seal into a pump. This definition is deceptively simple and so generic that it provides little to no value to the mechanic. Unfortunately, the seal installation instructions many mechanics receive are equally generic and fail to provide specific details on the required steps. Seal OEMs provide installation instructions with the mechanical seals. These instructions are often designed to cover the installation of the most common designs of the seal in the most common designs of pumps. This is an excellent starting point but these can also fail to capture the full scope of the installation process.

INSPECTION OF EQUIPMENT

A mechanical seal is installed into a centrifugal pump and therefore the pump serves as the foundation for the seal. The basic pump design, the overall seal chamber dimensions, the specific dimensions of critical fits, and the location of shaft and seal chamber features are critical to the overall fit of the mechanical seal into the pump. These need to be confirmed prior to installation.

In a larger sense, the overall condition of the pump is a critical consideration in seal performance. Many end users assume that a pump is in good condition if it can move fluid. As long as the pump hydraulics meet the performance requirements of the operation, the pump is not inspected. Pumps, however, wear out over time. Bearing fits can become looser. Wear ring clearance can become larger. Runouts and misalignments can become greater. It is not unusual to find that the most reliable seal performance comes immediately after a pump overhaul and that seal performance degrades after the pump has been operating for many years.

Before a seal is installed into a pump, the mechanic must inspect the pump to ensure that it is in satisfactory condition and seal design is correct for the pump.

Step 1 – Obtain Seal Assembly Drawing

The seal assembly drawing is the document that captures the most critical aspects of the seal including the basic seal design, installation instructions, port locations, and piping plans. This document is required to develop the specific procedures that the mechanic will use to install the seal. The mechanic must obtain the seal assembly drawing before attempting to install the seal in the equipment.

Step 2 - Check Critical Dimensions

A seal OEM will base the seal selection and design details on the information that they received as part of the order. Some of the most critical aspects of this information are the pump seal chamber dimensions and specific pump features around the seal chamber. The seal assembly drawing displays the dimensions and features that were used as the basis for the seal design.

Arguably, the most critical and precise dimensions required for a seal installation are the shaft outer diameter (OD) and the pilot diameter for the seal gland. Other critical dimensions include the seal chamber bore, the seal chamber depth, and the distance to the first obstruction. There is a tendency to get this dimensional information from the original pump OEM drawings, references to “identical” pumps, or from older seal drawings. While these sources are usually reliable, there may be applications where the original pump design was modified to accommodate a larger seal (e.g. increase seal chamber bore), include new pump features (e.g. add a port in the seal chamber), or repair damage (e.g. re-machine the seal chamber face).

Using the seal assembly drawing as a guide, the mechanic must confirm that all of the dimensions on the pump match the dimensions on the seal assembly drawing.

Step 3 - Confirm the Location of any Steps, Grooves, Keyways, Internal Ports, or Passageways

The critical features of the seal chamber and surrounding area are not limited to simple dimensions. Many pumps are designed with features which are required for the pump operation or which provide additional benefits for the seal.

Many pumps are designed with steps on the OD of the shaft. These steps are often used to provide specific dimensions for interfacing with other pump components. These steps may occur in the area of the seal chamber and the seal OEM must design the seal to either accommodate the step or avoid it. Steps may also occur in the bore of the seal chamber. These may have been added to accommodate earlier seal designs or repair seal chamber damage.

The pump OEM may add a relief on the OD of the shaft under the seal drive collar. This relief would allow the drive collar set screws to create set screws dimples or deformations without impacting the ability to remove the seal sleeve.

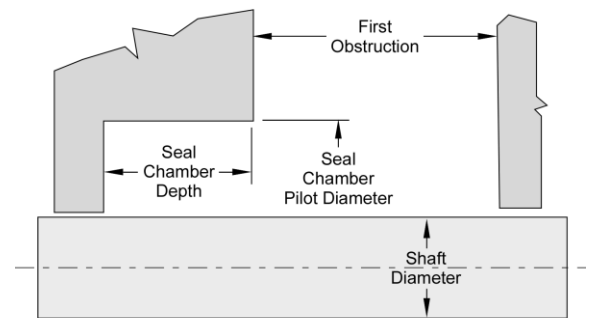


Figure 3 Critical pump dimensions

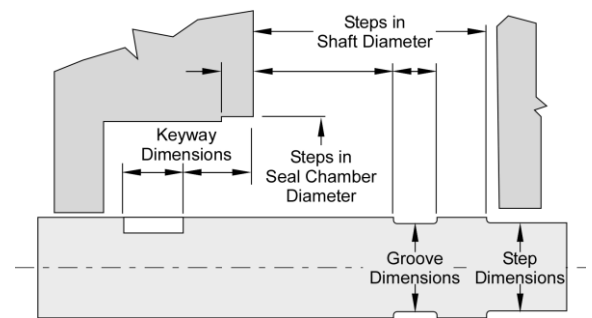


Figure 4 Critical pump features

For this to be effective, the axial location of the groove must match the location of the set screws on the drive collar.

In some high-pressure applications, the axial hydraulic thrust of the seal sleeve is greater than can be safely accommodated by set screws in the drive collar. One of the most common ways to increase the axial load capacity of the seal is to use a split ring style drive collar. These designs utilize a circumferential groove cut into the shaft to carry the axial load. The location and dimensions of the groove are critical for the seal design and are captured on the seal assembly drawing.

High torque applications can be equally challenging for set screw drive collars. In some applications, a keyway will be cut into the OD of the shaft and will, with the installed key, provide the torsional drive for the seal sleeve. The location and dimensions of the keyway and key are also critical for the seal design and are captured on the seal assembly drawing.

On most seal assemblies, the porting required for the seal is incorporated into the seal gland. In this way, the seal OEM can ensure that the porting location provides the maximum benefit for the seal. In some seal designs however, the porting cannot be designed into the gland due to space limitations or pump assembly requirements. In these cases, the porting will be incorporated into the pump design and these features are also captured in the seal assembly drawing.

Using the seal assembly drawing as a guide, the mechanic must confirm that all of the features and dimensions on the pump match the features and dimensions on the seal assembly drawing.

Step 4 – Confirm Coupling Space

In some pump designs (e.g. vertically suspended pumps and between bearing pumps) the seal can be installed into the pump without the need to remove the pump or driver (motor). This greatly simplifies the effort required to service the pump and minimizes the need to realign the pump and driver shafts after maintenance. In these cases, the seal assembly must be designed to fit between the ends of the motor shaft and the pump shaft after the coupling has been removed. This spacing is referred to as the coupling space or distance between shaft ends (DBSE). Prior to attempting to install the seal, the mechanic should confirm that the overall length of the seal is less than the DBSE.

Step 5 – Confirm Location of Brackets and Windows

The seal assembly contains a number of ports which connect the seal gland to piping or tubing from the seal piping plan. The pump however also has a number of brackets or braces to connect the fluid end to the hydraulic end of the pump. The seal assembly must be designed so the seal piping does not interfere with the pump brackets. The mechanic can confirm the location of the port and brackets from the seal assembly drawing.

Step 6 – Measure the Equipment Condition

One of the fundamental assumptions of good pump reliability is that the pump provides a good foundation for the seal. A pump that operates with minimal shaft movement and deflections and with proper alignment will minimize the motion in the mechanical seal. This will result in lower seal wear, lower leakage, and longer seal life. These alignments and runouts can be broken into several categories.

Concentric runout – While the pump shaft is generally located in the center of the seal chamber, it cannot be assumed that the shaft is perfectly concentric with the seal chamber bore or pilot diameter. A pump is an assembly of many components and the inevitable tolerances, clearances, and assembly variations virtually ensures that the shaft and seal chamber will not be perfectly concentric.

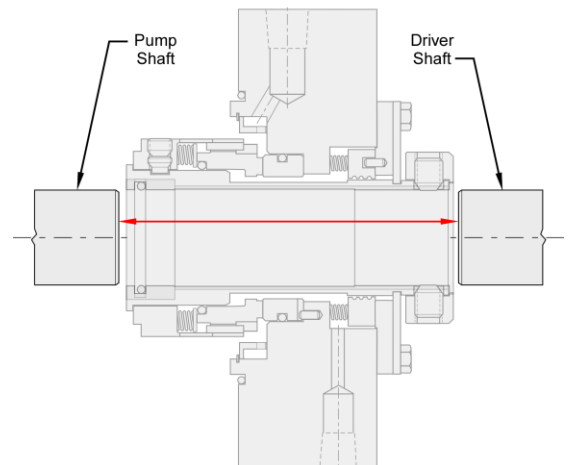


Figure 5 Distance between shaft ends

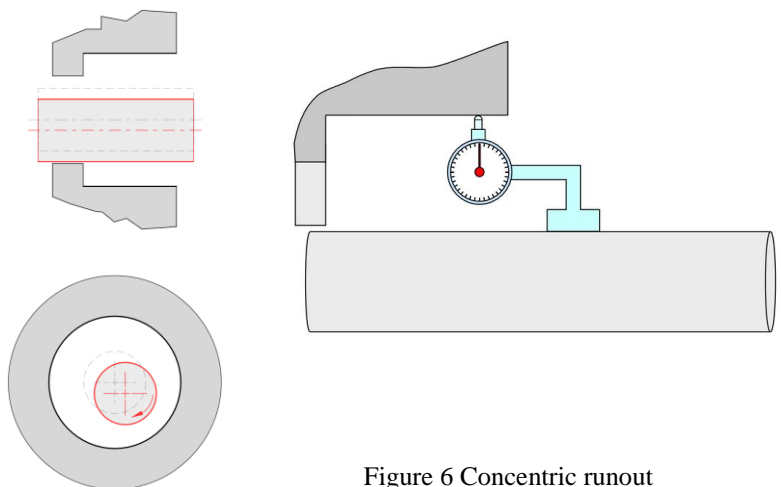


Figure 6 Concentric runout

Pump and seal OEMs recognize this and have developed standards for acceptable concentricity. API 682, API 610 and ASME B73 require that the concentricity must be less than 0.005" (0.125mm) TIR. This is measured by placing the dial indicator on the shaft and measuring the runout on the OD or ID pilot on the seal chamber of the pump.

Perpendicular runout – Perpendicular runout is the perpendicular deviation of the seal chamber face relative to the centerline of the rotating shaft. Like concentric runout, perpendicular runout is the result of multiple components, manufacturing tolerances, and clearances between the assembled pump components. Perpendicular runout however can have a greater impact on seal performance since some seal designs must continually compensate for this runout through continuous axial motion of the seal components. This will result in high wear on seal components as well as erratic and increased leakage.

Pump and seal OEMs again recognize the need to limit this type of runout to a minimum practical value. API 682 and API 610 require the perpendicular runout to be less than 0.0005" per inch of seal chamber bore (0.5 $\mu\text{m}/\text{mm}$) TIR. This is measured by placing the dial indicator on the shaft and measuring the runout on the face of the seal chamber.

Bent shaft runout - Bent shaft runout refers to an out-of-concentric condition where the deviation is constant relative to a point on the OD of the shaft. This can be measured by placing the dial indicator on the seal chamber and measuring the TIR on the OD of the shaft during one full revolution. Different pump designs and standards address this type of runout. The end user should refer to the equipment IOM for details on allowable bent shaft runout.

End float or axial play – All pump shafts are located axially in the pump by means of a thrust bearing. The axial location is required to ensure that the impeller remains in the correct location in the pump casing. Axial motion can also have a negative impact on seal and coupling performance. In most pump designs, the pump hydraulics create a net axial thrust in one direction so shaft motion only incurs as the pump ramps up to steady-state operation. If, however, a pump does not create a net thrust or the direction of the thrust changes, the shaft can move continuously back and forth resulting in additional wear on the seals and other pump components.

The thrust load is carried from the shaft into the thrust bearings. Different pump designs and application conditions can dictate the design of the thrust bearings used. These are typically either rolling element bearings or hydrodynamic bearings. The type and size of the bearing will dictate how much axial clearance should be in the assembled rotor and how much axial motion is possible in service. It is common to measure axial play or end float to determine the health of the bearings and to ensure a proper pump assembly.

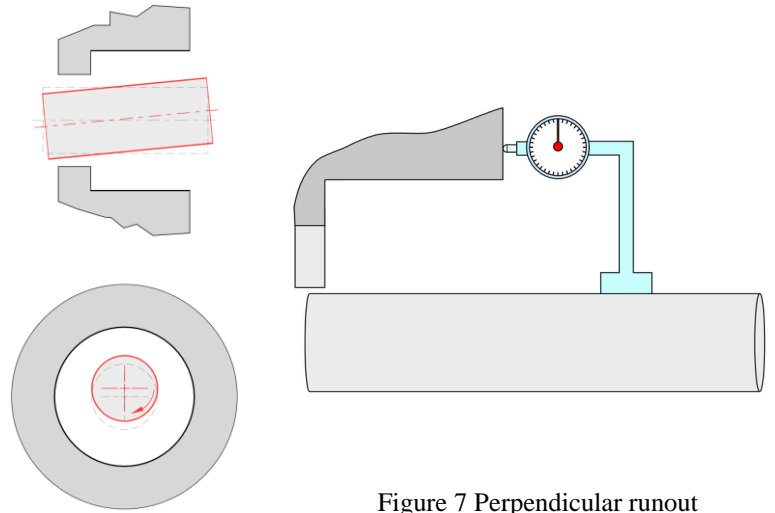


Figure 7 Perpendicular runout

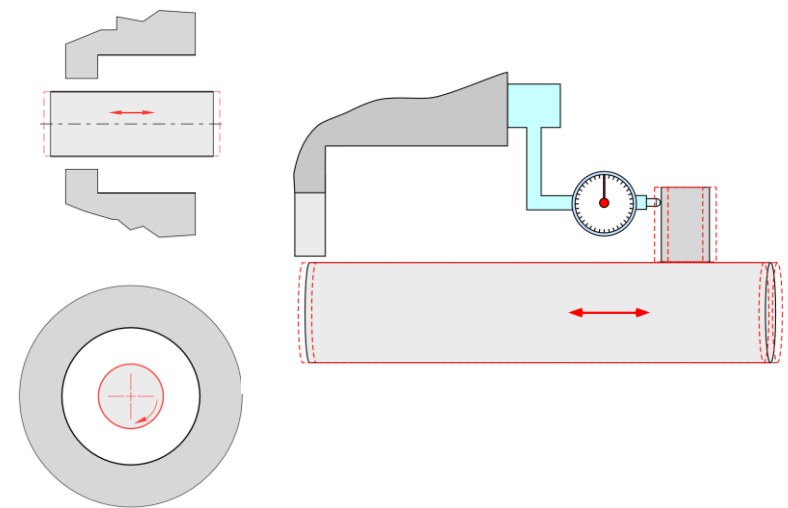


Figure 8 Shaft end float

INSPECTION OF THE SEAL CHAMBER

These first steps of the installation process were intended to confirm that the seal is designed correctly for the pump and that the overall pump condition is adequate for reliable operation. Dimensions and runouts are not the only considerations when installing a seal. The areas around the seal chamber must also be inspected and prepared for the seal installation. Some of these areas are obvious while others may be unique to only specific pump designs.

Step 7 - Check the Shaft for Burrs or Sharp Edges

Even a shaft which has been machined to the correct dimensions may not be ready for the seal installation. The seal sleeve is intentionally designed with a very small clearance between the shaft OD and the sleeve ID. This close clearance fit is required to minimize seal runout and improve seal performance. It also requires that the surface of the shaft is free from any defects or burrs which may cause the sleeve to hang-up during installation.

The most common seal sleeve design features a sleeve gasket (e.g. O-ring) on the ID of the sleeve to prevent process from leaking between the shaft and sleeve. The sleeve gasket is installed with a radial compression to ensure proper sealing during operation. Unfortunately, this gasket must also slide down a length of the shaft during installation thereby exposing the gasket to any defects or features on the shaft. This includes features that are intentionally designed into the shaft such as steps, chamfers, grooves, threads, or keyways. Any sharp edges or burrs can easily damage the sleeve gasket resulting in a leak which will occur as soon as process is introduced into the pump. The mechanic must inspect the OD of the shaft over the entire path that the seal will slide during installation. Any sharp edges must be properly prepared to eliminate the possibility of damaging the gasket.

Step 8 – Check the Shaft for Scratches, Corrosion, or Pitting.

Even if the shaft is manufactured correctly, its condition may have deteriorated while in operation. This may have occurred by exposure to the operating conditions or due to handling during pump and seal maintenance in the field. During a seal installation, set screws will create local indentations and burrs. Particles or burrs may become captured between the shaft and sleeve resulting in scratches on the shaft during seal installation or removal. Corrosion, pitting or even fretting may have occurred on the OD surfaces of the shaft in the seal chamber area.

Any scratches or damage which creates a raised feature can result in installation problems as described in Step 7. These raised surfaces must be filed down or stoned to create a smooth surface with the surrounding shaft. Other types of damage may result in shallow scratches or pitting which would not prevent the sleeve from sliding over the shaft. In many cases, this type of damage may be allowable and not impact seal performance. The mechanic though must carefully inspect the shaft and ensure that the damage is not located under the sleeve gasket or other critical seal components. The seal OEM can provide guidance in determining the suitability of used shaft relative to a seal application.

Step 9 – Check the Shaft for a Build-up of Debris

In some applications, process fluids or debris may buildup on the shaft and other exposed surfaces. Some of this debris may be a tenacious plating or even a corrosion layer on the shaft. Unfortunately, this may occur deep inside the seal chamber where it is difficult to see or nearly impossible to measure in an assembled pump. Since the clearance between the shaft and sleeve is so tight, even a very thin layer of debris may prevent proper seal installation. The mechanic should ensure that the shaft is free of any build-up all the way to the back of the seal chamber.

Step 10 – Check the Shaft for Required Components

In some pump designs, the shaft may require other components to help locate or position rotor elements or protect the shaft from the process. This may be some form of a stub sleeve or nut located near the back of the seal chamber. In some pump designs, the seal sleeve will seal on the pump sleeve to prevent process fluid from contacting the shaft. Any pump features that are required by the mechanical seal will be shown in the seal assembly drawing. The mechanics should verify that they are present prior to installing the seal.

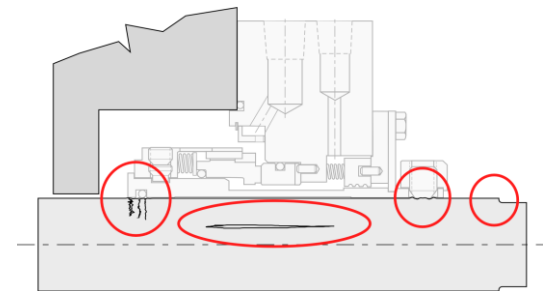


Figure 9 Common areas of shaft damage

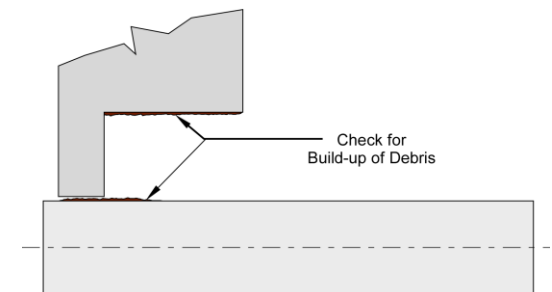


Figure 10 Common areas debris build-up

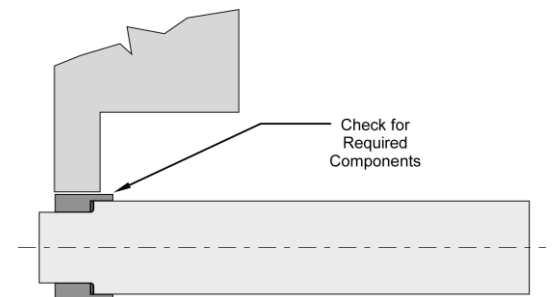


Figure 11 Other required shaft components

Step 11 – Check the Seal Chamber Face for Damage

Any scratches, gouges, or other damage which results in a raised surface will prevent the seal gland from properly contacting the seal chamber during installation. This can result in a cocked seal gland with the same impact as an out-of-perpendicular alignment. Any raised surfaces or damaged areas must be stoned flat prior the seal installation.

The seal chamber face not only locates the seal gland, it also provides the sealing surface for the gland gasket. The gland gasket is normally designed into the seal gland and is captured against the seal chamber face when the pump gland studs are tightened. Any damage, scratches, gouges, or corrosion in the gasket area may prevent the gasket from sealing and result in a seal leak as soon as the pump is flooded with process. Damage in this area will require re-machining the seal chamber face to ensure a smooth, flat, perpendicular surface.

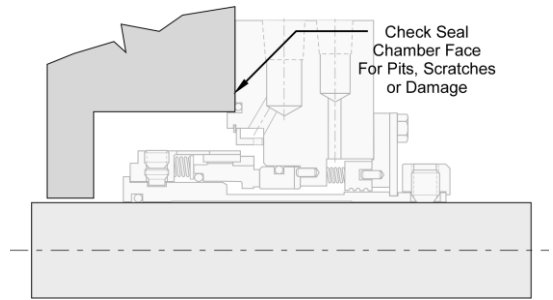


Figure 12 Checking seal chamber face

Step 12 – Check the Seal Chamber Face for Offset and Axial Misalignment at Split Line

Horizontally split case pumps are manufactured with an upper casing half, pump gasket, and lower casing half bolted together to create the finished pump. In most manufacturing processes, the pump is assembled, doweled for location, and finish machined to ensure proper alignment between the components. After years of service and multiple disassembly/assembly cycles, the pump halves may no longer align perfectly at the split line near the seal chamber. The two halves may be misaligned axially with a small step on the face of the seal chamber. This could result in a cocking of the seal gland during installation. This step can also result in improper loading of the gland gasket resulting in a leak at the split line. The upper and lower halves can also be misaligned horizontally resulting in an out of round seal chamber bore. This may make it impossible to install the pilot diameter of the seal gland into the seal chamber during installation. Both of these conditions can be detected during the runout checks in Step 6.

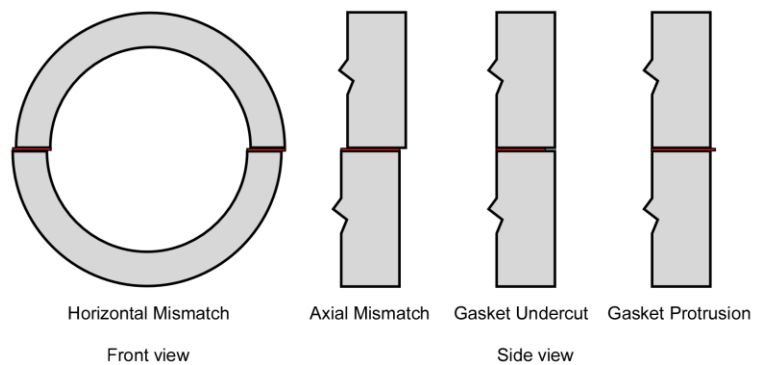


Figure 13 Mismatch between upper and lower pump halves at the split line at the seal chamber

Another common issue with horizontally split case pump is an improper alignment of the casing gasket with the critical surfaces of the seal chamber. The gasket must be precisely aligned with the face of the seal chamber. If the gasket is protruding above or located below the face of the seal chamber, the O-ring will not seal against this surface resulting in a leak between the gland and seal chamber face.

Step 13 – Check Seal Chamber for Required Components

A seal assembly may require separate components to be installed in the seal chamber prior to installation. The most commonly required component is a bushing assembly. This bushing may be required to isolate the seal chamber from the pump process. In other cases, the bushing may be required to increase or decrease the pressure in the seal chamber. If a close clearance bushing is being reused from a previous installation, it is common that it is removed, inspected, repaired (if required) and re-installed. Using the seal assembly drawing as a guide, the mechanic must ensure that all required pump or seal chamber components are installed prior to the seal installation.

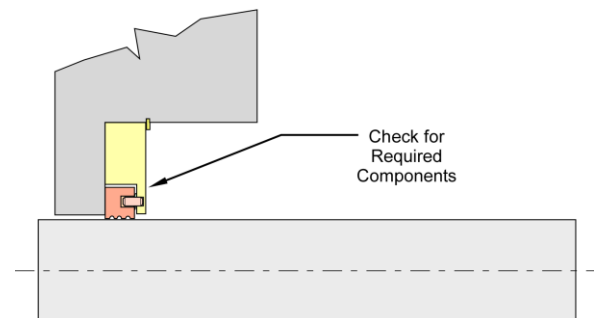


Figure 14 Other required components in the seal chamber

All of previous steps are an attempt to ensure that the pump is in a suitable condition for the installation of the mechanical seal. Unfortunately, these steps take time and, in some cases, require rework or minor modifications of the pump. These activities also require a skilled pump mechanic to perform the checks and take the appropriate actions to address any issues that are identified. Many end users, especially users with unspared equipment, are pressured to return the equipment to

operation as quickly as possible. This balance between equipment availability, repair costs, and best repair practices is a challenge for all pump users.

INSTALLATION

When many end users think of a seal installation, they consider the activity starting with the removal of the seal from the box. That is indeed the next step of the process. But even these steps require some attention to detail to ensure that the installation is performed correctly.

Step 14 – Read the Installation Instructions and Specific Installation Requirements from the Seal Assembly Drawing.

Many mechanics have significant experience with pumps and seals in their plants. Many of these mechanics are confident that they do not need to review the instructions or documentation that comes with the seal. In some cases, this practice has led to seal failures that could have been easily avoided. The installation instruction can provide specific details which are impossible to check without looking at the drawing and instructions. Some the details include lubricating specific surfaces, the order of specific steps, and torque values for installation fastener. Other instructions have safety implications such as connecting specific porting or removing shipping or setting fixtures. There is never any harm in becoming familiar with the installation requirements prior to starting the installation. In fact, it may just prevent a failure.

Step 15 - Remove the seal from its packaging

Seals are typically transported in a shipping container or box from the seal OEM to the purchaser or end user. This box is designed to protect the seal not only during shipment but also during storage, inventory, and transportation to the work site. The seal should remain in the shipping box until it is time for the installation.

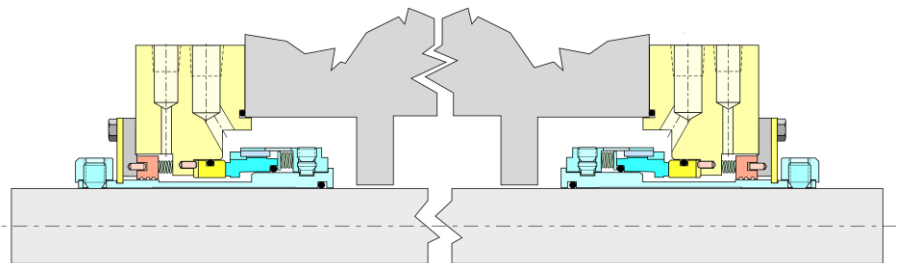
Inspect seal for the correct part number, seal model, and/or material codes – All seal boxes look somewhat similar. They may have the same basic size and color. They may have similar markings. The only way to ensure that the correct seal has been pulled for the installation is to check the part numbers and documentation. And then check again. Many seal part numbers are quite long and complex but each digit of the code has a specific meaning relative to the seal. Make sure that the seal is the correct seal for this pump.

Some pumps have standardized seal chambers and the end users stock seals which may be used in multiple pumps. Some end users may have the same seal in stock that differ only in the materials of construction. The same requirement applies that the mechanic must ensure that the correct seal has been provided for the installation.

Inspect box and seal for damage during storage and transportation – Even though the seal is packaged in a protective shipping container or box, the seal OEM has little control of the seal once it leaves their facility and damage may have occurred during transportation and storage. The mechanic must inspect the box and any internal packaging materials for damage before removing the seal. As the seal is removed from the box, the mechanic should look for signs of damage. If the setting plates are out of position, there are loose parts in the box, or the assembled seal makes rattling noises, it may indicate that the seal was dropped or otherwise damaged. Even finding signs like water or condensation in the box may indicate that the seal was not stored properly. In these cases, the seal should be returned to the OEM for inspection prior to installation.

Locate drawing and other documentation – All seals should be provided with drawings, instructions, or other types of documentation. The mechanic should confirm that the documentation matches the work order and pump number for the installation. The part numbers marked on the seal should also match the documentation. Ensure that the seal drawing and any installation instructions are available at the pump during the actual installation.

Ensure that the direction of rotation of the shaft matches the direction of rotation of the seal – Between bearing pumps will have seals at both ends of the pump casing. When facing the seals, this results in the shaft rotating clockwise on one end of the pump and



Seals in between bearing pumps may have features or components which are directionally specific. These include porting, pumping rings, face features, and sometimes drive mechanisms.

Figure 15 Different direction of rotation on each end of a between bearing pump

counterclockwise on the other end. Some seal designs are designed for a specific direction of rotation. This may be required by face features, pumping devices, or seal porting. Ensure that the direction of the seal matches the direction of rotation of the end of the pump where it will be installed.

Locate lubricants or other installation tools included with the seals – Some seals are provided with tools to aid with the installation of the seal. In other cases, installation materials such as a shaft lubricant may be included in the box. Locate any other tools provided with the seals since they may make installation easier.

Step 16 – Lubricate the Shaft

Lubricating the shaft not only makes the installation of the seal easier, it also protects the sleeve gasket and minimizes the potential for damage while it is sliding down the shaft. The lubricant is lightly applied by hand over the length of shaft where the O-ring will slide during installation. Only a very small amount of lubricant is required. If excessive lubricant is applied, it will be pushed into the seal chamber and may find its way onto the seal components or faces during installation or operation of the pump. The most common lubricants for many applications is a non-reactive grease or light oil. The end user must make sure that the lubricant selected is compatible with the seal materials (e.g. gaskets) and is acceptable for contact with the process fluid.

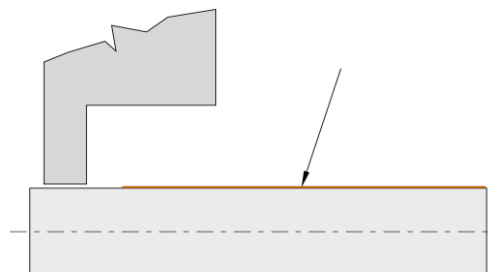


Figure 16 Lubricate shaft prior to installation

Step 17 - Align drive key slot, install drive key

On some seal designs, a drive key is required to transmit torque from the seal into the shaft. This is accomplished with a keyway in the shaft and a drive key installed in the keyway. In most designs the keyway is located deep inside the seal chamber. Once the seal assembly is being installed in the seal chamber, the mechanic cannot see the keyway which makes alignment of the sleeve and key difficult. It is useful to rotate the shaft so the keyway is located at the top of the shaft (12 o'clock position). When the seal is installed, the mechanic will know the location of the key. This is made easier if the key slot in the seal sleeve is also located at the 12 o'clock position.

Step 18 - Orient seal assembly with 12 o'clock at top

All seals designed for horizontal pumps are designed with an intended angular orientation. Some ports, like the flush port, are located at the top. Other ports, such as the drain, are always located at the bottom. The seal assembly drawing will show an end view of the seal assembly with the correct orientation.

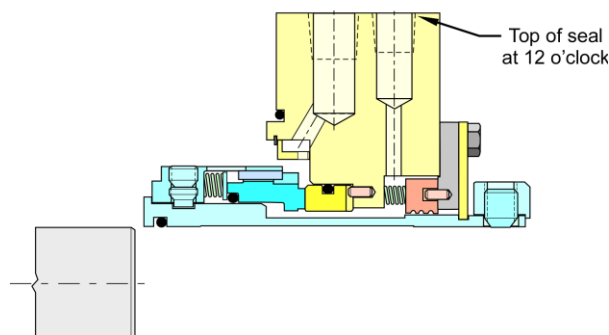


Figure 17 Orient seal assembly

Step 19 - If Required, Support the Shaft so it is Concentric with Seal Chamber

Some pump designs require that the bearing housings are removed during the seal installation. During this time, the pump shaft will not be located in the center of the seal chamber and it will be impossible to fully install the seal. In some cases, the shaft may need to be lifted during part of the installation to allow the seal to slide into position. It is important to install the bearings prior to releasing the support from the shaft. Most seal setting plates and shipping fixtures are not designed to take the weight of the pump rotor. Placing the entire weight of the rotor on the seal may damage internal seal components.

Step 20 – Slide the Seal Assembly Down the Shaft

At this point, the seal assembly can be slid down the shaft and into the seal chamber. In some smaller seals, this may be quite easy. On larger seals, this may take more effort.

Support the seal if required – Larger seals may be very heavy and difficult to move along the shaft. Many of these seals are provided with a connection point for a lifting eye at the 12 o'clock position. This will allow the mechanic to use a crane to support the seal's weight while it is being installed. If this feature is incorporated in the design, it will be shown on the seal assembly drawing.

Ensure the gland gasket is in position – Before the seal gets to the seal chamber face, ensure that the gland gasket is in the proper position (or groove). If this gasket falls out of the groove, the gasket

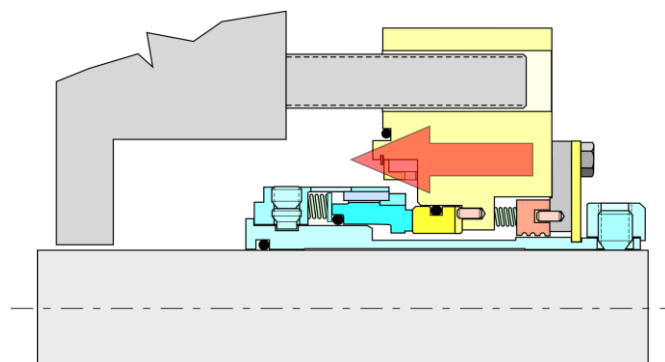


Figure 18 Slide seal assembly into position

will

prevent the seal gland from mating with the seal chamber face. It can also result in damage to the gland gasket resulting in a leak when process fluid is introduced into the pump.

Align the pump studs with the holes in the gland – Although the general orientation of the seal was checked in Step 18, the mechanic needs to take care at the seal gland approaches the end of the pump studs. The clearance between the pump studs and the holes in the gland is relatively tight and may require a slight alignment effort to slide the gland over the studs.

Move slowly over steps or other shaft features – As the seal is being installed, the sleeve gasket is sliding over the shaft surface. The smooth lubricated shaft will provide little resistance to moving the seal into the seal chamber. There may however be other features such as steps, grooves, or keyways on the shaft that the sleeve O-ring must slide over. This will increase the resistance during installation. The mechanic must slowly and carefully move the O-ring over the shaft features. This may require a slight twisting of the seal to ease the gasket over the features. If the shaft has been properly prepared and lubricated, this can be done without damaging the sleeve gasket. The mechanic however should never force a sleeve into position.

Step 21 – Slide the Seal Until the Gland Contacts the Seal Chamber Face

The seal assembly should slide freely until the seal gland contacts the seal chamber face. On most assemblies, there will be a very slight gap between the gland and the seal chamber face due to the gland gasket. This is especially true if the seal has a spiral wound gasket in this location. If the seal does not slide easily in into this final position, it may indicate that a burr or other debris is causing the sleeve to hang-up. Some end users have attempted to draw the seal gland into the final position using the pump studs. This can easily cause internal seal damage and is not recommend. If the seal does not move easily down the shaft, the seal should be removed and the seal and shaft inspected to determine the cause.

Step 22 - Torque the Pump Gland Bolts/Studs/Nuts

The seal gland must be properly attached to the pump seal chamber through the available pump studs or other fasteners. This connection is considered as part of the pressure casing or pressure boundary of the pump. The pump studs are part of the pump design and the required torque values can be found in the pump IOM or by contacting the pump OEM.

The torquing of the gland fasteners should follow the normal best practices for torquing bolted connections. The fasteners should be torqued to an intermediate value (e.g. 25% of full torque) alternating between opposing fasteners. After all fasteners are torques to this intermediate value, they torque should be incremented to 50%, 75%, and finally 100% in the same manner. If the fasteners are torqued in an uneven manner, the seal gland can become cocked resulting in a seal failure.

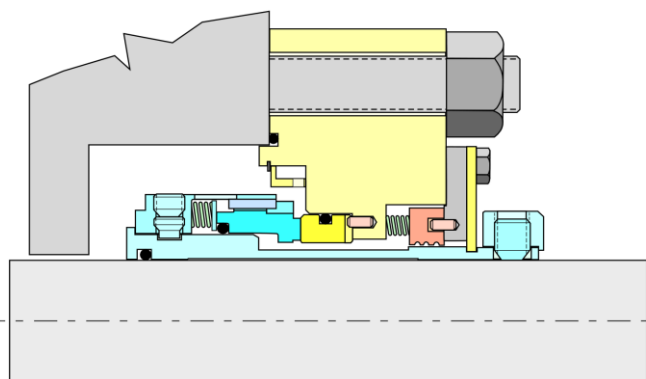


Figure 19 Torque gland bolts or nuts

Step 23 - Ensure Final Axial Shaft Position

At this point the seal is in the final axial position and the gland is properly attached to the seal chamber. The next step involves attaching the seal sleeve to the shaft. Before this can be done, the pump assembly and final shaft adjustments must be completed. In some pumps, this is the step where the thrust bearings are set. On other pump designs, the axial position of the shaft is adjusted to provide the highest pump efficiency or to position the rotor properly in the pump casing. All axial adjustments must be completed before installing the drive collar.

Step 24 – Install the Drive Collar

The drive collar is the seal component which attaches the rotating seal components to the pump shaft. The drive collar will normally handle all of the torsional load generated by the seal. The drive collar must carry all of the hydraulic and mechanical loads generated by the seal during operation of the pump. The installation of the drive collar is therefore critical to the success of the seal installation.

Seals are used in a wide variety of the applications with a wide range of operating conditions and equipment constraints. It is therefore no surprise that seal OEMs have developed a number of different drive collar designs to meet the unique requirements of a specific application. These can be divided into the general designs listed below and each of these designs have multiple variations. Each of these variations can also have unique installation requirements. For this reason, the mechanic should reference the installation instructions provided with the seal for their specific drive collar design.

Set screw drive collar – The set screw drive collar is the most popular drive collar design used in cartridge mechanical seals. The design is relatively simple and is relatively small. It can be positioned anywhere on the shaft and requires no shaft preparation. It does however have limitations in high pressure applications and it will create dimples on the pump shaft. The installation procedure generally only requires that the drive collar set screws are properly torqued during installation.

High temperature drive collar – A high temperature drive collar provides the combined function of a drive collar and sleeve gasket. This is necessary since high temperature applications require flexible graphite gasketing which must be mechanically loaded during installation. The drive collar installation procedure therefore requires both tightening screws to compress the graphite gasket followed by torquing the drive collar set screws into the shaft.

Split ring drive collar - The split ring drive uses a groove in the shaft to carry the axial loads generated by the seal assembly. This requires that a split ring is installed during the final stages of the seal installation. Adaptive components must be adjusted to connect the split ring to the sleeve and set screws must be torqued to attach the drive collar to the shaft. Torque is typically carried by a keyway on the inboard side of the seal sleeve.

Shrink disc drive collar – A shrink disc drive uses an assembly of tapered discs to convert axial loads in the shrink disc to radial loads onto the pump shaft. The requires precision dimensions on both the seal sleeve and pump shaft as well as some surface preparation (cleaning) of the pump shaft. The installation of the shrink disc requires a careful torquing of the screws on the assembly.

Step 25 - Remove setting plates

Setting plates are seal components which serve multiple purposes during the assembly, transportation, and installation of the seal. Like drive collars, seal OEMs have developed numerous design which each have specific advantages and disadvantages. In many cases, the actual design used is a matter of choice of the seal designer.

The setting plates and any other shipping fixtures will be shown on the seal drawing. All of the shipping or setting components must be removed after the drive collar installation is complete. In some cases, the setting plate may be simply slid away from the seal sleeve and tightened down in the retracted position. This way the components are left attached to the seal gland for future use. In other cases, the end user may prefer to fully remove the setting plates. If the setting plates are removed, they should be kept and re-installed prior to removing the seal from the pump.

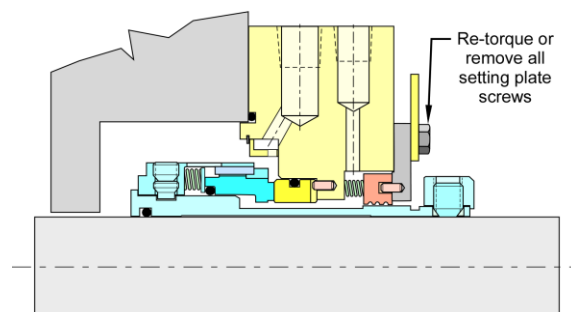


Figure 20 Remove setting plates

POST INSTALLATION INSPECTION

After the seal installation is complete, there are still some steps which should be taken to check for leak paths or other errors in the installation. There are no procedures which can fully inspect the installed seal nor predict its performance in operation. Some steps however can provide a level of confidence that the installation was successful.

Step 26 – Rotate the Shaft

In most pumps, the rotor or shaft will rotate freely if the pump is not connected to the motor. Rotors supported by rolling element bearings will rotate more freely than hydrodynamic bearing but with some effort, even these shafts be rotated by hand. After the seal installation is complete and the setting plates are removed, attempt to rotate the shaft by hand. There will be slight increase in drag but the shaft should still rotate. If the shaft rotated before the seal was installed and is binding after the seal installation, the end user should not start the pump without understanding the cause.

Step 27 – Air Testing the Pump

Air testing an assembled pump is becoming a more common practice for pump maintenance and seal installations. The pump is blanked off and the pump casing is pressurized with low pressure air. This allows the entire pump and seal assembly to be tested as a unit. This procedure is typically carried out in a pump shop since the both the suction and discharge flanges of the pump must be blocked (blind flanged). Any other connections into the pump casing must also be sealed prior to testing. The air test procedures for seals installed in pumps will be covered in new standards (specifically API 697) which will attempt to standardize both the test procedures and acceptance criteria for these tests.

Step 28 - Connect Ports on Seal Gland to the Appropriate Connections

Virtually all seal glands are provided with ports which provide the user with options for various piping plans. The seal installation must also ensure that the required ports are connected to the appropriate piping or tubing in the piping plan prior to filling the pump with process fluid. The port locations and marking can be found on the seal assembly drawing. Other details on the seal piping plans can be found on the seal assembly drawing or in API 682. All ports which are unused must be plugged prior to commissioning the pump

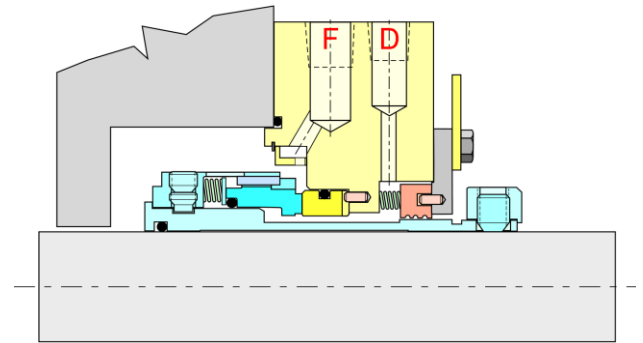


Figure 21 Connect all required ports

Step 29 - Pressurize the Pump

After the pump has been fully installed and all pump and seal commissioning procedures have been completed, the pump will be filled with process fluid and brought up to full pressure. This process can be as simple as opening a valve and fully pressurizing the pump. In other cases, this may require that a high temperature pump is slowly heated to full operating temperature over the course of several hours. Regardless of the procedures, the pump and seals should be checked for leakage as the pump is brought up to pressure.

CONCLUSIONS

There are many different pump designs and a wide variety of seal options which may be applied in the field. In all of these cases though the mechanical seal must be installed into the pump and the process of the seal installation will directly impact the performance of the seal. There is no one set of seal installation instructions that covers all seals but there are number of useful steps which should be a part of any installation procedure. Installations which follow best practices have a higher probability of long term reliability. Seals which are installed without regards for the condition of the equipment or special installation requirements of the seal will likely have a lower reliability. Fortunately, the seal OEMs can provide all of the information and support required to incorporate the best installation practices into the end user's procedures.

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DISCLAIMER

The information provided in the tutorial is intended to provide the reader with important considerations when developing or performing seal installation procedures. This document cannot however provide specific instructions for any specific field application since the pump design, seal design, application conditions, and other variables may require specific instructions not included in this tutorial. For this reason, the author, Flowserve Corporation, TAMU, TEES, or any other persons or entities associated with this paper assume no liability for the use of information provided or for any damages or consequences associated with the use of this information. For seal installation requirements for any specific application, please contact the seal OEM for a full engineering review.