PIP REEP005
Guidelines for Selection of
General Rotating Equipment Bearing
Lubrication Methods
PURPOSE AND USE OF PROCESS INDUSTRY PRACTICES

In an effort to minimize the cost of process industry facilities, this Practice has been prepared from the technical requirements in the existing standards of major industrial users, contractors, or standards organizations. By harmonizing these technical requirements into a single set of Practices, administrative, application, and engineering costs to both the purchaser and the manufacturer should be reduced. While this Practice is expected to incorporate the majority of requirements of most users, individual applications may involve requirements that will be appended to and take precedence over this Practice. Determinations concerning fitness for purpose and particular matters or application of the Practice to particular project or engineering situations should not be made solely on information contained in these materials. The use of trade names from time to time should not be viewed as an expression of preference but rather recognized as normal usage in the trade. Other brands having the same specifications are equally correct and may be substituted for those named. All Practices or guidelines are intended to be consistent with applicable laws and regulations including OSHA requirements. To the extent these Practices or guidelines should conflict with OSHA or other applicable laws or regulations, such laws or regulations must be followed. Consult an appropriate professional before applying or acting on any material contained in or suggested by the Practice.

This Practice is subject to revision at any time.
# PIP REEP005
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1. **Scope**

This Practice provides guidelines for selecting lubrication methods for bearings in general rotating equipment applications.

This Practice describes the product-lubrication, grease, wet sump, dry sump, and pressure-fed lubrication methods for lubricating bearings, and provides guidance for applying the methods to various applications.

2. **References**

Applicable parts of the following industry codes and standards and references shall be considered an integral part of this Practice. The edition in effect on the date of contract award shall be used, except as otherwise noted. Short titles are used herein where appropriate.

2.1 **Industry Codes and Standards**

- American Petroleum Institute (API)
  - Std. 614 - *Lubrication, Shaft-sealing, and Control-Oil Systems and Auxiliaries for Petroleum, Chemical, and Gas Industry Services*

3. **Definitions**

*miscibility*: the ability of two liquids, not mutually soluble, to mix

*wet sump method* (a.k.a. *oil-flooded method*): a static lubrication method using immersion or partial immersion of a bearing in oil

*dry sump method* (a.k.a. *pure oil mist method*): a lubrication method using only oil mist on a bearing

*service life*: the time period that a lubricant can reliably serve 99% of bearings in similar service without detrimental effect on bearing life

4. **General**

The lubrication method best suited for bearings in general rotating equipment applications should be based on the type, size of bearing, shaft speed, load on the bearing, available infrastructure, maintenance accessibility, and life cycle cost considerations.

5. **Product-Lubricated Bearings**

5.1 Product-lubricated bearings are typically provided in vertical turbine pumps and sealless pumps with sleeve bearings.

5.2 Product is used as a hydrodynamic fluid for supporting the pump shaft within one or more sleeve bearings.
5.3 In some cases, an external source of clean product may be required for the lubrication of the bearings.

5.4 Product-lubricated bearings may have axial or helical grooves to promote cooling and lubrication.

5.5 Except for sealless pumps, sleeve bearings are typically made of rubber, carbon, carbon-filled polytetrafluoroethylene (PTFE), or metal (e.g., bronze). Compatibility of the pumped fluid with the bearing material is critical to the success of product-lubricated bearings. If the pumped fluid is chemically active or contains solids, special considerations are required for selection of bearing materials.

5.6 For sealless pumps, pump manufacturer should be consulted for recommendations regarding product-lubricated bearing materials and design.

6. **Rolling Element Bearings**

6.1 **General**

6.1.1 Lubrication methods for rolling element bearings include grease, wet sump, and dry sump.

6.1.2 The reliability of rolling element bearings is heavily influenced by the loading, size, speed, bearing fit, alignment, and the temperature, viscosity, and cleanliness of the lubricant. Consequently, the lubricant should be maintained uncontaminated and within the appropriate temperature range to permit required flow and avoid deterioration.

6.2 **Grease Method**

6.2.1 The grease lubrication method is typically limited to equipment that operates at relatively low speeds and temperatures.

6.2.2 The grease lubrication method is used more often in vertical pumps than in horizontal pumps because of the difficulty of retaining oil in vertical pump bearing housings.

6.2.3 Grease may be packed in a bearing and sealed at the factory, or packed in a bearing housing surrounding the bearing. This is not always consistent among equipment manufacturers and should be confirmed by the manufacturer before the equipment is commissioned.

6.2.4 Grease in a bearing should be replaced or supplemented when it reaches its service life. Service life of grease depends on the type of grease; load, size, and speed of the bearing; and the environment. A bearing environment consisting of high temperatures and contaminants negatively influences service life.

6.2.5 The cost of lubrication is generally significantly less than the resulting cost of failing to lubricate often enough. Therefore, there exists the common tendency to over-grease the bearing. However, significant damage to equipment can often be attributed to over-greasing. Therefore, procedures developed for filling a bearing with grease should include instructions for the bearing drain plug to be removed and left open through the filling process and until the equipment has been operated for a time at a stable temperature.
6.2.6 Sealed-for-Life Bearings

6.2.6.1 Sealed-for-life bearings do not require lubrication for the life of the bearing. Sealed-for-life does not mean for the life of the equipment but the life of the bearing. Therefore, an appropriate bearing life should be calculated to confirm the suitability of sealed-for-life bearings for a particular equipment application.

6.2.6.2 Sealed-for-life bearings may be considered for applications where the bearing lubrication interval, determined by the service and environment, is sufficiently long and greasing is not required between equipment overhauls.

6.2.6.3 Sealed-for-life bearings should not be used in heavily loaded equipment applications where lubrication is required at intervals shorter than acceptable for the overhaul of the equipment.

6.2.7 Mixing Greases

6.2.7.1 Typically, mixing different types of grease should not be permitted.

6.2.7.2 During the operating life of the equipment, it may be required to use a new type of bearing grease because of the unavailability of the current grease or if the type of current grease is unknown. Procedures should be provided to ensure that the compatibility of the new and old greases is considered.

6.2.7.3 Greases with the same thickener (e.g., sodium, calcium, or lithium) and similar base oil can be mixed; however, chemical compatibilities should be confirmed before mixing. Typically, lithium- and calcium-based greases are miscible with each other but not with sodium-based greases.

6.2.7.4 Typically, mixing incompatible greases reduces the consistency of the mixture and, because the load capacity and operating temperature of the grease are affected, can cause bearing damage.

6.2.7.5 Caution is still warranted when mixing similar greases because the properties of the resultant mixture can be unpredictable and may not meet the needs of the service.

6.3 Wet Sump Methods

6.3.1 General

6.3.1.1 The wet sump lubrication method is the most common type used in horizontal rotating equipment where the lower section of the bearing housing serves as the sump.

6.3.1.2 Variations of the wet sump method, described later in this Practice, are the following:
   a. Simple-Wet-Sump Method
   b. Wet-Sump-with-Ring-Oil Method
   c. Wet-Sump-with-Flinger Method
   d. Wet-Sump-with-Purge-Mist Method
6.3.1.3 Wet sump lubrication methods should be used in conjunction with the following features for bearing isolation:

a. Bearing isolator seals that provide a positive static seal (e.g., dynamic O-ring) or magnetic-type bearing isolation seals. These types of bearing isolation seals provide a tight seal that precludes the ingress of atmospheric contaminants. Some labyrinth-type bearing isolation seals do not provide an atmospherically tight seal.

b. A diaphragm expansion chamber or a desiccant breather used in place of a vent. These devices preclude the ingress of atmospheric contaminants. These devices are not appropriate for wet-sump-with-purge-mist method lubrication applications.

c. A level gauge showing bearing oil level in conjunction with a constant level oiler with a pressure balancing line since internal pressures vary from slightly positive to slightly negative as the operating temperatures vary throughout the day.

6.3.2 Simple-Wet-Sump Method

6.3.2.1 The simple-wet-sump method is the standard lubrication method on many horizontal pumps.

6.3.2.2 If oil contamination or heat buildup in the bearing can occur, other lubrication methods should be considered for improved reliability.

6.3.2.3 The sump oil level should be maintained at the centerline of the lowest roller element in the bearing. This is accomplished by a constant level oiler with a typical capacity of 100 cc (4 ounces).

6.3.2.4 Problems that can occur with the simple-wet-sump method include the following:

a. If the oil level is high, frothing and foaming can occur, causing unnecessary heat to be generated and requiring additional power.

b. Proper oil level is confined to a small range. If the oil level falls below the lower rolling element, further lubrication is not possible.

c. In vented bearing housings that are not equipped with desiccant breathers, water vapor tends to condense inside the bearing housing, particularly on standby units. Water condensate displaces the lubricant and causes pitting of the lower rotating elements, resulting in shortened bearing life.

6.3.3 Wet-Sump-with-Ring-Oil Method

6.3.3.1 For the wet-sump-with-ring-oil method, a ring rides on the top of the shaft and within the oil sump. The ring is not attached but merely rests on top of the shaft. Typically, the ring rotates at about 50% of the shaft speed.

6.3.3.2 Maintenance of the proper oil level is critical to reliable operation. The ring bore should be immersed 6 mm to 9 mm (1/4 inch to 3/8 inch) in the oil.
6.3.3.3 The oil level is maintained so that the bottom of the ring is immersed in the oil sump. The oil is lifted and distributed as the ring turns.

6.3.3.4 An advantage of the wet-sump-with-ring-oil method, as compared with the simple-wet-sump method, is that the oil level is below the lowest rolling element, thus eliminating frothing and reducing heat and energy requirements.

6.3.3.5 Problems that can occur with the wet-sump-with-ring-oil method include the following:

a. During startup or in cold climates if the oil in the sump is too viscous, the ring can rotate at a significantly reduced speed which can restrict the oil from adequately lubricating the rolling elements.

b. For variable speed equipment applications, if the minimum speed of operation is too low, lubrication provided by the ring may not be adequate for reliable operation.

c. Rings that are out-of-round can fail to provide adequate lubrication.

d. Rings may wear, thereby contaminating the oil and shortening the bearing life.

6.3.4 Wet-Sump-with-Flinger Method

6.3.4.1 The wet-sump-with-flinger method is a commonly available lubrication method for most single-stage overhung pumps.

6.3.4.2 For the wet-sump-with-flinger method, a flinger (i.e., disc) is attached to the shaft. The flinger is immersed in the oil in the same manner as the ring-oil method.

6.3.4.3 Advantages of the wet-sump-with-flinger method include the following:

a. Typically more reliable than the simple-wet-sump method

b. Lubricates better than the ring-oil method for cold starts when the oil viscosity is higher

6.3.5 Wet-Sump-with-Purge-Mist Method

6.3.5.1 The wet-sump-with-purge-mist method incorporates features from the wet sump methods with the addition of an oil mist purge.

6.3.5.2 The oil mist purge is typically supplied from a central oil-mist-generating console. The droplet size of the oil mist purge is smaller than produced in the dry sump method (see Section 6.4) and does not directly wet or lubricate a bearing.

6.3.5.3 Because the bearing housing is under a slight positive pressure from the oil mist purge, the following advantages are realized:

a. Elimination of atmospheric contamination

b. Increased mean time between bearing failures similar to the dry sump method
6.3.5.4 The wet-sump-with-purge-mist method does not take full advantage of the energy savings that can be attributed to the dry sump method.

6.3.5.5 Consideration should be given to the pressure balancing of this lubrication method by using proper venting.

6.3.5.6 Drain provisions should be considered with the wet-sump-with-purge-mist method because the sump oil level increases gradually.

6.4 Dry Sump Method

6.4.1 The dry sump lubrication method uses a central oil mist generator that provides compressed dry air, saturated with oil mist, directly to the bearing housing.

6.4.2 Advantages of the dry sump method include the following:

a. Because the lubricating oil is once through, bearing wear particles are washed out and not recycled.

b. Rolling element bearings tend to operate at a cooler temperature compared with wet sump oil systems.

c. A transparent collection chamber at the bottom of the dry sump collects the oil mist condensate. The oil can be examined for color changes or spectrometric tested, enabling early detection of bearing distress.

d. Less energy is consumed than the wet sump methods.

e. The positive pressure within the bearing housing eliminates atmospheric contaminants, reducing the potential for corrosion or wear.

f. Lubrication-based bearing failures and associated maintenance costs are reduced.

g. A central oil mist generator can serve multiple pumps.

6.4.3 Disadvantages of the dry sump method include the following:

a. Higher installation costs

b. Once-through use of lubricating oil

c. Potential for emitting oil-mist into the environment

d. Housekeeping issues (e.g., may leave an oil film in the area)

e. Oil-mist console is a possible single point failure for all equipment serviced.

Comment: If the equipment is shop-tested as wet sump and final installation is dry sump, the slinger ring should be removed or made of a composite material to minimize oil contamination.
7. Hydrodynamic Bearings

7.1 Hydrodynamic bearings are more typically used on horizontal between-bearing-type rotating equipment. They are seldom used on overhung-type rotating equipment.

7.2 Hydrodynamic bearings are typically lined with bearing babbitt. Babbitt materials normally operate below 90°C (200°F) and lose strength rapidly with increasing temperature. At 120°C (250°F), a bearing babbitt retains only half of its room temperature strength.

7.3 Hydrodynamic bearings have three primary lubrication methods:
   a. Wet-Sump-With-Ring-Oil
   b. Wet-Sump-With-Ring-Oil and oil sump circulation
   c. Pressure-fed

7.3.1 Wet-Sump-With-Ring-Oil (See Section 6.3.3.)

7.3.2 Wet-Sump-With-Ring-Oil and oil sump circulation
   7.3.2.1 Wet-sump-with-ring-oil and oil sump circulation includes a pump, filters, and cooler to remove heat and maintain cleanliness of the oil in the sump. It does not provide pressurized oil to the bearing.

7.3.3 Pressure-fed
   7.3.3.1 For general rotating equipment with hydrodynamic radial or thrust bearings, pressure-fed lubrication may be used.
   7.3.3.2 The pressure-fed lubricant acts as both a lubricant and coolant.
   7.3.3.3 The pressure-fed lubrication system is typically used for general rotating equipment that operates at higher horsepower and speed.
   7.3.3.4 Pressure-fed lubrication should be designed in accordance with API Std.614.
   7.3.3.5 The oil film in pressure-fed lubrication may be as thin as 0.005 mm (0.0002 inch). Therefore, the oil should be filtered to remove particles larger than the minimum oil film thickness. Oil filtration is critical in pressure-fed lubrication applications and should be a part of the design of the lubrication system.