Koyo®

OIL SEALS & O-RINGS

JTEKT | JTEK

CAT. NO.R2001E-4

Koyo

Koyo Oil Seals: Fea res
Koyo O-Rings: Fea res
Koyo F nc ional Prod c s: Fea res
FEM (Fini e Elemen Me hod) Analysis

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Engineering Sec ion

Dimensional Tables

2. O-Rings
Engineering Sec ion

Dimensional Tables

3. Applica ion Examples
of Oil Seals and O-Rings

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Koyo Oil Seals: Fea res

1. Ligh weigh , compac , and energy-saving

Koyo oil seals offer high sealing performance, while being compact with reduced seal width. They help reduction of machine weight, size, and resource consumption

2. High sealing performance by op im m lip design

Koyo oil seals employ a linear-contact lip, which provides proper radial lip load. The lip design ensures excellent sealing performance, low torque, proper flexibility and high allowability for eccentricity.

3. Low hea genera ion and long service life by highly self-l brica ing r bber ma erials

Koyo O-Rings: Fea res

1. High sealing performance and reliabili y

High sealing performance against water, oil, air, various gases and chemicals.

2. Available in a f ll line p of designs and sizes

3. Easy handling

Vario s O-rings

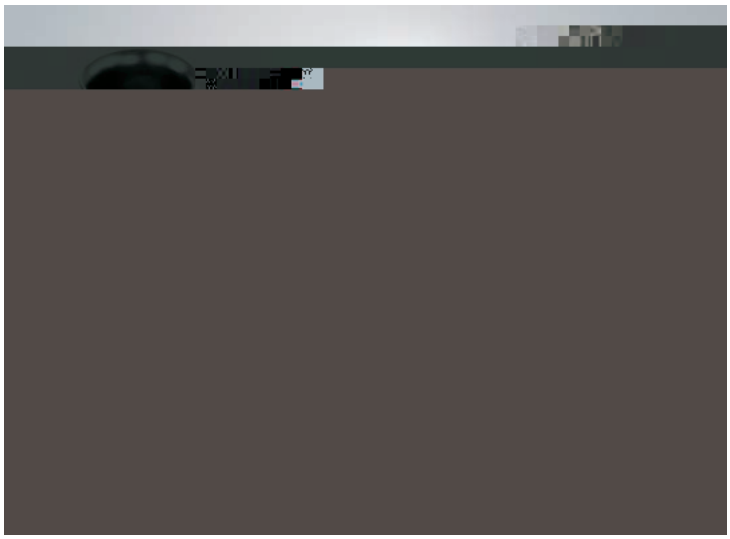
Koyo F nc ional Prod c s: Fea res

JTEKT produces various functional products based on advanced sealing technologies and sophisticated manufacturing expertise acquired through extensive research and development.

Koyo functional products are very helpful in improving machine performance, reducing weight, size, noise and vibration.

Consult JTEKT if there is no product in this catalog

2. F nc ional prod c s for mo orcycles



Vario s f nc ional prod c s

- Air cleaner joint
- Carburetor joint
- Muffler joints
- Plastic gear shafts
- Oil strainer
- Mesh gasket
- Ball-component clutch releases
- Vertical gaskets
- Chain tensioner
- Chain guide

FEM (Fini e Elemen Me hod) Analysis

JTEKT uses the non-linear finite element method to analyze non-linear materials such as rubber, for which accurate analysis was difficult before. The company has been studying sealing-mechanism theories by this method in order to develop new products.

The findings so far have been very useful for basic research as well as for rubber-component design.

The FEM is our common design tool today, enabling highly reliable analysis and evaluation, speeding up research and product development.

Press re deflec ion, s ress analysis

Under no load

1 Oil Seals

1.1

1.1 Nomencla re and f nc ions of seal

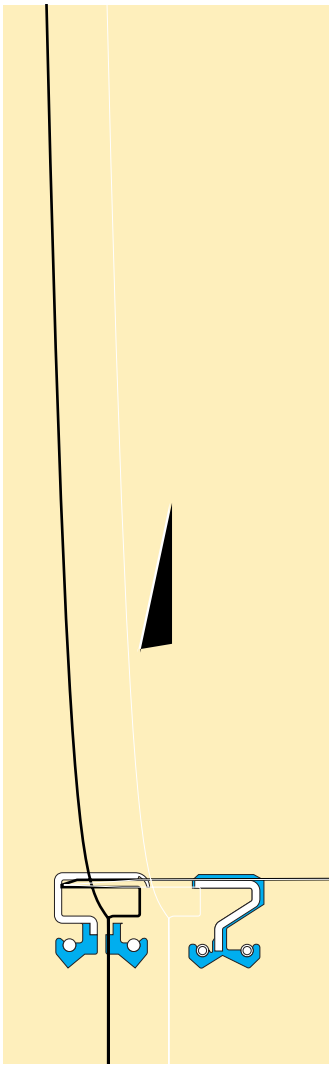
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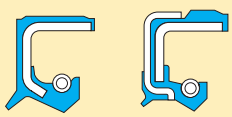
Oil seals work to prevent leakage of sealed objects

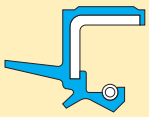
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1.3 Seal types













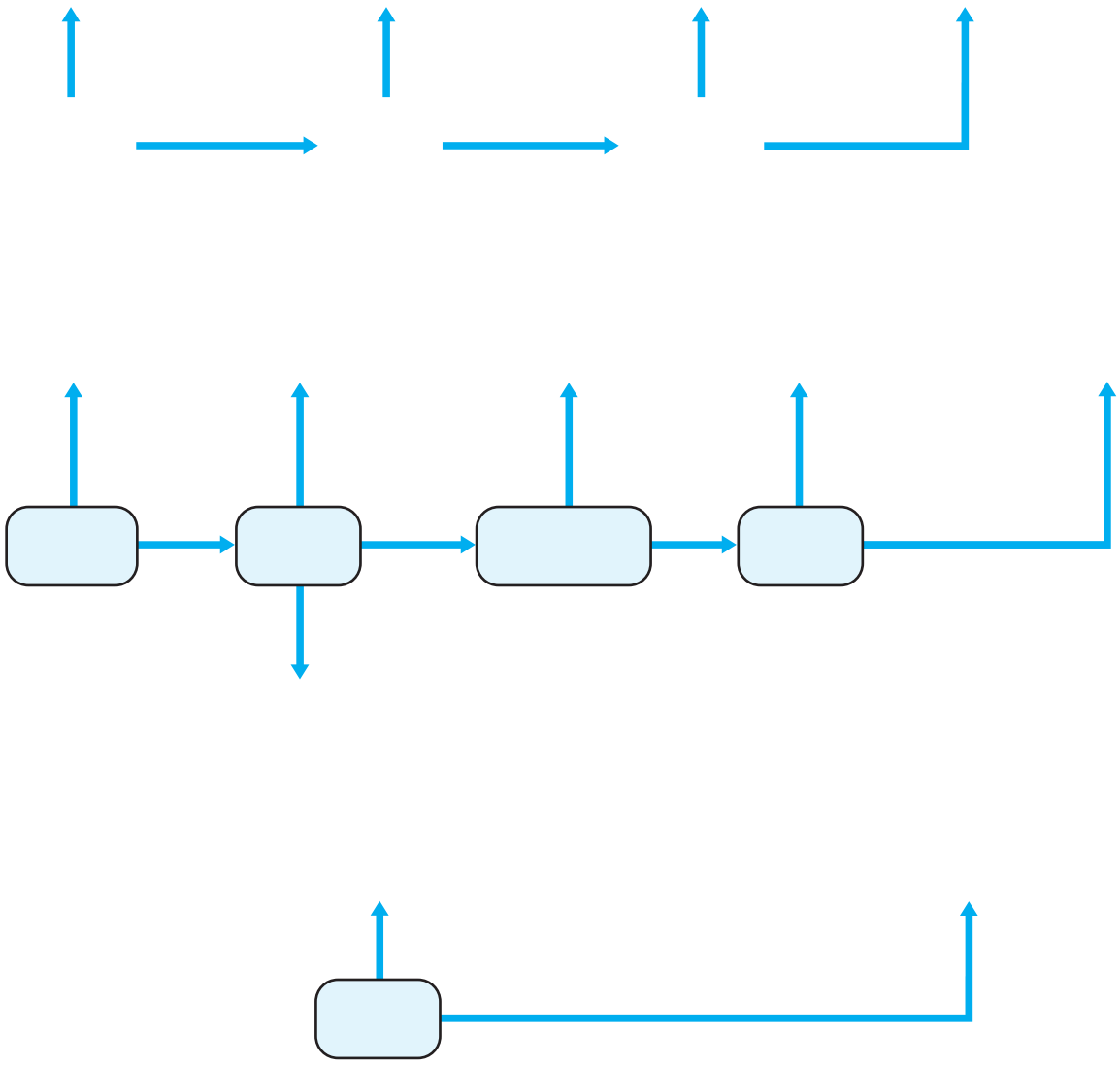
1.4 Selec ion of seal

(1) Selec ion of seal ype

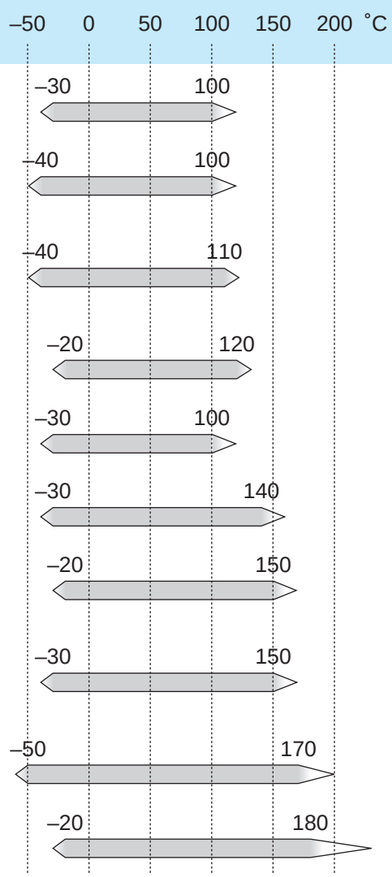
To select a seal type, seal O.D wall material, lip type, and whether a spring should be provided or not should be decided based on operational conditions as shown in flowcharts below.

If you need oil seals used under special conditions not covered in the flowcharts, refer to Section 1.3 Paragraph (2), "Special seal types and their features."

Table 1.4.1 Flowchar s for oil seal selec ion



Rubber material (ASTM[3] code)	Grade	Features	Operational temperature range [1)2)]
Nitrile rubber (NBR)	Standard type	Well-balanced rubber in resistance to high-, low- temperature, and to abrasion	–30 to 100
	Low-temperature resistant type	High resistant to both high- and low-temperatures and to abrasion	–40 to 100
	High- and low-temperature resistant type	Very strong and low strain. Superior in resistance to high- and low-temperature	–40 to 110
	Heat resistant type	Enhanced heat and abrasion resistance. Highly compatible with synthetic oil	–20 to 120
	For food processing machines	Nitrile rubber passed tests specified in the Food Sanitation Law	–30 to 100
Hydrogenated nitrile rubber (HNBR)	Standard type	Compared with nitrile rubber, superior in resistance to heat and to abrasion	–30 to 140
Acrylic rubber (ACM)	Standard type	High resistant to oil and to abrasion	–20 to 150
	High- and low-temperature resistant type	Improved low-temperature resistance. Low strain and same level heat resistance as standard type	–30 to 150
Silicone rubber (VMQ)	Standard type	Wide operational temperature range and good abrasion resistance	–50 to 170
Fluoro rubber (FKM)	Standard type	Most superior in heat resistance and good abrasion resistance	–20 to 180



When the new salesman asked the chief engineer how the elastic rubber is made, he got the reply: "After adding cross-linking chemicals to rubber polymers made from naphtha, high pressure is applied under high temperature. This creates a long-lasting elasticity. High stress conditions do wonders to things, even to humans."

Hearing this, the new salesman resolved to live like rubber, resilient and bouncing back into shape.

(3) Selec ion of me al case and spring ma erials

The materials of metal case and spring can be selected according to the substance to be sealed.

.4.4 Compa ibili y of me al-case and spring ma erials wi h s bs ance o be sealed

Material	Metal case		Spring	
Substance to be sealed	Cold rolled carbon steel sheet (JIS SPCC)	Stainless steel sheet (JIS SUS304)		Stainless steel wire (JIS SUS304)
Oil		–		–
Grease				
Water				
Seawater				
Water vapor				
Chemicals				
Organic solvent				

One customer called, "Some seals show oil leakage and some are OK. Please come and see immediately." A JTEKT service engineer visited the customer.

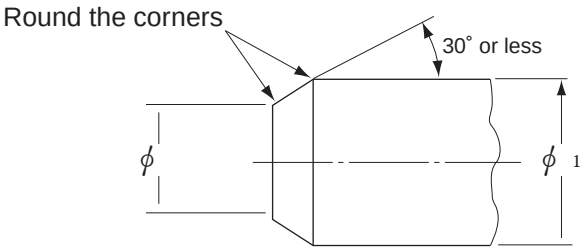
He checked shaft diameter and any damage, also visually checked the seals , but no possible cause of oil leakage was found.

He asked how the shaft surface was finished. It was paper lapped to get the desired level of surface roughness. He then checked the shaft surface and found that the leaking shaft had lead marks (spiral traces of lapping) running in the leaking direction. When he rotated the shaft in the reversing direction, no leakage occurred.

Showing a catalog, he advised the customer to finish shafts by plange cut grinding. Satisfied, he went back and felt it was a good day.

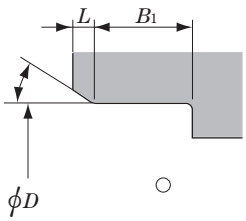
4) Shaft end chamfer

To protect seals from damage at mounting onto shafts, recommended chamfer on the shaft end is shown below.



3) Chamfer

Provide the chamfer at the housing bore inlet as shown below so that a seal can be mounted easily and avoided from damages.



(3) To al eccen rici y

When the total eccentricity is excessive, the sealing edge of the seal lip cannot accommodate shaft motions and leakage may occur.

Total eccentricity is the sum of shaft runout and the housing-bore eccentricity. It is normally expressed in TIR (Total Indicator Reading).

Shaft runout is defined as being twice the eccentricity between the shaft center and center of shaft-center rotation trajectory.

This is also normally expressed in TIR.

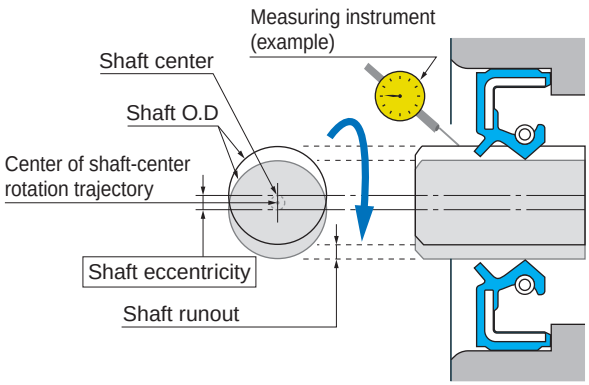
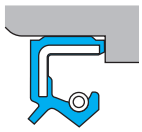
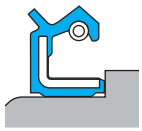


Fig. 1.5.5 Shaf r no

Housing bore eccentricity is defined as being the double of eccentricity between the housing-bore center and shaft rotation center. It is generally expressed in TIR (Total Indicator Reading).





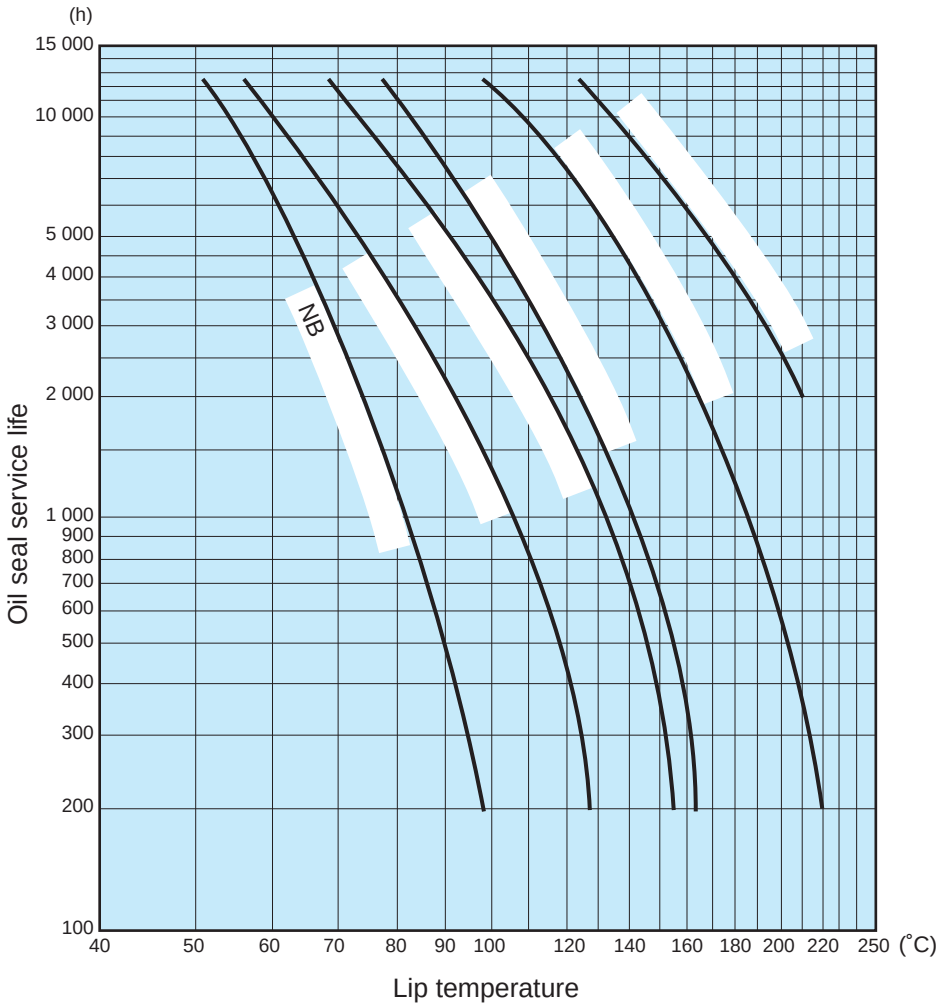
(2) Seal service life

The seal service life is defined as the time it takes to reach insufficient seal performance, which can be the result of wear on the lip rubber, chemical deterioration due to the use of oil or grease, or hardening.

It is not so easy to determine actual seal service life, because it is dependent on many factors, such as condition of operational temperature, eccentricity, rotational speed, substance to be sealed, and lubrication.

The diagram below (Fig. 1.6.3) shows the curves of estimated seal service life, obtained using major life-determining conditions as parameters, such as rubber material, lubricant, and lip temperature.

The service life shown in Fig. 1.6.3 is approximate, and the actual service life may be shorter depending on the operating conditions.



(3) Lip empera re

To determine the seal service life based on the above diagram, it is critical to estimate lip temperature precisely.

As the shaft rotates, the seal lip is heated due to friction. Lip temperature is dependent on the balance between the energy supplied by frictional heat and the radiated energy, which varies according to temperature difference and the construction surrounding the seal.

Many factors influence lip temperature, so it is difficult to determine this precisely.

The following is the procedure for estimation of lip temperature.

1.6 Seal charac eris ics

Lip empera re es ima ion me hod

① Calculate the peripheral speed at the sealing edge using the following equation

where,
: peripheral speed at the sealing edge, m/s
π: Ratio of circle circumference to diameter (3.14)
: Shaft diameter, mm
: Rotational speed, min^{-1}

② Determine the supposed ambient temperature
③ Find the point at which the ambient temperature curve meets the calculated shaft surface speed in Fig. 1.6.4
④ Read the ordinate value of the point
⑤ Obtain the estimated lip temperature by the sum of the ordinate value and ambient temperature

Example
Shaft diameter: ϕ50 mm
Rotational speed: 4 000 min^{-1}
Ambient temperature: 80 ˚C
Peripheral speed at the sealing edge can be obtained as follows;

$= \pi \times 50 \times 4\,000$ = 10.5 m/s

In Fig. 1.6.4, the cross of the curve for ambient temperature 80 ˚C and peripheral speed 10.5 m/s indicates that the lip temperature rise will be 20 ˚C.
Therefore, lip temperature is estimated 100 ˚C (80 + 20 = 100 ˚C).

(5) Allowable in ernal press re

Another factor that may deteriorate seal performance is internal pressure. The allowable internal pressure is also significantly dependent on runout of the shaft (sum of shaft runout and housing-bore eccentricity).

Fig.1.6.7 shows the example of allowable internal pressure actually measured with the oil seals attached to the shaft finished with the accuracy recommended in this catalogue and housing.

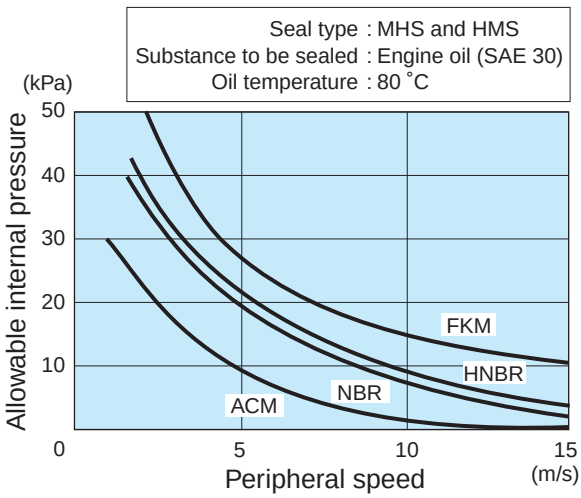


Fig. 1.6.7 Allowable in ernal press re for seal

Small talk 3

A precio s experience for a new salesman

"The oil seal melts down and oil leaks!"

Receiving an urgent phone call from a customer, a new salesman at JTEKT left the office immediately, believing that something critical had happened.

At the customer's site, the lip was abraded significantly and the rubber did look molten. The customer suspected that the material was the cause of the problem.

Browsing the catalog confusedly, he questioned the customer, remembering the sales-training lectures he had attended before. "How did you lubricate the seal before its initial use?"

Suspecting that insufficient initial lubrication might be the cause, he instructed the customer to coat grease around the lip and run the machine.

Two hours passed, and the seal still showed no leakage. An overhaul proved that the seal was in good condition, with negligible lip abrasion.

"I now thoroughly understand the importance of pre-lubrication," said the customer. It was a precious experience for the salesman as well.

(6) Seal orq e

The seal torque is determined by lip radial load, coefficient of friction, and shaft diameter, and can be calculated by the following equation:

$$T = \frac{1}{2 \times 1\,000} \quad R$$

where,

T : Seal torque, N · m
: Coefficient of friction at sealing edge (including oil viscosity)
: Shaft diameter, mm
R : Lip radial load, N

Lip radial load is determined by three factors: a component of stress caused by circumferential lip elongation that occurs when the seal is mounted on a shaft, a component stress caused by deflection at the lip base, and a component of spring load (Fig. 1.6.8).

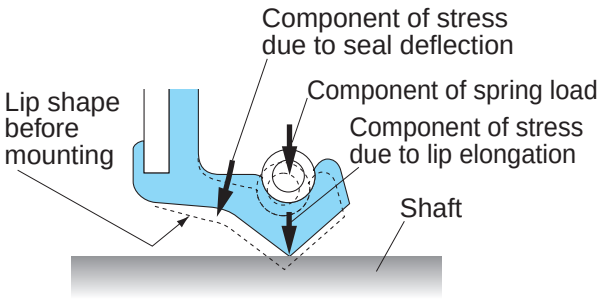


Fig. 1.6.8 Fac ors of lip radial load

The coefficient of friction at the sealing edge varies significantly depending on type of lubricants used and peripheral speed. To find rotational torques of oil seals, various operating conditions must be taken into consideration. For details, consult JTEKT.

1) Initial seal torque

Seal torque may be very high just after the seal mounting on a machine. However, it will become stable low torque within one or two hours (Fig. 1.6.9).

1.6 Seal charac eris ics

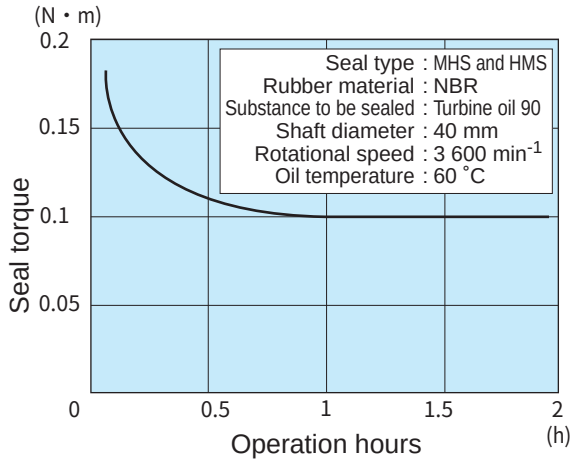


Fig. 1.6.9 Seal orq e change wi h passing ime (reference)

Initial high torque occurs because the coefficient of shaft-lip friction is unstable. As operation continues, the shaft and lip become running in each other, it stabilizes the friction coefficient and seal torque.

2) Factors for seal torque

Fig. 1.6.10 shows how rotational speed and lubricant influence seal torque. As this diagram shows, generally seal torque increases in proportion to shaft rotational speed increase. High viscosity lubricating oil also increases seal torque.

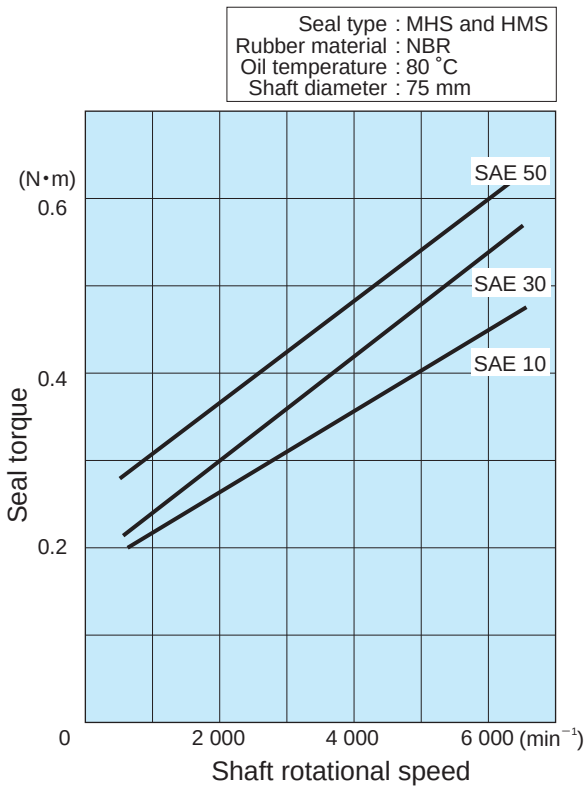
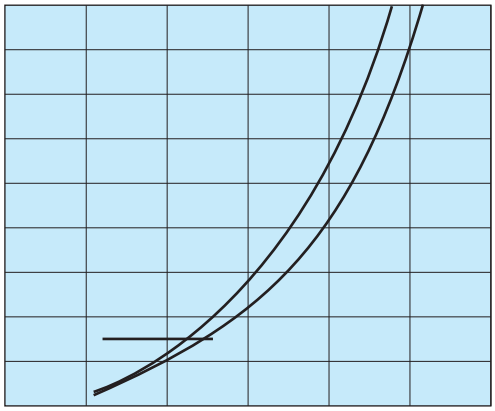


Fig. 1.6.10 Rela ion be ween ro a ional speed and seal orq e

Fig. 1.6.11 shows how shaft diameter influences seal torque. The larger shaft diameter, the higher the seal torque correspondingly.



1.7 Handling of seal

Carelessness in seal handling may cause oil leakage. Correct action should be taken for good inwards, storage, transportation, handling and mounting.

(1) S orage

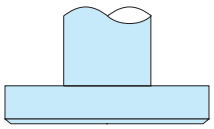
Follow the instructions below in the storing.

- Keep air-conditioned: Room temperature Max. 30 ˚C and humidity 40% to 70% on average. (See Fig. 1.7.1)
- Keep rule: Use older oil seals stored, first.
- Avoid: Direct/reflected of sunlight, ozone
- When storing oil seals in a worksite, keep them in sealed containers to protect them from dusts, sands, and other contaminations, as well as mechanical damages caused by various equipment or subjects dropped.
- Avoid storing oil seals in a stack or hung as such storage condition can lead to deformation of seal

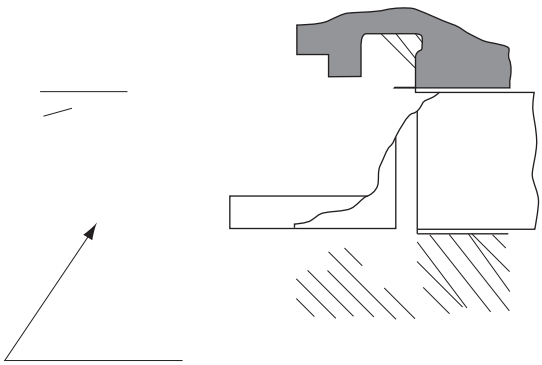
1.7 Handling of seal

6) When seal is pressed into housing bore, use pressing jig as shown in Fig. 1.7.4. When press-fitting an oil seal into the housing bore in the opposite direction, use the pressing jig as shown in Figs.1.7.5 and 1.7.6.

Jig for sho ldered ho sing bore



7) In case of shaft has spline, keyway, or holes, use seal protecting jig to prevent lip damage as illustrated bellow (Fig. 1.7.8).
If difficult to use jig, remove sharp corners, round the edges and coat enough grease.



1.7 Handling of seal

1.8 Ca ses of seal fail res and co n ermeas res

(1) Ca ses of seal fail res

To identify the causes of seal failure and take proper measures, it is critical to observe the seal lip closely and evaluate the failure in all respects, such as shaft surface roughness, contaminants and lubrication. Causes of major seal failure are listed below (Table 1.8.1).

Table 1.8.1 Ca ses of seal fail res

Factor				
1st	2nd	3rd	4th	5th
Leakage from seal	From lip	Damages on lip	Burrs on shaft chamfer	
			Spline, keyway on shaft	
			Entry of foreign materials	
			Wrong handling	
		Lip turned backward	Small shaft chamfer	
			Center off set at mount	
			Excessive inside pressure	
		Missing spring	Small shaft chamfer	
			Center off set at mount	
			Caused by Stick slip*	
		Lip hardened	High oil temperature	
			Poor lubrication	
			Excessive inside pressure	
		Lip softened	Improper rubber	
			Long time dip in cleaner, solvent	
		Heavy wear on shaft	Entry of foreign materials	
			Chemical wear	Depends on oil components
			Poor lubrication	
			Caused by Stick slip*	
		Heavy wear on lip	Poor lubrication	
			Excessive internal pressure	
			Rough shaft surface finish	
			Entry of foreign materials	
		Uneven wear on lip	Excessive eccentricity at mount	
			Inclined seal mounting	
		Rough face, Steaks on lip	Entry of foreign materials	
			Poor lubrication	
		Tear at seal heel bottom	Wrong handling	
			Reaction by impact pressure	
			Excessive inside pressure	
		Lip deformation (small interference)	High oil temperature	
		Lip face contact	Excessive inside pressure	
			Minus pressure between lips	
			Big shaft runout	
			Larger shaft diameter	
		Lip tear	Caused by Stick slip*	Poor lubrication
				Improper rubber
			Reaction by impact pressure	
		Blisters on lip	Deterioration of lubrication (directly under lip)	
			Mirror finish on shaft surface	
			Higher peripheral speed	
			Higher radial lip load	
		No abnormality on seal	Smaller shaft diameter	Small interference
			Improper shaft roughness	
			Damages on shaft	Big shaft runout
			Lead machining on shaft	Big eccentricity
			Poor lip followability	Small interference
				Lip high rigidity
				Poor low temperature resistance
			Wrong direction of seal mounting	
			Adhesion of foreign particles at mounting	
	From fitting area	Peeling, Scuffing, Damages, Deformation, Inclined mounting on seal	Smaller housing bore diameter	Large interference
			Small housing bore chamfer	
			Rough housing bore surface finish	
			Improper mounting tool	
		Oil seal fall-out	Larger housing bore	
			Smaller oil seal O.D	
			Improper oil seal press-fit position	
		No abnormality on seal	Larger housing bore	Small interference
			Smaller seal O.D	Small interference
			Rough housing bore surface finish	
			Damages or blowholes on housing bore	
			Wrong direction of seal mounting	

✻ Stick slip:
A friction related phenomena in which the sealing element tends to adhere and rotate with the shaft surface momentarily until the elastic characteristics of the sealing element overcome the adhesive force,causing the seal lip to lose contact with the rotating shaft long enough to allow leakage.
This cycle repeats itself continuously and is normally associated with non-lubricated and boundary-lubricated conditions.

Symptom	Phenomenon	Causes	Countermeasures
Damages on sealing edge	Visible damage on lip edge	1) Sharp edge or burrs on shaft chamfer 2) Shaft spline or keyway	

Table 8.2 Causes of seal failures and countermeasures (2)

Oil leakage from lip (2)

Symptom	Phenomenon	Causes	Countermeasures
Heavy wear on lip	Rough face and streaks	1) Poor lubrication 2) Rough shaft surface finish 3) Entry of foreign materials	• Take pre-lubrication on lip • Improve lubrication • Improve shaft surface finish (See page 19.) • Attach prevention device for foreign materials
	Hardening, Cracks	Excess heat generation due to 1) Poor lubrication 2) Running under conditions beyond specifications a) Excess peripheral speed b) Excessive inside pressure	• Improve lubrication • Examine cause of heat source • Change rubber to heat proof rubber (See Table 1.4.2 on page 16.) • Apply high pressure proof seal or breather (vent)
	Double-faced wear	• Excessive inside pressure	• Apply high pressure proof seal or breather (vent)
Lip uneven wear	Wear track width is uneven. Max. wear positions of main lip and minor lip are same.	1) Center offset between shaft and housing 2) Inclination of shaft	• Examine misalignment for sha… housing (Take countermeasure t… offset)
	Uneven wear		
	Wear track width is uneven. Max. and Min. wear areas are located 180° apart. (Main and minor lips show opposite pattern.)	Inclined seal was mounted into housing 1) Improper housing bore diameter 2) Improper housing bor… chamfer 3) Improper housi… corner radius 4) Improper	• C…
	Rough face and streaks on sealing edge	1) F… 2…	

Table 1.8.2 Ca ses of seal fail res and co n ermeas res (3)

Oil leakage from lip (3)

Symptom	Phenomenon	Causes	Countermeasures
Tear at seal heel bottom		1) Improper handling 2) Excessive inside pressure 3) Reaction by impact pressure	• Improve handling manner (Consult JTEKT.) • Apply high pressure proof seal or breather (vent) • Prevention of impact pressure by design change of machine structure
Lip deformation	Reduction of tightening interference due to rubber hardened	• Oil temperature rose up during operation	• Change rubber to high temperature proof rubber (See Table 1.4.2 on page 16.) • Examination of and countermeasure against the cause of temperature increase are required.
Lip face contact	Whole lip face shows sliding contact pattern	1) Excessive inside pressure happened 2) Minus pressure happened between lips 3) Big shaft runout 4) Larger shaft diameter	• Prevent excess pressure (change of machine structure) • Give clearance for minor lip • Improve shaft accuracy • Correct shaft diameter
Blister		• Increased agglomeration of high-temperature oil that entered the sliding surface a) Deterioration of lubrication (directly under lip) b) Mirror finish on shaft surface c) Higher peripheral speed d) Higher radial lip load	• Improve lip lubrication • Correct shaft surface finish to (0.1-0.32) µmRa and (0.8-2.5) µmRz • Reduce radial lip load of oil seal
–	No abnormality on seal but oil leakage is observed	1) Smaller shaft diameter 2) Improper shaft roughness 3) Damages on shaft 4) Lead machining on shaft 5) Poor lip followability a) Big shaft runout b) Big housing-bore eccentricity c) Small interference d) Lip high rigidity e) Poor low temperature resistance 6) Wrong direction of seal mounting	

Table 1.8.2 Ca ses of seal fail res and co n ermeas res (4)

Oil leakage from seal fi ing area (1)

Symptom	Phenomenon	Causes	Countermeasures
Peeling, scuffing on O.D wall		1) Smaller housing bore 2) In adequate housing bore chamfer 3) Rough housing bore surface finish 4) Centering offset between housing and seal mounting	• Correct housing bore diameter (See Table 1.5.2 on page 19.) • Correct housing bore chamfer (See Fig. 1.5.3 on page 20.) • Optimize the housing bore roughness • Improve mounting tool and handling manner (See Figs. 1.7.3 to 1.7.5 on page 27 to 28.)
Damages on O.D wall		1) Burrs on housing bore 2) Damages, or blowholes on housing bore	• Remove burrs, chips • Repair housing bore to eliminate damage, blowhole
Deformation		1) Smaller housing bore 2) Small housing bore chamfer 3) Improper seal mounting tool	• Correct housing bore diameter (See Table 1.5.2 on page 19.) • Correct housing bore chamfer (See Fig. 1.5.3 on page 20.) • Improve mounting tool (Consult JTEKT.)
Seal inclined mounting	Uneven fitting marks on seal O.D face	1) Smaller housing bore 2) Small housing bore chamfer 3) Poor parallel accuracy between mounting tool and housing	• Correct housing bore diameter (See Table 1.5.2 on page 19.) • Correct housing bore chamfer (See Fig. 1.5.3 on page 20.) • Improve mounting tool (Consult JTEKT.)
Oil seal fall-out		1) Larger housing bore 2) Smaller oil seal O.D 3) Improper oil seal press-fit position 4) Deformation of housing	• Use appropriate housing bore diameter (See Table 1.5.2 on page 19.) • Optimize the oil seal outer dimensions • Improve the outer circumference design (metal O.D wall, HR seal) • Correct the oil seal press-fit position (Consult JTEKT.) • Improve the rigidity of housing

	Type	Page
Standard type seals	Metal O.D wall seals 1 7~540	38
	Rubber O.D wall seals 1 6~300	
	YS type seals 1 220~1 640	56
	Assembled seals 1 41~440	72
Special seals	Full rubber seals d1 10~3 530	78
	MORGOIL seals Seal inner rings 1 167~1 593	84
	Scale seals Scale covers 195~1 595	86
	Water seals 1 219.2~1 460	90
	V-rings 38~875	92



HM HMA HMS HMSA
MH MHA MHS MHSA

S andard ypes

d_1 (16)~20

HM HMA HMS HMSA
MH MHA MHS MHSA

Koyo

d_1 (16)~(19)

Metal O.D wall	Rubber O.D wall



Boundary dimensions, mm			HM				HMA				HMS				HMSA				MH				MHA				MHS				MHSA			
1	D	.	N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F

S andard ypes

d_1 21~(28)

HM HMA HMS HMSA
MH MHA MHS MHSA

Koyo

d_1

Boundary dimensions, mm	HM				HMA				HMS				HMSA				MH				MHA				MHS				MHSA			
	N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F

S andard ypes

d_1 (28)~(35)

HM HMA HMS HMSA
MH MHA MHS MHSA

Koyo

d_1 (28)~(30)

Metal O.D wall	Rubber O.D wall

Boundary dimensions, mm		HM				HMA				HMS				HMSA				MH				MHA				MHS				MHSA			
		N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F

S andard ypes

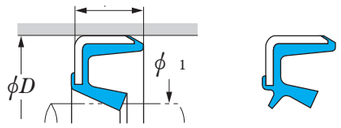
d_1 (35)~(50)

HM HMA HMS HMSA
MH MHA MHS MHSA

Koyo

d_1 (35)~(40)

Metal O.D wall	Rubber O.D wall



Boundary dimensions, mm			HM				HMA				HMS				HMSA				MH				MHA				MHS				MHSA			
1	D	.	N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F

S andard ypes

d_1 (50)~(70)

S andard ypes

d_1 (70)~(130)

HM HMA HMS HMSA
MH MHA MHS MHSA

Koyo

d_1 (70)~88

Metal O.D wall	Rubber O.D wall



Boundary dimensions, mm			HM				HMA				HMS				HMSA				MH				MHA				MHS				MHSA			
1	D	.	N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F

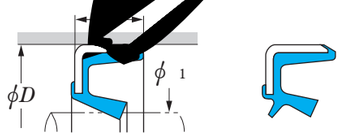
S andard ypes HMSA MHSA

d_1 (130)~(280)

Remarks
1) For seals marked , JT production.
2) The cross-sectional vi e oil seal shape.
3) Seal number is cons type code and dimensional numbers (bore diameter, outside diameter and width).
Example: HMSA55
4) Rubber code N re , A: acrylic rubber, S: silicone rubber, and F: fluoro rubber.
5) Consult JTEKT s nation on inventory, delivery, and production lots.

d_1 (130)

	Metal O.D wall	Rubber O.D wall



Boundary dimensions, mm			HM				HMA				HMS				HMSA				MH				MHA				MHS				MHSA			
1	D	.	N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F	N	A	S	F

d_1 (190)~(280)

S andard ypes

d_1 (280)~670

YS ype
d_1 220~335

YS YSN YSA YSAN

Koyo

Remarks

1) For seals marked , JTEKT owns molding dies for production.
2) The cross-sectional view indicates a representative oil seal shape.
3) Seal number is constructed by combination of type code and dimensional numbers (bore diameter, outside diameter and width).
   Example: YS32036018 (320X360X18 mm).
4) Seal number marked have suffix -1.

Boundary dimensions, mm			YS			YSN					YSAN	
			N	F	K	N	F	K	N	F	N	F
220	255	16				●						
230	264	16				●						
240	275	16				●						
250	285	16				●						
255	315	25	●									
265	305	18	●			●						
270	330	25	●									
280	320	18	●			●						
	330	20	●									
	340	25	●			●						
290	330	18	●									
	340	20	●									
	350	25	●									
	350	28							●			
	340	18	●	●		●	●					
	340	20	●									
	340	25	●									
	345	20	●									
	345	22	●									
	350	20	●									
	350	25	●									
	350	29							●			
	360	25	●			●						
	360	28							●			
304	342.1	17.5	●									

YS ype

d_1 336.6~(400)

YS ype
d_1 463.6~550

YS YSN YSA YSAN

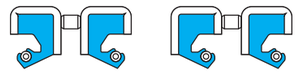
Example of seal number with spacer

(Various width spacers are available as like 10 mm.)

Example 1 **YS 320 360 18 D5** — Spacer width: 5 mm

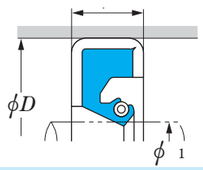


Example 2 **YS 320 360 18 2D5** — Spacer width: 5 mm



d_1 463.6~510

Seal type







◎

Boundary dimensions, mm			YS			YSN			YSA		YSAN	
1	D		N	F	K	N	F	K	N	F	N	F
	520	25								●		
	530	25	●							●		
	530	28								●		
480	520	20	●				●					
	530	20	●									
	530	22	●									
	530	25	●									
	540	25	●	●						●		
	540	28								●		
482.6	520.7	19	●	●								
490	530	20	●									
	540	25	●							●		
	550	25	●									
495.3	546.1	23.8	●									
500	540	20	●									
	550	20	●									
	550	25	●									
	560	25	●							●		
	560	28								●		
510	550	20	●									
	560	25	●	●			●					
	570	28								●		

d_1 514~550

Boundary dimensions, mm			YS			YSN			YSA		YSAN	
			N	F	K	N	F	K	N	F	N	F
	580	22	●									
	590	28										●
	600	25	●									
539.8	590.55	22	●									
540	580	20	●									
	580	25	●									
	590	20	●									
	590	25	●									
	600	25	●									●
	600	28										●
	610	25	●									
546.1	596.9	20.6	●									
	596.9	22.2	●									
550	590	20	●									
	600	20	●									
	600	25	●	●								
	610	23	●									
	610	25	●									
	610	28										●
	620	25	●	●								

YS ype

d_1 558~647.7

YS YSN YSA YSAN

Koyo

d_1 558~(600)

Boundary dimensions, mm			YS	YSN	YSAN
	630	20	●		
	630	25	●		
	640	25	●		
	640	28			●
	640	30			●
	650	25		●	
584.2	622.3	19	●		●
	635	25.4	●		
587	637	20	●		
590	630	20	●		
	640	20	●		
	640	25	●		
	650	28			●
600	640	19	●		

d_1 (600)~647.7

Boundary dimensions, mm			YS			YSN			YSA		YSAN		
635	N	F	K	N	F	K	N		N	F	239.52		
	680	25	●										
	680	28										●	
	690	25	●										
622.3	673.1	22.2	●										
630	670	20	●										
	670	25	●										
	680	25	●										
	690	25	●										
	690	30	●										
	700	30										●	
635	673.1	19.1	●										
	685	25	●										
	695	25	●										
640	680	20	●										
	690	25	●										
	700	25	●										
	700	28										●	
647.7	698.5	22.2	●										

YS ype

d_1 650~(810)

YS ype

d_1 (810)~(1 000)

YS YSN YSA YSAN

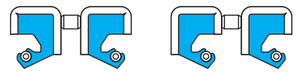
Example of seal number with spacer

(Various width spacers are available as like 10 mm.)

Example 1 **YS 320 360 18 D5** — Spacer width: 5 mm

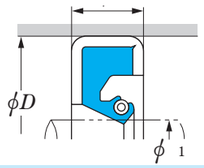


Example 2 **YS 320 360 18 2D5** — Spacer width: 5 mm



d_1 (810)~(889)

Seal type



Boundary dimensions, mm		YS			YSN			YSA		YSAN	
1	D	N	F	K	N	F	K	N	F	N	F

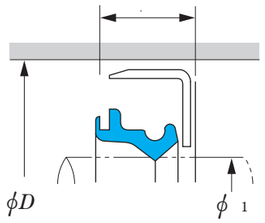
d_1 (889)~(1 000)

Assembled seals

d_1 41~440

HMSH

Seals with reinforcing inner metal ring



Assembled seals

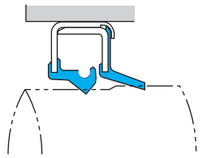
d_1 117~405

HMSH...J

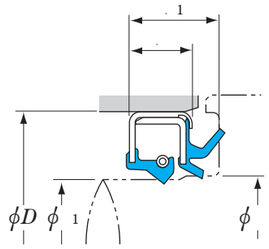
Seals with reinforcing inner metal ring



Design 1



Design 2



Design 3

Remarks 1) The cross-sectional view indicates a representative oil seal shape.
2) All seals use nitrile rubber.
3) Consult JTEKT for drain-provided seals.

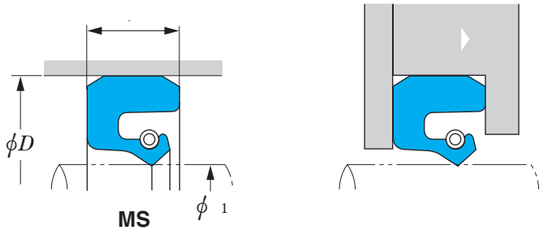
Boundary dimensions, mm

1	D	

F ll r bber seals

d_1 10~340

MS



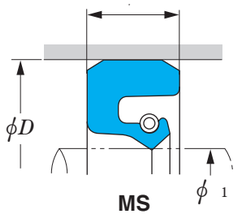
MS

Remarks
1) The cross-sectional view indicates a representative oil seal shape.
2) All seals use nitrile rubber.
3) Mounting width deviation should be as specified in the table below:

F ll r bber seals

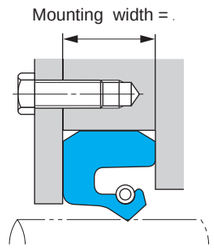
d_1 350~1 760

MS



MS

Mounting example



Remarks
1) The cross-sectional view indicates a representative oil seal shape.
2) All seals use nitrile rubber.
3) Mounting width deviation should be as specified in the table below:

Mounting width deviation (Unit : mm)

Mounting width = .	Deviation
— Up to 6	– 0.1 ~ – 0.2
Over 6 up to 10	– 0.1 ~ – 0.3
Over 10 up to 18	– 0.1 ~ – 0.4
Over 18 up to 30	– 0.1 ~ – 0.5

d_1 350~480

Boundary dimensions, mm			Seal No.
1	D	.	
350	390	25	MS 350 390 25
	400	20	MS 350 400 20
	400	21	MS 350 400 21
	400	25	MS 350 400 25
355	405	25	MS 355 405 25
360	404	20	MS 360 404 20
	405	25	MS 360 405 25
370	420	24	MS 370 420 24
	420	25	MS 370 420 25
	430	25	MS 370 430 25
380	420	20	MS 380 420 20
	428	20	MS 380 428 20
	430	25	MS 380 430 25
	440	25	MS 380 440 25
384	428	20	MS 384 428 20
390	435	25	MS 390 435 25
	450	25	MS 390 450 25
400	450	25	MS 400 450 25
410	460	25	MS 410 460 25
	470	25	MS 410 470 25
420	470	25	MS 420 470 25
	470	30	MS 420 470 30
	480	25	MS 420 480 25
430	480	25	MS 430 480 25
432	476	20	MS 432 476 20
440	490	25	MS 440 490 25
450	500	25	MS 450 500 25
457	508	21	MS 457 508 21
460	510	25	MS 460 510 25
	515	28	MS 460 515 28

d_1 490~610

Boundary dimensions, mm			Seal No.
1	D	.	
490	540	25	MS 490 540 25
495	545	25	MS 495 545 25
500	550	20	MS 500 550 20
	550	25	MS 500 550 25
	560	25	MS 500 560 25
	560	30	MS 500 560 30
510	560	25	MS 510 560 25

d_1 630~920

Boundary dimensions, mm			Seal No.
1	D	.	
630	680	25	MS 630 680 25
	680	30	MS 630 680 30
	700	30	MS 630 700 30
635	705	30	MS 635 705 30
650	700	30	MS 650 700 30
	705	19	MS 650 705 19
	710	30	MS 650 710 30

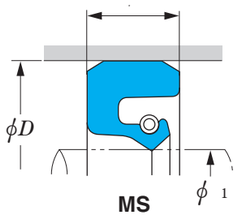
d_1 930~1 760

Boundary dimensions, mm			Seal No.
1	D	.	
930	1 000	30	MS 930 1000 30
950	1 010	30	MS 950 1010 30
960	1 020	25	MS 960 1020 25
1 000	1 050	30	MS 1000 1050 30
1 005	1 052	25	MS 1005 1052 25
1 030	1 080	30	MS 1030 1080 30

F ll r bber seals

d_1 1 880~3 530

MS



MS

◎

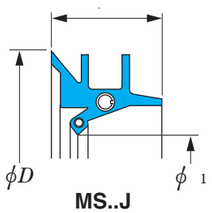
Remarks
1) The cross-sectional view indicates a representative oil seal shape.
2) All seals use nitrile rubber.
3) Mounting width deviation should be as specified in the table below:

MORGOIL seals

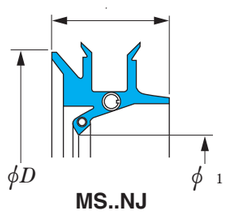
d_1 167~1 593

MS..J MS..NJ H..J H..JM H..PJ

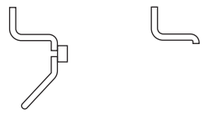
MORGOIL seals



MS..J



MS..NJ



Mounting example

Remarks 1) The cross-sectional view indicates a representative oil seal shape.
2) All seals use nitrile rubber.
Note 1) Special type code B represents "with a steel band" and W represents "with a wire."

Scale seals

d 195~1 595

Scale seals

d 280~1 193.8

WR...BJ

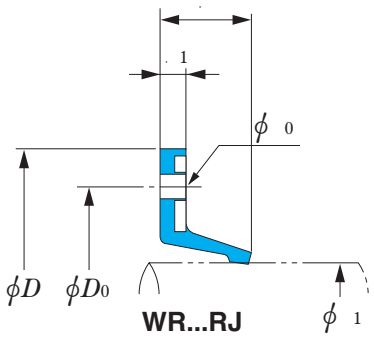
Remarks

Scale seals

d_1 210~1 203

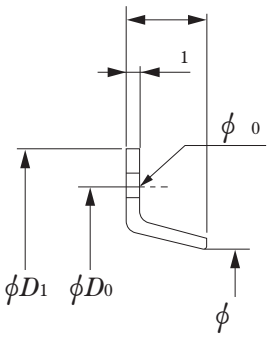
WR...RJ MH...J H...J

Scale seal



WR...RJ
MH...J

Scale cover



H...J

Remarks

1) The cross-sectional view indicates a representative oil seal shape.
2) All seals use nitrile rubber.
3) Consult JTEKT for drain-provided seals.

Boundary dimensions, mm

1	D	.	. 1	Scale seal No.	Boundary dimensions, mm D_1			1		D_0 mm	0 mm	Hole Q'ty (equally spaced)
210	300	16	4	MH 210 300 4J	218	300	18	2	H 210 300 18 J	275	10	Special
235	340	25	5	WR 235 340 25 RJ				W R 2 3 5 3 4 0 4 5				

V-rings

d 38~875

MV...A



2 O-Rings

2.1 Classification of O-ring and backup ring 94
(1) O-ring classification and application guide 94
(2) Backup ring types and material 94
2.2 Numbering systems of O-ring and backup ring 95
(1) O-ring designation numbers 95
(2) Backup ring designation numbers 95
2.3 Selection of O-ring 96
(1) O-ring materials 96
(2) Selection of O-ring material 98

2.1 Classifica ion of O-ring and back p ring

(1) O-ring classifica ion and applica ion g ide

O-rings are used in a various machines as a compact sealing component. O-rings can generally be classified into dynamic applications ("packing") and static applications ("gaskets").

Other classification is according to their properties, such as oil resistance. O-rings are specified in the industrial standards listed in Table 2.1.1.

Table 2.1.1 O-ring classifica ion and applica ion g ide

Application	General ind s rial machines				A omobiles		Aircraf
Standard	JIS B 2401			Old ISO 3601	JASO F 404		AS 568 AS 28775A
Classification	JIS code	Remarks (hardness measured by type A durometer)	Old JIS identification code	Remarks	Material class	Remarks	Remarks
Material	NBR-70-1	Mineral oil resistance (A70)	Class 1-A		Class 1-A	General mineral oil resistance	
	NBR-90	Mineral oil resistance (A90)	Class 1-B		Class 2	Gasoline resistance	
	NBR-70-2	Gasoline resistance (A70)	Class 2		Class 3	Animal oil, vegetable oil, and brake fluid resistance	For mineral-based fluids Class: JIS NBR-70-1 NBR-90 FKM-70
	EPDM-70	Animal oil, vegetable oil, and brake fluid resistance (A70)	Class 3				
	EPDM-90	Animal oil, vegetable oil, and brake fluid resistance (A90)	–	For mineral-based fluids Class: JIS NBR-70-1			
	VMQ-70	High-temperature application resistance (A70)	Class 4-C		Class 4-C	High-temperature application resistance	
	FKM-70	High-temperature application resistance (A70)	Class 4-D				
	FKM-90	High-temperature application resistance (A90)	–		Class 4-D	High-temperature application resistance	
	HNBR-70	Mineral oil and high-temperature application resistance (A70)	–				
	HNBR-90	Mineral oil and high-temperature application resistance (A90)	–		Class 4-E	High-temperature application resistance	
	ACM-70	High-temperature application and mineral oil resistance (A70)	–				
	SBR-70*	Animal oil and vegetable oil resistance (A70)	Class 3		Class 5	Coolant resistance	
Application	P: For dynamic use and static sealing V: For vacuum flanges G: For static sealing S: For slim static sealing (not standardized in the JIS)			For general industrial use	For dynamic use and static sealing		For static sealing

*: Not standardized in the JIS

(2) Back p ring ypes and ma erial

Backup rings are used with O-rings to prevent O-ring protrusion from the groove.

Backup rings are used for dynamic sealing and for static sealing of cylindrical surface.

Table 2.1.2 shows backup ring types and material.

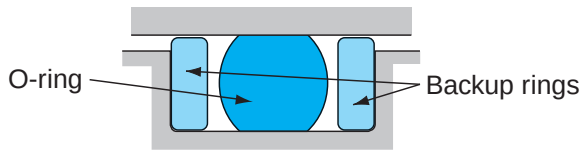
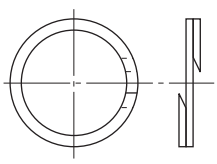
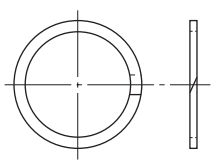
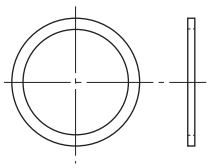


Fig. 2.1.1 O-ring ins alla ion wi h back p rings

Table 2.1.2 Back p ring ypes and ma erial

Applicable standard	JIS B 2407		
Type	T1: Spiral ring	T2: Bias-c ring	T3: Endless ring
Shape			
Material	Tetrafluoroethylene resin		
Applications	For dynamic sealing / static sealing of cylindrical surface		

2.2 Numbering systems of O-ring and back up ring

(1) O-ring designation numbers

O-ring designation number consists of material code, application code, and dimensional code.

Table 2.2.1 O-ring numbering system

Example

	P	26	JIS product [1]
1B	G	80	JIS product [1]
2	JASO	1013	JASO product [2]
	AS	325	AS product [3]
	B	0212G	ISO product [4]

Dimensional code
Application code
Material code

Notes 1) JIS: Japanese Industrial Standards
2) JASO: Japanese Automobile Standard Organization
3) AS: Aeronautical Standard
4) ISO: International Organization for Standardization

1) Material codes

Code	Standard (JIS B 2401)	
6B	HNBR-90	JASO F 404

∗: Not standardized in the JIS

2) Application codes

Code	Standard	Remarks
P	JIS B 2401-1	For dynamic use and static sealing
S	Slim series	For static sealing
JASO	JASO F 404	For dynamic use and static sealing
	AS 568	For static sealing
A B C D	For dynamic use and static sealing	JASO F 404

(2) Back up ring designation numbers

Backup ring designation number consists of type code and the O-ring number for which the backup ring is applied.

Table 2.2.2 Back up ring numbering system

Example

T1 P5

O-ring number
Type code

Type codes

Code	Backup ring shape
T1	Spiral
T2	Bias-cut
T3	Endless

Remark) Backup ring types and shapes are listed in Table 2.1.2.

2.3 Selec ion of O-ring

(1) O-ring ma erials

Materials conforming to JIS B 2401 or JASO F 404 standards are mainly used. Major rubber materials and their physical properties are listed in Table 2.3.1.

Consult JTEKT for special materials to suit a wide variety of applications.

Table 2.3.1 O-ring r bber ma erials and heir physical proper ies

Applicable standards		Class							
		NBR-70-1 Class 1-A	NBR-90 –	NBR-70-2 Class 2	– Hydrogenated nitrile rubber (HNBR)	Class 3 Styrene-buta-diene rubber (SBR)	Class 4-C Silicone rubber (VMQ)	Class 4-D Fluoro rubber (FKM)	– Ethylene-propylene rubber (EPDM)
Test items	Rubber materials, Applications	Nitrile rubber (NBR)	Nitrile rubber (NBR)	Nitrile rubber (NBR)					
		Mineral oil resistance		Gasoline resistance		Animal oil and vegetable oil resistance			Animal oil, vegetable oil, and brake fluid resistance
Normal properties	Hardness by durometer type A[1]	A70 ± 5	A90 ± 5	A70 ± 5	A90 ± 5	A70 ± 5	A70 ± 5	A70 ± 5	A90 ± 5
	Tensile strength (MPa), min.	10.0	14.0	10.0	16.0	9.8	3.5	10.0	10.0
	Elongation (%), min.	250	100	200	100	150	60	170	80
	Tensile stress (MPa), min. (at 100 % elongation)	2.5	–	2.5	–	2.7	–	2.0	–
Aging tests	Temperature and duration	120 ˚C, 72h		100 ˚C, 72h		100 ˚C, 70h			100 ˚C, 72h
	Change in hardness, max.	+ 10	+ 10	+ 10	+ 15	+ 10	+ 10	+ 5	+ 10
	Change in tensile strength (%), max.	– 15	– 25	– 15	– 30	– 15	– 10	– 10	– 15
	Change in elongation (%), max.	– 45	– 55	– 40	– 40	– 45	– 25	– 25	– 45
Compression set test	Temperature and duration	120 ˚C, 72h		100 ˚C, 72h		100 ˚C, 70h		200 ˚C, 72h	100 ˚C, 72h
	Compression set (%), max.	40	40	25	40	25	30	40	30
Immersion test	Temperature, duration, and testing oil	120 ˚C, 72h IRM901[2]		23 ˚C, 72h fuel oil No.1[2]		100 ˚C, 70h brake fluid[2]			100 ˚C, 72h brake fluid[2]
	Change in hardness	– 5 ~ + 8	– 5 ~ + 8	– 8 ~ 0	−5 ~ + 10	– 15 ~ 0	– 10 ~ + 5	– 10 ~ + 5	– 15 ~ 0
	Change in tensile strength (%), max.	– 15	– 20	– 15	– 20	– 40	– 20	– 20	– 40
	Change in elongation (%), max.	– 40	– 40	– 25	– 40	– 40	– 20	– 20	– 40
	Change in volume (%)	– 8 ~ + 5	– 8 ~ + 5	– 3 ~ + 5	−10 ~ + 5	0 ~ + 12	0 ~ + 10	– 5 ~ + 5	0 ~ + 12
	Temperature, duration, and testing oil	120 ˚C, 72h IRM903[2]		23 ˚C, 72h fuel oil No.2[2]				175 ˚C，72h IRM903[2]	
	Change in hardness	– 15 ~ 0	−10 ~ + 5	– 20 ~ 0	– 15 ~ + 5	–	–	−10 ~ + 5	–
	Change in tensile strength (%), max.	– 25	– 35	– 45	– 35			– 20	
	Change in elongation (%), max.	– 35	– 35	– 45	– 40			– 20	
		0 ~ + 20	0 ~ + 20	0 ~ + 30	0 ~ + 25			– 5 ~ + 5	
Corrosion test	Appearance	– 15							

Notes 1) Instantaneous values have been used.
2) For details, see the appendix of JIS B 2401-1.
3) Not standardized in the JIS.

(2) Selec ion of O-ring ma erial

O-rings have contact with substances to be sealed. Therefore, material should be chemically stable to such substances.

Table 2.3.2 below lists the substances with which each rubber material can remain stable. Consult JTEKT for further details.

Table 2.3.2 O-ring r bber ma erials and heir s abili y o fl ids

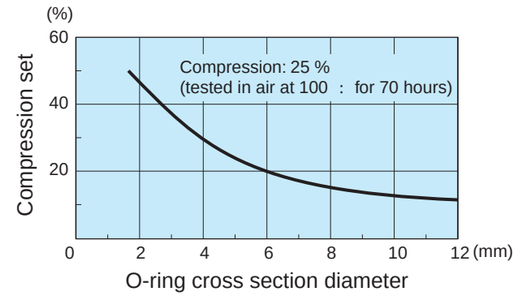
: Resistant to the substance

(3) Selec ion of cross sec ion diame er

When sealing fluid with O-ring, design the O-ring so that the depth of groove for fitting it is smaller than the thickness of the O-ring to compress (squeeze) it (provide compression amount). Determine this compression carefully, because O-rings may become permanently deformed if squeezed excessively, thus deteriorating sealing performance.

Generally, the compression rate of an O-ring should be between 8 % and 30 % in ring cross section diameter (the lower limit of 8 % for sufficient sealing performance and the upper limit of 30 % for limited compression set.).

Fig. 2.3.1 shows the relation between O-ring cross section diameter and compression set.



Larger cross section diameter offers more stable sealing performance. As shown in Fig. 2.3.1, when the O-ring compression rate is constant (25 % in the figure), the larger cross section diameter shows the smaller the compression set. Larger cross section diameter is advantageous in that it can accommodate errors in installation dimensions as well.

In dynamic-sealing applications, larger cross section diameter is less likely to twist during service or during installation. The largest cross section diameter possible should be selected providing it can fit in the available space.

2.4 O-ring echnical principles

Fig. 2.4.1 shows how O-ring can be deformed under pressure.

O-ring installed in a groove with compression (compression rate) of 8 % to 30 % provides a self-seal by its elasticity when the pressure is low.

When operation pressure is higher, the O-ring is pressed against one side of the groove, providing better sealing.

2.5 Fi ing groove design for O-ring

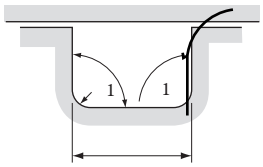
(1) Compression amo n and compression ra e

Table 2.5.1 lists the JIS-standard of O-ring Compression amount and compression rate.

See dimension table for each groove dimensions corresponding to O-ring number.

Compression amounts of standards other than JIS are shown in respective dimensional tables.

Fig.2.5.1 shows the details of relation between the shape of groove and the compression amount and compression rate.



(unit : mm)

1) Groove depth K

Determine dimension to obtain O-ring compression rate between 8 % and 30%.

Determine the radial gap by the consideration that the double radial gap (gap in diameter) should be less than the value shown in Fig. 2.5.2.

Compression amount = –

Compression rate = x 100 (%)

: O-ring cross section diameter

2) Groove width .

Determine groove width by the consideration that O-ring should not occupy more than 90 % of the groove space.

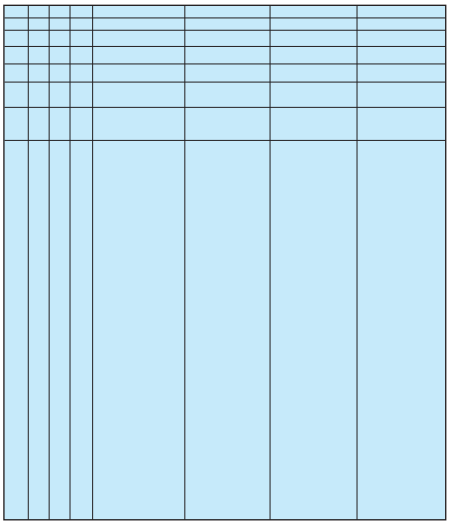
Occupancy percentage = x 100 (%)

Table 2.5.1 O-ring compression amo n and compression ra e

O-ring number	O-ring dimensions, mm			Compression amount and compression rate							
				For dynamic sealing /static sealing of cylindrical surface				For static sealing of flat surface			
				mm		%		mm		%	
	Cross section diameter	Bore diameter 1		Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
P3 ~ P10	1.9 ±0.08	2.8 ~ 9.8	Tolerances of O-ring bore diameter 1 are given in the dimensional table of the O-rings.	0.48	0.27	24.2	14.8	0.63	0.37	31.8	20.3
P10A ~ P18	2.4 ±0.09	9.8 ~ 17.8		0.49	0.25	19.7	10.8	0.74	0.46	29.7	19.9
P20 ~ P22		19.8 ~ 21.8									
P22A ~ P40	3.5 ±0.1	21.7 ~ 39.7		0.60	0.32	16.7	9.4	0.95	0.65	26.4	19.1
P41 ~ P50		40.7 ~ 49.7									
P48A ~ P70		47.6 ~ 69.6									
P71 ~ P125	5.7 ±0.13	70.6 ~ 124.6		0.83	0.47	14.2	8.4	1.28	0.92	22.0	16.5
P130 ~ P150		129.6 ~ 149.6									
P150A ~ P180		149.5 ~ 179.5									
P185 ~ P300	8.4 ±0.15	184.5 ~ 299.5		1.05	0.65	12.3	7.9	1.70	1.30	19.9	15.8
P315 ~ P400		314.5 ~ 399.5									
G25 ~ G40		24.4 ~ 39.4									
G45 ~ G70	3.1 ±0.1	44.4 ~ 69.4		0.70	0.40	21.85	13.3	0.85	0.55	26.6	18.3
G75 ~ G125		74.4 ~ 124.4									
G130 ~ G145		129.4 ~ 144.4									
G150 ~ G180	5.7 ±0.13	149.3 ~ 179.3		0.83	0.47	14.2	8.4	1.28	0.92	22.0	16.5
G185 ~ G300		184.3 ~ 299.3									

(2) Ex r sion in o gap from fi ing groove

The O-ring and backup ring extrusion into the gap from the fitting groove on cylindrical surfaces is mainly related to the gap amount of the cylindrical surface.
Pressure of fluid to be sealed or O-ring hardness also influence.
Fig. 2.5.2 shows the relation between these factors.



<O-ring test conditions>
1. Without backup ring
2. Expansion of cylinder inner diameter due to internal pressure of cylinder is not included.
3. These results were obtained after 100 thousand cycles at 2.5 Hz between zero pressure to the pressure specified in the diagram.

Expansion of cylinder inner diameter due to internal pressure of cylinder is not taken into consideration for the gap in the diagram above. If any expansion of the cylinder inner diameter may occur, the gap should be 75% of the values shown in the diagram, taking expansion of the gap into consideration.
Also, if an O-ring exceeds the values of the gaps in the figure above, use a backup ring.

(3) Fi ing groove s rface ro ghness

Fitting groove surface should be finished as specified in Table 2.5.2 below for the O-ring to have sufficient sealing performance and long service life, and to minimize frictional resistance.

(4) Chamfer of ins alla ion loca ion

Provide chamfers on all edges of the cylinder and piston rod to prevent O-ring damage during installation, as shown in Table 2.5.3.

When O-ring is used on piston seal, do not provide a pressure hole on the area on which the O-ring slides.
If the pressure hole must be installed in the area the O-ring is slid, chamfer the pressure hole (Fig.2.5.3). For the chamfering amount, see the Table 2.5.3.

(5) Ma erial and s rface finishing of fi ing groove par s

Cylinder material for dynamic-sealing application should be steel. The most suitable piston rod material is hardened steel.

Soft materials such as aluminum, brass, bronze, Monel metal and soft stainless steel are not suitable as a sliding surface material because of inferior in abrasion resistance.

For static-sealing applications, materials should have sufficient strength to normal operation pressure and should also be resistant to pulsating pressure.

Surface finishing methods to minimize friction are honing, varnishing (roller varnishing), and polishing after hard nickel plating.

Hard-nickel plating is preferable for the application which requires heat resistance, abrasion resistance and low-friction.

Table 2.5.4 shows materials for fitting groove parts and their compatibility

2.6 Handling of O-ring

(1) S orage

The following practices are advisable to keep O-ring quality for a long time.

- Do not store where exposed to direct sunlight.
- Store enclosed indoors where temperature is less than 30 ˚C and humidity is less than 65 %.
- Keep O-rings away from heat or ozone sources.
- O-rings should be sealed completely in packages when stored.
- Do not hang or suspend O-rings on hooks, wires, or strings.

(2) Handling

For good performance of O-ring, pay attention to the points shown below.

- Avoid reuse of used O-rings.
- When installing an O-ring, apply sealing medium (lubricant) to the O-ring and contact surface.
- Install an O-ring in the groove without twisting it.
- Do not clean O-ring equipped machine with cleaning oil or gasoline and protect O-ring from cleaning oil. Otherwise, it may be swollen, causing poor sealing performance.
- If an O-ring passes along the threaded surface or sharp edges on it during installation, provide any mechanism to prevent the O-ring from being damaged.

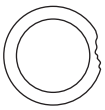
  When fitting an O-ring, insert the cap onto the threaded surface as shown in Fig.2.6.1.

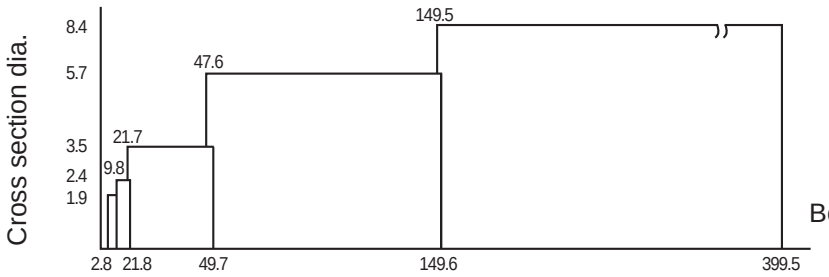
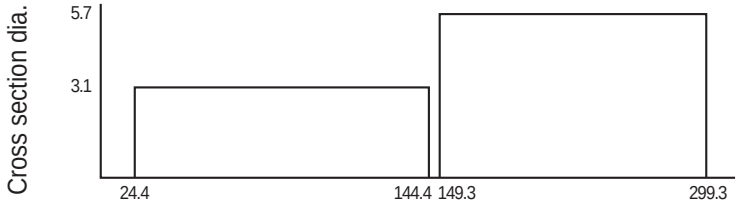
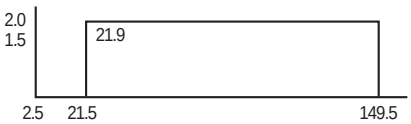
2.7 Typical O-ring fail res, ca ses and co n ermeas res

When leakage is observed, investigate the causes and implement proper countermeasures.

To identify the causes, it is critical to observe the O-ring closely and evaluate the failure in all respects, such as cylinder, piston, and medium to be sealed.

Table 2.7.1 O-ring fail res, ca ses and co n ermeas res

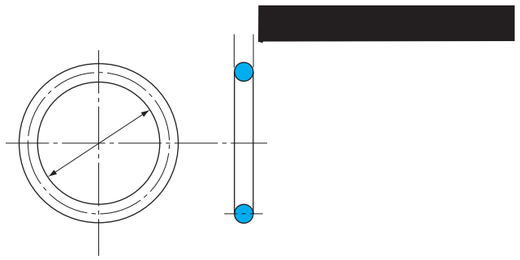
Phenomenon	Appearance Condition		Major causes	Countermeasures
Ⓓ **Twis**	Twisted and deformed		1) Excessive speed 2) Eccentric movements 3) Poor surface finish on sliding face 4) Twisted installation	• Replace with V-packing • Improve accuracy of equipment • Improve sliding surface finish • Install with care(Coat grease.)
Ⓓ **Chipping**	Partially chipped			

Code	O-ring dimensions (Unit mm)	Application	Page
JIS P		**General ind s rial machines** Dynamic/static sealing	108
JIS G		**General ind s rial machines** Static sealing	116
S			118
Old ISO A, B C, D E			120
JASO			124
AS			130
BACKUP RING			138
JIS V			142

P 3~35

JIS B 2401 P (for Dynamic and Static Sealing)

Material : JIS NBR-70-1, NBR-90, NBR-70-2, EPDM-70, EPDM-90, VMQ-70, FKM-70, FKM-90, HNBR-70, HNBR-90, ACM-70 and SBR-70 (Not standardized in the JIS)

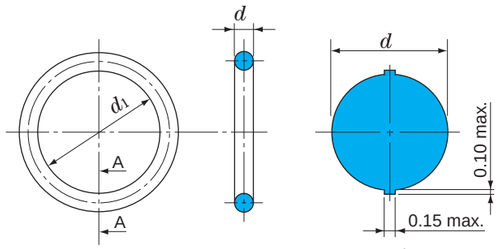


P 35.5~105

JIS B 2401 P (for Dynamic and Static Sealing)

Material : JIS NBR-70-1, NBR-90, NBR-70-2, EPDM-70, EPDM-90, VMQ-70, FKM-70, FKM-90, HNBR-70, HNBR-90, ACM-70 and SBR-70 (Not standardized in the JIS)

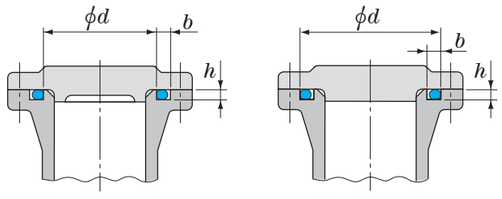
O-ring shape and dimensions (unit : mm)



Cross section A-A

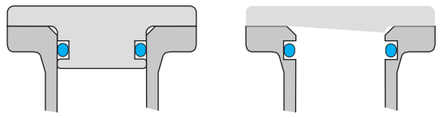
Fitting groove dimensions

Static sealing on flat surface



For external pressure

For internal pressure



P 35.5~105

unit : mm

Notes
1) The tolerance of bore diameter d_1 shows the specified values in JIS B 2401 for NBR-70-1, NBR-90, NBR-70-2, EPDM-70, EPDM-90 and SBR-70 (Not standardized in the JIS) products.
For VMQ-70 and ACM-70 products, the tolerance is 1.5 times these values, and for FKM-70, FKM-90, HNBR-70 and HNBR-90 products, 1.2 times.
2) For a static sealing application on a flat surface, design the groove according to dimension d for use under external pressure, or according to dimension d for use under internal pressure. An O-ring for use under external pressure can thus have its bore surface in close contact with the inner wall of the groove during use. Likewise an O-ring for use under internal pressure can thus have its circumferential surface in close contact with the outer wall of the groove.
3) The fitting code is corresponding to the d and d tolerances.
4) Eccentricity E means the difference between the maximum value and minimum value of dimension K.
The eccentricity can also be defined as double the coaxiality measurement.

JIS B 2401 P (for Dynamic and Static Sealing)

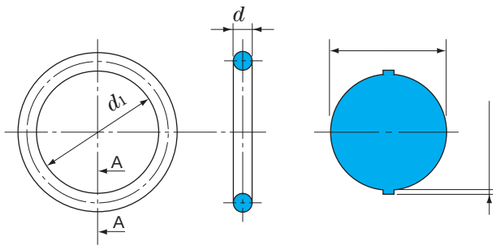
Material : JIS NBR-70-1, NBR-90, NBR-70-2, EPDM-70, EPDM-90, VMQ-70, FKM-70, FKM-90, HNBR-70, HNBR-90, ACM-70 and SBR-70 (Not standardized in the JIS)

Notes 1) The tolerance of bore diameter d_1 shows the specified values in JIS B 2401 for NBR-70-1, NBR-90, NBR-70-2, EPDM-70, EPDM-90 and SBR-70 (Not standardized in the JIS) products.
For VMQ-70 and ACM-70 products, the tolerance is 1.5 times these values, and for FKM-70, FKM-90, HNBR-70 and HNBR-90 products, 1.2 times.
2) For a static sealing application on a flat surface, design the groove according to dimension d for use under external pressure, or according to dimension d for use under internal pressure. An O-ring for use under external pressure can thus

G 25~300

JIS B 2401 G (for Static Sealing)

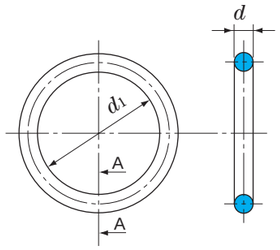
Material : JIS NBR-70-1, NBR-90, NBR-70-2, EPDM-70, EPDM-90, VMQ-70, FKM-70, FKM-90, HMBR-70, HMBR-90, ACM-70 and SBR-70 (Not standardized in the JIS)

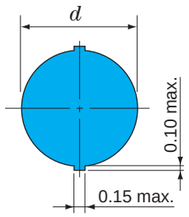


S 3~150

Slim Series (for Static Sealing)

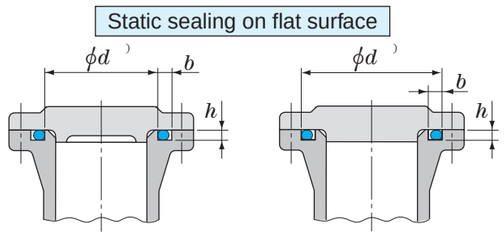
Material : JIS NBR-70-1 and FKM-70





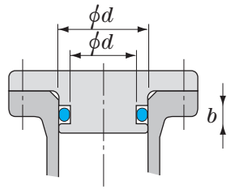
Cross section A-A.

Static sealing on flat surface



For external pressure

For internal pressure



Old ISO A,B,C,D
d_1 1.8~75

Old ISO 3601 (for General Industrial Applications)

Material : JIS NBR-70-1

1) Groove depth K

Determine dimension to obtain O-ring compression rate between 8 % and 30 %.

Compression rate = × 100 (%) = 8 % ~ 30 %

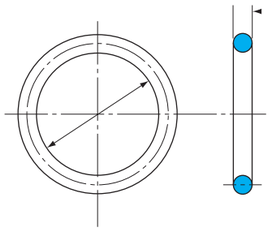
Determine the radial gap by the consideration that the double

JASO d_2 1.9

JASO F 404 (for Dynamic and Static Sealing)

Material : JASO classes 1-A, 2, 3, 4-C, 4-D, 4-E and 5

Koyo



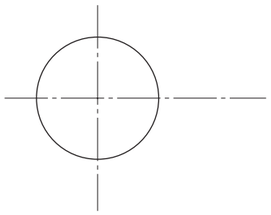
Notes 1) For a static sealing application on a flat surface, design the groove according to dimension for use under external pressure, or according to dimension for use under internal pressure. An O-ring for use under external pressure can thus have its bore surface in close contact with the inner wall of the groove during use. Likewise an O-ring for use under internal pressure can thus have its circumferential surface in close contact with the outer wall of the groove.

2) Eccentricity E means the difference between the maximum value and minimum value of dimension K.
The eccentricity can also be defined as double the coaxiality measurement.

JASO d_2 2.4

JASO F 404 (for Dynamic and Static Sealing)

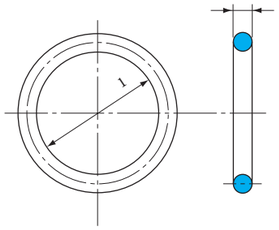
Material : JASO classes 1-A, 2, 3, 4-C, 4-D, 4-E and 5



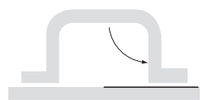
JASO d_2 3.5

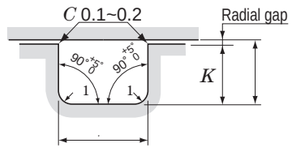
JASO F 404 (for Dynamic and Static Sealing)

Material : JASO classes 1-A, 2, 3, 4-C, 4-D, 4-E and 5



for Aircraft Hydraulic Applications




C 0.1~0.2
Radial gap
90°±5°
90°±5°
K
1
1

Back p Rings

P 3~165

JIS B 2407 P, G

Koyo

unit : mm

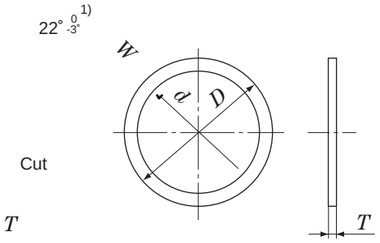
Spiral (T1)



Bias-c (T2)



Endless (T3)

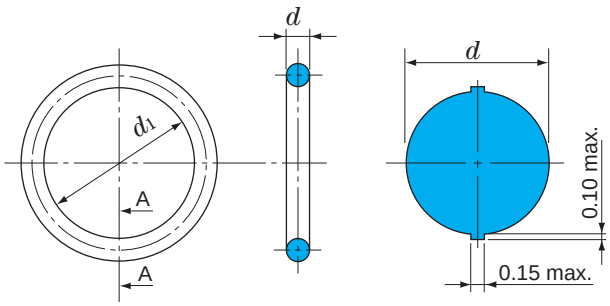


V 15~1 055

JIS B 2401 V (for Vacuum Flanges)

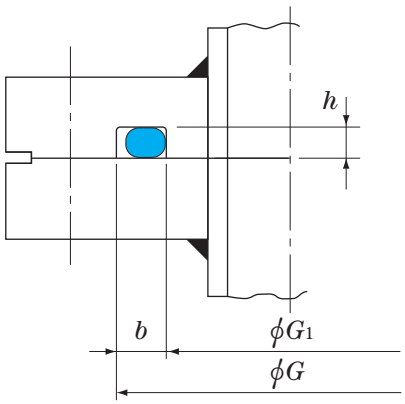
Material : JIS NBR-70-1, NBR-90, NBR-70-2, EPDM-70, EPDM-90, VMQ-70, FKM-70, FKM-90, HNBR-70, HNBR-90, ACM-70 and SBR-70 (Not standardized in the JIS)

O-ring shape and dimensions (unit : mm)



Cross section A-A

Fitting groove dimensions



V 15~1 055

unit : mm

O-ring dimensions		O-ring No.	Groove dimensions		
Bore dia. d_1 1)	Cross section dia. d		G_1	G	b

Note 1) The tolerance of bore diameter d_1 shows the specified values in JIS B 2401 for NBR-70-1, NBR-90, NBR-70-2, EPDM-70, EPDM-90 and SBR-70 (Not standardized in the JIS) products.
For VMQ-70 and ACM-70 products, the tolerance is 1.5 times these values, and for FKM-70, FKM-90, HNBR-70 and HNBR-90 products, 1.2 times.

3

3.1 Automobile 144
Automatic transaxle
Manual transaxle
Engine
Electric power steering
Driving wheel
Driven wheel

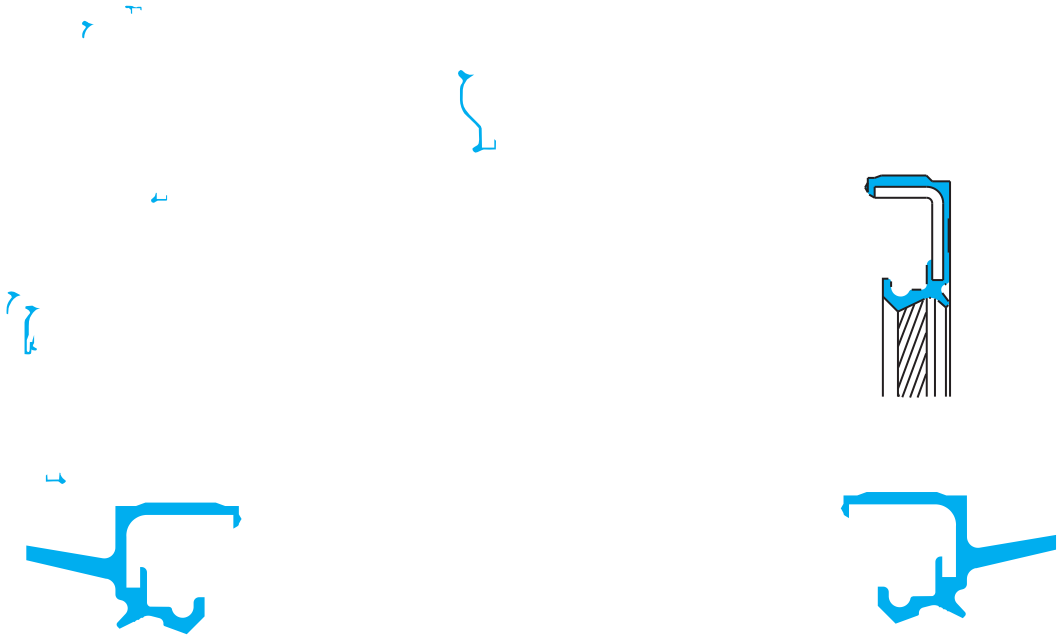
3.2 Motorcycle 147
Engine

3.3 Rolling mill roll necks 148
Rolling bearing
Oil-film bearing

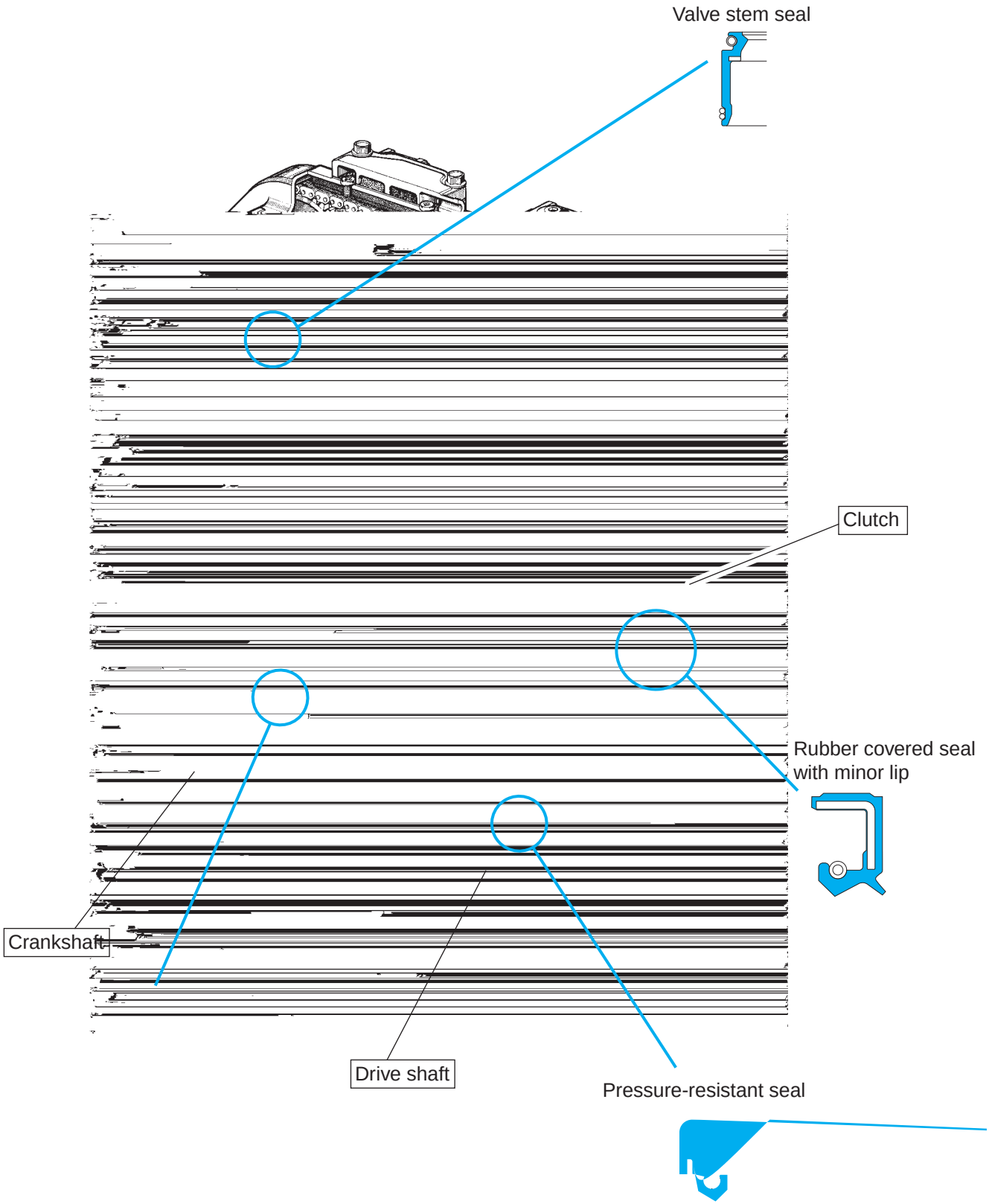
3. Applica ion Examples of Oil Seals and O-Rings

3.1 A omobile

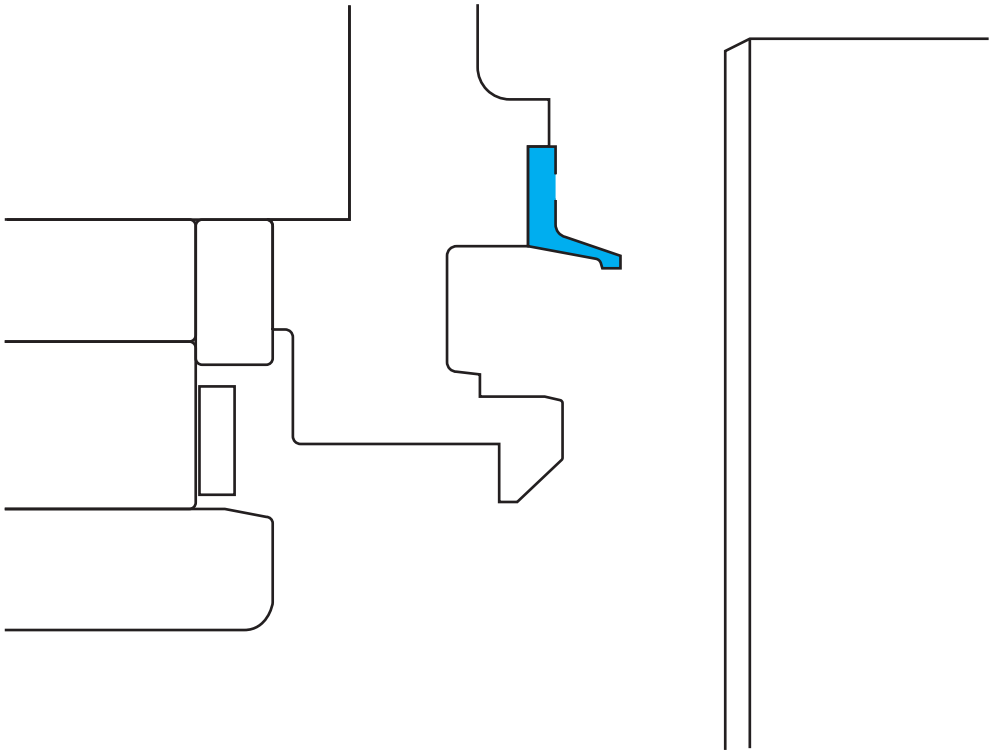
A oma ic ransaxle



3. Applica ion Examples of Oil Seals and O-Rings

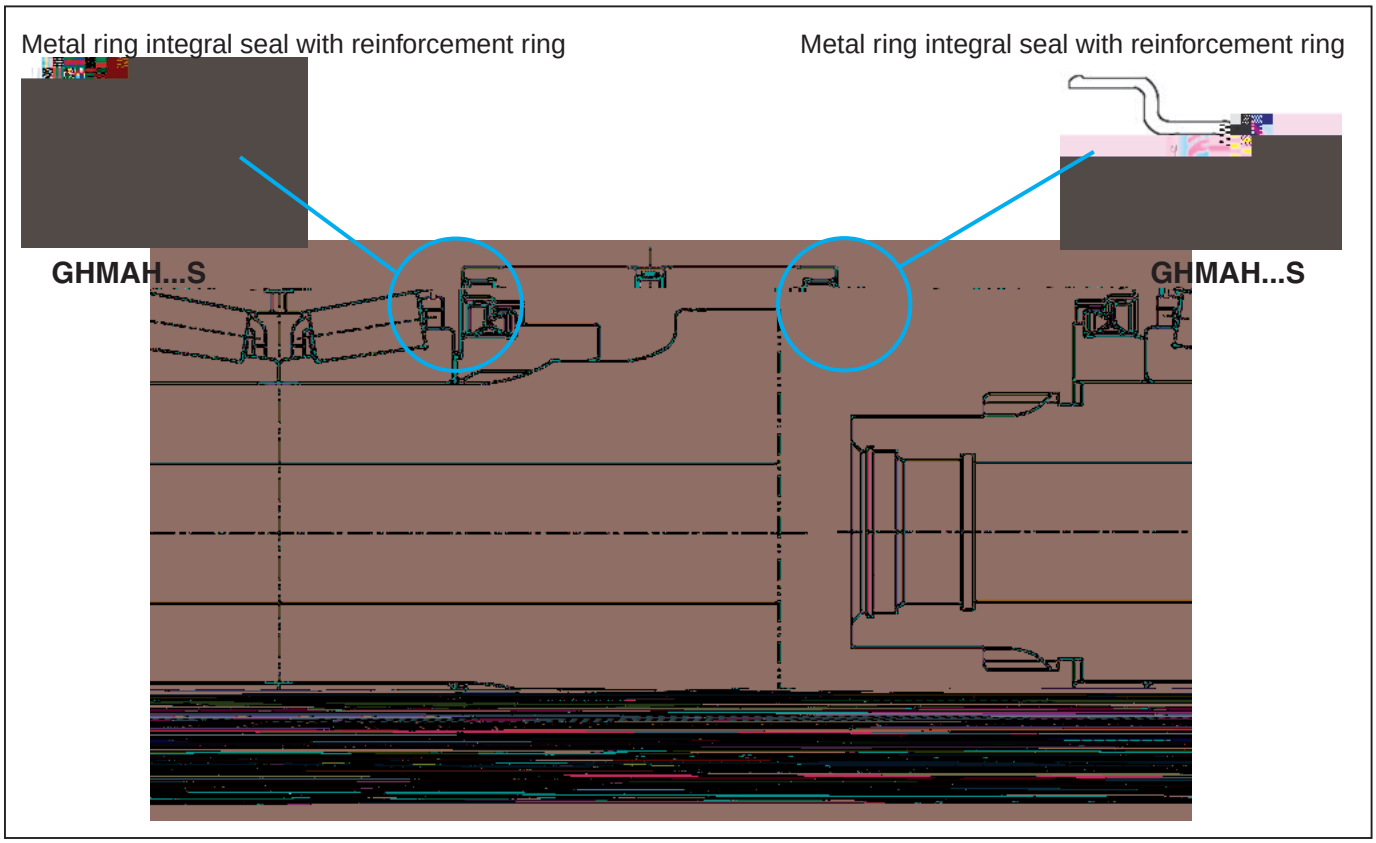

Valve stem seal
Clutch
Rubber covered seal
with minor lip
Crankshaft
Drive shaft
Pressure-resistant seal

3.3 Rolling mill roll necks

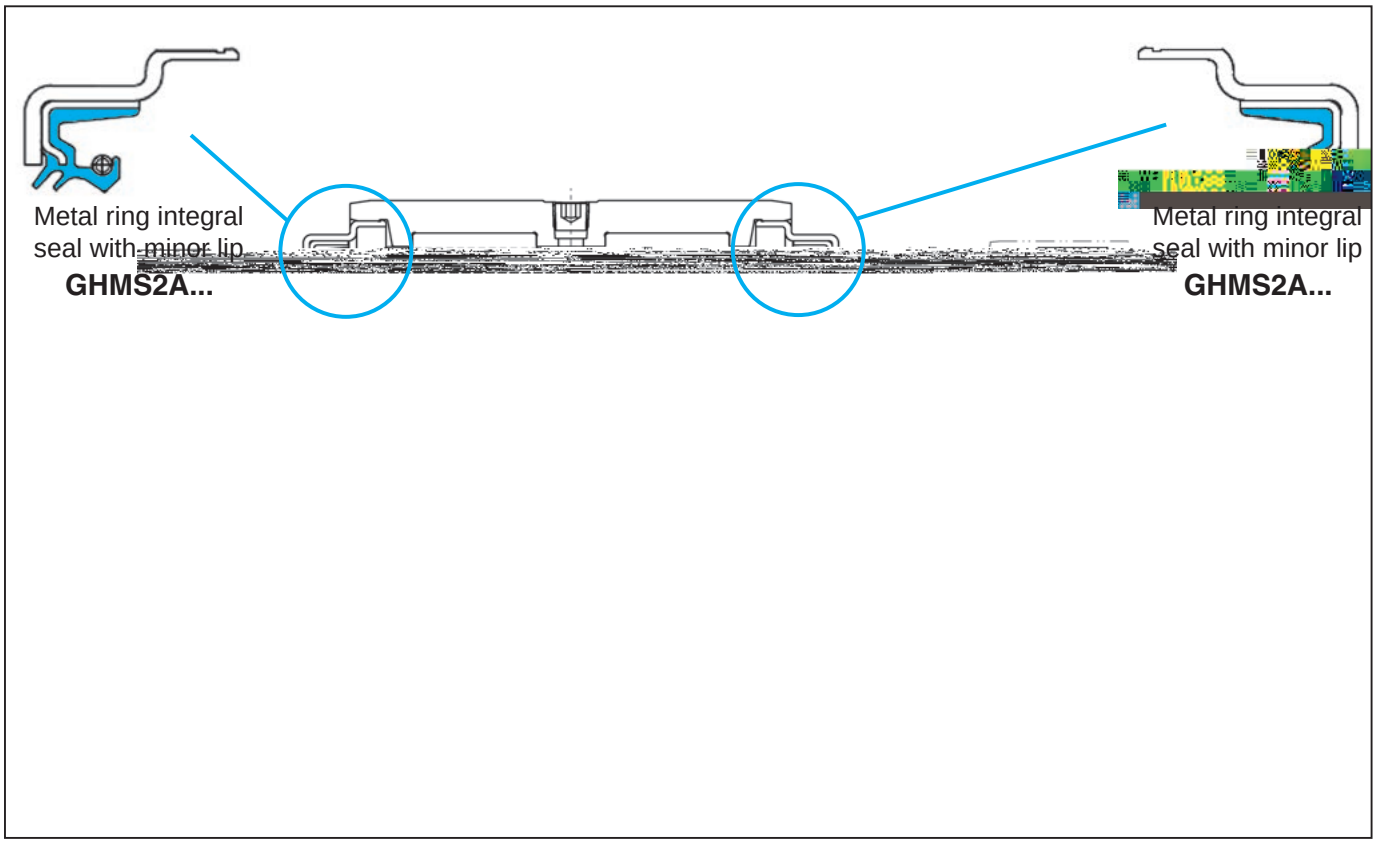


3.4 Rolling s ock axles

Do ble row apered roller bearing



Do ble row cylindrical roller bearing



3.6 Hydra lic mo or

4.1 Rubber-material varieties and properties 152

4.2 SI units and conversion factors 154

4.3 Shaft tolerance 158

4.4 Housing bore tolerance 160

4.5 : - < temperature conversion ta11.e Tc2u (-)Tj..... 152

4.1 R bber-ma erial varie ies and proper ies

~

Mass	SI ni s	O her Uni s[1)]	Conversion in o SI ni s	Conversion from SI ni s
Angle	rad [radian(s)]	° [degree(s)] ' [minute(s)] " [second(s)]	1° = π / 180 rad 1' = π / 10 800 rad 1" = π / 648 000 rad	1 rad = 57.295 78°
Leng h	m [meter(s)]	Å [Angstrom unit] µ [micron(s)] in [inch(es)] ft [foot(feet)] yd [yard(s)] mile [mile(s)]	1Å = 10^{-10} m = 0.1 nm = 100 pm 1µ = 1µm 1 in = 25.4 mm 1 ft = 12 in = 0.304 8 m 1 yd = 3 ft = 0.914 4 m 1 mile = 5 280 ft = 1 609.344 m	1 m = 10^{10}Å 1 m = 39.37 in 1 m = 3.280 8 ft 1 m = 1.093 6 yd 1 km = 0.621 4 mile
Area	m^2	a [are(s)] ha [hectare(s)] acre [acre(s)]	1 a = 100 m^2 1 ha = 10^4 m^2 1 acre = 4 840 yd^2 = 4 046.86 m^2	 1 km^2 = 247.1 acre
Vol me	m^3	r , L [liter(s)] cc [cubic centimeters] gal (US) [gallon(s)] floz (US) [fluid ounce(s)] barrel (US) [barrels(US)]	1 r = 1 dm^3 = 10^{-3} m^3 1 cc = 1 cm^3 = 10^{-6} m^3 1 gal (US) = 231 in^3 = 3.785 41 dm^3 1 floz (US) = 29.573 5 cm^3 1 barrel (US) = 158.987 dm^3	1 m^3 = 10^3 r 1 m^3 = 10^6 cc 1 m^3 = 264.17 gal 1 m^3 = 33 814 floz 1 m^3 = 6.289 8 barrel
Time	s [second(s)]	min [minute(s)] h [hour(s)] d [day(s)]		
Ang lar veloci y	rad/s			
Veloci y	m/s	kn [knot(s)] m/h	1 kn = 1 852 m/h	1 km/h = 0.539 96 kn
Accelera ion	m/s^2	G	1 G = 9.806 65 m/s^2	1 m/s^2 = 0.101 97 G

Note 1) : Unit can be used as an SI unit.
No asterisk : Unit cannot be used.

SI units and conversion factors (2)

Mass	SI units	Other Units[1)]	Conversion in o SI units	Conversion from SI units
Density	kg/m^3			
Linear density	kg/m			
Momentum	kg · m/s			
Moment of momentum, Angular momentum	kg · m^2/s			
Moment of inertia	kg · m^2			
Force	N [newton(s)]	dyn [dyne(s)]	1 dyn = 10^{-5} N	1 N = 10^5 dyn
		kgf [kilogram-force]	1 kgf = 9.806 65 N	1 N = 0.101 97 kgf
		gf [gram-force]	1 gf = 9.806 65 × 10^{-3} N	
		tf [ton-force]	1 tf = 9.806 65 × 10^3 N	
		lbf [pound-force]	1 lbf = 4.448 22 N	1 N = 0.224 809 lbf
Moment of force	N · m [newton meter(s)]	gf · cm	1 gf · cm = 9.806 65 × 10^{-5} N · m	
		kgf · cm	1 kgf · cm = 9.806 65 × 10^{-2} N · m	
		kgf · m	1 kgf · m = 9.806 65 N · m	1 N · m = 0.101 97 kgf · m
		tf · m	1 tf · m = 9.806 65 × 10^3 N · m	
		lbf · ft	1 lbf · ft = 1.355 82 N · m	1 N · m = 0.737 56 lbf · ft
Pressure, Normal stress	Pa [pascal(s)] or N/m^2 {1 Pa = 1 N/m^2}	gf/ cm^2	1 gf/ cm^2 = 9.806 65 × 10 Pa	
		kgf/mm^2	1 kgf/mm^2 = 9.806 65 × 10^6 Pa	1 MPa = 0.101 97 kgf/mm^2
		kgf/m^2	1 kgf/m^2 = 9.806 65 Pa	1 Pa = 0.101 97 kgf/m^2
		lbf/in^2	1 lbf/in^2 = 6 894.76 Pa	1 Pa = 0.145 × 10^{-3} lbf/in^2
		bar [bar(s)]	1 bar = 10^5 Pa	1 Pa = 10^{-2} mbar
		at [engineering air pressure]	1 at = 1kgf/cm^2 = 9.806 65 × 10^4 Pa	
		mH_2O, mAq [meter water column]	1 mH_2O = 9.806 65 × 10^3 Pa	
		atm [atmosphere]	1 atm = 101 325 Pa	
		mHg [meter mercury column]	1 mHg = $\frac{101\ 325}{0.76}$ Pa	
		Torr [torr]	1 Torr = 1mmHg = 133.322 Pa	1 Pa = 7.500 6 × 10^{-3} Torr
[redacted]	Pa · s	P [poise]	10	

Mass	SI ni s	O her Uni s[1)]	Conversion in o SI ni s	Conversion from SI ni s
Work,	J	eV [electron volt(s)]	1 eV = (1.602 189 2±0.000 004 6)×10 $^{-19}$ J	
	[joule(s)]	erg [erg(s)]	1 erg = 10^{-7} J	1 J = 10^{7} erg
	{1 J = 1 N · m}	kgf · m	1 kgf · m = 9.806 65 J	1 J = 0.101 97 kgf · m
energy		lbf · ft	1 lbf · ft = 1.355 82 J	1 J = 0.737 56 lbf · ft
Power	W	erg/s [ergs per second]	1 erg/s = 10^{-7} W	

SI ni s and conversion fac ors (4)

Mass	SI ni s	O her Uni s[1)]	Conversion in o SI ni s	Conversion from SI ni s
Elec ric c rren	A [ampere(s)]			
Elec ric charge, q an i y of elec rici y	C [coulomb(s)] {1 C = 1 A · s}	A · h	1 A · h = 3.6 kC	
Tension, elec ric po en ial	V [volt(s)] {1 V = 1 W/A}			
Capaci ance	F [farad(s)] {1 F = 1 C/V}			
Magne ic field s reng h	A/m	Oe [oersted(s)]	1 Oe = $\frac{10^3}{4\pi}$ A/m	1 A/m = $4\pi \times 10^{-3}$ Oe
Magne ic fl x densi y	T [tesla(s)] {1 T = 1 N/(A · m) = 1 Wb/m^2 = 1 V · s/m^2}	Gs [gauss(es)] γ [gamma(s)]	1 Gs = 10^{-4} T 1 γ = 10^{-9} T	1 T = 10^4 Gs 1 T = 10^9 γ
Magne ic fl x	Wb [weber(s)] {1 Wb = 1 V · s}	Mx [maxwell(s)]	1 Mx = 10^{-8} Wb	1 Wb = 10^8 Mx
Self ind c ance	H [henry (– ries)] {1 H = 1 Wb/A}			
Resis ance (o direc c rren)	Ω [ohm(s)] {1 Ω = 1 V/A}			
Cond c ance (o direc c rren)	S [siemens] {1 S = 1 A/V}			
Ac ive power	W {1 W = 1 J/s = 1 A · V}			

4.3 Shaf olerance

unit μm

Nominal shaf diame er mm		Devia ion classes of shaf diame er											
over	up to	d6	e6	f6	g5	g6	h5	h6	h7	h8	h9	h10
3	6	– 30 – 38	– 20 – 28	– 10 – 18	– 4 – 9	– 4 – 12	0 – 5	0 – 8	0 – 12	0 – 18	0 – 30	0 – 48
6	10	– 40 – 49	– 25 – 34	– 13 – 22	– 5 – 11	– 5 – 14	0 – 6	0 – 9	0 – 15	0 – 22	0 – 36	0 – 58

Nominal bore diameter mm		Deviation classes of housing bore diameter														
over	up to	E6	F6	F7	G6	G7	H6	H7	H8	H9	H10	JS5	JS6	JS7	J6	J7
10	18	+ 43 + 32	+ 27 + 16	+ 34 + 16	+ 17 + 6	+ 24 + 6	+ 11 0	+ 18 0	+ 27 0	+ 43 0	+ 70 0	± 4	± 5.5	± 9	+ 6	+ 10
18	30	+ 53 + 40	+ 33 + 20	+ 41 + 20	+ 20 + 7	+ 28 + 7	+ 13 0	+ 21 0	+ 33 0	+ 52 0	+ 84 0	± 4.5	± 6.5	±10.5	+ 8	+ 12
30	50	+ 66 + 50	+ 41 + 25	+ 50 + 25	+ 25 + 9	+ 34 + 9	+ 16 0	+ 25 0	+ 39 0	+ 62 0	+100 0	± 5.5	± 8	±12.5	+ 10	+ 14
50	80	+ 79 + 60	+ 49 + 30	+ 60 + 30	+ 29 + 10	+ 40 + 10	+ 19 0	+ 30 0	+ 46 0	+ 74 0	+120 0	± 6.5	± 9.5	±15	– 6	– 12
80	120	+ 94 + 72	+ 58 + 36	+ 71 + 36	+ 34 + 12	+ 47 + 12	+ 22 0	+ 35 0	+ 54 0	+ 87 0	+140 0	± 7.5	±11	±17.5		
120	180	+110 + 85	+ 68 + 43	+ 83 + 43	+ 39 + 14	+ 54 + 14	+ 25 0	+ 40 0	+ 63 0	+100 0	+160 0	± 9	±12.5	±20		
180	250	+129 +100	+ 79 + 50	+ 96 + 50	+ 44 + 15	+ 61 + 15	+ 29 0	+ 46 0	+ 72 0	+115 0	+185 0	±10	±14.5	±23		
		+142 +110	+ 88 + 56	+108 + 56	+ 49 + 17	+ 69 + 17	+ 32 0	+ 52 0	+ 81 0	+130 0	+210 0		±16	±26		
315	400	+161 +125	+ 98 + 62	+119 + 62	+ 54 + 18	+ 75 + 18	+ 36 0	+ 57 0	+ 89 0	+140 0	+230 0	±12.5	±18	±28.5		
400	500	+175 +135	+108 + 68	+131 + 68	+ 60 + 20	+ 83 + 20	+ 40 0	+ 63 0	+ 97 0	+155 0	+250 0	±13.5	±20	±31.5		
500	630														–	–

4.7 Viscosi y conversion able

Kinema ic viscosi y mm²/s	Saybol SUS (second)		Redwood R (second)		Engler E (degree)
	100 ˚F	210 ˚F	50 ˚C	100 ˚C	
2	32.6	32.8	30.8	31.2	1.14
3	36.0	36.3	33.3	33.7	1.22
4	39.1	39.4	35.9	36.5	1.31
5	42.3	42.6	38.5	39.1	1.40
6	45.5	45.8	41.1	41.7	1.48
7	48.7	49.0	43.7	44.3	1.56
8	52.0	52.4	46.3	47.0	1.65
9	55.4	55.8	49.1	50.0	1.75
10	58.8	59.2	52.1	52.9	1.84
11	62.3	62.7	55.1	56.0	1.93
12	65.9	66.4	58.2	59.1	2.02
13	69.6	70.1	61.4	62.3	2.12
14	73.4	73.9	64.7	65.6	2.22
15	77.2	77.7	68.0	69.1	2.32
16	81.1	81.7	71.5	72.6	2.43
17	85.1	85.7	75.0	76.1	2.54
18	89.2	89.8	78.6	79.7	2.64
19	93.3	94.0	82.1	83.6	2.76
20	97.5	98.2	85.8	87.4	2.87
21	102	102	89.5	91.3	2.98
22	106	107	93.3	95.1	3.10
23	110	111	97.1	98.9	3.22
24	115	115	101	103	3.34
25	119	120	105	107	3.46
26	123	124	109	111	3.58
27	128	129	112	115	3.70
28	132	133	116	119	3.82
29	137	138	120	123	3.95
30	141	142	124	127	4.07
31	145	146	128	131	4.20
32	150	150	132	135	4.32
33	154	155	136	139	4.45
34	159	160	140	143	4.57

Kinema ic viscosi y mm²/s	Saybol SUS (second)		Redwood R (second)		Engler E (degree)
	100 ˚F	210 ˚F	50 ˚C	100 ˚C	
35	163	164	144	147	4.70
36	168	170	148	151	4.83
37	172	173	153	155	4.96
38	177	178	156	159	5.08
39	181	183	160	164	5.21
40	186	187	164	168	5.34
41	190	192	168	172	5.47
42	195	196	172	176	5.59
43	199	201	176	180	5.72
44	204	205	180	185	5.85
45	208	210	184	189	5.98
46	213	215	188	193	6.11
47	218	219	193	197	6.24
48	222	224	197	202	6.37
49	227	228	201	206	6.50
50	231	233	205	210	6.63
55	254	256	225	231	7.24
60	277	279	245	252	7.90
65	300	302	266	273	8.55
70	323	326	286	294	9.21
75	346	349	306	315	9.89
80	371	373	326	336	10.5
85	394	397	347	357	11.2
90	417	420	367	378	11.8
95	440	443	387	399	12.5
100	464	467	408	420	13.2
120	556	560	490	504	15.8
140	649	653	571	588	18.4
160	742	747	653	672	21.1
180	834	840	734	757	23.7
200	927	933	816	841	26.3
250	1 159	1 167	1 020	1 051	32.9
300	1 391	1 400	1 224	1 241	39.5

Remark) 1 mm²/s=1 cSt (centi stokes)

Req es Form for Oil Seal Design and Prod c ion (2)

Shaft diameter	Changeable	Yes/No	To ϕ____	(max. min.)	Oil seal type	Your requested type	Yes (	) / No
Housing bore diameter	Changeable	Yes/No	To ϕ____	(max. min.)	Rubber material	Your requested type	Yes (	) / No
Width	Changeable	Yes/No	To ____	(max. min.)	Other			

MEMO

MEMO

KO

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