

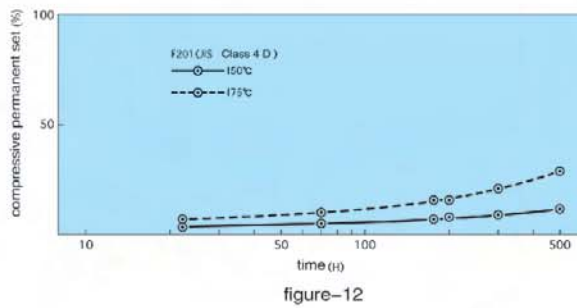
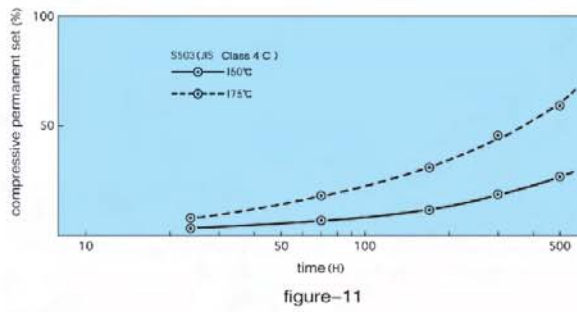
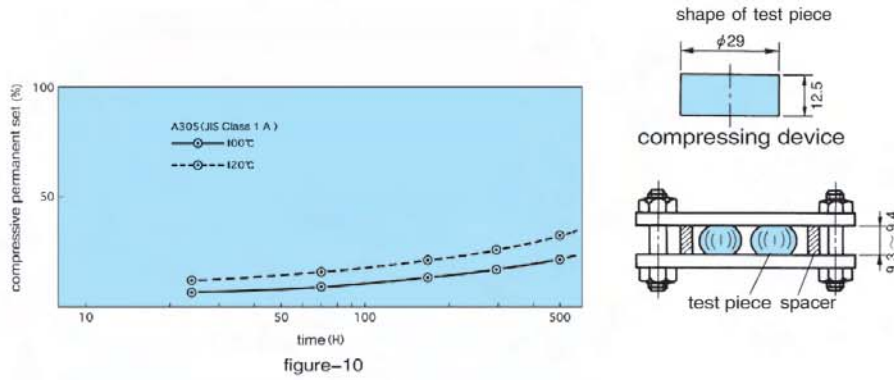
9. Reference

9-1. Compressive permanent set of NOK O – ring materials

Compressive permanent set is significant to O – rings' file time.

The following shows the characteristic of some representative materials for compressive permanent set.

Test method, JIS K 6262, environment medium: air



2-2 Sliding resistance of NOK O – ring

In dynamic sealing, sliding resistance is significant to performance of machine.

It difficult to express the sliding resistance of O – rings, as it is affected by many factors, such as compression allowance, surface machining precision of rod or cylinder, pressure, sliding speed, lubricating condition, temperature, hardness, and diameter dimension.

Figure – 13 shows the kinematic friction target value of standard O – ring in dynamic sealing (durometer A70).

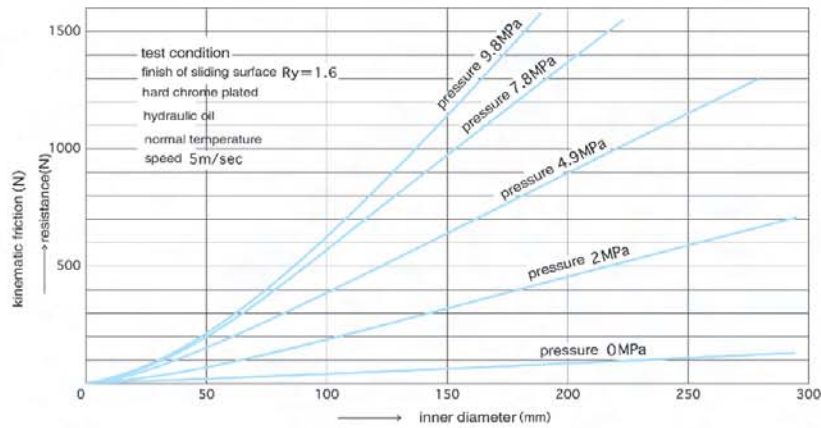


Figure-13 kinematic friction of O-ring

Figure – 13 kinematic friction of O – ring

Figure – 13 kinematic friction of O – ring

Note that the sliding resistance includes starting friction and kenematic friction, and the starting friction is 3 times larger than kenematic friction.

Lubrication of O – ring in dynamic sealing is significant to it's life time, especial for air sealing, adequate oil must be applied.

Pneumatic dynamic sealing O – rings

(1) friction characteristic

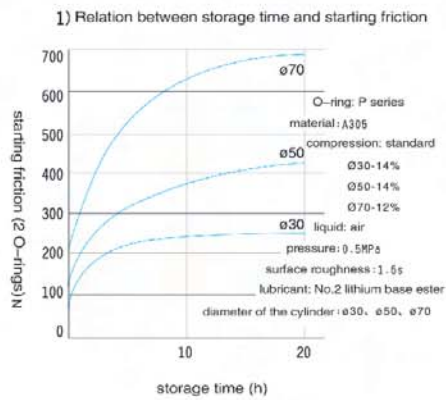


figure – 14

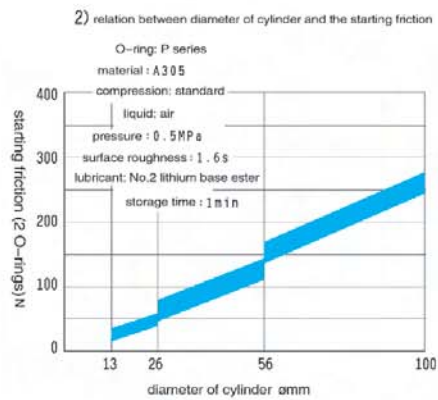


figure – 15

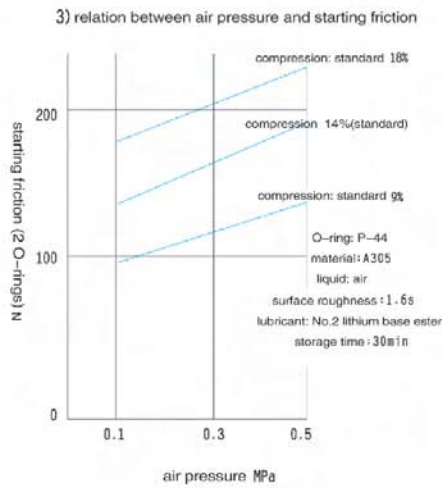


figure – 16

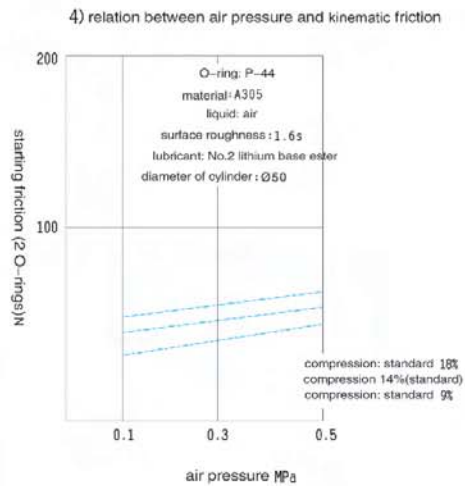


figure – 17

(2) life time test

Eg 1 life time test with transverse load

- ① O-ring used
- Piston seal, P-44 (NOK A305), 2pcs
 - rod seal P-18 (NOK A305) + LBHø18
 - compression P-44 14%, P-18 17%
- ② test condition
- Liquid: air (no oil injected)
 - Pressure, 05Mpa
 - Speed—0.3m/s
 - Stroke—300mm
 - Circulation—30C. P. M
 - temperature: normal temperature
 - diameter of cylinder— $\phi 50$
 - diameter of rod— $\phi 18$
 - transverse load, 7kg (1/20 of rated output)
 - lubricant, No. 2 lithium base ester
- ③ result
- No leakage after work of 400km, but a little wear.

Eg 2 life time test with high temperature, short stroke

- ① O-ring used
- Piston seal, P-44 (NOK A305), 2pcs
 - compression P-44 14%
 - rod seal, U packing + LBHø20
- ② test condition
- Liquid: air (no oil injected)
 - Pressure, 05Mpa
 - Speed—0.18m/s
 - Stroke—35mm
 - Circulation—150C. P. M
 - temperature— $70 \pm 5^{\circ}\text{C}$
 - diameter of cylinder— $\phi 50$
 - diameter of rod— $\phi 20$
 - transverse load, 7kg (1/20 of rated output)
 - lubricant, No. 2 lithium base ester
- ③ result
- No leakage after work of 400km, but a little wear.

Eg 3 life time test with vertical load

- ① O-ring used
- Piston seal, P-34 (NOK A305), 2pcs
 - compression P-34 14%
 - rod seal, U packing + LBH $\phi 16$
- ② test condition
- Liquid: air (no oil injected)
 - Pressure, 05Mpa
 - Speed—0.27m/s
 - Stroke—270mm
 - Circulation—30C. P. M
 - temperature: normal temperature
 - diameter of cylinder— $\phi 40$
 - diameter of rod— $\phi 16$
 - vertical load—10kg
 - lubricant, No. 2 lithium base ester
- ③ result
- No leakage after work of 450km, but a little wear.

10. Sealing KLUEBER lubricant

10-1. About NOK KLUEBER company

NOK KLUEBER company is a joint venture of NOK, one of the top 3 companies in sealing engineering industry, and KLUEBER LUBRICATION company, a Germany company which has specialized in special lubrication for 100 years.

NOK KLUEBER company inherited the advanced technique of both companies, and devel-

oped many practical products.

NOK KLUEBER company has now accumulated great lubrication technique, specially for critical conditions, such as high temperature, low temperature, high speed and high load, and has equipped manufacturing system.

A. Kinds of NOK KLUEBER lubricant

1. Common lubrication parts
Rolling bearing, sliding bearing, chain, gear, and all kinds of valves.
2. special lubricant
Lubricant for oxygen, vacuum, sliding surface(guiding rails), food machine and textile machine.
3. other lubricant
Silicone oil lubricant, solid lubricant, special releasing agent, anti-rust agent and sealing lubricant.

B. Characteristic of NOK KLUEBER lubricant

1. extreme high and low temperature.
Liquid lubricant, $-70 \sim 280^{\circ}\text{C}$, dry film lubricant: 1200°C
2. high speed
Dm · N value, 1,500,000
3. high load
Load ability is 2-4 time larger than universal lithium base ester.
4. long life time
Real record life time is 12,000 hours in 200°C .
5. environment factor resistance
It has special resistance to water, steam, ocean water, acid, alkali and other many chemical.
6. influence to material structure
It has no harm to rubber, plastic and paint.

Please refer to lubricant sample Cat. 904 for details.

10-2. Oil seal LKUEBER lubricant

Oil seal LKUEBER lubricant list

application	lubricant	influence to rubber				working temperature	cone penetration (NLGI)	application example	characteristic
		nitrile rubber	Acrylic rubber	silicon rubber	Fluorocarbon rubber				
All - purpose	SEALUBS1	○	○	○	○	-30 ~ 120	2	vehicle, construction and agriculture machines	rubber universal lubricant
water resistance	SEALUBS-8	○	○	×	○	-45 ~ 160	3	vehicle, houseware and appliance	water and steam resistance
low temperature and high speed	SEALUBS-14	○	○	○	○	-50 ~ 150	2	vehicle, household electrical devices, and production machines	widely used from low temperature to high temperature
food machines	KÜbersynth UHT 64-2403	○	○	○	○	-10 ~ 140	3	stirrer, chemical devices, vacuum devices	NSF H1* approved, water and steam resistance
	PARALIQU TE703	○	○	×	○	-50 ~ 150	3		
high temperature, solvent and chemical resistance	BARRIERAL55/2H1	○	○	○	○	-30 ~ 260	2	vehicle, chemical devices, and vacuum devices	great heat, solvent and chemical resistance

Note (1): influence to rubber

○ : resistant

× : non - resistant

※ NSF H1 lubricant

In inevitable case, applicable lubricant to be used in some portion where contact with foodstuffs.

[The influence to rubber is assessed based on average value, please confirm if the lubricant is applicable in real application.]

Appendix

tolerance of Shaft and dimension

unit: 0.001mm

classification of nominal dimension	5		6		7		8							9							10		11								
	IT	h5	IT	h6	IT	h7	IT	s7	f7	m7	k7	IT	h8	e8	IT	h9	e9	IT	h10	e10	IT	h11	e11								
	tolerance for upper dimension and lower dimension		tolerance for upper dimension and lower dimension		tolerance for upper dimension and lower dimension		tolerance for upper dimension and lower dimension							tolerance for upper dimension and lower dimension							tolerance for upper dimension and lower dimension		tolerance for upper dimension and lower dimension								
> 1	4	+6 +4	0	+10 +12	+10 +8	+6 +4	0	-2 -6	10	+24 +21	+18 +15	-	-4 -7	0	-3 -6	-14	14	0	-6 -14	-20	25	0	-14 -20	-60 -140	0	0	-20 -60	-140	40	0	60 -80
3	5	+9 +6	+4 0	+23 +20	+16 +12	+9 +7	0	-4 -10	12	+31 +27	+24 +20	-	+9 0	-4 -10	-20	30	0	-20 -30	-30	30	0	-20 -30	-70 -140	48	0	75 -75	-48	0	75 -75		
6	6	+12 +7	+4 0	+28 +24	+19 +15	+10 +7	0	-5 -13	15	+38 +34	+30 +25	+21 +16	+10 +5	-5 -13	-25	40	0	-13 -25	-40	36	0	-25 -40	-80 -150	58	0	90 -90	-58	0	90 -90		
10	8	+15 +9	+5 0	+34 +29	+23 +18	+13 +8	0	-6 -16	18	+46 +41	+36 +30	+25 +19	+12 +8	-6 -16	-32	40	0	-16 -32	-40	43	0	-16 -32	-50 -100	70	0	110 -110	-70	0	110 -110		
14	10	+17 +11	+5 0	+41 +35	+29 +21	+15 +9	0	-7 -20	21	+56 +49	+43 +36	+29 +23	+13 +8	-7 -20	-40	33	0	-20 -40	-65	52	0	-20 -40	-100 -160	84	0	130 -130	-84	0	130 -130		
20	14	+20 +13	+6 0	+50 +42	+33 +25	+18 +11	0	-9 -25	25	+68 +58	+45 +35	+30 +25	+15 +10	-9 -25	-50	39	0	-25 -50	-80	62	0	-25 -50	-120 -180	100	0	160 -160	-100	0	160 -160		
40	20	+24 +15	+6 0	+60 +51	+43 +30	+24 +12	0	-10 -30	30	+83 +71	+60 +41	+40 +22	+18 +12	-10 -30	-60	46	0	-30 -60	-100	74	0	-30 -60	-140 -200	120	0	190 -190	-120	0	190 -190		
65	28	+28 +16	+6 0	+70 +59	+45 +35	+25 +13	0	-12 -36	36	+106 +96	+72 +58	+48 +36	+20 +18	-12 -36	-72	54	0	-36 -72	-120	87	0	-36 -72	-160 -220	140	0	220 -220	-140	0	220 -220		
100	40	+33 +21	+7 0	+80 +68	+52 +40	+28 +14	0	-14 -43	40	+132 +105	+83 +67	+55 +43	+22 +15	-14 -43	-85	63	0	-43 -85	-145	100	0	-43 -85	-180 -250	160	0	260 -260	-160	0	260 -260		
140	50	+37 +24	+7 0	+86 +73	+57 +46	+33 +16	0	-15 -46	46	+148 +122	+96 +77	+63 +50	+25 +20	-15 -46	-100	72	0	-46 -100	-170	115	0	-46 -100	-200 -280	180	0	280 -280	-180	0	280 -280		
180	60	+43 +27	+7 0	+94 +81	+65 +52	+36 +16	0	-17 -50	50	+166 +146	+108 +86	+72 +56	+26 +20	-17 -50	-110	81	0	-50 -110	-190	130	0	-50 -110	-220 -300	210	0	300 -300	-210	0	300 -300		
200	70	+46 +29	+7 0	+103 +90	+73 +61	+40 +29	0	-18 -54	54	+184 +166	+126 +108	+81 +61	+29 +21	-18 -54	-120	89	0	-54 -120	-210	140	0	-54 -120	-240 -320	230	0	320 -320	-230	0	320 -320		
250	80	+50 +32	+7 0	+112 +100	+80 +68	+45 +33	0	-20 -58	58	+202 +186	+144 +126	+96 +78	+31 +21	-20 -58	-135	97	0	-58 -135	-240	155	0	-58 -135	-280 -360	250	0	360 -360	-250	0	360 -360		
400	100	+55 +35	+7 0	+122 +110	+90 +80	+50 +40	0	-22 -64	64	+232 +218	+174 +156	+114 +96	+40 +32	-22 -64	-165	108	0	-64 -165	-280	170	0	-64 -165	-320 -400	280	0	400 -400	-280	0	400 -400		

SI unit exchange table (unit in bold lined frame is SI unit)

force	N	dyn	kgf
	1	1×10^5	1.01972×10^{-1}
	1×10^{-5}	1	1.01972×10^{-6}
	9.80665	9.80665×10^5	1

viscosity	Pa · s	cP	P
	1	1×10^3	1×10
	1×10^{-3}	1	1×10^{-2}
	1×10^{-1}	1×10^2	1

note 1P = 1 dyn · s/cm² = 1g/cm · s
1Pa · s = 1N · s/m², 1cP = 1mPa · s

pressure	Pa	kPa	Mpa	bar	kgf/cm ²	atm	mmH ₂ O	mmHg or Torr
	1	1×10^{-3}	1×10^{-6}	1×10^{-5}	1.01972×10^{-5}	9.86923×10^{-6}	1.01972×10^{-1}	7.50062×10^{-3}
	1×10^3	1	1×10^{-3}	1×10^{-2}	1.01972×10^{-2}	9.86923×10^{-3}	1.01972×10^2	7.50062
	1×10^6	1×10^3	1	1x10	1.01972×10	9.86923	1.01972×10^5	7.50062×10^3
	1×10^5	1×10^2	1×10^{-1}	1	1.01972	9.86923×10^{-1}	1.01972×10^4	7.50062×10^2
	9.80665×10^4	9.80665×10	9.80665×10^{-2}	9.80665×10^{-1}	1	9.67841×10^{-1}	1×10^4	7.35559×10^2
	1.01325×10^5	1.01325×10^2	1.01325×10^{-1}	1.01325	1.03323	1	1.03323×10^4	7.60000×10^2
	9.80665	9.80665×10^{-3}	9.80665×10^{-6}	9.80665×10^{-5}	1×10^{-4}	9.67841×10^{-5}	1	7.35559×10^{-2}
	1.33322×10^2	1.33322×10^{-1}	1.33322×10^{-4}	1.33322×10^{-3}	1.35951×10^{-2}	1.31579×10^{-3}	1.35951×10	1

note 1Pa = 1N/m²

stress	Pa or N/m ²	MPa or N/mm ²	kgf/mm ²	kgf/cm ²
	1	1×10^{-6}	1.01972×10^{-7}	1.01972×10^{-5}
	1×10^6	1	1.01972×10^{-1}	1.01972×10
	9.80665×10^4	9.80665	1	1×10^2
	9.80665×10^4	9.80665×10^{-2}	1×10^{-2}	1

note 1Pa = 1N/m², 1MPa = 1N/mm²

dynamic viscosity	m ² /s	cSt	St
	1	1×10^6	1×10^4
	1×10^{-6}	1	1×10^{-2}
	1×10^{-4}	1×10^2	1

note 1St = 1cm²/s, 1cSt = 1mm²/s

power, energy, heat	J	kW · h	kgf · m	kcal
	1	2.77778×10^{-7}	1.01972×10^{-1}	2.38889×10^{-4}
	3.600×10^6	1	3.67098×10^5	8.6000×10^2
	9.80665	2.72407×10^{-6}	1	2.34270×10^{-3}
	4.18605×10^3	1.16279×10^{-3}	4.26858×10^2	1

note 1J = 1W · s, 1J = 1N · m
1cal = 4.18605J (according to regulations of measurement)

heat conductivity	w/(m · k)	kcal/(h · m · °C)
	1	8.6000×10^{-1}
	1.16279	1

note 1cal = 4.18605J (according to regulations of measurement)

power (power, horse power) heat volume	w	kgf · m/s	PS	kcal/h
	1	1.01972×10^{-1}	1.35962×10^{-3}	8.6000×10^{-1}
	9.80665	1	1.33333×10^{-2}	8.43371
	7.355×10^2	7.5×10	1	6.32529×10^2
1.16279	1.18572×10^{-1}	1.58095×10^{-3}	1	

note 1W = 1J/s, PS: french horse power
1PS = 0.7355kW (according to regulations of measurement)
Enforcement law)
1cal = 4.18605J (according to regulation of measurement)

heat conductivity factor	w/(m ² · k)	kcal/(h · m ² · °C)
	1	8.6000×10^{-1}
	1.16279	1

note 1cal = 4.18605J (according to regulations of measurement)

specific heat	J/(kg · k)	kcal/(kg · °C) cal/(g · °C)
	1	2.38889×10^{-4}
	4.18605×10^3	1

note 1cal = 4.18605J (according to regulations of measurement)