12. Sealing Devices

Bearing seals have two main functions: 1) to prevent lubricant from leaking out and 2) to prevent dust, water and other contaminants from entering the bearing. When selecting a seal the following factors need to be taken into consideration: the type of lubricant (oil or grease), seal sliding speed, shaft fitting errors, space limitations, seal friction and resultant heat, and cost.

Sealing devices for rolling bearings fall into two main classifications: contact and non-contact types.

12.1 Non-contact seals

Non-contact seals utilize a small clearance between the seal and the sealing surface; therefore, there is no wear, and friction is negligible.

Consequently, very little frictional heat is generated making non-contact seals very suitable for high speed applications.

As shown in Fig. 12.1, non-contact seals can have the simplest of designs. With its small radial clearance, this type of seal is best suited for grease lubrication, and for use in dry, relatively dust free environments.

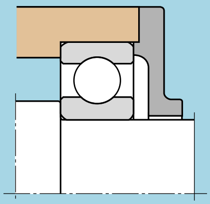


Fig. 12.1 Clearance seal

When several concentric oil grooves (Fig. 12.2) are provided on the shaft or housing, the sealing effect can be greatly improved. If grease is filled in the grooves, the intrusion of dust, etc. can be prevented.

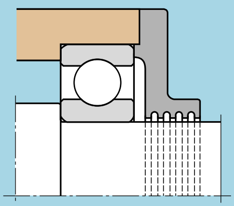


Fig. 12.2 Oil groove seal

For oil lubrication, if helical concentric oil grooves are provided in the direction opposite to the shaft rotation (horizontal shafts only), lubricating oil that flows out along the shaft can be returned to the inside of the housing (see Fig. 12.3). The same sealing effect can be achieved by providing helical grooves on the circumference of the shaft.

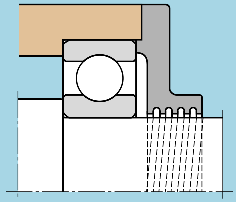


Fig. 12.3 Helical oil groove seal

Labyrinth seals employ a multistage labyrinth design which elongates the passage, thus improving the sealing effectiveness. Labyrinth seals are used mainly for grease lubrication, and if grease is filled in the labyrinth, protection efficiency (or capacity) against the entrance of dust and water into the bearing can be enhanced.

The axial labyrinth passage seal shown in Fig. 12.4 is used on one-piece housings and the radial seal shown in Fig. 12.5 is for use with split housings.

In applications where the shaft is set inclined, the labyrinth passage is slanted so as to prevent contact between the shaft and housing projections of the seal (Fig. 12.6).

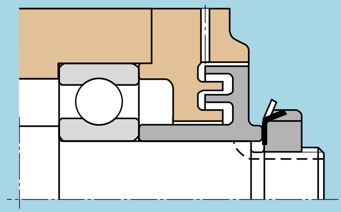


Fig. 12.4 Axial labyrinth seal

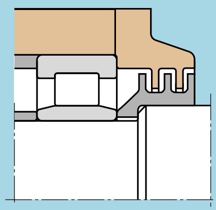


Fig. 12.5 Radial labyrinth seal

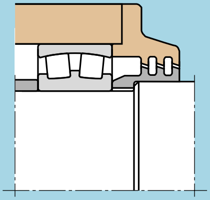


Fig. 12.6 Aligning labyrinth seal

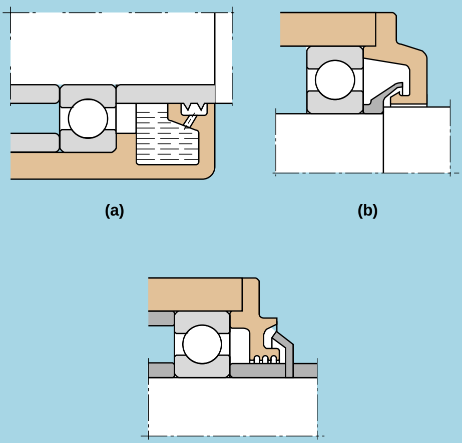
Axial and radial clearance values for labyrinth seals are given in Table 12.1.

Table 12.1 Clearance for labyrinth seals

Shaft diameter mm	Radial clearance on diameter mm	Axial clearance mm
~50	0.20~0.40	1~2
50~200	0.50~1.00	3~5

For oil lubrication, if projections are provided on the sleeve as shown in Fig. 12.7 (a), oil that flows out along the sleeve will be thrown off by centrifugal force and returned through ducts. In the example shown in Fig. 12.7 (b) oil leakage is prevented by the centrifugal force of the slinger.

Also, in Fig. 12.7 (c), a slinger can be mounted on the outside to prevent dust and other solid contaminants from entering.



(a) (b) (c)

Fig. 12.7 Slinger

12.2 Contact seals

Contact seals accomplish their sealing action through the constant pressure of a resilient part of the seal on the sealing surface. Contact seals are generally far superior to non-contact seals in sealing efficiency, although their friction torque and temperature rise coefficients are somewhat higher.

The simplest of all contact seals are felt seals. Used primarily for grease lubrication (Fig. 12.8), felt seals work very well for keeping out fine dust, but are subject to oil permeation and leakage to some extent. Therefore, the Z type rubber seal shown in Fig. 12.9 and GS type shown in Fig. 12.10, have been used more widely.

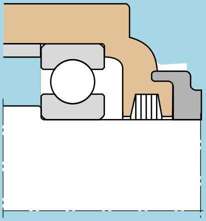


Fig. 12.8 Felt seal

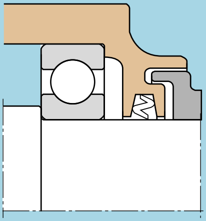


Fig. 12.9 Z Grease seal

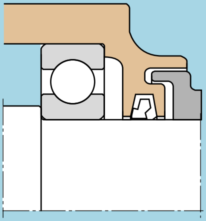


Fig. 12.10 GS Grease seal

Oil seals are used very widely and commonly, so their shapes and dimensions are standardized under JIS B2402. Using a ring shaped coil spring in the lip to exert optimum contact pressure and also to allow the seal lip to follow the shaft runout, gives this type of seal excellent sealing efficiency.

The direction of the sealing action changes depending on which direction the lip faces. If the lip faces outward (Fig. 12.11 (a)), it will protect against dust, water and other contaminants entering the bearing. If the lip faces inward (Fig. 12.11 (b)), it can prevent lubricant leakage from the housing.

For needle roller bearings, NTN's special seals are now available (see page E-82). Depending upon usage conditions, the seal lip may be made of nitrile rubber, silicone rubber, fluorinated rubber or PTFE resin etc.

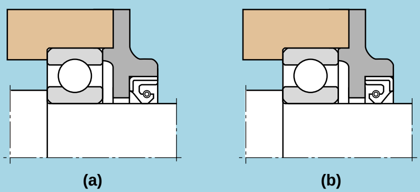


Fig. 12.11 Oil seal

V-ring seals shown in Fig. 12.12 are used for either oil or grease lubrication. As only the edge of the V-ring makes contact with the comparatively large seal lip, it is able to follow any side runout.

V-ring seals are very suitable for high speeds as the V-ring contacts the seal lip with only light contact pressure. For lip sliding speeds in excess of 12 m/s, the fit of the seal ring is lost and it needs to be held in place with a clamping band.

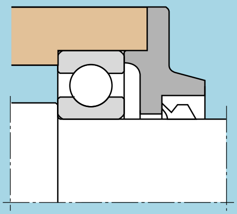


Fig. 12.12 V-Ring seal

These seals are made of elastic, high polymer material, and, depending on the type of material, they can be used for wide range of operational temperatures. The limiting operating temperature ranges for various materials are shown in Table 12.2.

Table 12.2 Permissible temperature of seals

Seal material		Permissible operating temperature range °C
Synthetic rubber	nitrile	–25 to 100
	acrylic	–15 to 160
	silicone	–70 to 230
	fluorinated	–30 to 220
PTFE synthetic resin		–50 to 220
Felt		–40 to 120

Allowable speeds for contact seals vary with the type of lubrication, operating temperature, roughness of the sealing contact surface, etc. A general reference chart showing allowable speeds for seal types is shown in Table 12.3.

Table 12.3 Allowable rubbing speed for seals

Type	Allowable speed, m/s
Felt	4
Grease seal	6
Oil seal, nitrile rubber	15
Oil seal, fluorinated rubber	32
V-ring	40

The general relationship between the shaft contact sealing surface roughness (R_a) and seal lip speed is shown in Table 12.4. In order to increase water resistance of the shaft, it should be heat treated or hard chrome plated, etc. The surface hardness of the shaft should be at least HRC40 or above, and if possible over HRC55.

Table 12.4 Surface roughness of shafts

Circumferential speed m/s		Surface roughness R_a
over	incl.	
	5	0.8a
5	10	0.4a
10		0.2a

12.3 Combination seals

Where operating conditions are especially severe (large amounts of water, dust, etc.), or in places where pollution caused by lubricant leakage cannot be tolerated; seals may be used in combination. Fig. 12.13 shows a combined labyrinth and oil groove slinger seal, and Fig. 12.14 shows a contact and non-contact seal combination.

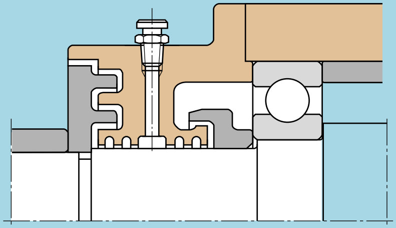


Fig. 12.13 Non-contact combination seal

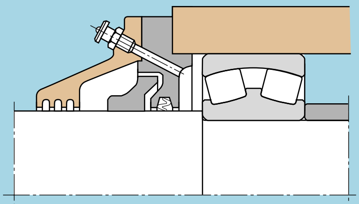


Fig. 12.14 Combined seal