# 8 HANDLING OF BALL BEARING UNITS

## 8.1 Bearing life

Even in bearings operating under normal conditions, the surfaces of the raceway and rolling elements are constantly being subjected to repeated compressive stresses which cause flaking of these surfaces to occur. This flaking is due to material fatigue and will cause the bearings to fail. The bearing life of a insert bearing is usually defined in terms of a insert bearing can undergo before flaking.

Some insert bearing failure is caused by seizing, abrasions, cracking, chipping, gnawing, rust etc, since these are caused by improper installation, insufficient or improper lubrication, faulty sealing or inaccurate bearing selection, they must be considered separately from bearing life.

### 8.1.1 Basic load rating and rated life

Basic load rating includes basic dynamic load rating and basic static load rating. The load applied to the insert bearing operating under a speedy rotating (n>10r/min) condition is defined as dynamic load C , while the load applied to the bearing operating under a static or slow oscillating and rotating (n≤10r/min) condition is defined as static load Co. Insert bearing is a kind of radial ball bearing, mainly take radial force. So, the basic load rating is radial basic dynamic load Cr and radial basic static load Cor.

Basic dynamic load rating Cr: the basic dynamic load rating is an expression of the load capacity of a bearing based on a constant load which the bearing can sustain for one million revolutions.

Basic static load rating Cor: the maximum applied radial load for contact stress occurring at the rolling element and raceway contact points.

——4600MPa for self aligning ball bearing
——4200MPa for radial ball bearing
——4000MPa for radial roller bearing

The load capacity of the bearing is expressed by the basic dynamic load rating and basic static load rating which is shown in the bearing dimension page.

Life: The life of a rolling bearing is defined as the total number of revolutions which the bearing is capable of enduring before the first evidence of fatigue flaking develops on any one of the rings or rolling elements.

Reliability: The reliability is the percentage of the bearing of a group of apparently identical bearings operating under identical conditions which can expect to attain or exceed a certain defined life. The reliability of an individual bearing is the probability of the bearing to attain or exceed a defined life.

Basic rating life: For a group of apparently identical rolling bearings operating under identical conditions, the basic rating life is defined as the total number of revolutions that 90% of the bearings can be expected to complete or exceed.

According to national standard GB/T6391-2003 (equaling to ISO281: 1990) , the basic rating life of radial ball bearing is calculated by following formula:

$$L_{10} = \left(\frac{Cr}{Pr}\right)^3$$

or $$\frac{Cr}{Pr} = L_{10}^{1/3}$$

Where: $L_{10}$: basic rating life($10^6$ r)
$C_r$: basic dynamic load rating
$P_r$: equivalent dynamic load

Equivalent dynamic load $P_r$: the equivalent dynamic load is a constant load with a fixed direction under

which the bearing life is identical to that of the bearing operating under actual load.

For a insert bearing operating with a constant rotation speed, the basic rating life can be expressed in terms of hours of operation, and is calculated in following formula:

$$L_{10h} = \frac{10^6}{60n}\left(\frac{C}{P}\right)^3$$

or

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

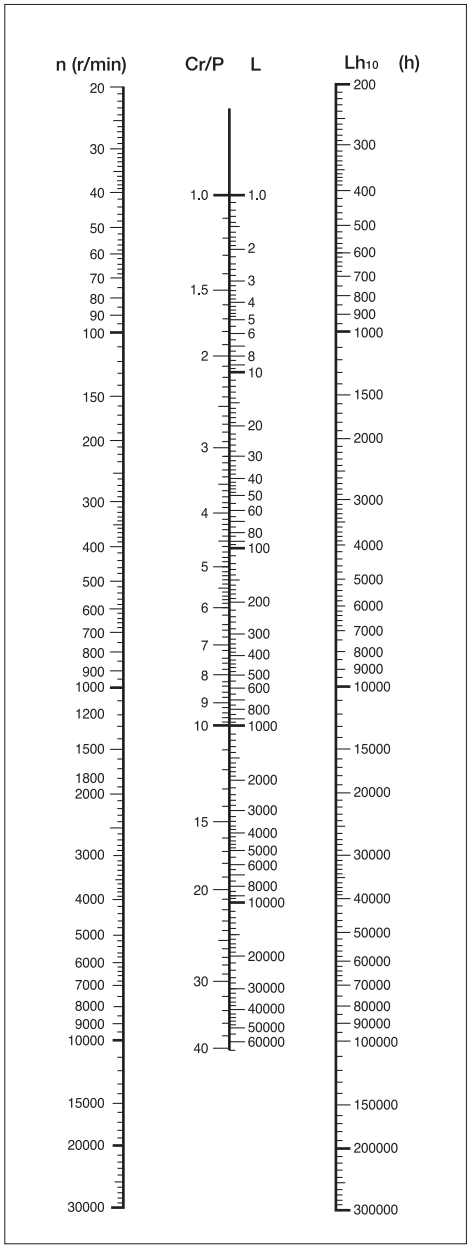
$$= \frac{16666}{n}\left(\frac{C}{P}\right)^3$$

Where: $L_{10h}$ = basic rating life (hours)
n = bearing rotation speed (r/min)

If the bearing operates under indeterminate loads and rotation speed, the following formula should be applied when calculating bearing rating life:

$$P_m = \sqrt[3]{\frac{\int_0^N P^3 dN}{N}}$$

Where: $P_m$ = mean equivalent dynamic load
P = equivalent dynamic load
N = total revolution numbers within one load changing cycle




### 8.1.2 Calculation method of equivalent dynamic load

The basic equivalent dynamic load is determined under a hypothetical condition. When calculating the bearing life, the actual load has to be converted into equivalent dynamic load which is in confirm with the load condition determining the equivalent dynamic load rating.

General equation for calculating the equivalent dynamic load:

$$P = XFr + YFa$$

Where P = equivalent dynamic load (N);
Fr = actual radial load (N)
Fa = actual axial load (N)
X = radial factor
Y = thrust factor

The axial load which insert bearing can carry is determined by the mounting method of the bearings on the shafts.

For the setscrews locking type or eccentric locking collar type bearings, if flexible shafts are applied and the setscrews are tightened enough, the axial load Fa which the bearing can carry must not surpass 20% of the radial load Fr.

For the adapter sleeve locking type bearing, if the nuts are properly tightened, the axial load Fa can be maximum 15%～20% of the radial load Fr.

The values of radial and thrust factors X and Y for insert bearings can be obtained from the following table:

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| $\frac{F_a}{C_O}$ | $\frac{F_a}{F_r} \leqslant e$ p=$F_r$ | | C2 | | | N | | | C3 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | $\frac{F_a}{F_r} > e$ | | e | $\frac{F_a}{F_r} > e$ | | e | $\frac{F_a}{F_r} > e$ | | e |
| | X | Y | X | Y | | X | Y | | X | Y | |
| 0.025 | 1 | 0 | 0.56 | 2.0 | 0.22 | 0.46 | 1.75 | 0.31 | 0.44 | 1.42 | 0.40 |
| 0.040 | 1 | 0 | 0.56 | 1.8 | 0.24 | 0.46 | 0.62 | 0.33 | 0.44 | 1.36 | 0.42 |
| 0.070 | 1 | 0 | 0.56 | 1.6 | 0.27 | 0.46 | 1.46 | 0.36 | 0.44 | 1.27 | 0.44 |
| 0.130 | 1 | 0 | 0.56 | 1.4 | 0.31 | 0.46 | 1.30 | 0.41 | 0.44 | 1.16 | 0.48 |
| 0.250 | 1 | 0 | 0.56 | 1.2 | 0.37 | 0.46 | 1.14 | 0.46 | 0.44 | 1.05 | 0.53 |

When twist load is applied to the bearings, the equivalent dynamic bearing load is calculated by:

$P_m = f_m \cdot P$

Where: $P_m$ = equivalent dynamic load when considering twist load
$f_m$ = when twist load is big :$f_m$=2

When shocking load is applied, equivalent dynamic load can be calculated by:

$P_d = f_d \cdot P$

Where: $P_d$ = equivalent dynamic load when considering shocking load （N）
$f_m$ = shocking load factor; which is defined as follows:

When no shocking load or minor shocking load is applied:

$f_d$ = 1～1.2

When adequate shocking load is applied:

$f_d$ = 1.2～1.8

### 8.1.3 Adjusted rating life equation

Normally the basic rating life L10 can be applied to calculate the bearing rating life, the bearing life is with 90% reliability.

However, in some applications a bearing life over 90% reliability may be required, moreover, the effect of bearing quality and operation conditions are expected to take into consideration when calculating bearing life, the adjusted bearing life $L_{nm}$ (n means failure rate,(100-n) means reliability) meet these requirements.

Bearing life Lnm, is adjusted bearing life under （100-n） % reliability、speicified bearing quality and operation conditions, it can be calculated by:

$L_{nm} = a_1 a_{xyz} L_{10}$

Life adjustment factor for reliability $a_1$ please refers to following table.

**Life adjustment factor for reliability $a_1$**

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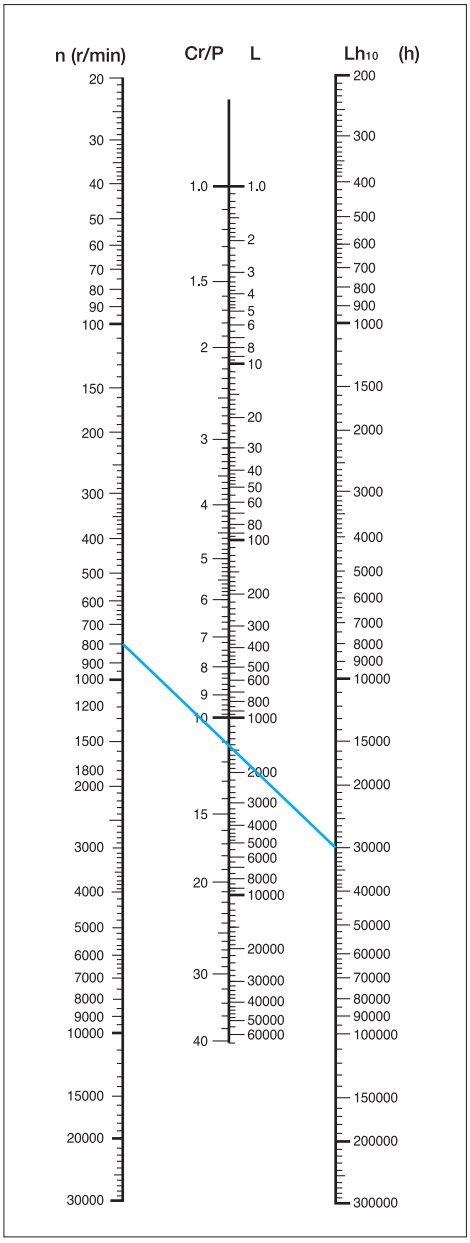
| Reliability | $L_{nm}$ | $a_1$ |
|---|---|---|
| 90 | $L_{10m}$ | 1 |
| 95 | $L_{5m}$ | 0.62 |
| 96 | $L_{4m}$ | 0.53 |
| 97 | $L_{3m}$ | 0.44 |
| 98 | $L_{2m}$ | 0.33 |
| 99 | $L_{1m}$ | 0.21 |

Life adjustment factor axyz include followings:

——material,
——lubrication,
——environment,
——Impurity particle,
——Internal stess,
——mounting,
——bearing load.

The bearing life is affected by any of above factors, so all factors must be taken into consideration when selecting bearing to avoid failure.

Please refer to national standard GB/T6391-2003 for bearing life calculating method.




### 8.1.4 Example of insert bearing selection

One ball bearing is to operate at at rotation speed of 800r/min, under only a radial load of Fr = 3000N, with a basic rating life of at least 30000 hours, select the bearing.

Solution 1:

According to formula

$$L_{10h} = \frac{10^6}{60n} L_{10} = \frac{16666}{n}\left(\frac{C}{P}\right)^3$$

From $L_{10h}$ = 30000 hours, rotation speed = 800r/m,
Under only a radial load, i.e. P = Fr = 3000N,
Therefore, C = 33877N.

Solution 2:

By connecting n(800r/m) and the required basic rating life $L_{10h}$ （30000hours） with a straight line on the fig,it can be found that C/P value is 11.3, C/P = 11.3, P = Fr = 3000N, thus the required basic dynamic load rating is C = 33900N

## 8.2 Selection of ball bearing units

As the excellent characteristics of ball bearing unit is recognized, its application fields are always expanded and at present it is used in all aspects of industrial activities in general.

Its expected service life can be extended twice by using the ball bearing unit correctly. On the contrary, inappropriate selection and handling will shorten the expected service life.

Therefore, it is necessary to examine the following items thoroughly, when the ball bearing unit is selected.

1. Size and nature of the working load.
2. Desirable minimum expected service life.
3. Operating speed of the shaft.
4. Bearing number and parallel application arrangement on the shaft in question.
5. Available space for assembling and disassembling work.
6. Appearance at the place to be used.
7. Gas generation and dust condition at the installation place.