Chapter B2

HNBR

Revision 5 October 25, 2017

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.

1. Seal material profile: HNBR

ASTM designation: HNBR

Common names: Hydrogenated Nitrile

Highly Saturated Nitrile

HSN[1]

Saturated Nitrile

Trade names: Therban (Mobay)

Zetpol (Zeon Chemical)

Tornac (Polysar)

General material description

Compared to NBR materials, HNBR offers outstanding abrasion resistance, good resistance to swelling and flex cracking, and improved temperature, chemical and compression set resistance. The improvements are gained by reducing unstable double bonds through saturation with hydrogen. The typically quoted temperature range for HNBR is -50 to 320°F (-46 to 160°C).[2] This is 70°F (39°C) hotter than the typically quoted maximum continuous operating temperature of NBR.

HNBR has a good overall balance of characteristics (chemical, abrasion, compression set resistance, etc.) for typical oilfield drilling service, and is widely used in that industry.

2. HNBR selection guidelines

Introduction

HNBR is the most common material used to manufacture Kalsi-brand rotary shaft seals. The available compounds are shown in Table 1, and the various hardness combinations available in dual durometer seals are shown in Table 2.

The softer compounds

The 65 to 75 durometer hardness compounds (-14, -16, and -17) are used almost exclusively as the outer, energizing portion of our dual durometer shaft seals. The 70

---

1 When HNBR was initially developed, it was commonly known as HSN.

2 With HNBR materials, one obvious sign of extended exposure to excessive heat is material embrittlement.

durometer, -14 material is a popular dual durometer energizing material because it has better compression set resistance than the 65 durometer, -17 compound, and provides lower interfacial contact pressure than the 75 durometer, -16 compound.

The 80 durometer, -10 compound

The 80 durometer, -10 compound is often recommended for low differential pressure conditions, such as oilfield rotary steerable tools, where shaft seals with lower running and breakout torque may be desirable. The compound is also a candidate for certain low differential pressure applications that may operate in unusually cold environments, such as oilfield surface equipment, mining equipment, and remotely operated underwater vehicles. We have successfully started -10 Wide Footprint-type shaft seals at -40°F (-40°C) in our laboratory.

Wide Footprint Seals made from the -10 HNBR compound have been satisfactorily tested in low differential pressure conditions at 302°F (150°C) with an ISO 32 viscosity grade lubricant and a wide range of our typically recommended axial spring loads.

The -11 compound

The -11 compound has a hardness range of 85 to 92 durometer Shore A, and typically runs about 87 to 88 durometer. It is the most popular compound for Wide Footprint and Axially Constrained Kalsi Seals, which are widely used as oilfield mud motor seals. We have performed a great many rotary tests with this material at temperatures up to 302°F (150°C) and pressures up to 1,500 psi (10.34 MPa) at speeds simulating oilfield drilling operations.

The -11 compound was the first HNBR compound ever adopted by Kalsi Engineering. It was adopted at a time when true 90 durometer HNBR compounds were unavailable. Although the -11 compound has a long history of success in high differential pressure service, the -15 material offers superior high pressure extrusion resistance, and should be considered in cases where seal geometry and radial cross-sectional depth are compatible with the -15 compound.

The 90 durometer, -15 compound

The 90 durometer, -15 compound offers better high pressure extrusion resistance than the -11 compound, however it is not recommended for axially constrained seals, and seals that have a small radial cross-sectional depth.

The -15 compound is presently the most popular dynamic lip material for dual durometer shaft seals. Because of the longstanding acceptance and popularity of the -11 compound, the -15 compound is currently underutilized in single durometer seals. We believe that many customers who use the -11 compound in high differential pressure service would be better served by the -15 compound. For example, the fixed location, pressure retaining seal of a mud motor is a prime candidate for the -15 compound, if it meets the cross-sectional depth criterion described below.

The -15 compound has been qualified for Wide Footprint Seals that have a 0.345” (8.76mm) or greater radial cross-sectional depth. The -15 compound has also been qualified in Wide Footprint Hybrid Seals in radial cross-sectional depths of 0.305” (7.75mm) or greater, using a ratio of two Type C enhanced lubrication waves to every one zigzag wave.[3] Since the Type C wave is the least aggressive Enhanced Lubrication wave, the -15 compound is also compatible with more aggressive wave patterns.

Higher than anticipated hydrodynamic leakage has been observed with Type C waves when used with the -15 compound. Before using this combination, consult the relevant test data, and make sure your lubricant reservoir is adequately sized. No such leakage affect has been observed when the -15 material is used with the zigzag waves of second generation Wide Footprint Seals.

The 95 durometer, -18 compound

The 95 durometer, -18 compound offers better high pressure extrusion resistance than the -15 compound, however it is only used as the inner lip material of a -107, -114, or -115 dual durometer shaft seal.

3. Environmental considerations

Using HNBR with diesel-based drilling fluids

Significant swelling of HNBR can occur with #2 diesel-based oil well drilling fluid. This is particularly the case with low aniline point diesel fuel. Differential pressure, barrier seals, and/or rotary seal spring loading should be used to help to minimize swelling when low aniline point environments are anticipated. If possible, drillers should consider the aniline point when specifying diesel-based drilling fluids. Due to its adverse effect on elastomers, low aniline point diesel muds should be avoided when possible.

Kalsi Engineering successfully performed a 500 hour, 250°F (121°C), 1,000 psi (6.89 MPa) rotary test with 7.2 lb/gal “neat” (i.e. 100% diesel fuel) #2 diesel-based

3 Our tests of 0.270" (6.86mm) radial cross-section, PN 641-19-11 and 641-19-15 Type C Wide Footprint Enhanced Lubrication Seals indicate that the -15 material no longer provides a benefit over the -11 material seal in such small cross-section Type C seals. As of this writing, the -15 material has not been tested in 0.270” radial cross-section seals that have more aggressive enhanced lubrication wave patterns.

drilling fluid using HNBR (85 to 92 Durometer Shore A) seals at a surface speed of 346 ft/minute (1.76 m/s). In rotary seal testing with other swell-inducing fluid media, however, swelling caused a significant reduction in high pressure extrusion resistance. To reduce the risk of swell-induced loss of extrusion resistance, an outboard barrier seal can be used to protect the high pressure shaft seal from the swell-inducing environment.

In applications with differential pressure, very little of the surface area of the rotary seal is actually exposed to and soaked by the drilling fluid. This helps to minimize swelling. In the aforementioned 1,000 psi lab test, swelling of the seal was limited to the small portion that was directly exposed to the drilling fluid at the extrusion gap between the seal carrier and the shaft. In low differential pressure applications, axial spring loading of the seal can also be employed to minimize swelling by establishing sealing contact pressure with the environment side groove wall. Similar to differential pressure, spring loading limits the area of the rotary seal that can be exposed to the drilling fluid.

Special precautions with winterized diesel based drilling fluids

Diesel-based drilling fluids are often more aggressive to HNBR seals in the wintertime due to the lower viscosity/condensate type winterizing additives. Benzene is even sometimes encountered in diesel-based drilling fluids on a seasonal basis, and dramatically reduces the life of HNBR-based rotary seals.

When using HNBR in the fixed location, higher differential pressure seal position of a downhole mud motor, the material(s) of the barrier seal(s) and the compensation piston sliding and rotary seals should be selected based on anticipated chemical exposure if winterized diesel-based drilling fluids are anticipated.

Using HNBR with brine-based drilling fluids

While HNBR is resistant to the salt solutions sometimes encountered in oil well drilling, and has good compatibility with water, steam, and formate brine, it is poor against zinc bromide and fair to poor against calcium bromide. Both bromides are sometimes encountered in brine drilling fluids. When using HNBR in the fixed location, high pressure seal position of a downhole mud motor, the material(s) of the outboard barrier seal should be selected for bromide resistance if brine-based drilling fluids are anticipated. FEPM and FKM are suggested as candidate barrier seal materials.

H_2S

HNBR is generally considered to be acceptable with concentrations of up to 7% H_2S at temperatures up to 300°F (149°C). At higher temperatures or concentrations, use FKM or FEPM. FEPM is preferred to FKM if explosive decompression is a concern.

Known media limitations:

Avoid benzene, zinc bromide, calcium bromide (may cause embrittlement), CaBr formates, strong acids, halohydrocarbons (carbon tet, trichlorethylene), ketones (MEK, acetone), esters. Slight deterioration occurs when exposed to the lubricant additive zinc dithiophosphate. High acrylonitrile (ACN) content is desirable for use with drilling fluids based on No. 2 diesel fuel.

Other resources on chemical compatibility

It is not practical to include comprehensive media compatibility information in this handbook, nor is it necessary in view of the available specialty literature. One such reference is the book **Chemical Resistance Guide for Elastomers IV** by Kenneth M. Pruett (Compass Publications, La Mesa, CA USA: 2014).

Table 1
Available HNBR materials for single durometer rotary seals

Material dash no.	Material description	Material hardness, Shore A Durometer
-10	HNBR (fully saturated, peroxide cured, up to 43% ACN)	80 ±5
-11	HNBR (peroxide cured, up to 43% ACN)	85 to 92
-14	HNBR	70 ±5
-15	HNBR	90 ±5
-16	HNBR	75 ±5
-17	HNBR	65 ±5

Table 2
HNBR material combinations for Dual Durometer rotary seals[4]

Material dash no.	Inner lip hardness, Shore A	Outer Lip hardness, Shore A
-100	80 ±5	65 ±5
-101	85 to 92	65 ±5
-102	90 ±5	65 ±5
-104	80 ±5	70 ±5
-105	85 to 92	70 ±5
-106	90 ±5	70 ±5
-107	95 ±5	70 ±5
-108	80 ±5	75 ±5
-109	85 to 92	75 ±5
-110	90 ±5	75 ±5
-112	85 to 92	80 ±5
-113	90 ±5	80 ±5
-114	95 ±5	80 ±5
-115	95 ±5	85 to 92

4 Techniques have been developed to manufacture our rotary seals in most hardness combinations without the need for special tooling.