TECHNICAL INSIGHT

NSK

PRODUCT AND APPLICATION ENGINEERING INFORMATION

A PUBLICATION OF NSK AMERICAS

LUBRICATION - OPTIMIZING BEARING LIFE

Lubrication is a critical component to extending bearing life. Without it the wear and heat caused by friction will quickly cause a bearing's life to come to a catastrophic end. Lubrication reduces friction between bearing components by providing a film that separates contacting surfaces. The thickness of this fluid film can directly correlate to the fatigue life of a bearing. A thick film will keep components separated and help increase life but if the film thickness is too thin the rolling surfaces will contact and cause life threatening friction.

The method of lubrication can also extend bearing life in other ways. Circulating lubrication may be used to dissipate heat by transferring it away from the bearing. This will keep the bearing cool and the reduce lubricant deterioration. Lubrication can also help prevent contaminants from entering the bearing and guard against corrosion.

GREASE AND OIL LUBRICATION

Either grease or oil lubrication can be used to ensure bearings run optimally and to reduce wear. The application and operating conditions have to be taken into account when choosing the type of lubrication. Different parameters and the recommended method of lubrication are listed in the table below.

TABLE 1: COMPARISON OF GREASE AND OIL LUBRICATION

Item	Grease Lubrication	Oil Lubrication
housing structure and sealing method	simple	may be complex, careful maintenance required
speed	limiting spirit is 65% to 80% of that with oil lubrication	higher limiting speed
cooling effect	poor	heat transfer is possible using forced oil circulation
fluidity	poor	good
full lubricant replacement	sometimes difficult	easy
removal of foreign matter	removal of particles from grease is impossible	easy
external contamination due to leakage	surroundings seldom contaminated by leakage	Often leaks without proper countermeasures. Not suitable if external contamination must be avoided.

TABLE 2: COMPOSITION OF LUBRICANTS

Grease consists of:	Oil consists of:
70 - 90% base oils	95 - 99% base oils
5 - 30% thickeners	-
1 - 5 % additives	1 - 5% additives

Base oils provide the lubricating media, thickeners give base oils a semi-solid consistency to maintain the lubricant at the point of contact, and additives change or improve various lubricant properties.

1. GREASE LUBRICATION

Increasingly high-performance machines need rolling bearings which fulfill the most exacting output and quality requirements. In order to meet the increasing demands and requirements of industry there are often a multitude of properties to consider when selecting a grease for your application.

Grease Selection Criteria

- Level of resistance to oxidation and heat / evaporation losses
- Load carrying ability
- Thickener / oil separation characteristics
- Consistency - NLGI grade
- Operating torque
- Temperature performance
- Chemical compatibility
- Noise level
- Water / corrosion resistance
- Compatibility with application materials
- Storage life
- Cost

Grease Quantity

Packing a bearing and housing with the appropriate amount of grease depends on a number of factors. Housing design and space, grease characteristics, and ambient temperature all factor into determining the initial grease quantity. Sufficient grease must be packed inside the bearing, including the cage guide face. The available space inside the housing to be packed with grease depends on the speed as follows:

- 1/2 to 2/3 of the space if the speed of rotation is less than 50% of the bearing limiting speed.
- 1/3 to 1/2 of the space if the speed of rotation is more than 50% of the bearing limiting speed.

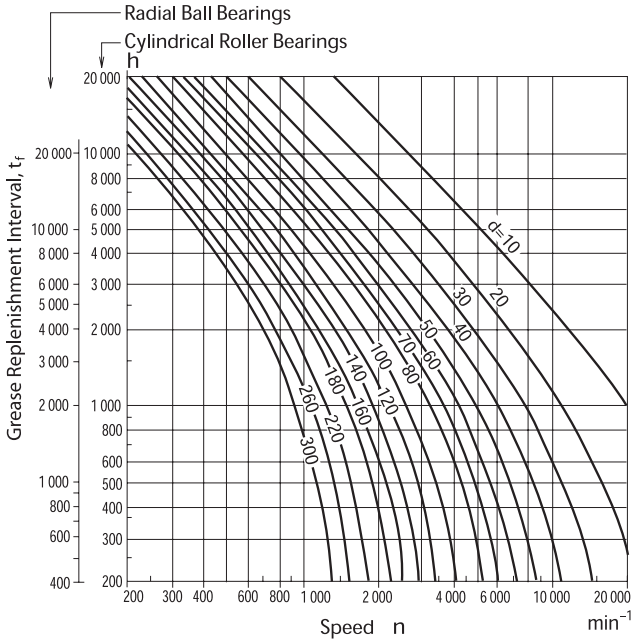
Replenishing Grease

Usually, grease does not need replenishing for a long time. In demanding operating conditions, such as high bearing temperatures or loads, grease has to be replenished or changed regularly. If lubrication is needed at short intervals, filling and draining nozzles must be set in suitable positions so that used grease can be replaced with fresh lubricant.

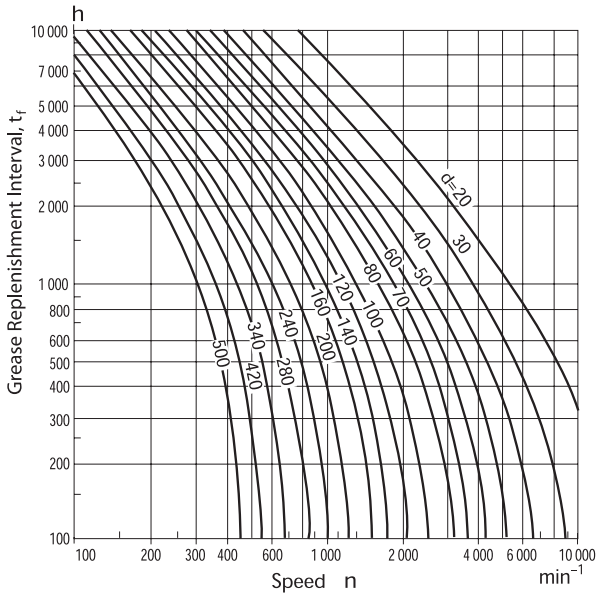
Even if high-quality grease is used, there is deterioration of its properties with time; therefore periodic replenishment is recommended. Chart 1 can be used to determine the replenishment interval for various bearing types at varying loads and speeds. For temperatures exceeding 70°C the replenishment time must be reduced by half for every 15°C temperature rise. This chart is to be used for high-quality lithium soap thickened-mineral oil greases. Loading adjustment can be determined by using the factors from Section 3 of Chart 1.

Sealed and shielded bearings are greased for the life of the bearing and should not be replenished with lubricant.

CHART 1: GREASE REPLENISHMENT INTERVALS



(1) Radial Ball Bearings, Cylindrical Roller Bearings



(2) Tapered Roller Bearings, Spherical Roller Bearings

(3) Load factor

P/C	0.06	0.1	0.13	0.16
Load factor	1.5	1	0.65	0.45

2. OIL LUBRICATION

Oil lubrication is most suitable for high limiting speeds. Generally speaking, oil lubrication systems are more complex and need careful maintenance.

The lubricating oils used for rolling bearings are normally highly refined mineral and synthetic oils with high levels of oil film strength plus excellent resistance to oxidation and corrosion. When choosing a lubricating oil, it is important to consider its viscosity in the relevant operating conditions. If the viscosity is too low, a proper oil film will not be able to form, which can cause abnormal wear and smearing. However, if the viscosity is too high, the lubricant can cause excessive friction, leading to an increase in bearing temperature and a considerable loss of energy.

TABLE 3: BEARING TYPES AND PROPER VISCOSITY OF LUBRICATING OILS

Bearing Type	Proper Viscosity at Operating Temperature
ball bearings and cylindrical roller bearings	higher than 13 mm^2/s
tapered roller bearings and spherical roller bearings	higher than 20 mm^2/s
spherical thrust roller bearings	higher than 32 mm^2/s

Table 3 provides a general recommendation for operating viscosity of the oil for normal operating conditions.

Chart 3 is for use to select the proper lubricating oil viscosity grade. It shows the relationship between oil temperature and viscosity. The vertical axis is for locating the proper viscosity at operating temperature. Using both Table 3 and Chart 3 an oil viscosity can be selected.

CHART 3: TEMPERATURE - VISCOSITY CHART

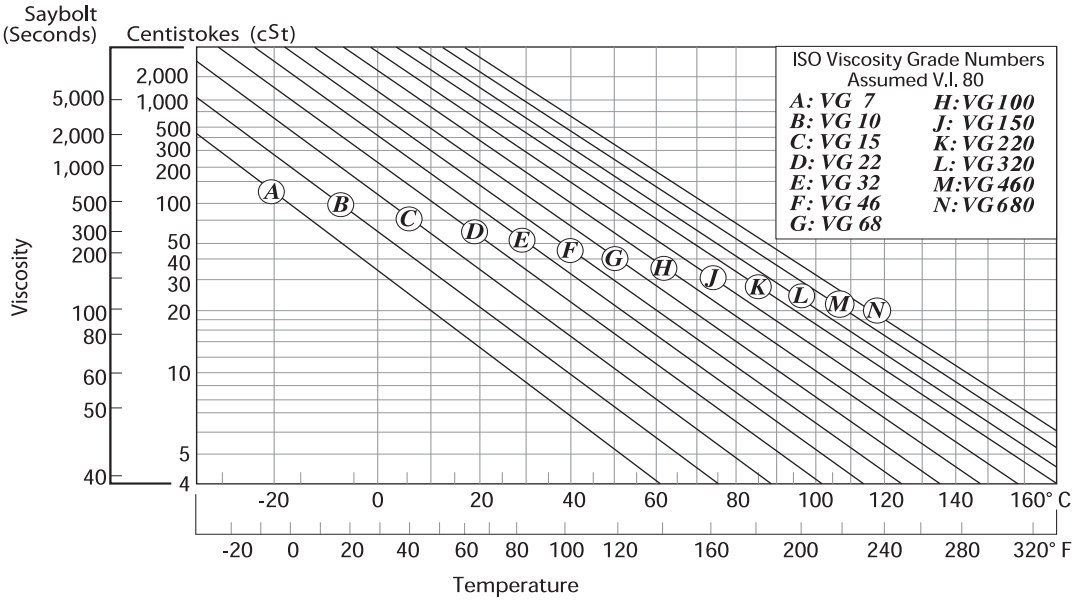


Table 4 provides common examples of lubrication oil grades based on oil temperature, bearing speed, and applied load. As shown, heavier oil grades are needed for higher operating temperatures, lower bearing speeds, and/or higher loads.

TABLE 4: EXAMPLES OF SELECTION OF LUBRICATING OILS

Operating Temperature	Speed	Light or Normal load	Heavy or Shock Load
-30 to 0°C	less than limiting speed	ISO VG 15, 22, 32 (refrigerating machine oil)	-
0 to 50°C	less than 50% of limiting speed	ISO VG 32, 46, 68 (bearing oil, turbine oil)	ISO VG 46, 68, 100 (bearing oil, turbine oil)
	50 to 100% of limiting speed	ISO VG 15, 22, 32 (bearing oil, turbine oil)	ISO VG 22, 32, 46 (bearing oil, turbine oil)
	more than limiting speed	ISO VG 10, 15, 22 (bearing oil)	-
50 to 80°C	less than 50% of limiting speed	ISO VG 100, 150, 220 (bearing oil)	ISO VG 150, 220, 320 (bearing oil)
	50 to 100% of limiting speed	ISO VG 46, 68, 100 (bearing oil, turbine oil)	ISO VG 68, 100, 150 (bearing oil, turbine oil)
	more than limiting speed	ISO VG 32, 46, 68 (bearing oil, turbine oil)	-
80 to 110°C	less than 50% of limiting speed	ISO VG 320, 460 (bearing oil)	ISO VG 460, 680 (bearing oil, gear oil)
	50 to 100% of limiting speed	ISO VG 150, 220 (bearing oil)	ISO VG 220, 320 (bearing oil)
	more than limiting speed	ISO VG 68, 100 (bearing oil, turbine oil)	-

Remarks: 1. For the limiting speed, use the values listed in the bearing tables.
2. Refer to Refrigerating Machine Oils (JIS K 2211), Bearing Oils (JIS K 2239), Turbine Oils (JIS K2213), Gear Oils (JIS K 2219).
3. If the operating temperature is near the high end of the temperature range listed in the left column, select a high viscosity oil.
4. If the operating temperature is lower than -30°C or higher than 110°C, it is advisable to consult NSK.

Different Types of Oil Lubrication:

1) Oil Bath Lubrication

Oil bath lubrication is often used for low and medium speeds. The oil level should be in the middle of the lowest rolling element. It is wise to install an oil gauge glass, so that you can monitor the correct oil level.

2) Oil Splash Lubrication

With this method, gear wheels or a flinger splash oil onto the bearings, without the bearings being dipped in oil. It is commonly used in transmissions and final drive gears.

3) Oil Circulating Lubrication

Oil circulating lubrication is commonly used for high-speed applications where bearings need to be cooled and used at high temperatures. With this method, oil is delivered on one side, it runs through the bearing and is then drained from the other side. Once it has been cooled in a storage tank, it passes through a pump and a filter, then fed back into the bearing. The outlet for the oil should be larger than the supply pipe so that surplus oil cannot back up.

4) Oil Injection Lubrication

Oil injection lubrication is often used for bearings with extremely high speeds, such as bearings in jet engines where the n x dm factor (dm: pitch circle diameter of the rolling element set in mm; n: speed in rpm) exceeds one million. With this system, pressurized lubricating oil is injected directly into the bearing by one or several nozzles. Using several nozzles enables more uniform cooling and a better temperature distribution for a minimal amount of oil.

5) Oil-Air Lubrication

With oil-air lubrication, a metering device periodically injects very small, consistent quantities of oil into pipes with a continuous flow of compressed air. The oil flows along the walls of the pipes at a constant speed. This type of lubrication is used in the main spindles of machine tools and other high-speed applications.

The Main Advantages of Oil-Air Lubrication Are:

- A minimum amount of oil is used, making this method suitable for high speeds because less heat is generated.
- The minimum amount of oil is always available, so the bearing temperature remains stable. Also, as little oil is used, there is virtually no air pollution.
- Only fresh oil is fed into the bearings so the oil does not deteriorate.
- The addition of compressed air generates a certain amount of overpressure. Dust and cutting oil cannot penetrate the system.

CONCLUSION

This information is a guideline to help select a starting point for bearing lubrication in your equipment. Bearing lubrication is not an exact science as many operating conditions can impact the lubricative properties and effectiveness. It is critical to monitor your bearing temperatures and make adjustments as necessary. Contact your NSK application engineer or lubrication supplier for additional support.