

Chapter C6

Hybrid Kalsi Seals



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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 Standard and Wide Footprint Kalsi Seals.

Hybrid Seals were developed for oilfield rotary steerable tools which use thin 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.

Hybrid Seals are also suitable for use with higher viscosity lubricants in applications that can accommodate the greater hydrodynamic pumping related leakage that is associated with more viscous lubricants.



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 are made in standard and wide footprint lip widths. The narrowest location of the wide footprint lip is 50% wider than the narrowest location of the standard width lip. This added lip width provides more sacrificial material to accommodate axially acting wear mechanisms such as extrusion damage and third body abrasive wear. The wider lip also reduces the severity of high pressure extrusion damage.

Hydrodynamic wave geometry

Hybrid Seals can be customized to produce the minimum achievable running torque for a given lubricant reservoir size and lubricant viscosity. The seals have a mixture of EL and zigzag waves. The typical ratio of EL waves to zigzag waves is roughly one out of three, but other ratios are possible, and have been built, for specific operating conditions. An increased ratio makes the performance more like an EL Seal, and a decreased ratio makes the performance less like an EL Seal.

In addition to the ratio of Enhanced Lubrication waves, the degree of lubricating aggressiveness of each EL wave can be custom tailored if desired. Several EL wave geometries are available, and are described in more detail in Chapter C5. At the time of this printing, most Hybrid Seals incorporate the most aggressive EL wave (type A).

The Hybrid Seal was developed before many of the less aggressive EL wave types were designed and characterized. The current approach to achieving the most efficient seal lubrication for a given lubricant volume is to select an EL Seal of the wave type with the appropriate hydrodynamic pumping related leakage. If further leakage reduction is required with the least aggressive wave type then a Hybrid seal with the least aggressive wave type and suitable wave ratio is designed. This produces a uniformly thicker film around the circumference of the sealing interface. Contact Kalsi Engineering for guidance on Hybrid or EL Seal selection.

Seal materials, radial cross-sectional depth

The tooling for Hybrid Seals is compatible with single durometer, -106 dual durometer, and -200 and -201 composite high temperature materials. The tooling is adaptable (at extra expense) to make any available dual durometer material combination.

The as-molded diameter of a seal depends on the molding shrinkage characteristics of the selected material, and the shrinkage that the mold was designed for. The shrinkage of some 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,

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or a new mold may be required that is tailored to the shrinkage characteristics of the material. In our testing experience, the -30 FKM material has higher hydrodynamic leakage than the -10 HNBR material.

The inclusion of EL waves provides enhanced performance over a comparable seal having only sine or zigzag waves, regardless of radial cross-sectional depth. 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 sealing 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 been qualified 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 one zigzag wave. The -11 (85-90 Shore A) HNBR material has been qualified in Type C Wide Footprint Hybrid Seals in cross-sections down to 0.270" (6.86mm), using the same wave ratio.



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). The dynamic surface and exclusion edge are in good condition. This is a PN 637-11-11 seal, which has two Type C EL waves for every one zigzag wave.

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 on the Hybrid Seal bounds the

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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, lubricant viscosity, operating temperature, surface speed, differential pressure, and extrusion gap size. Leakage increases as a function of decreasing operating temperature, differential pressure, and extrusion gap size, and as a function of increasing lubricant viscosity and surface speed.

EL performance data is provided in Chapter 5. For applications that require accurate 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.

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