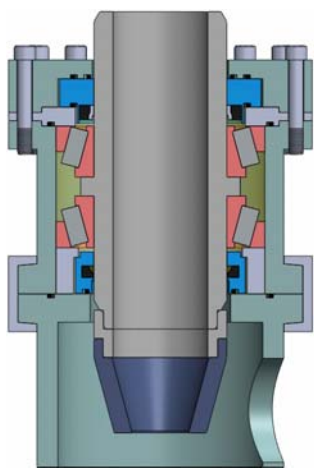
# Chapter E1

## Using Kalsi Seals in RCDs with lubricant overpressure



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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 https://www.kalsi.com/seal-handbook/.

## 1. Introduction

A rotating control device[1] (RCD) reduces formation damage in oilwell drilling (compared to overbalanced drilling) by maintaining the pressure of the annular fluid column of drilling mud at a pressure below, or comparable to, that of the reservoir. The reduction in formation damage helps to optimize the production potential of the well. Drilling with an underbalanced pressure condition allows the evaluation of well effluents while drilling. It also reduces differential sticking and allows less expensive drilling fluids to be used.

Early versions of Kalsi-brand rotary seals began to be used in RCDs in 1991. Since then, several advances in technology enable our seals to operate in more adverse RCD sealing conditions, including higher pressure, higher speed, less cooling, lower viscosity lubricants, and less complicated lubricant supplies. Our high-performance seals withstand relatively high pressure because they incorporate hydrodynamic pumping features that force a thin film of lubricant into the sealing interface during rotation. The resulting hydroplaning action reduces friction, wear, and seal-generated heat. We have developed innovative ways to implement high pressure seals into large diameter high pressure equipment to further improve performance.

This chapter provides guidance for implementing Kalsi Seals® into the type of RCD that maintains the seal lubricant at a pressure that is slightly greater than the wellbore pressure. The information in this chapter is also relevant to the design of other types of high pressure rotating equipment, such as water drilling heads.

## 2. Pressurized lubricant versus gravity fed lubricant

KLS® and BDRP seals™ that are compatible with a non-pressurized seal lubricant are described in Section C of this handbook. See the relevant chapters for seal descriptions, performance characteristics, and implementation recommendations.

### *Advantages and disadvantages*

RCDs that utilize a pressurized seal lubricant can operate at higher well pressures than RCDs that use a non-pressurized lubricant, but involve additional complexity.

1 Also known as a rotating head, rotary blowout preventer, rotating blowout preventer, rotating drilling head, rotating BOP, rotary BOP, rotary control device, and rotating diverter. If needed, we can provide batch acceptance information to help our customers meet the requirements of API Specification 16RCD, "**Specification for Drill Through Equipment—Rotating Control Devices**".

## 3. Pressurized lubricant systems

### *Introduction*

The conventional approach to implementing Kalsi Seals in a rotating control device is to

provide a lubricant supply that maintains the lubricant pressure at a value that is greater than the fluctuating drilling fluid pressure. The purpose of the lubricant overpressure system is to properly orient the mud-to-oil partitioning seal against the mud-side gland wall for good abrasive exclusion. In active RCD designs, the lubricant pressure may also be used to activate the packing element.[2]

Chapter D11 describes various types of pressurized lubricant supplies.

### *Computer-controlled lubricant overpressure*

Oilfield industry literature indicates that systems with computer-controlled pressure are successful in RCDs. Such systems maintain the lubricant pressure approximately 300 psi above the drilling fluid pressure.[3] Computer controlled systems also have the advantage of a large lubricant reservoir, which is good from a lubricant cooling standpoint, and for accommodating the increased hydrodynamic pumping related leakage of Enhanced Lubrication Seals™ (Chapter C5) and Plastic Lined Seals™ (Chapter C16). Wintertime operating conditions may require lower viscosity lubricants or lubricant heaters, to facilitate the lubricant circulation that is employed in computer-controlled systems.

### *Piston amplifier-controlled lubricant overpressure*

When sufficient room is available, the differential area piston amplifier type of lubricant reservoir shown in Chapter D11 may be appropriate for use with an RCD. Consider incorporating an automatic refill system, which can be controlled by the position of the piston rod.

### *Lubricant overpressure generated by controlled flow*

As described by Kalsi Engineering's U.S. Patent 7,798,496,[4] a lip seal can be used as the mud to oil partitioning seal and a Kalsi Seal™ can be used as the pressure retaining seal, if a lubricant having a controlled flow rate and a pressure greater than the mud pressure is introduced between the lip seal and the Kalsi Seal. One way to control the lubricant flow

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[2] For examples of active RCD arrangements, see US Patents 3,621,912, 5,178,215, 5,224,557, 5,588,491, and 5,662,171, and 9,316,319. Active RCDs may convey more breakout torque to the mandrel, compared to passive RCDs. Active RCDs typically pressurize at least part of the bearing housing, which increases bearing clearance, and therefore increases shaft runout and deflection — increasing the need for seal carriers or backup rings that follow lateral shaft motion. Active RCDs typically require a relatively complex lubricant pressure control system.

[3] For an example of a computer-controlled pressure system used to maintain 300 psi lubricant overpressure in an RCD, see U.S. Patent 6,554,016, titled *"Rotating blowout preventer with independent cooling circuits and thrust bearing".*

[4] Contact Kalsi Engineering, Inc. for licensing details.

rate is to use a positive displacement pump to supply the seal lubricant. The flow vents through the dynamic interface of the lip seal, and into the drilling mud, lubricating the lip. The slow constant flow provided by the pump causes the lubricant pressure to equal the mud pressure plus whatever slight differential pressure is required to vent the seal.

One advantage of such systems is hardware simplicity. Another is the low breakout torque of the lip seal, making the stripper rubber less likely to slip on the drill string. Yet another advantage is the contaminant flushing action of the lubricant flow that passes through the dynamic interface of the lip-type partitioning seal. When designing such a system, verify the venting pressure of the lip seal by testing. The outboard, mud side groove wall may need to be minimized to prevent the lip from sealing with respect to the groove wall.

## 4. Rotary seal locations in an RCD with lubricant overpressure

Figure 1 is a schematic showing two ways to arrange rotary seals in an oilfield RCD. The heart of the assembly is a rotating elastomeric packing element that seals around the rotating drillstring. The packer element is mounted on a bearing guided rotating shaft. Rotary seals partition the drilling fluid from the lubricant, retain the lubricant, and withstand the pressure difference between the drilling fluid and the atmosphere.

Due to scale, the seal carriers in Figure 1 are highly schematic, and do not show the laterally translatable seal mounting arrangements that are typically recommended for RCDs that have pressurized lubricant systems. If laterally translatable seal mounting arrangements are not used, the upper and lower radial bearings should be mounted within the housings that locate the rotary seals, to minimize shaft runout and deflection at the rotary seals. Seal grooves that are adjustable to unworn shaft locations help to extend the service life of the shaft between recoating. Some types of thrust bearings require preload springs to maintain force on the unloaded bearing; such springs are not shown.

In both images of Figure 1:

- The partitioning seal partitions pressurized drilling fluid from the pressurized seal lubricant, and the high-pressure seal retains the pressure of the seal lubricant.
- The pressure of the seal lubricant is pressurized to a value that is greater than the pressure of the drilling fluid in the wellbore.
- The bearing lubricant is preferably circulated for cooling purposes, extracting heat generated by the seals and bearings.

***The left-hand image of Figure 1***

In the left-hand image of Figure 1, oppositely facing Kalsi Seals are mounted above and below the bearings, and a pressurized lubricant is introduced between the seals. This arrangement has the disadvantage of pressurizing and expanding the bearing housing, which decreases bearing guidance of the rotating shaft.

The left-hand arrangement also has the potential disadvantage of exposing the high pressure shaft seal to environmental contaminants — for example, a drilling fluid spill. Because of this contamination risk, floating backup rings and plastic lined seals should be avoided at the high-pressure seal location of the left-hand image, unless they are well-protected by an outboard trash seal (not shown). An all elastomer high pressure seal and a laterally translating seal carrier (Chapter D16) would not require the protection of an outboard trash seal.

An advantage of the left-hand arrangement is that the heat zone created by the high pressure seal is well-separated from the heat zone created by the partitioning seal.

***The right-hand image of Figure 1***

In the right-hand image of Figure 1, oppositely facing Kalsi Seals are mounted below the bearings, and a pressurized seal lubricant is introduced between the seals. This arrangement has the advantage of preventing pressure-related expansion of the bearing housing, which helps to maintain good bearing guidance of the rotating shaft. It also has the advantage of protecting the pressure retaining seal from environmental contaminants. The low pressure bearing lubricant can easily be circulated for cooling purposes.

In the right-hand image of Figure 1, a third rotary seal, at the top of the unit, retains the bearing lubricant and protects the bearings from environmental contaminants. If the bearing lubricant is circulated, this upper seal must withstand the pressure generated by the viscous resistance of the lubricant. In surface units, this third rotary seal can be somewhat protected from environmental abrasives by using the weir and rotating cover that are described in U.S. Patent 8,505,924.[5]

If desired, pressure can be staged across the middle and upper rotary seals by introducing the bearing lubricant at a pressure that is about half that of the seal lubricant. Pressure staging requires that the upper seal be a type capable of withstanding significant differential pressure. For examples of how pressure staging can be accomplished in RCDs, see our US Patents 6,227,547 and 9,429,238.[6]

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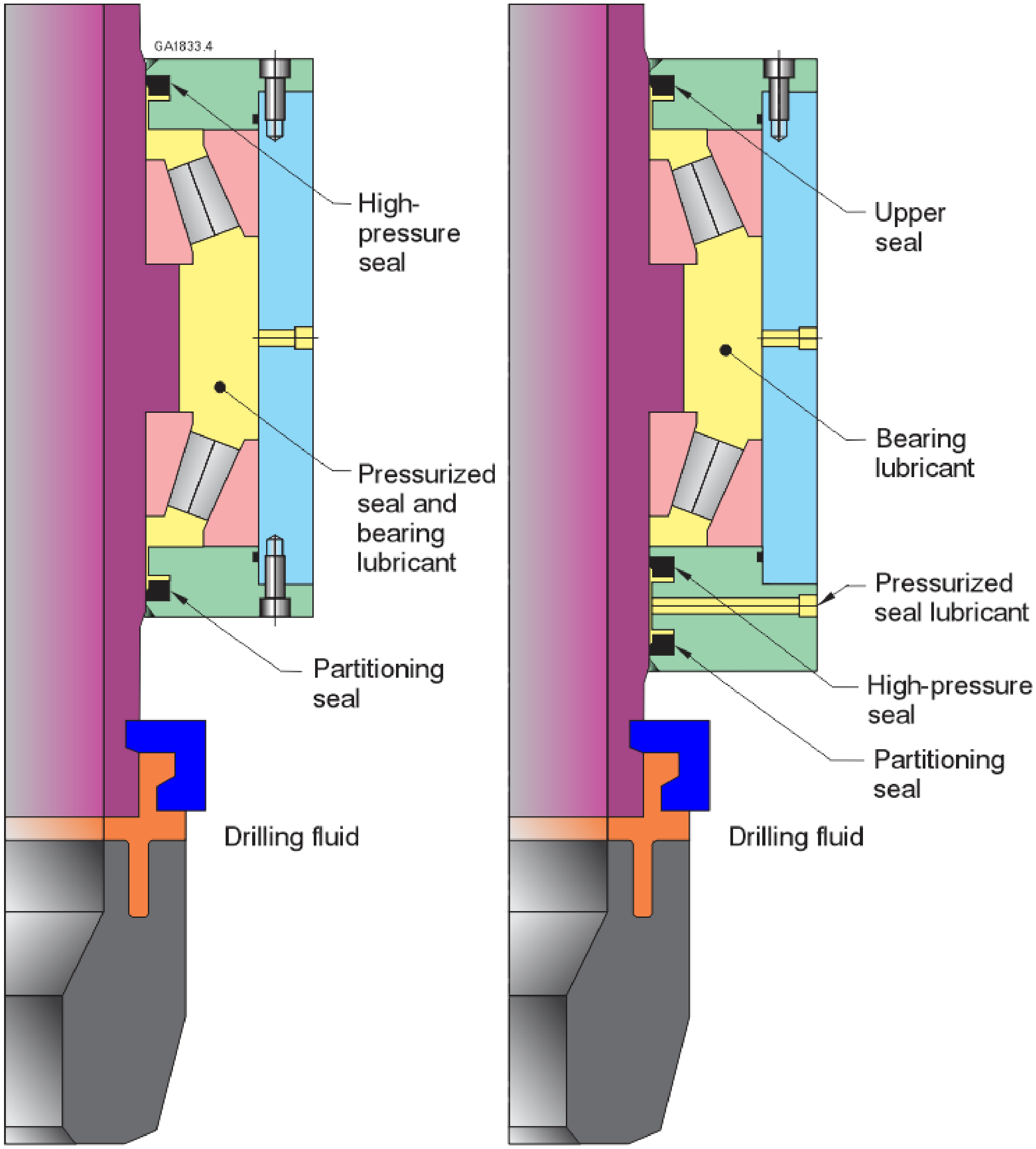


**Figure 1**

**Schematics of rotary seal locations in an RCD using pressurized seal lubricant**

These schematics of passive RCDs illustrate rotary seal locations in RCDs that use lubricant overpressure. These schematics are not intended to represent how to best implement bearings in an RCD and are not intended to illustrate how to design seal housings for RCDs. Due to scale, these schematics do not illustrate the laterally translating seal support mechanisms (Chapters D16, D17) that are ordinarily recommended for RCD service. The seal lubricant is pressurized to a value equal to or greater than the pressure of the drilling fluid. The lubricant over-pressure holds the partitioning seal flat against the lower wall of the seal groove, to prevent skew-induced wear and improve seal life. The high-pressure seal withstands the pressure difference between the lubricant pressure and the atmosphere.

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## 5. Adverse conditions encountered in RCD sealing

The rotating control device (RCD) presents many difficult rotary sealing challenges, including:

- Large sealing diameter
- Large manufacturing tolerances
- Large assembly clearances
- Limited axial space for the rotary seals
- Misalignment and runout due to severe mechanical loads
- Pressure induced breathing of large housing components
- Significant seal and bearing generated heat
- Large differential thermal expansion
- High differential pressure
- High surface speed
- Abrasive drilling fluid

## 6. Maintaining a suitable high-pressure extrusion gap in RCDs with pressurized lubricant

***Background information***

Properly implementing Kalsi Seals in high differential pressure applications requires meeting two basic extrusion gap requirements (Chapter D7):

1. The radial extrusion gap clearance must be small to control seal extrusion, and
2. Heavily loaded metal-to-metal contact at the extrusion gap must be avoided.

These two requirements are difficult to meet simultaneously with rotary shafts that have high side load and deflection. When lateral shaft motion exceeds radial extrusion gap clearance, the extrusion gap bore becomes a de-facto radial bearing and generates seal-damaging heat. Consequently, the seal experiences a lowered modulus of elasticity, which reduces extrusion resistance. The heat buildup also accelerates seal compression set. In severe cases, local seal melting can occur. The heavily loaded metal-to-metal contact can wear the RCD shaft and housing, increasing the extrusion gap, roughening the shaft, and damaging (burring) the critical extrusion gap corner on the low-pressure side of the seal. If relative axial motion occurs due to assembly clearances and component elasticity, then damage can result to the RCD seal, from riding over the roughened shaft surface. Roughening at the extrusion gap corner between the seal groove and the extrusion gap can also significantly accelerate seal extrusion damage.

If the radial extrusion gap clearance is too large, then the differential pressure causes the seal to protrude into the extrusion gap. Runout and pressure breathing can flex and destroy the protruding material, leaving a jagged seal edge that interferes with optimal seal lubrication. The differential pressure causes more protrusion, and the damage cycle eventually destroys the seal.

### *Description of the problem*

Several factors prevent a small shaft-to-housing extrusion gap in conventionally designed large diameter equipment such as RCDs. Manufacturing tolerances are necessarily large,[7] which directly affects the size of the extrusion gap. Large manufacturing tolerances also increase bearing internal and mounting clearances, thus permitting increased shaft runout and misalignment. Large components are often subject to significant elastic deformation when exposed to high pressure or large mechanical loads. Significant dimensional variability from differential thermal expansion caused by seal and bearing heat is also a concern.

Such dimensional variability can have a dramatic effect on assembly clearances and bearing internal clearances, which can permit large dynamic runout and articulation of the shaft and can cause large variations in the radial extrusion gap clearance. Consequently, in large diameter equipment such as rotary control devices, if the extrusion gap is sized for optimal high-pressure extrusion resistance, *then it is impossible to guide the shaft so precisely that it will not rub on the housing at the extrusion gap, without the use of a laterally translatable seal assembly*.

The failure sequence of dual stripper arrangements may have a significant effect on shaft diameter, and consequently, on shaft-to-housing extrusion gap clearance. Clearance analysis must be performed with the lower stripper element effective, and with the lower stripper element failed, and must consider any anticipated thermal expansion of the shaft.

### *Description of a hardware solution*

The solution for misalignment and pressure breathing issues, like those described above, lies in using laterally translating seal assemblies. Chapters D16 and D17 address these

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7 Figure 3.11 of the book "**Technical Drawing**", Seventh Edition (Macmillan Publishing Co.), provides total tolerance recommendations for diameters up to 21 inches (533.4 mm) for various machining methods. Divide total tolerance by two for bilateral tolerance.

design issues, and describes solutions that significantly extend rotary seal performance and life, compared to conventional non-translating designs. These laterally translating arrangements provide the small radial extrusion gap clearance necessary for optimum rotary seal operation in pressurized lubricant systems, while preventing the high frictional heat generation that can occur between the rotary shaft and a conventional seal carrier.

We recommend laterally translating seal assemblies for Kalsi Seals that are used as pressure retaining seals in rotating control devices. The high pressure seal can be mounted in either laterally translating seal carrier arrangement (Chapter D16) or a laterally translating backup ring arrangement (Chapter D17). The Type 2 laterally translating backup ring arrangement permits a smaller and more stable extrusion gap clearance, and for this reason is superior to the laterally translating seal carrier arrangement for high pressure sealing. When the laterally translating backup ring arrangement is used at the upper seal location of an RCD, however, an outboard seal of some type is required to protect the journal bearing surface of the backup ring from contaminants. It is preferred to locate the backup ring below the bearings.

If possible, the partitioning seal should also be mounted in a laterally translating seal carrier arrangement, such as the partially balanced seal carrier that is shown in Figure 2. Such seal carriers help to isolate the partitioning seal from dramatic compression changes caused by shaft deflection and runout, and help to protect the seal from constant radial sliding against the wall of the groove that mounts the seal. These factors help to reduce third body abrasion of the partitioning seal.

***Possible alternate solutions when laterally translating assemblies cannot be used***

Existing equipment may not accommodate the use of laterally translating seal assemblies and is likely to have relatively large extrusion gap clearance to accommodate shaft runout, misalignment, and vibration. Consider using plastic lined Kalsi Seals™ or Extra Wide Kalsi Seals™ with the low friction treatment in such situations, to have the best chance of bridging larger extrusion gap clearances.

A pair of 10.50” PN 682-20-318 plastic lined™ RCD seals was tested for 187 hours at 2,300 psi (15.86 MPa and 100 rpm, using a 0.020” radial extrusion gap clearance between the shaft and the seal carrier. The rotary seal that was closest to a small amount of coolant circulation was in perfect condition, and the seal that was farthest from the circulation was slightly worn and was exhibiting increasing leakage. Plastic lined seals should not be used where they may be exposed to abrasive media, such as drilling fluid.

Although we have no comparable test data with 10.50” all-elastomer Extra Wide Kalsi Seals,[8] we experience steady sales of large diameter Extra Wide Kalsi Seals in both single and dual durometer™ configurations. See the catalog section of the handbook and our blog for the latest test information.

If you are designing a new RCD that will not have floating seal carriers, minimize shaft runout to the extent possible, and implement the smallest extrusion gap clearance that can be achieved at the high-pressure seal, while reliably avoiding heavily loaded metal-to-metal contact. The attainable clearance depends on factors such as bearing installation clearance, bearing internal clearance, machining eccentricity, housing and shaft pressure breathing, and shaft misalignment from external factors such as crooked mounting of the RCD. The best results can be obtained if the upper and lower radial bearings are mounted directly in the housings that mount the rotary seals.

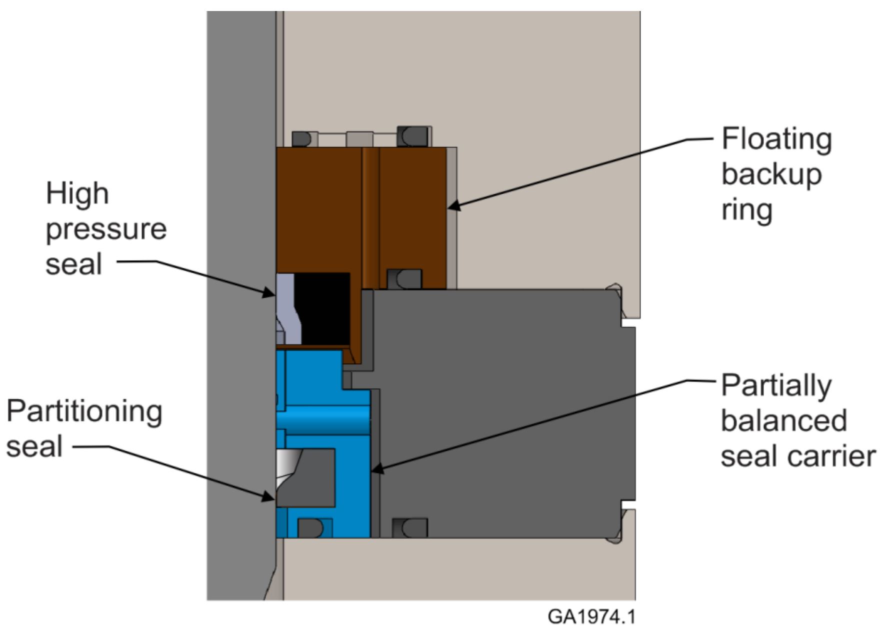


**Figure 2**

**Mounting the high-pressure seal and the partitioning seal below the bearings**

In this image, the high-pressure seal and the partitioning seal are mounted below the bearings (not shown) of an RCD. The high-pressure seal is mounted in an axially force balanced floating backup ring, and the mud-to-oil partitioning seal is mounted in a partially balanced seal carrier. This arrangement isolates the rotary seals from relative lateral shaft motion and provides the high-pressure seal with a very small extrusion gap clearance.

8 Much of our high-pressure testing with smaller (2.75”) Extra Wide Kalsi Seals has been with an ISO 150 viscosity grade lubricant at temperatures in the 120 to 170°F range, using a nominal radial extrusion gap clearance of 0.007". This extrusion gap is too small for an RCD with a non-floating seal carrier but can be achieved or surpassed (i.e. made even smaller) with a floating seal carrier or a floating backup ring. At 170°F, the lubricant viscosity would have been about 36 cSt, and seal lubrication was good.

## 7. Heat dissipation in RCDs

Dissipation of seal and bearing generated heat is a matter of significant concern in many types of equipment because high temperatures negatively impact seal pressure capacity and life. In large diameter, high pressure equipment such as rotary control devices, high surface speed increases the concern. Chapter D8 provides general information about heat transfer considerations. While third party patents protect certain approaches to heat dissipation in rotary control devices, expired patents mention other approaches.[9]

Our thermal analysis of rotary control devices indicates that circulation of a low-pressure coolant immediately outboard of the high-pressure rotary seal is very effective at controlling seal temperature. This arrangement requires a low pressure outboard seal, a small pump, and a heat exchanger. If the high pressure seal is located below the bearings, the bearing lubricant can be circulated as the low pressure coolant. In our analysis, even a coolant flow rate as low as one gallon per minute was very effective at minimizing the temperature of the high pressure seal.

***Seal generated heat***

Seal generated heat is a function of running torque and rotary speed. Among the various types of Kalsi Seals used in pressurized lubricant type RCDs, seals with enhanced lubrication™ wave patterns have the lowest running torque.

***Bench testing isn't the best indicator of whether circulation is required***

We know that in an RCD, circulation for cooling purposes is desirable in terms of obtaining the best high pressure seal performance. Although we perform full scale seal testing with and without cooling circulation, we don't believe our tests are a reliable indicator of whether circulation will be required on an actual RCD that has different heat transfer characteristics than our fixture. We recommend that RCDs be designed to accommodate circulation when possible. Testing can be performed to determine the pressure and speed capacity of the RCD with and without cooling.

## 8. Rotary seal breakout torque

***Introduction***

Rotary seal breakout torque can be a concern in passive pressure control devices, because they may depend solely on friction between the packer element and the drillstring to overcome seal and bearing breakout friction.

9 For examples of patents that mention fluid circulation in rotary control devices, see US Patents 4,143,881, 4,383,577, 5,178,215, 5,224,557, 5,588,491, 6,227,547, and 7,836,946.

***The high-pressure shaft seal***

Among the various types of Kalsi Seals that can be used to retain lubricant overpressure in RCDs, plastic lined Kalsi Seals have the lowest breakout torque. The breakout friction of Kalsi Seals with elastomeric lips can be reduced significantly with our low friction (LF) treatment. See Chapter C12 for information on the treatment, and for breakout torque test data.

In our 7-day, 1,000 psi room temperature breakout torque tests, seals with -106 construction were used as the baseline. Seals with the -106 construction *and* the low friction treatment had about 56% of the breakout torque of the baseline seals, and seals with the -307 plastic lined construction had about 32% of the breakout torque of the baseline seals. The breakout torque of -303 plastic lined seals was only slightly greater than -307 seals. A low viscosity lubricant, Aeroshell 560, was used to assemble the tests.

***The mud to oil partitioning seal***

In conventional lubricant overpressure type RCDs, the mud to oil partitioning seal is a single durometer, all elastomeric Kalsi Seal, which can be treated for reduced breakout torque if desired. See chapter C12 for breakout torque test data. Plastic Lined Kalsi Seals should not be used as partitioning seals.

The partitioning seal with the lowest breakout torque would be a lip seal used with a controlled flow of lubricant, as described above.

## 9. Pressure retaining seals for RCDs with lubricant overpressure

***Using Enhanced Lubrication Seals as pressure retaining seals***

While several types of Kalsi Seals are used as pressure retaining seals in rotating control devices, not every type of Kalsi Seal is suitable for sealing high differential pressure with the relatively low-viscosity lubricants that such devices may use. With 0.007” (0.18 mm) radial extrusion gap clearance, standard width Enhanced Lubrication Kalsi Seals$^{TM}$ are suitable for 1,500 to 2,000 psi (10.34 to 113.8 MPa) operation with lubricant viscosities as low as an ISO 32 viscosity grade, and can handle greater pressures with increased lubricant viscosity. Enhanced Lubrication Seals run much cooler than Kalsi Seals that have less aggressive wave forms, and are available in an extra-wide dynamic sealing lip width that provides more high pressure extrusion resistance at the expense of more breakout torque.

Enhanced Lubrication Seals have greater hydrodynamic pumping related leakage than Wide Footprint Seals$^{TM}$, particularly in conditions with lower operating pressure or low operating temperature. It is important to design the lubricant supply system with sufficient volume to accommodate this leakage. Figure 3 shows a dual seal arrangement where the outer seal captures leakage of the inner seal, and then returns it to the lubricant reservoir.[10]

### *Using Plastic Lined Kalsi Seals as pressure retaining seals*

We have tested PN 682-5-303 extra wide plastic lined seals™ in conjunction with a floating backup ring (Chapter D17) that simulated the 0.008” diametric clearance that a 10” floating backup ring would require. The lubricant pressure was 3,000 psi, and the shaft runout was 0.010” FIM. The first test completed its scheduled 200-hour duration, and the second test completed its scheduled 300-hour duration. The high performance rotary seals were still effective after the tests. The plastic lining bridges the extrusion gap better in high differential pressure conditions, compared to rotary seals made entirely from elastomer. This is because the modulus of the plastic lining is greater than the modulus of an elastomeric seal.

See Section 6 of this chapter for a description of a 187-hour, 2,300 psi (15.86 MPa) test of a pair of 10.50” plastic lined seals using a 0.040” diametric extrusion gap clearance. See the catalog section of the handbook and our blog for the latest test information.

### *Using zigzag-type Kalsi Seals as pressure retaining seals*

We have successfully tested 10.50” (266.7mm) PN 381-35-11 rotary seals with floating backup rings at a differential pressure of 1,500 psi (10.34 MPa) for 120 hours at 190 rpm using an ISO 320 viscosity grade synthetic hydrocarbon oil as the seal lubricant.

To simulate the cooling afforded by the limited drilling fluid exposure an RCD mandrel experiences in the region between the packing element and the mud-to-oil partitioning seal, a low-pressure coolant was circulated at three to four gallons a minute through a sealed channel that is axially remote from the test seal. The temperature of the coolant ranged from 108 to 114°F, and the temperature of the seal lubricant inboard of the test seal, ranged from 210 to 235°F. Although the Kalsi Seal was separated axially from the circulating coolant, it was in virtually new condition after the test.

From this test, we believe that the floating backup ring greatly improves the pressure retaining performance of zigzag-type Kalsi Seals, and allows them to operate cooler than they otherwise would. This may be a useful approach when attempting to design an RCD that has no external lubricant supply system.

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[10] U.S. Patent 8,505,924. Contact Kalsi Engineering for licensing information.

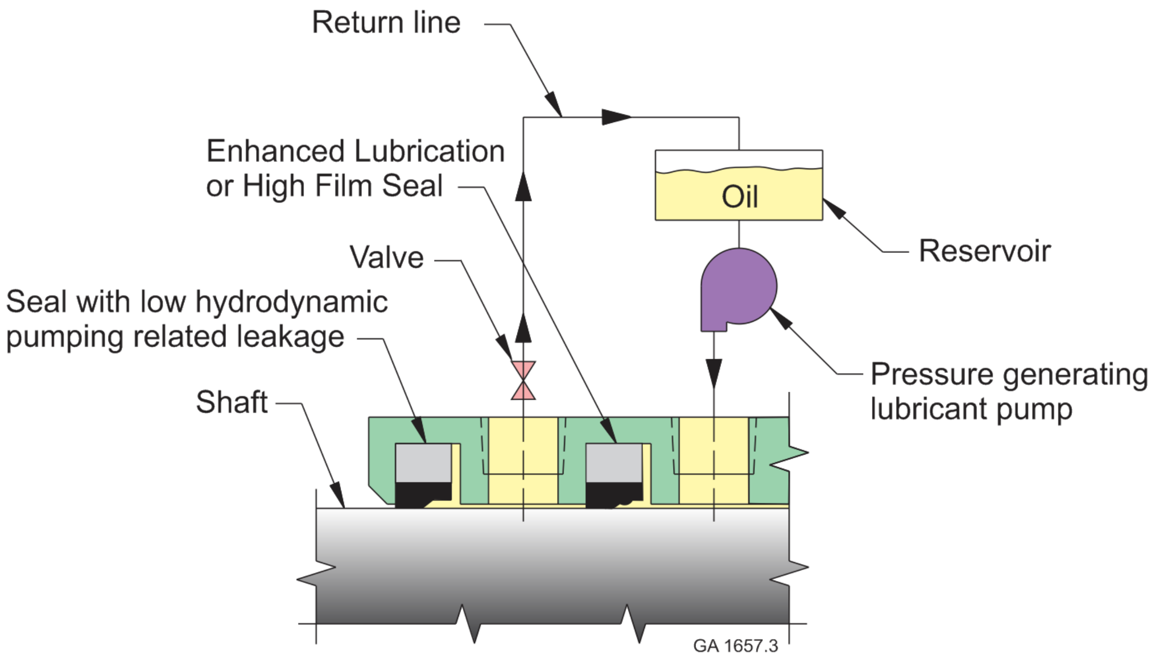


**Figure 3**

**Redundant seal arrangement for rotary control devices**

In some surface applications, such as rotary heads and rotary control devices, a pump generates lubricant overpressure, to help to exclude the process fluid from the bearing lubricant. In such applications, using a low leakage seal outboard of an Enhanced Lubrication or High Film Kalsi Seal™ can provide redundancy and reduced seal-generated heat, as this figure shows schematically. The inboard rotary seal retains the lubricant pressure, with minimal seal-generated heat. The outboard rotary seal runs with minimal seal generated heat at low differential pressure and captures the relatively high hydrodynamic pumping related leakage of the inboard seal. If the inboard seal eventually fails, then the operator closes the valve and continues to operate using the outboard seal to contain the lubricant pressure.

## 10. Subsea devices

Some systems, such as subsea devices, have one lubricant retention seal that excludes a pressurized environmental fluid and an opposite seal to exclude a variable pressure process fluid. In these systems, we recommend pressure compensating the lubricant to both fluids; this will keep the lubricant balanced to whichever is the greater of the two fluid pressures.

## 11. Lubricant considerations

***Figure 1 lubricant viscosity implications***

In the arrangement shown on the right-hand side of Figure 1, the seal lubricant is separate from the bearing lubricant. This means that the viscosity of the bearing lubricant can be selected based on the viscosity requirements of the bearings, and the viscosity of the seal lubricant can be optimized for the high-pressure and partitioning seals. For example, if enhanced lubrication seals are being used, the seal lubricant can be a relatively low viscosity lubricant, to minimize hydrodynamic pumping related seal leakage. It must be understood, however, that the hydrodynamic pumping related leakage of the high pressure seal will mix with, and ultimately lower, the viscosity of the bearing lubricant.

In the arrangement shown on the right-hand side of Figure 1, the rotary seals and the bearings share the same lubricant, and viscosity requirements of both must be met. For example, and ISO 150 viscosity grade lubricant may be satisfactory for the bearings, but the viscosity may be too low for some types of Kalsi Seals. For another example, an ISO 680 viscosity grade lubricant may be satisfactory for the bearings but will cause substantial hydrodynamic pumping related leakage with enhanced lubrication seals.

***Temperature considerations***

Lower temperatures increase lubricant viscosity, which increases hydrodynamic pumping related seal leakage. In RCDs that circulate the lubricant through a pinch valve to control lubricant overpressure, lower temperatures can increase the lubricant viscosity to the point where circulation becomes impossible. Regardless of how the lubricant overpressure is created, wintertime conditions can increase the lubricant viscosity to the point that the lubricant pressure can no longer track the mud pressure.

Since an RCD may be used in wintertime conditions, these temperature implications require an engineered solution. Possibilities include:

- Using lower viscosity lubricants in wintertime conditions.
- Using lubricant heaters.
- In seal arrangements like the right-hand side of Figure 1, using an arctic grade, high viscosity index hydraulic fluid as the seal lubricant.
- Using higher lubricant overpressure until the equipment warms up.

## 12. Full scale testing of RCD seals

To minimize scaling issues, Kalsi Engineering invested in a test fixture for testing RCD seals at pressures up to 3,500 psi. The fixture tests a pair of 10.50” seals at once, using a mandrel that approximates the thermal mass of an actual RCD mandrel. This allows us to perform more realistic comparisons of the pressure and speed capacity of various rotary shaft seal designs, compared to small diameter seal tests. Our willingness to invest in such research sets us apart as a rotary seal manufacturer.

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The pressure is supplied between the seals, so that each seal simulates the high-pressure rotary seal location of an RCD. By swapping out relatively inexpensive internal components, the fixture can be used with or without laterally translating seal assemblies, and with various amounts of extrusion gap clearance.

The fixture can be operated with or without a circulating coolant. The data acquisition system measures relevant parameters, and provides automatic shutdown if data exceeds predetermined limits. This allows the fixture to safely operate continuously, 24 hours a day, without human intervention. Test results are provided in seal-specific chapters in the catalog section (Section C) of this handbook. Contact us for additional information.

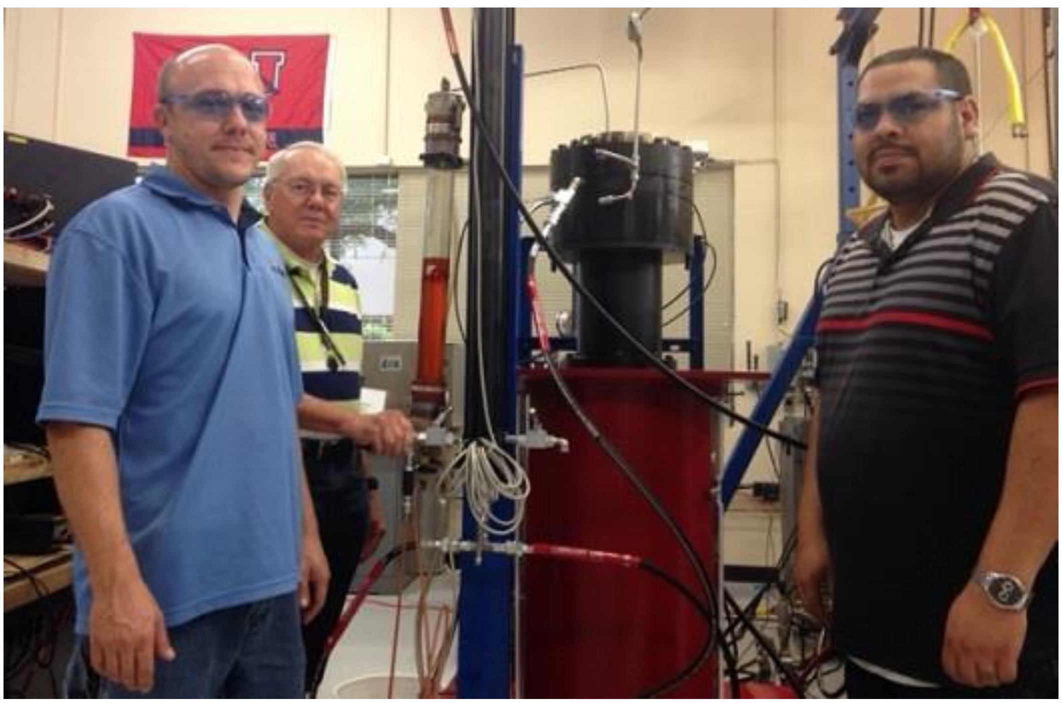

**Figure 4**

**RCD seal test fixture**

Our RCD seal test fixture allows us to test a pair of RCD seals at a time, using a mandrel that approximates the thermal mass of an actual RCD mandrel.