Chapter B3

FKM seal material

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1. Seal material profile: FKM

ASTM designation: FKM

Common names: fluorocarbon rubber

fluoroelastomer

Trade names: Viton (Dupont)

Fluorel (3M)

General material description

FKM, better known by the Dupont trade name "Viton", offers broad media compatibility, excellent high temperature and compression set resistance, and good flexing and tear resistance. It was originally developed for use with corrosive fluids, and offers useful resistance to petroleum products, silicone fluids and greases, diester lubricants, fuels, acids, esters, alcohol, halocarbons, ozone and most solvents.

Earlier grades of FKM had limited downhole applicability due to low resistance to amine attack. More recent grades address this limitation. Historically, the low temperature resistance of FKM is generally not as good as some other elastomers. More recent automotive specialty grades have been developed that remain pliable at lower temperatures, but give up some high temperature performance and chemical resistance.

FKM may experience hardening and cracking when exposed to steam or hot water, due to dehydrofluorination.

2. 80 Shore A -30 FKM seal material

The -30 FKM seal material is an advanced FKM with high fluorine content that is suggested for low differential pressure service in rotary seal applications requiring more temperature, chemical, or compression set resistance, or lower breakout friction, compared to HNBR seal materials. The -30 FKM material is suggested as a candidate for use against zinc and calcium bromides in oilfield applications, and with diesel-based drilling fluids. It has good acid and solvent resistance, and fair base resistance. It is not recommended for use against formates or formate brines. The estimated useful temperature range is 14 to 400°F (-10 to 204°C). The molding shrinkage rate for the -30 FKM material is very similar to HNBR. Accordingly, existing tooling can often be used with this material to produce nominally dimensioned rotary seals. Seal testing above 300°F (148.9°C) is performed in a fixture with a thermal fluid maintained at the test temperature and circulated around the seal carrier and shaft. Qualification testing of the material in rotating conditions includes:

- Testing of PN 587-12-30 seals in a flowing 400°F (204°C) thermal fluid environment with an ISO 1,000 viscosity grade seal lubricant and differential pressure of 15 psi at 480 RPM,
- Testing of PN 462-49-30 Axially Constrained Seals at 162°F and 340°F (72.2°C and 171.1°C) with ISO 680 and 1,000 viscosity grade seal lubricants and a drilling fluid environment to evaluate abrasive exclusion and interfacial lubrication in applications such as mud motors,
- Testing of miniature cross-section (0.145" and 0.186") Enhanced Lubrication Seals™ at temperatures of 162°F and 350°F (72.2°C and 176.7°C) using AeroShell Turbine Oil 560 to evaluate interfacial lubrication, and
- Testing of PN 507-5-30 seals at 300°F (148.9°C) and 480 rpm with an ISO 32 viscosity grade lubricant at 15 psi and various axial spring loads, to evaluate interfacial lubrication in applications such as oilfield rotary steerable tools.

Compression set and immersion testing of 80 Shore A -30 FKM seal material

Results from comparative immersion tests of the -11 HNBR and -30 FKM seal materials follow. In a 70-hour compression set test at 302°F (150°C) the compression set of the -30 FKM material was only 16% of that of the -11 HNBR material.

Original properties			
Property	ASTM	-11 HNBR	-30 FKM
Hardness	D2240	85a	83a
Tensile	D412	3892 psi	3354 psi
Elongation	D412	198%	186%
M100	D412	1900 psi	1504 psi
M50	D412	829 psi	610 psi

~50% Brine by Volume (70% CaCl Brine (9.25 lb) + 30% Diesel by weight), 70 Hours @ 257°F (125°C)			
Property	ASTM	-11 HNBR	-30 FKM
Δ Hardness	D2240	-5 points	-7 points
Δ Tensile	D412	-24.1%	+30.4%
Δ Elongation	D412	+6.6%	+40.6%
Δ M100	D412	-32.6%	-35.3%
Δ M50	D412	-38.5%	-25.3%
Δ Volume	D412	+9%	+2.8%

Valero #2 Diesel (low sulfur, summer blend), 70 Hours @ 74°F (23°C)			
Property	ASTM	-11 HNBR	-30 FKM
Δ Hardness	D2240	0 points	-3 points
Δ Tensile	D412	-10.7%	-5.3%
Δ Elongation	D412	-11.4%	+60.8%
Δ M100	D412	+0.1%	-23.5%
Δ M50	D412	-1.5%	-7.4%
Δ Volume	D412	+17.7%	+0.6%

Xylene, 70 Hours @ 74°F (23°C)			
Property	ASTM	-11 HNBR	-30 FKM
Δ Hardness	D2240	+1 points	-3 points
Δ Tensile	D412	-42%	+19%
Δ Elongation	D412	-33.9%	+24.8%
Δ M100	D412	-18.7%	-14.6%
Δ M50	D412	-26.7%	-12.3%
Δ Volume	D412	+17.7%	+0.6%

3. 85-92 Shore A -31 FKM seal material

The -31 seal material is an advanced FKM with high fluorine content that is suggested for service in rotary shaft seal applications requiring more temperature, chemical, or compression set resistance compared to HNBR. The -31 FKM material is suggested as a candidate for use against zinc and calcium bromides in oilfield applications and with diesel-based drilling fluids. It has good acid and solvent resistance, and fair base resistance. It is not recommended for use against formates or formate brines.[1] The estimated useful material temperature range is 14 to 400°F (-10 to 204°C). The molding shrinkage rate for the -31 FKM material is similar to HNBR. Existing tooling can often be used with this material to produce nominally dimensioned rotary seals. The material is qualified for 507, 568, 614, 637, and 641 series Kalsi Seals® and certain 344 and 587-series Kalsi Seals. Seal testing above 300°F (148.9°C) is performed in a fixture with a thermal fluid maintained at the test temperature and circulated around the seal carrier and shaft. Qualification testing of the material in rotating conditions includes:

- Testing of PN 507-5-31 seals at 375°F (190.6°C) with an ISO 1,000 viscosity grade lubricant and differential pressure of 15 psi.
- Testing of PN 507-5-31 seals at 350°F (176.7°C) with an ISO 1,000 viscosity grade lubricant and differential pressure of 250 psi.

1 One possible strategy for using a -31 seal as a pressure retaining seal in a zinc or calcium bromide environment is to employ an FEPM barrier seal outboard of a -31 FKM seal.

- Testing of PN 507-5-31 seals at 300°F (148.9°C) with an ISO 320 viscosity grade lubricant to evaluate abrasive exclusion and interfacial lubrication in applications such as mud motor sealed bearing assemblies, and
- Testing of PN 507-5-31 seals at 300°F (148.9°C) with an ISO 320 viscosity grade lubricant and differential pressure steps of 15, 500, 1,000, and 1,500 psi.

4. Available FKM materials for Kalsi Seals

FKM Seal Materials (Special Order)

Material dash no.	Material name	Material hardness, Shore A Durometer
-30	FKM	80 ±5
-31	FKM	85-92

5. Accommodating high temperature differential thermal expansion

For operation above 300°F (148.9°C), FKM seals typically require a wider groove width than similar HNBR seals. Most FKM seals are made in tooling originally designed for use with HNBR, and most grooves for HNBR seals are designed for the elastomer thermal expansion associated with 300°F (148.9°C) operation. Seal width prediction at various temperatures is provided in the handbook appendices.

For example, HNBR 0.345" cross-section Wide Footprint Seals™ have a 0.240" seal body width, and are typically used in a 0.289" wide seal grooves at temperatures up to 300°F (148.9°C). It is not practicable to design an FKM Wide Footprint Seal™ with a seal body width that is narrow enough to be compatible with a 0.289" groove width at 400°F (-204°C). The best option is to employ a 0.320" wide seal groove, which is wide enough to accommodate the thermal expansion of the 0.240" wide FKM seal body at 400°F (-204°C).

6. Environmental considerations

H_2S

FKM is generally considered to be acceptable with concentrations of up to 10% H_2S with no notable change in performance. FEPM is preferred to FKM if explosive decompression is a concern.