向创新挑战-NOK集团

NOK

2007 Edition

O-Rings

NOK Corporation

What is O – ring?

O – RINGS

O – ring is a kind of sealing ring to be installed in grooves. If subject to proper pressure, it will change to shape "O" (round shape).
It can be used to seal oil, water, air, gas and other fluids, both static and dynamic.

2. Characteristics and kinds of NOK O – rings

2 – 1. Characteristics

1. Small installation space is required.

Shape and structure of O – ring installation portion can be designed in a very simple way that makes the machine small and light – weighted.

2. Easy to use.

Shape of O – ring and the installation portion can be very simple, so It's very easy to install and remove.

3. Wide application

If properly selected, the O – ring can be used in the temperature range of – 60℃ – + 220℃, in water, oil, air and other gas and chemicals.

4. Multi – choice and cheap – priced

All kinds of materials and dimensions are available, and the price is very cheap.

2 – 2. Kinds

Table – 1 shows the kinds of NOK O – rings, and the dimensions are of JIS, ISO, JASO, AS and NOK standards.

Table – 1 Standards for NOK O – ring

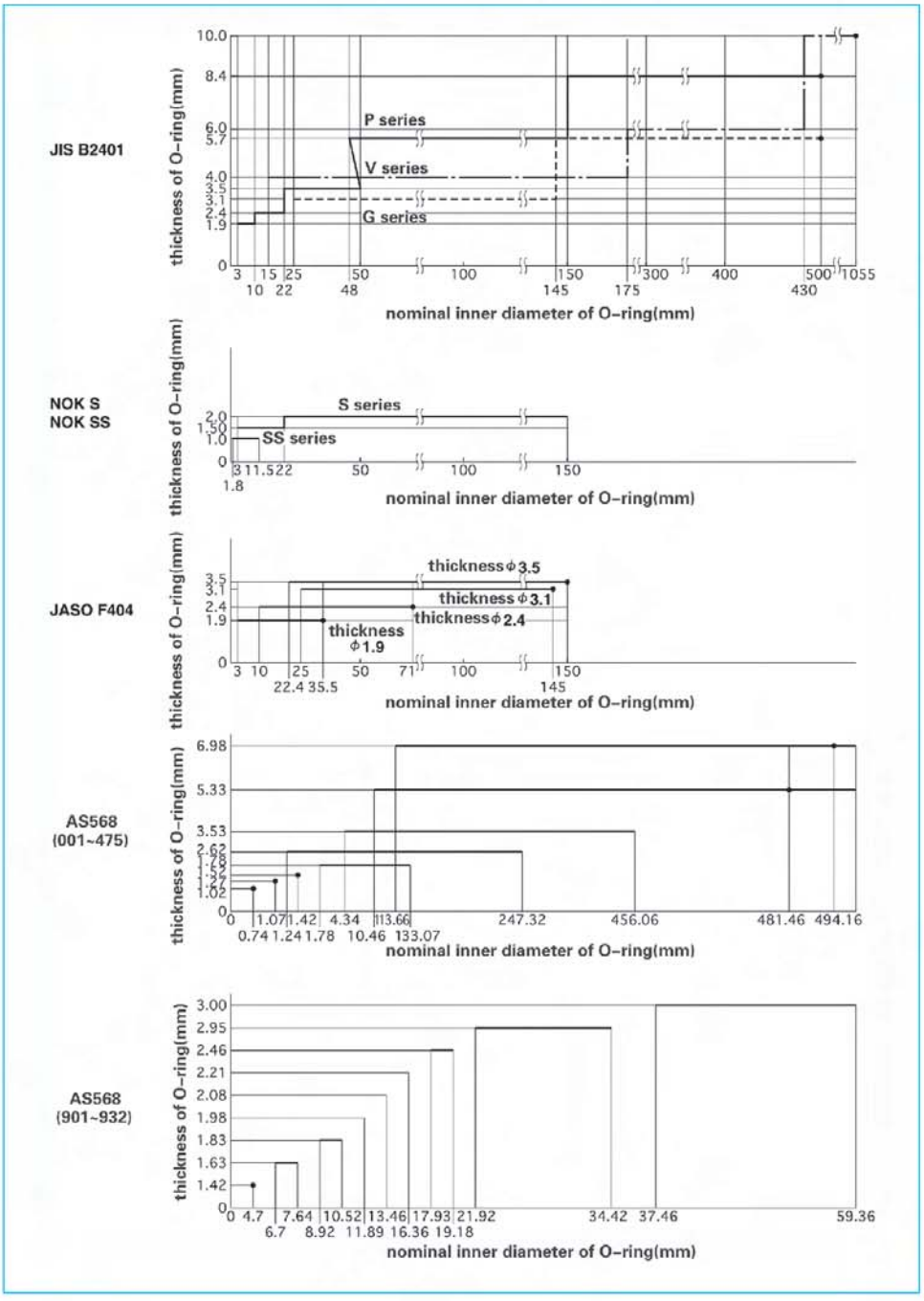
kind \ application		For general machinery					For vehicle		For aircraft
O – ring	standard	JIS B2401		ISO (industries general)	NOK IRON RUBBER P&G standard (accord with JIS B2401)	NOK S standard NOK SS standard	JASO F404		AS568 (former ARP568)
	sort according to material	JIS symbol	characteristic	material symbol	material symbol	material symbol	JASO symbol	characteristic	material symbol
		Class 1 A	mineral oil resistant	A305	U565 U801	A305 F201	Class 1 A – Class 2	mineral oil resistant – gasoline resistant	A305 A105 F201
		Class 1 B	mineral oil resistant				Class 3	animal and vegetable oil resistant	
		Class 2	gasoline resistant				Class 4 C	hot resistant	
		Class 3	animal and vegetable oil resistant				Class 4 D	hot resistant	
		Class 4 C	hot resistant				Class 4 E	hot resistant	
		Class 4 D	hot resistant				Class 5 H*	coolant resistant wear resistant	
	sort according to application	• P series (for static and dynamic sealing) • G series (for static sealing) • V series (for vacuum flange)		static sealing	• P series (for static and dynamic sealing) • G series (for static sealing)	• S series* (for low pressure static sealing) • SS series* (for low pressure static sealing)	cross – section diamter Φ1.9 series (former 1000 series) cross – section diamter Φ2.4 series (former 2000 series) cross – section diamter Φ3.1 series cross – section diamter Φ3.5 series (former 3000 series) (All for static and dynamic sealing)		for static sealing (former AN6227) for dynamic sealing
Shape and dimension of installation groove		JIS B2406 (For static and dynamic sealing) JIS B2290 (for vacuum flange)		—	JIS B 2406 (for static and dynamic sealing)	NOK S standard NOK SS standard	JASO F404		—
backup ring		JIS B 2407							
		T1	 spiral type			—	—		—
		T2	 biascut type						
		T3	 endless type						

note: ※NOK, S and SS sereis are designed for minimize machinery, espacially for those require small thickness O – rings.

note: JIS standards that are refer to aircraft, such as W1516, W1517, W2006, W1537 and W1538, have been abolished.

＊Material H is the name of NOK material symbol.

Figure – 1 The relationship between the inner diameter and thickness of NOK O – rings



2. Materials of NOK O – rings

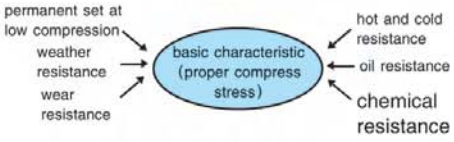
2 – 1. Characteristics of the materials required

Because O – rings will generate stress when being squeezed, the required basic characteristic of the materials used is to keep proper stress when it has not deformed abnormally.

This is also required in real application. Compound rubber is the best material with this characteristic.

But one material can not solve all problems, so material should be chosen according to specific application.

NOK has all kinds of materials available.



2 – 2. Kinds and characteristics of materials of NOK O – rings

NOK has standard materials that are JIS and JASO standards compliant and special materials for special applications. Table – 2 shows general used materials. For special materials, please contact us directly.

Talbe – 2 Kinds and characteristics of materials of NOK O – rings

kind	NOK material symbol	kinds of rubber	characteristic	JIS standard (equivalent B2 401 symbol)
standard material	A305 (NBR)	nitrile rubber	Most generally used material, with good oil, wear and hot resistance. It's fit for pneumatic purpose O – rings.	Class 1 A
	A105 (NBR)	nitrile rubber	With the same characteristic to A305, but better hardness and pressure resistance.	Class 1 B
	A122 (NBR)	nitrile rubber	With good resistance to kerosene and other light fuel oils. It's fit for fuel oil purpose O – rings.	Class 2
	R189	styrole rubber	With good resistance to animal and vegetable oils in glycol brake fluid.	Class 3
	S503 (VMQ)	silicone rubber	With the widest working temperature range among compound rubbers with good hot and cold resistance.	Class 4 C
	F201 (FKM)	fluoro rubber	Most extensively used compound rubber with best oil, chemical and hot resistansce.	Class 4 D
	T767 (ACM)	acrylic rubber	The hot resistance is better than nitrile rubber, and it has special resistance to it's especially fit for internal combustion engine oil, gear oil and torque converter oil.	*Class 4 E
	E116 (EPDM)	ethylene propylene rubber	With great resistance to coolant, steam, vegetable oil, brake fluid, and non – inflammable vegetable oil, but it can not be used with mineral oil.	Class 5*
	G607 (HNBR)	hydrogenated nitrile rubber	With better hot, oil, weather wear resistance and hardness than nitrile rubber.	H*
	U565 (PU)	NOK IRON RUBBER (polyurethane rubber)	With good rear and oil resistance, but will age in oils with chemical activity.	
	U801 (PU)	NOK IRON RUBBER (polyurethane rubber)	With the same characteristic to U565, but better hardness and pressure and wear resistance.	
other suggested material	A980 (NBR)	nitrile rubber	With the same charecteristic to A305, but better cold resistance.	
	A746 (NBR)	nitrile rubber	With better gas and weather resistance than other nitrile rubbers. It has been certified by Japanese LPG (liquefied petroleum gas) association.	
	E700 (EPDM)	ethylene – propylene rubber	With better life time than other ethylene – propylene rubbers, and as it can be used for water rotating rings; and with other characteristics, such as hardness, wear and chlorine resistance, and solvent cracking ability.	
	S740 (VMQ)	silicone rubber	With better hot water and steam resistance than other silicone rubbers, and with great compressive permanent set	
	FL68 (FKM)	fluoro rubber	With the same oil, chemical and hot resistance to F201, and it's cold resistance is the best among fluororubbers. It's extensively used in gasoline applications.	
	F440 (FKM)	fluoro rubber	With the same oil, chemical and hot resistance to F201, and it's fit for gas leaking prevention in semiconductor manufacturing devices as other fluororubbers do. And it has good compressive permanent set.	

※ Class 4 E and Class 5 are standard materials for JASO F404.
※ Material H is the name of NOK material symbol.

𝒮 – 𝒮. Standard values and test values of the NOK O – ring standard materials

Table 3 – 1 Standard values and test values (average values from real tests)

kind of material / test item	JIS symbol	Class 1 A		Class 1 B		Class 2	
	NOK equivalent symbol	A305		A105		A122	
	application	for mineral oil application		for mineral oil application		for gasoline application	
	standard value / test value	standard value	test value	standard value	test value	standard value	test value
normal condition	hardness (durometer A)	70 ±5	71	90 ±5	91	70 ±5	71
	tensile strength (Mpa)	> 9.8	20.8	> 14	18.1	> 9.8	20.9
	elongation (%)	> 250	340	> 100	150	> 200	420
	tensile stress (Mpa) (at 100% elongation)	> 2.7	4.5	—		> 2.7	4.3
aging test	temp. and time	120℃ 70h		120℃ 70h		100℃ 70h	
	change in hardness (Points)	< +10	+3	< +10	+3	< +10	+4
	change in tensile strength (%	< −15	+2	< −25	+10	< −15	+4
	change in elongation (%	< −45	−7	< −55	−37	< −40	−23
compression set test	temp. and time	120℃ 70h		120℃ 70h		100℃ 70h	
	compression set (%)	< 40	13	< 40	26	< 25	18
oil resistance test 1	temp. and time	120℃ 70h		120℃ 70h		23℃ 70h	
	oil used	lubricant No. 1		lubricant No. 1		fuel oil No. 1	
	change in hardness (Points)	−5 ~ +8	±0	−5 ~ +8	+3	−8 ~ 0	−1
	change in tensile strength (%	< −15	+2	< −20	−13	< −15	−4
	change in elongation (%	< −40	−12	< −40	−23	< −25	−5
	change in volume (%)	−8 ~ +5	−3.6	−8 ~ +5	−4.3	−3 ~ +5	+0.6
oil resistance test 2	temp. and time	120℃ 70h		120℃ 70h		23℃ 70h	
	oil used	lubricant No. 3		lubricant No. 3		fuel oil No. 2	
	change in hardness (Points)	−15 ~ 0	−7	−10 ~ +5	−8	−20 ~ 0	−12
	change in tensile strength (%	< −25	−11	< −35	−13	< −45	−32
	change in elongation (%	< −35	−13	< −35	−13	< −45	−32
	change in volume (%)	0 ~ +20	+11.8	0 ~ +20	+10.7	0 ~ +30	+24.3
low temperature bending test	TR_{10} value (℃) elongation 50%	—	−24	—	−23	—	−22

TR_{10} value is short for Temperature – Retraction, which means the recoverability at low temperature condition, for rubbers, it's bending recoverability.

O – ring can best take advantage of rubbers' flexibility, and low temperature bending ability could be concluded from TR value. 10 in "TR_{10}" refer to the temperature at which 10% set is recovered. From experience, we can know that this value always shows the limitation of O – ring's low temperature bending ability.

Class 3		Class 4 C		JIS symbol	kind of material / test item
R189		S503		NOK equivalent symbol	
for animal and vegetable oil application		for hot application		application	
standard value	test value	standard value	test value	standard value/test value	
70 ±5	73	70 ±5	70	hardness (durometer A)	normal condition
> 9.8	19.4	> 3.4	6.1	tensile strength (Mpa)	
> 200	350	> 60	150	elongation (%)	
> 2.7	6.1	—	4.9	tensile stress (Mpa) (at 100% elongation)	
100℃ 70h		230℃ 24h		temp. and time	aging test
< +10	+2	< +10	+1	change in hardness (Points)	
< −15	−6	< −10	+12	change in tensile strength (%)	
< −45	−9	< −25	−6	change in elongation (%)	
100℃ 70h		175℃ 22h		temp. and time	compression set test
< 25	10	< 30	10	compression set (%)	
100℃ 70h		175℃ 70h		temp. and time	oil resistance test 1
brake fluid		lubricant No. 1		oil used	
−15 ~ 0	−3	−10 ~ +5	−5	change in hardness (Points)	
< −40	−5	< −20	+1	change in tensile strength (%)	
< −40	−11	< −20	+2	change in elongation (%)	
0 ~ +12	+2.5	0 ~ +10	+4.5	change in volume (%)	
—		—		temp. and time	oil resistance test 2
—		—		oil used	
—		—		change in hardness (Points)	
—		—		change in tensile strength (%)	
—		—		change in elongation (%)	
—		—		change in volume (%)	
—	−51	—	−43	TR_{10} value (℃) elongation 50%	low temperature bending test

Table 3 – 2 Standard values and test values (average values from real tests)

※ Material H is the name of NOK material symbol.

kind of material / test item		JIS symbol	Class 4 D		Class 4 E※		Class 5※	
		NOK equivalent symbol	F201		T767		E116	
		application	for hot application		for hot application		for coolant application	
		standard value / test value	standard value	test value	standard value	test value	standard value	test value
normal condition	hardness (durometer A)		70 ±5	71	70 ±5	73	70 ±5	72
	tensile strength (Mpa)		> 9.8	14.2	> 5.9	12.8	> 9.8	20.9
	elongation (%)		> 200	230	> 100	180	> 150	220
	tensile stress (Mpa) (at 100% elongation)		> 1.9	4.1	—		> 2.7	5.5
aging test	temp. and time		230℃ 24h		150℃ 70h		120℃ 70h	
	change in hardness (Points)		<+5	±0	<+10	+2	<+10	+1
	change in tensile strength (%		<−10	−4	<−30	+2	<−20	−2
	change in elongation (%		<−25	−10	<−40	−13	<−40	−4
compression set test	temp. and time		175℃ 22h		150℃ 70h		120℃ 70h	
	compression set (%		<40	7	<60	30	<40	5
oil resistance test 1	temp. and time		175℃ 70h		150℃ 70h		100℃ 70h	
	oil used		lubricant No. 1		lubricant No. 1		coolant	
	change in hardness (Points)		−10 ~ +5	±0	−7 ~ +10	−3	−5 ~ +5	+1
	change in tensile strength (%		<−20	+2	<−30	+2	<−30	−16
	change in elongation (%		<−20	−4	<−40	−7	<−30	−6
	change in volume (%)		−5 ~ +5	±0.0	−5 ~ +5	−0.3	−5 ~ +10	+1.2
oil resistance test 2	temp. and time		175℃ 70h		150℃ 70h		—	
	oil used		lubricant No. 3		lubricant No. 3		—	
	change in hardness (Points)		−10 ~ +5	−2	−20 ~ 0	−13	—	
	change in tensile strength (%		<−20	−7	<−40	−15	—	
	change in elongation (%		<−20	+9	<−40	−9	—	
	change in volume (%)		−5 ~ +5	+2.4	0 ~ +30	+15.9	—	
low temperature bending test	TR_{10} value (℃) elongation 50%		—	−15	—	−18	—	−49

TR_{10} value is short for Temperature – Retraction, which means the recoverability at low temperature condition, for rubbers, it's bending recoverability.

O – ring can best take advantage of rubbers' flexibility, and low temperature bending ability could be concluded from TR value. 10 in "TR_{10}" refer to the temperature at which 10% set is recovered. From experience, we can know that this value always shows the limitation of O – ring's low temperature bending ability.

※ Class 4 E and Class 5 are the standard material for JASO F404.

H*		NOK standard		NOK standard		JIS symbol	kind of material / test item
G607		U565		U801		NOK equivalent symbol	
for wear application		for pressure application		for pressure · wear application		application	
standard value	test value	standard value	test value	standard value	test value	standard value / test value	
70 ±5	70	90 ±5	92	93 ±5	95	hardness (durometer A)	normal condition
> 16.7	23.5	> 19.6	28.4	> 29.4	43.1	tensile strength (Mpa)	
> 150	240	> 200	290	> 300	550	elongation (%)	
—		—		—		tensile stress (Mpa) (at 100% elongation)	
120℃ 70h		80℃ 70h		80℃ 70h		temp. and time	aging test
< +10	+5	−5 ~ +5	±0	−5 ~ +5	±0	change in hardness (Points)	
< −15	+4	< −20	+2	< −20	+1	change in tensile strength (%)	
< −40	−4	< −20	+1	< −20	+2	change in elongation (%)	
120℃ 70h		80℃ 70h		80℃ 70h		temp. and time	compression set test
< 20	10	< 40	25	< 50	32	compression set (%)	
120℃ 70h		80℃ 70h		80℃ 70h		temp. and time	oil resistance test 1
lubricant No. 1		lubricant No. 1		lubricant No. 1		oil used	
−5 ~ +10	+5	−5 ~ +5	±0	−5 ~ +5	±0	change in hardness (Points)	
< −20	−4	< −20	−1	< −20	±0	change in tensile strength (%)	
< −35	−10	< −20	+2	< −20	−2	change in elongation (%)	
−15 ~ +5	−5.2	−5 ~ +5	+0.1	−5 ~ +5	−0.3	change in volume (%)	
120℃ 70h		80℃ 70h		80℃ 70h		temp. and time	oil resistance test 2
lubricant No. 3		lubricant No. 3		lubricant No. 3		oil used	
−10 ~ +10	+1	−5 ~ +5	−1	−10 ~ 0	±0	change in hardness (Points)	
< −30	+4	< −20	−5	< −20	−3	change in tensile strength (%)	
< −30	−6	< −20	+2	< −20	−4	change in elongation (%)	
−10 ~ +10	+3.3	0 ~ +10	+8.5	0 ~ +10	+5.4	change in volume (%)	
—	−22	—	−30	—	−29	TR_{10} value (℃) elongation 50%	low temperature bending test

4. How to choose O – ring material

O – rings shown in this document are not fit for designing and manufacturing of medical devices, so please do not apply them to medical devices that are used to transplant, or contact body fluid or tissues.
Also if make use of atomic pouser, machine related food, please contact us individually

4 – 1. Temperature range and sealing medium

Please choose materials according to specific application conditions so as to best take advantage of O – rings.

Please choose according to Table 4 – 1, which shows O – ring materials' working temperature range and their resistance to sealing medium.

Table 4 – 1Choose NOK O – ring material

material / target working temperature / sealing medium		standard material											other suggested material					
		A305	A105	A122	R189	S503	F201	T767	E116	G607	U565	U801	A980	A746	E700	S740	FL68	F440
numbers in bracks are ( )the MAX values		(120) 100	(120) 100	(100) 80	(100) 80	(220) 200	(220) 200	(150) 130	(150) 130	(130) 110	(100) 80	(100) 80	(100) 80	(120) 100	(150) 130	(220) 200	(220) 200	(220) 200
0℃																		
−50℃		−30	−25	−25	−50	−50	−15	−20	−50	−30	−30	−35	−50	−25	−50	−55	−30	−15
lubricant oil	internal combustion engine oil	◎	◎	○	×	△	○	◎	×	◎	○	○	◎	○	×	△	◎	○
	gear oil	◎	◎	○	×	△	○	◎	×	◎	△	○	○	○	×	△	◎	○
	machine oil	◎	◎	◎	×	○	◎	◎	×	◎	◎	◎	○	◎	×	○	◎	◎
	spindle oil	◎	◎	◎	×	△	◎	○	×	◎	◎	◎	○	◎	×	△	◎	◎
	refrigerator oil (mineral oil)	○	○	◎	×	△	◎	○	×	○	◎	◎	○	◎	×	△	◎	◎
	cup grease	◎	◎	◎	×	△	◎	○	×	◎	○	○	◎	◎	×	△	◎	◎
	lithium grease	◎	◎	◎	×	◎	◎	◎	×	◎	○	○	◎	◎	×	◎	◎	◎
	silicone grease	◎	◎	◎	○	×	◎	◎	◎	◎	◎	◎	○	◎	◎	×	◎	◎
hydraulic oil	turbine oil	◎	◎	◎	×	○	○	◎	×	◎	◎	◎	○	◎	×	○	◎	◎
	oil and wear emulsion	◎	◎	◎	△	△	△	×	△	◎	△	△	○	◎	△	○	○	△
	water and glycol	○	○	○	○	△	△	×	◎	○	△	△	○	○	◎	○	○	△
	phosphate ester oil	×	×	×	×	○	◎	×	◎	×	×	×	×	×	◎	○	◎	◎
	silicon oil	◎	◎	◎	○	×	◎	◎	◎	◎	◎	◎	○	◎	◎	×	◎	◎
	brake fluid	△	△	△	◎	○	△	×	◎	△	×	×	△	△	◎	○	△	△
	hydraulic torque converter oil	△	△	◎	×	△	○	◎	×	△	○	○	△	◎	×	△	◎	○
fuel oil	light oil and kerosene	△	△	◎	×	×	◎	×	×	○	△	△	△	◎	×	×	◎	◎
	heavy oil	△	△	○	×	×	◎	×	×	△	△	△	△	○	×	×	◎	◎
	gasoline	△	△	○	×	×	◎	×	×	△	×	×	△	○	×	×	◎	◎
water	water or warm water	○	○	○	○	○	△	×	◎	○	○	○	○	○	◎	◎	○	△
	steam or hot water	○	○	○	○	△	△	×	◎	○	×	×	○	○	◎	◎	△	△
	water with antifreeze	○	○	○	△	△	△	×	◎	○	○	○	○	○	◎	◎	○	△
	cutting fluid with water	○	○	○	△	△	△	×	△	○	△	△	○	○	△	○	○	△
chemical	20% salt solution	△	△	△	○	△	○	△	◎	△	△	△	△	△	◎	△	◎	○
	30% sulfuric acid solution	○	○	○	○	○	○	△	◎	○	△	△	○	○	◎	○	◎	○
	10% nitric acid solution	×	×	×	×	×	△	×	○	×	△	△	×	×	○	×	◎	△
	30% sodium hydroxide solution	◎	◎	◎	◎	×	×	×	◎	◎	×	×	◎	◎	◎	×	△	×
	benzene	×	×	×	×	×	△	×	×	×	×	×	×	×	×	△	△	
	trichloro ethylene	×	×	×	×	△	△	×	×	×	×	×	×	×	×	△	△	
	essence of wine	○	○	○	◎	○	○	×	◎	○	△	△	○	○	◎	○	○	○
	alcohol	◎	◎	◎	◎	◎	◎	△	◎	◎	○	○	◎	◎	◎	◎	◎	◎
	acetone	×	×	×	△	△	×	×	○	×	×	×	×	×	○	△	×	×
gas	liquefied petroleum gas	○	○	◎	×	×	◎	△	×	○	○	○	○	◎	×	△	◎	◎
	coal gas	○	○	◎	△	△	◎	○	△	○	○	○	○	◎	△	△	◎	◎
	ozone	△	△	△	△	◎	◎	◎	◎	○	○	○	△	△	◎	◎	◎	◎
	freon R134a	×	×	△	×	×	×	×	◎	△	×	×	×	×	◎	×	×	×
	freon 22	△	△	△	○	×	△	△	△	△	×	×	△	△	△	×	△	△
others	Food Hygiene Law*					◎			◎		◎	◎			◎	◎		
	vacuum, gas − 10^{-4}mmHg	◎	◎	◎			◎			◎			◎	◎			◎	◎
	vacuum 10^{-4} – 10^{-9}mmHg						◎										◎	◎
	leakage																	◎

◎ : resistance。 ○ : resistance in normal condition。 △ : resistance in specific condition。 × : no resistance。

* Please contact NOK if you want to use these material。

4-2. NOK's off the shelf rubber materials

Besides standard materials, NOK also has all kinds of specific application rubber material off the shelf. Please provide us with valuation form, as sometimes new molds are needed.

Table 4-2 NOK' s off the shelf rubber materials

kind	application and characteristic	50(durometer A)	60(durometer A)	70(durometer A)	80(durometer A)	90(durometer A)
nitrile rubber (NBR)	universal	A162	A402	A305 Class 1A	A403	A105
	for fuel		A179	A122 Class 2 A908 equivalent to Class 2		A147
	for LPG			A746		
	for low temperature		A627	A626	A980	A377
	for food hygiene			A368	A168	
butyl rubber(IIR)	universal			B383(75)		
styrenebutadienerubber(SBR)	universal			R189 Class 3		
silicon rubber (VMQ)	universal	S796		S503 Class 4 C S811 equivalent to Class 4 C		
	for hydrolytic decomposition		S532	S740		
	for high intensity			S682		
	for UL		S681	S820		
	for waterproofing	S208(with oil)				
fluorosiliconerubber(FVMQ)	universal			S924		
ethylene-propylene rubber(EPDM)	for low μ	E270	S386	E931		
	for brake fluid		E622	E116 Class 5	E340	E619
	for water	E270	E616	E116 Class 5 E700, E575	E340	
	for R134a			E116 Class 5	E340	
hydrogenated nitrile rubber (HNBR)	universal			G607H*	G361	G506
	for R134a		G636	G861(75)	G859	
	for low temperature			G294		G115(85)
	for water and glycol					G124
	for high pressure					G588(95)
acrylic rubber (ACM)	universal			T767 Class 4 E		T183
	for low temperature and CS			T667		
fluoro rubber (FKM)	universal and for CS	F195	T134	F201 Class 4 D	F204	F940
	for wear		F320	F274(75)	F753	F357
	for additive			FP13	FP33	
	for low temperature				FL68	
	for leakage			F440		
chloroprene rubber(CR)	universal			M352		

( ) : Hardness in brackets are Shore Hardness A values. ※ H : NOK material symbol for HNBR.

Table 4-3 Material kinds of NOK's colored O-ring

Kinds of rubber	Reference (SAE ARP 1832 material color)
hydrogenated nitrile rubber(HNBR)	Green
fluororubber(FKM)	Brown
ethylene-propylene rubber(EPDM)	Purple
chloroprene rubber(CR)	Red
silicon rubber(VMQ)	red brown
fluorosilicone rubber(FVMQ)	cyan
nitril rubber(NBR)	No equivalent color
acrylic rubber(ACM)	No equivalent color