4. Bearing lubrication

The correct bearing lubrication has a direct influence on the bearing life. Lubricant creates between the rolling element and bearing ring a carrying lubricating film which hinders their metal contact. It lubricates surfaces where friction arises, it has cooling effect, it protects the bearing from corrosion and in many cases seals the bearing space. In the most cases - approximately 90%, bearings are lubricated with grease or oil, in rare exceptions by other lubricating means. When deciding which lubricant and which lubrication type should be used, operating conditions, characteristic qualities of the lubricant, equipment design and operating economy should be taken into account.

4.1 Grease lubrication

In the design practice grease lubrication is preferred to oil lubrication from the point of view of arrangement simplicity, utilization of the sealing capabilities and simple maintenance. For reliable bearing operation 1/3 to 1/2 of its free space is filled with grease at the first assembly. A greater grease amount has negative influence on the operation. Higher passive resistances cause the inner bearing space warming up undesirabely, which can lead to its breakdown. Bearings making only a small number of revolutions during operation, from the point of view of corrosion protection should be completely filled.

4.1.1 Relubrication Interval

Relubrication interval is the period during which the grease has the necessary lubricating properties. After this period bearing must be relubricated, and old lubricant must be removed from the bearing space completely. Relubricating period depends on the bearing type and size, rotational speed, operating temperature and grease quality. The recommended relubrication period for individual bearing types at normal load ($P \leq 0{,}15\ C$) and normal operational conditions is shown in diagrams in Figure 21 and 22. The diagrams are valid for common grease and temperatures to +70°C. For temperatures over +70°C, the relubrication period is shortened for each 15°C on the half of original value. For temperatures under +40°C the relubrication period can be doubled.
For small sized, especially single row ball bearings, the relubrication periods are several times longer than the bearing life, that is why the bearings are, as a rule, not relubricated.

For this reason it is advantageous to use these bearings shielded or sealed on both sides and filled with grease. For some rotational speeds the relubrication period is out of the diagram curve i.e. the permissible limit for grease lubrication has been reached and oil lubrication should be used.

Necessary grease quantity for relubrication is calculated from the equation:

$$Q = 0{,}005 \cdot D \cdot B$$

Q	- grease quantity	[g]
D	- bearing outer diameter	[mm]
B	- bearing width	[mm]

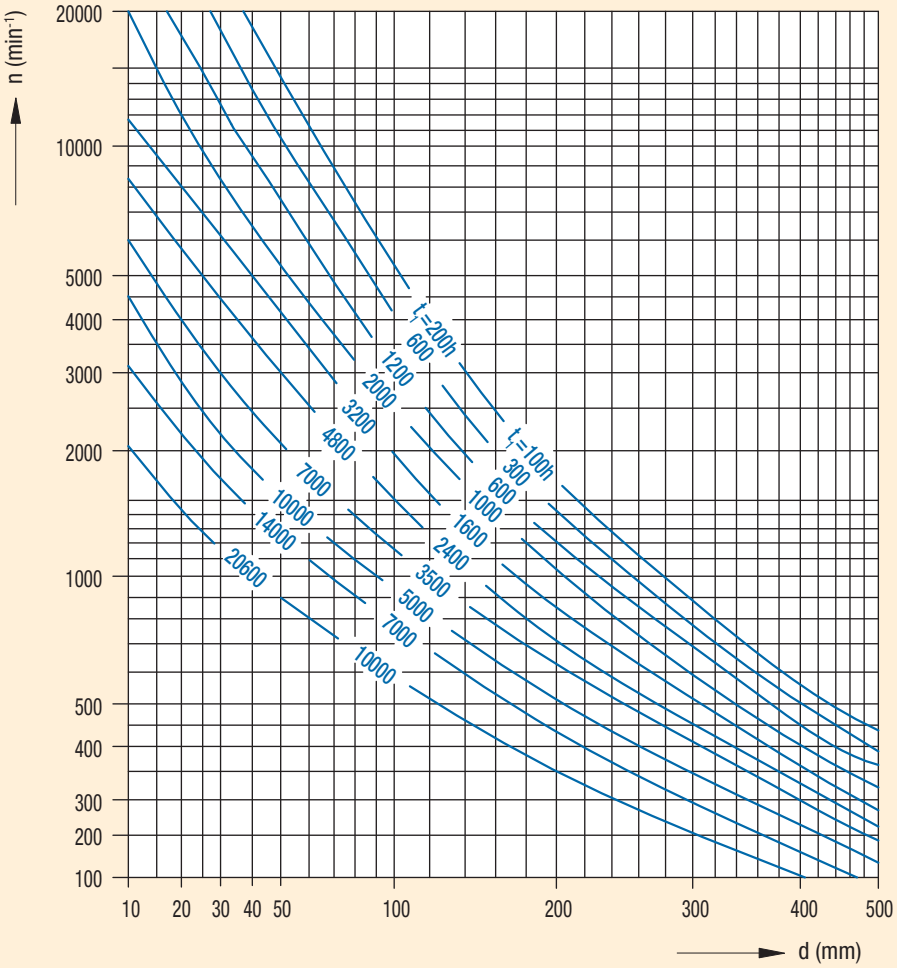
For bearings with higher rotational speed requiring a more frequent relubrication, it is necessary to remove the used lubrication from the bearing space so that temperature increase should not occur. For this reason the grease escape valve is suitable.

4.1.2 Bearing Grease

Bearing grease is produced most often of quality mineral or synthetic oils (sometimes with additives), thickened with fatty acid metallic soaps. Grease must have good lubricating properties and high chemical, temperature and mechanical stability. The grease list of bearing lubricants is in Table 36.

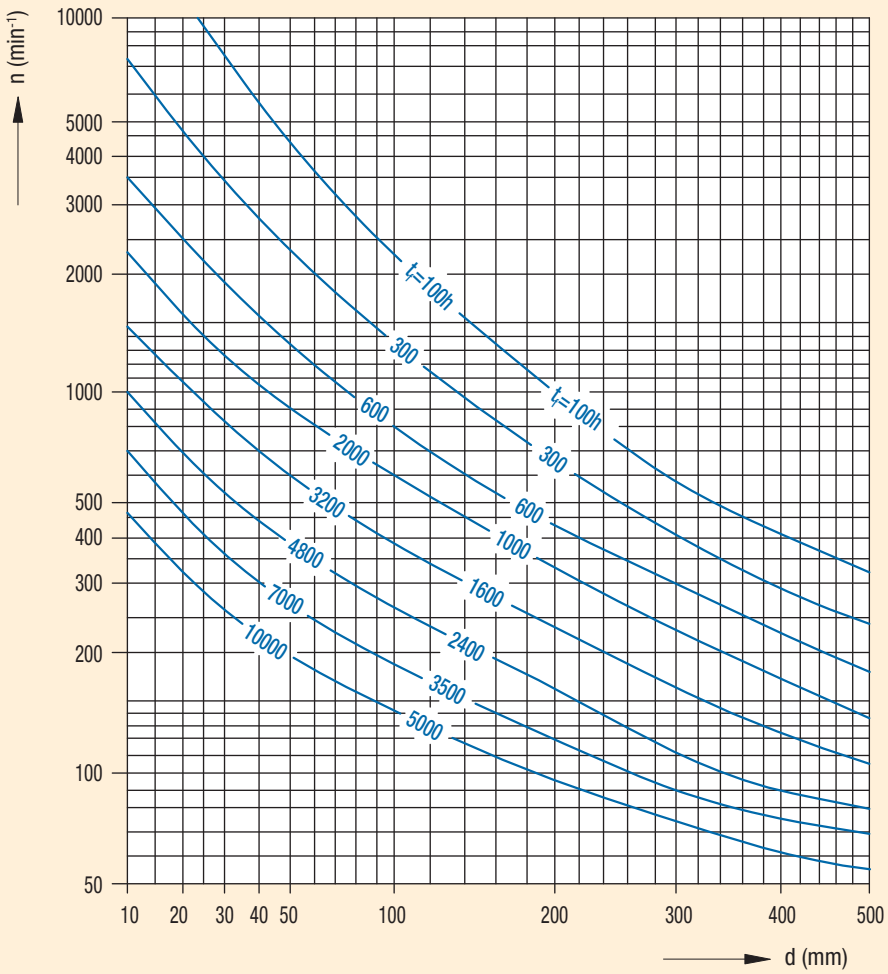
Rolling Bearing Grease Properties				Tab. 36
Kind of Grease		Properties		
Thickening Agent	Basic Oil	Operating Temperature Extent [°C]	Resistance against Water	Application
lithium soap	mineral	- 20 ÷ 130	resistant	multi-purpose lubricant
lime soap	mineral	- 20 ÷ 50	high resistant	good sealing effect against water
soda soap	mineral	- 20 ÷ 100	irresistant	emulsifies with water
aluminium soap	mineral	- 20 ÷ 70	resistant	good sealing effect against water
complex lithium soap	mineral	- 20 ÷ 150	resistant	multi-purpose lubricant
complex lime soap	mineral	- 30 ÷ 130	high resistant	multi-purpose lubricant suitable for higher temperatures and load
complex soda soap	mineral	- 20 ÷ 130	resistant	suitable for higher temperature and load
complex aluminium soap	mineral	- 20 ÷ 150	resistant	suitable for higher temperature and load
complex barium soap	mineral	- 30 ÷ 140	resistant	suitable for higher temperature and load
bentonite	mineral	- 20 ÷ 150	resistant	suitable for high temperatures at low rotational speed
polyurea	mineral	- 20 ÷ 160	resistant	suitable for high temperatures at medium rotational speed
lithium soap	silicon	- 40 ÷ 170	high resistant	suitable for wide temperature range at medium rotational speed
complex barium soap	ester	- 60 ÷ 140	resistant	suitable for higher temperatures and higher rotational speeds

Figure 21


n (min⁻¹)
20000
10000
5000
4000
3000
2000
1000
500
400
300
200
100
10
20
30
40
50
100
200
300
400
500
d (mm)
t_h=200h
600
1200
2000
3200
4800
7000
10000
14000
20600
t_h=100h
300
600
1000
1600
2400
3500
5000
7000
10000

Valid for double row spherical roller bearings, single row tapered roller bearings and thrust ball bearings

Figure 22



4.2 Oil lubrication

Oil lubrication is used, when operating rotational speed is so high that the grease relubrication period is too short. Another reason can also be the necessity of heat transfer from the bearing, or the high temperature of environment, which does not enable utilization of grease, or if surrounding parts are already lubricated by oil (e.g. geared wheels in the gear box). Except for some cases, spherical roller thrust bearings are always lubricated by oil.
When oil lubricating, lubricating must be secured both at starting and during operation. Excess oil increases temperature and bearing temperature.
Oil feed into bearing is secured in various design ways, out of which oil bath lubrication with oil level reaching middle of the lowest rolling element, oil circulation lubrication, jet lubrication, oil mist lubrication etc., are the most common.

4.2.1 Bearing Oils

For bearing lubrication mostly refined oils with good chemical stability which can be improved by antioxidizing agents are used.
The decisive oil property is kinematic viscosity which decreases with increasing temperature. Suitable oil viscosity ν_1 can be stated according to the diagram (see Figure 23) dependence on the bearing mean diameter $d_s = (d+D)/2$ and rotational speed n. If the operating temperature is known or it can be found out, according to the diagram (see Figure 24) suitable oil and viscosity ν at internationally standardized temperature 40°C being necessary for calculation of ratio is determined.

By ratio $\kappa < 1$ it is recommended to use EP oil with additives which improve the oil film load rating.
By value κ decrease under 0,4 oils with EP additives are always used.
If the ratio κ is greater than 1, improved arrangement reliability is reached in operation.

Example:
- bearing d = 180 mm, D = 320 mm, d_s = 250 mm
- rotational speed n = 500 min^{-1}
- presumed operating temperature 60°C

For these conditions according to diagram (see Figure 23) the minimum kinematic viscosity is ν_1= 17 $mm^2.s^{-1}$.

If the operating temperature is 60°C, the oil selected according to the diagram (see Figure 24) at standardized temperature 40°C must have kinematic viscosity ν min 35 $mm^2.s^{-1}$.

For thrust spherical roller bearings the lubricating oil kinematic viscosity is approximately stated in dependence on n x d, where n is the bearing rotational speed in revolutions per minute and d is the bore diameter in mm, according to table 37. Lower values are valid for bearings with lower load, for which is valid $P_a \leq 0,1\ C_a$. Higher values are valid for $P_a > 0,1\ C_a$.

Oil Viscosity for Spherical Roller Thrust Bearings	Tab. 37
d.n	Kinematic Oil Viscosity mm^2s^{-1} at 40°C
1 000	250 to 550
10 000	100 to 250
100 000	45 to 100
200 000	30 to 80

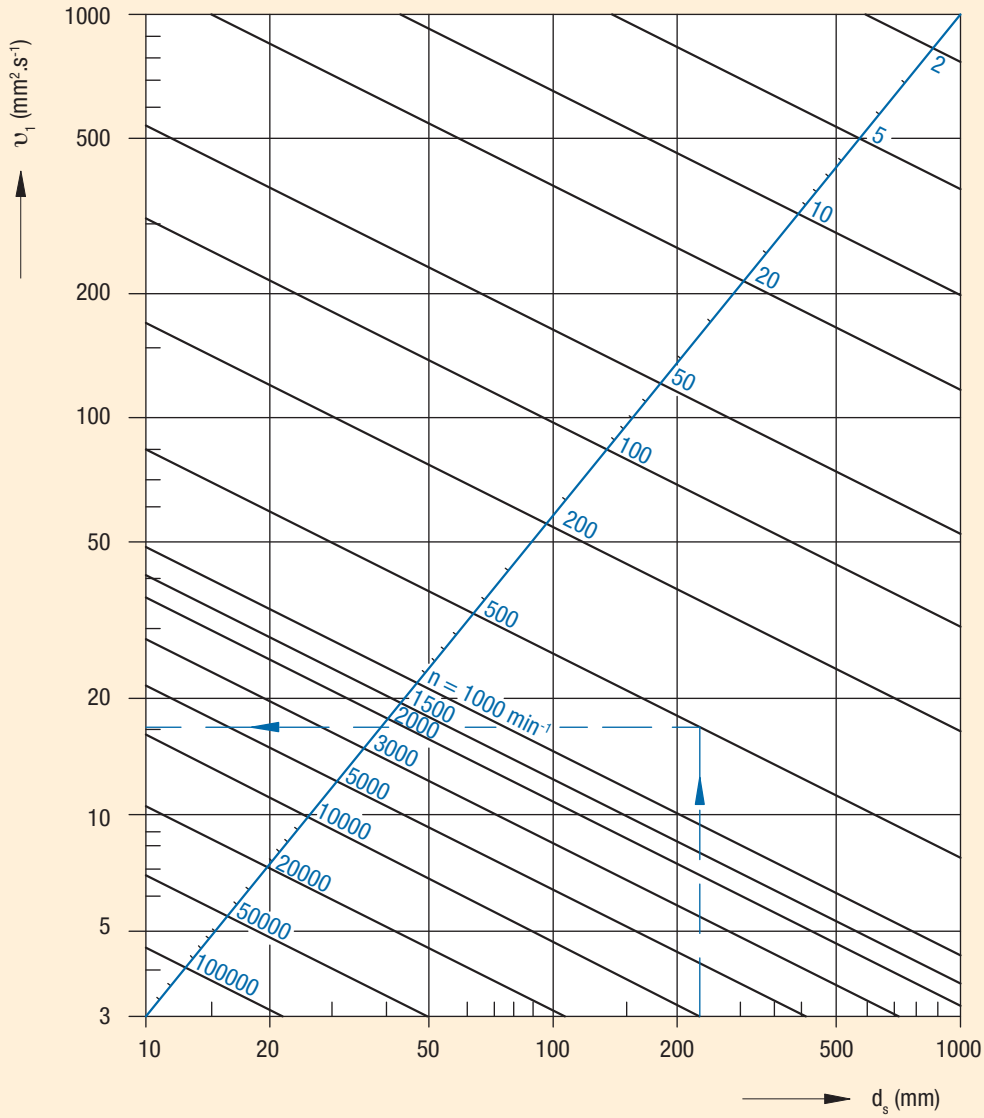
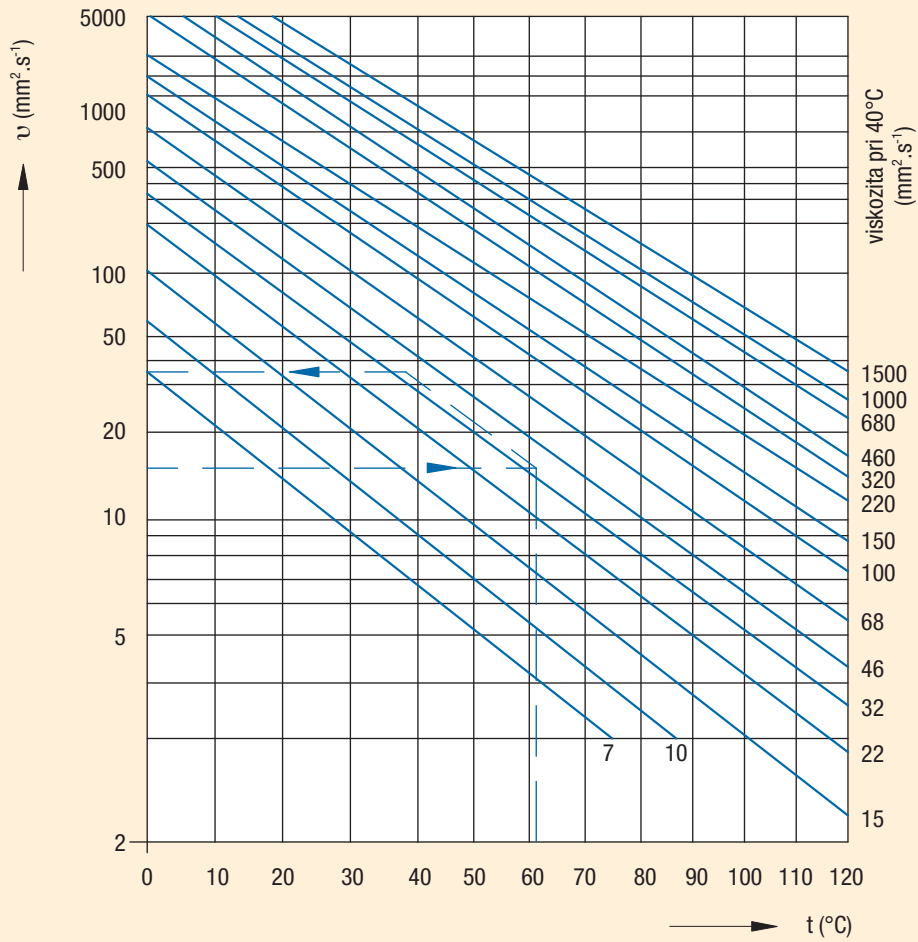

υ1 (mm².s⁻¹)
1000
500
200
100
50
20
10
5
3
10
20
50
100
200
500
1000
ds (mm)
2
5
10
20
50
100
200
500
n = 1000 min⁻¹
1500
2000
3000
5000
10000
20000
50000
100000

Figure 24



4.3 Lubrication with solid lubricants

Solid lubricants are used for bearing lubrication when the grease or oil cannot fulfil the requirements for reliable lubrication in conditions of limiting friction or from the viewpoint of high operating temperatures, chemical influences, etc.

In this case it is necessary to consult the bearing use with mentioned special workstations.