Bearing rating life

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For estimating the expected bearing life, you can use the following approaches:

- If you have experience with the operating conditions related to lubrication and contamination, and know that the conditions you are working with do not have a dramatic effect on the life of your bearings, use the basic rating life calculation.
- In most other cases, use the SKF rating life.
- However, for hybrid bearings, use the SKF Generalized Bearing Life Model.

Size selection based on rating life

Basic dynamic load rating C
Equivalent dynamic bearing load, P
Life modification factor, aSKF
Lubrication condition – the viscosity ratio, κ
Fatigue load limit, Pu
Contamination factor, ηc

What is a rating life and why use it?

The fatigue life of an individual bearing is the number of revolutions (or the number of operating hours at a constant speed) that the bearing operates before the first sign of metal fatigue (rolling contact fatigue (RCF) or spalling) occurs on one of its rings or rolling elements. Both laboratory tests and practical experience show considerable variations in the fatigue life of identical bearings operating under identical conditions.

When you want to avoid fatigue failures of the bearing before your application reaches its desired lifetime, you can use a statistical approach to determine the bearing size. The rating life L_{10} is the fatigue life that 90% of a sufficiently large group of identical bearings operating under identical conditions can be expected to attain or exceed.

The rating life L_{10} is a proven and effective tool which can be used to determine a bearing size that is adequate to avoid fatigue failures. Compare the calculated rating life to the service life expectations of the bearing application. You can use your experience from previous selections, if available, or apply the guidelines regarding the specification life of various bearing applications provided in table 1 and table 2.

Basic rating life

If you consider only the load and speed, you can use the basic rating life, L_{10}.

The basic rating life of a bearing in accordance with ISO 281 is

$$L_{10} = \left(\frac{C}{P}\right)^p$$

You can use SKF Bearing Select to perform this calculation.

If the speed is constant, it is often preferable to calculate the life expressed in operating hours using

$$L_{10h} = \frac{10^6}{60\ n} L_{10}$$

where

L_{10}	basic rating life (at 90% reliability) [millions of revolutions]
L_{10h}	basic rating life (at 90% reliability) [operating hours]
C	basic dynamic load rating [kN]
P	equivalent dynamic bearing load [kN]
n	rotational speed [r/min]
p	exponent of the life equation = 3 for ball bearings = 10/3 for roller bearings

SKF rating life ×

For modern high-quality bearings, the calculated basic rating life can deviate significantly from the actual service life in a given application. Service life in a particular application depends not only on load and bearing size, but also on a variety of influencing factors including lubrication, degree of contamination, proper mounting and other environmental conditions.

ISO 281 uses a modified life factor to supplement the basic rating life. The life modification factor a_{SKF} applies the same concept of a fatigue load limit P_u (Fatigue load limit, P_u) as used in ISO 281. Values of P_u are listed in the data tables. Just as in ISO 281, to reflect three of the important operating conditions, the life modification factor a_{SKF} takes the lubrication conditions (Lubrication condition – the viscosity ratio, κ), the load level in relation to the bearing fatigue load limit, and a factor η_c for the contamination level (Contamination factor, η_c) into consideration using

$$L_{nm} = a_1\ a_{SKF}\ L_{10} = a_1\ a_{SKF} \left(\frac{C}{P}\right)^p$$

You can use SKF Bearing Select to perform this calculation.

If the speed is constant, the life can be expressed in operating hours, using

$$L_{nmh} = \frac{10^6}{60\ n} L_{nm}$$

where

L_{nm}	SKF rating life (at 100 – n[1)] % reliability) [millions of revolutions]
L_{nmh}	SKF rating life (at 100 – n[1)] % reliability) [operating hours]
L_{10}	basic rating life (at 90% reliability) [millions of revolutions]
a_1	life adjustment factor for reliability (table 3, values in accordance with ISO 281)
a_{SKF}	life modification factor

C	basic dynamic load rating [kN]
P	equivalent dynamic bearing load [kN]
n	rotational speed [r/min]
p	exponent of the life equation = 3 for ball bearings = 10/3 for roller bearings

[1)] The factor n represents the failure probability, which is the difference between the requisite reliability and 100%.

For 90% reliability:

L_{nm} = SKF rating life (at 100 - n[1)]% reliability) [million revolutions]

Becomes:

L_{10m} = SKF rating life [million revolutions]

Since the life adjustment factor a_1 is related to fatigue, it is less relevant for load levels, P, below the fatigue load limit P_u. Dimensioning with life adjustment factors reflecting very high reliability (such as 99%) will result in large bearings for given loads. In these cases, the bearing load must be checked against the minimum load requirement for the bearing. Calculating minimum load is described in Requisite minimum load.

Table 4 provides commonly used conversion factors for bearing life in units other than million revolutions.

SKF Generalized Bearing Life Model ×

The SKF Generalized Bearing Life Model (GBLM) enables prediction of bearing rating life for bearings and operating conditions, which are not covered by other bearing life models. The SKF GBLM separates surface and subsurface failure modes (fig. 1). The model evaluates surface fatigue with advanced tribology models and subsurface fatigue with a classical Hertzian rolling contact model. It includes the effects of lubrication, contamination, and raceway surface properties, which influence the stress distribution in the rolling contact area.

The general mathematical representation used to calculate the rating life is:

$$L_{nGM} = a_1 \left[\frac{1}{L_{10.surf}} + \frac{1}{L_{10.sub}} \right]^{-\frac{1}{e}}$$

where

L_{nGM}	rating life (at 100 – n[1)] % reliability) based on the SKF GBLM [millions of revolutions]
a_1	life adjustment factor for reliability (table 3, values in accordance with ISO 281)
$L_{10.surf}$	surface rating life (at 90% reliability) based on the SKF GBLM [millions of revolutions]
$L_{10.sub}$	subsurface rating life (at 90% reliability) based on the SKF GBLM [millions of revolutions]
e	mathematical constant: ~ 2,718

The SKF GBLM is available for hybrid bearings. You can use SKF Bearing Select to perform this calculation.

[1)] The factor n represents the failure probability, which is the difference between the requisite reliability and 100%.

Calculating bearing life with variable operating conditions ×

In some applications – for example, industrial gearboxes, vehicle transmissions or windmills – the operating conditions, such as the magnitude and direction of loads, speeds, temperatures and lubrication conditions, are continually changing. In these types of applications, bearing life cannot be calculated without first reducing the load spectrum or duty cycle of the application to a limited number of simplified load cases (diagram 1).

For continuously changing loads, each different load level can be accumulated and the load spectrum reduced to a histogram plotting constant-load blocks. Each block should characterize a given percentage or time-fraction during operation. Heavy and normal loads consume bearing life at a faster rate than light loads. Therefore, it is important to have peak loads well represented in the load diagram, even if the occurrence of these loads is relatively rare and of relatively short duration.

Within each duty interval, the bearing load and operating conditions can be averaged to a representative, constant value. The number of operating hours or revolutions expected from each duty interval, showing the life fraction required by that particular load condition, should also be included. Therefore, if N_1 equals the number of revolutions required under the load condition P_1, and N is the expected number of revolutions for the completion of all variable loading cycles, then the cycle fraction $U_1 = N_1/N$ is used by the load condition P_1, which has a calculated life of L_{10m1}. Under variable operating conditions, bearing life can be rated using

$$L_{10m} = \frac{1}{\frac{U_1}{L_{10m1}} + \frac{U_2}{L_{10m2}} + \frac{U_3}{L_{10m3}} + \dots}$$

where

L_{10m}	SKF rating life (at 90% reliability) [million revolutions]
L_{10m1}, L_{10m2}, ...	SKF rating lives (at 90% reliability) under constant conditions 1, 2, ... [million revolutions]
U_1, U_2, ...	life cycle fraction under the conditions 1, 2, ... $U_1 + U_2 + \dots U_n = 1$

The use of this calculation method is well suited for application conditions of varying load level and varying speed with known time fractions.