

Chapter C3

Wide Footprint Kalsi 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.

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1. Wide Footprint Seals

The Wide Footprint Seal™ (Figure 1) was developed to provide longer life in severe service conditions, such as abrasive environments and high differential pressure, where very low hydrodynamic leakage is required. They are designed to have a hydrodynamic pumping related leak rate that is similar to Standard Kalsi Seals, allowing them to be a direct replacement for Standard Kalsi seals in oilfield downhole service. Wide Footprint Seals are available in sizes that are directly interchangeable with Standard Kalsi Seals that have 0.300” (7.62mm) and 0.335” (8.51 mm) radial cross-sections.

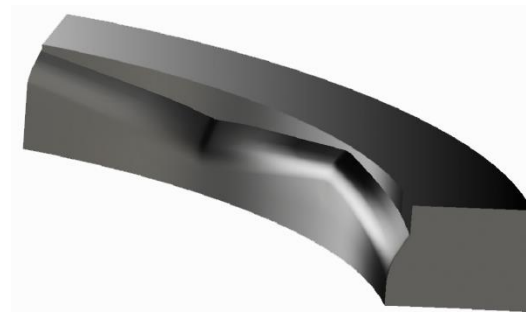


Figure 1
Wide Footprint Seals

The Wide Footprint Kalsi Seal is engineered to provide enhanced performance in severe service applications that require low hydrodynamic pumping related seal leakage.

Wide Footprint features and benefits

The geometry of the Wide Footprint Seal was developed using finite element analysis (FEA), coupled elasto-hydrodynamic lubrication (EHL) analysis, and testing. The result is a rotary seal that provides dramatically improved abrasive exclusion, interfacial lubrication, and extrusion resistance compared to the Standard Kalsi Seal. Wide Footprint Seals also provide significantly higher dimensional compression, to better compensate for radial wear and compression set.

The narrowest locations of the dynamic sealing lip are significantly wider, compared to Standard Kalsi Seals. In cross-sectional sizes of 0.335” (8.51 mm) and larger, the width increase is 50%. This increased lip width provides significantly more sacrificial material to accommodate any axial wear or extrusion damage that may occur in severe applications.

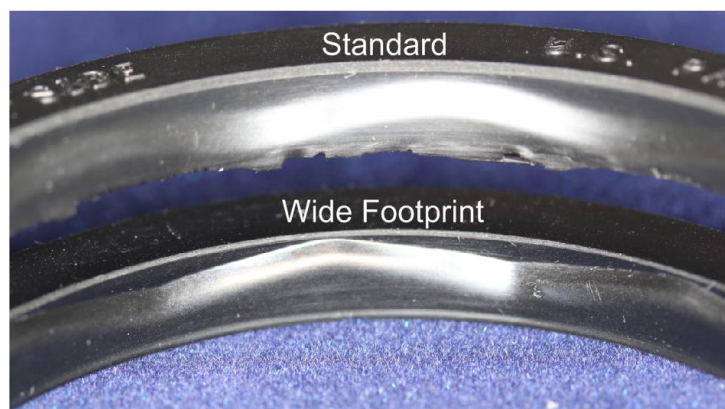
For available seal sizes, visit kalsiseals.com.

Wide Footprint performance testing

Laboratory tests of Standard Kalsi Seals and Wide Footprint seals have been performed over a range of pressures and speeds. Under conditions where severe abrasive wear mechanisms have been found to limit the life of Standard Kalsi Seals, no discernable wear was present on the Wide Footprint Seals (Figure 2). Extensive testing has also shown that Wide Footprint Seals have noticeably better extrusion resistance than Standard Kalsi Seals (Figure 3).

**Figure 2**

The Wide Footprint Seal exhibits no wear after a 115 hour rotary test with highly abrasive oilfield drilling fluid at 200°F.

**Figure 3**

These two Kalsi Seals were tested simultaneously in the same seal carrier, and retained a lubricant pressure that was incrementally increased to 1500 psi. The extrusion gap clearance was twice the typically recommended size. The 344 series Standard Kalsi Seal (top) sustained significant extrusion damage, while the 507 series Wide Footprint Seal remained in good condition.

For available seal sizes, visit kalsiseals.com.

Wide Footprint Seal implementation considerations

Wide Footprint Seals are recommended as an alternative to Standard Kalsi Seals to achieve reduced seal wear and longer life in well cooled pressure retaining applications having a limited reservoir size. For example, Wide Footprint Seals are preferred over Standard Kalsi Seals for the pressure sealing location in oilfield mud motors having small reservoirs. When the reservoir size can accommodate more hydrodynamic leakage, Hybrid or Enhanced Lubrication Wide Footprint Seals are preferable.

As with the Standard Kalsi Seal, the use of positive lubricant pressure differential or axial spring loading is recommended for Wide Footprint Seals to prevent skew-induced wear. If neither is practical, the Axially Constrained Seal is typically recommended.

Lubricant recommendations

Most of our rotary testing of HNBR seals has been with synthetic hydrocarbon (SHC) lubricants. For typical mud-motor service conditions, a lubricant having an ISO 320 viscosity grade, or greater is recommended for Wide Footprint Seals made with our -11 and -15 HNBR compounds. (The -15 compound has only been qualified for Wide Footprint Seals that have a 0.345" or greater radial cross-sectional depth.)

Wide Footprint Seals made from the -10 HNBR compound and the -30 FKM compound have been satisfactorily tested at 302°F (150°C) with an ISO 32 viscosity grade lubricant and a wide range of our typically recommended axial spring loads. Wide Footprint Seals made from the -11 HNBR compound should not be used with an ISO 32 viscosity grade lubricant.

2. Kalsi Seal torque and rotary leakage test examples

Kalsi Engineering has performed a number of laboratory tests of 2.75" (69.85 mm) ID, 0.345" (8.76 mm) radial cross-section PN 507-5-11 seals to characterize hydrodynamic running torque and rotary leakage.

Figure 4 shows the upper bound leakage of the Standard Kalsi Seal at 162°F (72.2°C) using a lubricant viscosity and a seal material commonly recommended for high differential pressure usage. This leakage also bounds the leakage test data for the Wide Footprint Seal, as shown in Figure 5. Therefore the same process for estimating Standard Kalsi Seal leakage is used for estimating Wide Footprint hydrodynamic leakage.

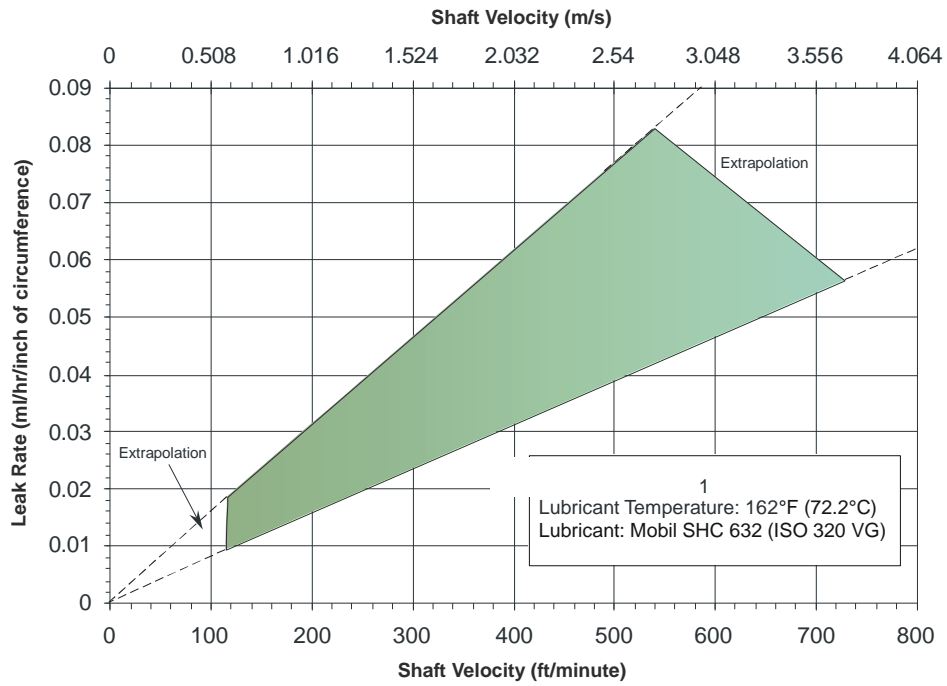


Figure 4

Hydrodynamic leakage characteristics of a Standard Kalsi or Wide Footprint Seal using an ISO 320 viscosity grade lubricant at 162°F (72.2°C).

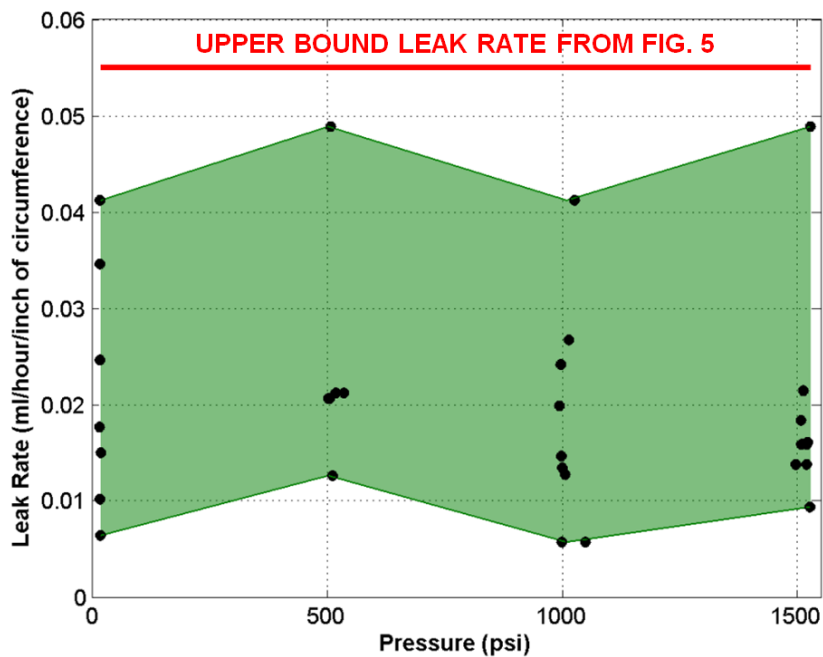


Figure 5

Hydrodynamic leakage characteristics of a PN 507-5-11 Wide Footprint Kalsi Seal using an ISO 320 viscosity grade lubricant at 200°F (93.3°C).

For available seal sizes, visit kalsiseals.com.

3. Estimating Wide Footprint Seal hydrodynamic leakage

To estimate upper bound rotary hydrodynamic leakage Q (ml per hour) for 0.345" (8.76 mm) radial cross-section Wide Footprint Seals with the -11 HNBR material, use Equation 1 with lubricant viscosity constants from Figure 6.

Equation 1:

$$Q = Y \times S^2 \times V_{RPM}$$

Where:

Q = hydrodynamic leakage, ml per hour

S = shaft diameter, inches

Y = viscosity constant from Figure 6

V_{RPM} = shaft velocity, revolutions per minute

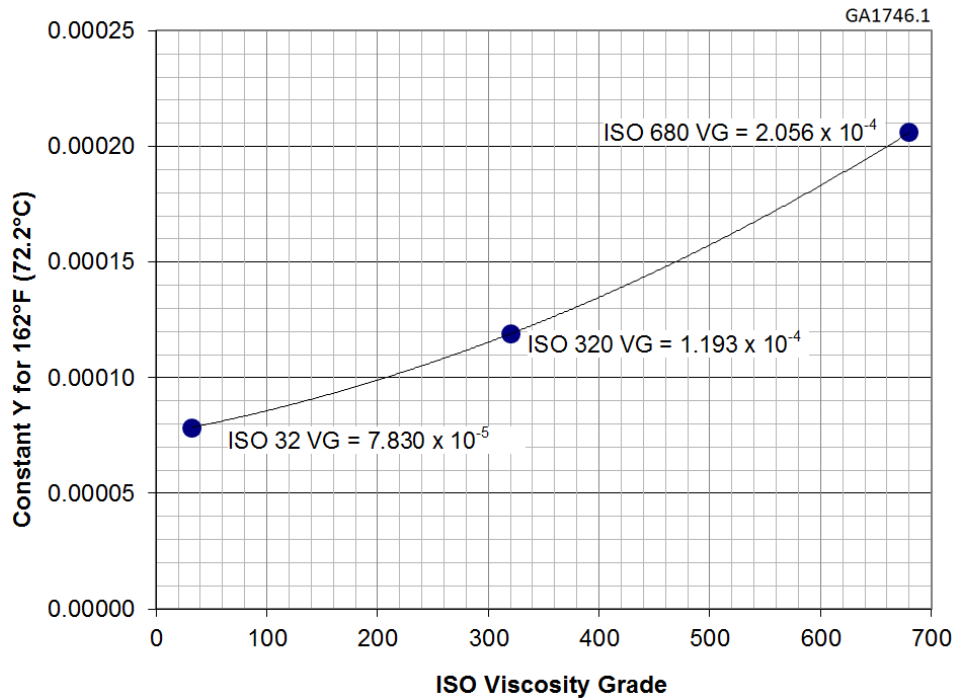


Figure 6

Viscosity Constant Y for Standard or Wide Footprint Kalsi Seals

Viscosity Constant Y at 162°F (72.2°C) for Standard or Wide Footprint Kalsi Seals with various ISO Viscosity Grade¹ lubricants. These constants represent upper bound leakage from empirical data.

¹ The viscosity range in centistokes at 104°F (40°C) for each ISO viscosity grade is the viscosity represented by the grade name $\pm 10\%$. For example, the 104°F (40°C) viscosity of ISO 680 viscosity grade is 612 to 748 cSt.

4. Increased compression for use with increased shaft deflection

Mud motors in high build rate applications experience increased lateral shaft deflection due to higher side load. This deflection decreases the compression of the rotary seal over part of the circumference of the seal. Some motor manufacturers may have an interest in increasing nominal seal compression to ensure more residual compression when shaft deflection occurs.

A larger radial seal cross-section can be used to increase dimensional compression with or without increasing the percentage of compression. For example, a 0.345” cross-section Wide Footprint Seal at 10.44% compression has 0.036” dimensional compression, while a 0.400” cross-section seal at the same percentage of compression has 0.042” dimensional compression.

As another example, a 0.359” cross-section Wide Footprint Seals having a specific material and geometry combination were successfully tested in a standard 0.309” groove depth to achieve 0.050” dimensional compression at 13.93% compression. As a result of this testing, which was conducted at 300°F, 0.359” cross-section Wide Footprint Seals are being offered with this specific material and geometry combination for flow-restrictor-type mud motor operating conditions.

5. Using a large seal cross-section to reduce contact pressure

A larger radial cross-section can be used to reduce the percentage of compression of a wide footprint rotary seal, without decreasing dimensional compression. One reason for doing this is to reduce torque. For example, a 0.420” cross-section Wide Footprint Seal at 0.036” compression has 8.6% compression. By comparison, as stated above, a 0.345” cross-section rotary seal at 0.036” compression has 10.44% compression.