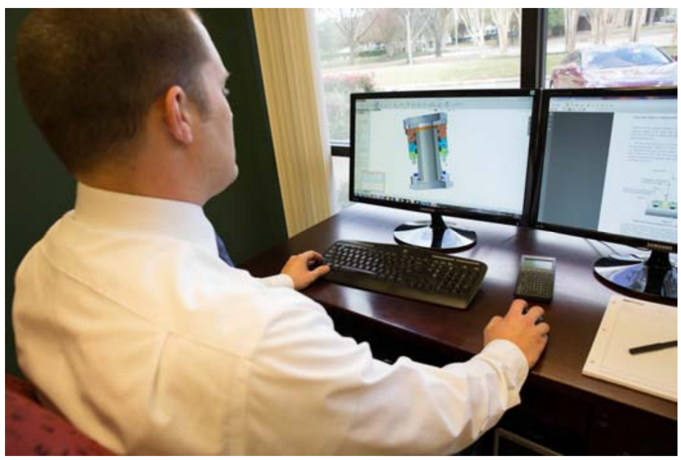
Chapter D1

Engineering overview



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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

This chapter provides a general introduction to the Engineering Section of this seal handbook, and to the general topic of implementing Kalsi-brand rotary seals in mechanical equipment.

2. A broad overview of applications that use Kalsi Seals®

What are Kalsi Seals, and what are they used for?

Kalsi Seals are rotary shaft seals that establish sealing between a shaft and a housing that have relative rotation with respect to one another. All Kalsi Seals are designed to be exposed to and retain a lubricant and to exclude an environment, and most are designed to exclude an abrasive environment. All Kalsi Seals have hydrodynamic features that use a small amount of the lubricant to lubricate the dynamic sealing interface between the seal and the shaft in response to relative rotation. Specific Kalsi Seal™ designs have been developed to address the following types of rotary service:

1. Service where the pressure of a lubricant can be significantly higher than the pressure of the environment.[1]

2. Service where the pressure of the environment can be significantly higher than the pressure of the lubricant.[2]

3. Service where the pressures of the lubricant and the environment are substantially the same, and the rotary seal may experience modest levels of reversing differential pressure.[3]

The various styles of Kalsi Seals, and the types of service they are intended for, are described in the Catalog and Technical Data Section of this handbook. Many rotary seal applications have more than one service condition, and the service conditions may vary from one seal location to another.

Most applications use at least two rotary seals and a lubricant reservoir

Kalsi Seals are used in a variety of ways, but at the most fundamental level, a Kalsi Seal implementation typically employs at least two rotary seals. This is because Kalsi Seals require and slowly consume a seal lubricant, and a pair of rotary seals is typically necessary to retain the seal lubricant. The lubricant consumption is related to the above-

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1 For example, a hydraulic swivel seal, the fixed location seal of an oilfield mud motor, or the pressure retaining seal of a rotary control device (RCD) with a pressurized seal lubricant,

2 For example, the pressure retaining seal of an RCD with a gravity fed seal lubricant.

3 For example, the rotary seal in the pressure compensation piston of a mud motor or roller reamer.

described hydrodynamic interfacial lubrication, and only occurs during periods of relative rotation between the seal and the shaft. Because of this lubricant consumption, a lubricant supply reservoir is typically required.

3. Basic seal implementation concepts and nomenclature

Figure 1 is a fragmentary representation of a Kalsi Seal installation that only shows one of the two rotary seals that would typically be required to contain the lubricant, and only shows one of the bearings that guide the shaft. Although the Kalsi Seal in Figure 1 is lubricated by the bearing lubricant, arrangements are possible where the seal lubricant is isolated from the bearing lubricant.

The bearing type that is shown in Figure 1 is entirely arbitrary. Although a needle roller bearing is illustrated, journal bearings or other types of rolling element bearings may be equally or more appropriate for your rotary seal application.

A Kalsi Seal is located by a circular groove in a housing. In many cases, the groove is simply lathe cut into the housing, as illustrated in Figure 1. In certain cases, one of the groove walls is established by a separate component that is retained to the housing. Some circumstances call for this removable groove wall to be rigidly attached to the housing, while other circumstances call for it to be radially movable relative to the housing.

The groove, in conjunction with the rotary shaft, defines a gland that radially compresses the seal (Figure 2). The compression-induced interfacial contact pressure between the seal and the mating shaft and groove surfaces establishes sealing in the same manner as an O-ring, and other types of interference seals.

The groove also supports the seal against any differential pressure that may be acting across the seal. In Figure 1, the differential pressure is acting from the lubricant side of the seal, and the seal is being supported by the environment side groove wall. Some Kalsi Seals are designed for differential pressure acting from the environment side of the seal, and are supported by the lubricant side groove wall. Other Kalsi Seals are designed for low levels of reversing pressure differential, and contact both groove walls simultaneously.

A systems approach is needed for optimum rotary seal performance

Implementing a rotary seal is more challenging than implementing a static seal, because of complexities related to elastic deflection and relative motion of the shaft and housing, the need for a seal lubricant, and various other factors. A systems approach is necessary to obtain optimum rotary seal performance and service life.

The system must incorporate an appropriate groove width, radial gland depth, and extrusion gap geometry. Shaft material, surface hardness, and surface finish are also important considerations. In higher speed and pressure combinations, shaft cooling may be necessary to avoid overheating, or special seal geometries may be in order. Mounting clearances and tolerances must be evaluated in terms of their effect on seal compression and extrusion gap clearance. Inadvertent metal-to-metal contact at the extrusion gap between the shaft and the seal housing should be avoided in most cases to prevent seal and hardware damage. Shaft runout and deflection should be minimized when practicable, or addressed by laterally floating seal housing or backup ring arrangements. High pressure lubricant retention service and low pressure abrasive exclusion service each have their own special implementation considerations in terms of seal selection and gland and extrusion gap sizing. Various chapters in the Engineering Section of this handbook cover these machine design topics, and many others, in detail. Customer support personnel are available to provide training, guidance, and implementation review.

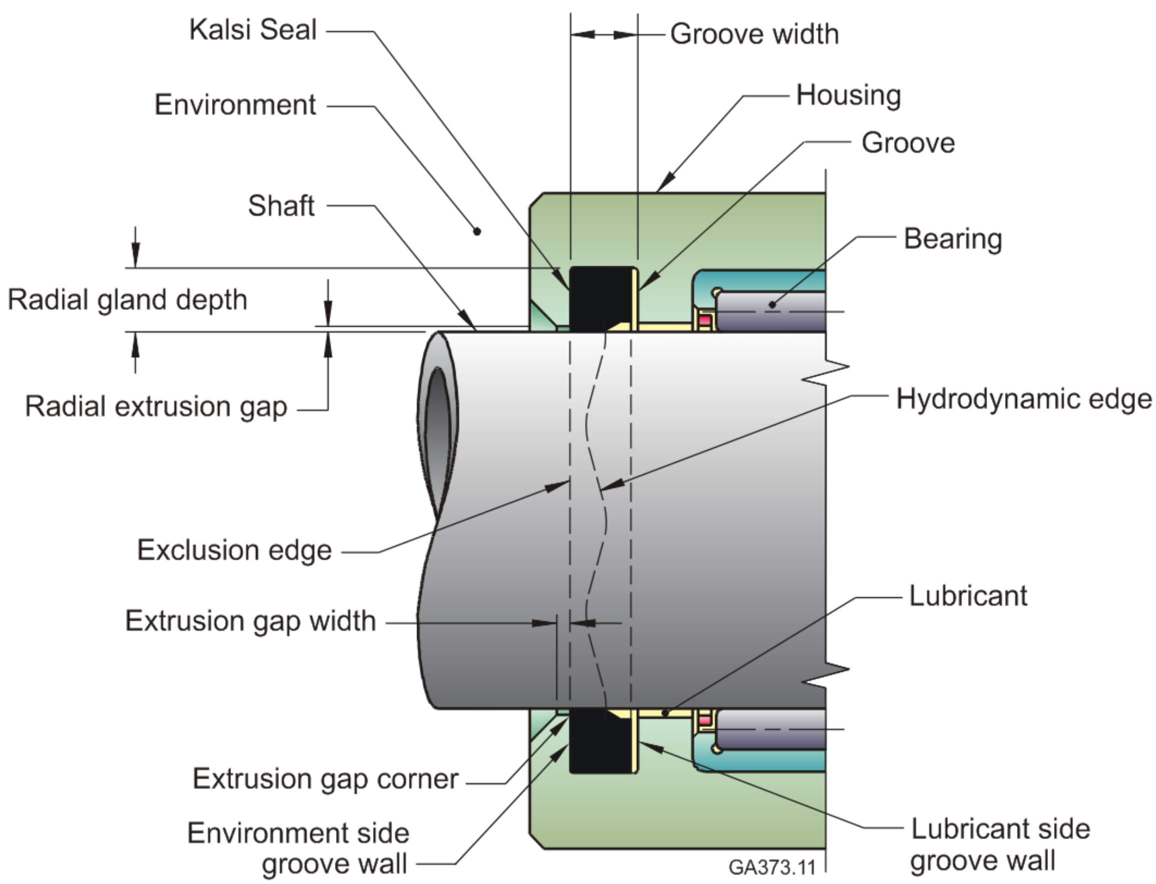

Figure 1

Kalsi Seal nomenclature

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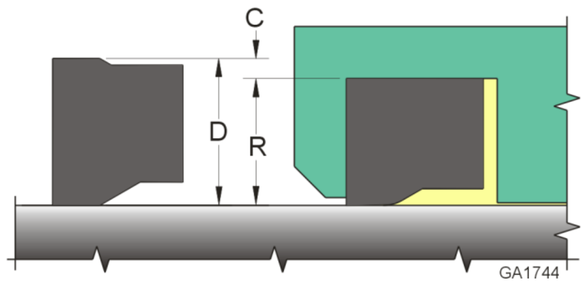

Figure 2

Kalsi Seals are radially compressed when installed

The radial cross sectional depth D of the uninstalled Kalsi Seal is greater than the radial depth R of the gland. When installed, the Kalsi Seal is compressed by radial compression dimension C. This radial compression can be expressed as a dimension, or as a percentage of D. The radial compression establishes sealing force against the shaft.

4. Using a pair of rotary seals to contain a pressurized process fluid

Figures 3 and 4 show pairs of rotary seals being used to retain a pressurized environment (a process fluid), preventing it from escaping into a lower pressure environment—the atmosphere. The figures are schematic, and do not show bearings, the lubricant reservoir, etc. Actual implementation can take many different forms

In Figure 3, the seal lubricant is supplied from a lubricant supply that provides lubricant at a pressure that is equal to or greater than the pressure of the pressurized process fluid. The inboard (right-hand) rotary seal partitions the process fluid from the lubricant, and the outboard (left-hand) rotary seal retains the pressure of the lubricant.

In hardware designs where the lubricant pressure is equal to the process fluid pressure, the partitioning seal should be axially spring loaded (not shown) or axially constrained through seal design (not shown) to inhibit abrasive wear.

In hardware designs where the lubricant pressure is greater than the process fluid pressure, the pressure difference holds the partitioning seal flat against the environment side groove wall, which improves environmental exclusion and reduces abrasive wear of the seal and the shaft. Some individuals mistakenly believe that lubricant over-pressure is provided to lubricate the seals. The lubrication actually occurs when rotation forces lubricant past the hydrodynamic inlets, and into the dynamic sealing interface. The only purpose of the lubricant over-pressure is to hold the seal flat against the environment side gland wall, to improve the exclusion of environmental abrasives.

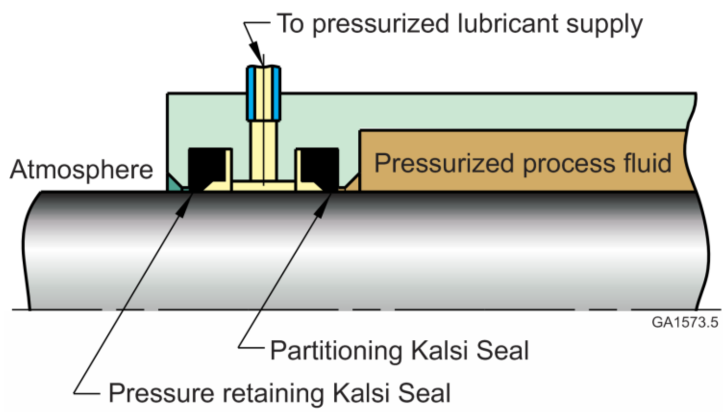

Figure 3

Using two rotary seals and a pressurized lubricant to retain a process fluid

In this schematic, the lubricant supply pressurizes the lubricant between the two rotary seals to a value that is equal to or slightly greater than the pressure of the process fluid. Various lubricant pressure supplies are described in this handbook. Some are external (as implied by this sketch), and some are integrated into the equipment. The inboard, right-hand seal serves as a partition between the lubricant and the process fluid, and the outboard, left-hand seal serves as the pressure retaining seal. If the lubricant pressure is equal to the process fluid pressure, the partitioning seal is axially spring loaded, or axially constrained by a special seal body design.

In Figure 4, the seal lubricant is supplied from a gravity fed lubricant supply that provides lubricant at a pressure that is less than the pressure of the pressurized process fluid. The inboard (right-hand) rotary seal is a special type of Kalsi Seal that is designed for situations where the pressure of the process fluid environment is greater than the pressure of the seal lubricant. The outboard (left-hand) seal can be a simple lip-type oil seal, as shown, that merely retains the low pressure seal lubricant.

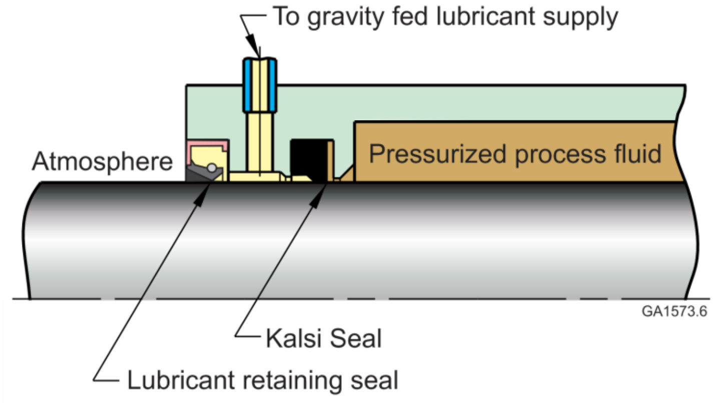

Figure 4

Using two rotary seals and an unpressurized lubricant to retain a process fluid

In this schematic, the lubricant between the two rotary seals is gravity fed from a reservoir, and is at a pressure that is significantly less than the pressure of the process fluid. The inboard, right-hand seal is a Kalsi Seal that has been specially designed for conditions where the pressure of the process fluid environment is greater than the pressure of the seal lubricant. The outboard seal is a simple lip-type oil seal that retains the low pressure seal lubricant.

5. The lubricant supply reservoir

As previously noted, a Kalsi Seal installation requires a lubricant supply reservoir to accommodate the hydrodynamic pumping related seal leakage that occurs during shaft rotation. The lubricant supply also accommodates any thermal expansion of the lubricant.

Although Figures 3 and 4 imply an external lubricant supply, arrangements are possible where the lubricant supply is integral to the hardware. For example, see Figure 5. Chapter D11 describes various types of lubricant supplies.

6. Equipment immersed in a pressurized environment

Figure 5 is a schematic example of a piece of equipment immersed in a pressurized abrasive environment, exposing both ends of the rotary shaft to the environment. A pair of Kalsi Seals excludes the environment, and retains the lubricant, which lubricates the seals and the bearings that guide the rotary shaft.

An axially movable piston balances the lubricant pressure to the environment pressure. The axial stroke of the piston defines the volume of the lubricant supply (other types of lubricant supplies are possible). Because the pressure of the lubricant (oil) is equal to the pressure of the environment in Figure 5, Axially Constrained Kalsi Seals™ are employed. An axially spring loaded seal could also be incorporated.

In some types of immersed equipment, such as oilfield rotary steerable tools, substantially balanced pressure conditions exist for both rotary seals. In other types of immersed equipment, such as oilfield mud motor sealed bearing assemblies, one seal is exposed to balanced pressure, and the other is exposed to differential pressure. In such cases, one end of the tool uses a different type of seal than the other end of the tool.

7. Using Kalsi Seals as hydraulic swivel seals

Figure 6 is a schematic example of a swivel that conducts hydraulic fluid from a stationary housing to a rotary shaft. A pair of Kalsi Seals defines the hydraulic circuit, and the seals are lubricated by the hydraulic fluid.

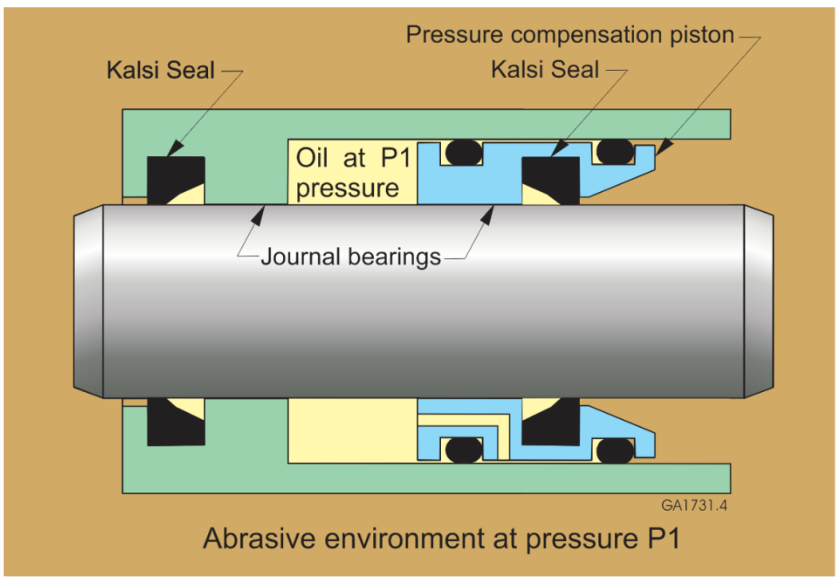

Figure 5

Rotary seals protecting equipment immersed in a pressurized environment

In this schematic example, a pair of Kalsi Seals exclude the pressurized abrasive environment and retain the seal and bearing lubricant.

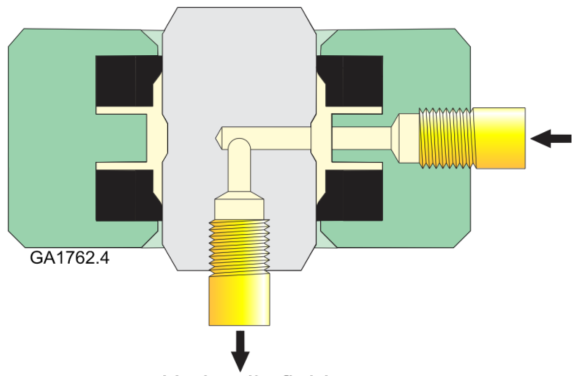

Figure 6

Kalsi Seals defining a hydraulic circuit

In this schematic example, a pair of Kalsi Seals defines a hydraulic circuit between a stationary housing and a rotary shaft. The hydraulic fluid lubricates the seals. (Bearings are not shown.)

8. Kalsi Seal orientation

The orientation of a Kalsi Seal is critical. The wavy hydrodynamic edge of the dynamic sealing lip must face the lubricant. On all but the smallest seals, the lubricant side of the seal is marked "lubricant side" for easy identification. On High Film Seals™, the lip geometry is directional, and must match the direction of shaft rotation.

9. Kalsi Seal training classes

Kalsi Seal-related engineering and shop training classes are available at no cost at our facility, and via Internet conferencing. In many cases, we may be able to provide free on-site training at your facility.

The engineering training (Figure 7) is a 3-1/2 hour review of the Kalsi Seals Handbook, with comprehensive discussions on critical elements of implementing Kalsi Seals. Based on the number of questions and group size, the time may vary. Our staff can tailor the presentation to cover oilfield-specific sealing applications such as mud motors, rotary steerable tools, rotary control devices (RCD's), swivels, and other drilling equipment, or equipment in other industries.

The shop training provides a general introduction to the Kalsi Seal, and describes items to look for during equipment disassembly, and good assembly practices. This class is kept to about 45 minutes to limit its impact on production.

Figure 7

Seal training classes

Seal related engineering and shop training classes are available in person, or via Internet conferencing. Our staff can tailor the classes to your specific rotary seal application.

10. Tolerances

A number of the chapters in this seal handbook reference hardware tolerances. Newly minted engineers seldom have training or experience in the application of tolerances, yet they are often the most likely to be tasked with creating drawings. As a result, many component features receive inappropriate tolerances, and the potential consequences of tolerance stack-up, such as unintended interference or excess free play, are often ignored.

Part of the problem is that young engineers typically have no understanding of the accuracy potential of various machining processes. One good source of such information is the book “**Technical Drawing**” (Macmillan Publishing).

We encourage new engineers to attend a basic geometric dimensioning and tolerancing seminar, so that they receive exposure to basic inspection, dimensioning, and tolerancing practices.