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NOK Oil Seal Materials

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NOK rubber material is considered environmental effect.

D. NOK OIL SEAL MATERIALS

An oil seal is constructed of rubber (seal lips and outer surfaces), a garter spring and an internal case.
The following materials are used for each part.

Rubber

1. Rubber Types

Table 1 shows the types and features of the various rubber materials used in oil seals, and **Table 2** shows their resistance to oils and chemicals.

When selecting a lip material for a seal application, please refer to **Table 3** "Types and Primary Uses of NOK's Lip Materials".

Table 1: Rubber Types and Characteristics Used in NOK's Oil Seals

Item / Type	Oil Resistance See Note(1)	Alkali Resistance	Acid Resistance	Water Resistance	Weather Resistance	Abrasion Resistance	Temperature Range (℃) See Note(2)		Features
							Lower Limit	Upper Limit	
Nitrile Rubber (NBR)	◎	○	○	○	△	◎	−40	+125	This material is most often used in oil seals due to its excellent resistance to mineral oil and abrasion; however, oil seals made of this rubber cannot be used for polar solvents, such as ketone or ester.
Hydrogenated Nitrile Rubber (HNBR)	◎	○	○	○	○	◎	−25	+140	This rubber has similar characteristics to nitrile rubber for oil seal use, but has better resistance to heat, oils, and weather than standard nitrile rubber.
Acrylic Rubber (ACM)	◎	×	△	△	◎	◎	−25	+150	This rubber has the same good oil resistance as nitrile rubber, and has good heat resistance similar to silicone rubber. Weather resistance is also excellent. Resistance to alkalis or water is inferior to that of other types of rubber.
Silicone Rubber (VMQ)	○	×	△	△	◎	○	−60	+225	This rubber is highly resistant to heat, cold, and weather, but its resistance to alkalis or water is inferior to that of other types of rubber.
Fluorocarbon Rubber (FKM)	◎	△	○	○	◎	◎	−20	+250	This rubber has heat resistance surpassing that of silicone. It also has excellent resistance to oils and chemicals. This material is the best rubber for oil seals due to its well-balanced characteristics.
Ethylene-Propylene Rubber (EPDM)	×	○	○	◎	◎	○	−40	+125	This rubber has excellent resistance to water, polar solvents, inorganic chemicals, and weather. 7Its oil resistance is inferior.
Styrene-Butadiene Rubber (SBR)	×	○	△	○	△	◎	−45	+100	This rubber has excellent resistance to polar solvents and water. Its oil resistance is inferior.
Tetrafluoroethylene Resin (PTFE)	◎	◎	◎	◎	◎	◎	−65	+260	This material has the maximum degree of resistance to heat, cold, chemicals, and weather, and a lower coefficient of friction. It is not as elastic as rubber.
Fabric	◎	◎	◎	◎	◎	◎	−50	+160	Since the primary material is synthetic fiber, resistance to heat and fraying is superior to that of conventional felt.

Remarks: ◎ Resistant
○ Resistant Except in Special Cases
△ Not Resistant Except in Special Cases
× Not Resistant

Note(1): Oil resistance does not include resistance to phosphoric ester or water-glycol fire resistant fluid.

Note(2): Temperatures shown in the temperature range are based on the following codes.

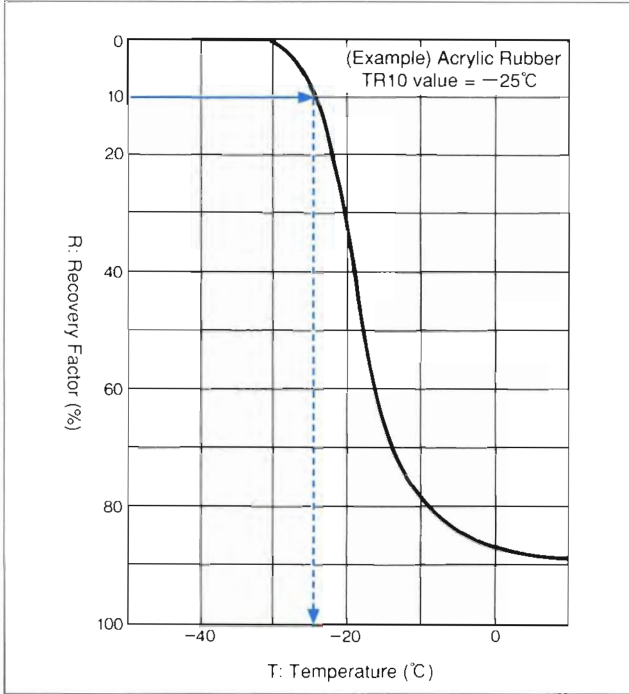
Upper Temperature Limits

Is defined as the highest temperature that allows a maximum tensile strength change of 630%, an elongation change of −50%, or a hardness change of 615 points after the completion of a 70-hour air-oven aging test.
[This maximum temperature applies to the heat-resistant reference temperature for material evaluation as defined in ASTM (The American Society for Testing and Materials) D2000 Line Call-outs.]

Lower Temperature Limits

The TR10 value is used to determine the low temperature limits.
TR is an abbreviation for "temperature-retraction," as defined in JIS K 6261. TR represents the recovery properties during low temperatures, and nearly equals the recovery properties of rubber-like elasticity.
The TR10 value indicates the temperature when a given strain is recovered by 10%. Figure 1 shows a typical TR curve.

Figure 1: TR Diagram



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Cold Temperature Resistance of Oil Seals

The cold temperature resistance of an oil seal is determined by a complicated interaction of various elements, such as the characteristics of the lip material and fluids to be sealed, shaft run-out, and start up speed.

The lip of the oil seal flexes only a few percent when the run-out of the shaft is only a few percent.

Therefore, NOK uses the TR10 value for lip materials as an index of the lowest allowable temperature. Under actual use conditions, even if the temperature is lower than the TR10 value, the temperature at the sealing edge increases due to friction immediately after start-up, allowing rubber-like elasticity to be recovered and thus retain good sealing performance.

However, even if the temperature is higher than the TR10 value, leakage may occur if the shaft run-out is too severe for the lip to follow properly. Thus, it is dangerous to determine the allowable temperature of oil seals solely on the TR10 value. These and other factors mentioned should be taken into consideration.

Table 2: Oil and Chemical Compatibility of Various Rubber Materials

Oil/Chemical \ Rubber Type		Nitrile Rubber	Hydrogenated Nitrile Rubber	Acrylic Rubber	Silicone Rubber	Fluorocarbon Rubber	Ethylene-Propylene Rubber	Styrene-Butadiene Rubber	Tetrafluoroethylene resin
Engine Oil	SEA #30	◎	◎	◎	◎	◎	×	×	◎
	SEA 10W-#30	◎	◎	◎	○	◎	×	×	◎
Gear Oil	Automotive	◎	◎	◎	△	○	×	×	◎
	Class 2 industrial use (extreme-pressure), synthetic base	◎	◎	△	△	○	△	△	◎
Torque Converter Oil Automatic Transmission Fluid		◎	◎	◎	×	○	×	×	◎
Brake Fluid	DOT 3 (glycol base)	△	×	×	○	×	○	○	◎
	DOT 5 (glycol base)	△	×	×	○	×	○	○	◎
	DOT 5 (silicone base)	◎	◎	◎	×	◎	○	○	◎
Class 2 Turbine Oil		○	○	◎	△	◎	×	×	◎
Machine Oil (No.2 spindle oil)		○	○	○	×	◎	×	×	◎
Hydraulic Fluid (mineral oil base)		◎	◎	◎	△	◎	×	×	◎
Fire Resistant Fluid	Phosphate Base	×	×	×	◎	△	×	×	◎
	Water + Glycol Base	○	○	×	△	△	×	×	◎
Cutting Fluid		○	◎	△	△	◎	×	×	◎
Grease	Mineral Oil Base	◎	◎	◎	◎	◎	×	×	◎
	Silicone Base	◎	◎	◎	×	◎	◎	○	◎
	Fluorine Base	◎	◎	◎	◎	△	◎	○	◎
Refrigerants	R12+Paraffin Base	○	◎	×	×	×	×	×	◎
	R134a+Glycol Base	△	○	×	×	×	◎	×	◎
Gasoline		△	○	×	×	○	×	×	◎
Light Oil, Kerosene		△	○	×	×	◎	×	×	◎
Heavy Oil		○	◎	△	×	◎	×	×	◎
Anti-Freeze Solution (ethylene glycol base)		○	○	×	△	×	◎	◎	◎
Water, Warm Water		○	◎	×	○	○	◎	◎	◎
Sea Water		○	◎	×	×	○	◎	◎	◎
Water, Steam		×	○	×	×	×	○	△	◎
10% Hydrochloric Acid Solution		○	○	○	○	○	◎	○	◎
30% Sulfuric Acid Solution		△	△	△	×	△	○	△	◎
10% Nitric Acid Solution		×	△	×	×	△	○	×	◎
40% Sodium Hydroxide Solution		○	◎	×	×	×	◎	◎	◎
Benzene		×	×	×	×	×	×	×	◎
Ethyl Alcohol		○	○	×	○	○	◎	◎	◎
Methyl Ethyl Ketone		×	×	×	△	×	×	×	◎

Remarks : ◎ Resistant
○ Resistant Except in Special Cases
△ Not Resistant Except in Special Cases
× Not resistant

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2. Types and Primary Uses of NOK Lip Materials

Various NOK seals using the types of rubber introduced in **Table 1** are available. **Table 3** shows the types and primary uses of typical NOK lip materials.
Each lip material is designed for outstanding sealing performance and the best balance between each property inherent to a raw material.
To obtain well-balanced lip materials, it is vital to select proper raw materials or compounding chemicals, and apply appropriate compounding techniques. At NOK, we develop high-quality raw materials and compounding chemicals, combined with research about the effect of each material on the sealing function, in order to create an optimal material for oil seals.
Furthermore, we apply the results of this research and technology to manufacture better lip materials.

Table 3: Types and Primary Uses of Typical NOK Lip Materials

NOK Lip Material		Hardness	Temperature Range	Primary Uses	Fluid to be Sealed		
Rubber Type	Material Symbol (Color)	(Durometer A)	(℃)		Mineral Oil	Muddy Water, Water	Grease
Nitrile Rubber (NBR)	A727 (Black)	70	−30～+120	Standard material (for rotating shafts)	○		○
	A941 (Black)	80	−25～+100	Standard material for medium-to-large diameter (150 mm or larger) shafts (for rotating shafts)	○		○
	A795 (Black)	80	−11～+100	Standard material (for reciprocating shafts and high pressure), fuel oil resistance	○		○
	A275 (Black)	70	−40～+100	Cold and weather resistance (for rotating shafts)	○		○
	A427 (Black)	80	−40～+100	Cold resistance (for reciprocating shafts)	○	○	○
	A571 (Black)	75	−25～+100	Abrasion resistance from muddy water (for rotating shafts)		○	○
	A368 (Black)	75	−20～+100	Compliance with the Food Sanitation Law (for rotating shafts)			○
	A989 (Black)	70	−20～+100	Special material (MO type)	○	○	○
	A103 (Black)	70	−22～+100	Water resistance (for rotating shafts)		○	
				Special material (TCJ type)	○		○
	A104 (Black)	80	−21～+100	Special material (MG type)	○	○	○
	A134 (Black)	60	−20～+100	Special material (VR type)		○	○
Hydrogenated Nitrile Rubber (HNBR)	G418 (Black)	75	−25～+130	Special material (for reciprocating shafts, MOY type)	○		
Acrylic Rubber (ACM)	T303 (Black)	80	−15～+150	Standard material (for rotating shafts)	○		○
	T599 (Black)	80	−25～+140	Cold resistance (for rotating shafts)	○		○
	T945 (Black)	80	−37～+160	Heat and cold resistance material (for rotating shafts)	○		○
Silicone Rubber (VMQ)	S728 (Black)	80	−45～+170	Standard material (for rotating shafts)	○		
	S817 (White)	75	−45～+170	Compliance with the Food Sanitation Law (for rotating shafts)			○
Fluorocarbon Rubber (FKM)	F585 (Brown)	75	−15～+200	Standard material (for rotating shafts)	○		○
	F975 (Brown)	80	−15～+200	Special material (for reciprocating shafts)	○		○
	F548 (Black)	85	−16～+200	Pressure resistance (for rotating shafts)	○		○
	F129 (Black)	70	−15～+200	Special material (VR type)			○
Tetrafluoroethylene Resin (PTFE)	31BF (Black)	Durometer D 65	(−50)～+220	Special material (J type), resistance to chemicals and heat, low friction	○		○
	40WF (White)			Compliance with the Food Sanitation Law (for rotating shafts)			○
Fabric	31FH (Black)	—	(−50)～+160	Material for secondary/dust lips, air permeability	—		

Note(1): Ethylene-propylene rubber and styrene-butadiene rubber (not listed in Table 3) are also available for special uses.

Note(2): Temperatures listed are based on the following criteria.
Upper Limit: A yardstick for temperatures that can be used relative to the function of oil seals.
Lower Limit: The TR10 value for each lip material is used.

Note(3): For details on resistance of various lip materials to sealing fluids, see Chapter 7 (page J-7)

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The various degrees of resistances and the temperature ranges shown in **Tables 2** and **3** are for informational purposes only. Users should carefully read Chapter E "NOK Oil Seal Application Guide" and Chapter J "Oil and Chemical Resistance of NOK Lip Materials."

To safeguard the function of the oil seal, careful attention is required regarding the application's operating temperatures, as temperature directly affects the both the seal and the fluids.

Rubber is sensitive to changes in temperature. A change in rubber at higher temperatures produces a chemical change in which elasticity is lost because the high polymers of the rubber are excessively cut or bonded due to heat, oils, chemicals or ozone. Therefore, the proper working temperature can be determined by the correlation between temperature and time. For example, relatively high temperatures may be used for short periods of time. Conversely, lower temperatures may be used for longer periods of time.

Another change in rubber properties at very low temperature is hardening caused by less active polymers. This reversible phenomena is dependent on temperature only. The normal rubber-like elasticity of an oil seal is recovered when the ambient temperatures return to normal.

Garter Springs and Metal Cases

NOK's garter springs and cases are made from the materials shown in **Table** 4.
Standard materials for garter springs and cases are used in oil seals for lubricant or grease sealing.
Special materials are used for sealing water, corrosive chemicals, or gas.

Table 4: Types and Applications of Garter Spring and Metal Case Materials

Spring and metal case materials / Fluid to be Sealed	Garter spring			Metal Case		
	Standard materials	Special materials		Standard materials	Special materials	
	JIS G 3521 SW (hard-drawn copper wire) JIS G 3522 SWP (piano wire)	JIS G 4309 SUS (stainless steel wire)		JIS G 3141 SPCC (cold-rolled steel sheet and strip) JIS G 3131 SPHC (hot-rolled steel sheet and strip)	JIS G 4305 SUS (cold-rolled stainless steel sheet) JIS G 4307 SUS (cold-rolled stainless steel strip)	
		304	316		304	316
Lubricants, grease	○	○	○	○	○	○
Water	×	○	○	×	○	○
Steam	×	○	○	×	○	○
Sea water	×	×	○	×	×	○
Acids	×	×	○	×	×	○
Alkalis	×	○	○	×	○	○

Remarks : ○ Can be used
× Do not use

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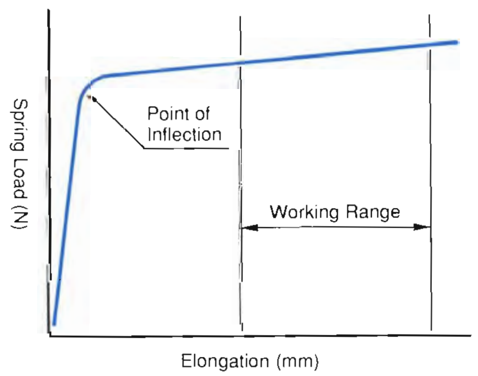
The Function of a Garter Spring

A garter spring increases and maintains the pressure of the sealing lip on the shaft. Since garter springs used in oil seal have the characteristics shown in Figure 2, it is possible to obtain the load necessary for good sealing with little elongation. As shown in Figure 2, even if a garter spring is elongated to some extent, the spring load does not change significantly. The length of a garter spring in an oil seal is determined by considering the proper amount of elongation required to ensure that it can function properly within the working range defined in Fig. 2.

Figure 2: Characteristics of Garter Springs Used in Oil Seals



The Function of a Metal Case

Cases plays an important role in maintaining the retention strength between the seal and the housing bore, thus keeping the seal lip at its intended position.