Life and load rating

BEARING LIFE

When bearings rotate, the inner and outer rings and rolling elements are constantly loaded. This produces material fatigue and eventually bearing failure. The total number of revolutions before a failure occurs is called the basic rating life.
Life of individual bearings varies considerably, even if they are of the same size, same material, same heat treatment and are under the same operating conditions.
Statistically, the total number of revolutions reached or exceeded by 90% of a sufficiently large group of apparently identical bearings before the first evidence of material fatigue occurs is called the basic rating life.

BASIC DYNAMIC LOAD RATING"Cr"

The basic dynamic load rating of a bearing with rotating inner ring and stationary outer ring is that load of constant magnitude and size which a sufficiently large group of apparently identical bearings can endure for a basic rating life of one million revolutions.
Radial bearings take central load. Values given for Cr in the dimension tables of this catalogue are for standard high chromium steel. 85% of the chromium steel values should be used for stainless steel.

LIFE FORMULA

The equation for the basic rating life for dynamically loaded ball bearings is as follows:

$$L_{10}=(Cr/P)^3(\times 10^6 \text{Revolutions}),\ L_{10}h=16667/n\cdot(Cr/P)^3(\text{Hours})$$

whereby:
L_{10}=BASIC RATING LIFE
Cr=BASIC DYNAMIC LOAD RATING(N)
n=R.P.M.(REVOLUTIONS PER MINUTE)
$L_{10}h$=BASIC RATING LIFE IN OPERATING HOURS
P=EQUIVALENT LOAD(N)

EXAMPLES OF RATING LIFE $L_{10}h$ VALUES USED:

OPERATING CONDITIONS	BASIC RATING LIFE $L_{10}h$
Infrequent operation.	500
Short or intermittent operation. Failure has little effect on function.	4,000～8,000
Intermittent operation. Failure has significant effect on function.	8,000～12,000
8 hours of non-continuous operation.	12,000～20,000
8 hours of continuous operation.	20,000～30,000
24 hours continuous operation.	40,000～60,000
24 hours of guaranteed trouble-free operation.	100,000～200,000

ADJUSTED LIFE FORMULA

The above life formula is for general use. In cases where a reliability of over 90% is required and where influences apart from load and speed or operating frequency should be taken into account for the rating life, ISO 281, 1990 gives an extended life formula:

$$Lna=a_1\times a_2\times a_3\times(Cr/P)^3\times 10^6 \text{ (Revolutions)}$$

whereby:
Lna=Adjusted rating life in millions with a reliability of (100-n)% (n=the reliability rate)
Cr=BASIC DYNAMIC LOAD RATING(N)
P=EQUIVALENT DYNAMIC LOAD(N)
a_1=Factor for a reliabillity other than 90%
a_2=Factor for non-conventional materials
a_3=Factor for non-conventional operating conditions, in particular lubrication

(1) RELIABILITY FACTOR a_1
When a reliability of over 90% is required, the corresponding factor should be selected from the following table.

●RELIABILITY FACTOR a_1

Reliability	90	91	92	93	94	95	96	97	98	99	(99.6)	(99.9)
a1	1.00	0.92	0.84	0.77	0.64	0.62	0.53	0.44	0.33	0.21	(0.10)	(0.037)

(2) MATERIAL FACTOR a_2
Improvement in manufacturing techniques for raw material and for heat treatment of components have led to an extended fatigue life for bearings.
Our standard bearing material is a superior quality of vacuum degassed steel leading to an extended life for bearings.
The basic load ratings given in this catalogue have been established by taking this longer life into consideration. This gives an increase in the operating life in hours of a factor of 2.2 and a factor of 1.3 for the load carrying capacity. The material factor a_2=1.

(3) OPERATING CONDITIONS FACTOR a_3

This is an adjustment factor to meet non-conventional operating conditions for lubrication, temperature and load.
Under good lubrication conditions with a permanent oil film between rolling elements and rings, the factor a_3=1.
In unfavourable conditions ($d_m \cdot n \leqq 10{,}000$), a factor $a_3 < 1$ must be selected.d_m = mean bearing diameter = (D+d)/2 , n = operating speed.
At temperatures above 120℃, greater dimensional changes occur and the material hardness deteriorates which affects the bearing life.
The operating factor f_t for temperature can be taken from the following table:

●OPERATING TEMPERATURE AND LIFE COMPENSATION FACTOR f_t

BEARING TEMPERATURE (℃)	120	150	175	200	225	250	275	300
TEMPERATURE FACTOR (f_t)	1.00	0.90	0.85	0.75	0.65	0.60	0.52	0.45

Heat stabilized bearings, where the dimensions are stable above 120℃, are available on request.

BASIC STATIC LOAD RATING "Cor"

The Basic Static Load Rating applies to bearings where rotating motion does not occur or occurs only infrequently.
The Basic Load Ratings and calculation methods in this catalogue are based on methods described in ISO 281 and on ISO Recommendations NR.76, taking into account the current level of bearing technology.
Excessive static load causes brinelling at the contact point between the rolling element and raceway.
As a standard of permissible static load, the basic load rating Cor for radial bearings is specified as follows:
Maximum contact pressure at the contact point between rolling element and bearing ring to be 4200 MPa and total permanent deformation of the bearing of appr. 1/10000th of the rolling element's diameter.
Basic Static Load Rating for stainless steel is 80% of that for standard bearing steel.

EQUIVALENT DYNAMIC BEARING LOAD "P"

Load conditions on bearings are usually a combination of radial and axial loads. In order to establish the equivalent radial load with definite force and direction we use the following formula:

●RADIAL LOAD FACTOR AND AXIAL LOAD FACTOR

Fa/(ZD²)	e	Fa/Fr≦e		Fa/Fr>e	
		X	Y	X	Y
0.172	0.19	1	0	0.56	2.30
0.345	0.22	1	0	0.56	1.99
0.689	0.26	1	0	0.56	1.71
1.03	0.28	1	0	0.56	1.55
1.38	0.30	1	0	0.56	1.45
2.07	0.34	1	0	0.56	1.31
3.45	0.38	1	0	0.56	1.15
5.17	0.42	1	0	0.56	1.04
6.89	0.44	1	0	0.56	1.00

$P=XFr+YFa(N)$

Fr=RADIAL LOAD(N)
Fa=AXIAL LOAD(N)
X=RADIAL LOAD FACTOR
Y=AXIAL LOAD FACTOR
D=BALL DIAMETER(mm)

EQUIVALENT STATIC RADIAL LOAD "Po"

For ball bearings subject to both radial and axial loads, the static radial load with definite force and direction is called the Equivalent Static Radial Load.
The higher value from the two formula shown below should be used.

$Po=0.6\times Fr+0.5\times Fa(N)$、$Po=Fr(N)$

SAFETY MODULUS"fs"

Permissible equivalent static load depends on basic static load rating.
But using limit of bearing charge by using condition. Accordingly we use safety modulus which is experimental value.

$fs=Cor/Po$

fs=SAFETY MODULUS
Cor=BASIC STATIC LOAD RATING(N)
Po=EQUIVALENT STATIC RADIAL LOAD(N)

USING CONDITION	fs
NORMAL OPERATION	1.0
SHOCK LOAD	1.5
SILENT AND HIGH ACCURATE ROTATION	2.0