Chapter D19

Seal assembly and disassembly guidelines

Revision 8 October 12, 2020

Individual chapters of the Kalsi Seals Handbook™ are periodically updated. To determine if a newer revision of this chapter exists, please visit https://www.kalsi.com/seal-handbook/.

1. Introduction

This chapter provides general guidelines for assembly and disassembly with typical solid cross-section, direct compression-type[1] Kalsi-brand rotary shaft seals. Not all seal applications are alike, and modified procedures may be necessary for your specific equipment and seal characteristics.

Retrain periodically

Periodically retraining assembly personnel is important, to keep them well versed in proper procedures, and aware of the consequences of improper component handling, assembly, and lubricant filling. Kalsi Engineering provides several training programs to assist you in maintaining employee skill levels.

2. Rotary seal storage / age control / shelf life

1. To maximize shelf life[2], store Kalsi Seals® away from ultra-violet light and direct sunlight at temperatures less than 120°F (48.9°C) in a location away from radiation and heat sources (registers, radiators, etc.), and away from electric motors and other ozone sources. Elastomer deterioration increases with increasing temperature. The ideal storage temperature is 40 to 80°F (4.4 to 26.7°C), with a relative humidity of 25 to 65%. Avoid very moist or dry storage conditions. To ease handling, seals that have been stored at cold temperature should be warmed to room temperature before installation.
2. Store seals in the original packaging (Figure 1), to protect the seals from ultra-violet light,[3] oxygen, ozone, dust and other contaminants, and to maintain positive identification and traceability. (The inspection code provides traceability to seal inspection and batch documentation.) The seal package also provides the cure date and recommended shelf life.
3. Store seals in a relaxed condition, free from compression and tension.
4. Rotate stock to use older seals first.
5. Visually inspect seals for deterioration and damage before use.

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1 For example, 344, 381, 432, 462, 507, 568, 587, 614, 637, 641, 655, 660, 673, and 674 series seals.

2 One source of information on elastomer shelf life is MIL-STD-695.

3 The ingredient in a shipping bag that protects the contents from ultra-violet light is a clear, cloudy additive. Some ultra-violet light resistant bags are colored black or amber, for identification purposes. Kalsi-brand rotary shaft seals are typically shipped in clear ultra-violet resistant bags so the content of the bags is readily visible. The color of a bag does not contribute to its resistance to ultra-violet light. The clear bags that we use have the same resistance to ultra-violet light as the color coded black and amber bags (300 to 380 nanometers).

Figure 1

Store rotary shaft seals in the original packaging. The package label contains information critical to positive identification, traceability and age control. The package protects the seals from ultraviolet (UV) light, oxygen, ozone, dust, and other contaminants.

3. Equipment disassembly and inspection

1. Use appropriate safety practices, such as wearing goggles and rubber gloves for protection from solvents, and wearing steel-toed shoes for protection from falling articles.
2. Disassemble the mechanical parts as required. Beware that exposure of some lubricants to high temperatures can lead to lubricant breakdown and gas formation, which can build up pressure in the lubricant reservoir. Some types of reservoirs are pressurized using compressed springs, or a gas charge. Use appropriate caution during disassembly to avoid injury.
3. Extract the used Kalsi Seals. Avoid damaging the housing extrusion gap corner that is located between the environment-side groove wall and the extrusion gap bore, because corner damage can damage the Kalsi Seal™ (Figure 5). If seal extraction requires prying, pry on the lubricant end of the seal with a soft tool to avoid damaging the environment-side extrusion gap corner (See Figure 2). To avoid

Contact Kalsi Engineering | Search this handbook groove damage, drive a pick or other tool into the seal, as an alternate way to remove used Kalsi Seals (Figures 3 and 4).[4]

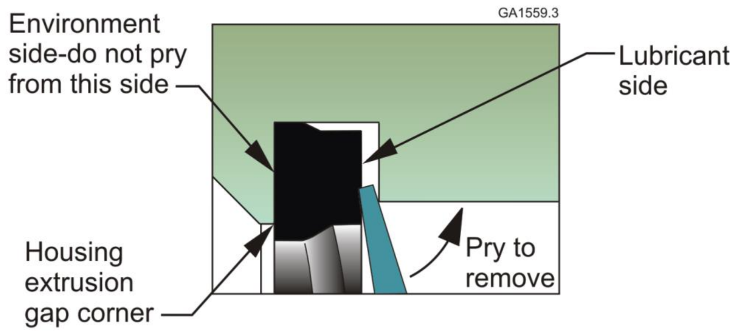

Figure 2

Pry only on the lubricant side of the seal to avoid extrusion gap damage

When extracting the Kalsi Seal, pry only from the lubricant side (as shown here) using a tool made from a relatively soft material, or use a sharp pick pushed directly into the seal. **Do not pry from the environment-side of the seal** because it can damage the housing extrusion gap corner. If the environment-side extrusion gap corner becomes damaged, then seal life will be shorter, especially in high-differential pressure applications, because the corner damage can cut the seal, and can accelerate seal extrusion damage.

Figure 3

A pick type tool for removing seals

Kalsi Engineering has used the Stanley 82-114 tool to remove -11 Kalsi Seals as small as 1.188” ID (30.18 mm) from one-piece grooves. This tool is part of the Stanley 82-115 pick and hook set.

4 The screw-based extraction tool, and extraction method shown in U.S. Patents 1,665,988 and 5,836,099 may also be useful in extracting rotary seals.

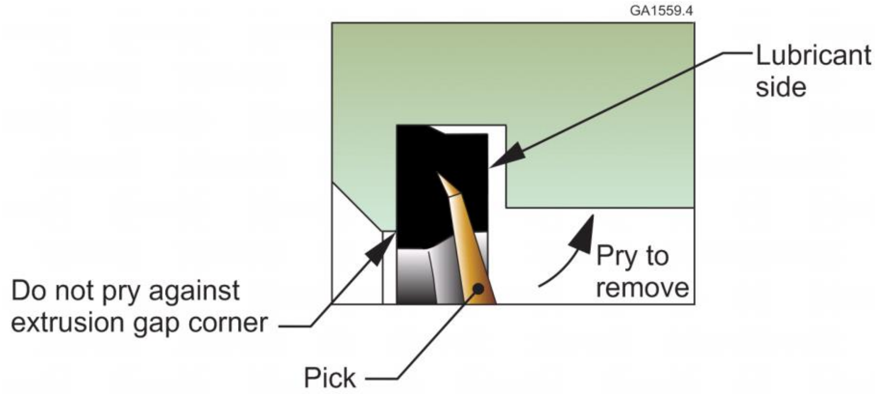

Figure 4

Using a pick to remove a Kalsi Seal

To use a pick type tool to pry the Kalsi Seal out of the groove, drive the pick into the used seal before prying.

Figure 5

Extrusion gap corner burrs can damage seals

Projecting burrs at the extrusion gap corner can cause several types of rotary shaft seal damage. One type is accelerated extrusion damage at the location corresponding to the burr. Another, shown here, is a cutting action by the burr in the event of circumferential seal slippage. Kalsi Engineering tested this seal in high-differential pressure conditions using a seal carrier that lacked grit blasting of the groove bore. The white dot is an indexing mark used to detect circumferential seal slippage.

4. Clean the mechanical parts thoroughly to eliminate foreign material, such as machining chips and other metallic particles, dirt, machining or plating fluids, environmental media such as drilling mud, and so forth. Pay particular attention to the rotary seal groove and the seal running areas of the shaft. One potential source of foreign material is inadequately filtered part cleaning solution.

   Foreign material can cause wear of bearings and rotary shaft seals. If trapped between the seal and the shaft, or between the seal and the groove bore, a piece of foreign material may also cause static leakage and increased dynamic leakage.

Avoid cleaning solutions that deposit solids on the shaft, such as phosphate based cleaner/rust inhibitors[5]. Phosphate based cleaners are known to cause significantly higher seal running torque and accelerated seal wear. “Parkerizing”, a phosphate-based corrosion resistant coating for metal surfaces, may cause similar problems.

Some cleaning solutions have solvent qualities or other qualities that may be incompatible with certain elastomers. As a precaution, do not allow such cleaning solutions to contact new rotary shaft seals. For example, never use such a solution to flush contaminants out of a sealed and assembled piece of equipment.

5. Before installing the Kalsi Seal, wipe the seal groove dry to inhibit circumferential seal slippage. Reapply grit blasting (Chapter D5) to the groove bore as needed to maintain the recommended surface finish.
6. Inspect the installation paths and seal running areas of the shaft, looking for wear, corrosion, and other damage that could adversely affect the rotary shaft seals. Polish, hone, strip and recoat, or replace hard coatings as necessary, to restore the recommended surface finish (Chapter D2). If recoating is necessary, then inspect both the new coating and the installation chamfer prior to use of the refurbished part. Improperly done, recoating can leave sharp features on the installation chamfer; removing such features before use is imperative (Figure 6).

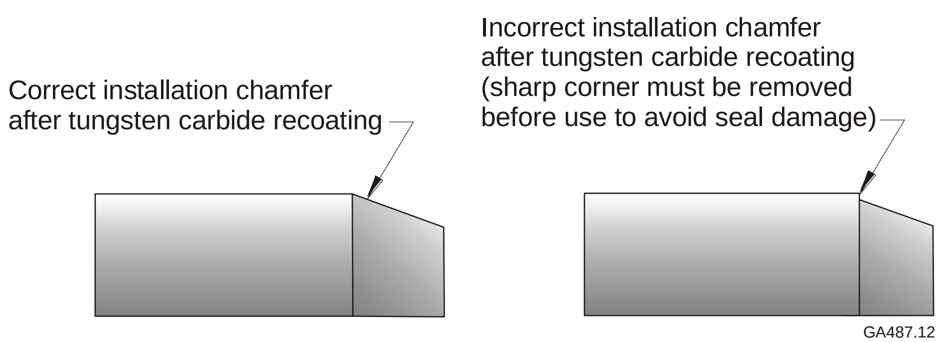

Figure 6

Inspect the corner of the installation chamfer after tungsten carbide recoating of the shaft, to avoid sharp corners that could twist or damage the rotary shaft seal during assembly.

7. Inspect the seal housing for defects that could harm the rotary shaft seal during operation, and repair or replace components as necessary. Examples of such defects are:

5 Kalsi Engineering uses inexpensive farm-grade alcohol for parts cleaning.

- Damaged extrusion gap corners, such as nicks, burrs, displaced metal (Figure 7), or excessively large radii.[6] (Figure 8 shows a way to dress corner damage.)
- Seal groove worn out of tolerance from circumferential seal slippage,
- Roughening on the inner portion of the environment-side groove wall (Figure 9) which can detrimentally anchor seal material and increase third-body abrasive wear of the seal,
- An extrusion gap bore that has worn oversize, and
- A journal bearing that has worn oversize, particularly if it permits metal-to-metal contact between the shaft and the extrusion gap bore, or can cause inadequate radial seal compression.

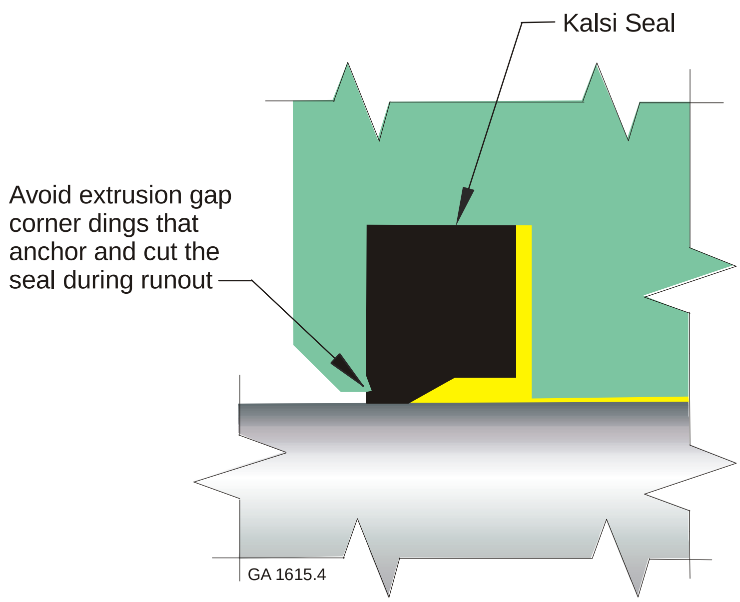

Figure 7

Avoid nicks, burrs, and displaced metal at the extrusion gap corner, because they serve as anchor points that can cut the rotary shaft seal during shaft runout, and during any circumferential seal slippage that may occur. This is important in both high and low differential pressure applications. In high differential pressure applications, extrusion gap corner damage can cause significantly accelerated seal extrusion damage. Corner damage may also increase the force required to install the seal onto the shaft.

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6 An excessively large extrusion gap corner radius can occur if the corner becomes damaged (i.e., nicks & burrs), and someone attempts to sand down the damage with abrasive paper.

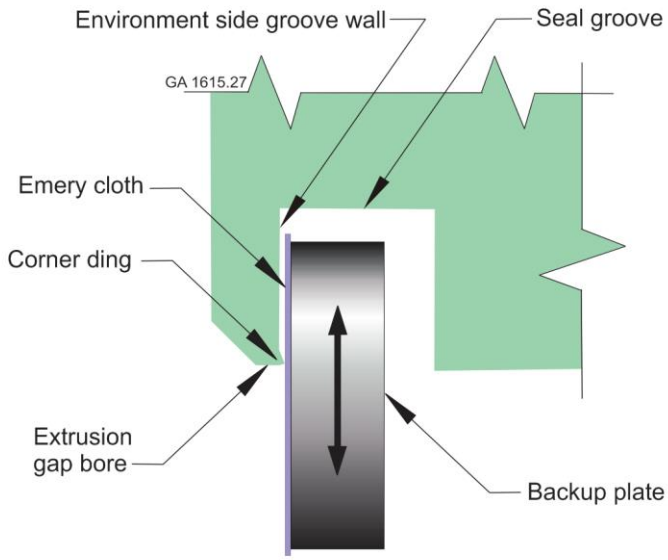

Figure 8

Displaced metal from extrusion gap corner dings can sometimes be dressed down with emery cloth that is backed by a flat piece of metal. The use of a flat piece of metal helps to avoid creating a wavy groove wall. It is therefore preferred over freehand use of abrasive paper.

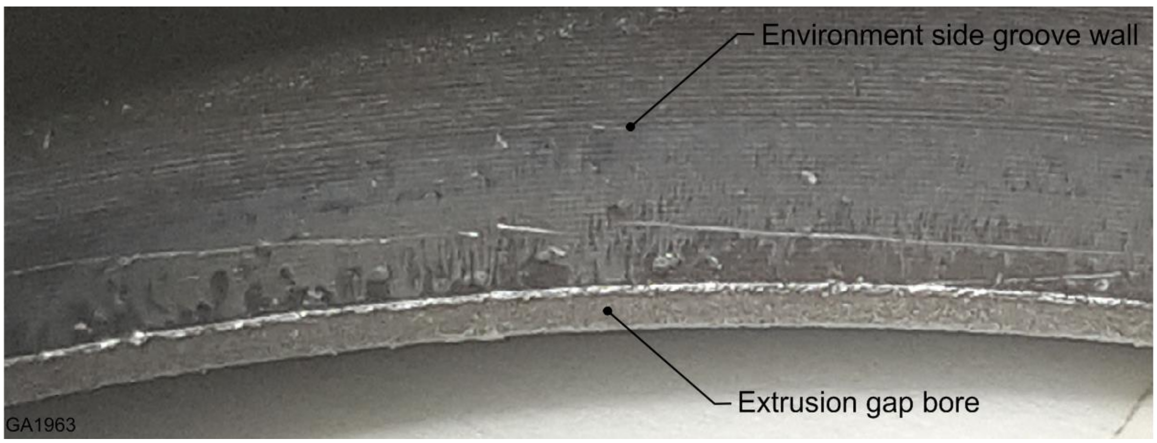

Figure 9

This photo is an enlargement of the flat environment-side seal groove wall and the adjacent radially inwardly facing extrusion gap bore of a seal carrier made from UNS S17400. The seal carrier was used in tests of Kalsi-brand rotary seals that were operating on a shaft with ~0.010” runout FIM in the presence of a drilling fluid environment. Note the radially oriented wear marks on the groove wall near the intersection with the extrusion gap bore. This wear is the result of radial sliding between the rotary seal and the groove wall due to shaft runout.[7] As this type of wear increases, the abrasion resistance of the seal decreases.

7 The use of floating seal carriers may reduce the degree of radial sliding between the rotary seal and the groove wall.

4. Rotary shaft seal installation and equipment assembly

1. Use appropriate safety practices during shaft seal installation and equipment assembly. Examples include wearing goggles and rubber gloves for protection from solvents, etc. and wearing steel-toed shoes for protection from falling articles.
2. Ensure that any newly manufactured hardware is free of manufacturing debris, such as metal chips, dried cutting fluid, dried plating fluid, etc.
3. Degrease the seal groove with an evaporative-type residue-free solvent degreaser (Figure 10).

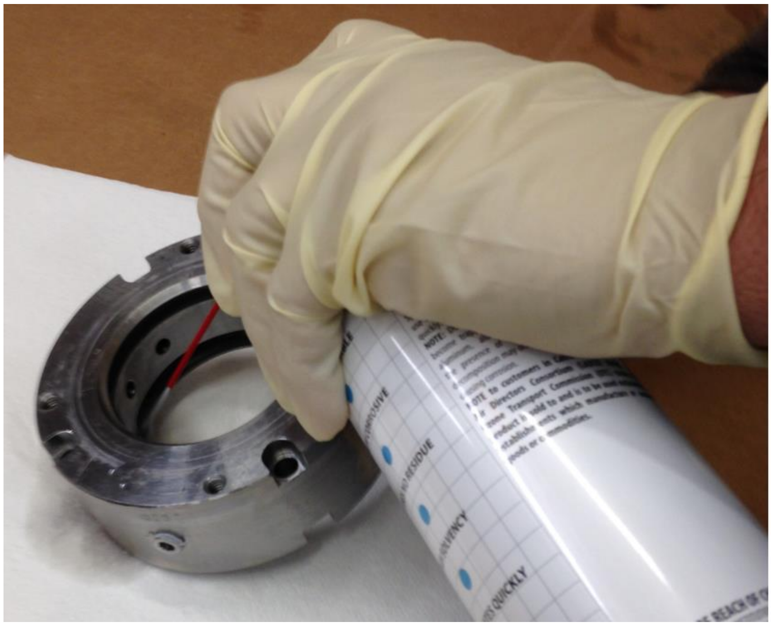

Figure 10

Degrease the seal groove

Beware that immersion in a typical parts cleaner solution usually leaves a seal carrier slightly oily, because the solution becomes contaminated with lubricant over time. To inhibit circumferential seal slippage, degrease the seal groove using an evaporative-type residue-free solvent degreaser. Allow the degreaser to evaporate before inserting the rotary seal.

4. Observe proper seal orientation when inserting the seal into the groove. The end of the seal marked “lubricant side” must face a lubricant (see Figure 11). To inhibit circumferential seal slippage, **do not** lubricate the groove and **do not** lubricate the seal (Figure 12) prior to installing the seal into the groove (Figure 13).

   The unfolded insertion technique shown in Figure 14 works well with larger diameter seals that are constructed entirely from elastomer. The folded seal insertion technique shown in Figure 15 works with elastomeric seals as small as the 1.375” ID -11 ACS Seal™, and may work with even smaller sizes as well. For convenience, a custom insertion tool (Figure 15) can hold small diameter seals in the folded condition. After insertion, check to ensure that no portion of the seal is twisted in the groove.

Small diameter or wider seals (and seals that incorporate metal springs, fabric reinforcement, or plastic) may require a removable groove wall, to allow insertion of the seal into the groove without damaging the seal. For an example of a removable groove wall, see Figure 16. For additional information about small diameter seals and removable groove walls, see Chapter D6.

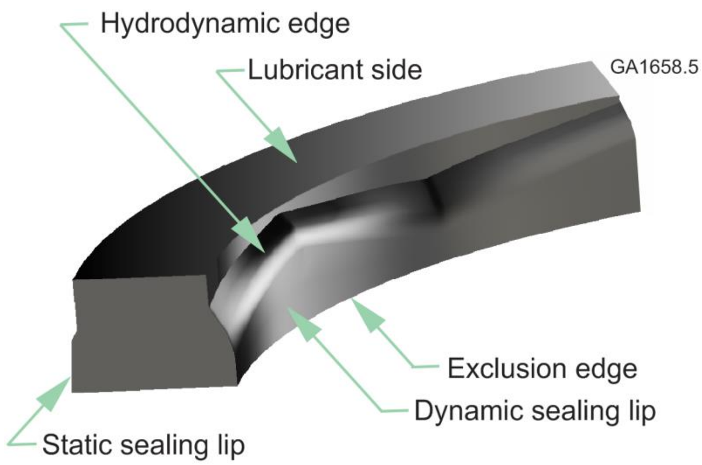

Figure 11

Kalsi Seal orientation is critical because the wavy hydrodynamic edge must face a lubricant. On most seals, the lubricant side is marked “lubricant side”. A Wide Footprint Kalsi Seal™, shown here, is suitable for either direction of rotation. On certain types of Kalsi-brand oil seals, such as High Film Seals™, the lip geometry is directional, and must match the direction of shaft rotation.

Figure 12

Do not lubricate the outside diameter of the Kalsi Seal or the seal groove!

Neither the Kalsi Seal nor its seal groove should be lubricated prior to inserting the seal into the groove. Instead, the seal groove should be thoroughly degreased with an evaporative-type residue-free solvent degreaser prior to inserting the seal, and both the seal and the groove should be dry at the time of seal insertion.

Figure 13

Larger diameter seals can be installed using the technique shown here. Part of the seal is inserted laterally into the groove, then the protruding loop is popped into the groove. After insertion, check to ensure that no portion of the seal is twisted in the groove.

Figure 14

Seals that are constructed entirely of elastomer can be folded, as shown here, to facilitate insertion into the seal groove. This technique is not applicable to seals that incorporate plastic or incorporate a metal spring.

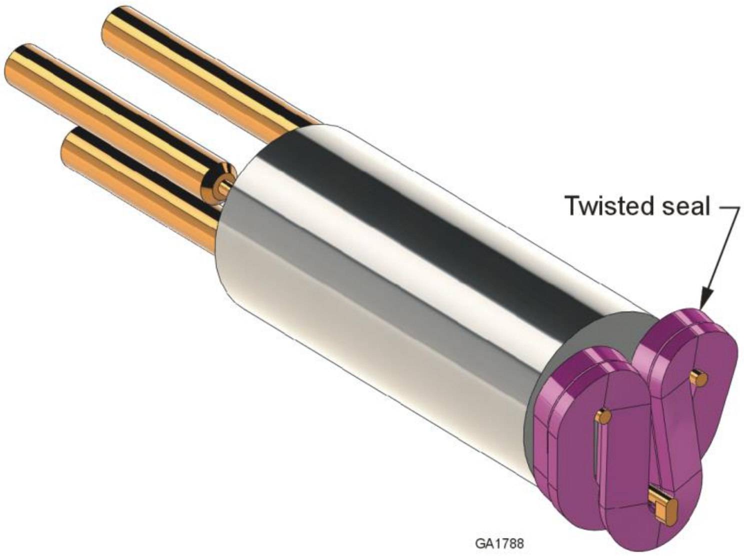

Figure 15

Custom built tools can facilitate insertion of small diameter elastomeric seals

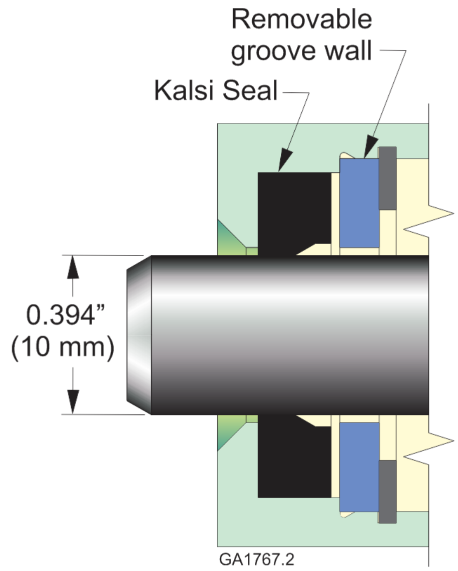

Figure 16

Some seals require a removable groove wall

Some seals cannot be installed without the use of a removable groove wall. Examples include small diameter elastomeric seals, and many seals that include plastic, fabric reinforcement, and/or metal springs in their construction.

5. Lubricate the seal installation path on the shaft, including the installation chamfer and the sealing surface. The same lubricant used in the machinery can serve this purpose. If the machinery uses a low viscosity lubricant, then using a higher viscosity lubricant (such as Mobil SHC-1000) can lower seal installation force, breakout torque, and the risk of circumferential slippage at startup. Lubricant should be compatible with the seal material, the process fluid and the temperature range of the application, and with any lubricant filtration and circulation equipment employed.

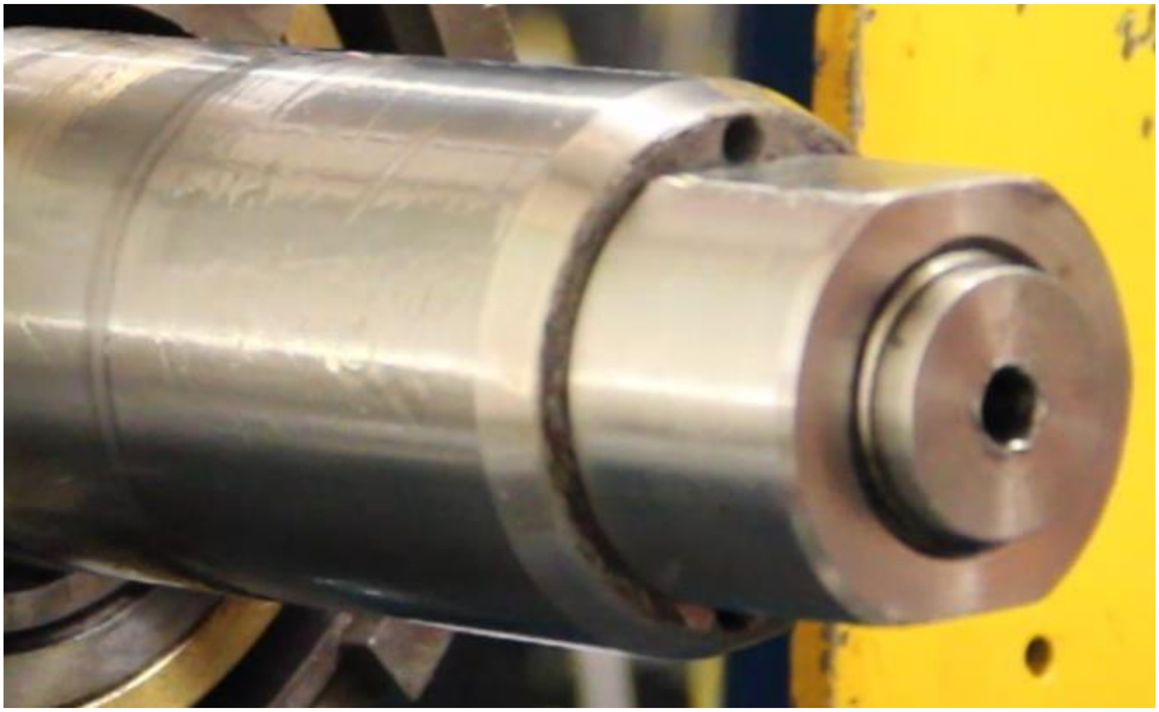

Figure 17

Lubricate the seal installation path

The seal installation path includes any shaft surface the seal touches during installation, including the installation chamfer and the sealing surface. Lubricate the seal installation path prior to installing the seal onto the shaft.

6. After installing the seal into the groove of the seal carrier, lightly lubricate the inside diameter of the seal to reduce installation force, to help prevent installation damage, and to reduce startup torque. Do not slather lubricant all over the bore of the seal carrier (Figure 18); just apply the lubricant to the inside diameter of the seal. Prior to the seal being compressed between the groove and the shaft, excess lubricant within the seal carrier may inadvertently result in lubricant seeping between the static lip of the seal and the mating bore of the seal groove. In our experience, the use of a higher viscosity lubricant (such as Mobil SHC-1000) can reduce seal installation force, breakout torque, and the risk of circumferential slippage at startup.[8]

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8 In startup tests conducted in a room temperature environment, lubricating the dynamic surface of the rotary seal with Valvoline multi-service grease prior to installation also reduced the risk of circumferential seal slippage at startup.

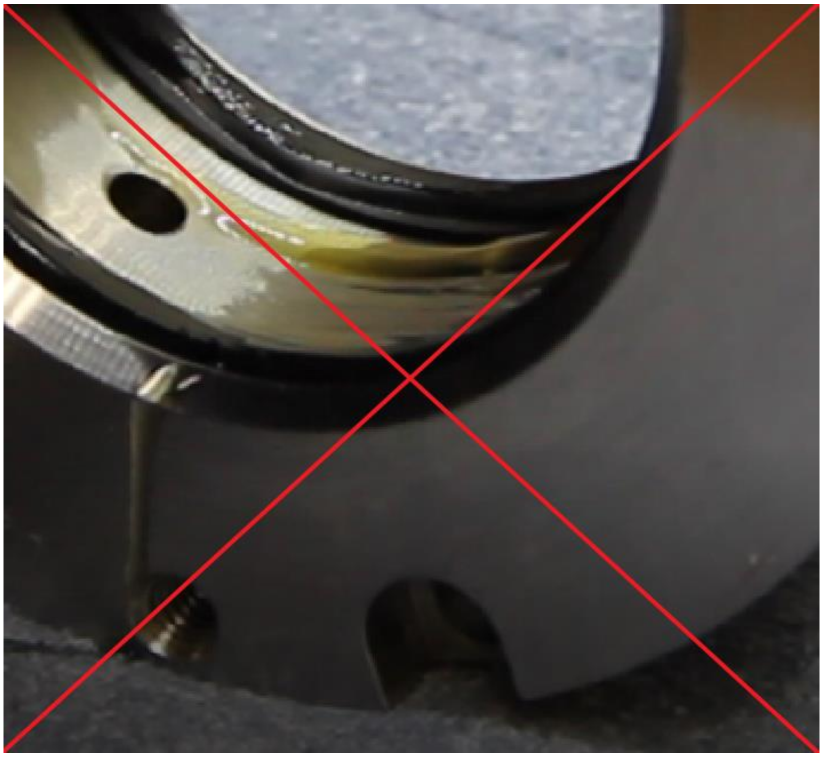

Figure 18

Do not slather the seal carrier with lubricant

It is not beneficial to slather the bore of the seal carrier with lubricant — and in some cases, it may be detrimental, because it may result in inadvertent lubrication of the static lip of the rotary seal, which increases the risk of circumferential slippage at startup. After the dry, unlubricated seal is installed in the dry, unlubricated groove of the seal carrier, apply a light coating of lubricant to the inner-most surface of the seal. Do not apply lubricant to the inner surfaces of the seal carrier, except in cases were a bore of the seal carrier serves as a journal bearing.

7. Align the shaft carefully to ensure that initial seal contact takes place on the shaft installation chamfer, and then insert the shaft. Improper insertion can damage or roll the seal (see Figure 19). Large diameter, solid cross section seals require considerable force to install, and typically require mechanical assistance, such as a hydraulic press or a simple thread-driven press. If a seal requires an unusually large amount of force to install, then check to make sure that the groove width or diameter isn't too small, and check for the improper installation chamfer conditions shown in Figures 6 and 19. For additional information on the seal installation path, see Chapter D3.

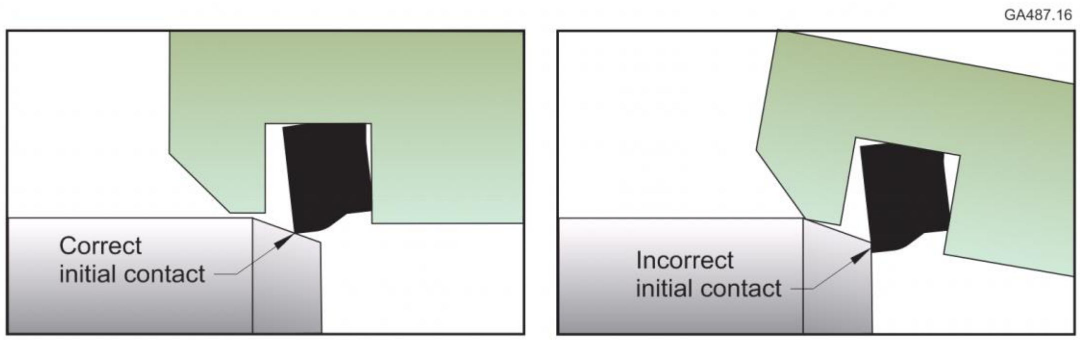

Figure 19
To avoid seal damage, be sure the seal makes initial contact with the installation chamfer, and not with the shaft shoulder.

8. Add lubricant to the equipment in a manner that eliminates air, so the hydrodynamic edge of the Kalsi Seal is next to lubricant, rather than air. Beware of the bell jar effect (Figure 20). See Section 5 of this chapter for a variety of methods to fill equipment with lubricant while eliminating air.
9. Do not overfill the lubricant reservoir. The reservoir must allow room for lubricant thermal expansion. Failure to allow room for lubricant thermal expansion can cause seal and hardware damage, as described in Chapter D13. In some equipment with piston-based lubricant reservoirs, the piston is not accessible for observation during the filling process. To prevent overfilling in such applications, consider using a custom designed syringe (e.g., a manually operated plunger-based reciprocating pump) that can be temporarily attached to draw a known amount of lubricant from the reservoir after the piston has been pumped to the completely full position. As the lubricant is extracted, the piston moves away from the full position.
10. If a lubricant overpressure-type Kalsi Seal will encounter an abrasive process fluid, then seat the seal against the environment-side groove wall by temporarily applying approximately 100 psi (690 kPa) lubricant pressure.

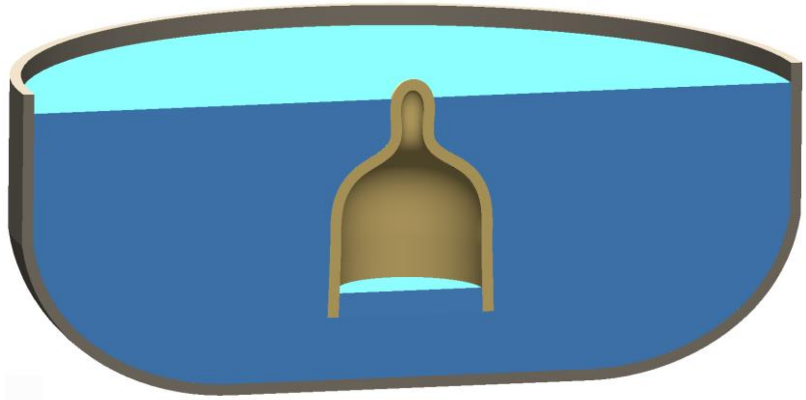

Figure 20

Beware of the 'bell jar effect'

In this simple experiment, the trapped air within a submerged bell jar prevents the interior of the bell jar from filling up with water. Likewise, air within an assembly can prevent lubricant from reaching a rotary shaft seal, especially in vertical shaft arrangements. In some equipment, it may be possible to use a custom syringe (e.g., a manually operated plunger-based reciprocating pump) to draw air out of a region that experiences the bell jar effect, allowing oil to enter the region.

5. Lubricant filling methods

Filling horizontal shaft applications

In horizontal shaft applications, fill the lubricant through a port on the bottom side of the housing, and allow the air to escape at a port on the top side, as shown in Figure 21. Kalsi Engineering uses this method to fill the majority of its rotary seal test fixtures. A small pocket of air is present at the top side of the seal grooves due to bell jar effect, but it does no harm if the assembly remains horizontal during operation, or if the end of the tool with the air vent port is slightly elevated.

Depending on the construction of the lubricant reservoir, either the lubricant reservoir, a lubricant pump, or an air over oil-based lubricant transfer tank (Figure 22) can be used to fill the seal housing.

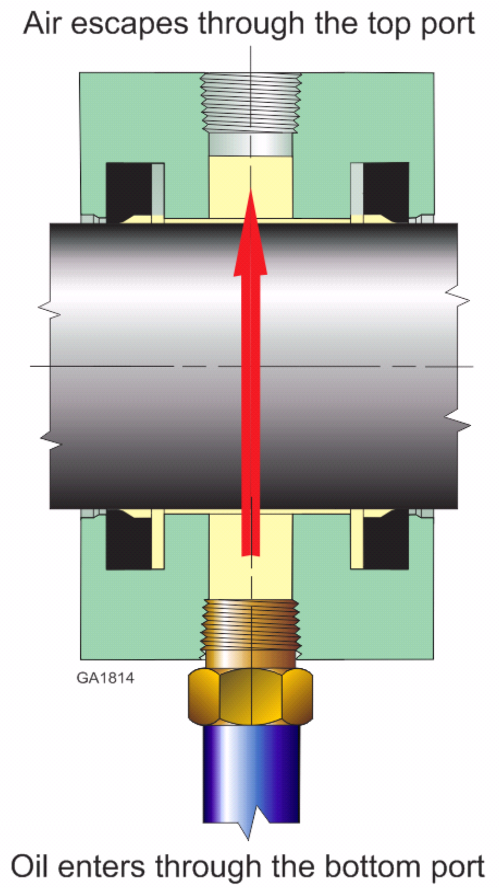

Figure 21

In horizontal shaft applications, one can eliminate air by performing the oil fill through the bottom port of the seal housing. As the oil enters and rises, it displaces the air, which escapes through the temporarily open top port.

Figure 22

A simple air over oil-based lubricant transfer tank

We at Kalsi Engineering use air over oil tanks like this to fill the lubricant reservoirs and seal housings of our horizontal shaft-type rotary seal test fixtures. Shop air pressure, introduced through the quick connect coupling at the top of the tank, forces the lubricant through the valve at the bottom of the tank, and into the test fixture. A pressure relief valve limits pressure within the tank. The tank is disconnected from the test fixture prior to use, to isolate the tank from the lubricant pressure of the test fixture.

Vacuum filling of the seal lubricant

Vacuum filling is desirable for vertical shaft applications that run at relatively low lubricant pressure, because it helps to prevent the formation of an air pocket below the upper rotary seal. If an air pocket is large enough, it can cause lubricant starvation of the upper seal. Vacuum filling also is desirable when minimizing lubricant pressure lag is important because it takes time for a piston or diaphragm to move and collapse entrained air and air pockets.

Evacuate the lubricant region of the equipment using a vacuum pump[9]. Introduce the lubricant into the evacuated area, then pressurize the lubricant to force a complete fill, valving off the pressure for a short period to verify sealing integrity. Beware that drawing oil into your vacuum pump may damage it; Figure 23 shows a way to protect a vacuum pump from accidental oil entry.

One risk of vacuum filling is that the vacuum can pull streams of air into the lubricant if a filling system leak occurs. To avoid this situation, periodically check the entire filling system for leaks; also check the equipment being filled, to detect leaks prior to introducing the lubricant. One way to check for leaks is to draw a vacuum on the system, then monitor the vacuum gauge for a few minutes to see if the vacuum pressure changes. Use clear tubing on vacuum filling systems to facilitate identification and elimination any entrained air problems. If opting not to use vacuum filling techniques, then purge any hoses that are a part of the rotary equipment to eliminate air from the hoses.

Lubricant typically contains a significant amount of entrained air. To prove this to yourself, put lubricant in a clear vessel and pull a vacuum on it, and watch the bubbles come streaming out. In vertical shaft equipment, the entrained air may contribute to an air pocket that causes lubricant starvation at the upper rotary seal. In such applications, it is desirable to degas the lubricant, and then evacuate the equipment with a vacuum pump before filling with lubricant. Figure 24 is a schematic representation of a lubricant degasser.

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9 Commercial lubricant filling systems are available that have heaters to lower the viscosity of high viscosity lubricants, for ease of filling.

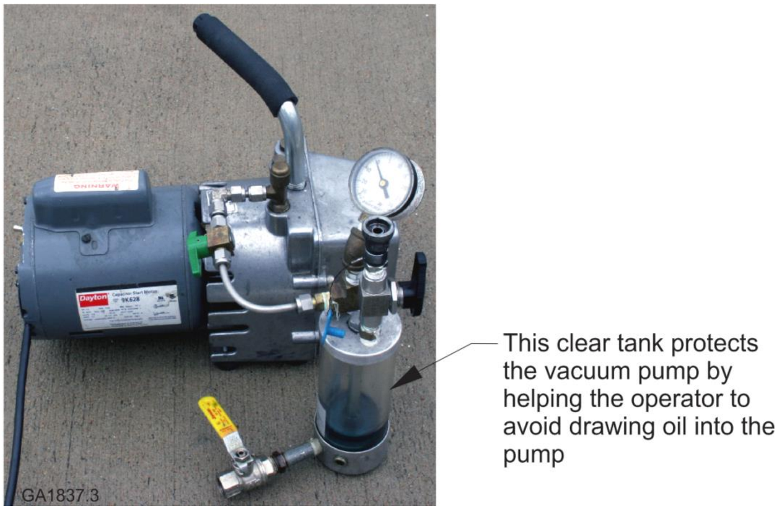

Figure 23

Oil can damage vacuum pumps. To prevent drawing oil into the pump, incorporate a clear tank, as shown, and draw the vacuum through the clear tank. The operator can visually detect the entry of oil into the clear tank before the oil enters and damages the vacuum pump.

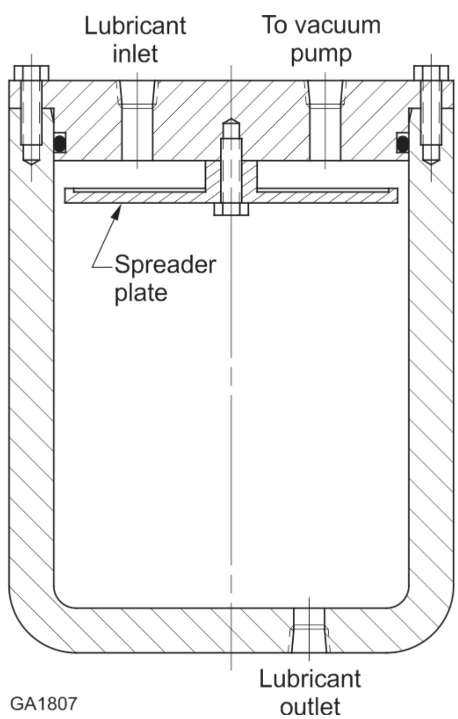

Figure 24

Lubricant degasser

A lubricant degasser is a vacuum chamber that includes a spreader plate. As the lubricant enters, it spreads out thin on the spreader plate, so air bubbles can quickly rise to the surface and break.

Exploiting gravity to achieve a good fill in vertical shaft equipment

Figure 25 shows a simple method for filling swivel type devices that have a journal bearing relationship between the seal carrier and the rotary shaft. It also works with certain other types of rotary equipment. Orient the shaft vertically, and then push the housing down over the top of the shaft until the lower rotary seal engages the shaft. Pour some lubricant into the housing to create a pool of lubricant, then install the housing the rest of the way onto the shaft. (If using hollow shafts, then you may need to cap or plug the shaft so that the housing can hold a suitable volume of lubricant.) With simple housings that contain few, if any, internal components, this method eliminates nearly all the air by effectively immersing the inside of the housing in lubricant throughout the installation process. To ensure a complete fill, be sure that the initial pool of lubricant is enough to overflow the housing during installation. Perform the installation in a tub to capture the lubricant overflow.

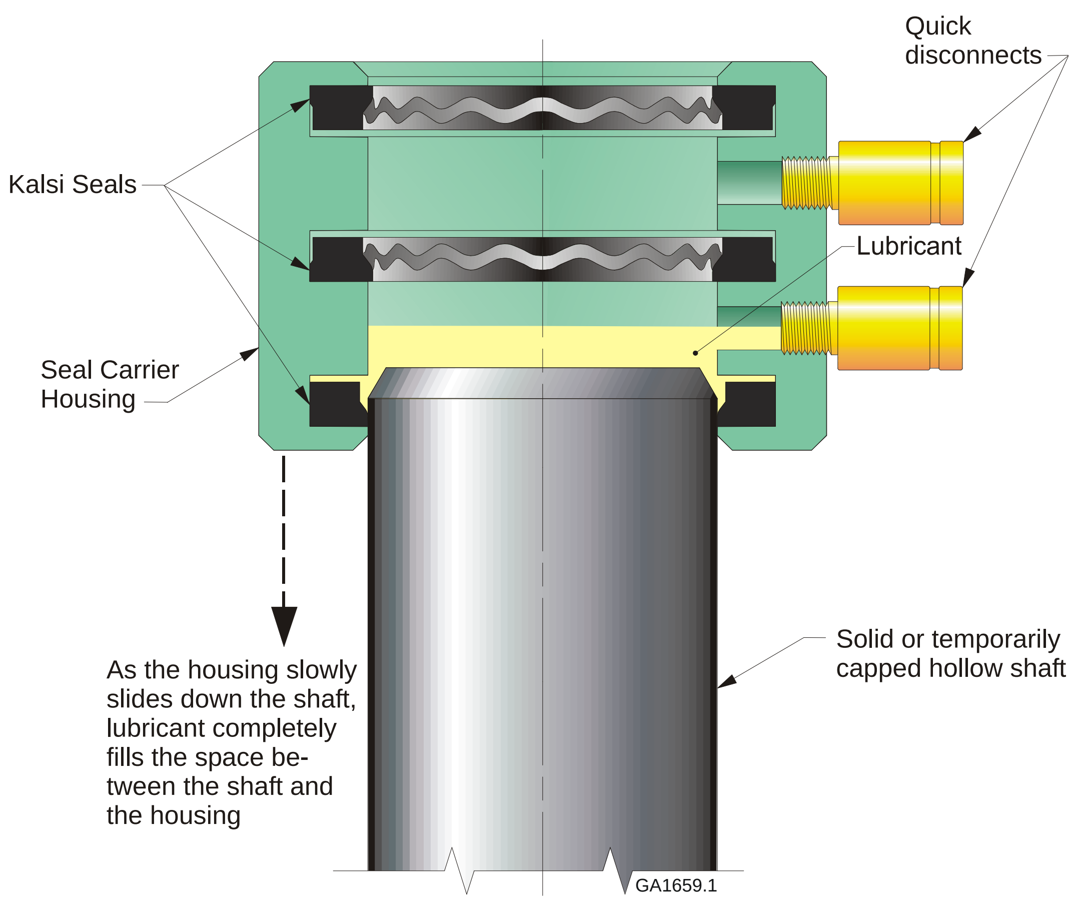

Figure 25

One method of eliminating air from the lubricant is to use the seal carrier housing as a reservoir that floods all housing-to-shaft clearances with lubricant during housing installation. This provides the same effect as submerging the equipment in a tank of lubricant during assembly.

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6. Shop training classes

Kalsi Seal shop training classes (Figure 26) are available at our location or yours, or via Internet conferencing. The training provides a general introduction to the Kalsi Seal with a review of items to look for during disassembly of equipment, and a review of good equipment assembly practices. This class is kept to about 45 minutes to limit its impact on the customer's production.

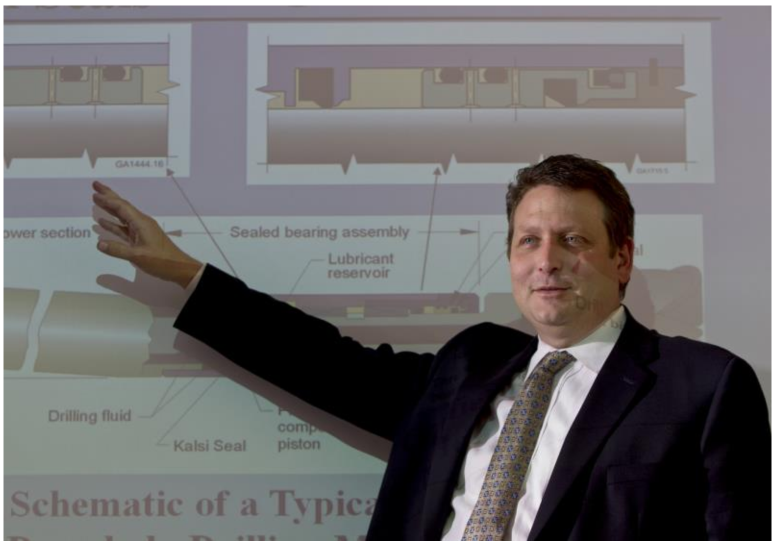

Figure 26

Rotary shaft seal training classes

Seal related shop and engineering training classes are available in person, or via Internet conferencing. Kalsi Engineering can tailor the classes for relevance to your specific rotary shaft sealing application. Shop training typically covers equipment disassembly and inspection, rotary shaft seal installation, equipment assembly, and lubricant fill.