13. Bearing seals

Bearing seals have two main functions: to prevent lubricating oil from leaking out, and to prevent dust, water, and other contaminants from entering the bearing. Bearings have to be adequately lubricated to prevent direct metallic contact between the rolling elements, raceways and cages., to prevent wear and to protect the bearing surfaces against corrosion.

13.1 Sealed bearings

Bearings with shields or seals filled with grease are widely used. Grease has the advantage over oil that it is more easily retained in the bearing arrangement. These bearings has the following advantages:

(1) Lubricated for life and maintenance-free

(2) Suited for normal and light load, modrate and low speed

(3) Low production cost

(4) No need of relubrication of greasing

According to the above advantages and their simplicity of housing and seal design, these bearings are widely used in electric appliance and electric motor industries. Table 13-1 list three types of shielded and sealed bearings and their construction and characteristics.

13.2 Sealing devices

When selecting a seal, the following factors need to be taken into consideration: the type of lubricant (oil or grease), seal peripheral speed, shaft fitting errors, space limitations, seal friction and resultant heat increase, and cost. Sealing devices for rolling bearings fall into two main classifications: non-contact seals and contact seals.

13.2.1 Non-contact seals

Non-contact seals utilize a small clearance between the shaft and the housing cover. Therefore friction is negligible, making them suitable for high speed applications. In order to improve sealing capability, clearance spaces are often filled with lubricant.

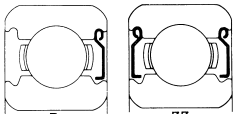
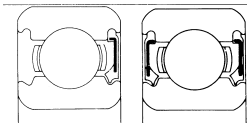
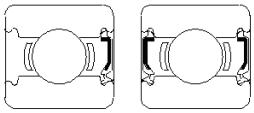
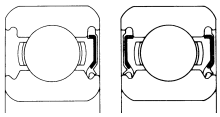
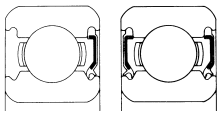
13.2.2 Contact seals

Contact seals accomplish their sealing action through the contact pressure of a resilient part of the seal (the lip is often made of synthetic rubber) and 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 higher. Furthermore, because the lip portion of a contact seal rotates while in contact with the shaft, the allowable seal peripheral speed varies depending on seal type.

Lubrication is necessary at the contact surface between the lip portion of the contact seal and the shaft. Ordinary bearing lubricant can also be used for this purpose.

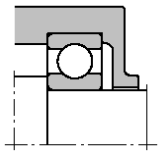
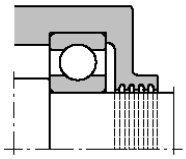
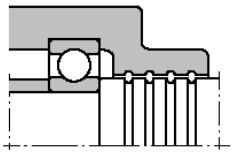
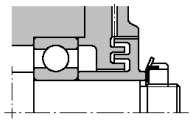
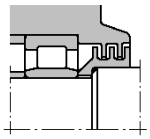
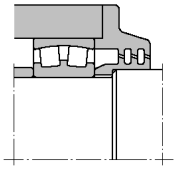
The following chart lists Table 13-2~13-4 the special characteristics of seals and other points to be considered when choosing an appropriate seal.

Table13-1 Construction and characteristics of shielded and sealed bearings

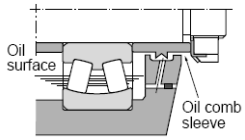
Code	Type and construction	Explanation
Z ZZ	 SHIELD	• Metal shield plate is affixed to outside ring • Inner ring incorporates a V-groove and labyrinth clearance • Non-contact type • Low torque • Limiting speed same as open type • Very good in dust proofing, poor in water proofing, relative wide allowable temperature range
LB LLB	 SEAL	• Outer ring incorporates synthetic rubber molded to a steel plate • Seal edge is aligned with V-groove along inner ring surface with labyrinth clearance • Non-contact type • Low torque • Limiting speed same as open type • Better than ZZ-type in dust proofing, poor in water proofing • Allowable temperature range: -25~120°C
LU LLU	 Standard SEAL	• Outer ring incorporates synthetic rubber molded to a steel plate • Seal edge contacts V-groove along inner ring surface • Contact type • Medium to low torque as standard • Excellent in dust proofing, very good in water proofing • Allowable temperature range: -25~120°C
LU-X LLU-X	 SEAL	• Outer ring incorporates synthetic rubber molded to a steel plate • Seal edge contacts V-groove along inner ring surface • Contact type • Rather high torque • Excellent in dust proofing, very good in water proofing, better than LLU seals • Allowable temperature range: -25~120°C
LH LLH	 SEAL	• Outer ring incorporates synthetic rubber molded to a steel plate • Basic construction the same as LU type, but specially designed lip on edge of seal prevents penetration by foreign matter • Contact type • low torque construction; Much better that LLU-type • Much better that LLB-type in dust proofing, very good in water proofing • Allowable temperature range: -25~120°C

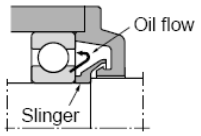
Please consult TPI about applications which exceed the allowable temperature range of products listed on this table.

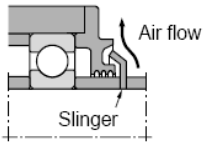
Table13-2 Non-contact seals

<table>
<tr><th>Type</th><th>Seal construction</th><th>Seal characteristics and selection considerations</th></tr>
<tr><td>Clearance seal</td><td>  </td><td>This is an extremely simple seal design with a small radial clearance. • In order to improve sealing efficiency, 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 shaft-housing contact during operation.</td></tr>
<tr><td>Oil groove seal</td><td> 
  </td><td>Several concentric oil grooves are provided on the housing inner diameter to greatly improve the sealing effect. When the grooves are filled with lubricant, the intrusion of contaminants from the outside is prevented.
Oil groove clearance (reference)
<table><tr><th>Shaft diameter mm</th><th>Clearance mm</th></tr><tr><td>50 Up to
50 or above</td><td>0.2～0.4
0.5～1.0</td></tr></table></td></tr>
<tr><td>Labyrinth</td><td> 
a. Axial labyrinth seal
 
b. Radial labyrinth seal
 
c. Aligning labyrinth seal</td><td>This seal has a labyrinth passageway on the axial side of the housing.

A labyrinth passageway is affixed to the radial side of the housing. For use with split housings. This offers better sealing efficiency than axial labyrinth seals.

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.
Labyrinth clearance (reference)
<table><tr><th rowspan="2">Shaft diameter mm</th><th colspan="2">Clearance mm</th></tr><tr><th>Radial direction</th><th>Axial direction</th></tr><tr><td>—～ 50
50～200</td><td>0.2～0.4
0.5～1.0</td><td>1.0～2.0
3.0～5.0</td></tr></table></td></tr>
<tr><td>Slinger</td><td> 

a. Oil comb sleeve
 

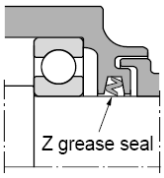
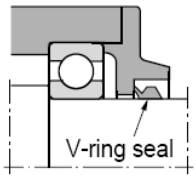
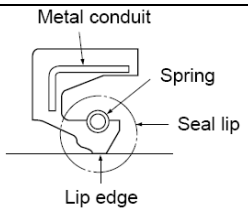
b. Internal slinger
 

c. External slinger</td><td>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.

By providing a slinger inside the housing, centrifugal force guides the lubricant flow back on the bearing and helps prevent it from dirtying the work environment.

By mounting a slinger on the outside of the housing, centrifugal force helps to prevent dust and other solid contaminants from entering.</td></tr>
</table>

Table13-3 Contact seals

<table>
<tr><th>Type</th><th>Seal construction</th><th>Seal characteristics and selection considerations</th></tr>
<tr><td>Z grease seal</td><td> 
</td><td>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 (bearing housing).</td></tr>
<tr><td>V-ring seal</td><td> 
</td><td>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. Grease can be used on both sides of the seal. 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.</td></tr>
<tr><td>Oil seal</td><td> 

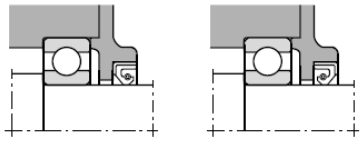
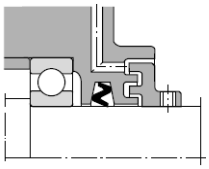
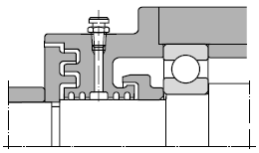
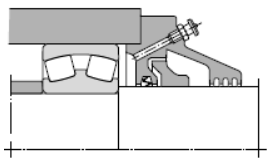

</td><td>Oil seals are widely used, and their shapes and dimensions are standardized under JIS B 2402.
In this design, a ring-shaped spring is installed in the lip section. As a result, optimal contact pressure is exerted between the lip edge and shaft surface, and sealing efficiency is good.
When the oil seal and the bearing are in very close proximity, internal bearing clearances are sometimes too small to accommodate the additional heat generated by friction between the seal and shaft.
In addition to considering the heat generated by contact seals at various peripheral speeds, internal bearing clearances must also be selected with caution. Depending upon the direction in which the lip faces (in toward the bearing or away from the bearing) contact oil seals are very effective at preventing lubricant leakage from the housing or contaminants from infiltrating the bearing.
Allowable speed/temperature according to seal type/material (reference)
<table>
<tr><th colspan="2">Seal type/material</th><th>Allowable peripheral speed m/s $\left(v_{(m/s)}=\frac{\pi \times d_{(mm)} \times n_{(r/min)}}{60,000}\right)$</th><th>Allowable temp °C</th></tr>
<tr><td rowspan="3">Oil seals</td><td>Nitrile rubber</td><td>16 or less</td><td>-25 〜+120</td></tr>
<tr><td>Acrylic rubber</td><td>26 or less</td><td>-15 〜+150</td></tr>
<tr><td>Fluorinated rubber</td><td>32 or less</td><td>-30 〜+200</td></tr>
<tr><td>Z-seal</td><td>Nitrile rubber</td><td>6 or less</td><td>-25 〜+120</td></tr>
<tr><td>V-ring</td><td>Nitrile rubber</td><td>40 or less</td><td>-25 〜+120</td></tr>
</table></td></tr>
</table>

Table13-4 Combination seals

<table>
<tr><th>Type</th><th>Seal construction</th><th>Seal characteristics and selection considerations</th></tr>
<tr><td>Z-seal + Labyrinth seal</td><td>  </td><td>This is an example of an axial labyrinth seal which has been combined with a Z-seal to increase its sealing efficiency. 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.</td></tr>
<tr><td>Labyrinth seal + Oil groove seal + Slinger</td><td>  </td><td>This is an example of an axial labyrinth seal which has been combined with a Z-seal to increase its sealing efficiency. 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.</td></tr>
<tr><td>Oil groove seal + Slinger + Z-seal</td><td>  </td><td>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. The combination is widely used on mining equipment and as a sealing system with plummer blocks in extremely dusty application conditions.</td></tr>
</table>