12. External bearing sealing devices

External seals have two main functions: to prevent lubricating oil from leaking out of the bearing, and to prevent dust, water, and other contaminants from entering inside the bearing. When selecting a seal, the following factors should be considered, in addition to the application's operating conditions: Type of lubricant (grease or oil), seal lip speed, shaft misalignment, space limitations, seal friction and heat generation, and cost.

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

- **Non-contact seals**: Non-contact seals utilize a small clearance between the shaft and the housing, or between the shaft and sealing apparatus. Therefore friction is negligible, making them suitable for high speed applications.

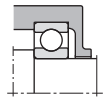
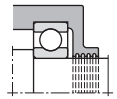
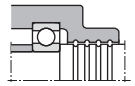
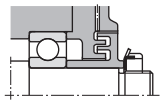
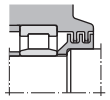
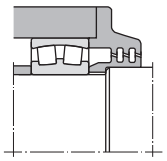
  In order to improve sealing capability, the gaps between the shaft and sealing apparatus are often filled with lubricant.

- **Contact seals**: A contact seal is a seal in which a molded synthetic rubber lip on a steel plate is pressed against the shaft. Contact seals are generally far superior to non-contact seals in sealing effectiveness, although their friction torque and temperature rise coefficients are higher. Furthermore, because the lip portion of a contact seal slides while in contact with the shaft, the allowable lip speed may vary based on the seal design.

  The surface at which the seal lip contacts the shaft must be lubricated. Ordinary bearing lubricant can also be used for this purpose.

  Table 12.1 lists the special characteristics of seals and other points to be considered when choosing an appropriate seal.

Table 12.1 Seal characteristics and selection considerations

Type	Seal construction	Designation	Seal characteristics and selection considerations
Non-contact seals		**Clearance seal**	This is an simple seal design with a small radial clearance between the shaft and housing.
		**Oil groove seal** (oil grooves on housing side)	Several concentric oil grooves are provided on the housing bore diameter to improve the sealing effectiveness. When the grooves are filled with lubricant, the ingress of external contaminants is prevented.
		**Oil groove seal** (oil grooves on shaft side and housing side)	Oil grooves are provided on both the shaft outside diameter and housing bore diameter for a seal with even greater sealing effectiveness.
		**Axial labyrinth seal**	This seal has a labyrinth passageway on the axial side of the housing.
		**Radial labyrinth seal**	A labyrinth passageway is located on the radial side of the housing. For use with split housings. This offers better sealing effectiveness than axial labyrinth seals.
		**Aligning type labyrinth seal**	The seal's labyrinth passageway is slanted and has sufficient clearance to prevent contact between the housing projections and the shaft, even as the shaft realigns.

Cautionary points regarding selection

- In order to improve sealing effectiveness, clearances between the shaft and housing should be minimized. However, care should be taken to confirm shaft/bearing rigidity and other factors to avoid direct contact between the shaft and housing during operation.

Oil groove clearance (reference)

Shaft diameter mm	Clearance mm
Up to 50	0.2–0.4
50 or more	0.5–1.0

- Oil groove width, depth (reference)
  Width: 2 to 5 mm
  Depth: 4 to 5 mm
- Three or more oil grooves should be provided.
- Sealing effectiveness can be further improved by filling the oil groove portion with grease of which ASTM worked penetration is 150 to 200.
- Grease is generally used as the lubricant for labyrinth seals, and, except in low speed applications, is commonly used together with other sealing devices.

Cautionary points regarding selection

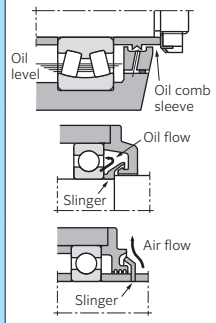
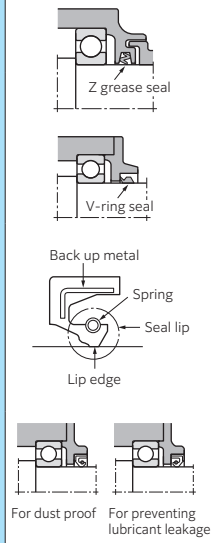
- In order to improve sealing effectiveness, labyrinth passageway clearances should be minimized. However, care should be taken to confirm shaft/bearing rigidity, fit, internal clearances and other factors to avoid direct contact between labyrinth projections during operation.

Labyrinth clearance (reference)

Shaft diameter mm	Clearance mm	
	Radial direction	Axial direction
Up to 50	0.2–0.4	1.0–2.0
50 to 200	0.5–1.0	3.0–5.0

- Sealing effectiveness can be further improved by filling the labyrinth passageway with grease of which ASTM worked penetration is 150 to 200.
- Labyrinth seals are suitable for high speed applications.

External Bearing Sealing Devices

Type	Seal construction	Designation	Seal characteristics and selection considerations
Non-contact seals		**Oil comb sleeve**	In this design, lubricating oil that makes its way out of the housing along the shaft is thrown off by projections on the oil comb sleeve and recirculated.
		Slinger provided in the housing	Seal type whereby a slinger is provided in the housing that prevents lubricant from leaking by centrifugal force produced via rotation.
		Slinger provided outside the housing	By mounting a slinger on the outside of the housing, centrifugal force helps to prevent dust and other solid contaminants from entering.
			Cautionary points regarding selection • Seal type that utilizes centrifugal force of the slinger mounted on rotating shaft. • If mounted on the inside of the housing, the slinger should function to seal in lubricant by the centrifugal force produced by rotation. • If mounted on the outside of the housing, the slinger should function to seal out foreign matter by the fan effect produced by rotation. • These seal types are commonly employed together with other sealing devices.
Contact seals		**Z grease seal**	In cross section resembling the letter "Z"; this seal's empty spaces are filled with grease. The seal is commonly used with a plummer block (housing).
		V-ring seal	This design enhances sealing efficiency with a lip that seals from the axial direction. With the aid of centrifugal force, this seal also offers effective protection against dust, water, and other contaminants entering the bearing. Can be used for both oil and grease lubrication. At seal peripheral speeds in excess of 12 m/s, seal ring fit is lost due to centrifugal force, and a clamping band is necessary to hold it in place.
		Oil seal	Oil seals are widely used, and their shapes and dimensions are standardized under JIS B 2402. In this design, a ring-shaped spring is installed in the lip section. As a result, contact pressure is exerted between the lip edge and shaft surface, and sealing effectiveness is good. When the bearing and oil seal are in close proximity, the internal clearance of the bearing may be reduced by heat produced by the oil seal. In addition to considering the heat generated by contact seals at various peripheral speeds, internal bearing clearances must also be selected with caution. Depending on its orientation, the seal may function to prevent lubricant from leaking out or foreign matter from getting in.

Cautionary points regarding selection

Shaft surface roughness (reference)

Peripheral speed m/s	Surface roughness *Ra*	Surface roughness *Rz*
Up to 5	0.8	3.2
5 to 10	0.4	1.6
10 or more	0.2	0.8

Shaft material (reference)

Material	Machine structural carbon steel Low carbon alloy steel Stainless steel
Surface hardness	HRC 40 or more necessary HRC 55 or more advisable
Processing method	Final grinding without repeat (moving), or buffed after hard chrome plating

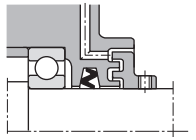
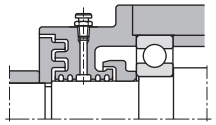
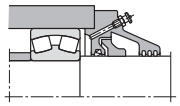
Allowable speed/temperature according to seal type/material (reference)

Seal type/material		Allowable peripheral speed m/s $V(\mathrm{m/s}) = \frac{\pi \times d\,(\mathrm{mm}) \times n\,(\mathrm{min^{-1}})}{60\,000}$	Allowable temp °C
Oil seal	Nitrile rubber	16 or below	−20 to 120
	Acrylic rubber	26 or below	−15 to 150
	Fluorinated rubber	32 or below	−20 to 230
Z grease seal	Nitrile rubber	6 or below	−20 to 120
V-ring	Nitrile rubber	40 or below	−20 to 120

External Bearing Sealing Devices

NTN

Commentary

Type	Seal construction	Designation	Seal characteristics and selection considerations
Combination seals		**Z-seal + Labyrinth seal**	This is an example of an axial labyrinth seal which has been combined with a Z-seal to increase its sealing effectiveness. The axial labyrinth seal is affixed to the shaft with a setting bolt or other method. In the diagram on the left, both the direction of the Z-seal and the labyrinth seal are oriented to keep dust and other contaminants out of the bearing. Because a Z-seal has been incorporated, the allowable peripheral speed should not exceed 6 m/s.
		**Labyrinth seal + Oil groove seal + Slinger**	This is an example of a combination of three different non-contact seals. It has the advantage of preventing both lubricant leakage from inside the bearing and infiltration of dust and other contaminants from the outside. It is widely used on mining equipment and as a sealing system with plummer blocks in extremely dusty application conditions.
		**Oil groove seal + Slinger + Z-seal**	This is an example where an oil groove seal and slinger have been combined with a Z-seal to increase its sealing efficiency. In the diagram on the left, all three seals have been oriented to keep dust and other contaminants out of the bearing. It is widely used on mining equipment and as a sealing system with plummer blocks in extremely dusty application conditions.