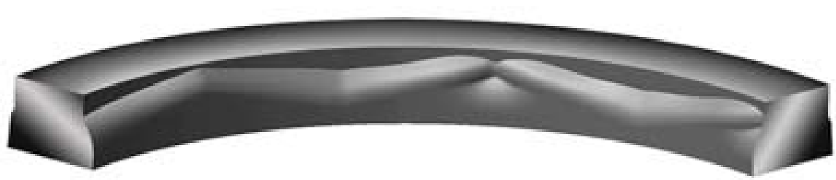
Chapter C6

Hybrid Kalsi Seals



Revision 5 February 25, 2021

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/.

NOTICE: The information in this chapter is provided under the terms and conditions of the Offer of Sale, Disclaimer, and other notices provided in the front matter of this handbook.

© 2021 Kalsi Engineering, Inc. All rights reserved.

1. Hybrid Seals™

The Hybrid Seal™ geometry (Figure 1) mixes Enhanced Lubrication™ (EL) waves with zigzag waves. This arrangement reduces the overall rate of hydrodynamic pumping related leakage compared to pure EL Seals, while still providing a significant increase in rotary shaft seal performance compared to seals with only zigzag waves.

Figure 1
Hybrid Seals mix several different wave types

Hybrid Seals mix higher leakage Enhanced Lubrication waves with lower leakage zigzag waves. This provides lower hydrodynamic pumping related leakage than a seal with only Enhanced Lubrication waves, and provides lower running torque than a seal with only zigzag or sine waves. A Wide Footprint Hybrid Seal™ is shown here.

2. Options

Lip width

Hybrid Seals were originally developed in "standard" and "wide footprint" lip widths for oilfield rotary steerable tools that use low viscosity lubricants and may also have poor heat transfer due to the use of stainless steel shafts or sleeves. They have been tested in HNBR materials with axial spring loading up to 45 psi equivalent pressure.

Extra Wide Hybrid Seals™ with Type C EL waves are designed for pressure retaining service in oilfield mud motor sealed bearing assemblies. They were developed to have approximately the same leakage as 507-series Wide Footprint Seals™ when used with the higher viscosity lubricants required for the proper lubrication of the bearings used in mud motor sealed bearing assemblies. An ISO 320 viscosity grade or higher lubricant is required. Other EL wave types can be incorporated.

Wider lips:

- Provide more sacrificial material to accommodate axially acting wear mechanisms such as extrusion damage and third body abrasive wear.
- Reduce high pressure extrusion damage.
- Increase seal generated heat.

For available seal sizes, visit kalsiseals.com.

We tested a pair of 2.75” ID Extra Wide Hybrid Seals with Type C EL waves (756-1-11) using an ISO 320 VG lubricant maintained at 302°F. The seals were installed in a seal carrier with a 0.020” radial extrusion gap and ran on a shaft made with 0.010” intentional runout. The rotary seal test successfully ran 24 hours with 1,500 psi differential pressure across the seal and 24 hours with 1,000 psi differential pressure across the seal with the shaft rotating at 480 RPM. We ran a pair of 507 Seals at the same conditions and the seals catastrophically failed at 1,500 psi differential pressure after one hour of testing.

Hydrodynamic wave geometry

Hybrid Seals are typically recommended when seals with a full complement of EL waves produce more hydrodynamic pumping related leakage than the lubricant reservoir of an application can accommodate. Two seal design variables that allow seal leak rate to be customized are EL wave type and the ratio of EL waves to zigzag waves. Several EL wave geometries are available, and they vary from having very high to very low leak rates. These waves are described in more detail in Chapter C5. A higher ratio of EL waves to zigzag waves makes performance and leak rate more like an EL Seal. Contact Kalsi Engineering for guidance on Hybrid or EL Seal selection.

Seal material

Tooling for Hybrid Seals can be manufactured around the shrink rate of any of our available seal materials. Molds for Hybrid Seals are typically designed for the shrink rate of -10 and -11 HNBR seal materials.

The shrinkage of some seal materials will be different than the shrinkage the mold was designed for. As a result, the shaft diameter may need to be adjusted to the as-molded diameter of the seal, or a new mold may be required that is tailored to the shrinkage characteristics of the seal material.

Seal radial cross-section

The inclusion of EL waves provides enhanced performance over a comparable seal having only sine or zigzag waves, regardless of radial cross-sectional depth. Larger cross-sections have more initial compression to deal with shaft runout and deflection without increasing interfacial contact pressure and should be used whenever possible.

The use of harder sealing materials becomes more problematic with smaller cross-sections, and wider dynamic lips. This is due to the increased percentage of compression that often occurs with smaller cross-sections, and the higher modulus of harder seal materials. Both of these factors lead to increased interfacial contact pressure, making it harder to lubricate the dynamic interface. The -15 (90 Shore A) HNBR material has

For available seal sizes, visit kalsiseals.com.

been tested in Type C Wide Footprint Hybrid Seals in radial cross-sectional depths down to 0.305” (7.75mm), using a ratio of two EL waves to every zigzag wave. The -11 (85-90 Shore A) HNBR material has been tested in Type C Wide Footprint Hybrid Seals in cross-sections down to 0.270” (6.86mm), using the same wave ratio (Figure 2). These tests were conducted with the relatively high viscosity lubricants indicated by the bearing requirements of mud motor sealed bearing assemblies.

Figure 2

This 0.270” (6.86mm) cross-section Wide Footprint Hybrid Seal was tested at 346 ft/minute (1.76 m/s) and a bulk lubricant temperature of 300°F (148.9°C), with differential pressures that were incremented up to 1500 psi (10.34 MPa). This is a PN 637-11-11 seal, which has two Type C EL waves for every zigzag wave. The dynamic surface and exclusion edge of this HNBR seal are in good condition.

3. Hybrid Seal torque and rotary leakage test discussion

Kalsi Engineering has performed a number of laboratory tests of Hybrid Seals to characterize rotary seal performance (running torque and hydrodynamic pumping related leakage). The testing shows that the per wave hydrodynamic pumping related leakage of the EL wave times the number of EL waves bounds the hydrodynamic pumping related leakage of a Hybrid Seal operating at the same conditions.

The hydrodynamic leakage of a Hybrid Seal is sensitive to EL wave type, installed radial compression, lubricant viscosity, operating temperature, surface speed, differential pressure, and extrusion gap size. Leakage increases as a function of decreasing percent radial compression[1], operating temperature, differential pressure, and extrusion gap size, and as a function of increasing lubricant viscosity and surface speed. In our testing experience, the -30 FKM seal material has higher hydrodynamic leakage than the -10 HNBR seal material.

---

[1] A pair of 756-2-11 seals with 8.7% radial compression had 6.3 ml/hour leak rate. A pair of 756-1-11 seals with 10.4% radial compression had a leak rate of less than 0.5 ml/hour. The tests were run with an ISO 460 VG lubricant at 162°F and 480 RPM.

For available seal sizes, visit kalsiseals.com.

EL performance data is provided in Chapter 5. For applications that require hydrodynamic leakage prediction, contact Kalsi Engineering for input or additional test data.

4. Spring loaded test discussion

For balanced pressure applications, such as rotary steerable tools, axial spring loading (Chapter D9) is required to prevent skew induced wear. The Hybrid Seal has been tested with axial spring loading up to 45 psi equivalent pressure in HNBR -10 and -11 material. The testing indicates that the per wave EL hydrodynamic pumping related leakage at 15 psi bounds the hydrodynamic pumping related leakage of a spring-loaded Hybrid Seal operating at the same conditions.

5. Identifying EL wave type

To ensure the correct EL/Hybrid Seal is installed in an apparatus, the seals are marked with the EL wave type at one location on the ID of the seal, as shown in Figure 3. Verification of the wave type marking should be performed, as there are several EL/Hybrid Seals available for some shaft diameters.

Figure 3

EL wave types are indicated with the corresponding letter at one location on the ID of the seal.

For available seal sizes, visit kalsiseals.com.