Chapter D6

Small diameter seals

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

1. Introduction

The smaller the seal diameter, the more difficult installation and extraction become. Very small diameter Kalsi Seals require a removable groove wall (as shown in Figures 4 and 5) to permit seal insertion. The removable groove wall is particularly important when inserting seals made of harder elastomers. The smaller the radial cross-section of the seal, the greater the interfacial contact pressure (Figure 9). Larger cross sections are preferable when practicable.[1]

2. Will my seal install into a one-piece groove?

One key factor that influences whether an elastomer-based[2] Kalsi-brand rotary seal can be installed into a one-piece groove is the aspect ratio ID_{SEAL}/D shown in Figure 1. In our tests with 1.187" (30.16mm), 1.375" (34.93mm), and 1.500" (38.10mm) Kalsi Seals made from -11 HNBR material, it was possible to manually install the seals into a one-piece groove if the ID_{SEAL}/D aspect ratio was greater than 4.4; however installation was difficult, even at an aspect ratio of 5. In our tests with 0.980" (24.89mm) seals made from -10 HNBR material, installation into a one-piece groove was impossible at an aspect ratio of 3.55, and possible but difficult at an aspect ratio of 4.43. Testing to date has been limited to Standard and Axially Constrained Kalsi Seals.

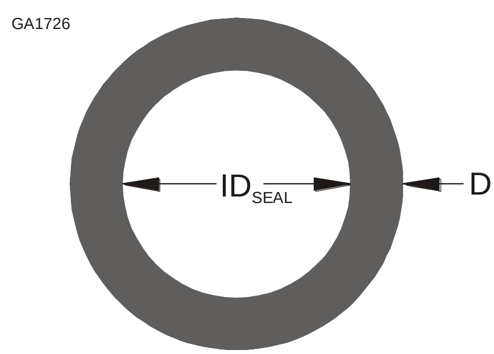

Figure 1

Seal aspect ratio influences ease of insertion

If the ID_{SEAL}/D aspect ratio is greater than 4.4, then typically it is possible to install Kalsi Seals made from –11 material into a one-piece groove, without resorting to a removable groove wall. However, installation can be difficult even at an aspect ratio of 5.

1 In micro-bore (small diameter) mud motor sealed bearing assemblies, rotary seals with larger radial cross-sections may not be practical for the pressure retaining seal, because a larger seal cross-section requires that a smaller diameter, weaker and more flexible mandrel be used.

2 Small and medium diameter plastic lined Kalsi Seals cannot be installed into a one-piece seal groove without damage, and require a removable groove wall.

Our installation tests with small diameter seals were performed manually, which causes significant finger strain. Because of such strain (Figure 2), an installation tool (Figure 3) may be desirable if a number of assemblies are involved. Seals having a smaller ID_{SEAL} than we tested will be more difficult to handle, and may require a removable groove wall (Figures 4 and 5), even if the aspect ratio is greater than 5.

Before settling upon a one-piece groove configuration for small diameter seals, build and test a hardware mockup to evaluate ease of assembly, and to determine the need or desirability of an installation tool, or a removable groove wall. Be aware that the farther the seal groove is located from the end of the seal housing, the more difficult seal installation becomes.

3. Inserting small aspect ratio seals into a one-piece groove

Small diameter seals have to be folded for insertion into a one-piece groove, as shown in Figure 2. Such folding reduces the seal to a dimension that allows insertion into the seal carrier bore. After inserting the lower portion of the seal into the groove, the remainder of the seal can be unfolded into the groove.

Figure 2
Folding small seals

Folding small seals facilitates insertion into the seal groove. Performing this job manually causes finger strain for the mechanic, as evidenced here by fingertip coloration.

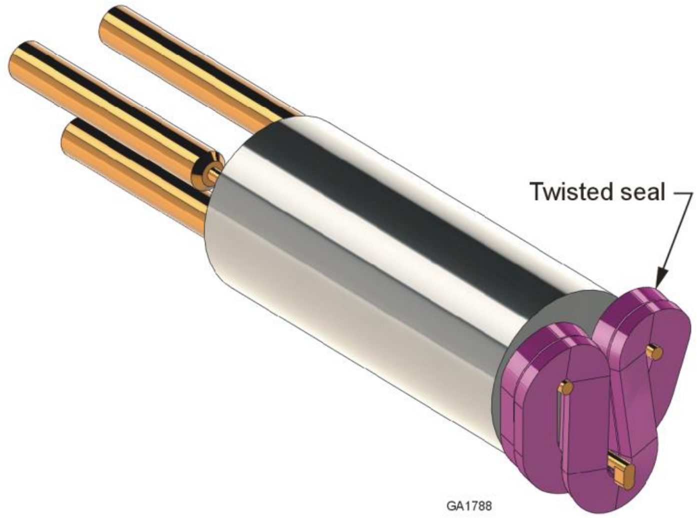

Figure 3

Seal installation tool

A custom installation tool can hold a seal in the folded position for insertion into the seal groove. Extraction of the lower rod allows the seal to unfold into the groove. Use of the installation tool can reduce finger strain for the mechanic.

4. Removable groove wall design

When dictated by seal aspect ratio or installation difficulty, use a removable groove wall (Figures 4 and 5). An important goal when designing such arrangements is to maintain concentricity, because eccentric extrusion gaps increase high-pressure extrusion damage, and may increase third-body abrasive wear. As shown in Figure 5, it may only be necessary to make the inner portion of the groove wall removable.

Using a removable groove wall in a compensation piston

Figure 5 shows how to incorporate a removable groove wall in a compensation piston to accommodate a small diameter rotary seal that has a relatively large radial cross section. Three radial pins position the journal bearing axially and prevent the journal bearing from rotating relative to the remainder of the piston. The radial pin holes are match drilled and reamed through both piston members simultaneously. If desired, a retaining ring could capture the journal bearing, and a single radial pin could prevent journal bearing rotation. In addition to the sliding seal, two O-rings provide friction with respect to the housing, to prevent the piston from spinning with the rotating shaft. A radial vent hole communicates with the clearance fit at the OD of the journal bearing to prevent pressure locking between the sliding seal and the first O-ring. The retaining pin holes prevent pressure locking between the two O-rings. See Chapter D14 for additional information on compensation piston design.

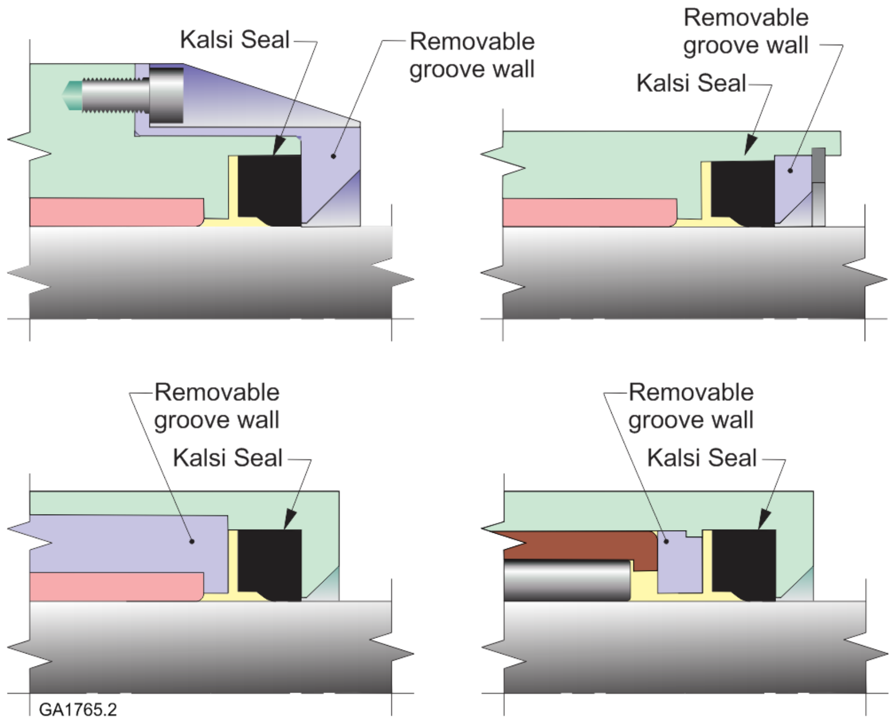

Figure 4

Removable Groove Wall

A removable groove wall allows small diameter seals to be installed in their grooves. In many cases, it will be desirable to pin or key the removable wall to prevent rotation.

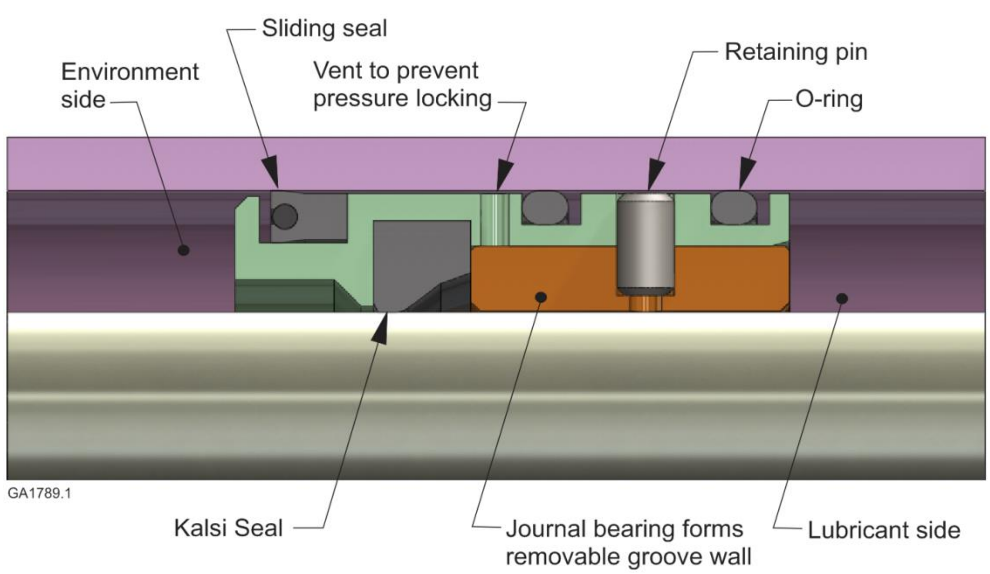

Figure 5

Removable groove wall in an oilfield mud motor compensation piston

Three radial pins retain the journal bearing, which forms a removable groove wall.

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5. An option for removing small seals from one-piece grooves

Although it is usually possible to extract small diameter seals from one-piece grooves using conventional techniques, the process can be difficult, due to seal stiffness. Figures 6 and 7 show a seal extraction technique that can be used when the same fluid is located on the inside and outside of the carrier during operation. Figure 6 illustrates a configuration intended for applications where there is no possibility that the seal will experience differential pressure acting from the environment side.

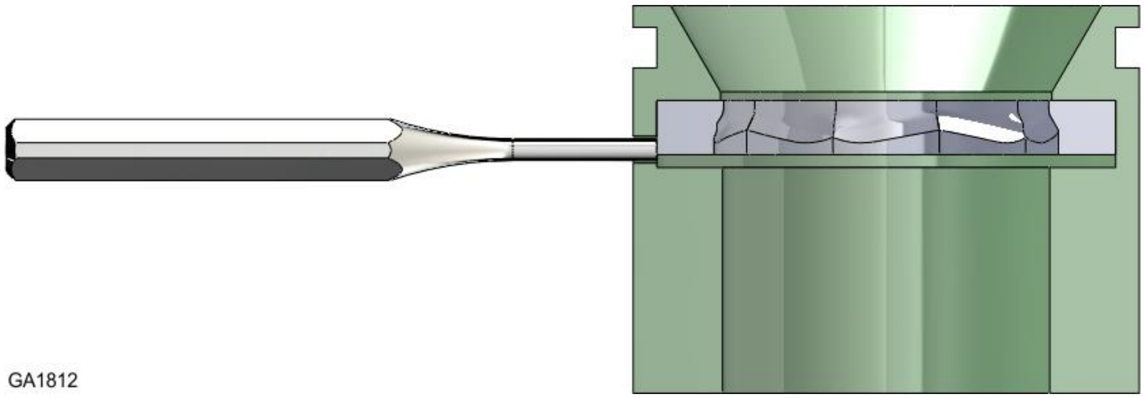

Figure 6

Using a radial hole and punch to remove small diameter seals

The technique shown here is intended for applications where there is no possibility of differential pressure acting from the environment side of the seal during service. Because of the O-ring location, both the inside and outside of the carrier are exposed to the same fluid, and the radial hole does not produce a leak path. The punch pushes one side of the seal out of the groove, so the mechanic can easily pry the remainder of the seal from the groove.

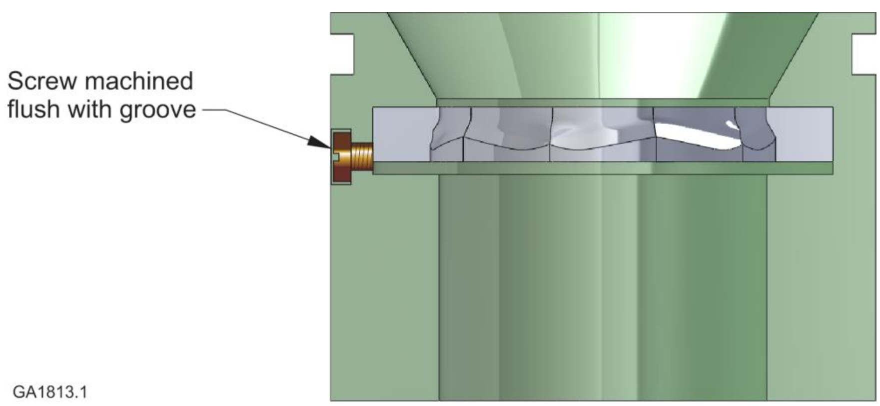

Figure 7

Plugging the hole for support in reverse pressure situations

Plugging the radial hole with a screw machined flush with the groove bore, as shown here, provides support to the seal in the event it experiences temporary differential pressure acting from the environment side.

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6. Installed width increases as diameter increases

For the same cross sectional dimensions and dimensional compression, the installed width of a small diameter seal is greater than the installed width of a large diameter seal (Figure 8, and Appendix 3). This effect is due to the increased circumferential compression experienced by small diameter seals. For very small diameter seals, the groove width needs to compensate for this effect. Paradoxically, circumferential compression has much less effect on the seal radial cross sectional depth D.

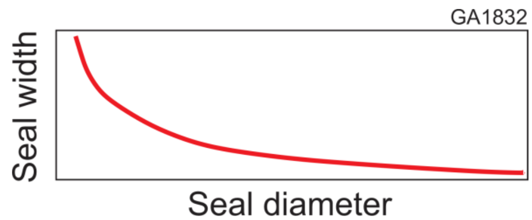

Figure 8

Small diameter seals have greater installed width

For seals with the same cross sectional dimensions and dimensional compression, installed width increases as diameter increases.

7. Small cross sections increase interfacial contact pressure

Interfacial contact pressure relates to the percentage of cross sectional compression and the modulus of the seal material. For the same amount of dimensional compression, a small cross section seal has a higher percentage of compression (Figure 9). This means that smaller cross section seals have higher interfacial contact pressure for the same dimensional compression, and therefore are more difficult to lubricate and have higher breakout torque. For these reasons, larger cross section seals are preferable whenever they fit within equipment dimensional constraints, and very small cross sections typically use less dimensional compression than larger cross sections.

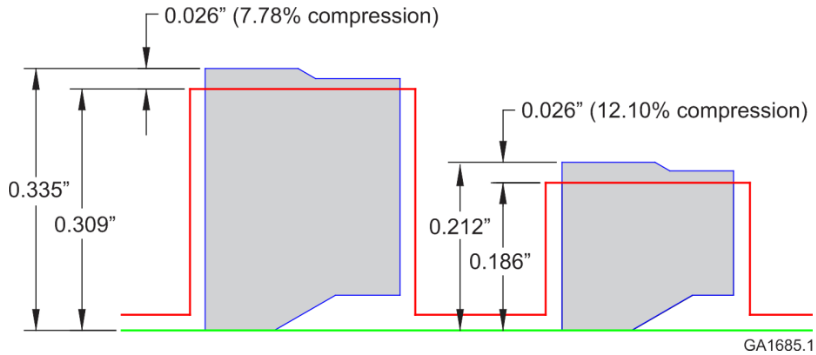

Figure 9

Small seals have greater contact pressure for the same dimensional compression