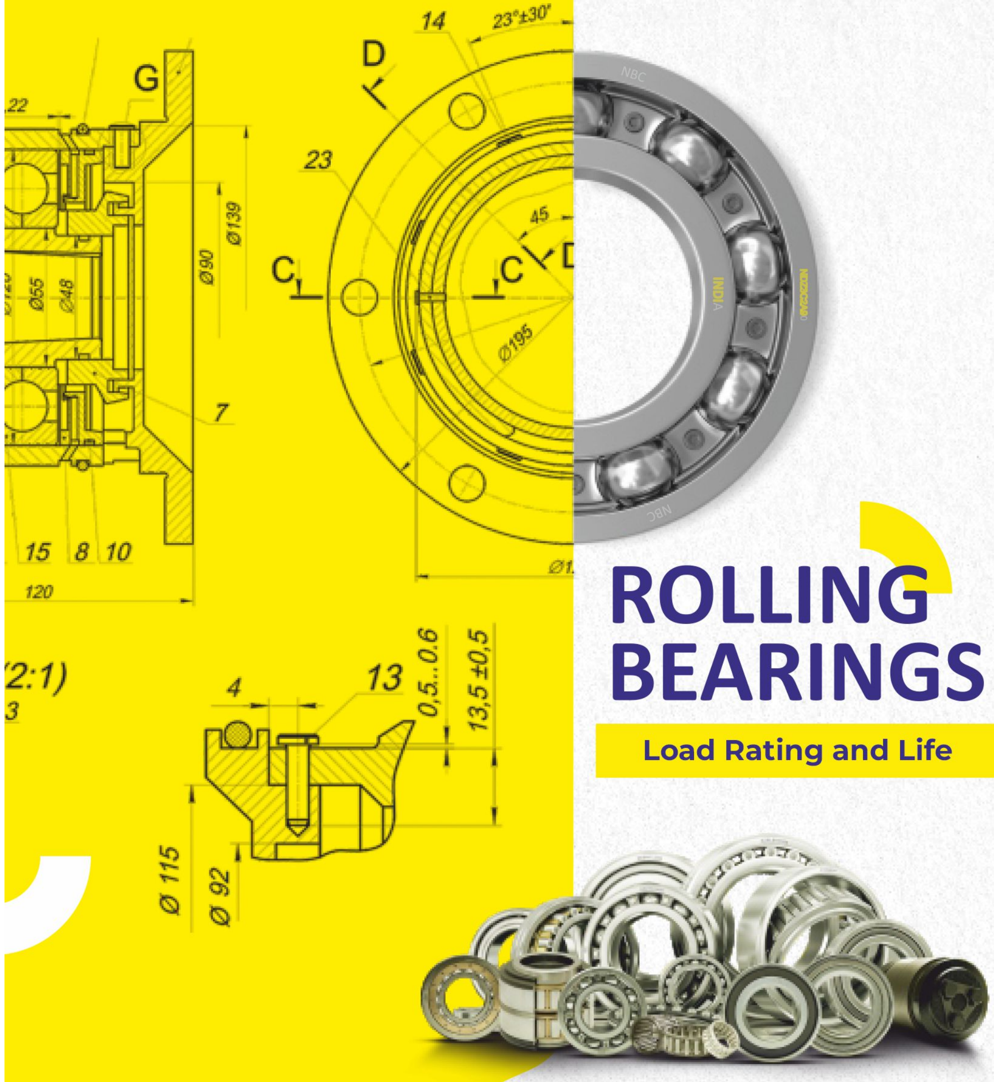
CELEBRATING 75 YEARS

CK BIRLA GROUP

nbc®
flexible solutions



ROLLING BEARINGS

Load Rating and Life

2 WHEELERS
3 WHEELERS
4 WHEELERS
TRACTORS
LCV, HCV
INDUSTRIES
RAILWAYS
AEROSPACE

WINNER DEMING GRAND PRIZE

---

nbc®
flexible solutions

CATALOGUE/TC-106, 01/2024

This version supersedes all previously published versions. All the bearing mentioned in this catalogue are manufactured with normal tolerance class. We can, however, supply other class bearing against specific requirement.

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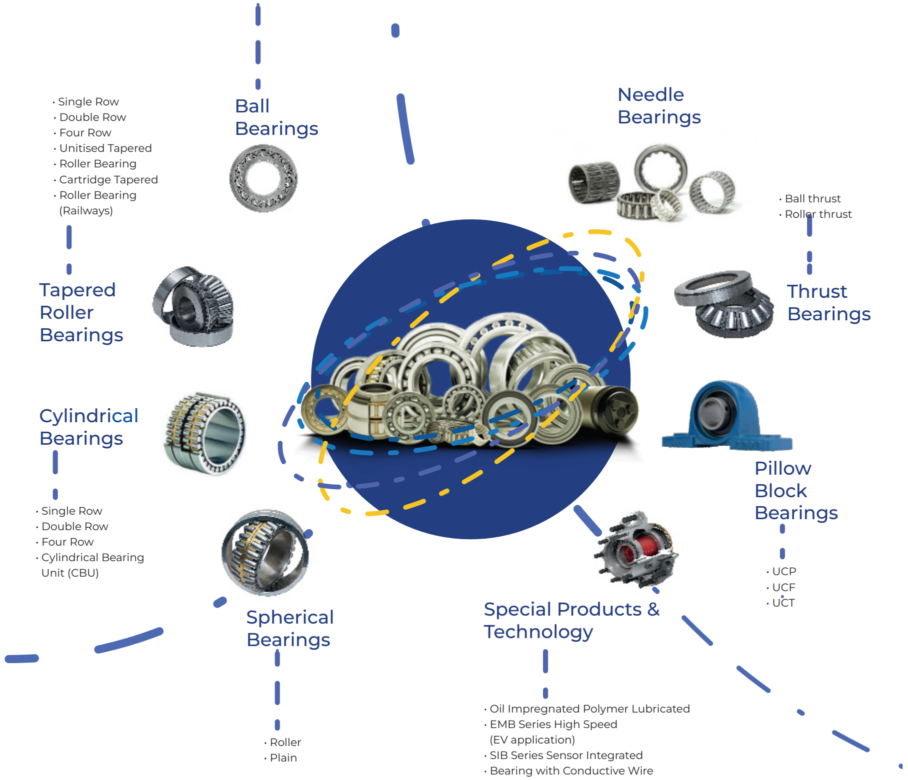
Founded in 1946, NBC is India's first bearings manufacturer and the last word in quality and durability. In 2020, the company acquired leading European manufacturer, Kinex Bearings to further boost its expertise.

75 years since its beginning, NBC remains India's leading bearings manufacturer andexporter. NBC is also the world's only bearings manufacturer to receive the prestigious Deming Grand Prize for Total Quality Management.

- 1946 India's first bearing manufacturer
- 250+ million bearings manufactured/ annum
- 3100+ variants of bearings offered
- 5 manufacturing locations
- Leading exporter
- Happy customers in 30+ countries
- R&D and Innovation Centre
- 2800+People
- Automotive
- Industrial
- Railway
- Aerospace

Products from NBC

Since the challenges faced by industry are many, NBC offers a diverse range of exceptional bearings. NBC bearings are available in sizes from 04 mm bore to 2000 mm outer diameter.



Ball Bearings
- Deep Groove
- Gen - 1
- Gen - 3
- Angular Contact

Tapered Roller Bearings
- Single Row
- Double Row
- Four Row
- Unitised Tapered
- Roller Bearing
- Cartridge Tapered
- Roller Bearing (Railways)

Cylindrical Bearings
- Single Row
- Double Row
- Four Row
- Cylindrical Bearing Unit (CBU)

Spherical Bearings
- Roller
- Plain

Special Products & Technology
- Oil Impregnated Polymer Lubricated
- EMB Series High Speed (EV application)
- SIB Series Sensor Integrated
- Bearing with Conductive Wire
- TRB Hub Unit
- Low Torque TRB
- Pre-set Hub
- Insuohm Series (Insulated)
- Ceramic Rolling Element (Hybrid)
- TRB Matched Set
- Black Oxide Treatment
- HCR Series

Pillow Block Bearings
- UCP
- UCF
- UCT

Thrust Bearings
- Ball thrust
- Roller thrust

Needle Bearings

∗ Products with special features like high temperature application, special heat treatment, coated roller/races and cage options are also available across product range.

4.1 BEARING LIFE

Bearings are integral component in any machinery application. The premature failure of a bearing can result in costly unplanned downtime that could have been prevented using the proper predictive measures. Bearing life, in the broad sense is the period during which bearings continue to operate and satisfy their required functions.

During operation bearing fail mainly due to

(I) Human error

- Improper mounting
- Improper bearing selection
- Design not ok
- Insufficient maintenance

(II) Metal Fatigue type of failure of a material, occurring under alternating loads

Under load zone as the rolling element rotate to the bottom of the bearing they are compressed between the rings. As they rotate back to the top, the compressed metal expands to its original state. This constant compression and expansion of metal after many revolutions of the bearing increases stress which causes cracks in the material. This leads to fatigue failure. This flaking is due to material Fatigue and will eventually cause the bearing to fail.

The effective life of a bearing is usually defined in terms of the total numbers of revolutions a bearing can undergo before flaking of either the raceway surface or the rolling elements surfaces occurs.

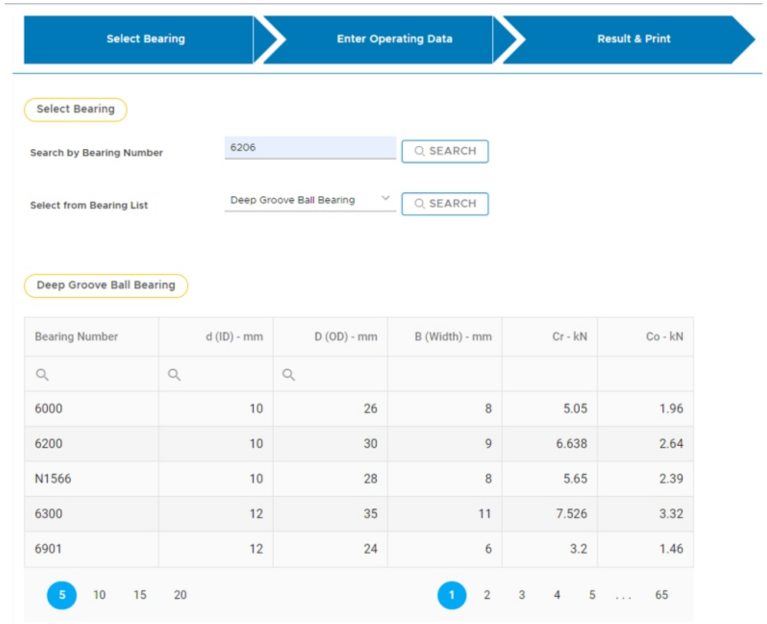
When a group of apparently identical bearings operate under identical load conditions, the life of individual bearings show a considerable dispersion. Therefore, a statistical definition of the life is applied for the calculation of the bearing life. When selecting a bearing, it is not correct to regard the average life of all bearings as the criterion of life: It is more practical to adopt the life that the majority of bearing will attain or exceed.

In simplest calculation the bearing life is calculated in terms, L_{10} life, with 90% reliability, how many hours a bearing will last under a given load and speed as per the formula given in ISO 281 STD. For this reason the basic rating life of a group of bearings is defined as the number of revolutions (or hours at some given constant speed) that 90% of the group of bearings will complete or exceed before the first evidence of fatigue develops. There is a 10% probability that at the applied load and speed, 10% of a population of identical bearings would suffer a fatigue failure. Note that this does not address failures caused by other conditions such as contamination, wear, misalignment, and improper lubrication.

Another method is the use of adjusted or advanced life calculation procedures based on ISO 281 or a bearing manufacturer's in-house calculation methods. These methods take into account oil viscosity, oil temperature and the contamination level in the oil during operation.

The bearing life can be calculated using the tool on NBC.website (https://lifecalc.nbcbearings.com/bearingtool/#/bearingcalculator).

The tool is easy to use and gives quick calculations for Basic rating life & Modified rating life calculation at different reliability, considering environmental and application conditions with accurate ISO factor as per ISO281 and TS16281 standards. Flexibility to calculate life considering custom bearing data. With this tool it is easy to select bearing at an early stage and make initial assessment.

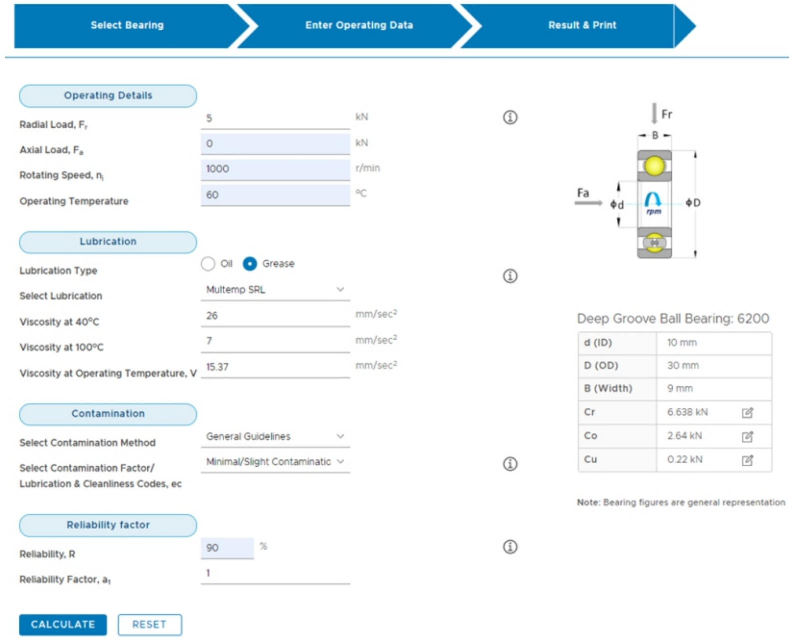


Select Bearing

Search by Bearing Number	6206
Select from Bearing List	Deep Groove Ball Bearing

Deep Groove Ball Bearing

Bearing Number	d (ID) - mm	D (OD) - mm	B (Width) - mm	Cr - kN	Co - kN
6000	10	26	8	5.05	1.96
6200	10	30	9	6.638	2.64
N1566	10	28	8	5.65	2.39
6300	12	35	11	7.526	3.32
6901	12	24	6	3.2	1.46



Operating Details

Radial Load, F_r	5	kN
Axial Load, F_a	0	kN
Rotating Speed, n_i	1000	r/min
Operating Temperature	60	ºC

Lubrication

Lubrication Type	○ Oil ● Grease	
Select Lubrication	Multemp SRL	
Viscosity at 40ºC	26	mm/sec^2
Viscosity at 100ºC	7	mm/sec^2
Viscosity at Operating Temperature, V	15.37	mm/sec^2

Contamination

Select Contamination Method	General Guidelines
Select Contamination Factor/ Lubrication & Cleanliness Codes, ec	Minimal/Slight Contaminatic

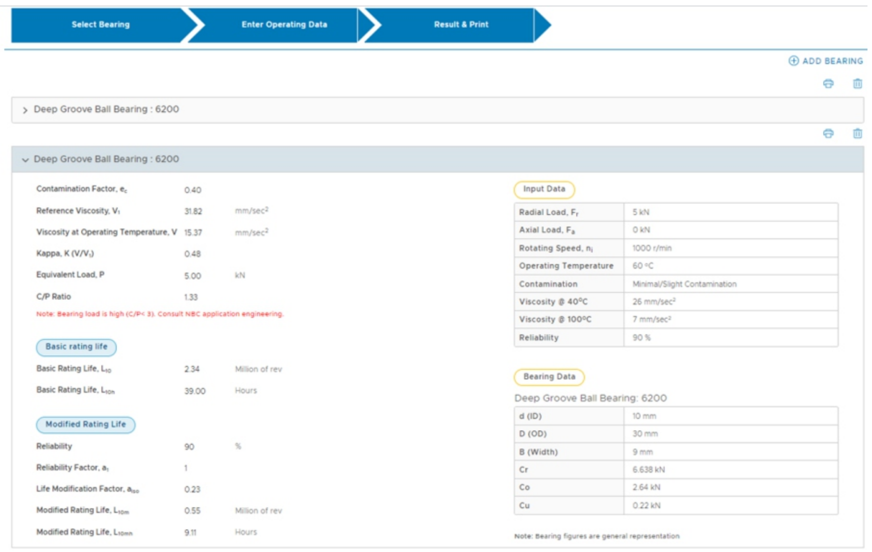
Reliability factor

Reliability, R	90	%
Reliability Factor, a_1	1	

Deep Groove Ball Bearing: 6200

d (ID)	10 mm
D (OD)	30 mm
B (Width)	9 mm
Cr	6.638 kN
Co	2.64 kN
Cu	0.22 kN

Note: Bearing figures are general representation



Deep Groove Ball Bearing : 6200

Deep Groove Ball Bearing : 6200

Contamination Factor, e_c	0.40	
Reference Viscosity, V_1	31.82	mm/sec^2
Viscosity at Operating Temperature, V	15.37	mm/sec^2
Kappa, K (V/V$_1$)	0.48	
Equivalent Load, P	5.00	kN
C/P Ratio	1.33	

Note: Bearing load is high (C/P< 3). Consult NBC application engineering.

Basic rating life

Basic Rating Life, L_{10}	2.34	Million of rev
Basic Rating Life, L_{10h}	39.00	Hours

Modified Rating Life

Reliability	90	%
Reliability Factor, a_1	1	
Life Modification Factor, a_{iso}	0.23	
Modified Rating Life, L_{10m}	0.55	Million of rev
Modified Rating Life, L_{10mh}	9.11	Hours

Input Data

Radial Load, F_r	5 kN
Axial Load, F_a	0 kN
Rotating Speed, n_i	1000 r/min
Operating Temperature	60 ºC
Contamination	Minimal/Slight Contamination
Viscosity @ 40ºC	26 mm/sec^2
Viscosity @ 100ºC	7 mm/sec^2
Reliability	90 %

Bearing Data

Deep Groove Ball Bearing: 6200

d (ID)	10 mm
D (OD)	30 mm
B (Width)	9 mm
Cr	6.638 kN
Co	2.64 kN
Cu	0.22 kN

Note: Bearing figures are general representation

Basic dynamic load

Every bearing is designed for a certain load referred as the dynamic load rating C. It is used for calculating basic rating life. The basic dynamic load is defined as the constant stationary load which a group of bearings with stationary outer ring can endure for a rating life of one million revolutions of the inner ring. It refers to pure radial load for radial bearings and to pure axial load for thrust bearings.

Basic rating life (L_{10})

It gives the calculation of basic rating life L_1 with 90% reliability. It is based on Lundberg and Palmgren fatigue theory which gives a rating life. The fae behaviour of the material determines the dynamic load carrying capacity of the rolling bearing. The relationship among the bearing basic dynamic load rating, the bearing load and the basic rating life, is given by formula:

$L_{10h} = (C/P)^P$
L_{10h}= Basic Rated Life in millions of revolutions
C = Basic dynamic rated Load, N
(Cr: radial bearings, Ca: thrust bearings)
P = Equivalent Dynamic Load, N
(Pr: radial bearings, Pa: thrust bearings)
p=3.....................For ball bearings
p=10/3................. For roller bearings

If the speed is constant, it is often preferable to calculate the life in terms of operating hours using the formula:

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

Where,
L_{10h}, basic rating life (at 90% reliability).........in hours
Another method to calculate life in hours is using the above formula

The basic rating life can also be expressed in terms of kilometers for wheel bearings as shown in formula below :

$$L_{10S} = \frac{\pi D}{1000} \times L\,10$$

Where ,
D = Wheel diameter in mm
L = Basic rating life in kms

The relationship between Rotational speed n and speed factor *fn* as well as the relation between the basic rating life L_{10h} and the life factor *fn* is shown in table 4.1
The value of *fn* and the rating life for ball and roller bearing can be found by means of this table.

$L_{10h} = 500(fn)^p$
$f_h = fn(\frac{C}{P})$
$fn = \left(\frac{33.3}{n}\right)^{1/p}$

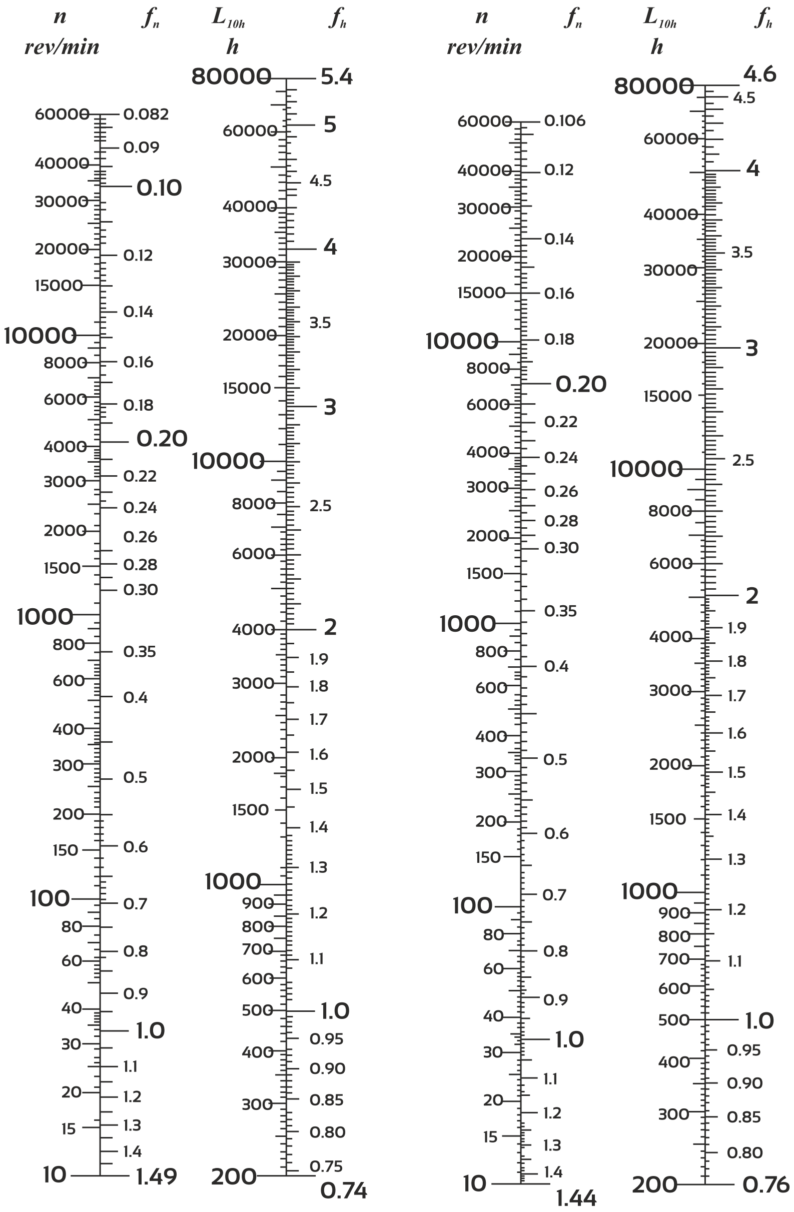
Where
L_{10h} = basic rating in hours of operation
f_h = life factor
fn = speed factor
n = operating speed, rev./min

Note: For a required life, the basic rated dynamic load (C) can be calculated using the formula and table 4.1, if for an operating condition, equivalent load (P) and speed (n) are given. Based on the dynamic load (C) value obtained, bearing can be selected from the catalogue. The values of 'fh and fn' can be taken from table 4.1

C = P(fh/fn)

Where, f_h = life factor
fn= speed factor
P= equivalent load

Table 4.1 Bearing rating life scale



Ball Bearings

Roller Bearings

Life calculation of multiple bearing

When several bearings are used in machines, all the bearings in the machine system are considered as a whole when computing bearing life

$$L = \frac{1}{\left(\frac{1}{L_1^{e}} + \frac{1}{L_2^{e}} + \cdots \frac{1}{L^{ne}}\right)^{1/e}}$$

where,

L : Total basic rating life of entire unit, h

L_1, L_2 ...Ln: Basic rating life of individual bearings, 1, 2....n, h

e = 10/9...................For ball bearings

e = 9/8.....................For roller bearings

When the load conditions vary at regular intervals, the life can be given by formula

$$Lm = \left(\frac{\phi 1}{L_1} + \frac{\phi 2}{L_2} + \cdots \frac{\phi}{L_1}\right)^{-1}$$

Where,

L m: Total life of bearing

Φj : Frequency of individual load conditions (ΣΦ j = 1)

L j: Life under individual conditions

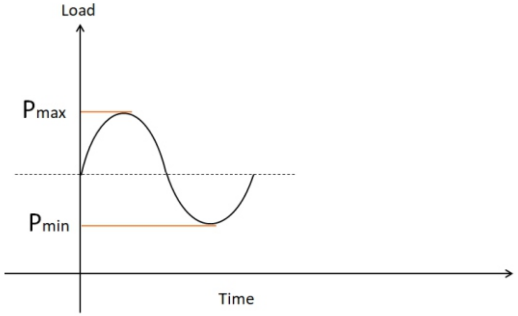
Equivalent load for operating conditions with variable loads and speeds

1. Sinusoidal Loads at constant Speed

Equivalent Load

$$P_e = 0.68\, P_{max} + 0.32\, P_{min}$$

-Main Bearing , Big End Bearing of Crank Shaft .

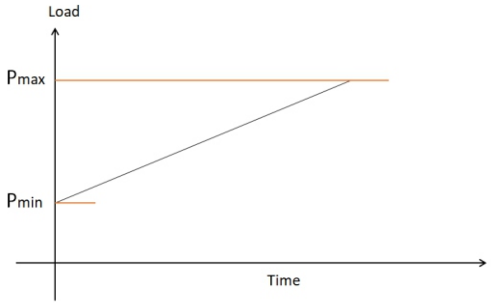


2. Linear Load Variation

Equivalent Load

$$P_e = \frac{P_{min} + 2P_{max}}{3}$$

-Centrifugal Casting of Steel Pipes
-Basket Type centrifuges for
 Sugar Crystallization
-Pinching Roll Hot Strip Mill



3. Fluctuating Load at Constant Speed

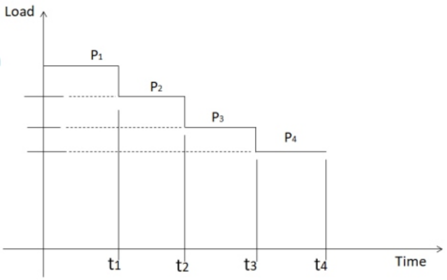
Equivalent Load

$$P_e = \left(P_1^n\, t_1 + P_2^n\, t_2 + P_3^n\, t_3 + \text{------}\; P_z^n\, t_z\right)^{1/n}$$

n- life exponent Factor For Ball
 And Roller Bearings

$$Pe = \sum_{i=1}^{Z} P_i^n ti$$

t - Total Time of duty circle



-Many steel Application
-Reversible 6 Hi Mill Skin Pass Mill
-Windmill

4. Variable Speed Constant Load

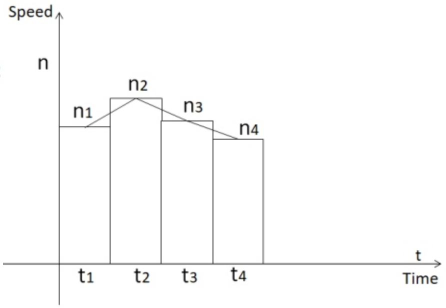
Equivalent Speed

$$n_e = n_1 t_1 + n_2 t_2 + n_3 t_3 + \text{-----}\; n_z t_z$$

$$ne = \sum_{i=1}^{Z} ni\, ti$$

t - Total Time of duty circle

- Wind Mill

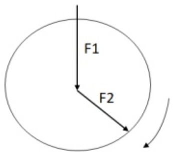


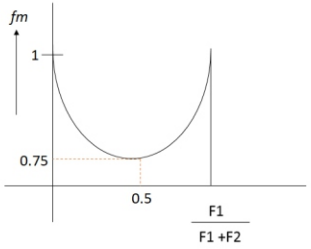
5. Rotating Load at Constant Speed

Equivalent Load

$$Pe = fm\,(F1 + F2)$$

- Vibratory Screen





6. Swivel Motion

For Swivel Motion

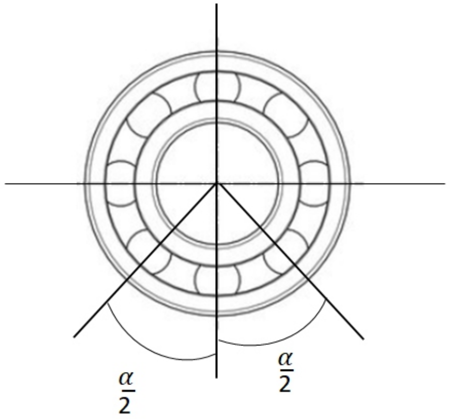
Equivalent Speed

$$ne = \frac{n_{osc} \times \alpha}{180^\circ}$$

n_{osc}= Number of oscillations /min

α = swivel Angle in degrees

- Convertor Bearing in Steel



4.2 Life adjustment factor for Reliability, a_1

The values for the reliability adjustment factor, a_1 can be calculated for a reliability of 90 % or higher (a failure probability of 10 % or less) are shown in Table 4.2

Table 4.2 Reliability adjustment factor, a_1

Reliability (%)	L_{nm}	a_1
90	L_{10m}	1
95	L_{5m}	0.64
96	L_{4m}	0.55
97	L_{3m}	0.47
98	L_{2m}	0.37
99	L_{1m}	0.25
99.2	$L_{0.8m}$	0.22
99.4	$L_{0.6m}$	0.19
99.6	$L_{0.4m}$	0.16
99.8	$L_{0.2m}$	0.12
99.9	$L_{0.1m}$	0.093
99.92	$L_{0.08m}$	0.087
99.94	$L_{0.06m}$	0.080
99.95	$L_{0.05m}$	0.077

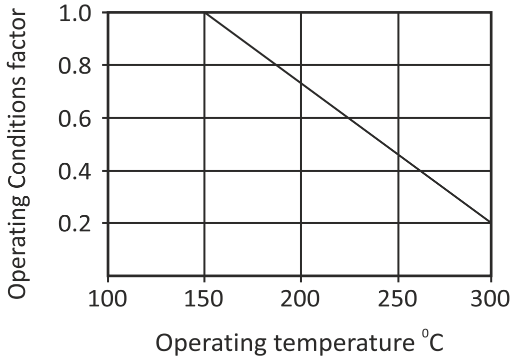
4.3 Thermal stabilization of Rolling bearings at high temperature

Bearing components are heat treated to ensure the performance under load and at the same time they must be stable enough to undergo limited dimensional changes over a period. Dimensional stability is an important parameter in rolling bearings. For bearings operating under high temperature (beyond 120°C) the components often softens and dimensional changes occur. For example, if inner ring bore size increases, it will result in creeping on shaft and loss of clearance in the bearing. For high temperature applications, NBC has developed unique heat treatment solutions (TS treatment) to stabilize bearing dimensions up to certain temperatures class.

Table 4.3 : Treatment class for stabilization

Stabilization Treatment Symbol	Max. Stabilization Temperature	Multiplication Factor
TS2	160°C	1.0
TS3	200°C	0.73
TS4	250°C	0.48

Note: However beyond the stabilization temperature class the treatment makes the bearing softer and life is affected. The life is adjusted by multiplying the values given in the table above (or use the graph below).



4.4 NEI life enhancement for Rolling Bearing

In addition to design parameters the service life of rolling bearings can be greatly enhanced by material and heat treatment processes. A special heat treatment is given to the bearings .This alter the microstructure which in turns improves the yield strength and rolling contact fatigue properties. The special heat treatment process leverages the combined advantage of having modified surface and core microstructure to significantly extend the bearing life. To prove the effectiveness of bearing made from special manufacturing process extensive laboratory and field tests were carried out. The positive results from the test helped in deciding the life multiplication factor for NEI bearings. However the selection of the special treatments depends on the application and type of bearing. Consult NEI representative for additional information and support. Refer the table 4.4 for special treatment factors.

Table 4.4 : Special treatment factors

Special Treatment	Life Multiplication factor
MLB	4.0
AST	2.0
TMB	2.2
4T	1.4

4.5 Modified rating life (L_{nm})

The rating life modified for 90% or other reliability for bearing with fatigue load, and/or special bearing properties, and/or contaminated lubricant and other non – conventional operating conditions.

The modified rating life is calculated according to the formula prescribed in ISO281:2007.

$$L_{nm} = a_1 \cdot a_{ISO} \cdot L_{10}$$

L_{nm} modified rating life [10^6 revolutions]

a_1 reliability adjustment factor

a_{ISO} life modification factor for operating conditions

This method evaluates the bearing life by using the life modification factor (a_{ISO}) and the life adjustment factor for reliability (a_1).

a_{ISO} essentially takes account of:

- Load on bearing
- Internal geometry of the bearing,
- Manufacturing quality,
- Fatigue limit of material,
- Lubrication method, type of lubricant, viscosity, additives,
- Cleanliness and filtration,
- Operating temperature and bearing speed.

$$a_{ISO} = f\left[\frac{e_c\, C_u}{P}\, K\right]$$

Where,

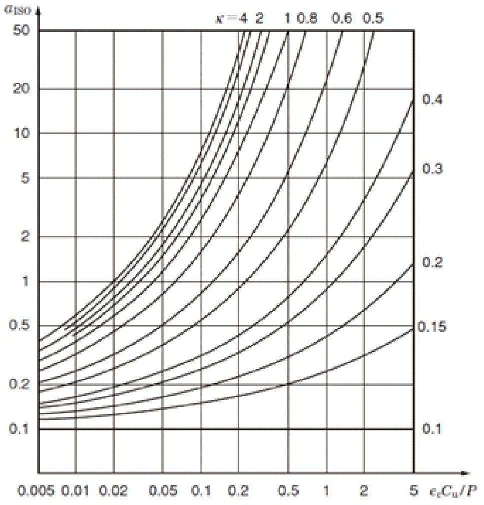
e_c - Contamination factor

C_u - Fatigue load limit in newton

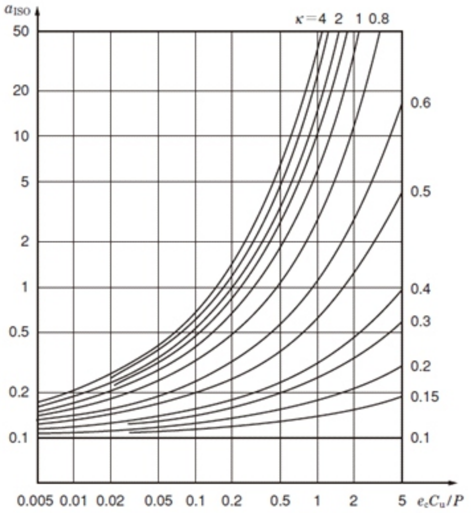
K - Viscosity ratio (kappa)

P - Dynamic Equivalent load in newton

The life modification factor (a_{iso}) can be estimated from graphs and equations given in ISO281:2007 standard.

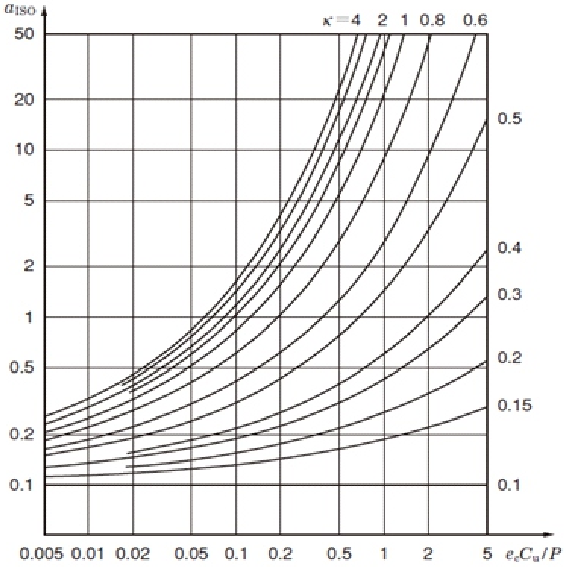


Life modification factor a_{ISO} (Radial ball bearings) Fig.4.1

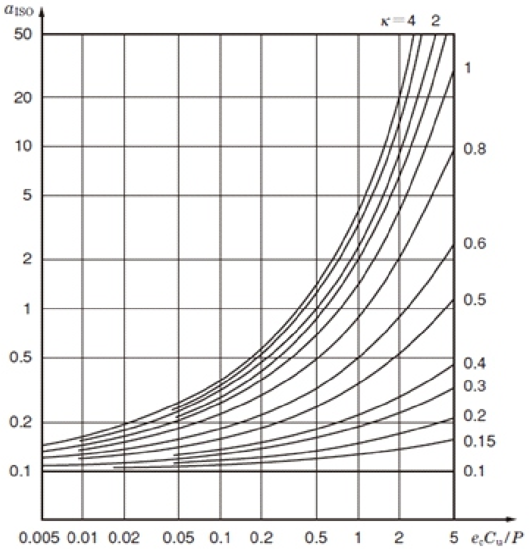


Life modification factor a_{ISO} (Radial roller bearings) Fig.4.2

The life modification factor (a_{iso}) can be estimated from graphs and equations given in ISO281:2007 standard.



Life modification factor a_{iso} (Thrust ball bearings) Fig.4.3



Life modification factor a_{ISO} (Thrust roller bearings) Fig.4.4

4.6 Viscosity Ratio (Kappa), K

The key characteristic of a lubricant is the ability of the lubricant to separate moving parts. Operating conditions play a key role in determining the appropriate viscosity for a given component and application. The condition of the lubricant is defined by the viscosity ratio, K for adequate lubrication.

$$K = \frac{V}{V_1}$$

Where

V is the actual Kinematic Viscosity

V_1 is the Reference Kinematic Viscosity

The viscosity ratio (k) is an indicator of the quality of the lubricant film thickness formation. The reference Kinematic viscosity takes account of the minimum oil film thickness, h min in relation to the contacting surface irregularities to provide adequate film formation. The lubricant must have minimum viscosity. Lubricant film thickness (h) min is affected by various factors including viscosity, temperature, relative surface velocity, load, contact area, deformation, and lubricant regime.

The influence of oil film thickness (h) on bearing life is given by a factor, ∧

At operating conditions, specific film thickness parameter, ∧ is the ratio of lubricant film thickness (h) within the contact divided by the composite roughness (σ) of the two contacting surfaces. .

∧ is determined by,

$$\Lambda = \frac{h}{s}$$

Where,
'h' is the oil lubricant film thickness
's' is the root mean square surface roughness

$$S = \sqrt{s_1^2 + s_2^2}$$

S_1 is the surface roughness of contacting body 1
S_2 is the surface roughness of contacting body 2

∧ is used as an indicator of the lubricant regime. With ∧ value, it can be identified which lubricant regime is present in an operating contact within bearings.

In Liquid Lubrication, regimes can be based on specific film thickness parameter, ∧ as:

- $\Lambda > 3$ → full film (thick film) lubrication, hydrodynamics
- $1.2 > \Lambda > 3$ → mixed or thin film lubrication
- $\Lambda < 1.2$ → boundary lubrication

In order to form an adequate lubrication film, viscosity ratio (K) is based upon mineral oil and contacting surfaces of machined bearing components. But the viscosity ratio, $K = V/V_1$ can only be approximated for synthetic oils.

Hence for more detail estimation of viscosity ratio K, specific film thickness parameter Λ can be applied. Calculation of Λ considers lubricant film thickness, surface roughness ,P-V coefficient etc.

When ratio (Λ) is calculated, the kappa value, K can be approximately estimated by the following equation as given below.

$$K \approx \Lambda^{1,3}$$

Most of the application are designed for lubrication condition with viscosity ratio (kappa) ranging from 1 to 4. Refer table 4.5

Table 4.5 Viscosity ratio (Kappa), K condition

4	Full fluid-film lubrication
>4	In the regime of full fluid
<4	Mixed friction. Lubricating greases containing antiwear additives have to be used
1	The basic rating life of the roller bearing is acheived
<0.4	Mixed friction with increased solid contact; the grease has to contain EP additives.

Note: For K value below 1

- If the K value is low due to speed, then bearing selection is based on static safety factor.
- If the K value is low because of low viscosity, then select higher viscosity lubricant or improve cooling.

For K value less than 1, extreme pressure (EP)/ anti-wear (AW) additives are recommended.

Considering EP additive as per ISO281:

For viscosity ratio, k<1 and contamination factor, $e_c \geq 0{,}2$ calculation can be carried out using k=1 if a lubricant with proven effective EP additive is used. In this case the life modification factor, a_{ISO} shall be limited to $e_c \leq 3$ If the calculated value of aiso for the actual k is greater than 3 then this value can be used in calculation.

Viscosity grade in accordance with ISO 3448 are listed in the table 4.6 with grade at 40° C. Higher the K value, better is the bearing life.

Table 4.6 Kinematic viscosity limits at 40°C(105°F)

Viscosity grade	mean	min.	max.
	mm^2/s		
ISO VG 2	2,2	1,98	2,46
ISO VG 3	3,2	2,88	3,52
ISO VG 5	4,6	4,14	5,06
ISO VG 7	6,8	6,12	7,48
ISO VG 10	10	9,00	11,0
ISO VG 15	15	13,5	16,5
ISO VG 22	22	19,8	24,2
ISO VG 32	32	28,8	35,2
ISO VG 46	46	41,4	50,6
ISO VG 68	68	61,2	74,8
ISO VG 100	100	90,0	110
ISO VG 150	150	135	165
ISO VG 220	220	198	242
ISO VG 320	320	288	352
ISO VG 460	460	414	506
ISO VG 680	680	612	748
ISO VG 1 000	1 000	900	1 100
ISO VG 1 500	1 500	1 350	1 650

Calculation of Kappa value

Kappa value, k (Viscosity ratio)

$$\text{Kappa } k = \frac{\text{Viscosity under operating temperature}}{\text{Minimum viscosity under mean dia and operating speed (Reference viscosity)}}$$

More than 80% of all rolling bearings are lubricated with grease. Therefore selection of grease is critical. Not only will correct grease selection, prolong the life of the bearing, it also ensures smoother running. C/P ratio is the measure of the bearing dynamic capacity 'C' in relation to load (P). Based on C/P ratio, type of grease can be selected. Refer table below.

Load ratio C/P

C/P	Load	Criteria for selection
>30	Very low loads	Max. permissible load for sllicone greases
20-30	low loads	Dynamically light greases
8-20	Medium loads	Greases containing antiwear addltives
4-8	High loads	A Greases with EP and antiwear addltivesis to used. Reduced grease/bearing life to be expected
<4	Extremely High loads	A Greases with EP antiwear addltives + solid lubricants is to to be used.A consicerably reduced grases/ bearing life is to be expected

Induced Thrust Load Reaction Taper Roller Bearing

Taper roller bearing due to their design when loaded radially, produces thrust reaction (the thrust load in opposite direction is induced on shaft axis), which if not accommodated will push the inner and outer ring apart, the bearing will separate.
Radial load on bearing A for example will generate axial thrust on bearing B.
One of the reason taper roller bearings are always used in pairs.

These thrust reaction are important part and needs to be taken into consideration

Thrust reaction factor $K = 0.4 \cot\alpha$

α Half Included angle of cup

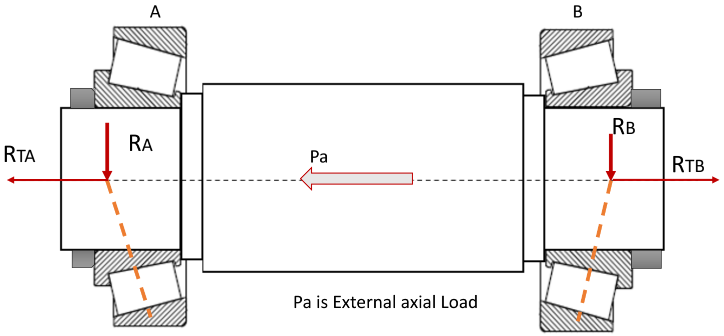
Thrust reaction due to radial load when load zone is equal less than 180 ^{o}

$$R_T = \frac{0.47\ Fr}{K}$$

R_T is the Induced thrust load due to radial load Fr when load zone approaches 360^{o} quite obvious, load zone nearing 360 ^{o} indicates combined radial and thrust load is applied

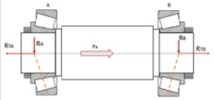
$$R_T = \frac{0.6\ Fr}{K}$$

Back-to-back Arrangement



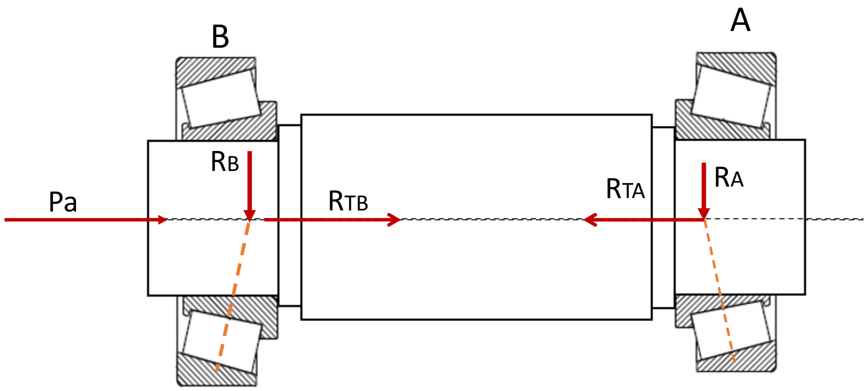
R_A - Radial Load on Bearing A
R_{TA} - Thrust Load Induced By radial load

R_B - Radial Load on Bearing B
R_{TB} - Thrust Load Induced By radial load

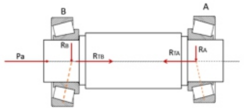
Load Centers		Load Condition	Axial Load Bearing A	Axial Load On Bearing B
		$R_{TA} = \frac{0.47\ R_A}{Y_A}$ $R_{TB} = \frac{0.47\ R_B}{Y_B}$		
Load Zone Less or equal to 180^{o}	Case 1	If $R_{TA} \leq R_{TB} + Pa$	Then Axial Thrust Load on Bearing A $FaA = R_{TB} + Pa$ $FaA = \frac{0.47\ R_B}{Y_B} + Pa$	*No Axial Thrust is taken on Bearing B in Load Calculations*
	Case 2	If $Pa + R_{TB} \leq R_{TA}$	*No Axial Thrust on Bearing A in Load Calculations*	$FaB = R_{TA} - Pa$ $FaB = \frac{0.47\ R_A}{Y_A} - Pa$

YA – Thrust Reaction Factor Bearing A
YB – Thrust Reaction factor Bearing B

Face To face arrangement



RA - Radial Load on Bearing A
RTA - Thrust Load Induced By radial load
RB - Radial Load on Bearing B
RTB - Thrust Load Induced By radial load
Pa - External axial load

Load Centers		Load Condition	Axial Load Bearing A	Axial Load On Bearing B
		$R_{TA} = \frac{0.47 R_A}{Y_A}$ $R_{TB} = \frac{0.47 R_B}{Y_B}$		
Load Zone Less or equal to 180°	Case 1	If $R_{TA} \leq R_{TB} + Pa$	Then Axial Thrust Load on Bearing A $FaA = R_{TB} + Pa$ $FaA = \frac{0.47 R_B}{Y_B} + Pa$	*No Axial Thrust is taken on Bearing B in Load Calculations*
	Case 2	If $Pa + R_{TB} \leq R_{TA}$	*No Axial Thrust on Bearing A in Load Calculations*	$FaB = R_{TA} - Pa$ $FaB = \frac{0.47 R_A}{Y_A} - Pa$

YA – Thrust Reaction Factor Bearing A
YB – Thrust Reaction factor Bearing B

4.7 Contamination factor (e_c)

The factor is used to consider the contamination level of the lubricant. The life reduction caused by contamination depends on lubricant film thickness, size and distribution of solid contaminant particles and types of contaminants (soft, hard etc.).As a general guideline the values for solid contamination factor, e_c can be taken from the table (ISO281:2007)

Table 4.7 for contamination factor, e_c

Contamination level	e_c	
	$D_{pw} < 100$mm	$D_{pw} \geq 100$mm
Extreme cleanliness Particle size of order of lubricant film thickness laboratory conditions	1	1
High cleanliness Oil filtered through extremely fine filter: conditions typical for bearings greased for life and sealed	0.8 to 0.6	0.9 to 0.8
Normal cleanliness Oil filtered through fine filter: conditions typical for bearings greased for life and shielded	06. to 0.5	08. to 0.6
Slight contamination	0.5 to 0.3	0.6 to 0.4
Typical contamination Conditions typical of bearings without seals: course filtering: wear particles from surroundings	0.3 to 0.1	0.4 to 0.2
Severe contamination Bearing environment heavily contaminated and bearings arrangement with inadequate sealing	0.1 to 0	0.1 to 0
Very severe contamination	0	0

Dpw is the mean pitch diameter of bearing in mm

Note: For advance and detailed method for calculation of e_c factor for different lubriation method in grease and oil (bath or circulation),refer ISO 16889 and ISO 4406 standards.

4.8 Estimating Contamination factor, ec, based on lubricant cleanliness

4.8.1 Lubricant system cleanliness level

The method for classifying the applicable contamination level for a range of cleanliness code is defined in ISO 4406.In this system the solid particle count data is converted into code using scale number. The code is assigned based on ISO 4406 which provides the method of measuring and describing the cleanliness level for lubricating system. Lubricant gets contaminated by debris resulting from wear or during assembly or dust in the air etc. To determine how clean the lubricant (oil or grease) is for a given application, a sample is taken for analysis.

There are two methods for checking contamination level in lubricant.

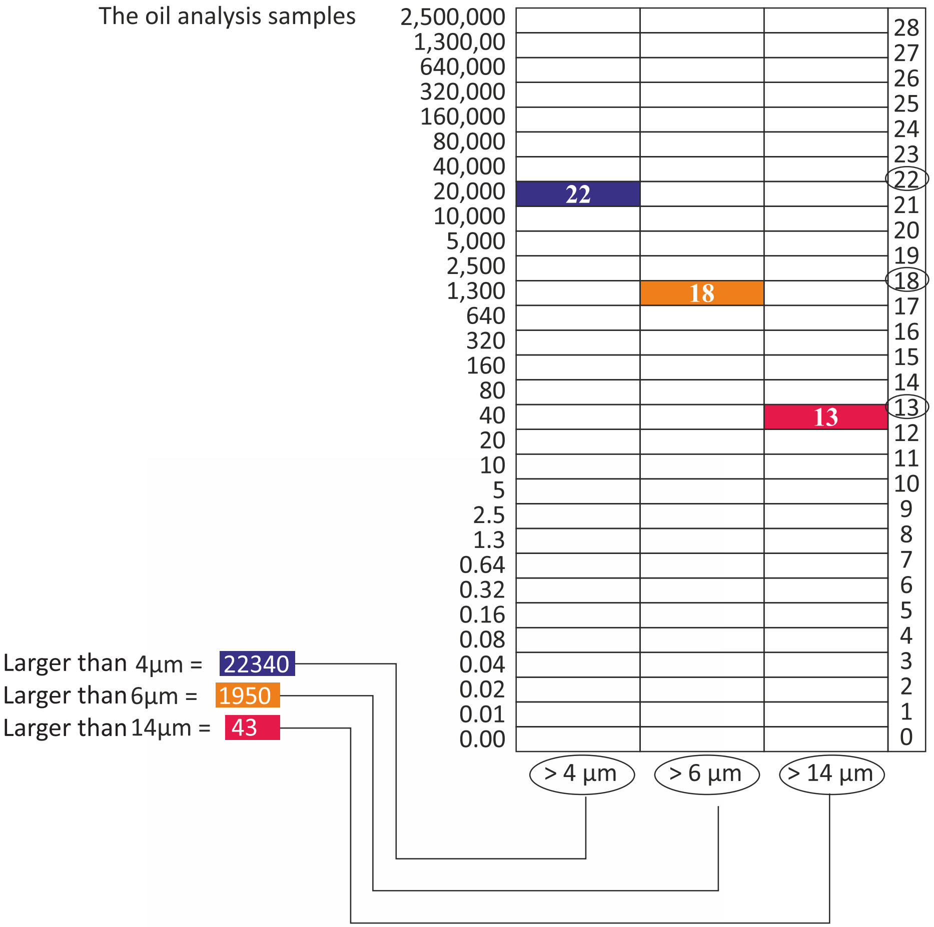
- Microscopic counting method. This method uses two particle sizes: ≥ 5 µm and ≥ 15 µm.
- Automatic Optical single particle counter in accordance with ISO 11171. It uses three particle sizes: ≥ 4 µm(c), ≥ 6 µm(c) and ≥ 14 µm(c).

ISO classification for scale number

Number of Particles per ml		ISO 4406
More than	Up to & including	Scale Number
8,000,000	16,000,000	24
4,000,000	8,000,000	23
2,000,000	4,000,000	22
1,000,000	2,000,000	21
500,000	1,000,000	20
250,000	500,000	19
130,000	250,000	18
64,000	130,000	17
32,000	64,000	16
16,000	32,000	15
8,000	16,000	14
4,000	8,000	13
2,000	4,000	12
1,000	2,000	11
500	1,000	10
250	500	9
130	250	8
64	130	7
32	64	6
16	32	5
8	16	4
4	8	3
2	4	2

Example of contamination level classification for lubricating system.

The oil analysis samples send through APC (Automatic optical particle counter) . Amount of dirt particles in a 1ml sample larger than specified sizes 4um/6um/14um



Particle count data converted into ISO Code: 22/18/13

4.8.2 Filter Absolute Rating:

An absolute rating gives the size of the largest particle that will pass through the filter or screen. Essentially, this is the size of the largest opening in the filter although no standardized test method to determine its value exists. Still, absolute ratings are better for representing the effectiveness of a filter. A filter rating is an indication of filter efficiency and is expressed as a reduction factor (β). The filter is for the specified particle size. Filter rating β is expressed as a ratio between the number of specified particles before and after filtering. This can be calculated using

$$\beta_{x(c)} = \frac{n_1}{n_2}$$

Where

$\beta_{x(c)}$ = filter rating related to a specified particle size x

x = particle size(c)(µm) based on the automatic particle counting method,calibrated in accordance with ISO 11171

n_1 = number of particles per volume unit larger than x, upstream of the filter

n_2 = number of particles per volume unit larger than x, downstream of the filter

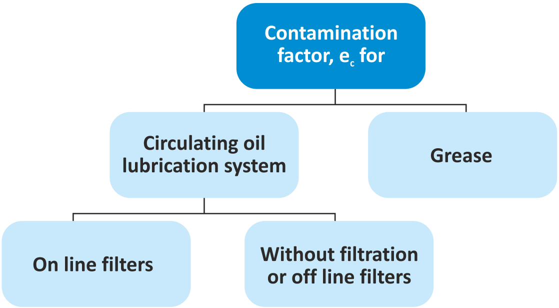
For example, a "β5(c) = 10" means that only 1 in 10 particles, 5µm or larger, passes through the filter.

4.9 Method for determing Contamination factor, e_c based on cleanliness code and filter ratio

Contamination factor can be estimated once the contamination level is known for lubricating system. The contamination factor apart from particle counts also depends on size of bearing and lubrication condition.

As per ISO 281, the contamination factor can be determined by means of diagram or equation for the following lubrication method.

- Circulating oil with oil filtered on line before supply to bearing.
- Oil bath lubrication or Circulating oil with off line filter
- Grease lubrication



4.9.1 Lubricating system

4.9.1.1 Contamination factor, e_c for circulating oil lubrication system with in line filters.

For circulating oil systems with on line filters, before the oil is supplied to the bearing the contamination factor can be determined using graphs as per ISO 281 Standard.

Note: The diagram to be used is selected on the basis of the filter retention rate βx(c) according to ISO 16889 and the oil cleanliness code according to ISO 4406. The index (c) is the particle size according to ISO 1171

Fig. 1. Contamination coefficient for circulating oil lubrication with on-line filter - filter rating $\beta_{6(C)}$ = 200, cleanliness code acc. to ISO 4406 -/13/10

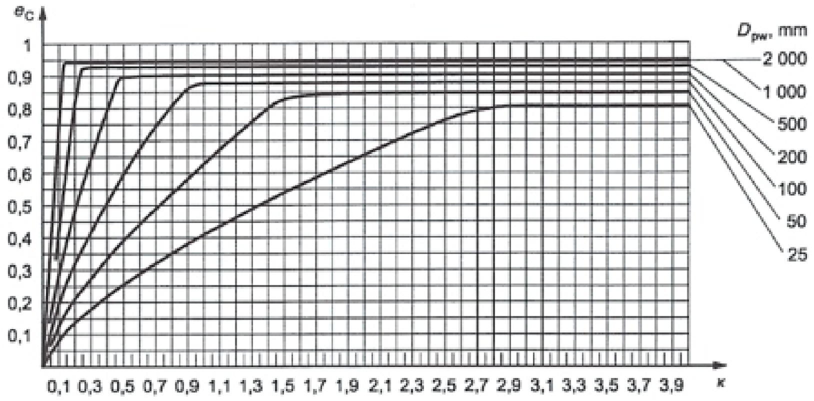
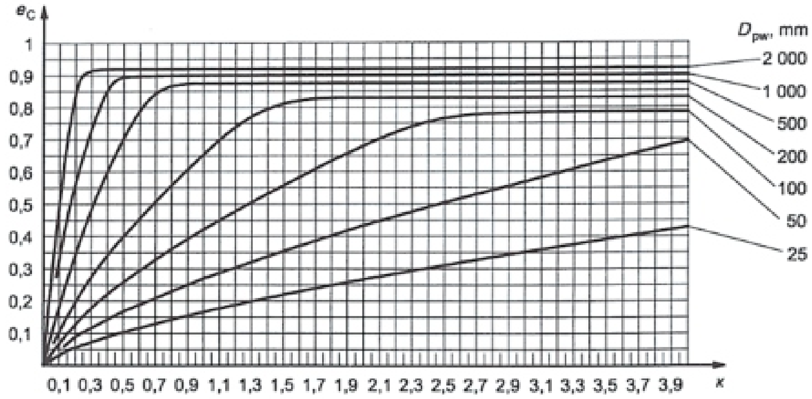
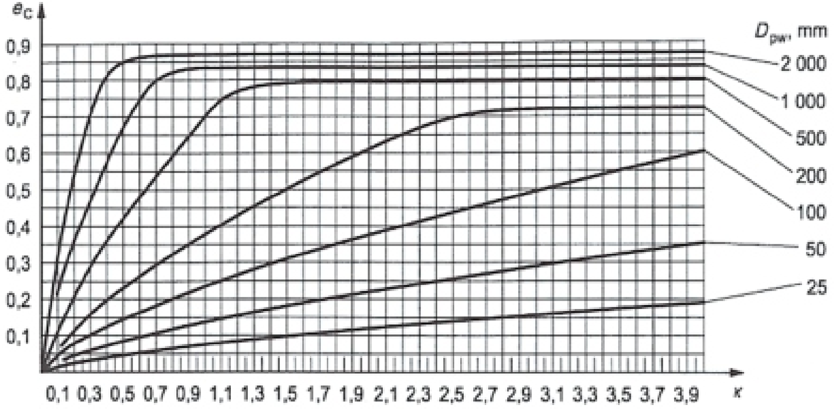


Fig. 2. Contamination coefficient for circulating oil lubrication with on-line filter - filter rating $\beta_{12(C)}$ = 200, cleanliness code acc. to ISO 4406 -/15/12



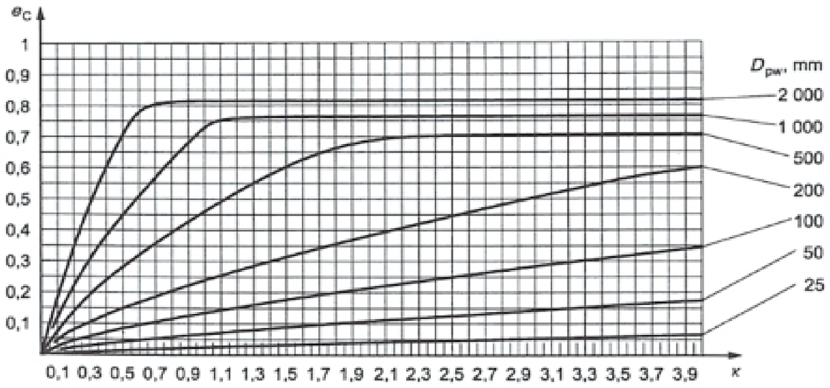
Cleanliness codes range ISO 4406: - /15/12, - /16/12, - /15/13, - /16/13

Fig. 3. Contamination coefficient for circulating oil lubrication with on-line filter - filter rating $\beta_{25(C)}$= 75, cleanliness code acc. to ISO 4406 -/17/14



Cleanliness codes range ISO 4406: - /17/14, - /18/14, - /18/15, - /19/15

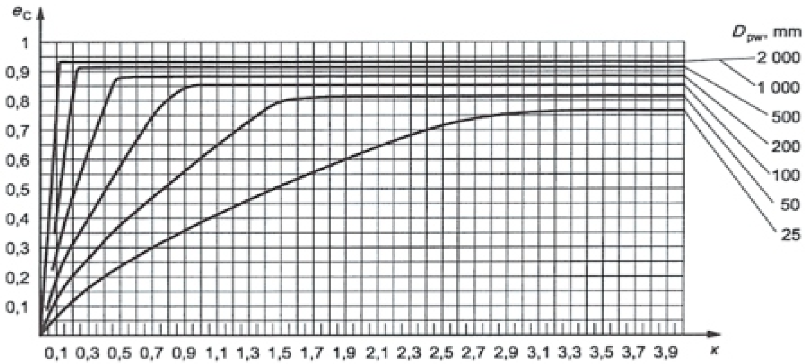
Fig. 4. Contamination coefficient for circulating oil lubrication with on-line filter - filter rating $\beta_{40(C)}$ = 75, cleanliness code acc. to ISO 4406 -/19/16



Cleanliness codes range ISO 4406: - /19/16, - /20/17, - /21/18, - /22/18

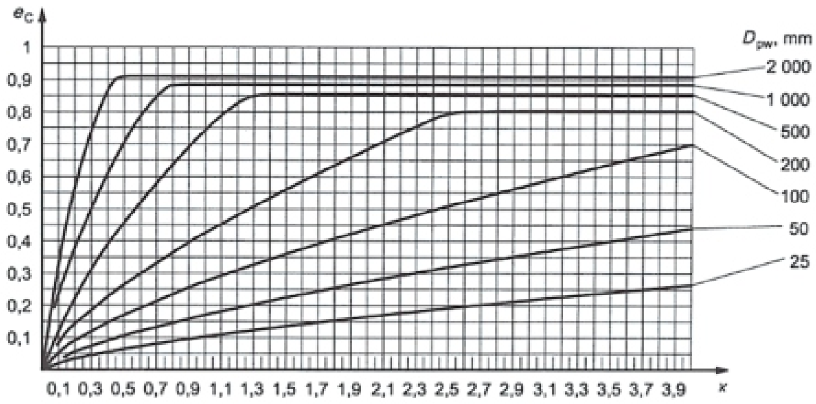
4.9.1.2 Contamination factor, e_c for circulating oil lubrication system witout filteration or with off line filters.

Fig. 5. Contamination coefficient for oil lubrication without filters or with off-line filters - cleanliness code acc. to ISO 4406 -/13/10



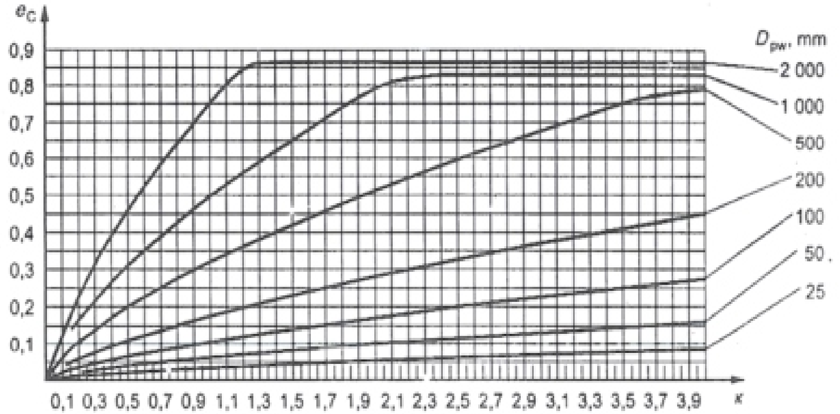
Cleanliness codes range ISO 4406: - /13/10, - /12/10, - /11/9, - /12/9

Fig. 6. Contamination coefficient for oil lubrication without filters or with off-line filters - cleanliness code acc. to ISO 4406 -/15/12



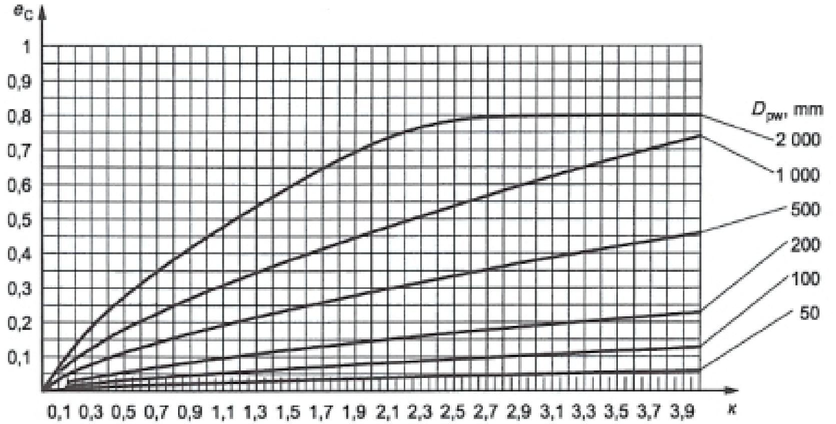
Cleanliness codes range ISO 4406: - /15/12, - /14/12, - /16/12, - /16/13

Fig. 7. Contamination coefficient for oil lubrication without filters or with off-line filters - cleanliness code acc. to ISO 4406 -/17/14



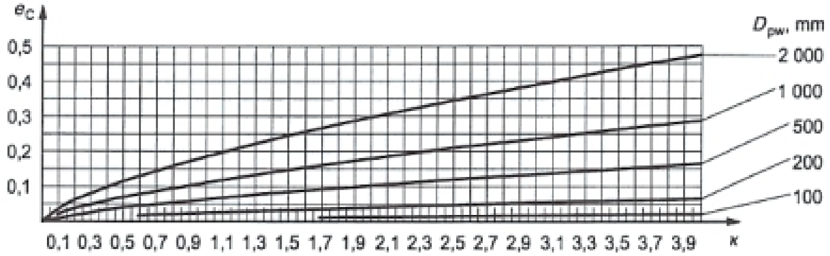
Cleanliness codes range ISO 4406: - /17/14, - /18/16, - /20/17, - /21/17

Fig. 8. Contamination coefficient for oil lubrication without filters or with off-line filters - cleanliness code acc. to ISO 4406 -/19/16



Cleanliness codes range ISO 4406: - /19/16, - /18/16, - /20/17, - /21/17

Fig. 9. Contamination coefficient for oil lubrication without filters or with off-line filters - cleanliness code acc. to ISO 4406 -/21/18



Cleanliness codes range ISO 4406: - /21/18, - /21/19, - /22/19, - /23/19

4.8.2 Contamination factor, e_c for grease lubrication

Working conditions	Contamination level
Very clean assembly with careful washing, rinse; very good sealing regard to working conditions; continuous regraessing or often lubrication;	High cleanliness
Sealed bearings, greased for life with effective sealing with regard to working conditions	
Clean assembly with washing and rinse; good sealing with regard to working conditions; regreassing according to manufactures specifications;	Normal cleanliness
Sealed bearings, greased for life with properly choosen sealing with regard to working conditions, e.g. bearing with Z type shields	
Clean assembly; sealing with regard to working conditions; regressing according to manufactures specification;	Slight or typical cleanliness
Assembly in working; bearing and assembly insufficiently washed after mounting: poor sealing with regard to working conditions; regreasing intervals longer than recommended by manufacture	Severe contamination
Assembly in contaminated environment; insufficient sealing: very long regreasing intervals	Very severe contamination

Refer to the figures below for contamination factor in grease lubrication.

Fig.10. Contamination coefficient for grease lubricant - High cleanliness

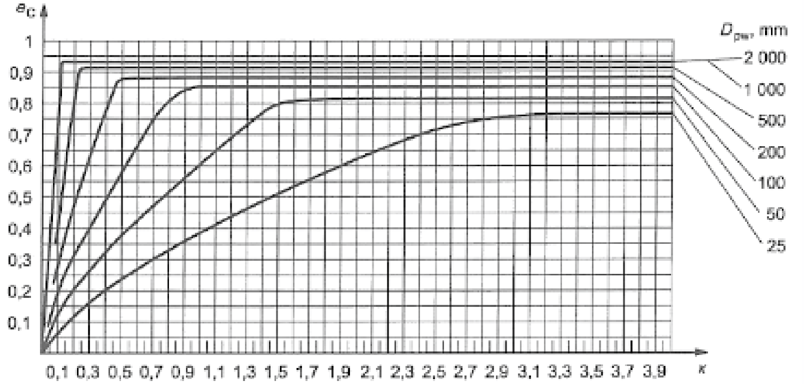


Fig.11. Contamination coefficient for grease lubricant - Normal cleanliness

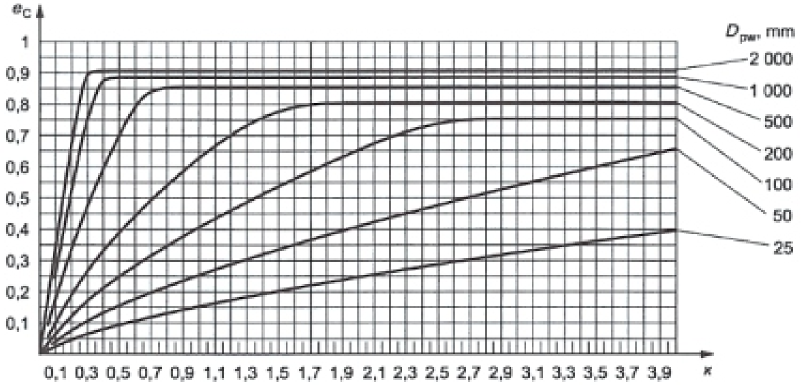


Fig.12. Contamination coefficient for grease lubricant - Slight or typical cleanliness

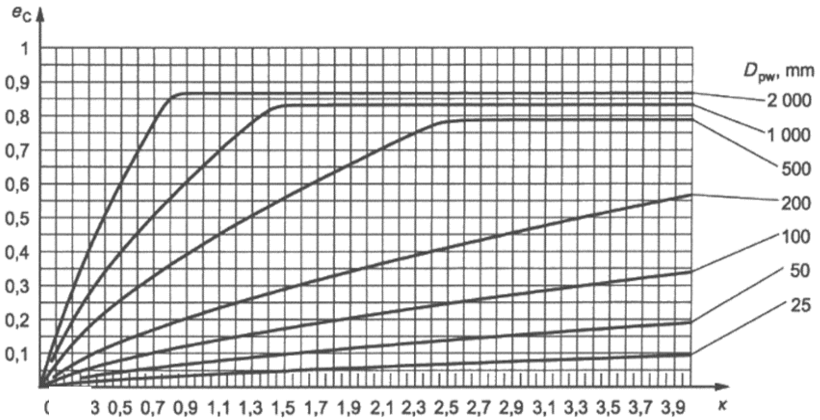


Fig.13. Contamination coefficient for grease lubricant - Severe contamination

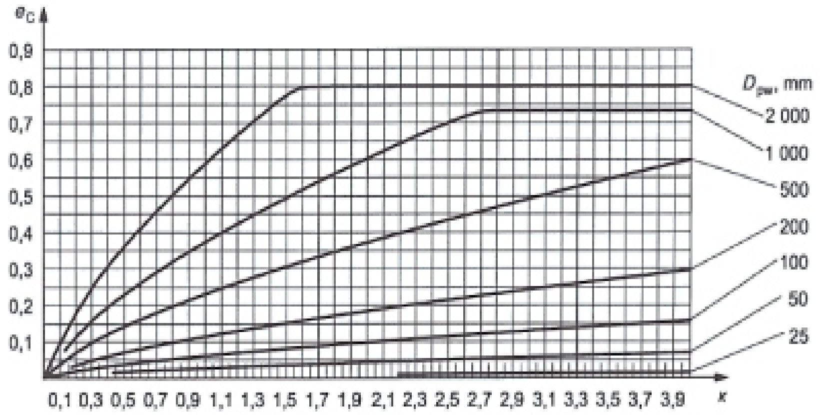
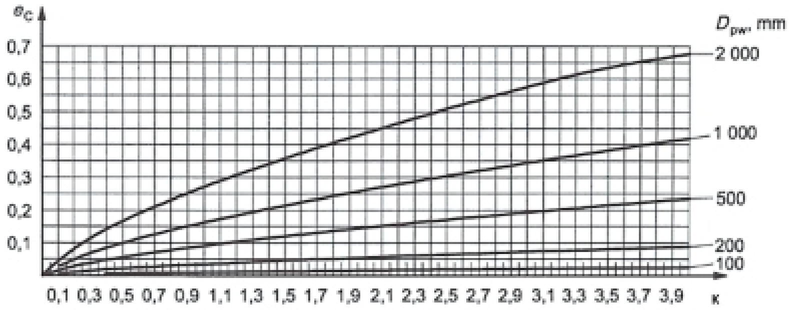


Fig.14. Contamination coefficient for grease lubricant - Very severe contamination



4.10 Basic Static Load Rating (Co)

The Static load is defined in ISO 76. It is the load acting on a non-rotating bearing. Permanent deformation appears in rolling elements and raceways under static load of moderate magnitude and increases gradually with increasing load. The permissible static load, therefore, depends upon the permissible magnitude of permanent deformation.

Experience shows that total permanent deformation of 0.0001 times of the rolling element diameter ,occurring at the most heavily loaded rolling element and raceway contact can be tolerated in most bearing applications without impairment of bearing operation.

In certain applications where subsequent rotation of the bearing is slow and where smoothness and friction requirements are not too exacting, a much greater total permanent deformation can be permitted. On the other hand, where extreme smoothness is required or friction requirements are critical, less-total permanent deformation may be tolerated.

For purpose of establishing comparative ratings, the basic static load rating therefore, is defined as that static radial load which corresponds to a total permanent deformation of rolling element and raceway at the most heavily stressed contact set at 0.0001 times of the rolling element diameter. It applies to pure radial load for radial bearing and pure axial load for thrust bearing.

In single row angular contact bearing, the basic static load rating relates to the radial component of the load, which causes a purely radial displacement of the bearing rings in relation to each other.

The maximum applied load values for contact stress occurring at the rolling element and raceway contact points are as follows:

For ball bearing	4200 MPa
For self-aligning ball bearing	4600 MPa
For roller bearing	4000 MPa

The static equivalent load is defined as that static radial load, which, if applied to Deep Groove Ball bearings, Angular Contact or Roller bearings would cause the same total permanent deformation at the most heavily stressed rolling element and raceway contact as that which occurs under the actual conditions of loading. For thrust bearings the static equivalent load is defined as that static, central, purely axial load which, if applied, would cause the same total permanent deformation at the most heavily stressed rolling element and raceway contact as that which occurs under the actual condition of loading.

4.11 Life factor for application

	Life factor f_h							
Service Requirements	**< 1.0**	**1.0-2.0**	**2.0-2.5**	**2.5-3.0**	**3.0-3.5**	**3.5-4.0**	**4.0-5.0**	**> 5.0**
Machines used occasionally	Door mechanism measuring instruments							
Equipment for short period or intermittent service interruption permission		Medical equipment	Household appliances, electric hand tools, agriculture machines, lifting tackles in shop					
Intermittent service machines high reliability				Power station auxiliary equipment, construction machines, Crane sheaves elevators, Conveyors, deck cranes, Cranes	Crane Sheaves			
Machines used for 8 hours a day but not always in full operation		Automobiles, motor cycles internal grinding spindles, ore tub axles	Buses, Trucks	Wood working machines, gear drives, plunger pumps vibrating screens	Small electric motors, grinding spindles, boring machine spindles rotary crushers, industrial Wagon axles	Lathe spindles, press flywheels printing machines	Agitators important gear units	
Machines fully used for 8 hours			Small rolling mill roll necks	Large rolling mill roll necks, rolling mill table rollers, excavators centrifugal separators continuous operation conveyors	Industrial electric motors, blowers, air conditioners street car or freight wagon axles, general machinery in shop, continuous operation cranes	Large electric motors, rolling mill gear units plastic extruders, rubber-plastics calendar rolls, railway vehicle axles, traction motors, conveyors in general use	Locomotive axles, railway vehicle gear units, false twist textile machines	
Machines continuously used for 24 hours a day					Loom	Electric motors in shop compressors, pumps	Textile machines, mine winches, iron industry conveyors	Paper making machine, main rolls machines
Machines continuously used for 24 hours a day with maximum reliability pumps								Power station equipment, water supply equipment for urban areas, mine drain

Reference life for machine application under operational conditions

Operation classification	*L*10h life (reference)				×10^3 h
	～4	4～10	12～25	25～50	50～
Machines used for short periods or occasionally	Household appliances Electric hand tools	Farm machinery			
Short period or intermittent use, but with high reliability requirements	Medical appliances Measuring instruments	Home air conditioning motor Construction equipment Elevators Cranes	Crane (sheaves)		
Machines not in constant use	Automobiles	Small motors Buses/trucks gear drives Woodworking machine	Machine spindles Industrial motors Crushers Vibrating screens Coal pulverizer	Main gear drives Rubber/plastic Calendar rolls Printing machines Conveyor bearings	
Machines in constant use over 8 hours a day		Rolling mills Escalators Conveyors Centrifuges	Railway vehicle axles Air conditioners Large motors Compressor pumps	Locomotive axles Traction motors Mine hoists Pressed flywheels	Papermaking machines
24 hour continuous operation					Water supply equipment Pumps Power generating equipment

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05

Accuracy and Tolerances