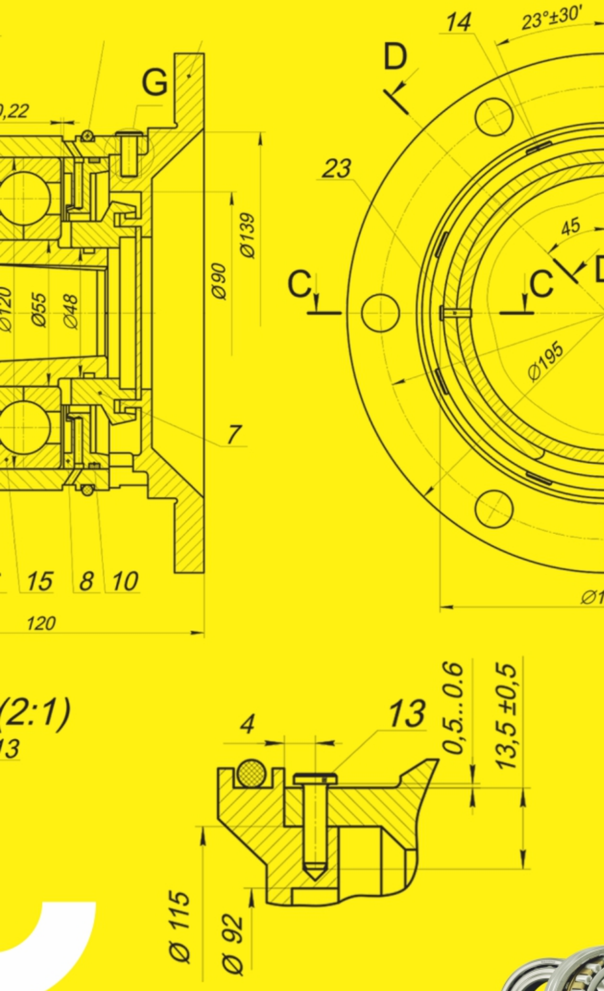
CELEBRATING 75 YEARS

CKA Birla Group | nbc



SPHERICAL BEARING

TECHNICAL CATALOGUE

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

WINNER DEMING GRAND PRIZE

CATALOGUE/TC-106, 03/2021

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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A symbol of dependability and flexible engineering solutions, NBC Bearings is the brand of National Engineering Industries. Founded in 1946, National Engineering Industries Ltd (NEI) is India's leading bearings manufacturer and exporter, renowned for excellence in quality and delivery. In 2021, NBC bearings completed 75 years of its incorporation.

Headquartered in Jaipur, having started with 30,000 bearings in 19 sizes in 1946, NBC has evolved to manufacture over 200 million bearings each year and supplying in 2300+ sizes to serve a host of customers in India and over 30 other countries across five continents in automotive, railways and industrial segments. NBC also serves the Indian aftermarket through a countrywide network of 550+ authorized stockists and thousands of retailers.

With an employee strength of over 2,800 and five manufacturing plants in Jaipur, Newai (Rajasthan), Manesar (Haryana) and Vadodara (Gujarat), NEI is equipped with global manufacturing and process technology and one of the best R&D centres in the country. In 2020, NEI acquired Kinex Bearings based in Europe.

Industry segments NEI caters to:

Automotive: Leading supplier to automotive OEMs and aftermarket with a wide range of products and services.

Railways : Partnering Railways around the world with bearings for Locomotives, Wagons and Coaches.

Industrial: Catering to diverse industries from Power, Steel, Cement, Construction, Mining to Electric motor, Material Handling, Textile etc.

Apart from being technologically advanced, the company practices methods of sustainability by using alternate sources of energy and increasing the efficiency of the manufacturing process by leveraging on the power of digitization.

MILESTONES

1946
Company Established as National Bearing Company

1958
Company is Renamed National Engineering Industries Limited (NBC); NBC Trademark Retained

1981
Bearing production started in Newai, Rajasthan

1982
Technical Collaboration with BRENCO, USA, for Cartridge Taper Roller Bearing

1985
Technical Collaboration with NTN Japan

1995
ISO 9001 Certification

2000
ISO-14001 & QS-9001 Certification.

2003
TS 16949 Certification Achieved

2005
Bearing production started in Manesar, Haryana

2006
AAR Certification Achieved

2007
TPM Excellence Award

2010
Deming Application Award

2014
Bearing production started in Savli, Gujarat

2015
NBC becomes the only bearing mfg. company in the world to get Deming Grand Award

2017-18
Industry 4.0 Journey Started, GPTW Certified

2020
Acquired Kinex Bearing, Europe

In India's top 100 companies to work for

Launched Needle Roller Bearings

Jaipur site IGBC Platinum certified

2021
Great Place To Work Top 30 best workplace in mfg.

NBC Amsted Seals JV started

nbc®

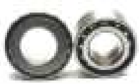
Manufacturing Capabilities

- Four modern manufacturing plants with installed annual capacity of over 200 Million bearings.
- All manufacturing facilities equipped with cutting edge technology which helps producing best-in-class products with superior quality.
- Fully automatic plants with built in Poka-Yoke system ensures defect free jobs with minimal human interventions.
- Embraced Industry 4.0 and concept of connected enterprise to improve productivity, efficiency and become cost competitive to deliver value to customers.
- As a step towards sustainability, utilising alternate source of energy and making entire manufacturing process more efficient by leveraging power of digitalizatio
- Well equipped to address volatile customer demand with multiple International and technical collaborations for state-of-the-art technology and advanced products.

Our Technology Partners

Technology Collaboration with NTN Japan for Ball & Taper Roller Bearings (Since 1985)

Technology Partnership with Amsted Rail Group (USA) for Cartridge Taper Roller Bearings (CTRB) for Railways (Since 1982) and PreSet Hub Assembly for heavy duty trucks.



Technology Partnership with IZUMI Machine Tools Japan for Grinding & Super Finishing Machines (Since 1996)

APPLICATIONS

Engine

Transmission

PreSet Hub

Electric Vehicles

Technology Centre

PRODUCT DEVELOPMENT
- Program Management
- Sourcing
- New Product Development

APPLICATION ENGINEERING
- Capturing voice of customers
- System Level Analysis
- Value Engineering

CENTRAL ENGINEERING
- Plant Support
- New Process Development

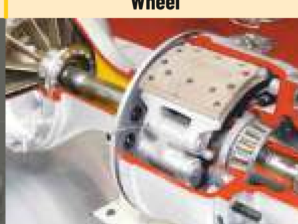
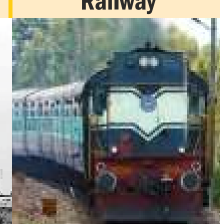
TECHNOLOGY FUNCTION
- Low Torque Bearings
- Fuel Efficient Bearings
- Tribiology & Metallurgical Enhancements

ADVANCED PRODUCTS & TECHNOLOGY
- Sensor Bearings
- Bearings for EV
- BSVI Compliant Bearings
- Special Coated Bearings

PRODUCT ENGINEERING
- Product Design
- Process Design
- Tool Design

PRODUCT VALIDATION AND TESTING
- Fatigue Testing
- Seal Testing
- Application Testing

APPLICATIONS

Differential	Wheel	Industrial	Railway
			

Value Proposition

- Flexibility to provide new products within 150 days from concept to development
- Assured Total Cost of Ownership (TCO) benefit
- Well-equipped to accommodate varying customer demands
- EDI capable warehouse facilities in North America & European Union
- Local Sales/Tech support in USA, Germany and Japan
- Leading R&D centre in India with state-of-the-art testing and research facilities
- Proven track record, as reliable bearing supplier to major Tier 1 and OEMs in India, North America & European Union

nbc®
flexible solutions

1.0 Bearing Material

The selected material must be suitable for the operating environment and must meet the technical requirements for the application. The components of rolling bearing during operation are subjected to cyclic load and deformation, still they must maintain dimensional accuracy.

To accomplish this, the raceways and rolling elements must be made of a material having following properties:

- High Hardness,
- Resistant to Rolling Fatigue,
- Wear Resistant,
- Good Dimensional Stability
- High Impact Strength
- Corrosion Resistance
- Uniformity of Structure

The bearings are made of either high carbon or low carbon steel. Depending upon the selection of material, process of hardening is selected.

The bearing components are hardened by the following method.

Through-Hardening

Through-hardened bearings feature a uniform hardness throughout the cross section. Mostly used in application which are not highly misaligned and shock loads are moderate. This is a regular process for most of the bearing used in various applications.

Induction-Hardening

It is a type of surface hardening in which a 'metal part' is induction-heated and then quenched. Hardening may be done on the surface or throughout the entire surface and properties of the remaining part remains unaffected.

Case-Hardening

It is a process of heating the metal so that the surface is hard and the core is soft. This process is used when bearing are subjected to high impact loads. It can minimize wear & tear and increase the strength of the steel surface. This process can done by Carburizing and Nitriding.

The bearing operating temperature under standard heat treatment process with normal tempering is around 120°C. For bearing to operate at temperature higher than 120°C, special heat treatment process is required.

2.0 Bearing Designation

The bearing designation may consist of a basic designation with or without prefixes and suffixes. It includes

- Bearing type
- Boundary dimensions
- Basic design

The number and letter combinations indicates bearing type and dimensions. Basic design includes tolerances, internal clearances & other related specifications. In bearing designation system:

- The first digit indicates the bearing type.
- The second & third identify the ISO dimension series. The second digit indicates the width or height series. The third digit indicates the diameter series.
- The last two digits indicates the bearing bore, which multiplied by 5 gives the bearing bore diameter in mm.

There are exceptions in the basic bearing designation system:

1. Bearings size code for the following bore diameter are:

    00 = 10 mm

    01 = 12 mm

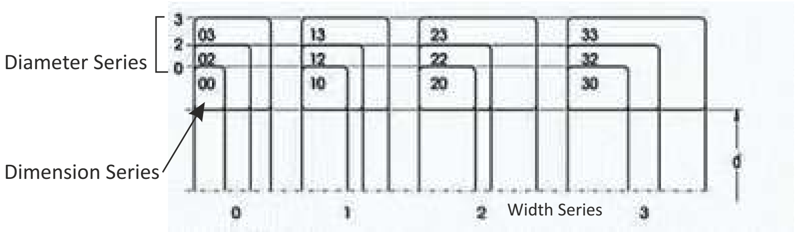
    02 = 15 mm

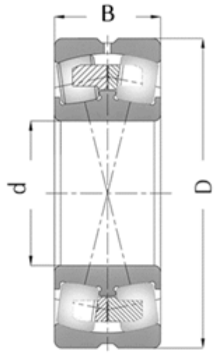
    03 = 17 mm

2. For bearings with a bore diameter < 10 mm, or ≥ 500 mm, the bore diameter (d) is generally given as 617/7 (d = 7 mm) or 294/530 (d = 530 mm).

3. In case of standard bearing, when bearing diameter are non-standard, then it is denoted as 63/28 (d=28 mm)

Bearing Series indicates the bearing type and the dimension series.

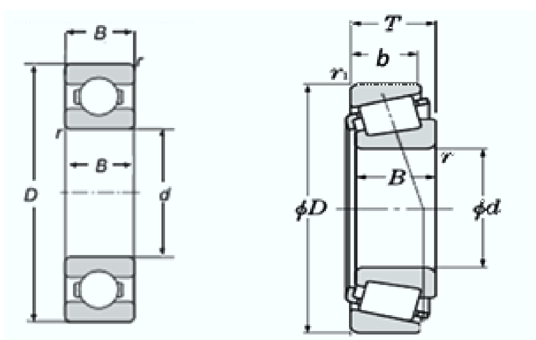


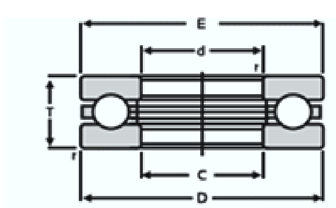


The bearing boundary /fitment dimensions consists of bore, outer diameter, width size & chamfer dimensions and are based on the ISO dimensional system which specifies the following dimensions for rolling bearings: bore diameter, d, outside diameter, D, width, B or T and chamfer dimension, r.

The boundary dimensions for metric bearings based on ISO standards are:

- ISO15 for radial rolling bearings, except tapered roller bearings, insert bearings and needle roller bearings
- ISO355 for tapered roller bearings
- ISO104 for thrust bearings





Bearing Designation (Examples)

Rolling bearing part numbers indicate bearing type, dimensions, tolerances, internal construction & other related specifications.

6 2 07 Z C3

- C3 — Radial internal Clearance C3
- Z — Shielded (one side)
- 07 — Nominal bore diameter 35mm
- 2 — Diameter series 2
- 6 — **Deep groove ball bearing**

2 2 3 28

- 28 — Nominal bore diameter 140mm
- 3 — Diameter series 3
- 2 — Diameter series 2
- 2 — **Spherical roller bearing**

7 2 12 C

- C — Contact angle 15°
- 12 — Nominal bore diameter 60mm
- 2 — Diameter series 2
- 7 — **Angular contact ball bearing**

NU 3 30 C3

- C3 — Radial internal clearance C3
- 30 — Nominal bore diameter 150mm
- 3 — Diameter series 3
- NU — **Cylindrical roller bearing NU type**

3 0 2 04

- 04 — Nominal bore diameter 20mm
- 2 — Diameter series 2
- 0 — Width series 0
- 3 — **Tapered roller bearing**

1 2 06 K

- K — Tapered bore (1:12)
- 06 — Nominal bore diameter 30mm
- 2 — Diameter series 2
- 1 — **Self Aligning ball bearing**

CMJ 30 35 17 S

- S — Type of cage, S stands for weld cage
- 17 — Width
- 35 — Roller Set Outer Diameter
- 30 — Roller Set Bore Diameter
- CMJ — **Cage Type based upon Profile**

Needle roller bearing

Bearing Basic Number

Series code	Interpretation			Diameter code	Interpretation
	Bearing type	Dimension series code			Bore dia., mm
		Width series	Dia. Series		
68 *69* *60* *62* *63*	Deep groove ball bearings	-	8 9 0 2 3	*/0.6* */1.5* */xx*	0.6 1.5 xx
78 *79* *70* *72* *73*	Angular contact ball bearings	-	8 9 0 2 3	*00* *01* *02* *03*	10 12 15 17
12 *13* *22* *23*	Self aligning ball bearings	-	2 3 2 3	*04* *05* . . *92* *96*	dia. code multiplied by 5 gives the bore dia. Value in mm
NU10 *NU2* *NU22* *NU3* *NU23* *NU4* *NNU49* *NN30*	Roller bearings NU, NJ, NH, NUP, N, NF, NNU, NN, RNU, RN Cylindrical	1 - 2 - 2 - 4 3	0 2 2 3 3 4 9 0	*/500* */530* */560* . . */2,360* */2,500*	500 530 560 . . 2,360 2,500
302 ***303*** ***313*** ***320*** ***322*** ***323*** ***329*** ***330*** ***331*** ***332***	Tapered roller bearings	0 0 1 2 2 2 2 3 3 3	2 3 3 0 2 3 9 0 1 2		
239 ***230*** ***240*** ***231*** ***241*** ***222*** ***232*** ***213*** ***223***	2- Spherical roller bearings	3 3 4 3 4 2 3 1 2	9 0 0 1 1 2 2 3 3		
292 ***293*** ***294***	2- Spherical roller bearings	9 9 9	2 3 4		

Bearing Nomenclature:

CODE	INTERPRETATION (PREFIXES)
4T	Case carburized bearing (Inner ring, outer ring & roller)
TS1-	Bearing with special heat treatment for operating temp. up to 130°C
TS2-	Bearing with special heat treatment for operating temp. up to 160°C
TS3-	Bearing with special heat treatment for operating temp. up to 200°C
TS4-	Bearing with special heat treatment for operating temp. up to 250°C
TM-	Long life special heat-treated bearing (one ring)
TMB-	Long life special heat-treated bearing (both the rings)
AST-	Bearing with one of the components treated in carbo nitriding (rollers are with normal heat treatment)
ASTB-	Bearing with both the components treated in carbo nitriding (rollers are with normal heat treatment)
CR-	Creep resistance bearing with single side O-ring on outer race
CR2-	Creep Resistance bearing with both side 'O' ring on outer race
L-	Light series (taper roller bearing-inch series)
LM-	Light medium series (taper roller bearing- inch series)
HM-	Heavy medium series (taper roller bearing- inch series)
M-	Medium series (taper roller bearing- inch series)
H-	Heavy series (non-interchangeable with other cones & cups- for taper roller bearing inch series)
HH-	Heavy series (non-interchangeable with other cones & cups for taper roller bearing- inch series)
N-	Taper bearing having non-standard boundary dimensions
N-	Cylindrical bearing having non-standard boundary dimensions
NA-	Cones mated with double cup to form double row non-adjustable bearing (non-interchangeable with other cones & cups)
X-	Inch series tapered roller bearing converted into metric series
T-	Tapered roller thrust bearing
J-	Inch series bearing with metric designation
SP-	Standard bearing with deviations in Dimensions(OD/width etc.) from original bearing number
QJ-	Four point angular contact ball bearing
BB,LS,MS-	Ball bearing with non-standard boundary dimensions
Nxxxx	Ball bearing having non-standard boundary dimensions (xxx - is auto generated numeric digit i.e. 123 etc.)

Note: For any Prefix not found in the table, please contact NEI Engineering

Suffixes for Internal Design Modification Code

CODE	INTERPRETATION
A-	Internal design modification from A onward
B-	Contact angle 40°, angular contact ball bearing
B-	Contact angle 10° ~17°, Tapered roller bearings
C-	contact angle 15°, angular contact ball bearing
C-	Contact angle 17° ~24°, Tapered roller bearings
C(n),CS(n)	Deep groove ball bearing with increased/different load ratings (C1, CS1 etc.)
D-	Contact angle 24° ~32°, Tapered roller bearings
E-	Cylindrical/Spherical roller bearing with optimized internal geometry for increased load rating
E-	Tapered roller bearing with special crown on raceways
F-	For different bearing stand requirement other then ISO
M-	Modified design (ball bearing, tapered roller bearing)
X(n)-	Special feature (Inner ring or outer ring) e.g. X1, X2
SPL-	Optimized internal design for low torque
C-	Spherical roller bearing with symmetrical rollers, flangeless inner ring, a non-integral guide ring between the two rows of rollers centered on the inner ring and one pressed steel window-type cage for each roller row
CA-	Spherical roller bearing with one-piece machined brass cage (double pronged), symmetrical rollers and retaining ribs
CC-	Similar to 'C' configuration but with enhanced roller & raceways surface finish
V-	Full complementary cylindrical roller bearing
LT-	Optimized internal design for low torque
AN	Special groove profile for Inner or Outer ring.

Note: For any Suffix not found in the table, please contact NEI Engineering

Suffixes for Seal/Shield

CODE	INTERPRETATION
LB-	Synthetic rubber seal, non-contact type, on one side
LLB-	Synthetic rubber seal, non- contact type, on both side
LH-	Low friction synthetic rubber seal , contact type, double lip , on one side
LLH-	Low friction synthetic rubber seal , contact type, double lip , on both side
LU-	Synthetic rubber seal, contact type, double lip , on one side
LLU-	Synthetic rubber seal, contact type, double lip , on both side
LV-	Low friction synthetic rubber seal , contact type, triple lip , on one side
LLV-	Low friction synthetic rubber seal , contact type, triple lip , on both side
LUA-	Acrylic rubber seal (Contact type), single side with Seal groove on Inner race
LLUA-	Acrylic rubber seal (Contact type), both side with Seal groove on Inner race
LUA1-	Fluorine rubber seal (FKM), LU type, on one side, for high temperature up to 200° C
LLUA1-	Fluorine rubber seal, LU type, on both side, for high temperature up to 200° C
LUA2-	Silicone rubber seal, LU type, on one side, for extreme tempreture-100 to +200° C
LLUA2-	Silicone rubber seal, LU type, on both side, for extreme temp. -100 to +200°C
RS-	NBR rubber seal (Contact type), single side with no Seal groove on Inner race
RSS-	NBR rubber seal (Contact type), on both with no Seal groove on Inner race
Z-	Metallic shield, single side
ZZ-	Metallic shield , double side
ZA-	Removable pressed steel shield, on one side
ZZA-	Removable pressed steel shield, on both side
LW-	Synthetic rubber (NBR) seal, contact type, four-lip, on one side, for wheel application
LLW-	Synthetic rubber (NBR) seal, contact type, four-lip, on both side, for wheel application
LWA-	Acrylic rubber (ACM) seal, contact type, four-lip, on one side, for wheel application

Note: For any Suffix not found in the table, please contact NEI Engineering

Suffixes for Seal/Shield

LLWA-	Acrylic rubber (ACM) seal, contact type, four-lip, on both side, for wheel application
LWA1-	Fluorine rubber seal (FKM), contact type, four-lip, on one side, for wheel application
LLWA1	Fluorine rubber seal (FKM), contact type, four-lip, on both side, for wheel application
L-	Seal Groove for Flange type Polyamide cage
Lt1	Low torque seal for UTRB

Suffixes : Cage

J-	Pressed steel cage
T2X-	Polyamide cage
T2X1-	Polyamide Cage with Flange
G2-	Pin type steel cage
TF	Pressed steel cage with Tufftride Treatment
M	Machined brass cage, (spherical / cylindrical roller bearing)

Suffixes: External design modification code

D-	Double row outer ring or inner ring
K-	Tapered bore, 1/12 taper on dia.
K30-	Tapered bore, 1/30 taper on dia.
N-	Standard locating snap ring groove on outer ring
N1-	Locating snap ring groove on outer ring with knurling
NR-	Locating snap ring on outer ring
NX(n)-	Non-standard locating snap ring groove on outer ring (NX1, NX2...)
N2X(n)-	Both sides non-standard locating snap ring groove on outer ring (N2X2, N2X3...)
G-	Helical groove in bearing bore (Multi-row tapered / cylindrical roller bearing components)
W-	Lubrication grooves / slots in the side faces of the bearing rings (Multi-row tapered roller bearings)
W3	Bearing with blind hole in outer ring for Pin fitting(Ball Bearing)
W33-	Bearing with annular groove and three lubrication holes in the outer ring (Spherical roller bearing)
W33X-	Similar to 'W33' configuration but with six lubrication holes

Note: For any Suffix not found in the table, please contact NEI Engineering

Suffixes: Bearing arrangement type code

DB-	Two single-row deep groove/angular contact ball/ tapered roller bearing matched for mounting in a back-to-back arrangement
DF-	Two single-row deep groove/angular contact ball/ tapered roller bearing matched for mounting in a face-to-face arrangement
DT-	Two single-row deep groove/angular contact ball/ tapered roller bearing matched for mounting in a tandem arrangement
TSF	Flanged cup

Suffixes: Internal clearance code

C2-	Clearance less than Normal
CN-	Normal clearance
C3-	Clearance greater than normal
C4-	Clearance greater than C3
C5-	Clearance greater than C4
CNL-	Radial clearance range on lower side of CN
C3L-	Radial clearance range on lower side of C3
C4L-	Radial clearance range on lower side of C4
C5L-	Radial clearance range on lower side of C5
CNH-	Radial clearance range on higher side of CN
C3H-	Radial clearance range on higher side of C3
C4H-	Radial clearance range on higher side of C4
C5H-	Radial clearance range on higher side of C5
CS(n)-	Special radial clearance as per customer requirement (e.g. CS1, CS2 etc.)

Suffixes: Tolerance class code

P0-	Normal Tolerance class (Class 0, 6X) specified by IS/ISO/JIS
P6-	Tolerance class 6 specified by IS/ISO/JIS
P5-	Tolerance class 5 specified by IS/ISO/JIS
P4-	Tolerance class 4 specified by IS/ISO/JIS
P2-	Tolerance class 2 specified by IS/ISO/JIS

Note: For any Suffix not found in the table, please contact NEI Engineering

Suffixes: Noise class code

EM-	Noise level class for electric motor application
EMB-	Bearing for Electric motor vehicle
EML-	Low Noise bearings

Suffixes for Internal Design Modification Code

CODE	INTERPRETATION (PREFIX)
C	Needle roller and machined cage assembly
CBC	"Needle roller and machined cage assembly for piston pins”
PC	"Needle roller and machined cage assembly for crank pins”
CJ・・S	Needle roller and weld cage assembly
CMJ・・S	Needle roller and weld cage assembly
CV・・S	Needle roller and weld cage assembly
HC	Drawn-cup needle roller bearing
HMC	Drawn-cup needle roller bearing for heavy loading
HC-F	Speical Type Drawn-cup needle roller bearing
F	Flat end type roller

CODE	INTERPRETATION (SUFFIX)
CAGE	
Q	Soft Nitriding on cage
E	Carburizing + Hardening + Tempering HT on cage
D	Black Oxide on cage
C	Copper Plating on cage
S	Silver Plating on cage
ROLLER	
-	Through Hardened treatment on roller
AS	Carbonitriding Treatment on Roller
E1	Crowning (End drop) on roller
SF	Improved surface finish on roller OD

Note: For any Suffix not found in the table, please contact NEI Engineering

3.0 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 inappropriate
- Insufficient maintenance

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

Under load zone as the rolling element rotate to 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 occurs either in the raceway surface or in the rolling elements surfaces.

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 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.

Basic dynamic load (C)

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.

3.1 BASIC RATING LIFE (L_{10})

ISO:281 gives the calculation of basic rating life L_{10} with 90 % reliability. It is based on Lundberg and Palmgren fatigue theory which gives a rating life. The fatigue 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 (as per ISO:281 Standard):

$$L_{10} = (C/P)^{p}$$

Where,

L_{10} = 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

The basic rating life can also be expressed as:

- 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

n, is the speed, rev/min

- The basic rating life 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_{10S} = Basic rating life in kms.

Using life factor(fh) and speed factor(fn), basic rating life can be calculated in hours using the following formula

L_{10h} = $500(f_h)^p$

f_h = $f_n(\frac{c}{p})$

f_n = $\left(\frac{33.3}{n}\right)^{1/p}$

Where

L_{10h} = basic rating in hours of operation

f_h = life factor

f_n = speed factor

n = operating speed, rev./min

The relationship between rotational speed 'n' and speed factor 'f_n' as well as the relation between the basic rating life L_{10h} and the life factor 'f_h' is shown in table 3.1

Note: For a required life, the basic rated dynamic load (C) can be calculated using the formula and table 3.1, 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 'f_h and f_n' can be taken from table 3.1

$C = P (f_h / f_n)$

Where,

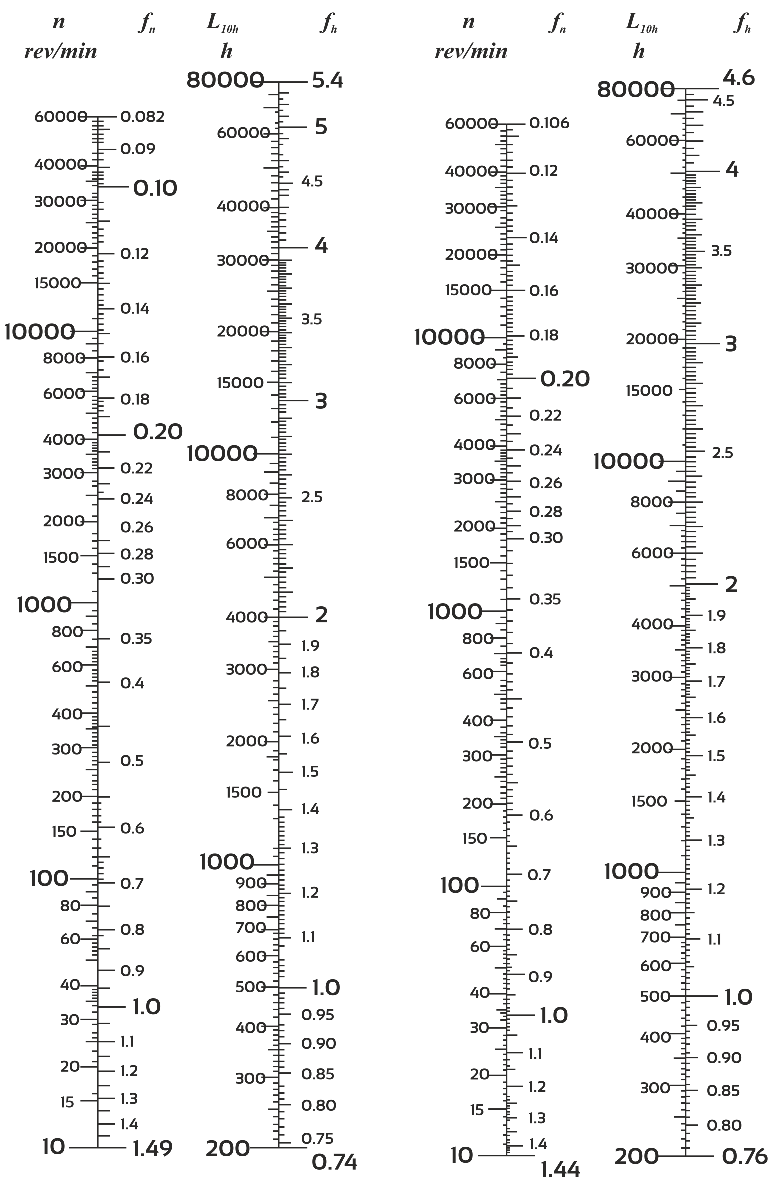
f_h= life factor

f_n= speed factor

P= equivalent load

Table 3.1 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

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

where,

L : Total basic rating life of entire unit, h

L_1, L_2 ...L_n: 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

$$L_m = \left(\frac{\phi_1}{L_1} + \frac{\phi_2}{L_2} + \cdots \frac{\phi}{L_1}\right)^{-1}$$

Where,

L m: Total life of bearing

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

L j: Life under individual conditions

3.2 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 3.2

Table 3.2 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

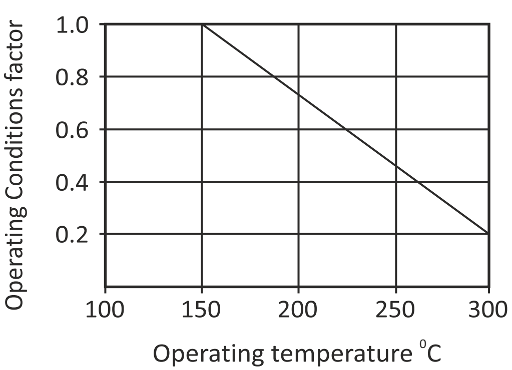
3.3 Thermal stabilization of Rolling bearings at high temperature

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^{0}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 3.3 : 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).



3.4 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 3.4 for special treatment factors.

Table 3.4 : Special treatment factors

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

3.5 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,

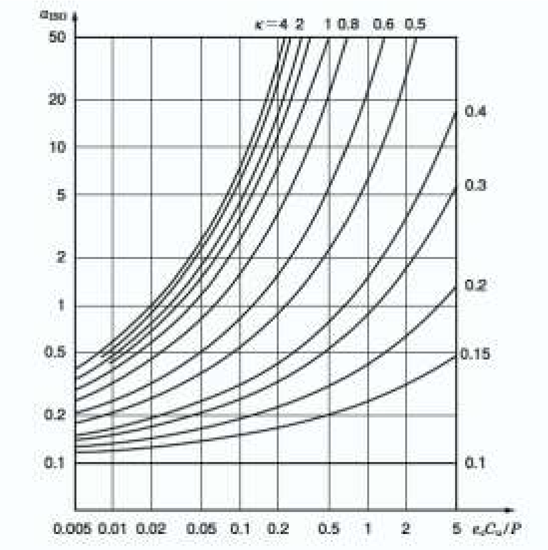
e_c - Contamination factor

C_u - Fatigue load limit in newton

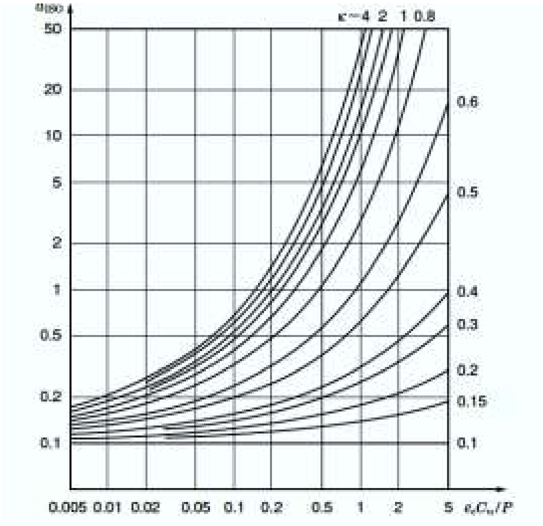
K - Viscosity ratio (kappa)

P - Dynamic Equivalent load in newton

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

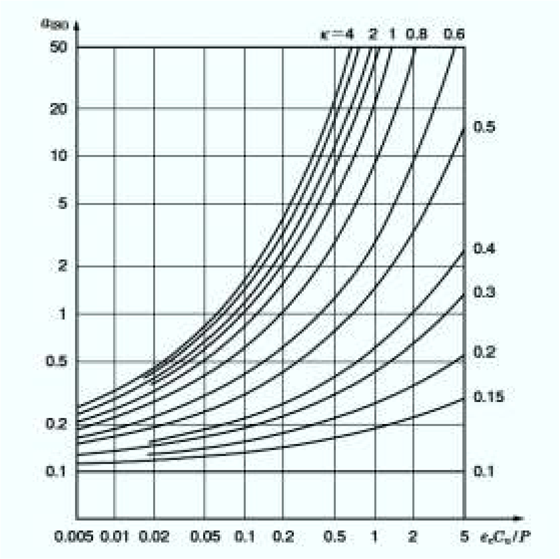


Life modification factor a_{ISO} (Radial ball bearings) Fig. 3.1

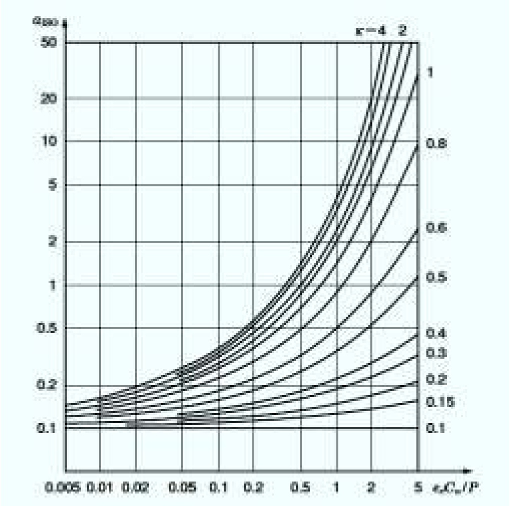


Life modification factor a_{ISO} (Radial roller bearings) Fig. 3.2

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.3.3



Life modification factor a_{ISO} (Thrust roller bearings) Fig.3.4

3.6 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, ʌ

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

ʌ 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

$\wedge$ is used as an indicator of the lubricant regime. With $\wedge$ 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, $\wedge$ as:

- $\Lambda > 3 \rightarrow$ full film (thick film) lubrication, hydrodynamics
- $1.2 > \wedge > 3 \rightarrow$ mixed or thin film lubrication
- $\Lambda < 1.2 \rightarrow$ 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.

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

Most of the application are designed for lubrication condition with viscosity ratio (kappa) ranging from 1 to 4. Refer table 3.5

Table 3.5 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 3.6 with grade at 40^0 C. Higher the K value, better is the bearing life

Table 3.6 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

3.7 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 3.7 for contamination factor, e_c

Contamination level	e_c	
	D_{pw} < 100mm	$D_{pw} \geq$ 100mm
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.

3.8 Method for checking contamination level in lubricant

3.8.1 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.

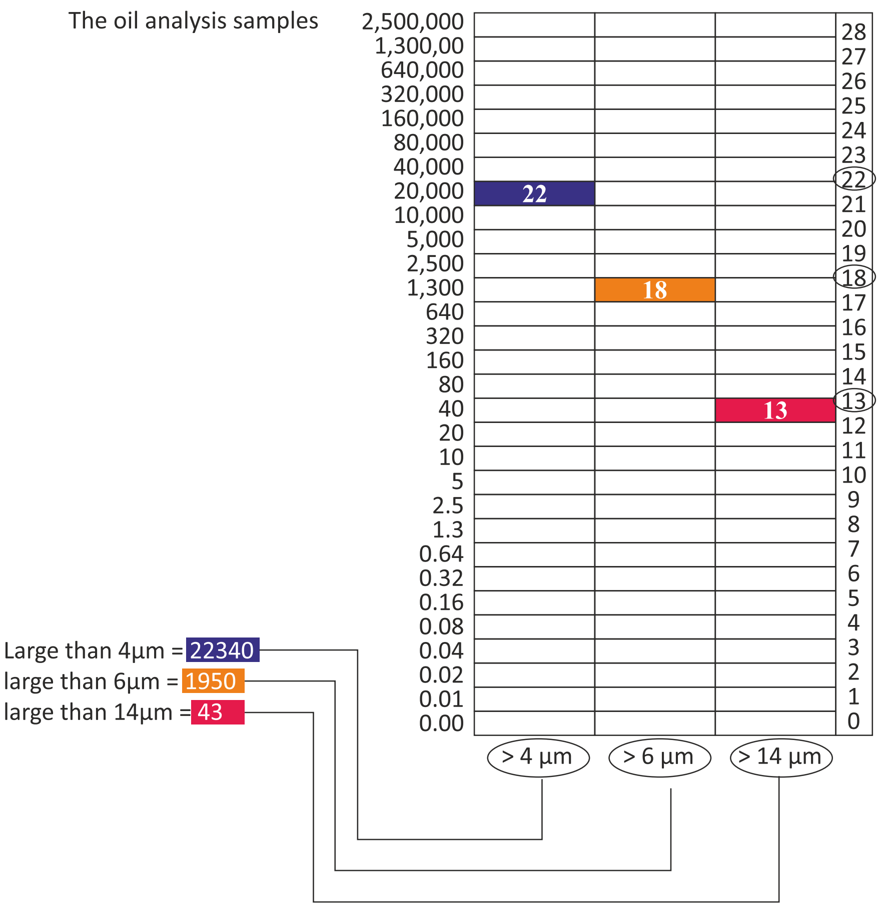
- Microscopic counting method. This method uses two particle sizes: ≥ 5 µm and ≥ 15 µm.
- Automatic Optical single particle counter in accordance with ISO 11171. It uses three particle sizes: ≥ 4 µm(c), ≥ 6 µm(c) and ≥ 14 µm(c).

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
1	2	1

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

3.8.2 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

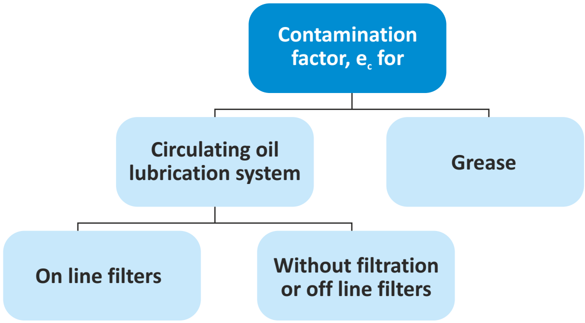
For example, a "β5(c) = 10" means that only 1 in 10 particles, 5µm or larger, passes through the filter.

3.9 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



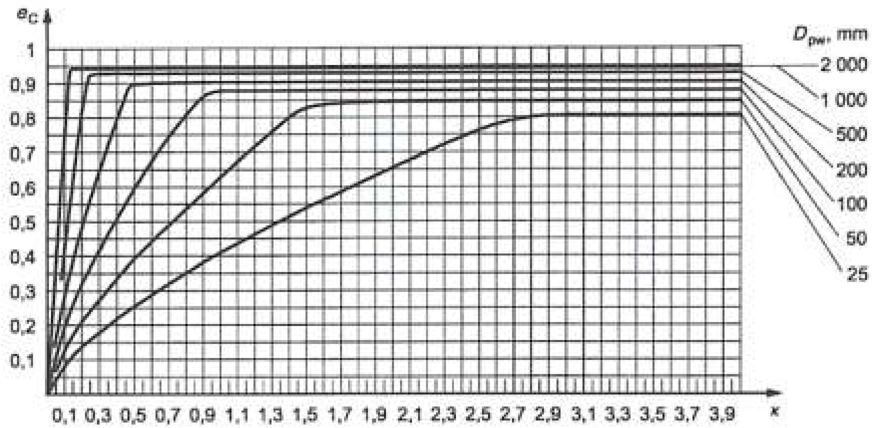
3.9.1 Lubricating system

3.9.1.1 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.

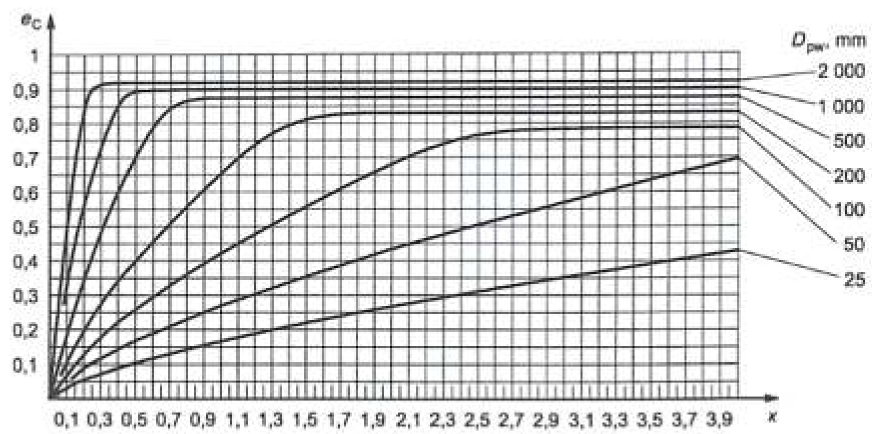
Note: The diagram to be used is selected on the basis of the filter retention rate βx(c) according to ISO 16889 and the oil cleanliness code according to ISO 4406. The index (c) is the particle size according to ISO 1171

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



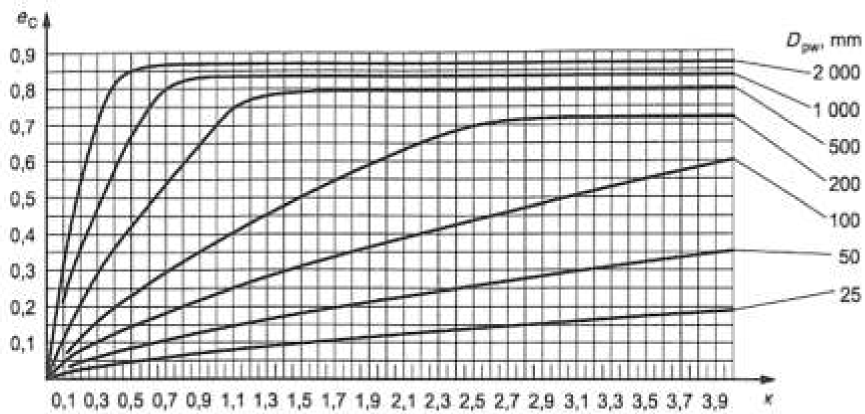
Cleanliness codes range ISO 4406: - /13/10, - /12/10, - /13/11, - /14/1114/11

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



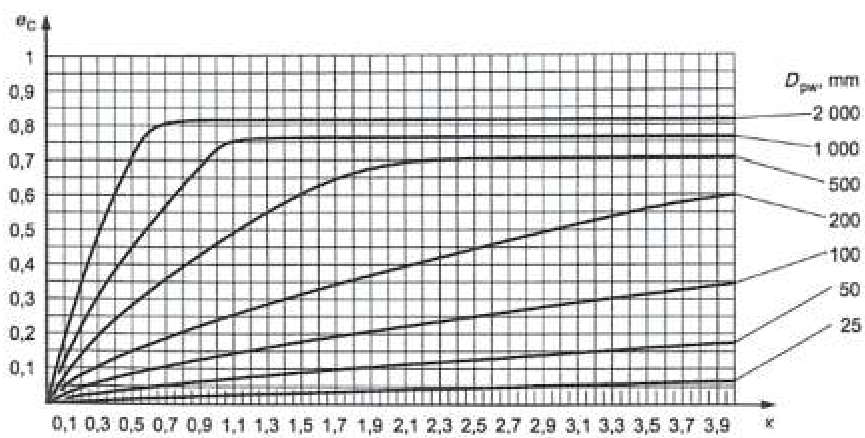
Cleanliness codes range ISO 4406: - /15/12, - /16/12, - /15/13, - /16/13

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

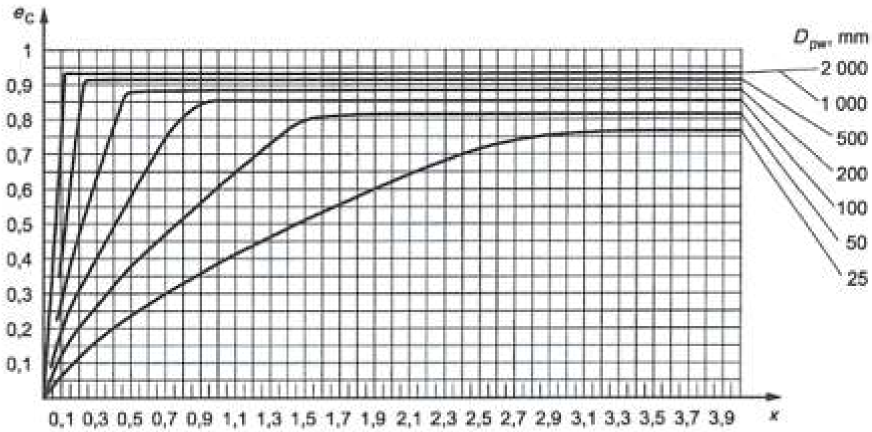
Fig. 4. Contamination coefficient for circulating oil lubrication with on-line filter - filter rating $\beta_{40(C)}$ = 75, cleanliness code acc. to ISO 4406 -/19/16



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

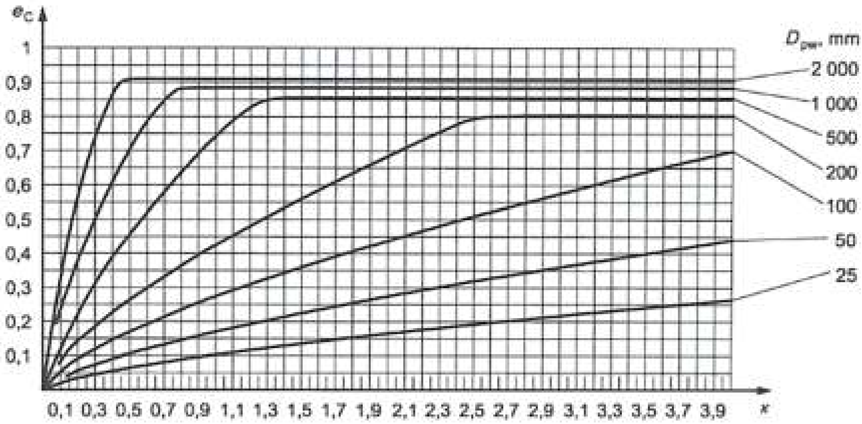
3.9.1.2 Contamination factor, e_c for circulating oil lubrication system witout filteration or with off line filters.

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



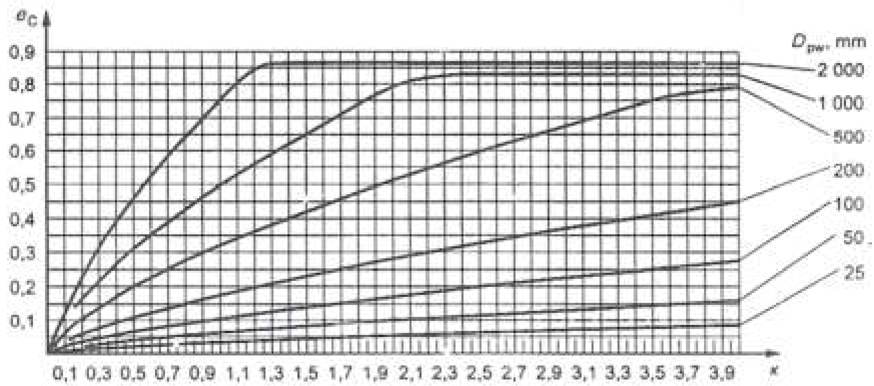
Cleanliness codes range ISO 4406: - /13/10, - /12/10, - /11/9, - /12/9

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



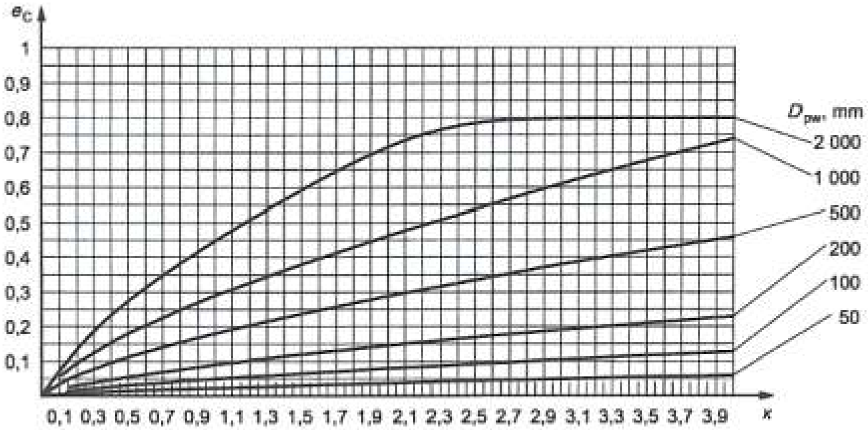
Cleanliness codes range ISO 4406: - /15/12, - /14/12, - /16/12, - /16/13

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



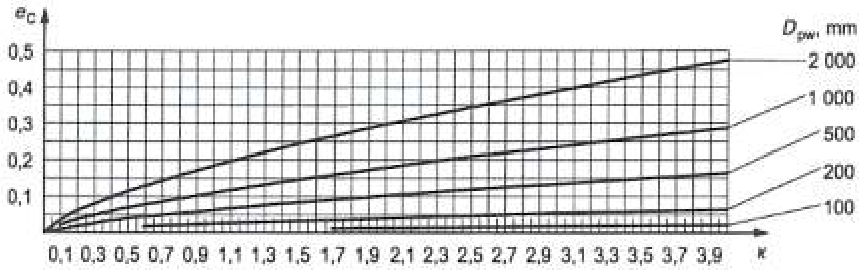
Cleanliness codes range ISO 4406: - /17/14, - /18/16, - /20/17, - /21/17

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

3.9.2 Contamination factor, e_c for grease lubrication

Grease lubrication is used when the bearing operates under normal temperature and speeds. Grease has several advantages over oil, including improved protection against moisture & contaminants and has simple application procedure. Grease selection varies with the application and operating conditions of bearings. Contamination effects grease life. The contamination level changes with the type of working conditions (refer table). If the working conditions are very clean ,contamination level is low but if the bearing operates in harsh environment then contamination level is high. Contamination value is used in the calculation of bearing life and can be calculated from graph using viscosity ratio (K) and bearing size (Dpw).

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

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

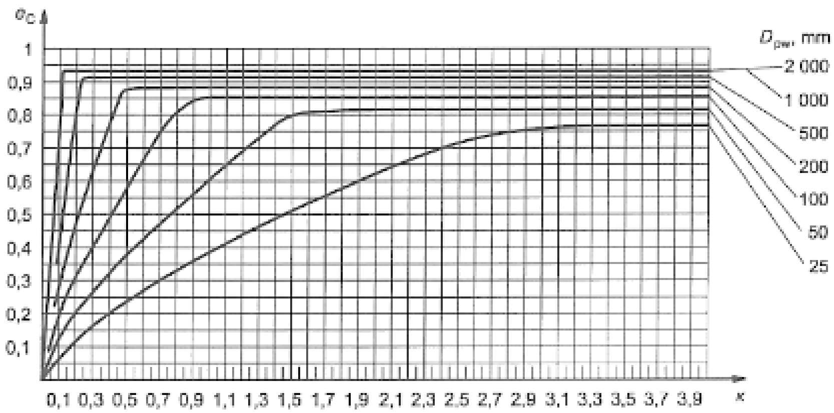


Fig.11. Contamination coefficient for grease lubricant - Normal cleanliness

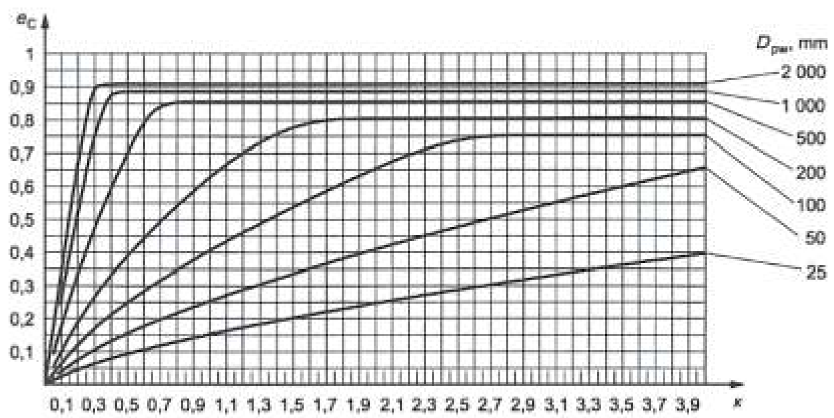


Fig.12. Contamination coefficient for grease lubricant - Slight or typical cleanliness

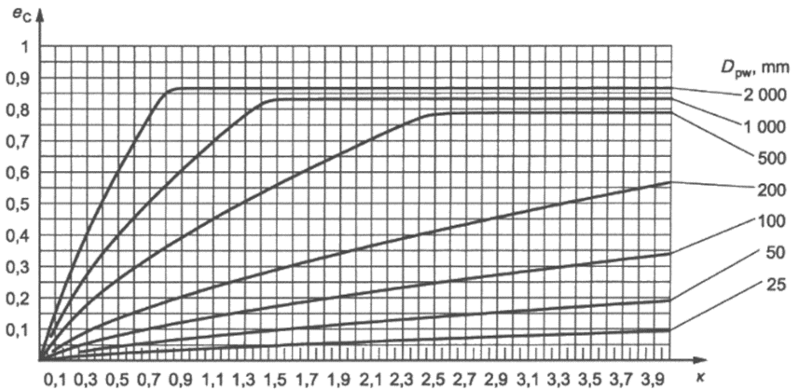


Fig.13. Contamination coefficient for grease lubricant - Severe contamination

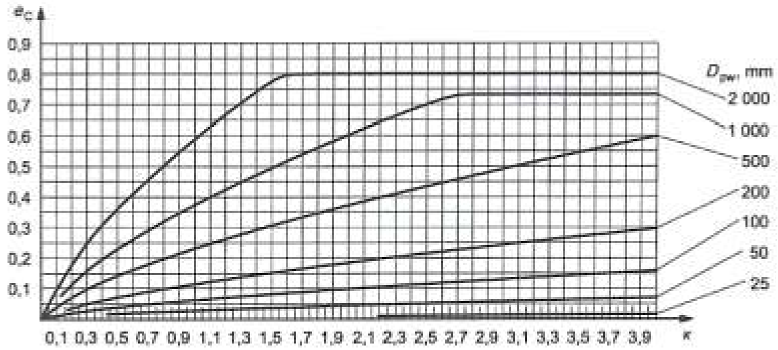
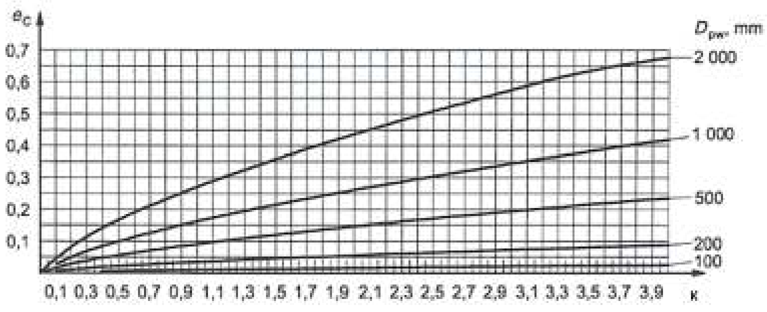


Fig.14. Contamination coefficient for grease lubricant - Very severe contamination



3.10 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

Static Equivalent Load (Po)

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.

For radial bearings equivalent static load can be calculated from the formula:

$Po = X0 . Fr + Y0 . Fa$

Po equivalent static load, KN

Fr actual radial load, KN

Fa actual axial load, KN

X0 bearing radial load factor

Y0 bearing axial load factor

Note: The equivalent static bearing load (Po or Por) formula is provided for various types of bearings in data table of the catalogue.

Bearing selection based on static loading conditions:

The static equivalent load which can be permitted on the bearing is limited by the basic static rating. Bearing size must be selected based on static load on the bearing taking into account the possible effects of permanent deformation:

- The bearing is not rotating or rotates under load at low speed ($n < 10$ r/min)
- Bearing is subjected to continuous high loads.
- Slow oscillating movements under load.

Static Safety Factor,(So)

When bearing service life is affected by permanent deformation depending upon static load and operating requirement such as smooth running or vibration, shock etc. the static safety factor is calculated to assess the load level on the bearing.

The static safety factor is given by

So = Co/Po

So static safety factor

Co basic static load rating, KN

Po equivalent static bearing load, KN

Minimum safety factor values So

Operating condition	Ball bearing	Roller bearing
General application	1~2	1.5 ~3

When vibration and/or shock loads are present, a load factor based on the shock load needs to be included in the Po max value. For more information, please contact NBC Engineering.

3.11 Life factor for application

Service Requirements	Life factor f_h < 1.0	1.0-2.0	2.0-2.5
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			
Machines used for 8 hours a day but not always in full operation		Automobiles, motor cycles internal grinding spindles, ore tub axles	Buses, Trucks
Machines fully used for 8 hours			Small rolling mill roll necks
Machines continuously used for 24 hours a day			
Machines continuously used for 24 hours a day with maximum reliability pumps			

Life factor f_h

2.5-3.0	3.0-3.5	3.5-4.0	4.0-5.0	> 5.0
Power station auxiliary equipment, construction machines, Crane sheaves elevators, Conveyors, deck cranes, Cranes	Crane Sheaves			
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	
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	
	Loom	Electric motors in shop compressors, pumps	Textile machines, mine winches, iron industry conveyors	Paper making machine, main rolls machines
				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)				$\times 10^3$ 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

4.0 Accuracy &Tolerances along with pattern

For a specific operation the bearing must have the right dimensions, tolerance & accuracies. Bearing consists of inner ring, outer ring, cage and rolling elements.

Bearing boundary dimensions are standardized by ISO (International Standard Organization)

This has been done to:

- Facilitate interchangeability of bearing
- Standardize shaft and housing dimensions

The dimensions which determine the fitment are standardized. This is not applicable to the internal dimensions, such as the size and quantity of the rolling elements. The main dimensions of metric rolling bearings are defined in the following ISO dimension plans:

- ISO 15 :Radial rolling bearing excluding single row needle roller bearings, insert bearings and tapered roller bearings
- ISO104 :Axial /Thrust bearings
- ISO 355 :Taper roller bearing

The tolerances and accuracies of these components are specified by ISO 492/582/199 & DIN620 as given in table.

Standard	Applicable standerd	Bearings Types
Japanese industrial standard (JIS)	JIS B 1514	All type
International Organization for Standardization (ISO)	ISO 492	Radial bearings
	ISO 199	Thrust ball bearings
	ISO 578	Tapered toller bearings (Inch series)
	ISO 1224	Precision instrument bearings
Deutsches Institut fur Normung (DNI)	DIN 620	All type
American National Standards Institute (ANSI) American Bearing Manufacturer's Association (ABMA)	ANSI/ABMA Std.20	Radial bearings (Except tapered roller bearings)
	ANSI/ABMA Std.19.1	Tapered roller bearings (Metric series)
	ANSI/ABMA Std.19	Tapered roller bearings (Inch series)

4.1 Dimensional Accuracy

The accuracy of rolling bearings is classified as 'Dimensional accuracy' and ' Running accuracy'.

Dimensional accuracy indicates the tolerance and tolerance limits of boundary dimensions. It is a measure of the bearing's external dimensions - bore diameter, outer diameter and assembled width and are important for bearing mounting on shaft & housing. Tolerances are a measure between the standard value and the actual bearing dimension measured along one plane. The symbols for the mean bore and outer diameter tolerances are dmp and Dmp.

Dimensional accuracy includes

Tolerances for:

- Boundary dimensions
- Chamfer dimensions
- Width variation
- Tapered bore diameter

Form tolerances of individual rings are also included in dimensional accuracies. It relates how much a bearing can deviate from the standard shape (cylindricity, perpendicularity etc.).

They are indicated by the letter V. The maximum variation in the mean bore and outer diameter tolerances are denoted by Vdmp and VDmp.

Inner ring form are indicated as:

- Single plane bore diameter variation-Vdp (roundness),
- Mean single plane bore diameter variation-Vdmp (taper),
- Width variation-VBs (parallelism of side faces),
- Raceway roundness & taper, flatness of faces

Outer ring Form are indicated as:

- Single plane outside diameter variation-VDp (roundness),
- Mean single plane outside diameter variation-VDmp (taper),
- Width variation- VCs (parallelism of side Faces),
- Raceway roundness & taper, flatness of faces.

4.2 Running Accuracy (As per ISO: 1132-1 & 2)

Running accuracy indicate allowable limit for bearing run out during operation. It provides radial & axial run out on bore & outside cylindrical surface.

Running accuracy includes	Allowable limit for: ● Radial runout for inner & outer ● Outside cylindrical surface variation ● Face runout with bore

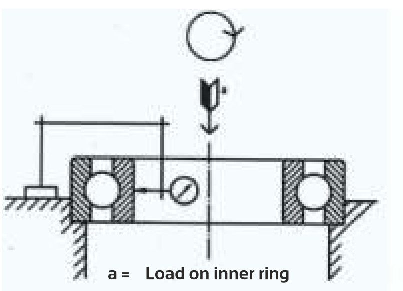
Running accuracies in bearing are:

Radial Runout	● **Kia-**Radial run-out of assembled bearing inner ring ● **Kea-**Radial runout of assembled bearing outer ring
Face run-out with raceway	● **Sia-**Assembled bearing inner ring face run-out with raceway ● **Sea-**Assembled bearing outer ring face run-out with raceway
Thickness variation	● **Ki-**Inner ring raceway to bore thickness ● **Ke-**Outer ring raceway to outside surface thickness variation
Face runout with bore	● **Sd-**Face runout with inner ring bore reference face
Raceway parallelism with face	● **Sa-** Raceway parallelism inner ring face ● **Se-** Raceway parallelism outer ring face
Outside surface inclination	● **SD-** Variation of outside surface inclination with face

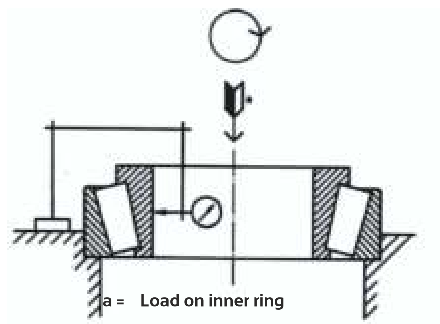
4. 2.1 Radial Run-out

(A) Radial run-out of assembled bearing inner ring, 'Kia' (radial bearing):

Difference between the largest and the smallest of the radial distances between the bore surface of the inner ring, in different angular positions of this ring and a point in fixed position relative to the outer ring. At the angular position of the point mentioned, or on each side and close to it, rolling elements are to be in contact with both the inner and outer ring raceways and (in a tapered roller bearing) the cone bad face rib, the bearing parts being otherwise in normal relative positions.



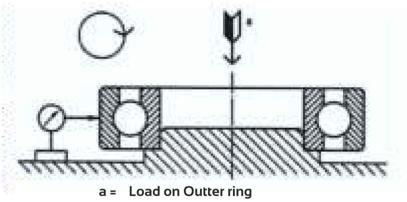
Kia MEASUREMENT OF BALL BEARING



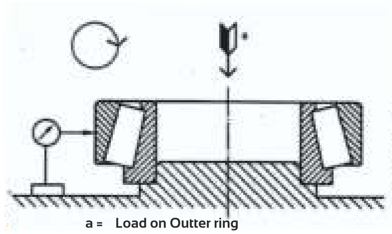
Kia MEASUREMENT OF TAPER ROLLER BEARING

(B)Radial runout of assembled bearing outer ring. 'Kea' (radial bearing):

Difference between the largest and the smallest of the radial distance between the outside surface of the outer ring in different angular positions of this ring and a point in a fixed position relative to the inner ring. At the angular position of the point mentioned, or on each side and close to it, rolling elements are to be in contact with both the Inner and outer ring raceways and (in a tapered roller bearing) the cone back face rib, the bearing parts being otherwise in normal positions.



Kea MEASUREMENT OF BALL BEARING

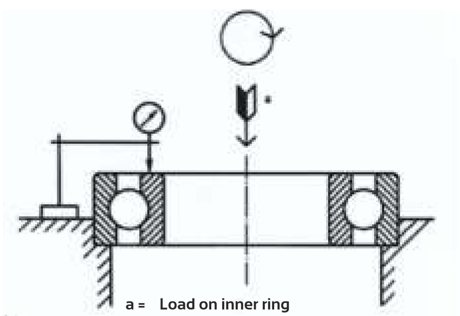


Kea MEASUREMENT OF TAPER ROLLER BEARING

4.2.2 Face run-out with raceway

(A) Assembled bearing inner ring face run-out with raceway, 'Sia' (Groove type radial ball bearing):

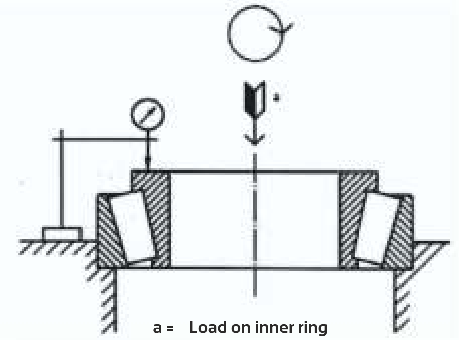
Differences between the largest and the smallest of the axial distances between the reference face of the inner ring, in different relative angular positions of this ring, at a radial distance from the inner ring axis equal to half the inner ring raceway contact diameter, and a point in a fixed position relative to the outer ring. The inner and the outer ring raceways are to be in contact with all the balls.



Sia MEASUREMENT OF BALL BEARING

(B) Assembled bearing cone back face run-out with raceway, 'Sia' (Taper roller bearing):

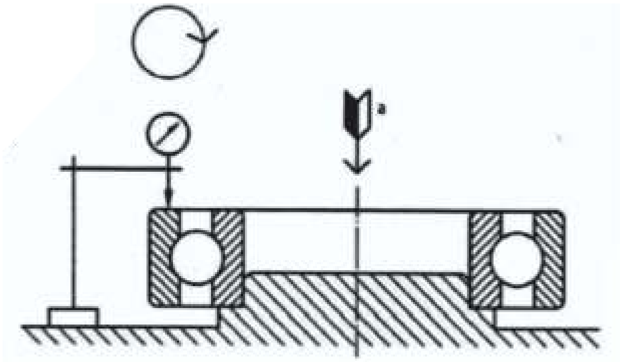
Difference between the largest and the smallest of the axial distances between the cone back face, in different angular positions of the cone, at a radial distance from the cone axis equal to half the cone raceway contact diameter and a point in a fixed position relative to the cup. The cone and cup raceways and the cone back face rib are to be in contact with all the rollers, the bearing parts being otherwise in normal relative positions.



Sia MEASUREMENT OF TAPER ROLLER BEARING

(C) Assembled bearing outer ring face run-out with raceway 'Sea' (Groove type radial ball bearing):

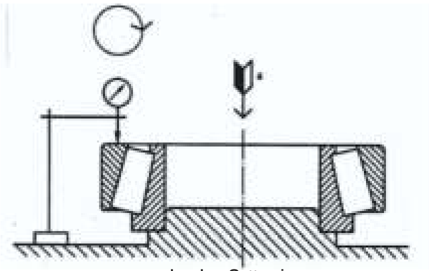
Difference between the largest and the smallest of the axial distances between the reference face of the outer ring ,in different relative angular positions of this ring, at a radial distance from the outer ring axis equal to half the outer ring raceway contact diameter, and a point in a fixed position relative to the inner ring. The inner and outer ring raceways are to be in contact with all the balls.



Sea MEASUREMENT OF BALL BEARING

(D) Assembled bearing cup back face run-out with raceway 'Sea' (Taper roller bearing):

Difference between the largest and the smallest of the axial distances between the cup back face, in different angular positions of the cup, at a radial distance from the cup axis equal to half the cup raceway contact diameter, and a point in a fixed position relative to the cone. The cone and cup raceways and the cone back face rib are to be in contact with all the rollers, the bearing parts being otherwise in normal relative positions.



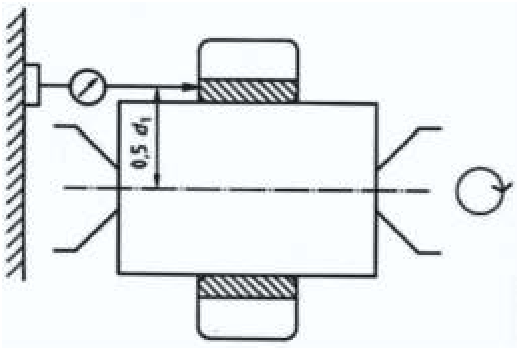
a = Load on Outter ring

S_{ea} MEASUREMENT OF TAPER ROLLER BEARING

4.2.3 Face run-out with bore

Face run-out with bore 'Sd' (inner ring reference face):

Difference between the largest and the smallest of the axial distances between a plane perpendicular to the ring axis and the reference face of the ring, at a radial distance from the axial of half the inner ring raceway contact diameter.



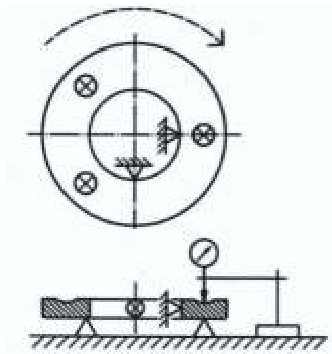
S_d MEASUREMENT

4.2.4 Raceway parallelism with face

Raceway parallelism with face, ' Si' or ' Se'

(inner or outer ring of groove type radial ball bearing reference face) :

Difference between the largest and the smallest of the axial distances between the plane tangential to the reference face and the middle of the raceway.

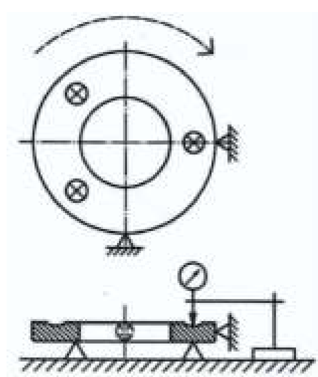


S_i MEASUREMENT

4.2.5 Out side surface inclination

Variation of outside surface generatrix inclination with face, 'SD' (outer ring basically cylindrical surface reference face):

Total variation of the relative position in a radial direction parallel with the plane tangential to the reference face of the outer ring, of points on the same generatrix of the outside surface at a distance from the side faces of the ring equal to the maximum limits of the axial chamfer dimension.

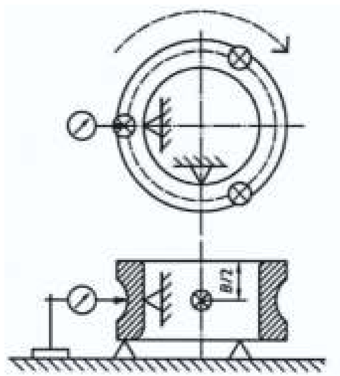


S_e MEASUREMENT

4.2.6 Thickness-variation

(A) Inner ring raceway to bore thickness variation, 'Ke' (radial bearing):

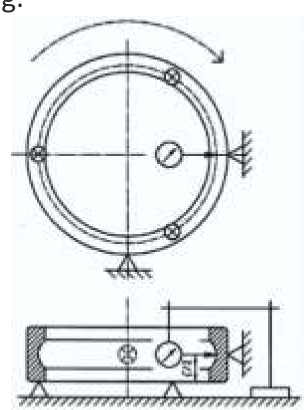
Difference between the largest and the smallest of the radial distances between the bore surface and the middle of a raceway on the outside of the ring.



K_i MEASUREMENT

(B) Outer ring raceway to outside surface thickness variation, 'Ke' (radial bearing):

Difference between the largest and the smallest of the radial distances between the outside surface and the middle of a raceway on the inside of the ring.

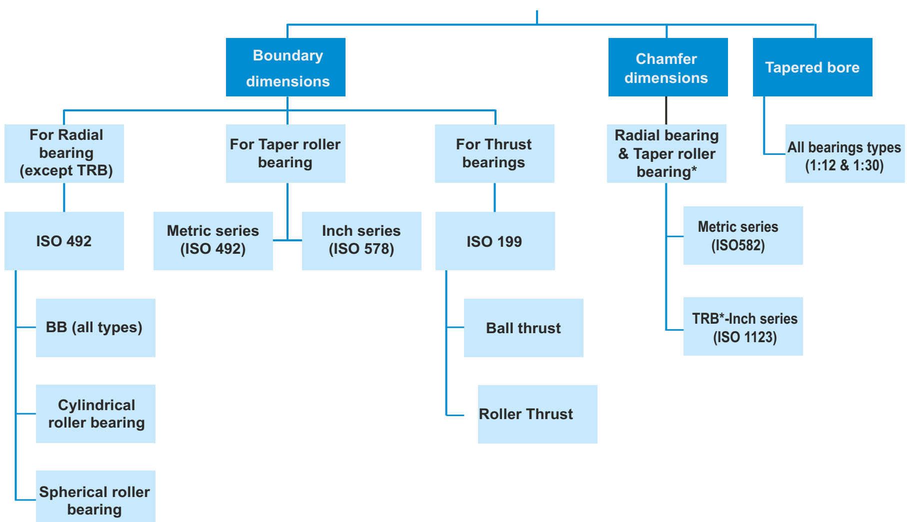


K_e MEASUREMENT

4.3 Tolerances

The fit of the bearing on the shaft and in the housing significantly affects the operational behavior of Rolling bearings. Tolerance is "the total amount a specific dimension is permitted to vary." It is the difference between the maximum and minimum limits. This can be shown as upper and lower limits or an allowable amount above and below a nominal dimension. Tolerances for the rolling bearing include tolerances for boundary dimensions, chamfer dimensions and tapered bore.

Tolerances As Per Standard



Consolidated table for applicable STD for different tolerance classes for Rolling bearing.

Bearing type		Applicable Standards	Tolerance classes & comparison among standards					Reference table no
Radial ball bearings		ISO 492	Class 0,6X	Class 6	Class 5	Class 4	Class 2	Table 5.3.1, 5.3.2
		JIS B 1514	Class 0,6X	Class 6	Class 5	Class 4	Class 2	
		DIN 620	P0	P6	P5	P4	P2	
		ABMA Std. 20	ABEC - 1	ABEC - 3	ABEC - 5	ABEC - 7	ABEC - 9	
Radial roller bearings (except tapered roller bearings)		ISO 492	Class 0,6X	Class 6	Class 5	Class 4	Class 2	Table 5.3.1, 5.3.2
		JIS B 1514	Class 0,6X	Class 6	Class 5	Class 4	Class 2	
		DIN 620	P0	P6	P5	P4	P2	
		ABMA Std. 20	RBEC - 1	RBEC - 3	RBEC - 5	-	-	
Tapered roller bearings	Metric series	ISO 492	Class 0,6X	Class 6	Class 5	Class 4	Class 2	Table 5.4.1, 5.4.2
		JIS B 1514	Class 0,6X	Class 6	Class 5	Class 4	Class 2	
		DIN 620	P0	P6	P5	P4	P2	
		ABMA Std. 20	Class K	Class N	Class C	Class B	Class A	
	Inch series	ISO 578	Class 4	-	Class 3	Class 0	Class 00	Table 5.5.1, 5.5.2, 5.5.3
		JIS B 1514	Class 0,6X	Class 6	Class 5	Class 4	Class 2	
		DIN 620	P0	P6	P5	P4	P2	
		ABMA Std. 19	Class 4	Class 2	Class 3	Class 0	Class 00	
Thrust bearings (all types)		ISO 199	Normal class	Class 6	Class 5	Class 4	-	Table 5.6.1, 5.6.2
		JIS B 1514	Class 0,6X	Class 6	Class 5	Class 4	Class 2	
		DIN 620	P0	P6	P5	P4	P2	
		ABMA Std.	-	-	-	-	-	

Note: Reference Standards and organizations

JIS : Japanese Industrial Standard

BAS : The Japan Bearing Industrial Association Standard

ISO : International Organization for Standardization

ANSI : American National Standards Institute, Inc.

ABMA : American Bearing Manufactures Association

DIN : Deutsches Institut für Normung

BS : British Standards Institution

F : Association Francaise de Normalisation

4.3.1 Tolerances For Radial Bearings as per ISO 492, IS 5692

(Except Tapered Roller Bearings)

d = bearing bore diameter, nominal

d1 = basic diameter at theoretical large end of a basically tapered bore

Δds = deviation of a single bore diameter

Δdmp = single plane mean bore diameter deviation (for a basically tapered bore **Δ**dmp refers only to the theoretical small end of bore)

Δd1mp = mean bore diameter deviation at theoretical large end of a basically tapered bore

Vdp = bore diameter variation in single radial plane

Vdmp = mean bore diameter variation (this applies only to a basically cylindrical bore)

α = half of the total angle of inner ring bore (for taper bore bearings)

D = bearing outside diameter, nominal

D1 = outer ring flange outside diameter, nominal

Δ Ds = deviation of single outside diameter

Δ Dmp = single plane mean outside diameter deviation

VDp = outside diameter variation in a single radial plane

VDmp = mean outside diameter variation

B = inner ring width, nominal

ΔBs = deviation of single inner ring width

VBs = inner ring width variation

C = outer ring width, nominal

C1 = outer ring flange width, nominal

ΔCs = deviation of single outer ring width

ΔC1s = deviation of a single outer ring flange width

VCs = outer ring width variation

VC1s = outer ring flange width variation

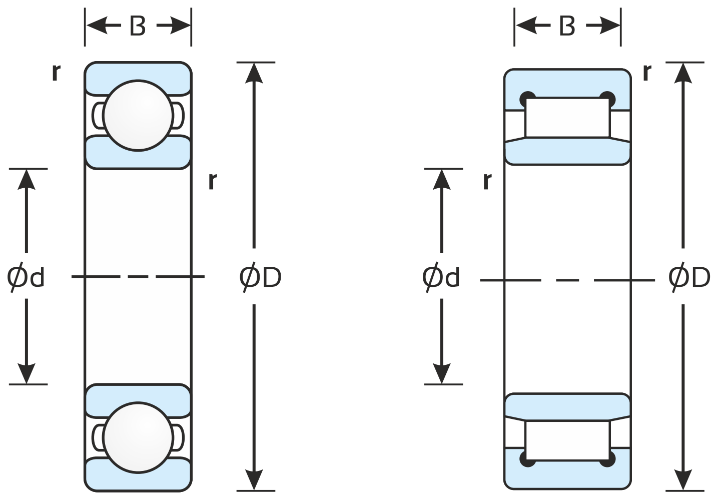
Kia = radial run out or assembled bearing inner ring

Kea = radial run out or assembled bearing outer ring

Sd = inner ring reference race (back face, where applicable) run out with bore

SD = variation of bearing outer surface generatix inclination with outer ring reference face (back face)

SD1	=	variation of bearing outside surface generatix inclination with flange back race
Sia	=	assemble bearing inner ring race (back face) runout with raceway
Sea	=	assembled bearing outer ring face (back face) runout with raceway
Sea1	=	assembled bearing outer ring flange (back face) runout with raceway



Tolerances for Normal Torelance Class Radial Bearings (Except Tapered Roller Bearing) - Metric Series

Table 4.3.1-1: Inner Ring

Values in microns													
d (mm)		Δ dmp		Vdp			Vdmp	Kia	ΔBS			VBS
				Diameter Series								
				9	0,1	2,3,4			All	Normal	Modified	
Over	Including	High	Low	Max			Max	Max	High	Low		Max
2.5	10	0	-8	10	8	6	6	10	-	-120	-250	15
10	18	0	-8	10	8	6	6	10	-	-120	-250	20
18	30	0	-10	13	10	8	8	13	-	-120	-250	20
30	50	0	-12	15	12	9	9	15	-	-120	-250	20
50	80	0	-15	19	19	11	11	20	-	-150	-380	25
80	120	0	-20	25	25	15	15	25	-	-200	-380	25
120	180	0	-25	31	31	19	19	30	-	-250	-500	30
180	250	0	-30	38	38	23	23	40	-	-300	-500	30
250	315	0	-35	44	44	26	26	50	-	-350	-500	35
315	400	0	-40	50	50	30	30	60	-	-400	-630	40
400	500	0	-45	56	56	34	34	65	-	-450	-	50
500	630	0	-50	63	63	38	38	70	-	-500	-	60
630	800	0	-75	94	94	55	55	80	-	-750	-	70
800	1000	0	-100	125	125	75	75	90	-	-1000	-	80

Table 4.3.1-2: Outer Ring

Values in microns												
D (mm)		Δ Dmp		VDP				VDmp	Kea	ΔCS ΔC1S		VCS VC1s
				Open Bearings			Capped Bearing					
				Diameter Series								
				9	0,1	2,3,4	2,3,4					
Over	Including	High	Low	Max			Max	Max	Max	High	Low	Max
6	18	0	-8	10	8	6	10	6	15	Identical to Δ Bs and VBs or Inner ring of same bearing		
18	30	0	-9	12	9	7	12	7	15			
30	50	0	-11	14	11	8	16	8	20			
50	80	0	-13	16	13	10	20	10	25			
80	120	0	-15	19	19	11	26	11	35			
120	150	0	-18	23	23	14	30	14	40			
150	180	0	-25	31	31	19	38	19	45			
180	250	0	-30	38	38	23	-	23	50			
250	315	0	-35	44	44	26	-	26	60			
315	400	0	-40	50	50	30	-	30	70			
400	500	0	-45	56	56	34	-	34	80			
500	630	0	-50	63	63	38	-	38	100			
630	800	0	-75	94	94	55	-	55	120			
800	1000	0	-100	125	125	75	-	75	140			
1000	1250	0	-125	155	155	94	-	94	160			
1250	1600	0	-160	200	200	120	-	120	190			
1600	2000	0	-200	250	250	150	-	150	220			
2000	2250	0	-250	310	310	190	-	190	250			

4.4 Basic Tolerance for Tapered Bore

d- Nominal bore diameter

d1- Basic diameter at the theoretical large end of a tapered bore

B- Nominal bearing inner ring width

- In case of taper 1/12: The basic diameter at the theoretical large end of the bore: d= d+1/12B
- In case of taper 1/30: The basic diameter at the theoretical large end of the bore: d= d+1/30B

The tolerances for a tapered bore, taper 1:12comprise

a). Mean diameter tolerance, given by limits for the actual mean diameter deviation at the theoretical small end of the bore, Δdmp

b). Taper tolerance diameter, given by limits for the difference between the actual mean diameter deviations at the two ends of the bore, Δd1mp- Δdmp

c). Tolerance for the diameter variation, Vdp' is given by a maximum value applying in any radial plane of the bore.

For taper 1/12, normal taper angle (half the cone angle):

a = 2°23'9.4"

= 2.385 94

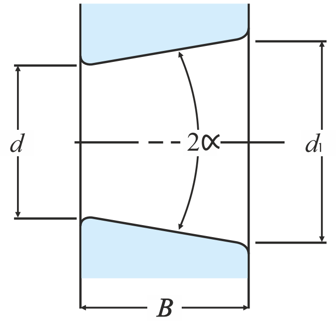
=0.041643 rad

For taper 1/30, normal taper angle (half the cone angle):

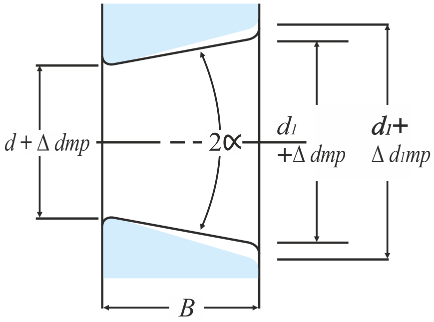
a = 0° 57' 17.4"

= 0.95484

=0.016665 rad



Theoretical tapered hole



Tapered hole having dimensional Difference of the average bore Diameter within the flat surface

Table 4.4-1 Tolerance and allowable values (Class 0) of tapered hole of radial bearings (standard tapper ratio 1:12)

Unit : µm

d (mm)		Δ dmp		Δ d1mp - Δ dmp		Vdp
Over	Including	High	Low	High	Low	Max.
-	10	+22	0	+15	0	9
10	18	+27	0	+18	0	11
18	30	+33	0	+21	0	13
30	50	+39	0	+25	0	16
50	80	+46	0	+30	0	19
80	120	+54	0	+35	0	22
120	180	+63	0	+40	0	40
180	250	+72	0	+46	0	46
250	315	+81	0	+52	0	52
315	400	+89	0	+57	0	57
400	500	+97	0	+63	0	63
500	630	+110	0	+70	0	70
630	800	+125	0	+80	0	-
800	1000	+140	0	+90	0	-
1 000	1250	+165	0	+105	0	-
1250	1600	+195	0	+125	0	-

Table 4.4-2: Tolerance and allowable value (Class 0) for tapered bore (1: 30) of Radial bearing Unit : µm						
d (mm)		Δ dmp		Δ d1mp - Δ dmp		Vdp
Over	Including	High	Low	High	Low	Max.
80	120	+ 20	0	+ 35	0	22
120	180	+ 25	0	+ 40	0	40
180	250	+ 30	0	+ 46	0	46
250	315	+ 35	0	+ 52	0	52
315	400	+ 40	0	+ 57	0	57
400	500	+ 45	0	+ 63	0	63
500	630	+ 50	0	+ 70	0	70

4.5 Selection of accuracy class for specific application

For all types of general application normal class tolerances are applicable. But in some cases as required it can be changed. But for few applications listed below the bearings can have a tolerance class of 5, 4 or higher.

Required performance	Specific applications examples	Tolerance class
High accuracy is required during operation	Computers, magnetic disc spindles	P5, P4, P2
	Radar / parabola antenna slewing shafts	P4
	Machine tool spindles	P5, P4, P2
	VTR drum spindle	P5, P4
	Printing press roll bearing	P5
	Aluminum foil roll necks	P5
	Roll neck mill backing bearings	P4
Very High speed	LNG pumps	P5
	Gyroscope	P4
	High frequency machine spindle	P4
	Superchargers	P5, P4
	Jet engine spindles and accessories	P5, P4
	Centrifugal separators	P5, P4
	Dental drill	P2
	Turbo molecular pump spindles and touch-down	P5, P4
Low torque & low variation is required.	Control equipment (synchronous motors, servomotors)	P4
	Measuring instruments	P5
	Machine tool spindles	P5, P4, P2

5.0 Bearing Internal Clearance

5.1 Type of Clearance During Operation

Internal clearance of a bearing is an important factor affecting not only the bearing performance but also the proper functioning of a machine. Bearing internal clearance is defined as the relative movement of either rings in radial or axial direction, when one ring is fixed. Movement in the diametrical direction is radial clearance, while movement in the shaft's direction is axial clearance. Internal clearance is critical to bearing performance for many reasons. The amount of clearance influences the load distribution in a bearing, which in turn affects smooth operation. It also influences bearing noise and vibration. There are three types of clearance present in the bearing during operation.

Initial clearance: The clearance present inside the bearing before it is mounted on a shaft or housing.

Mounted clearance: The clearance in the bearing after mounting but before the bearing comes into operation.

Operating clearance: The clearance remaining in the bearing after temperature affect and mounting.

For satisfactorily performance bearings must have the appropriate operating clearance. If sufficient amount of clearance is not present in the bearing it may fail. For calculating clearance, effect of fits and temperature is considered. The selection of the clearance is dependent upon the application. In some cases negative clearance (preload) is required when stiffness or bearing positioning is important. Bearing internal clearances changes due to:

- Thermal expansion or contraction of shaft or housing.
- Elastic deformation of rings under load
- Axial clamping can influence clearance or preload.
- Misalignment during running
- Improper mounting of bearing

To get the accurate measurement of internal clearance a certain 'measured load' has to be applied on the raceways. However, under this 'measured load' a slight elastic deformation of the bearing occurs due to which the measured internal clearance value will be slight greater than the true clearance value. This difference between the bearing's true clearance and the measured clearance under the load must be compensated. These compensation values are given in Table 5.1 (Table Below)

Nominal Bore Diameter *d* mm over	incl.	Measuring Load N	{Kgf}	Adjustment of internal clearance (Unit μm) C2	CN	C3	C4	C5
10 [1]	18	24.5	{ 2.5 }	3 ~ 4	4	4	4	4
18	50	49	{ 5 }	4 ~ 5	5	6	6	6
50	200	147	{ 15 }	6 ~ 8	8	9	9	9

Note : For roller bearings the amount of elastic deformation is small enough, to be ignored.

Radial clearance of the bearing is built up for following reasons:

1. Accommodate the reduction of clearance in a bearing due to interference for inner ring on the shaft or outer ring in the housing.
2. Accommodate the minor changes in the dimensions of parts without affecting the bearing performance.
3. Compensate for the differential expansion of the two rings when the inner ring of a bearing operates at a higher temperature than the outer ring.
4. It allows a slight misalignment between the shaft and the housing and thereby prevents the premature failure of the bearing.
5. It affects the end play of radial ball bearing, and also affects their capacity for carrying axial loads, the greater the radial clearance the greater the capacity for supporting axial load.

Important: Once ball and roller bearings are mounted and running, a small amount of radial internal or running clearance is normally desirable. In the case of bearings under radial load, quieter running is generally obtained when this clearance is minimum.

5.2 Types of Radial Internal Clearance:

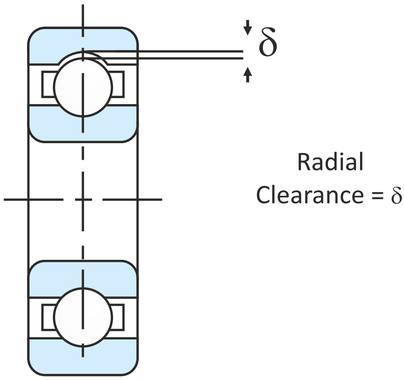
Radial bearings are made with following different ranges of radial internal clearance- C2, Normal, C3 and C4

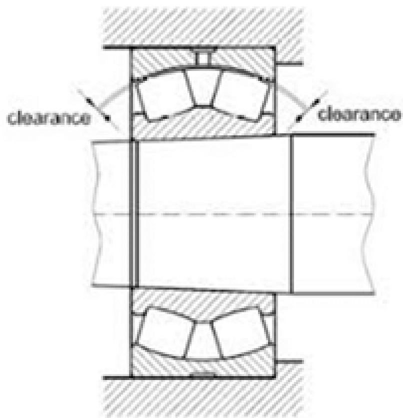
C2: These bearings have the smallest amount of radial internal clearance. They should only be used where freedom is required in the assembled bearings and there is no possibility of the initial radial internal clearances being eliminated by external causes. Therefore, special attention must be given to the seating dimensions as the expansion of the inner ring or contraction of the outer ring may cause tight bearings. In this respect a C2 bearing should not be used unless recommended.

CN: This grade of radial internal clearance is intended for use where only when one ring is made an interference fit and there is no appreciable loss of clearance due to temperature difference. ball and roller bearings for general engineering applications are usually of this clearance.

C3: This grade of radial internal clearance should be used when both rings of a bearing are made an interference fit or when only one ring is an interference fit but there is likely to be some loss of clearance due to temperature differences. It is the grade normally used for radial ball bearings that take axial loading but for some purposes even bearings with C4 clearance may be required.

C4: Where there will be some loss of clearance due to temperature differences and both rings are interference fit, this grade of radial internal clearance is employed. One example of its use is in bearings for traction motors. Customers should always consult us before ordering bearings with this grade of radial internal clearance.





5.3 Criteria For Selection of Internal Clearance

The internal clearance of a bearing under operating conditions (effective clearance) is usually smaller than the same bearing's initial clearance before being installed and operated. This is due to several factors including bearing fit, the difference in temperature between the inner and outer rings, etc. As a bearing's operating clearance has an effect on bearing life, heat generation, vibration, noise, etc. Care must be exercised in selecting the most suitable operating clearance.

Effective Internal Clearance:

The internal clearance differential between the initial clearance and the operating (effective) clearance (the amount of clearance reduction caused by interference fits, or clearance variation due to the temperature difference between the inner and outer rings) can be calculated by the following formula:

$\delta_{eff} = \delta_o - (\delta_f + \delta_t)$

Where,

δ_{eff}: Effective internal clearance, mm

δ_o: Bearing internal clearance, mm

δ_f: Reduced amount of clearance due to interference, mm

Reduced clearance due to interference:

After installation of bearings with interference fit on shaft and housing, the inner ring will expand and the outer ring will contract; thus reducing the bearings' internal clearance. The amount of expansion or contraction will depend on the shape of the bearing, the shape of the shaft or housing, dimensions of the respective parts, and the type of materials used. The differential can range from approximately 70% to 90% of the effective interference.

$\delta_f = (0.70 \sim 0.90)\, \Delta d_{eff}$

Where,

δ_f: Reduced amount of clearance due to interference, mm

Δd_{eff}: Effective interference, mm

Reduced internal clearance due to inner/outer ring temperature difference.

In operation, normally the outer ring will be 5 to 10˚C cooler than the inner ring or rotating parts. However, if the cooling effect of the housing is large, the shaft is connected to a heat source, or a heated substance is conducted through the hollow shaft; the temperature difference between the two rings can be even greater. The amount of internal clearance is thus further reduced by the differential expansion of the two rings as given in the formula:

$\delta t = \alpha . \Delta T . Do$

Where,

δt: Amount of reduced clearance due to heat differential, mm

α : Bearing material expansion coefficient 12.5 × 10-6/˚C

ΔT: Inner/outer ring temperature differential, ˚C

Do: Outer ring raceway diameter, mm

Outer ring raceway diameter, Do, values can be approximated by using formula

For ball bearings and spherical roller bearings,

$Do = 0.20\,(d + 4.0D)$

For roller bearings (except spherical roller bearing),

$Do = 0.25\,(d + 3.0D)$

Where,

d: Bearing bore diameter, mm

D: Bearing outside diameter, mm

Spherical Roller Bearing (Cylindrical Bore)

Table 5.1 Radial internal clearance for Spherical roller bearing with cylindrical bore.

Clearance values in microns

Nominal bore diameter d mm		Bearing with cylindrical bore									
		C2		CN		C3		C4		C5	
over	Incl.	min	max	min	max	min	max	min	max	min	max
14	18	10	20	20	35	35	45	45	60	60	75
18	24	10	20	20	35	35	45	45	60	60	75
24	30	15	25	25	40	40	55	55	75	75	95
30	40	15	30	30	45	45	60	60	80	80	100
40	50	20	35	35	55	55	75	75	100	100	125
50	65	20	40	40	65	65	90	90	120	120	150
65	80	30	50	50	80	80	110	110	145	145	180
80	100	35	60	60	100	100	135	135	180	180	225
100	120	40	75	75	120	120	160	160	210	210	26
120	140	50	95	95	145	145	190	190	240	240	300
140	160	60	110	110	170	170	220	220	280	280	350
160	180	65	120	120	180	180	240	240	310	310	390
180	200	70	130	130	200	200	260	260	340	340	430
200	225	80	140	140	220	220	290	290	380	380	470
225	250	90	150	150	240	240	320	320	420	420	520
250	280	100	170	170	260	260	350	350	460	460	570
280	315	110	190	190	280	280	370	370	500	500	630
315	355	120	200	200	310	310	410	410	550	550	690
355	400	130	220	220	340	340	450	450	600	600	750
400	450	140	240	240	370	370	500	500	660	660	820
450	500	140	260	260	410	410	550	550	720	720	900
500	560	150	280	280	440	440	600	600	780	780	1,000
560	630	170	310	310	480	480	650	650	850	850	1,100
630	710	190	350	350	530	530	700	700	920	920	1,190
710	800	210	390	390	580	580	770	770	1,010	1,010	1,300
800	900	230	430	430	650	650	860	860	1,120	1,120	1,440
900	1,000	260	480	480	710	710	930	930	1,220	1,220	1,570
1,000	1,120	290	530	530	780	780	1,020	1.020	1,330	1,330	1,720
1,120	1,250	320	580	580	860	860	1,120	1,120	1,460	1,460	1,870
1,250	1,400	350	640	640	950	950	1,240	1,240	1,620	1,620	2,080

Spherical Roller Bearing (Tapered bore)

Table 5-2: Radial internal clearance for Spherical roller bearing with tapered bore

Clearance values in microns

Bore diameter d (mm)		Group 2 (C2)		Group N (CN)		Group 3 (C3)		Group 4 (C4)		Group 5 (C5)	
Over	Incl.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
18	24	15	25	25	35	35	45	45	60	60	75
24	30	20	30	30	40	40	55	55	75	75	95
30	40	25	35	35	50	50	65	65	85	85	105
40	50	30	45	45	60	60	80	80	100	100	130
50	65	40	55	55	75	75	95	95	120	120	160
65	80	50	70	70	95	95	120	120	150	150	200
80	100	55	80	80	110	110	140	140	180	180	230
100	120	65	100	100	135	135	170	170	220	220	280
120	140	80	120	120	160	160	200	200	260	260	330
140	160	90	130	130	180	180	230	230	300	300	380
160	180	100	140	140	200	200	260	260	340	340	430
180	200	110	160	160	220	220	290	290	370	370	470
200	225	120	180	180	250	250	320	320	410	410	520
225	250	140	200	200	270	270	350	350	450	450	570
250	280	150	220	220	300	300	390	390	490	490	620
280	315	170	240	240	330	330	430	430	540	540	680
315	355	190	270	270	360	360	470	470	590	590	740
355	400	210	300	300	400	400	520	520	650	650	820
400	450	230	330	330	450	450	570	570	720	720	910
450	500	260	270	270	490	490	630	630	790	790	1000
500	560	290	410	410	540	540	680	680	870	870	1100
560	630	320	460	460	600	600	760	760	980	980	1230
630	710	350	510	510	670	670	850	850	1090	1090	1360
710	800	390	370	370	750	750	960	960	1220	1220	1500
800	900	440	640	640	840	840	1070	1070	1370	1370	1690
900	1000	490	710	710	930	930	1190	1190	1520	1520	1860

6.0 Lubrication

6.1 Function of the lubricant

The main function of lubricant is to provide a lubricating film between the rolling elements and the raceway of the bearing in order to prevent wear and allow smooth rotation of the contact surfaces to prolong the service life of the bearings.

The characteristics of lubricants are as follows:

(1) Reduction of Friction and Wear

Preventing direct metal to metal contact between the bearing elements and rings by providing a thin film. This film reduces the friction and wear in the contact areas.

(2) Extension of Fatigue Life

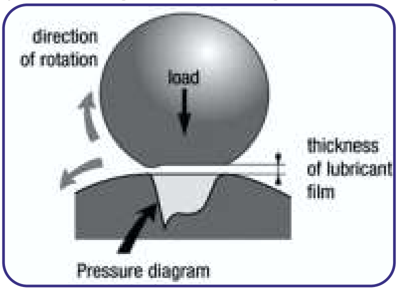
Lubricants improve the rolling fatigue life of bearings greatly by providing a thin film between the rolling contact surfaces.

(3) Dissipation of Frictional Heat

Lubricant acts as a coolant to carry away frictional heat from contact surfaces prevent the bearing from overheating.

(4) Others

Lubricants also helps to prevent foreign material from entering the bearings and protect against rusting.



The first step in the lubrication selection is to consider whether to use Oil lubrication or Grease lubrication for the particular application and should be decided in the design process.

6.2 Selection of the type of lubrication

The guideline is allowing the selection of the proper lubricant for the wide range of bearing types and operating conditions. The first consideration is method of lubrication is best for the particular application. Bearing lubrication method is broadly classified into three categories: Oil lubrication, Grease lubrication and solid lubrication. Satisfactory bearing performance can be achieved by adopting the most suitable for the application and operating condition. First two methods are being used in most of the applications. A comparison of grease and oil lubrication is given in Table 6.1 & 6.2.

Table 6.1 Comparison of grease and oil lubrication characteristics

Method	Grease Lubrication	Oil Lubrication
Handling	□	△
Reliability	o	□
Cooling Effect	x	o
Seal Structure	o	△
Power Loss	o	o
Environment Contamination	o	△
High speed rotation	x	o

□ : Very Good   o : Good   △ : Fair   x : Poor

Table 6.2 Comparison of grease lubrication and oil lubrication

	Oil lubrication	Grease lubrication
Advantages	•Good coverage in the bearing • Dissipating heat • Easy monitoring of the lubricant • Good physical and chemical stability	•Cleanliness of the system •Sealing easier •Assembly simplicity •Reduction or elimination of relubrication •Possibility of using pre-greased bearings
Disadvantages	• Necessary of a lubrication system • Poor protection against oxidation and moisture in case of long stops • Starting delay when circulation of oil is necessary prior to rotation	•Cost effectiveness •Higher friction coefficient than for oil •Poorer dissipation of heat •Replenishment (if necessary) difficulty •Grease leakage, contamination or ageing

6.3 Grease Lubrication

Thanks to its ability to dispense the lubricating film over time, grease lubricants offer an additional advantage when being used in maintenance-free applications. Most of NBC bearings are grease-lubricated, with different greases.

The following section will give broad guideline in selecting the appropriate lubricating grease. Before that let us discuss the characteristics of greases.

6.3.1 Characteristics of greases

Grease is a semi-fluid to solid and in which liquid lubricant is dispersing in a thickening agent called soap. Additives may also add to bring certain specific properties. The concept of fill for life in most of the applications has made grease as an integral component of the bearing. The service life of the bearing and its behaviour in diverse environments are largely determined by the properties of the grease.

6.3.1.1 Speed factor n. dm

The dm. N factor is the first step for choosing a bearing lubricant that will perform well under a given set of conditions. The factor is obtained by multiplying the bearing speed in rpms by the average of the outer diameter and bore diameter of the bearing in millimetres. DN factor of a bearing is critical to preventing lubricant starvation, which is characterized by decreasing lubricant film thickness. In case outer ring rotation consider only outer diameter to calculate DN factor.

6.3.1.2 Base Oil Viscosity

The base oil of the grease provides the separation between two surfaces of mating parts. Therefore, selecting the correct viscosity is very important. Knowing the speed factor value and operating temperature, the minimum viscosity requirement can be selected.

Grease made with low viscosity base oils is more suitable for high speeds and low to medium load application, while greases made with high viscosity base oils are more suited for low speed and heavy loads. However, the thickener also influences the lubricating properties of grease; therefore, the selection criteria for grease is not the same as for lubricating oil.

6.3.1.3 Operating temperature range

Due to friction between the rolling elements and ring raceways, the operating temperature of a bearing is likely to increase; however, in some application, external process-related temperature can influence the bearing such that its final operating temperature may be much higher. Therefore, make sure that the operating temperature range of the grease must be within the range of operating temperatures as per grease manufacturers. Grease temperature ranges are defined by both the dropping point of the grease thickener and composition of the base oil. If the operating temperature range is wide, synthetic greases offer advantages.

The high temperature limit for lubricating greases is a function of the oxidation stability. Starting torque in a grease-lubricated bearing at low temperatures can also be critical. It is recommended that greases are not used below 20°C than the lower operating temperature of the grease as stated by the grease manufacturer

6.3.1.4 Base oil Type

Once the viscosity has been determined, it's time to consider additives and base oil types. Most greases are produced using API Group II and III mineral oil base stocks for most applications. Synthetic oils such as Polyalphaolefin (PAO), diester or silicone oil are mainly used as the base oil for grease.

Demanding applications like high or low operating temperatures, a wide ambient temperature range, or any application where extended relubrication intervals are desired, then synthetic base oil can be used.

6.3.1.5 Additives

Additives are primarily include enhancing the existing desirable properties, suppressing the existing undesirable properties, and imparting new properties. The most common additives are oxidation and rust inhibitors, extreme pressure, antiwear, and friction-reducing agents.

It is recommended that extreme pressure additives be used in heavy load applications. For long use without replenishment, an antioxidant should be added.

6.3.1.6 Thickener Type

Thickeners are a fibrous matrix that contains the base oil. Under load, oil is released into the contact surfaces to provide lubrication. When the load is released, the oil is drawn back into the thickener matrix. The thickener in a grease is the component that sets grease apart from fluid lubricants. Thickener consist of two types, metallic soaps and non-soaps. Metallic soap thickeners include lithium, sodium, calcium, etc. Non-soap base thickeners are divided into two groups; inorganic (silica gel, bentonite, etc.) and organic (polyurea, fluorocarbon, etc.).

Poly-urea and other non-metallic soaps are generally superior in high temperature properties. However, this type of grease does not have a high working temperature unless the base oil also must have heat resistant. The highest possible working temperature for grease should be determined considering the heat resistance of the base oil.

Lithium-complex and urea thickeners are commonly being used in wheel bearing applications. However, grease for EV wheel application required lower torque, hence, more shear-stable di-urea thickeners could perform better.

6.3.1.7 Grease Consistency

The consistency of the grease is determined by the thickener concentration, thickener type and the viscosity of the base oil. In simple terms consistency expresses a measure of the relative hardness of a grease. The NLGI has established guidelines scale to indicate grease consistency as per Table 6.3. The consistency generally chosen for bearings is grade 2 & 3. Speed factor and operating temperature determine the best consistency for a given application.

Higher speed factors require higher consistency greases.

A common mistake when selecting a grease is to confuse between consistency and the base oil viscosity. The NLGI number relates to the consistency of the grease. It is possible to create NLGI #2 grease using ISO VG 10 base oil or ISO VG 1000 base oil. One would never use ISO VG 10 oil in an application that demands ISO VG 1000.

Table 6.3 Relationship between consistency and application of grease

NLGI Consistency No.	Worked Penetration	Working conditions
0	355~385	□ For centralised greasing use □ When fretting is likely to occur
1	310~340	□ For centralised greasing use □ When fretting is likely to occur □ For low temperature
2	265~295	□ For general use □ For selected use □ For high temperature
3	220~250	□ For selected ball bearings □ For high temperature
4	175~205	□ For special use

Table 6.4 Relationship between consistency and application of grease

Working condition	Suitable Grease
Smooth running (Low noise level)	Grease with NLGI 2
Vertical mount	Good adhesion property with NLGI 3 or 4
Outer ring rotation or centrifugal force on bearing	NLGI between 2 to 4
High temperature	Synthetic base oil with NLGI 2 or 3
Low temperature	Low viscous base oil with NLGI 1 or 2
Contaminated environment	NLGI 3 grease

NBC supply pre-greased with sealed and shielded bearing that is appropriate for the application. Contact NBC team for assistance in choosing the grease for your application. The following page will help to make an initial choice.

Standard greases and their characteristics are listed in Table 6.5. As performance characteristics of even the same type of grease will vary widely from brand to brand.

E-mobility has brought new challenge into the bearing design and lubrication. One of the challenges is grease with little electrical conductivity could extend the life of the bearing against serious bearing damage. To choose lubricant for electric vehicle application, contact NEI technical cell.

Table 6.5 Grease varieties and characteristics

CHARACTERISTICS	GREASE NAME				
	Lithium grease			Calcium grease (cup grease)	Sodium grease (fiber grease)
Thickener	Lithium Soap			Calcium Soap	Sodium Soap
Base Oil	Mineral oil	Synthetic oil (diester oil)	Synthetic oil (Silicon oil)	Mineral oil	Mineral oil
Dropping point (°c)	170 to 190	170 to 230	220 to 260	80 to 100	160 to 180
Operating temp. Range (°c)	-30 to +120	-50 to +130	-50 to +180	-10 to +70	0 to +110
Rotational range	Medium to high	High	Low to medium	Low to medium	Low to high
Mechanical stability	Excellent	Good to excellent	Good	Fair to good	Good to excellent
Water resistance	Good	Good	Good	Good	Bad
Pressure resistance	Good	Fair	Bad to fair	Fair	Good to excellent
Remarks	Most widely usable for various rolling bearings	Superior Low, Temperature & friction characteristics. Suitable for bearings for measuring instruments & extra small ball bearings for small electric motors.	Superior, High & low temperature characteristics.	Suitable for application at Low rotation speed & under light load. Not applicable at high temperature	Liable to emulsify in the presence of water. Used at relatively high temperature.

Table 6.5 Grease varieties and characteristics (contd.)

	GREASE NAME				
	Complex Base Grease		Non- Soap Base Grease		
CHARACTERISTICS					
Thickener	Lithium Complex Soap	Calcium Complex Soap	Bentone	Urea Compounds	Fluorine Compunds
Base Oil	Mineral Oil	Mineral Oil	Mineral Oil	Mineral Oil/Synthetic Oil	Synthetic Oil
Dropping point (°c)	250 or Higher	200 to 280	-	240 or higher	250 or Higher
Operating temp. Range (°c)	-30 to +150	-10 to +130	-10 to +150	-30 to +150	-40 to +250
Rotational range	Low to High	Low to Medium	Medium to High	Low to High	Low to Medium
Mechanical stability	Good to Excellent	Good	Good	Good to Excellent	Good
Water resistance	Good to Excellent	Good	Good	Good to Excellent	Good
Pressure resistance	Good	Good	Good	Good to Excellent	Good
Remarks	Superior mechanical stability and heat resistance. Used at relatively high temperature.	Superior pressure resistance when extreme pressure agents is added. Used In bearings for rolling mills.	Suitable for application at high temperature & under relatively heavy load	Superior water resistance, oxidation stability, and heat stability. Suitable for application at high temperature & high rotation speed.	Superior chemical resistance and solvent resistance. Usable upto 250 °C.

6.3.2 Relubrication Intervals

Grease replenishment or exchange is required if the grease service life is shorter than the anticipated bearing life. In this case grease deteriorates with the passage of time, fresh grease must be re-supplied at proper intervals. The replenishment time interval depends on the type of bearing, dimensions, bearing's rotating speed, bearing temperature, and type of grease.

The bearings are re-lubricated by means of grease guns through lubricating nipples. If frequent re-lubrication is required, grease pumps and volumetric metering units must be used. It is essential that the fresh grease displace the spent grease, so that the grease get exchanged, but over greasing should be prevented.

a) Grease quantities (M1) for weekly to yearly relubrication [g]:

$M1 = D \cdot B \cdot X$

Table: 6.6 Reduction factor (X)

Relubrication	X
weekly	0.002
monthly	0.003
yearly	0.004

b) Grease quantity (M2) for extremely short relubrication intervals [g]:

$M2=(0.5\text{-}20)\cdot V[kg/h]$

c) Grease relubrication quantity (M3) prior to restarting after several years of standstill [g]:

$M3 = D \cdot B \cdot 0.01$

Where

V = free space in the bearing

D = Outer dia of the bearing (mm)

B = Width of the bearing (mm)

Grease replenishment intervals can also be calculated by using following graph. This chart indicates the replenishment interval for standard rolling bearing grease when used under normal operating conditions.

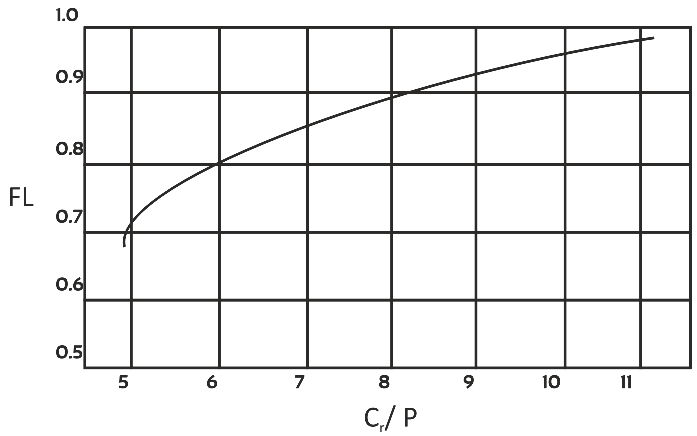


Fig. 6.1 Value of adjustment factor FL depends on bearing load

Example:

Find the grease lubrication interval for ball bearing 6205 with a radial load 1 .4 kN operating at 4800 r/min

From the bearing tables the allowable speed for bearing 6205 is 13000 r/min & a radial load of 1.4 kN

Cr/Pr = 14/1 .4 kN = 10

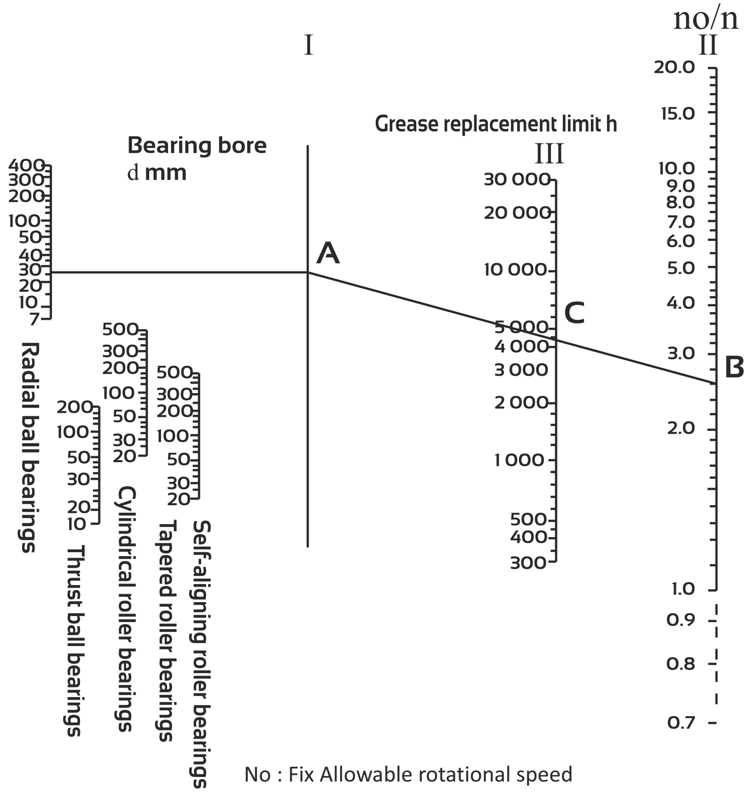
From fig.-1 adjusted load FL is 0.98

n0 = 0.98x13000 = 12740 r/min

Therefore n/n0 = 12740/4800 = 2.6

Using the chart in fig.-6.2 locate the point corresponding to bore diameter d=25 mm on the vertical line for radial ball bearings. Draw a straight- horizontal line to vertical line (I). After that draw a straight-line from that point (A in example) to a point on the line II which corresponds to the n0 /n value (2.6 in example). Point C, where this line intersects vertical line indicates the lubrication interval 'h' which is approximately 4500 hours.

Relubrication should be done to avoid grease deterioration having an adverse effect on the bearing life. However, High performance greases can extend relubrication intervals and grease life. The grease used for relubrication must be the same as that used in initial greasing. If other greases are used, the miscibility and compatibility of the greases must be checked.



No : Fix Allowable rotational speed (dimensions table)
n : Operating rotational speed

Fig. 6.2 Diagram for grease interval

6.3.3 Grease quantity for initial fill and relubrication

The amount of grease used in any given situation will depend on many factors relating to the size and shape of the housing, space limitations, bearing's rotating speed, grease characteristics, and ambient temperature.

The quantity of grease for ordinary bearings is determined as follows. Enough grease must be packed inside the bearing including the cage guide face. The available space inside the housing to be packed with grease depends on the speed as follows:

Table: 6.7 Speed factor with % filled quantity of grease

Speed	Speed factor	Grease fill
very slow	<50 000	60-80 %
slow to normal	50 000 to 200 000	25-60 %
high	200 000 to 600 000	15-30 %
very high	>600 000	15-20 %

It must be in mind that excessive grease will generate heat when churned and will consequently cause temperature rise which in turn causes the grease to soften and may allow leakage. With excessive grease fills oxidation and deterioration may cause lubricating efficiency to be lowered. Where speeds are high and temperature rises need to be kept to a minimum, a reduced amount of grease should be used.

The standard bearing space can be found by below formula V=K.W

where,

V : Quantity of bearing space open type (approx.) cm3

K : Bearing space factor **(Table 6.8)**

W: Mass of bearing kg

Table 6.8 Bearing space ratio (K)

Bearing Type	Retainer Type	K
Ball Bearings [(1)]	Pressed Retainer	61
NU-cylindrical Roller Bearings [(2)]	Pressed Retainer Machined Retainer	50 36
N-cylindrical Roller Bearings [(3)]	Pressed Retainer Machined Retainer	55 37
Tapered Roller Bearings	Machined Retainer	46
Spherical Roller Bearings	Pressed Retainer Machined Retainer	35 28

Notes:

1 Remove 160 Series

2 Remove NU4 Series

3 Remove N4 Series

In general, the permissible working temperature is limited by the degree of mechanical agitation to which the grease is subjected, and we shall be pleased to recommend suitable lubricants for varying conditions on receipt of necessary particulars, before the bearings are set to work, they should be thoroughly charged with grease in such a manner as to ensure the efficient coverage of all working surfaces. The housing should also be lightly packed with grease, it being important that a reserve supply of lubricant should be maintained in actual contact with the bearing to promote satisfactory and continuous lubrication. if two bearings are mounted in the same housing, they, for this reason, should be separated by distance pieces. If correctly applied, one charge of grease will last for a very long period, varying with the condition of working. If the bearing temperature exceeds 70 °C, the replenishment time interval must be reduced by half for every 15 °C temperature rise of the bearings.

6.3.4 Mixing Different Types of Grease

In general, mixing grease with different types of thickneners may destroy its composition and physical properties. Even if the thickeners are of the same type, possible differences in the additive may cause detrimental effects. Different brands of grease must not be mixed even same physical properties as the additives may differ. In cases where change of the grease used becomes necessary, all remaining old grease must be removed. Also, the remaining lubricant in housing cavities, lubrication pipes or grooves must be carefully removed. Especially in the changer over period, special attention should be paid to the lubrication situation in the bearing arrangement. If required, the defined relubrication intervals should be shortened during such a conversion period.

6.3.5 Compatibility

Grease formulated with base oil, the additives and the thickener. For higher performance from grease Lubricants must always be checked for their compatibility with other lubricants, Seal and the environment.

6.4 Oil lubrication

Oil lubrication is generally used when the bearing is adapted in a mechanism that is already lubricated (gear reducer, gearbox) or else when it can benefit from a central lubrication system.

- Oil is a better lubricant for high speeds or high temperatures. It can be cooled to help reduce bearing temperature.
- It is easier to handle and control the amount of lubricant reaching the bearing.
- Oil can be introduced to the bearing in many ways, such as drip-feed, pressurized circulating systems, oil bath or air-oil mist. Each is suited for certain types of applications.

In this section, the properties and characteristics of lubricants for typical roller bearing applications are listed. These general characteristics have resulted from long, successful performance in these applications

Types of oils

Lubricating oils are commercially available in many. Oils are classified Animal & Vegetable oils, Mineral oil and Synthetic oil.

6.4.1 Mineral oil

Oils are refined from crude petroleum oil, with additives to improve certain properties. Petroleum oils mostly used for oil-lubricated applications of bearings.

6.4.2 Synthetic oils

Synthetic oils cover a broad range of categories and include polyalphaolefins (PAO), Silicon oil, Fluorinated oil, Polyglycols and various esters. In general, synthetic oils are less prone to oxidation and can operate at extreme temperatures.

The polyalphaolefins (PAO) have a long straight hydrocarbon chain chemistry provide superior performance. Therefore, PAO oil is mostly used in the oil-lubricated applications of bearings when severe temperature or when extended lubricant life is required.

Selection of the proper type of oils depends on bearing speed, load, operating temperature and lubrication method.

6.4.3 Additives

Additives are substances formulated for improvement of chemical and physical properties of base oil, which results in enhancing the lubricant performance and extending the equipment life. The most commonly used additives are the Friction modifiers, Anti-wear additives, Extreme pressure (EP) additives, Rust and corrosion inhibitors, Anti-oxidants, Detergents, Dispersants, Pour point depressants and Viscosity index improvers. Great care must be used in choosing an additive. One must check with the lubricant manufacturer to check the influence of the additive on the bearing performance.

- Extreme pressure

  Protects metal surfaces against micro-welding and necessary when the bearing is highly loaded.

- Anti-wear

  Reduces the wear of the metal surfaces by forming a protective surface layer.

- Anti-corrosion

  Protects metal surfaces against corrosive attacks.

6.4.4 Viscosity

When selecting a lubricating oil, the viscosity at the operating conditions is important. If the viscosity is too low, a proper oil film is not formed and abnormal wear and seizure may occur. On the other hand, if the viscosity is too high, excessive viscous resistance may cause heating or large power loss. In general, low viscosity oils should be used at high speed; however, the viscosity should increase with increasing bearing load and size.

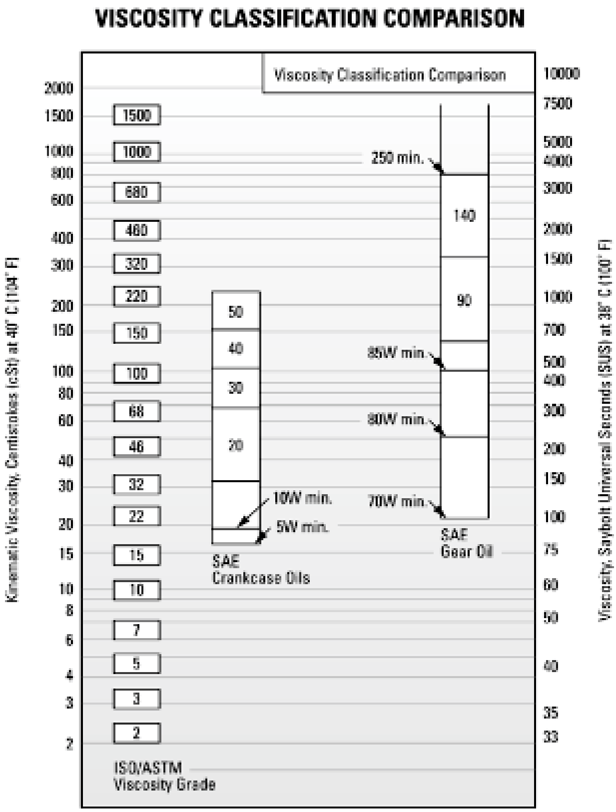
In regard to operating temperature and lubrication, Table 6.9 lists the required oil viscosity for different types of rolling bearings under normal operating conditions. Fig. 6.2 is an oil viscosity - operating temperature comparison chart for the purpose of selecting a lubrication oil with viscosity characteristics appropriate to an application.

Table 6.9 Bearing Types and Proper Viscosity of Lubricating Oils

Bearing Type	**Proper Viscosity at Operating Temperature**
Ball Bearings and Cylindrical Roller Bearings	Higher than 13 mm^2/s
Tapered Roller Bearings and Spherical Roller Bearings	Higher than 20 mm^2/s

Note: 1 mm^2/s=1cst (centistokes)

Since oil viscosity varies inversely with temperature, a viscosity value must always be stated with the temperature at which it was determined. There are several classifications of oils based on viscosity grades. The most familiar are the Society of Automotive Engineers (SAE) classifications for automotive engine and gear oils.



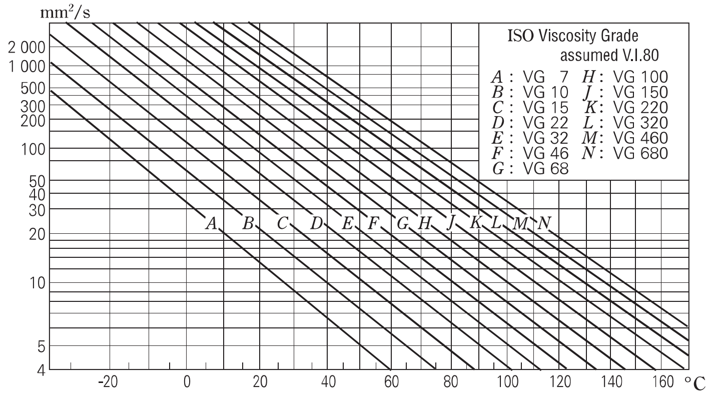


Fig. 6.3 Relation between lubricating oil viscosity and temperature

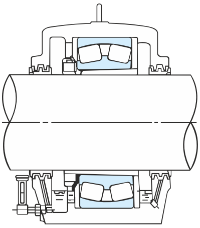
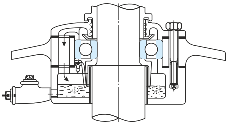
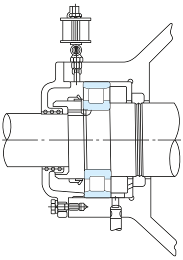
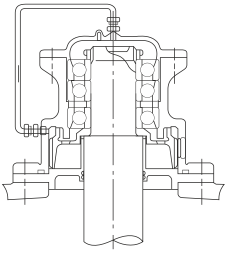
Table 6.10 Selection standards for lubricating oils (Reference)

Bearing operating temperature	Speed factor	Lubricating oil ISO viscosity grade (VG)		Suitable bearing
		Normal load	Heavy load or shock load	
—30 to 0	Up to allowable revolutions	22, 32	46	All types
0 to 60	15,000 Up to	46, 68	100	All types
	15,000 to 80,000	32, 46	68	All types
	80,000 to150,000	22, 32	32	All types but thrust ball bearings
	150,000 to 500,000	22, 32	10	Single row radial ball bearings, cylindrical roller bearings
60 to100	15,000 Up to	220	150	All types
	15,000 to 80,000	150	100	All types
	80,000 to 150,000	100, 150	68	All types but thrust ball bearings
	150,000 to 500,000	68	32	Single row radial ball bearings, cylindrical roller bearings
100 to 150	Up to allowable revolutions	320		All types
0 to 60	Up to allowable revolutions	46, 68		Self-aligning roller bearings
60 to 100	Up to allowable revolutions	150		-

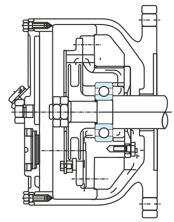
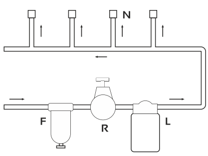
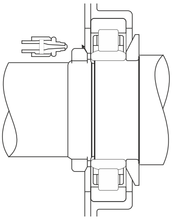
Please consult NEI technical cell in cases where operating conditions fall outside the range covered by this table.

Method of oil lubrication
- Oil bath
- Splash
- Drop feed
- Forced oil
- Disc Lubrication
- Spray
- Oil Jet

6.4.5 Methods of Oil Lubrication

Oil bath lubrication • This method is mostly used for slow and intermediate speed operation. • The bearing operates in an oil bath made by filling the housing with oil. • Too much oil causes excessive temperature rise (through agitation) while too little oil may cause seizing. • It is desirable to install an oil gauge so that the oil level can easily be checked. • In the case of a vertical shaft, 50-80% of the ball / roller bearing should be submerged when the bearing is idle.	
Splash lubrication • In this method oil is splashed by impellers attached to a shaft without direct submersion • This method is effective for high speeds. • One example, bearings and gears in a gear box. Where the gears may splash the oil. • A magnet should be placed at the bottom to prevent worn particles entering the bearings.	
Drop-Feed lubrication • This is a lubrication method where an oil pot (called "oiler") is installed at the upper portion of housing and oil drips from the oiler through a tiny hole. • The dripping oil is converted to fog or mist on collisions with the rotating shaft / bearing parts. • This method is more effective for comparatively high speeds and light loads rather than medium loads. • Although application capability is great irrespective of shaft mounting (vertical or horizontal) • Always remember to top off the oiler before it runs dry.	
Forced oil circulation • This method is commonly used for high speed operation requiring bearing cooling and for high temperatures environment. • Oil is travelled through the bearing and drains out through the pipe on the left. • After being cooled in a reservoir, it returns to the bearing through a pump and filter. • The oil discharge pipe should be larger than the supply pipe so an excessive amount of oil will not back up in the housing	

Methods of Oil Lubrication (contd.)

Disc Lubrication • In this method, a partially submerged rotating disc rotates and picks up oil from the casing then drains down through the bearing, lubricating it.	
Spray lubrication (oil-mist lubrication) • Filtered oil is blown through a lubrication sprayer (using dry compressed air), emerging in an atomized form. • This lubrication method is high effectiveness of cooling and prevention of bearings from dust or water invasion due to high internal pressure associated. • This method has often been used for bearings with high speed main spindle bearings or grinding machines. • Also it recently has become popular for bearings mounted on metal rolling mills.	
Oil Jet lubrication • This method lubricates by injecting oil under high pressure directly into the side of the bearing. • This is a reliable system for high speed, high temperature or otherwise severe conditions. • Used for lubricating the bearings in jet engines, gas turbines and other high-speed equipment. • Machine tools is one example of this type of lubrication.	

6.4.6 Compatibility

Performance of the lubricating oil also depends on compatibility with contact parts. Their behaviour must be checked in relation to plastics, seal materials (elastomers) at operating temperature. Though Synthetic oils enhance performance must always be checked for their compatibility.

6.5 Solid and Dry Lubrication

Solid lubricants are materials, which in solid phase reduce friction between surfaces sliding against each other, without the need for a liquid medium. Generally, these lubricants are applied on the contact surfaces by different coating process are adopted to use Molybdenum disulphide (MoS2) and tungsten disulphide (WS2).

For more details, please contact NEI technical cell.

6.6 Oil impregnated ball bearing

Oil impregnated ball bearing is a type of polymer lubricant composed lubricating oil in the matrix. The special solution works similar to grease but by applying a special treatment process, the polymer solidifies retaining a large proportion of the lubricant within the bearing. Unlike grease, the OIBB is solid polymer matrix can prevent dirt or foreign particles entering into the contact.

For more details, please contact NEI technical cell.

7.0 Friction & Temperature

7.1 Friction

Frictional resistance to motion in a rolling bearing arises from various sources; the following commonly predominate:

1. Rolling friction: Elastic hysteresis and deformation at raceway contacts.

2. Sliding friction: Sliding from unequal curvatures in contact areas, sliding contact of the cage with rolling elements and guiding surfaces, sliding between the ends of rollers and ring flanges, and seal friction;

3. Lubricant friction: Viscous shearing on rolling element, cage, and raceway surfaces; churning and working of lubricant dispersed within the bearing cavity.

For most normal operating conditions, the total frictional moment can be estimated with sufficient accuracy as load dependent using a constant coefficient of friction:

$M = 0.5 \times \mu \times P \times d$

Where,

M = bearing frictional moment, calculated at the bearing bore radius (N mm)

μ = coefficient of friction for the bearing (Table 7.1)

P = bearing load (N)

d = bearing bore diameter (mm)

The starting coefficient of friction can generally be taken as being about 60% higher than the running values given in Table 7.1. More accurate calculations of bearing friction are available which account for variations in the coefficient of friction with relative bearing load, bearing size, and cross section series.

Table 7.1 Co-efficient of friction for rolling element bearing

Bearing Types	Approximate values of μ
Deep Groove Ball Bearings	0.0015[a]
Cylindrical Roller Bearings with cage	0.0011[b]
Cylindrical Roller Bearings full complement	0.002 [a,b]
Spherical Roller Bearings	0.0018
Tapered Roller Bearings	0.0018

Note: [a] Apply to unsealed bearing

[b] No appreciable axial load (Fa= 0)

7.2 Bearing operating temperature

Operating temperature bears important relations to bearing and seal friction, design of the bearing assembly, and especially lubrication considerations

Generally, all friction loss in a bearing is transformed into heat within the bearing itself and causes the temperature of the bearing to rise. The amount of thermal generation caused by friction moment can be calculated using the below equation.

$$Q = 0.105 \times 10^{-6} \times M \times n$$

where,

Q : Thermal value, kW

M : Friction moment, N.mm

n : Rotational speed, rpm

Bearing operating temperature is determined by the equilibrium or balance between the amount of heat generated by the bearing and the amount of heat conducted away from the bearing. In most cases the temperature rises sharply during initial operation, then increases slowly until it reaches a stable condition and then remains constant. The time it takes to reach this stable state depends on the amount of heat produced, heat capacity/diffusion of the shaft and bearing housing, amount of lubricant and method of lubrication. If the temperature continues to rise and does not become constant, it must be assumed that there is some improper function.

Possible causes of abnormal temperature increase may be due:

- Bearing misalignment
- Moment load
- Incorrect installation
- Insufficient internal clearance
- Excessive pre-load, too much or too little lubricant.

8.0 Limiting Speed

As bearing rotational speed increases, the temperature of the bearing also increases due to friction heat generated in the bearing interior. If the temperature continues to rise and exceeds certain limits, the efficiency of the lubricant drastically decreases, this causes damage to the bearing such as seizure and the bearing can no longer continue to operate in a stable manner.

Therefore, the maximum speed at which it is possible for the bearing to continuously operate without the generation of excessive heat beyond specified limits is called the limiting speed or allowable speed (r/min).

The factors that can affect the maximum allowable bearing speed include:

(1) Bearing type

(2) Bearing dimension and accuracies

(3) Lubrication system

(grease lubrication, air-oil lubrication, jet lubrication, etc.)

(4) Internal clearance or preload on the bearing

(5) Bearing arrangement (2-row, 3-row, 4-row)

(6) Bearing load

(7) Accuracies of shaft, housing, etc.

(8) Type of Cage

Because of the many factors involved in determining the speed capabilities of a rolling bearing, it is impossible to develop a simple formula to establish an exact value for the limiting speed. Besides the precision of the bearing itself, the magnitude and direction of the load, the type of cage, the type of lubricant and lubrication system, the rate of heat dissipation, the alignment, the mounting practice, and the balance of the rotating components all play a significant role. Since each application must be evaluated on its own merits, it is recommended the to consulted the NBC Application Engineering Department when the speed approaches the limiting value.

The maximum allowable speeds listed in the bearing dimensions tables are reference values and are applicable only to individual bearings that are adequately lubricated and correctly preloaded under a condition where the heat is reliably removed from the bearing arrangement. The limiting speeds listed in the bearing tables for grease and oil lubrication are for standard NBC bearings under normal operating conditions, correctly installed, using the suitable lubricants with adequate supply and proper maintenance.

In the case of grease lubrication, these speeds are attainable only when the bearing is filled with an adequate amount of high-quality grease, the bearing is sufficiently run in, and heat is removed by an arrangement such as a cooling jacket. The maximum allowable speed of a particular bearing can vary depending on the relation between heat generation and heat dissipation in the bearing as well as how well the bearing is lubricated.

The bearing dimensions table gives approximate Allowable rotational speeds for grease and oil lubrication. The values are based on the following:

- The bearing must have the proper internal clearance prescribed in the NBC Engineering standard design specifications and must be properly installed.
- A quality lubricant must be used.
- The lubricant must be replenished and changed when necessary.
- The bearing must be operated at normal operating temperature under ordinary load conditions ($P \leqq 0.09\ Cr$, $Fa / Fr \leqq 0.3$).

- If load is P ≦ 0.04 Cor, the rolling elements may not turn smoothly. If so, please contact NBC Engineering for more information.
- Allowable rotational speed for bearings with contact seal (LLU type) or low-torque seal (LLH type) is determined according to the circumferential speed of the seal.
- For bearings to be used other than standard mentioned conditions please consult to NBC engineering for limiting speed.

9.0 Bearing fits with shaft & housing

9.1 The Necessity of a Proper Fit

In some cases improper fit may lead to damage and shorten bearing life. Therefore, it is necessary to make a careful analysis while selecting a proper fit.

Some of the negative conditions caused by improper fit are listed below:

- Raceway cracking, early pitting and displacement of raceways
- Raceway & shaft or housing abrasion caused by creeping in fretting corrosion
- Seizing caused by loss of internal clearance
- Increased noise & lowered rotational accuracy due to raceway groove deformation.

Selection of fits : Selection of proper fit depended upon thorough analysis of bearing operating conditions, including consideration of following factors:

(1) Condition of Rotation

This condition refer to the rotation of bearing ring being considered in relation to the direction of load. There are 3 different conditions:

- Rotating load
- Stationery load
- Direction of load indeterminate

(2) Magnitude of the load

The interference fit of a bearing's inner ring on its seating will be loosened with the increasing load, as the ring will expand under the influence of rotating load, & ring may begin co creep. If it is of shock character, greater interference is required.

The loss of interference due to increasing load can be estimated using the following equation:

When Fr ≤: 0.3Cor

$$\Delta\, dp = 0.08 \sqrt{\frac{d.Fr}{B}}$$

When Fr ≥ 0.3 Cor

$\Delta dp = 0.02\,(Fr/B)$

where,

Δdp = Interference decrease of inner ring (µm)

Fr = Radial load (N)

B = Inner ring width (mm)

Cor= Basic static load (N)

(3) Bearing Internal Clearance

An interference fit of a bearing on the shaft or in housing means that ring is elastically deformed (expanded or compressed) and bearing's internal clearance reduced.

The internal clearance and permissible reduction depend on the type and size of the bearing.

- The reduction in clearance due to interference fit can be so large that bearings with an internal clearance which is greater than normal have to be used.
- The expansion of the inner ring and contraction of outer ring can be assumed to be approximately 60-80% of the interference, depending on the material of shaft and housing.

(4) Temperature Condition

Interference between inner ring & steel shalt is reduced as a result of temperature increase (difference between bearing temperature and ambient temperature). This can result in an easing of fit of the inner ring on its seating. While outer ring expansion may result in increase in clearance.

The decrease of the interference of the inner ring due to this temperature difference may be calculated using following equation: $\Delta dt = 0.0015 \times d \times \Delta T$

Where Δdt= effective interference for temperature difference (μm)

ΔT=Temperature difference between bearing temperature ambient temperature (deg. C).

d =Bearing bore diameter (mm)

(5) Running Accuracy Requirement

To reduce resilience and vibration, clearance fit should generally not be used for bearings, where high demands are placed on running accuracy.

(6) Design& Material of Shaft & Housing

The fit of a bearing ring on its seating must not lead to uneven distortion of the ring (out of roundness).This can be caused by discontinuity in the housing surface. Split housings are therefore not suitable where outer rings are to have an interference fit.

(7) Ease of Mounting &Dismounting

Bearings with clearance fit are usually easier to mount or dismount than those having interference fit. Where operating condition necessitate interference fit and it is essential that mounting &dismounting can be done easily, separable bearings or bearings with taper bore and adaptor or withdrawal sleeve may be used.

(8) Displacement of Non-Locating bearings

If non-separable bearings are used as floating bearings, if the ring is under stationary load, so that axial displacement has to take place in the housing bore, a hardened intermediate bushing is often fitted to the outer ring.

(9) Effective Interference and finish of shaft &housing

Roughness of the fitted surface is reduced since the roughness of the fitted surface is reduced during fitting, the effective interference becomes less than the apparent interference.

The amount of this interference decrease varies depending on roughness of the surfaces.

Normally, manufacturers assume the following interference reductions:

For ground shaft: 1-2.5 Micron

Machined Shaft: 5-7 Micron

(10) Fitting stress & ring expansion and contraction

While calculating the minimum required amount of interference, following factors should be factors should be taken into consideration:

- Interference is reduced by radial load
- Interference is reduced by difference between bearing temperature and ambient temperature
- Interference is reduced by variation of fitted surfaces

Important details on fits: Maximum interference should not exceed the ratio of 1:1000 of shaft or outside diameter.

Tight interference fits are recommended for:

(a) Operating conditions with large vibrations or shock loads

(b) Application using hollow shaft of housing with thin walls

(c) Application using housing made of light alloys or plastic.

Loose interferences are recommended for:

(a) Application requiring high running accuracy

(b) Application using small size bearings or thin walled bearings.

Shaft and housing material, geometry, hardness and surface finish must be carefully controlled.

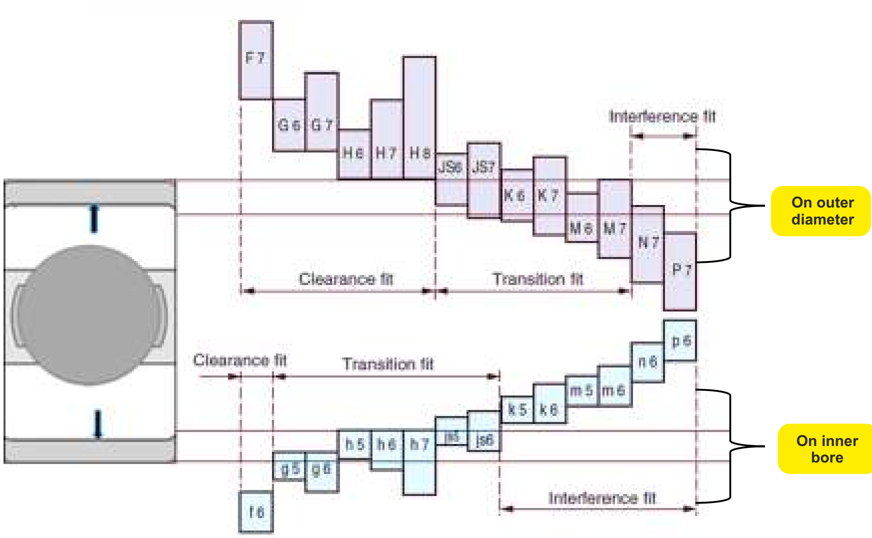
- Ground shafts should be finished to 1 .3 micron Ra or better;
- For turned shafts a finish of 2.5 micron Ra or better; and
- Housing bores should be finished to 4 micron Ra or better.

To avoid shearing of aluminum and magnesium housing during bearing installation, steel inserts should be used; alternatively special lubricants may be used for Freezing and heating to facilitate assembly. A minimum interference fit of 0.0015" and 0.001" per inch of diameter is required for magnesium and aluminum housing respectively.

Where bearings are to be pressed onto a hollow shaft, allowance must be made for contraction of the hollow shaft in order to maintain the desired radial pressure.

9.2 housing & Shaft Tolerance Class

NEI engineering department should be consulted for proper fitting practices on all special applications. For normal class bearing shaft and housing tolerances are given in table below. The tolerances are for solid steel shaft & housing of cast iron and steel.



Shaft & Housing tolerances

Shaft tolerance class generally for radial bearings (classes 0, 6X and 6)

Type of load	Condition	Example	Shaft diameters			
			Ball bearings	Cylindrical, neddle and tapered roller bearings	Spherical roller bearings	Tolerance class symbol
Rotating inner ring load	Light and variable loads (P<0,06C)	Conveyers lightly loaded mechanisms, bearings	18...100 >100...140	≤40 >40...100	- -	j6 k6
	Normal and heavy loads (P>0, 06C)	General mechanical engineering electric motors, turbines, pups, gearboxes,	≤18 >18...100 >100..140 >140...200 >200...280 - -	- ≤40 >40...100 >100..140 >140...200 >200...400 - -	- ≤ 40 > 40...65 > 65..100 > 100...140 > 140...280 > 280...500 > 500	j5 K5(k6) m5(m6) m6 n6 p6 r6 r7
	Heavy loads and shock loads, ardous working conditions (P>0, 12C)	Heavy duty railway vehicles axle bearings, traction motors, rolling mills	- - -	>50...140 >140...200 200	>50...100 >100...200 > 200	n6 p6 r6
	High running accuracy, light loads (P<0,06C)	Machine tools	≤ 18 > 18...100 > 100...200 -	- ≤ 40 > 40...100 > 140...200	- - - -	h5 j5 k5 m5
Stationary inner ring load	Radial bearings with cylindrical core		All diameters			
	Easy axial displacement of inner ring on shaft desirable	Wheels on non-roating shafts (free wheels)				g6(f6)
	Axial displacement of inner ring on shaft not necessary	Tension pullyes, sheaves				h6
Axial load	Common to all shaft diameter. Shaft & inner is not fixed		≤250 >250	≤250 >250	<250 >250	j6 js6

Fits for shaft for Tapered bore bearing (normal class) with adapter / withdrawal sleeve

All loads	**For all sizes general applications**	**All shaft diameters**	**h9**

Housing tolerance class generally for radial bearings (classes 0, 6X and 6)

Split or Single (Housing rotating outer ring load)				
Load type	Conditions	Example	Tolerance class	Outer ring axial displacement in non - separable bearing
Rotating outer ring load	Light and variable loads (P≤0,06C)	Roller bearing wheel hubs, connecting rod bearing	M7	Outer ring cannot move axially
	Normal and heavy loads (P>0,06C)	Ball bearing wheel hubs, connecting rod bearings, crane traveling wheels	N7	
	Rotating outer ring load Heavy loads on bearings in thin walled housings, heavy shock loads (P>0,12C)	Conveyer rollers, rope sheaves, belt tension pulleys	P7	
Direction of load indeterminate	Normal and heavy loads (P > 0,06C). Outer ring displacement is not necessary	Crank shaft main bearing	K7	Outer ring cannot move axially
		Electric motors, pumps crankshaft main bearing		
	Heavy shock loads	Traction motors	M7	

Split or Single Housing (Stationary outer load)				
Load type	Conditions	Example	Tolerance class	Outer ring axial displacement in non- separable bearing
Stationary outer load	Loads of all kinds	General mechanical engineering, railway axle boxes	H7	Outer ring can move axially
	Light and normal loads Desirable outer ring displacement (P≤0,12 C)		H8	Outer ring cannot move axially
	Quiet operation	Electric motor	H6	
	Heat conduction through shaft	Drying cylinders, large electrical machines with spherical roller bearings	G7	
Direction of load indeterminate	Light and normal loads Desirable outer ring displacement (P≤0,12 C)	medium-sized electric motors, pumps, crankshaft main bearings	J7	Outer ring can move axially

Numeric value table of fitting for radial bearing of 'Normal class' for metric size

Table for fit on shaft

Unit µm

Nominal bore diameter of bearing d (mm) Over	Incl.	Δdmp high	low	g_5	g_6	h_5	h_6	j_5	js_5	j_6
3	6	0	-8	4T - 9L	4T - 12L	8T - 5L	8T - 8L	11T - 2L	10.5T - 2.5L	14T - 2L
6	10	0	-8	3T - 11L	3T - 14L	8T - 9L	8T - 9L	12T - 2L	11T - 3L	15T - 2L
10	18	0	-8	2T - 14L	2T - 17L	8T - 8L	8T - 11L	13T - 3L	12T - 4L	16T - 3L
18	30	0	-10	3T - 16L	3T - 20L	10T - 9L	10T - 13L	15T - 4L	14.5T - 4.5L	19T - 4L
30	50	0	-12	3T - 20L	3T - 25L	12T - 11L	12T - 16L	18T - 5L	17.5T - 5.5L	23T - 5L
50	80	0	-15	5T - 23L	5T - 29L	15T - 13L	15T - 19L	21 - 7L	21.5T - 6.5L	27T - 7L
80	120	0	-20	8T - 27L	8T - 34L	20T - 15L	20T - 22L	26T - 9L	27.5T - 7.5L	33T - 9L
120	140									
140	160	0	-25	11T - 32L	11T - 39L	25T - 18L	25T - 25L	32T - 11L	34T - 9L	39T - 11L
160	180									
180	200									
200	225	0	-30	15T - 35L	15T - 44L	30T - 20L	30T - 29L	37T - 13L	40T - 10L	46T - 13L
225	250									
250	280									
280	315	0	-35	18T - 40L	18T - 49L	35T - 23L	35T - 32L	42T - 16L	46.5T-11.5L	51T - 16L
315	355									
355	400	0	-40	22T - 43L	22T - 54L	40T - 25L	40T - 36L	47T - 18L	52.5T - 12.5L	58T - 18L
400	450									
450	500	0	-45	25T - 47L	25T - 60L	45T - 27L	45T - 40L	52T - 20L	58.5T-13.5L	65T - 20L

Table for fit on Housing

Unit µm

Nominal outside diameter of bearing D (mm) Over	Incl.	ΔDmp high	low	G_7	G_6	H_7	J_6	J_7	Js_7	K_6
6	10	0	- 8	5L - 28L	0 - 17L	0 - 23L	4T - 13L	7T - 16L	7.5 - 15.5L	7T - 10L
10	18	0	- 8	6L - 32L	0 - 19L	0 - 26L	5T - 14L	8T - 18L	9T - 17L	9T - 10L
18	30	0	- 9	7L - 37L	0 - 22L	0 - 30L	5T - 17L	9T - 21L	10.5T - 19.5L	11T - 11L
30	50	0	- 11	9L - 45L	0 - 27L	0 - 36L	6T - 21L	11T - 25L	12.5T - 23.5L	13T - 14L
50	80	0	- 13	10L - 53L	0 - 32L	0 - 47L	6T - 26L	12T - 31L	15T - 28L	15T - 17L
80	120	0	- 15	12L - 62L	0 - 37L	0 - 50L	6T - 31L	13T - 37L	17.5T - 32.5L	18T - 19L
120	150	0	- 18	14L - 72L	0 - 43L	0 - 58L	7T - 36L	14T - 44L	20T - 38L	21T - 22L
150	180	0	- 25	14L - 79L	0 - 50L	0 - 65L	7T - 43L	14T - 51L	20T - 45L	21T - 29L
180	250	0	- 30	15L - 91L	0 - 59L	0 - 76L	7T - 52L	16T - 60L	23T - 53L	24T - 35L
250	315	0	- 35	17L - 104	0 - 67L	0 - 87L	7T - 60L	16T - 71L	26T - 61L	27T - 40L
315	400	0	- 40	18L -115L	0 - 76L	0 - 97L	7T - 69L	18T - 79L	28.5T -68.5L	29T - 47L
400	500	0	- 45	20L -128L	0 - 85L	0 -108L	7T - 78L	20T - 88L	31.5T -76.5L	32T - 53L

Numeric value table of fitting for radial bearing of 'Normal class' for metric size

Table for fit on shaft

Unit µm

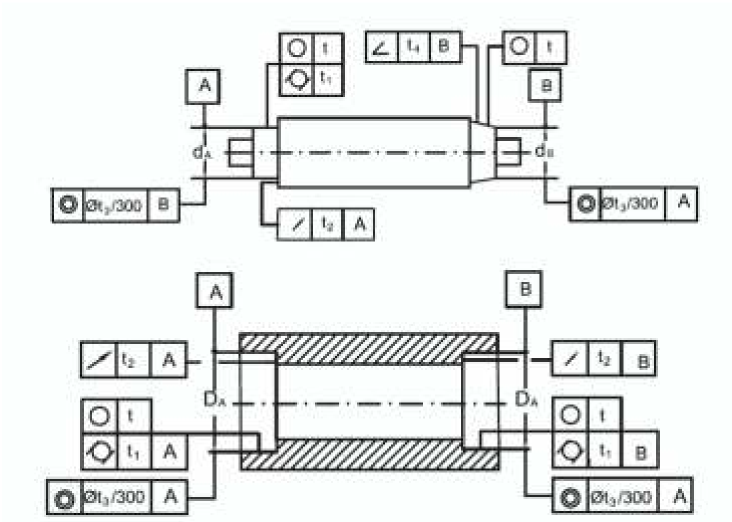
Nominal bore diameter of bearing d (mm) Over	Incl.	Δdmp high	low	js_6	k_5	k_6	m_5	m_6	n_6	p_6	r_6
3	6	0	-8	12T - 4L	14T - 1T	17T - 1T	17T - 4T	20T - 4T	24T - 8T	28T - 12T	-
6	10	0	-8	12.5T - 4.5L	15T - 1T	18T - 1T	20T - 6T	23T - 6T	27T - 10T	32T - 15T	-
10	18	0	-8	13.5T - 5.5L	17T - 1T	20T - 1T	23T - 7T	26T - 7T	31T - 12T	37T - 18T	-
18	30	0	-10	16.5T - 6.5L	21T - 2T	25T - 2T	27T - 8T	31T - 8T	38T - 15T	45T - 22T	-
30	50	0	-12	20T - 8L	25T - 2T	30T - 2T	32T - 9T	37T - 9T	45T - 17T	54T - 26T	-
50	80	0	-15	24.5T - 9.5L	30T - 2T	36T - 2T	39T - 11T	45T - 11T	54T - 20T	66T - 32T	-
80	120	0	-20	31T - 11L	38T - 3T	45T - 3T	48T - 13T	55T - 13T	65T - 23T	79T - 37T	-
120	140										113T - 63T
140	160	0	-25	37.5T-12.5L	46T - 3T	53T - 3T	58T - 15T	65T - 15T	77T - 27T	93T - 43T	115T - 65T
160	180										118T - 68T
180	200										136T - 77T
200	225	0	-30	44.5T-14.5L	54T - 4T	63T - 4T	67T - 17T	76T - 17T	90T - 31T	109T - 50T	139T - 80T
225	250										143T - 84T
250	280										161T - 94T
280	315	0	-35	51T - 16L	62T - 4T	71T - 4T	78T - 20T	87T - 20T	101T - 34T	123T - 56T	165T - 98T
315	355										184T - 108T
355	400	0	-40	58T - 18L	69T - 4T	80T - 4T	86T - 21T	97T - 21T	113T - 37T	138T - 62T	190T - 114T
400	450										211T - 126T
450	500	0	-45	65T - 20T	77T - 5T	90T - 4T	95T - 23T	108T - 23T	125T - 40T	153T - 68T	217T - 132T

Table for fit on Housing

Unit µm

Nominal outside diameter of bearing D (mm) Over	Incl.	ΔDmp high	low	K_7	M_7	N_7	P_7
6	10	0	- 8	10T - 13L	15T - 8L	19T - 4L	24T - 1L
10	18	0	- 8	12T - 14L	18T - 8L	23T - 3L	29T - 3L
18	30	0	- 9	15T - 15L	21T - 9L	28T - 2L	35T - 5L
30	50	0	- 11	18T - 18L	25T - 11L	33T - 3L	42T - 6L
50	80	0	- 13	21T - 22L	30T - 13L	39T - 4L	52T - 8L
80	150	0	- 15	25T - 25L	35T - 15L	45T - 5L	59T - 9L
120	180	0	- 18	28T - 30L	40T - 18L	52T - 6L	68T - 10L
150	200	0	- 25	28T - 37L	40T - 25L	52T - 13L	68T - 3L
180	250	0	- 30	33T - 43L	46T - 30L	60T - 16L	79T - 3L
250	315	0	- 35	36T - 51L	52T - 35L	66T - 21L	88T - 1L
315	400	0	- 40	40T - 57L	57T - 40L	73T - 24L	98T - 1L
400	500	0	- 45	45T - 63L	63T - 45L	80T - 28L	108T - 0

9.3 Shaft and housing accuracies



Tolerance name	Fit	Symbol of deviation	Permissible deviation depending on the tolerance class				
			P0 P6X	P6	P5	P4(SP)	P2(UP)
Tolerance of dimension	shaft	- -	IT6(IT5)	IT5	IT4	IT4	IT3
	housing		IT7(IT6)	IT6	IT5	IT4	IT4
Tolerance of roundness and cylindricity	shaft	○ ⌭ t, t_1	$\frac{IT4}{2}\left(\frac{IT3}{2}\right)$	$\frac{IT3}{2}\left(\frac{IT2}{2}\right)$	$\frac{IT2}{2}$	$\frac{IT1}{2}$	$\frac{IT0}{2}$
	housing	t, t_1	$\frac{IT5}{2}\left(\frac{IT4}{2}\right)$	$\frac{IT4}{2}\left(\frac{IT2}{2}\right)$	$\frac{IT3}{2}$	$\frac{IT2}{2}$	$\frac{IT1}{2}$
Tolerance of face runout	shaft	↗ t_2	IT4 (IT3)	IT3 (IT2)	IT2	IT1	IT0
	housing		IT5 (IT4)	IT4 (IT3)	IT2	IT2	IT1
Tolerance of concentricity	shaft	◎ t_3	IT5	IT4	IT4	IT3	IT3
	housing		IT6	IT5	IT5	IT4	IT3
Tolerance of angularity	shaft	∠ t_4	$\frac{IT7}{2}$	$\frac{IT6}{2}$	$\frac{IT4}{2}$	$\frac{IT3}{2}$	$\frac{IT2}{2}$

For IT grade values refer table for ISO tolerance grade.

Table: ISO Tolerance grade for dimensions

Nominal Dimension Over	incl.	IT0	IT1	IT2	IT3	IT4	IT5	IT6	IT7	IT8	IT9	IT10	IT11	IT12
mm		µm												
1	3	0.5	0.8	1.2	2	3	4	6	10	14	25	40	60	100
3	6	0.6	1	1.5	2.5	4	5	8	12	18	30	48	75	120
6	10	0.6	1	1.5	2.5	4	6	9	15	22	36	58	90	150
10	18	0.8	1.2	2	3	5	8	11	18	27	43	70	110	180
18	30	1	1.5	2.5	4	6	9	13	21	33	52	84	130	210
30	50	1	1.5	2.5	4	7	11	16	25	39	62	100	160	250
50	80	1.2	2	3	5	8	13	19	30	46	74	120	190	300
80	120	1.5	2.5	4	6	10	15	22	35	54	87	140	220	350
120	180	2	3.5	5	8	12	18	25	40	63	100	160	250	400
180	250	3	4.5	7	10	14	20	29	46	72	115	185	290	460
250	315	4	6	8	12	16	23	32	52	81	130	210	320	520
315	400	5	7	9	13	18	25	36	57	89	140	230	360	570
400	500	6	8	10	15	20	27	40	63	97	155	250	400	630
500	630	-	-	-	-	-	28	44	70	110	175	280	440	700
630	800	-	-	-	-	-	35	50	80	125	200	320	500	800
800	1000	-	-	-	-	-	36	56	90	140	230	360	560	900
1000	1250	-	-	-	-	-	42	66	105	165	260	420	660	1050
1250	1600	-	-	-	-	-	50	78	125	195	310	500	780	1250
1600	2000	-	-	-	-	-	60	92	150	230	370	600	920	1500
2000	2500	-	-	-	-	-	70	110	175	280	440	700	1100	1750

10.0 Condition Monitoring Services

Condition Monitoring is the potential technique of predicting the failures and improving assets reliability. Today's competitive market demands qualitative products, with zero defects. Therefore optimal productivity and smooth processes are only possible when machines operates within vibration tolerances.

Uncontrolled vibrations creates undesirable behavior in machineries leads to catastrophic failures. Condition monitoring leads to predict remaining useful life of assets and improves its reliability. It allows to use exact permissible life of assets.

To maintain healthy conditions of machine and predicting its failure is our business. We provide intelligent solutions of condition monitoring in order to improve assets reliability. Our expertise in various streams of condition monitoring helps industries to maintain their assets failure free.

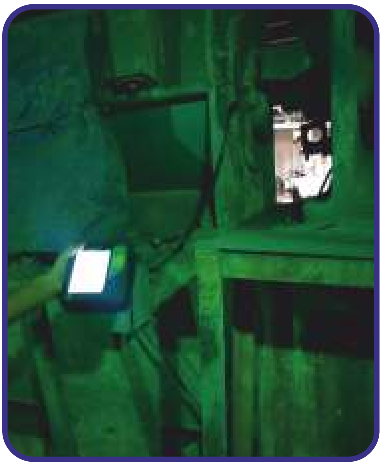
We provide smart solutions to industries through

- Vibration Analysis & Fault Diagnosis
- Laser Alignment
- In-Situ Dynamic Balancing
- Thermography

Vibration Analysis & Fault Diagnosis

Vibration Signature analysis is the process by which intelligent information is extracted about machinery condition from vibration data during machine operation. We Perform fault diagnosis based upon vibration signature and predicts various machinery faults.

Our expertise in vibration analysis and fault diagnosis provides intelligent solutions for protecting machinery from catastrophic failures.



Laser Alignment

Alignment practices are often required to protect equipment's from premature failures. Misaligned condition of assets often leads to more power consumption, severe vibration levels, and premature bearing failures.

Our expertise in laser alignment offers alignment solution to industries. We offer field laser alignment, which makes alignment process fast and accurate by avoiding trail & error method.

We perform laser alignment for shaft in coupled & Un-coupled condition, torsion shaft alignment, ID&FD fan alignment, cooling tower fan shaft alignment, wind mill alignment, cardon shaft alignment, soft foot correction and thermal growth compensation.

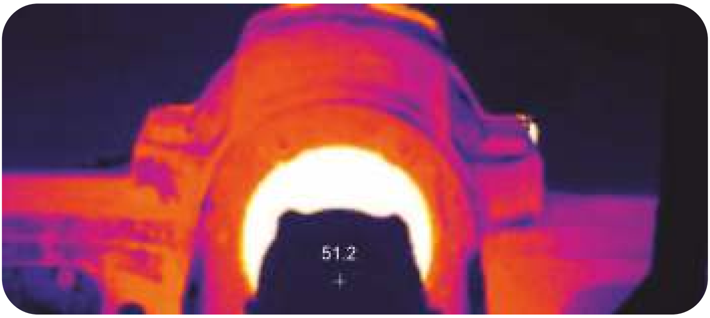
In-Situ Dynamic Balancing

Unbalance Condition of machine is one of the most common contributors to vibrations in rotating machines. If unbalance remains uncorrected, it may lead to severe vibration problems, premature bearing failures, low performance of machines than expected, and more power consumptions.

We offer highest balancing grade by measuring phase very precisely using latest FFT data collector and laser based optical phase reference.

Thermography

Infrared thermography is a technique that produces a visible graph or a thermographic image of thermal energy radiated by objects.



Thermography often required to detect hot and cold spot, condition monitoring of insulation lining of boiler, steam pipeline and hot air ducts. Detection of thermal abnormalities are also performed using thermography.

We offer thermography services for all critical equipment's

A complete smart solution to protect critical assets from failures through condition monitoring is our prime objective. High end equipment's with advanced method of analysis is the key differentiating element of our service.

11.0 Bearing Fitment & Handling

11.1 Fitment

Rolling bearing is a very precise product and its mounting deserves careful attention. Mounting is an important function as it:

- Ensures safety of the equipment and the operator
- Minimizes breakdown and reduces downtime
- Bearing can perform to its maximum load carrying capacity
- Enhance the bearing life
- Prevent creeping of rings on shaft under load

The characteristics and assembly of the bearing should be thoroughly studied before mounting. The sequence of mounting must be established and verified. Mounting process is an important factor that affect the service life of bearing. Few basic rules should be obeyed while mounting such as:

- keeping the mounting area absolutely clean
- Protection of all bearing parts from contamination and corrosion
- Proper cleaning of bearing component
- Checking bearing fitment dimensions
- Using proper tools for mounting
- Follow mounting sequence
- Post mounting checks
- Exact quantity of Lubricant must be filled in the bearing
- After assembly check correctness of bearing functioning

Tips for bearing maintenance to help ensure a longer life span.

Handle with care

Bearings are delicate enough to get damaged quickly. As such, it is very important that they are stored horizontally in a clean and dry environment with their packaging intact. Do not expose them to any airborne contaminants, as even a tiny speck of dirt can cause premature failure. Never hammer or pound them, or apply a direct force on it or its outer ring, which can cause damage to the rolling elements, resulting in misalignment. The most important thing to remember is to never remove bearings from their packaging until ready for use.

Absolute cleanliness is essential when handling bearings. They should not be removed from their wrappings until required for fitting. All tools, shaft, housings and other components must be perfectly clean. If fitting operations are delayed or interrupted the assembly should be wrapped with grease proof paper to exclude dirt and dust.

Check the bearing housing and shaft

Whenever a bearing is used for mounting, it is crucial that the housing and shaft are inspected for any sort of physical condition or damage. Always use a soft cloth to wipe the surfaces clean and make sure any nicks and burrs are removed.

Mount the bearings correctly

The method used to mount the bearings depends on the type of bearing. For example, bearings with cylindrical bores are generally mounted through a press fit method. Bearings with tapered bores can be mounted directly on tapered or cylindrical shafts with the use of tapered sleeves. The fits of the rings with shaft and housing on bearing seating are very important Therefore ensure that the shaft and housing seating are of correct size and of good shape.

All shoulders must be smooth and square with the axis of rotation. drive one ring on its seating by blows on the other. Such blows would irretrievably damage the balls or rollers and raceways.

Where the ring of a bearing is against an abutment, make sure it is tight fit. For heavy interference fits, inner rings may be shrunk on to the seating after heating in clean mineral oil at a temperature of approximately 100°C. Be sure that the bearing is in contact with the abutment shoulder after it has cooled.

Avoid preheating or overheating

The maximum heating allowed on the bearings depends on the heat treatment of the material. If they are heated above the permitted limit, they can permanently deform or soften the bearing steel, lowering load carrying capacity and resulting in a failure. Always heat the bearings using induction heaters, and never with an open flame.

Always use the proper tools

Specialized tools like bearing pullers, bearing fitting tool kits, oil injector kits, hydraulic nuts, or induction heaters should be used in the mounting and dismounting processes. These tools ensure the smooth process of mounting or dismounting, in order to minimize the risk of damage. Apply pressure evenly around the rings. "A press is better than a hammer."

Should a hammer be used ,mild steel or brass tube of suitable size, faced up square, should be interposed between it and the bearing. This will distribute the force of the blows (or rather taps), which should be given progressively around the ring.

When the parts are separable, roller bearings are brought together, the inner ring, the outer ring and the rollers must all be square with the other. If not square, then the rollers would not slide freely, and force would have to be used to bring the parts together. Such force would result in the rollers and raceways becoming scored and this, in addition to causing noisy running could cause early failure of the bearing.

Avoid corrosion

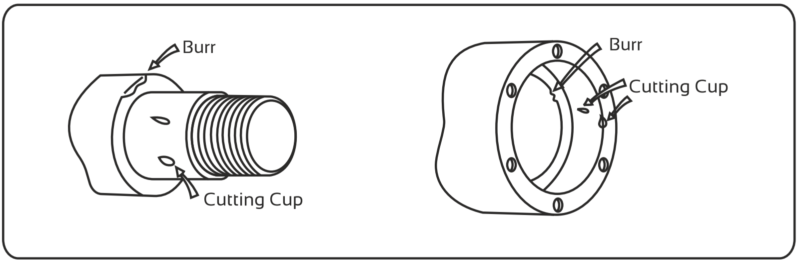
It is crucial that you should not expose bearings to the presence of water for a long time, as it will lead to rust and corrosion. It will also cause the premature failure of the bearings, which can affect the machine performance and productivity. As a result, it will increase your operating costs. Also, make sure to wear gloves when handling bearings. Perspiration can also lead to rust and corrosion.

Proper lubrication

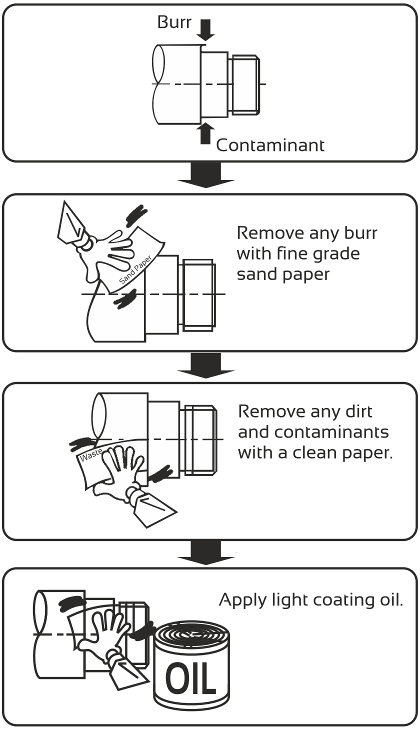
If you want to have a prolonged life of your bearings, it is crucial that they should be properly lubricated. The correct lubricant depends on the environmental conditions, temperature, speed and load. In this case, it is advisable that you should follow your manufacturer's recommendations.

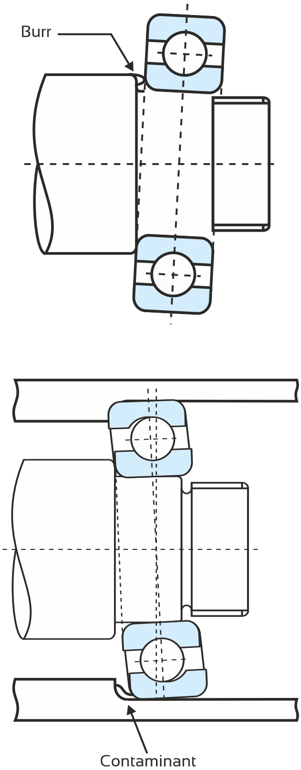
11.2 Preparations Before Mounting

- Do not remove the bearings from their packaging until just before use.
- The bearings are covered with anti-corrosion oil. The oil should not be wiped out from bearing surfaces until bearing is not used. At the time of mounting wipe out oil from bearing outer surface and bore only. Sealed /shield bearings must never be washed before mounting.
- Clean shaft and housing. Any burrs, cutting chips, rust or dirt should be removed from the bearing mounting surfaces by using fine grade sand papers/ file. Installation can then be simplified if the clean surfaces are lubricated with spindle oil. Ensure that lubricating holes and threaded holes are clean.

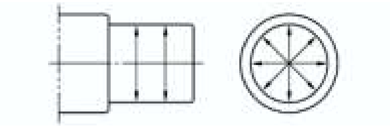


9.1.2 Preparation Procedure

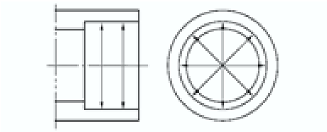




- Check dimensions, shoulder and finishing of shaft and the housing as per the drawing.The shaft diameter and housing bore diameter should be measured at the several points. Tapered shaft must be checked with ring gauge and sine bar. The diameter of straight shaft and housing is usually checked with micrometer and internal gaiuge. Check the size at two different positions and at four locations

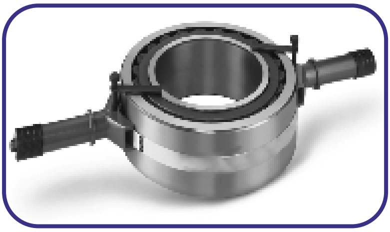


Shaft



Housing

- Check dimensions, shoulder and finishing of shaft and the housing as per the drawing.The shaft diameter and housing bore



11.3 Mounting

Bearing mounting depends upon the type of bearing, application, size of bearing. Avoid direct hammer blows on the bearings while mounting. Make sure that cage and seals are not hit directly. Mounting can be done in the following ways.

- **Mechanical Mounting**
  - Hammer & mounting sleeve
  - Fitting tools/ Spanner
  - Press
- **Temperature mounting (hot & cold)**
  - Induction heating
  - Oil bath heating
  - Using dry ice or liquid nitrogen
- **Other mounting methods**
  - Oil injection
  - Hydraulic push up

11.3.1 Mechanical method

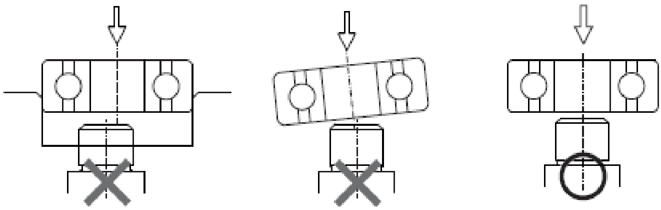
The method used to mount the bearings depends on the type of bearing. The bearings are with cylindrical bore and tapered bore.

- Non-separable bearing, the component which is tight fit is mounted first in housing or shaft.

- Separable bearing, inner can be mounted independently of outer. During assembly, care must be taken to align the shaft properly with housing.

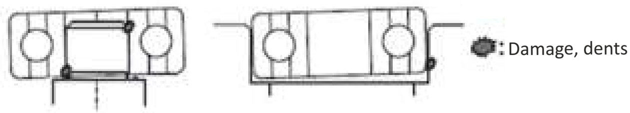
Alignment

Ensure proper alignment of shaft or housing with the inner or outer. If either of the component is misaligned, it will get stuck.



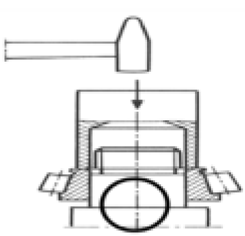
Off center　　　Tilted　　　Good

Misalignment Due to Contamination and Damage

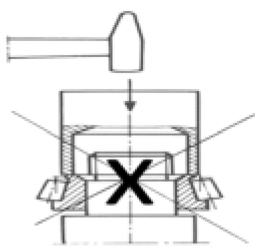


Inner mounting on shaft

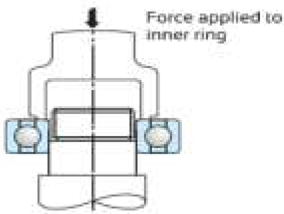
While pressing on the shaft apply force on the inner ring face.



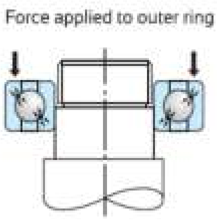
Correct method
As fitting tool face is
Resting on the bearing face



Not ok as fitting tool
is touching the cage



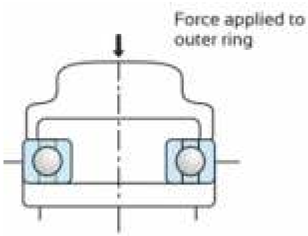
Right Method



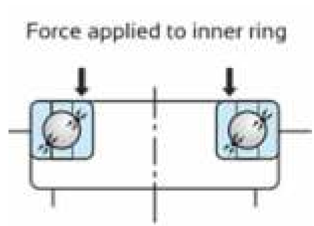
Wrong Method

Outer ring mounting in housing

During pressing in the housing apply force on the outer ring face.



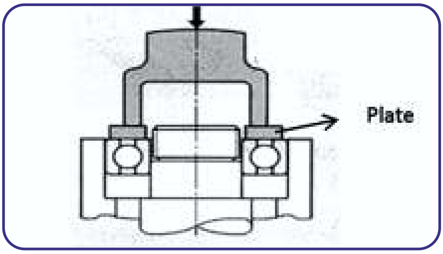
Loads on outer ring
(Right Method)



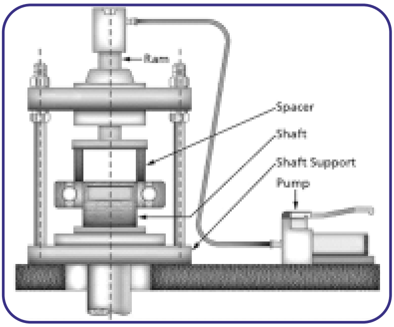
Loads on inner ring
(Wrong Method)

Mounting both housing and shaft together

When both inner and outer are mounted together, than force is applied by a fitting tool on the plate that is placed on the face of the bearing as shown.



Mounting by hydraulic press



11.3.2 Temperature Mounting

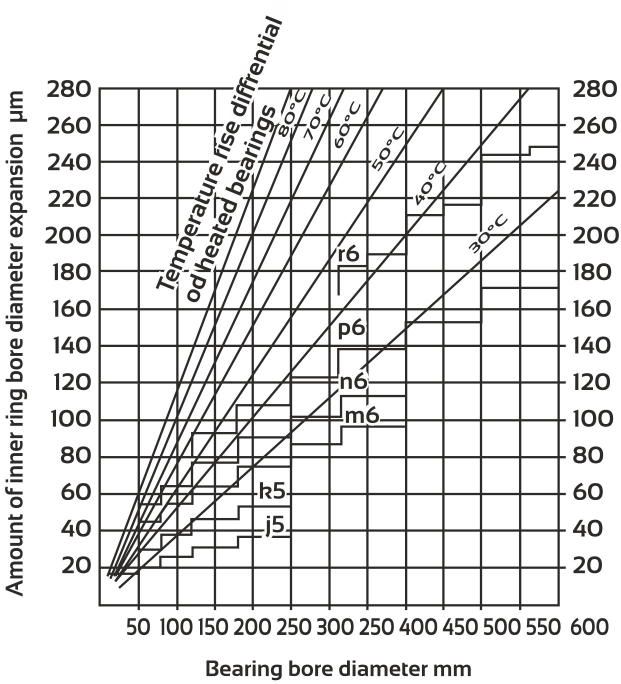
(Heat expansion of inner ring to ease installation)

Oil bath method

Commonly used for large bearings and bearings with a heavy interference fit.

1. Immersion of the bearing in heated oil is the most common method. Use clean oil and suspend the bearing in the oil with a wire or support it underneath using a metal screen in order to avoid uneven heating of bearing elements.

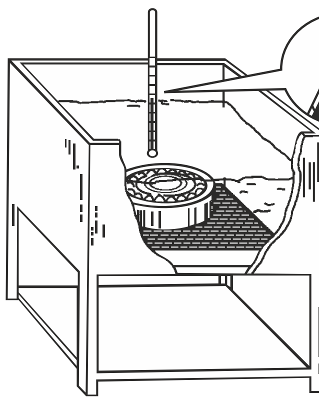
2. The temperature to which the inner ring should be heated depends upon the amount of interference fit i.e. the diameter of the interference fit surfaces. Refer to the following graph to determine the proper temperature.



3. To prevent gaps from occurring between the inner ring and shaft shoulder, bearings which have been heated and mounted on the shaft should be held in place until they have cooled completely.

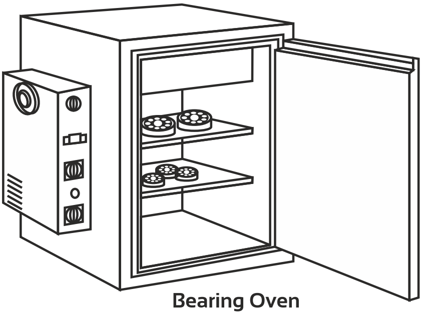
Precautions : Bearings should never be heated over 120°C.

For higher operating consult NBC. Temperature mounting cannot be used for pre- greased and sealed or shield bearings.



Bearing Oven

This method can also be used for heating pre-greased bearings. Bearings must not be heated above 80-85°C. The seals on the bearing must never touch the plate of oven. Always keep a ring between bearing and oven plate.



Bearing Oven

Induction Heating

This method can also be used for the inner rings of roller bearings. Bearings are dry and can be heated up in a short period of time. After using this method, administer a de-magnetizing treatment to the bearing.

11.4 Mounting Bearings on Tapered Bore

Tapered bore bearings are always mounted with interference fit and this will depend upon how far the bearing is driven on the tapered shaft. During mounting the radial clearance decreases. Hence it is important to check the clearance as the bearing is pushed up the shaft.

Bearings with tapered bores can be mounted directly on tapered or cylindrical shafts with the use of tapered sleeves. However, pressure should be applied only with a press fit because without it the raceways can be damaged.

In case of tapered sleeve and nut bearings, the clamping nut must not be over-tightened, for this could expand the inner ring and eliminate all clearance within the bearing, or even fracture the inner ring. We recommend that after the nut has been tightened by hand pressure, use a pin hammer. Give one or two light hammer blows to the handle of the spanner. This should tighten the nut just sufficiently.

If possible, check that the sleeve is still clamped firmly to the shaft after a few days of running. As an additional precaution we recommend that whenever the bearings are fitted, check the rotation of the shaft as it tends to tighten the nut on the sleeve. To assist customers who use torque spanners we recommend that the following torque be applied to the clamping nut for light series bearings.

Shaft Diameter	Torque on Nut
1” (25mm)	7.6 Kg.m
1.5” (38 mm)	12.4 Kg.m
2” (50mm)	17.25 Kg.m
3”(75mm)	30.3 Kg.m

For medium series bearing we recommend that the above values be increased by approximately 50 percent.

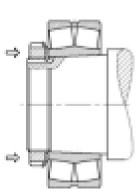
Mounting can be done in the following ways.

For shaft diameter up to 75 mm.

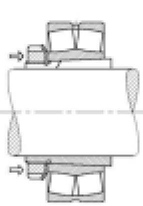
- By pushing the bearing directly on the shaft by a fitting tool or a lock nut.
- Using adaptor sleeve and sleeve locking nut.

  For shaft diameter more than 75 mm.

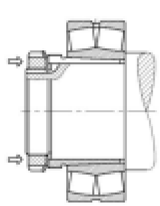
- Oil injection method. Shaft and sleeve with duct. Duct is used to feed oil under pressure to bearing seating. As the bearing expand radially, the sleeve is inserted axially with adjusting bolts.
- Hydraulic nut cum dial pressure gauge arrangement



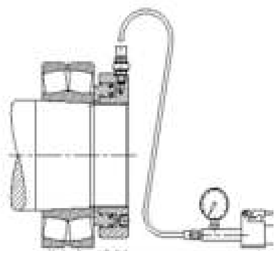
Mounting bearing Directly over shaft with lock nut Lock nut is clamped against the face of bearing



Bearing mounted on adaptor sleeve with adaptor sleeve lock nut



Bearing mounted on withdrawal sleeve with lock nut



Hydraulic nut & dial cum pressure gauge arrangement

11.5 Measuring of Radial Clearance Reduction for Bearings with Tapered Bore

While mounting large bearings on tapered shaft it is important to measure radial clearance otherwise due to reduction of clearance there is possibility of bearings getting jammed during mounting. Follow the steps :

1. Measure the initial clearance before mounting.
2. Rotate the bearing 4-5 times before measuring the clearance in mounted bearing
3. Measure the clearance between the rolling element and outer ring

(Note: measurement may be affected due to weight of bearing or if the shape of the outer gets deformed after mounting. Also if the feeler gauge positioning is not ok).

Feeler gauge

Checking clearance with feeler gauge

While Mounting spherical roller bearing on the tapered shaft, radial clearance must be checked and for Permissible residual clearance refer table below.

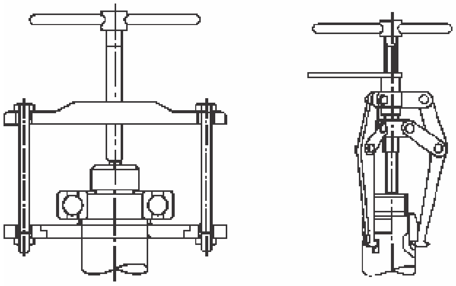
Table for permissible residual clearance

Bearing Bore Diameter d		Reduction in Radial Clearance		Push-in amount in axial direction				Minimum Permissible Residual Clearance	
				Taper 1:12		Taper 1:30			
over	incl	min.	max.	min.	max.	min.	max.	CN	C3
30	40	0.025	0.03	0.4	0.45	-	-	0.01	0.025
40	50	0.03	0.035	0.45	0.55	-	-	0.015	0.03
50	65	0.03	0.035	0.45	0.55	-	-	0.025	0.035
65	80	0.04	0.045	0.6	0.7	-	-	0.03	0.04
80	100	0.045	0.055	0.7	0.85	1.75	2.15	0.035	0.05
100	120	0.05	0.06	0.75	0.9	1.9	2.25	0.045	0.065
120	140	0.06	0.07	0.9	1.1	2.25	2.75	0.055	0.08
140	160	0.065	0.08	1	1.3	2.5	3.25	0.06	0.1
160	160	0.07	0.09	1.1	1.4	2.75	3.5	0.07	0.11
160	200	0.08	0.1	1.3	1.6	3.25	4	0.07	0.11
200	225	0.09	0.11	1.4	1.7	3.5	4.25	0.08	0.13
225	250	0.1	0.12	1.6	1.9	4	4.75	0.09	0.14
250	280	0.11	0.14	1.7	2.2	4.25	5.5	0.1	0.15
280	315	0.12	0.15	1.9	2.4	4.75	6	0.11	0.16
315	355	0.14	0.17	2.2	2.7	5.5	6.75	0.12	0.18
355	400	0.15	0.19	2.4	3	6	7.5	0.13	0.2
400	450	0.17	0.21	2.7	3.3	6.75	8.25	0.14	0.22
450	500	0.19	0.24	3	3.7	7.5	9.25	0.16	0.24
500	560	0.21	0.27	3.4	4.3	8.5	11	0.17	0.27
560	630	0.23	0.3	3.7	4.8	9.25	12	0.2	0.31
630	710	0.26	0.33	4.2	5.3	10.5	13	0.22	0.33
710	800	0.28	0.37	4.5	5.9	11.5	15	0.24	0.39
800	900	0.31	0.41	5	6.6	12.5	16.5	0.28	0.43
900	1000	0.34	0.46	5.5	7.4	14	18.5	0.31	0.74
1000	1120	0.37	0.5	5.9	8	15	20	0.36	0.53

11.6 Dismounting

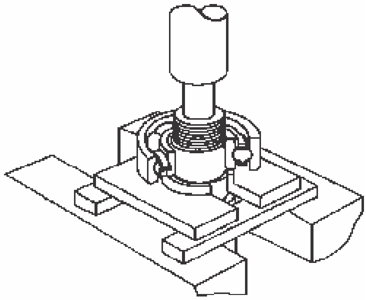
A bearing may be removed for periodic inspection. If the removed bearing is to be used again or it is removed only for inspection, it should be dismounted as carefully as when it was mounted. If the bearing has a tight fit, its removal may be difficult. The means for removal should be considered in the original design of the adjacent parts of the machine. When dismounting, the procedure and sequence of removal should first be studied using the machine drawing and considering the type of mounting fit in order to perform the operation properly. In case of non-separable bearing, the ring having loose fit must be withdrawn first. For separable bearing the rings can be dismounted independent of each other.

Small size bearings can be dismounted using press or mechanical puller. In case of large size bearings (bore>75 mm) it is recommended to use oil injection method and puller both.

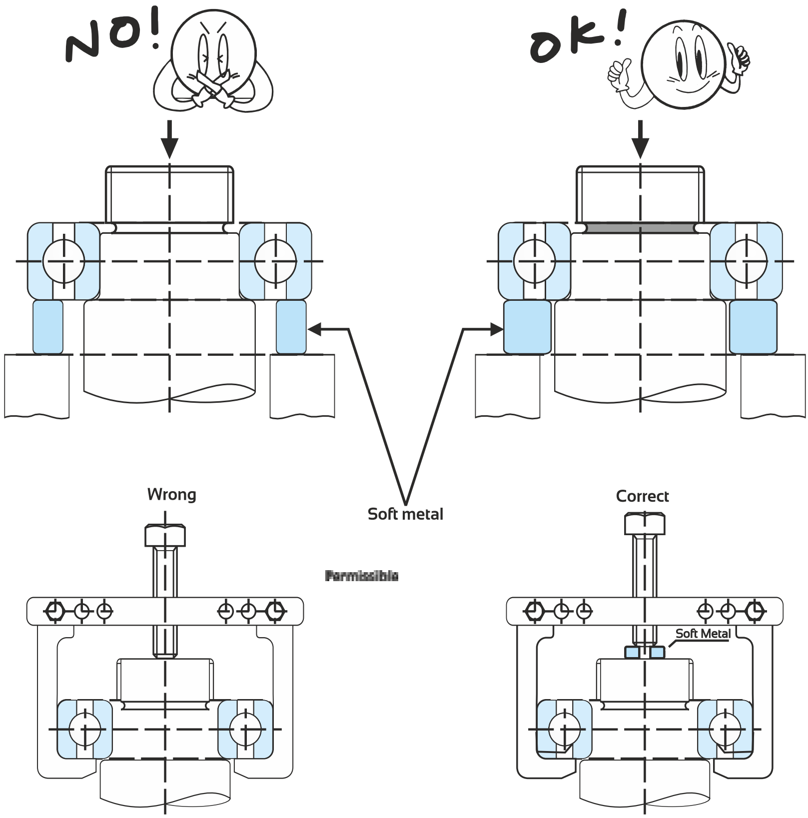


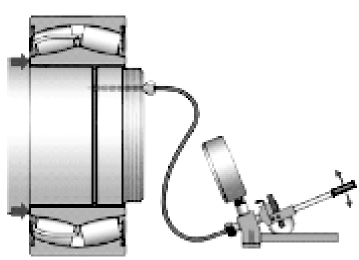
(a) (b)

Removal Using a Bearing puller



Removal Using a spacer





Removal by hydraulic pressure

11.7 Bearing Cleaning

It is seldom necessary to clean bearings with the sole object of removing the rust preventive oil, which they are coated before being packed. Rust preventives with a petroleum jelly base have certain lubrication qualities and in any case since the amount used for the protection of bearings is small, no harm is done with the grease or oil used for lubrication.

As a rule washing shall only be done when bearings have become dirty or when the mechanism in which they are used is so sensitive that even slight irregular resistance to rotation is not permissible. When bearings are inspected, the appearance of the bearings should first be recorded and the amount and condition of the lubricant should be checked. After the lubricant has been sampled for examination, the bearings should be cleaned. Cleaning media most commonly employed for used bearing are:

(a) Benzene

(b) White Spirit (Low flash point)

(c) Turpentine

(d) Paraffin Oil

(e) Light Spindle Oil

(f) Trichloro Ethylene

(g) Carbon Tetra Chloride

(h) Petroleum Ether

Method of cleaning

Rough cleaning

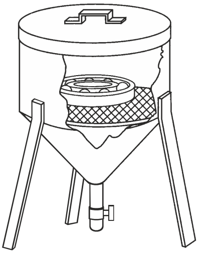
In Rough cleaning a separate container should be used and to support the bearing. A screen is provided in the container . All the cleaning media as mentioned above can be used for cleaning bearing, if bearing is very dirty, Gasoline should be used. Care should be taken to prevent igniting and to prevent rusting after cleaning.

In rough cleaning, each bearing is moved about vigorously without rotating it, since any trapped foreign matter can scratch the rolling elements & trace. If the oil is heated it cleans the bearing effectively. However, never heat the oil above 100°C. After as much as possible of the dirt has been removed this way, the bearing is transferred to the final cleaning.

Final cleaning

Now bearing is submerged in clean oil & rotated gently the inner ring or outer ring so that inside of the bearing will also be cleaned. After that, rotate the bearing faster until all trace of dirt has been removed. Now remove the bearing from bath and wipe it with a clean cloth, apply a coat of rust preventive oil to the bearing and wrap it is not going to be used immediately. It is necessary to always keep rinsing oil clean.

After any cleaning process it is necessary to protect the bearing by dipping it in hot petroleum jelly or oil, or by applying the grease to be used that it reaches every part of the surface. In the latter case rotation of bearings is necessary while grease is being applied.



Cleaning Apparatus

11.8 Inspection and Evaluation of Bearings

After being thoroughly cleaned, bearings should be examined for the condition of their raceways and external surfaces, the amount of cage wear, the increase in internal clearance, and degradation of tolerances. These should be carefully checked, in addition to examination for possible damage or other abnormalities, in order to determine the possibility for its reuse.

In the case of small non-separable ball bearings, hold the bearing horizontally in one hand, and then rotate the outer ring to confirm that it turns smoothly.

Separable bearings such as tapered roller bearings may be checked by individually examining their rolling elements and the outer ring raceway.

Large bearings cannot be rotated manually; however, the rolling elements, raceway surfaces, cages, and contact surface of the ribs should be carefully examined visually. The more important a bearing is, the more carefully it should be inspected.

The determination to reuse a bearing should be made only after considering the degree of bearing wear, the function of the machine, the importance of the bearings in the machine, operating conditions, and the time until the next inspection. However, if any of the following defects exist, reuse is impossible and replacement is necessary.

(a) When there are cracks in the inner or outer rings, rolling elements, or cage.

(b) When there is flaking of the raceway or rolling elements.

(c) When there is significant smearing of the raceway surfaces, ribs, or rolling elements.

(d) When the cage is significantly worn or rivets are loose.

(e) When there is rust or scoring on the raceway surfaces or rolling elements.

(f) When there are any significant impact or brinell traces on the raceway surfaces or rolling elements.

(g) When there is significant evidence of creep on the bore or the periphery of the outer ring.

(h) When discoloration by heat is evident.

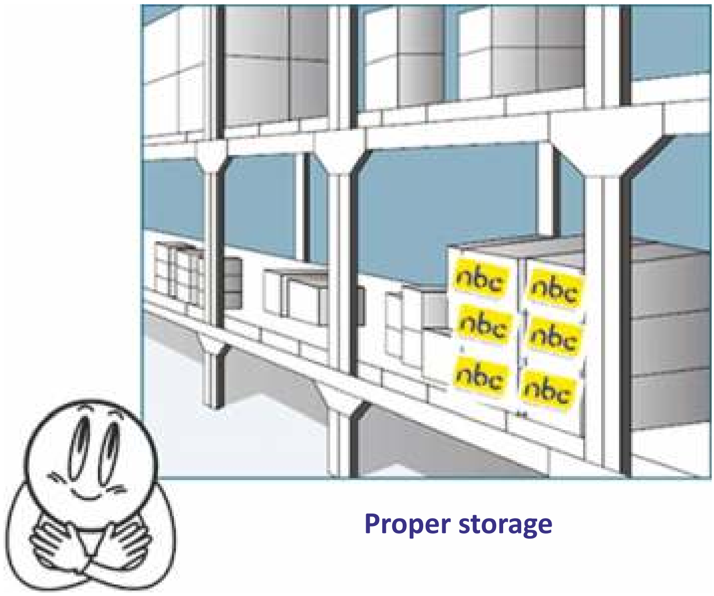
(i) When significant damage to the seals or shields of grease sealed bearings has occurred

11.9 Bearing Handling & Storage

11.9.1 Storage

Importance of proper bearing storage

- Store the bearings in their original packing to avoid any contamination or corrosion
- Place large and heavier bearings on a flat surface with complete support at the bottom.
- Never store the bearings in upright position
- Store bearings in cool and dry rooms away from direct sunlight
- Avoid contact with aggressive media like chemicals, gases, acidic fumes etc. during storage
- Open bearings (without seal or shield) can be stored up to five years. Sealed and Shielded (Greased) bearings needs regular attention



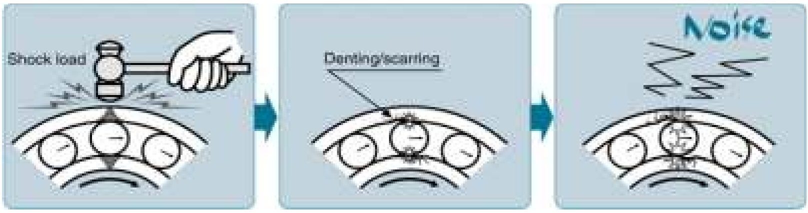
Proper storage

11.9.2 Bearing Handling

Bearings carry their loads along an extremely narrow contact surface between the rolling elements and the inner and outer raceway surfaces.

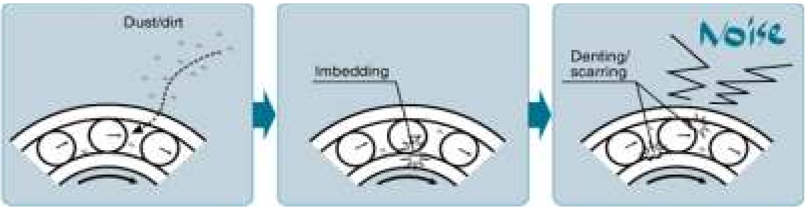
If an excessive load or impact is applied to this narrow area of contact, brinelling and/or scarring will occur. This damage leads to objectionable noise and vibration levels and rough bearing rotation. (Even dropping bearings on the floor will cause this type of damage.)

Bearings are very susceptible to impacts and shock loads!



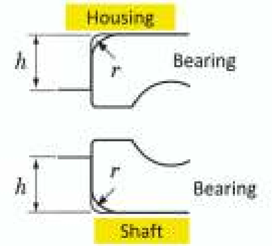
Bearings are very susceptible to foreign particle contamination!

If foreign particles infiltrate the bearing during rotation, denting and/or scarring will occur and this will lead to poor bearing rotation and excess noise.



11.10 Abutments for Bearings

1. Shaft and housing abutments for a ball or roller bearing must be flat and square with the axis of rotation.
2. An abutment must be deep enough to clear the unground corner radius of a bearing ring and contact its ground face.
3. The radius at the root of an abutment must be smaller than the corner radius of the ring located against that abutment, alternatively the root may be undercut.
4. The edge of an abutment must be reduced or chamfered, as a burred edge can so easily dent or distort a bearing ring.



The fillet radius (r) of shaft / housing, should be smaller than the chamfer dimensions of the bearing.

Ball Bearings, Angular Contact and Duplex Bearings

When a bearing carries heavy axial load, abutments must be deeper i.e. it should not extend beyond the inner ring outside diameter or below the outer ring bore. A deep abutment can cause difficulties when a bearing is removed from its seating and, therefore, it is advantageous to provide grooves or holes on such an abutment so that a suitable extraction tool can be used.

Roller Bearings

Bearings not carrying axial loads

The maximum abutment depth is more important for these bearings than for ball bearings. The maximum inner abutment diameter and minimum outer ring abutment diameter are recommended accordingly. Broadly these coincide with the diameter of the inner and outer ring raceways respectively.

Bearings carrying axial load

Abutments for these bearings should extend beyond the raceways to avoid shear stresses in the lips. Every possible care is necessary to ensure that the abutments are flat and square with the axis of rotation.

Thrust Bearings

Abutments for Thrust bearings should extend beyond the pitch circle diameter of the balls to prevent the washers moving under load.

For standard Thrust bearings with one small bore washer and one large bore washer, the approximate pitch circle diameter

$$= \frac{\text{Small bore diameter} + \text{Large outside diameter}}{2}$$

In case of bearings with two bore washers, use the pitch circle diameter for the same basic bearing size with one large bore washer and one small bore washer.

12.0 Bearing Failure

12.1 Bearing Failure

Rolling bearing consists of Inner ring, outer ring, rolling elements and cage/retainer to hold the rolling elements (ball/roller) at their respective position. Application of rolling bearing can be seen almost everywhere e.g. aerospace, railways, automotive and industrial segment.

In general, if rolling bearings are used properly they will continue to run till their predicted fatigue life. In the rolling bearing, failure can happen due to a number of reasons. Most common are:

- Fatigue failure
- Lubrication problem
- Contamination

But the type of failure varies depending upon the industry and application.

Proper investigation of the root cause of a bearing failure is necessary to make suitable recommendations for eliminating the cause of failure. However, sometimes it becomes difficult or even impossible to ascertain the exact root cause of a bearing failure when bearing subjected to advance stage or catastrophic mode failure. In such cases, finding out primary cause may become a tricky task as the evidence is likely to be lost. If all the variables and conditions are known at the time of failure occurrence or prior to the time of failure including the application and operating conditions then, by understanding the traces of failure and defining its probable causes, the possibility of similar type of failure in the future can be avoided. Moreover, two or more failure patterns can occur simultaneously and reduce the bearing life exponentially. Proper examination of contact traces, seating of bearing and running path pattern on the raceways for given application can help us in conducting proper root cause analysis of a bearing failure. Failure in bearing can take place due to human error and fatigue failure.

In contrast to fatigue life, bearings premature failure due to human error include:

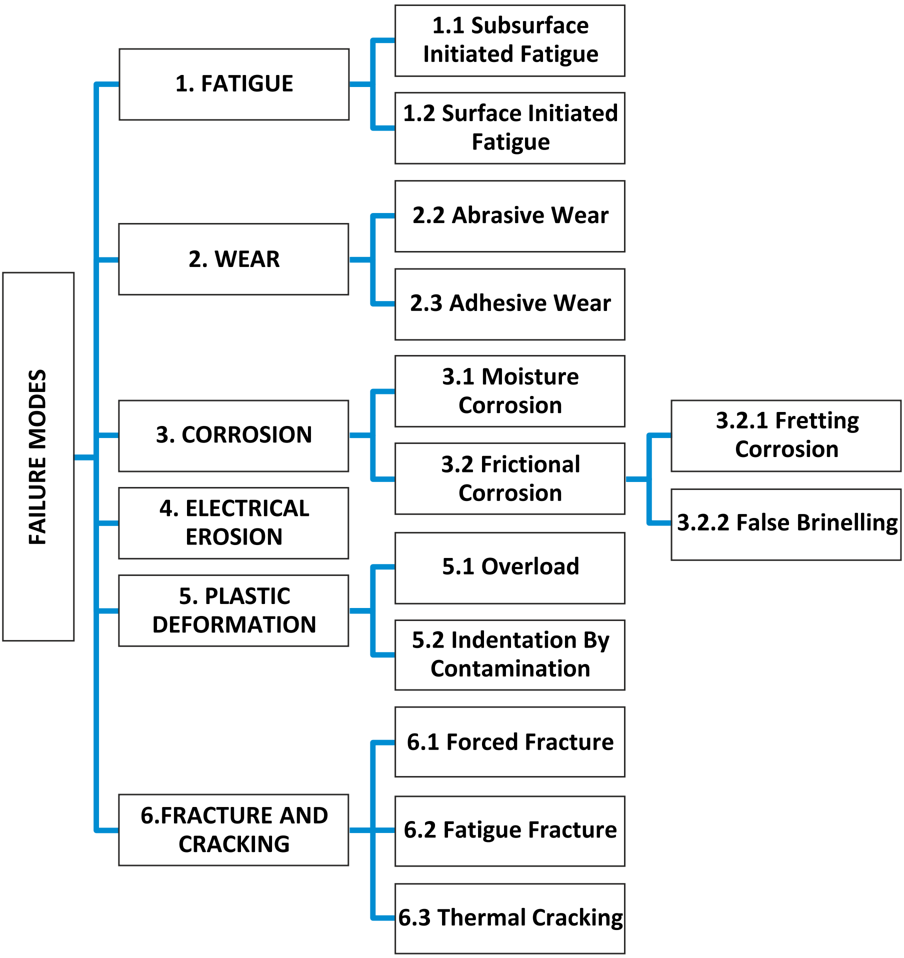
1. Improper mounting/handling practice
2. Wrong bearing selection
3. Inappropriate operating condition
4. Insufficient lubrication
5. Solid or liquid contamination
6. Wrong lubrication selection
7. Material fault/inclusion
8. Deviation/abnormality in manufacturing process

12.2 Classification of Failure Modes in Rolling Bearing

While performing bearing failure analysis, it is first and foremost important to understand the basic classification of different types of failures modes and what causes them. Rolling bearing failures are classified strictly according to their primary causes which constitutes of wear, indentation, surface distress, corrosion and electric current damage. Each of the different causes of bearing failure produces its own characteristic damage. Such damages are known as primary damage which gives rise to secondary or advance mode of failure which constitutes of flaking, cracks and cage damage. This will result in scrapping of the bearing due to excessive internal clearance, noise, vibration etc. A failed bearing can frequently display a combination of primary & secondary damages. The classification of bearing failure is based on ISO 15243:2004. The failure modes are divided into 6 main modes and sub-modes based on the appearances and features that are visible on the bearing components surfaces.

(Note: Bearing manufacturers can classify bearing failures in their own way and use different terminology)

Failure modes classification as per ISO 15243:2004
(Rolling Bearing Damage and Failures)



1. Fatigue

Fatigue is visible as flaking of particles from the surface. During service bearing surface undergoes repetitive loading from rolling elements. Due to repteated stress there is change in the microstructure between the rolling elements and the raceways. This results into material removal from bearing components surface(s).This is called bearing fatigue failure or flaking.

Flaking occurs when small chips of bearing material gets tear off from the smooth surface of the raceway or rolling elements due to rolling fatigue, thereby creating regions having rough and coarse texture.Flaking may be caused at initial stage of bearing life by

- over-load during operation
- excessive load due to improper handling,
- poor shaft or housing accuracy,
- installation error,
- ingress of foreign objects
- rusting, etc.

If the flaking is noticed at its initial stage then it is possible to identify its cause and the appropriate action can be taken to prevent its recurrence. When flaking propogates further, it makes its presence known in the form of noise and vibrations which indicates it is time to change the bearing.

Fatiuge failures are:

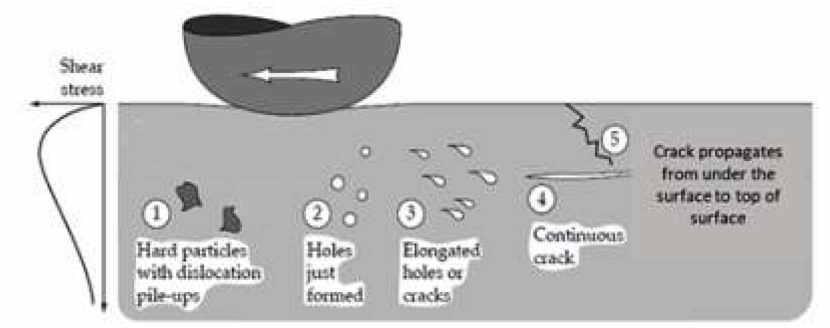
- Subsurface initiated
- Surface initiated

Subsurface Initiated fatigue

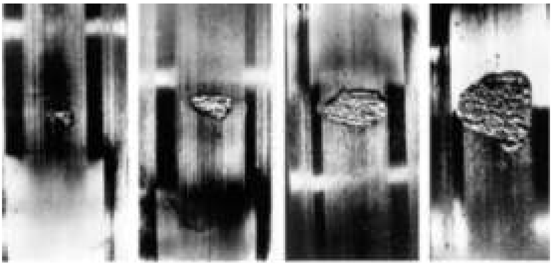
During operation, there are repeated cyclic stress in the rotating part and constant stresses in the stationary part. Under load zone the rolling elements are compressed due to maximum load and as they move out of load zone they expand due to minimum load.

Depending upon the operating condition (i.e load, operating clearance and temperature) and number of stress cycles over a period of time, there is a build-up of residual stresses that will cause micro cracks to be initiated at a certain depth under the surface i.e. subsurface. These cracks will propagate from under the component surface to top of the surface.

Illustration of a process of subsurface crack formation.



In another case, presence of higher nonmetallic inclusion in bearing material may lead to sub-surface initiated fatigue. During operation, beneath the bearing surface which undergoes repetitive loading condition these nonmetallic inclusion acts like stress riser and create micro cracks which finally may lead flaking. Initially fatigue is visible as flaking which propagates to spalling (pitting) and then peeling as shown in figure below- progression of subsurface fatigue.



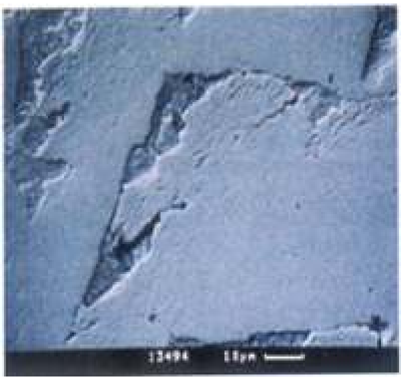
Stage 1 Stage 2 Stage 3 Stage 4

Surface Initiated fatigue

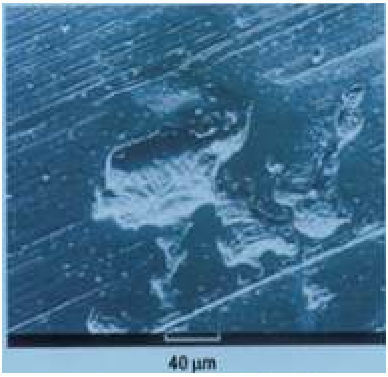
Fatigue initiated from the surface is mainly caused due to surface distress. Surface distress is the damage to the rolling contact surface roughness under the reduced lubrication or wrong lubricant selection.It may also occur when lubrication is contaminated with foreign particles due to poor sealing of bearing which may result into high stress concentration on bearing surfaces. This in turn will give metal to metal contact, together with a certain percentage of sliding motion causing the formation of

- Surface microcracks
- Surface microspalls

Micro-cracks can start in the asperties, followed by micro spalls, finally leading to micro flaking



Micro Cracks



Micro Spalling

Causes	Countermeasures
• Insufficient lubrication • Inadequate lubrication • Contamination • Improper mounting	• Lubricant quantity and filling method should be proper to avoid metal to metal contact • Lubricant properties should satisfy bearing operating conditions ex. EP additive grease can be used in extreme pressure conditions. • Lubricant should be free from any dust or contamination • Follow standard mounting practices.

Localized flaking on the Inner ring of DRAC due to improper lubrication.

Localized flaking on the bearing raceway corresponding to rolling element pitch, due to faulty assembly of the bearing (misalignment or less clearance) in application.

Localized flaking on cup of taper roller bearing caused due to impact loading	
Flaking in the load zone on the outer ring of taper roller bearing caused by excessive loading	
Axially displaced flaking pattern of uniform width and in opposite direction of Inner & outer raceway due to high axial load in application.	

2. Wear

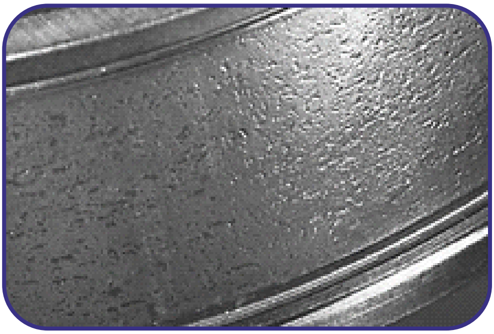
Wear is the progressive removal of the material resulting from interaction of the asperities of two sliding or rolling/sliding contacting surfaces during application. There are two basic mechanism of wear in rolling element bearings:

- Abrasive wear
- Adhesive wear.

2.1 Abrasive wear (particle wear; three body wear)

Abrasive wear is the result of inadequate lubrication or fine foreign particles entry in the bearing.

Sand, fine metal particles from grinding/machining and fine metal/carbides from gears will wear or lap the rolling elements and races. The surfaces become dull to a degree, which varies according to the coarseness and nature of the abrasive particles. These particles increase in numbers as the material is worn away from the running surfaces and the cage. Finally, wear progresses with time which ultimately results in flaking and thus failure of the bearing.

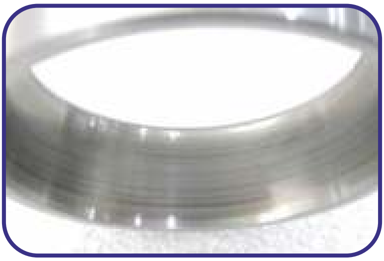


Abrasive wear on the inner ring raceways of a double-row cylindrical roller bearing with central rib

In tapered bearings, the roller head surface and cone flange/rib face will have more wear comparatively to the raceways due to both sliding and rolling contact at flange surface. This wear will result in increased end play or internal clearance which will result in misalignment in the bearing and thus reduces fatigue life. Abrasive wear can also affect other parts of the machine where bearings are used.

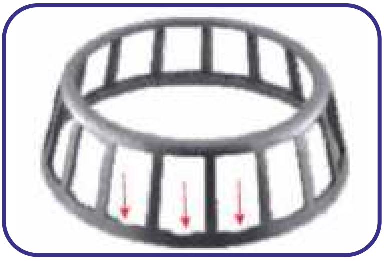
Excessive wear of rollers head either due to excessive preloading or heavy contamination

Causes	Countermeasures
• Sealing ineffective • Contaminated lubricant due to worn out particles from bearing/adjacent components. • Improper cleaning before and during mounting operation.	• Check/ improve the sealing effectiveness. • Always use fresh/clean lubricant. Change oil at specified intervals of mileage covered. • Unpack the bearing at the time of mounting only. Use clean tools and keep the area cleaned where bearing is mounted.



Grooving on cup raceway and rollers outer diameter surface of Taper roller bearing due to fine size hard contaminants

Excessive wear of cage pocket as a result of flaking on single ball



Heavy wear on retainer pockets of taper roller bearing due to over rolling of hard contaminants between rollers head surface and retainer pockets

Wear caused by inadequate lubricant

Causes	Countermeasures
• Lubricant has gradually been used up /lost its .	• Check that the lubricant reaches the bearing/ frequent lubrication.

Inner ring of taper roller bearing plastically deformed and discolored due to lack of lubrication or loss of lubricating properties in high temperature application

2.2 Adhesive wear (smearing, skidding, galling)

Adhesive wear is a transfer of material from one surface to another with frictional heating and sometimes, tempering or re-hardening of the surface. This produces localized stress concentrations with the potential for cracking or flaking of the contact areas.

Smearing (skidding) - Occurrence of surface roughness due to inadequate lubrication between the surfaces which results in sliding/slipping of rolling elements and transfer of material between

Creep- When there is a small clearance between the bearing ring and its seating surface the rolling motion of the ring against its seating with a minute difference in the rotational speeds is termed as Creep.

When creep occurs, the asperities in the ring /seating surface contact region are over rolled, which can cause the surface of the ring to take a shiny appearance.

Mirror like/shiny appearance on bore & OD surface due to creeping caused by micro-motion

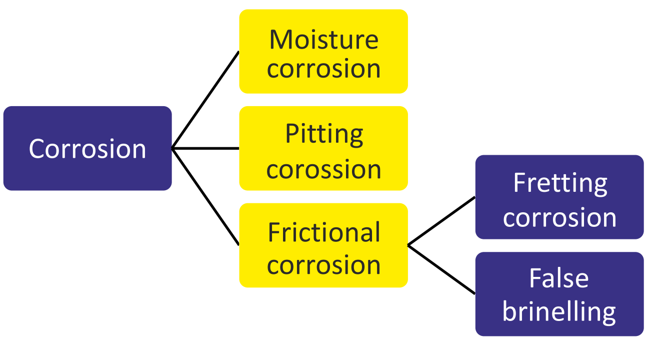
Seizing marks on Inner & outer ring - Rotary motion between rings and shaft/housing with loose fits under circumferential /static load or insufficient axial support of rings can cause cold welding at the fitting surfaces (inner ring bore, outer ring outside diameter) and axial mating surfaces or shiny appearance of contact areas where surface roughness is good. Wear of fitting surface and face perhaps causes reduction in preload or clearance enlargement.

Seizing marks on inner ring bore surface due to loose fits

3. Corrosion

It is the gradual destruction of materials (usually metals) by chemical and/or electrochemical reaction with their environment.

In case bearing is handled or stored improperly which resulted into removal of rust preventive oil film or when water enter through defective or inadequate seals or sometimes from condensation under certain conditions, black oxide commonly called "water etch" will form at respective rolling positions.



3.1 Moisture corrosion (oxidation, rust)

When steel, used for rolling bearing components comes in contact with moisture e.g. water or acid, oxidation of surfaces takes place. Subsequently the formation of corrosion pits occurs & finally leads to flaking of the surface and could initiate cracking. It is most often caused by condensate collecting in the bearing housing due to temperature changes. Rust will form if water or corrosive agents reach the inside of the bearing.

Causes	Countermeasures
• Improper lubricant used • Damaged, worn or inadequate sealing can lead to entry of water, moisture or corrosive substance in the bearing • High temperature & high humidity environment while stationary • Poor packaging or storing conditions • Bearing handling with bare hands	• Study of lubrication suitability as per the application • Improve sealing mechanism • Anti-rust treatment for periods of non-running • Follow best practices for storage and handling • Improve handling methods i.e. usage of gloves

Moisture corrosion on Inner race bore of Taper Roller Bearing

Moisture corrosion on outer ring of Spherical Roller Bearing

Contact corrosion on cone raceway of Taper Roller Bearing at roller pitch distance

3.2 Pitting Corrosion

Pitting corrosion is a localized form of corrosion by which cavities or "holes" are produced in the material. Pitting is considered to be more dangerous than uniform corrosion damage because it is more difficult to detect, predict and design against. Corrosion products often cover the pits.

- Factors influencing pitting: Cl- content, pH value, temperature, presence of oxidizing agent

Pitting corrosion on balls of deep groove ball bearing

3.3 Frictional Corrosion

Frictional corrosion is a chemical reaction caused by relative micro movements between mating surfaces under certain frictional conditions. These micro-movements lead to oxidation of the surface and the material becomes visible as powdery rust and/or loss of material from one or both mating surfaces.

3.3.1 Fretting Corrosion

Fretting corrosion occurs when there is relative movement between bearing ring and shaft or housing, on account of the fit being too loose. The relative movement may also cause small particles of material to become detach from the surface. These particles oxidize quickly when exposed to the oxygen in the atmosphere; powdery rust develops (iron oxide). The bearing surface becomes shinny or a discolored blackish red.

Causes	Countermeasures
• Vibrations with small amplitude • Insufficient interference • Poor lubrication • Form disturbance of fitting surfaces • Shaft deflection or housing deformation	• Maintain desired preload in the bearing • Improve fits • Use of proper lubricant/ lubricant film at fitting surfaces • Shaft or housing rigidness to bending

Fretting corrosion on cone bore of Taper Roller Bearing due to micro movement between cone and shaft

3.3.2 False Brinelling

When bearing is stationary, lubrication film between the rolling elements and the raceways is very thin; gives metal to metal contact and the vibration produce small relative movements of rolling elements and rings. As a result of these relative movements, small particles break away from the surfaces and thus would lead to the formation of depressions on the raceways with a combination of corrosion & wear depending on the intensity of the vibrations, the lubrication conditions and load.

In the case of stationary bearings, the depression appears at rolling pitch and can often be discolored reddish or shinny. For the case of bearings in running condition (while rotation) false brinelling caused by vibration are visible in the form of closely spaced flutes.

Causes	Countermeasures
• Oscillation or vibration while bearing is stationary e.g. while transportation • Oscillations with small amplitude • Poor lubrication	• Secure shaft & housing while transportation • Radially preload the bearing or provide a vibration damping base • Use oil or high consistency grease when bearings are used for oscillation motion • Use of proper lubricant

Brinelling mark on cup raceway due to vibrations

False brinelling marks along with roller dents near large face of Taper Roller Bearing due to vibrations

False brinelling and contact corrosion marks on cup raceway of Taper Roller Bearing due to water/moisture entry and vibrations

4. Electric Erosion

Electrical erosion is the removal of material from the contact surfaces caused by the passage of electric current. When electric current passes through a bearing, arcing and burning occur through the thin oil film at points of contact between the races and rolling elements. The material is heated to temperatures ranging from tempering to melting levels. This leads to the appearance of discolored areas, varying in size, where the material has been tempered, re-hardened or melted. Small craters also form where the metal has melted.

Craters formed by current leakage resulting in fluting

Fluting on inner ring raceway with dark colored balls

5. Plastic Deformation

Permanent deformation occurs whenever the yield strength of the material is exceeded. This can occur in two different ways:

- On a macro scale, where the contact load between a rolling element and the raceway causes yielding over a substantial portion of the contact footprint.
- On micro scale, where a foreign object is over-rolled between a rolling element and the raceway and yielding occurs only a small part of contact point.

5.1 True Brinelling

Overloading of a stationary bearing by static load or shock load leads to plastic deformation at the rolling element/raceway contacts. Overloading can occur by excessive preloading or due to incorrect handling during mounting.

Ball bearings are subjected to indentations if the pressure is applied to the wrong race such that it passes through the balls during the mounting or dismounting operations or if it is subjected to abnormal loading in stationary condition.

Causes	Countermeasures
• Excessive load/ mounting pressure • Shock during transport or due to improper mounting/careless handling • Mounting pressure applied to wrong race	• Improvement in mounting and handling practices. • Apply mounting pressure to the ring with interference fit.

True brinelling mark on inner race shoulder of Ball Bearing due to improper mounting/dismounting

5.2 Indentation

5.2.1 Indentation from foreign particles

When foreign particles get trapped and over-rolled between the rolling surfaces, indentations are formed on raceways and rolling elements. The size and shape of the indentation depends on the nature of the particles. It can be caused by –

i. Soft particles e.g. fibers or wood

ii. Hardened steel particles e.g. from gears or bearing itself.

iii. Hard mineral particles e.g. grinding wheels

Causes	Countermeasures
• Ingress of solid foreign particles into the bearing • Trapping of flaked particles	• Lubrication oil change at defined service interval • Improve sealing • Cleanliness to be maintained while bearing mounting operation • Check for the involved & other bearings/components for flaking/damage

Wear and indentation on cup raceway soft foreign particle contamination

Wear and indentation on inner ring raceway of Cylindrical Roller Bearing due to soft foreign particle contamination

Wear and indentation on inner ring raceway of Double Row Spherical Roller Bearing due to soft foreign particle contamination

6. Fracture

Crack initiates and propagates when the ultimate tensile strength of the material is locally exceeded. Fracture is the result of a crack propagating to the point of complete separation of the component.

6.1 Forced fracture

Forced fracture is due to stress concentration in excess of the material tensile strength and is caused by local over-stressing, e.g. from impact, or by over-stressing due to an excessive interference fit.

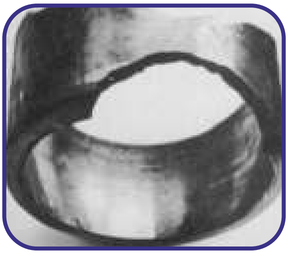

Forced fracture of Outer ring caused by a direct impact blow

Forced fracture due to excessive interference fit

6.2 Fatigue fracture

Frequent exceeding of the fatigue strength limit under bending, tension or torsion conditions results in fatigue cracking. A crack is initiated at a stress raiser and propagates in steps over a part of the component cross section, ultimately resulting in a forced fracture.

Fatigue fracture is sometimes caused by insufficient support of the bearing ring in the housing or on the shaft



Fatigue fracture of Outer ring caused by insufficient support in the housing

Fatigue fracture of an outer ring from snap ring groove in Double Row Angular Contact Ball Bearing caused by axial loading

6.3 Thermal cracking (heat cracking)

Thermal cracking is caused by high frictional heating due to sliding motion. Crack usually propagates at right angle to the direction of sliding. Hardened steel components are sensitive to thermal cracking due to re-hardening of the surfaces in combination with the development of high residual tensile stress.

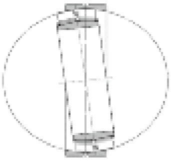
Thermal cracking on cone bore of taper roller bearing

Spherical Roller Bearing

Spherical Roller Bearing Configuration

When the operating conditions demand housing and shaft alignment the right choice is Spherical roller bearing. NEI manufacturers wide range of spherical roller bearings in steel and brass with variety of variants to meet customer requirements. These bearings can withstand high loads and compensate for misalignments and deflections. NBC Spherical roller bearings are designed for various industrial applications subjected to impact, vibrations and heavy loads. Bearings are designed based on specific application with optimized internal geometry for various equipment in different applications to withstand toughest requirement of heavy duty machines and harsh environment.

Spherical roller bearing inner consists of two rows with symmetrical rollers and outer. The inner raceways are separated by a rib. The outer has a spherical raceway. These bearings have a large capacity for radial loads and axial loads in either directions. In addition to straight bore, tapered bore are also available. The standard taper ratio of 1:12 have 'K 'suffix. With a taper ratio of 1:30 the suffix is 'K30'. The spherical roller bearing have a self-aligning property and therefore is suited for use where misalignment occurs between housing and shaft.



Steel press cage and machined brass cages are widely used in Spherical roller bearings. The bearings with steel cage has 'CC' suffix and with brass cage 'MB' suffix.

Brass cage (MB)

Steel cage (CC)

Type of configuration

CA - Bearing with symmetrical rollers and retaining ribs. The cage is a one-piece, double pronged machined cage of brass

CC - Bearing with symmetrical rollers, flangeless inner ring, a non-integral guide ring between the two rows of rollers and two pressed steel window-type cage

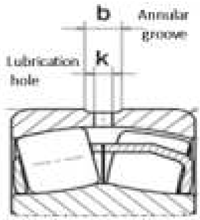
MB - Bearing with two machined brass cage

For vibratory screens special designed bearings with superior class & clearance with coated bore (VSC) and without coating in bore (VS) variants.

Bearings with tapered bore are specified by attaching the suffix “K” to the end of the bearing’s basic number. The standard taper ratio is 1:12. For bearings in series 240 and 241 the suffix “K30” indicates the taper ratio for bearings is 1:30. Most tapered bore bearings incorporate the use of adapters and withdrawal sleeves for shaft mounting.

K- Tapered bearing bore, taper 1:12

K30 - Tapered bearing bore, taper 1:30



W33 – Outer ring with annular groove(b) & lubrication hole (k)

W20 – Outer ring with lubrication hole (k)

Oil inlets and oil groove dimensions

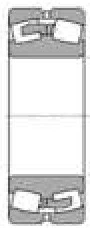
Spherical roller bearings with an outer diameter of 320mm or more are provided with an oil inlet and oil groove on the outer ring for the purpose of supplying lubricant to the bearing’s moving parts. When necessary, oil inlets and oil grooves can also be provided on bearings with outer diameters less than 320 mm.

W33-Bearing with annular groove and three lubrication holes in the outer ring

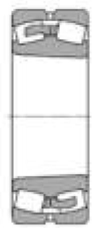
W33X-Bearing with annular groove and six lubrication holes in the outer ring

W20 - Three lubrication holes in outer ring

(Note: Number of lubrication holes can be increased based on bearing size and application requirement.)



Cylindrical bore



Tapered bore

The lubricator is fitted in the hole. Lubricant flows outwards from the center of the bearing outer between the rollers and raceways flushing the bearing.

Adapters and withdrawal sleeves

Adapter are used for installation of bearings with tapered bore on cylindrical shafts. Withdrawal sleeves are also used to install and disassemble bearings with tapered bore from cylindrical shafts. In disassembling the bearing from the shaft, the nut is pressed down against the edge of the inner ring utilizing the bolt provided on the withdrawal sleeve, and then the sleeve is drawn away from the bearing's inner diameter surface. As shown in diagram, it is designed to reduce friction by injecting high pressure oil between the surfaces of the adapter sleeve and bearing inner bore by means of a pressure fitting.

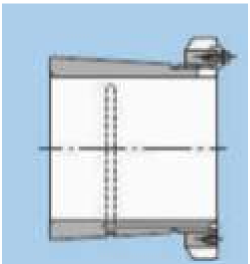
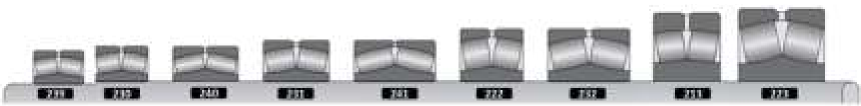


Diagram 2

Based on the application, different variants are selected. NBC spherical roller bearings are manufactured with various designs:

• Bearing with two brass cage	
• Bearing with single brass cage	
• Bearing with steel cage	
• Bearing with polyamide cage	

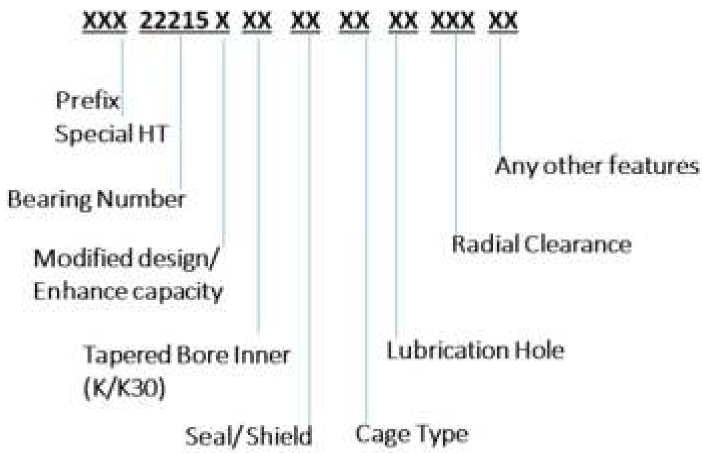
Bearing Designation & Nomenclature for Spherical Roller Bearings



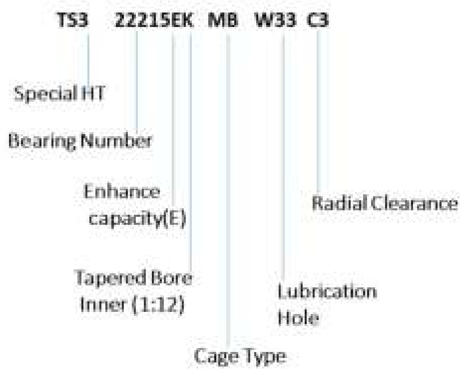
Bearing basic number & Dimension series code

Series code	Width series	Dia. Series
239	3	9
230	3	0
240	4	0
231	3	1
241	4	1
222	2	2
232	3	2
213	1	3
223	2	3

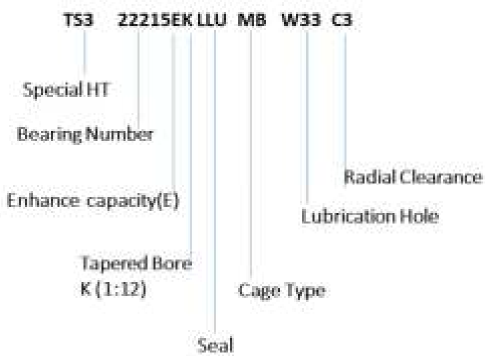
Nomenclature



Nomenclature – Plain bearing



Nomenclature – Sealed bearing



Code	Interpretation (Prefixes)
4T	case carburized bearing (Inner ring, outer ring & roller)
TS1	Bearing with special heat treatment for operating temp. uo to 130°C
TS2	Bearing with special heat treatment for operating temp. up to 160°C
TS3	Bearing with special heat treatment for operating temp. up to 200°C
TS4	Bearing with special heat treatment for operating temp. up to 250°C
TM	Long life special heat-treated bearing (one ring)
TMB	Long life special heat-treated bearing (both the rings)
AST	Bearing with one of the components treated in carbo- nitriding (rollers are with normal heat treatment)
ASTB	Bearing with both the components treated in carbo- nitriding (rollers are with normal heat treatment)

Prefixes /Suffixes

Suffixes for design modification code

Code	Interpretation (Suffixes)
E	Optimized internal geometry for increased load rating
M	Modified design (ball bearing, tapered roller bearing)
X(n)	Special feature (Inner ring or outer ring) e.g. X1, X2
CA	one-piece machined brass cage (double pronged)
CC	Two steel cage
MB	Two brass cage with integrated rib
K	Tapered bore, 1:12 taper on dia.
K30	Tapered bore, 1:30 taper on dia.
W33	Bearing with annular groove and three lubrication holes in the outer ring
W20	Bearing with lubrication holes only in the outer ring
W33Y	Bearing with annular groove and four lubrication holes in the outer ring
W33X	Bearing with annular groove and six lubrication holes in the outer ring

Seal/Shield type code

ZZ	Non - contact shield on both side
LLU-	Synthetic rubber seal, contact type, double lip , on both side
LLV	Low friction synthetic rubber seal , contact type, triple lip , on both side
LLUA1	Fluorine rubber seal, LU type, on both side, for high temperature up to 200° C
LLUA2	Silicone rubber seal, LU type, on both side, for extreme temp. -100 to +200°C

Bearings are also available with single side seal

Suffix for cage Suffixes:

C	Pressed steel cage
T2X-	Polyamide cage
TF	Pressed steel cage with Nitride Treatment
M	Machined brass cage

Suffixes: Internal clearance code

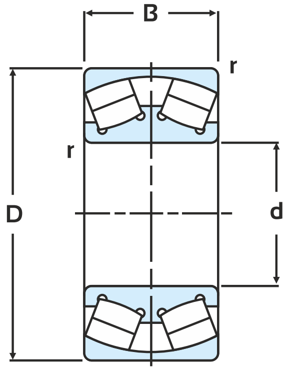
C2-	Clearance less than Normal
CN-	Normal clearance
C3-	Clearance greater than normal
C4-	Clearance greater than C3
C5-	Clearance greater than C4

Suffixes: Tolerance class code

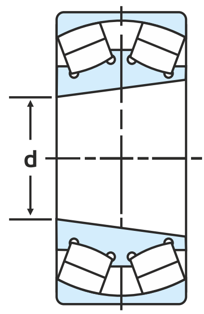
P0-	Normal Tolerance class (Class 0, 6X) specified by IS/ISO/JIS
P6-	Tolerance class 6 specified by IS/ISO/JIS
P5-	Tolerance class 5 specified by IS/ISO/JIS
P4-	Tolerance class 4 specified by IS/ISO/JIS
P2-	Tolerance class 2 specified by IS/ISO/JIS

Note: For any Suffix/Prefix not found in the table, please contact NEI Engineering

Spherical Roller Bearing



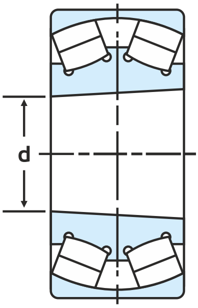
Cylindrical bore



Tapered bore (K)
(1:12)

Boundary Dimensions				Basic Load Rating				Fatigue load limit
				Dynamic	Static	Dynamic	Static	
mm				KN		Kgf		KN
d	D	B	r	Cr	Cor	Cr	Cor	Cu
25	52	18	1	42.1	43.5	4293	4436	5.3
25	52	18	1	42.1	43.5	4293	4436	5.3
25	52	18	1	39.0	43.5	4293	4436	5.3
25	52	18	1	39.0	43.5	4293	4436	5.3
30	62	20	1	51.7	55	5272	5608	6.7
30	62	20	1	51.7	55	5272	5608	6.7
30	62	20	1	52.0	55	5302	5608	6.7
30	62	20	1	52.0	55	5302	5608	6.7
35	72	23	1.1	68.0	77	6934	7852	9.4
35	72	23	1.1	69.8	73.9	7118	7536	9.0
35	72	23	1.1	69.8	73.9	7118	7536	9.0
35	72	23	1.1	70.4	78.7	7179	8025	9.6
35	72	23	1.1	70.4	78.7	7179	8025	9.6
40	80	23	1.1	79.1	87.9	8066	8963	10.7
40	80	23	1.1	79.1	87.9	8066	8963	10.7

nbc flexible solutions



Tapered bore (K30)
(1:30)

Equivalent radial load
dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{F_r} \leqq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	Y_1	0.67	Y_2

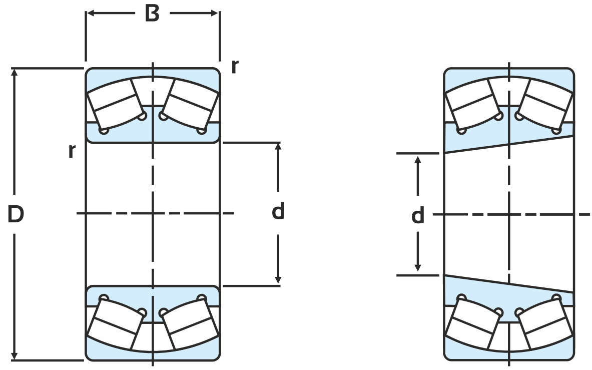
static

$P_{or} = F_r + Y_o F_a$

For values of e, Y_2 and Y_o see the table below.

e	Y_1	Y_2	Y_o	Bearing Number	Mass Kg. (Approx.)
0.35	1.9	2.9	1.9	22205 CC W33	0.18
0.35	1.9	2.9	1.9	22205K CC W33	0.16
0.35	1.9	2.9	1.9	22205 MB W33	0.19
0.35	1.9	2.9	1.9	22205K MB W33	0.17
0.32	2.1	3.1	2.1	22206 CC W33	0.28
0.32	2.1	3.1	2.1	22206K CC W33	0.27
0.33	2.0	3.0	2.0	22206 MB W33	0.32
0.33	2.0	3.0	2.0	22206K MB W33	0.28
0.31	2.2	3.0	2.2	22207K CA W33	0.43
0.32	2.1	3.2	2.1	22207 MB W33	0.45
0.32	2.1	3.2	2.1	22207K MB W33	0.43
0.32	2.1	3.2	2.1	22207 CC W33	0.44
0.32	2.1	3.2	2.1	22207K CC W33	0.41
0.28	2.4	3.5	2.3	22208 CC W33	0.53
0.28	2.4	3.5	2.3	22208K CC W33	0.52

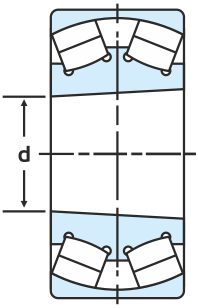
Spherical Roller Bearing



Cylindrical bore

Tapered bore (K) (1:12)

Boundary Dimensions				Basic Load Rating				Fatigue load limit
				Dynamic	Static	Dynamic	Static	
mm				KN		Kgf		KN
d	D	B	r	Cr	Cor	Cr	Cor	Cu
40	80	23	1.1	80.5	90.4	8209	9218	11.0
40	80	23	1.1	80.5	90.4	8209	9218	11.0
40	80	23	1.1	80.5	90.4	8209	9218	11.0
40	80	23	1.1	80.5	90.4	8209	9218	11.0
40	90	23	1.5	85.6	88.1	8729	8984	10.7
40	90	23	1.5	85.6	88.1	8729	8984	10.7
40	90	23	1.5	85.6	88.1	8729	8984	10.7
40	90	23	1.5	85.6	88.1	8729	8984	10.7
40	90	33	1.5	123.6	142.1	12603	14490	17.3
40	90	33	1.5	123.6	142.1	12603	14490	17.3
40	90	33	1.5	123.6	142.1	12603	14490	17.3
40	90	33	1.5	123.6	142.1	12603	14490	17.3
45	85	23	1.1	82.6	91.3	8423	9310	11.1
45	85	23	1.1	82.6	91.3	8423	9310	11.1
45	85	23	1.1	82.6	95	8423	9687	11.6
45	85	23	1.1	82.6	95	8423	9687	11.6



Tapered bore (K30)
(1:30)

Equivalent radial load
dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{F_r} \leqq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	Y_1	0.67	Y_2

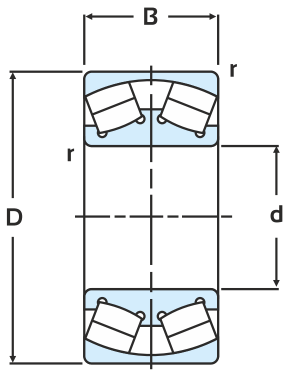
static

$P_{or} = F_r + Y_o F_a$

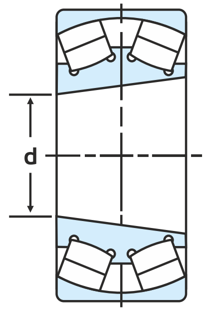
For values of e, Y_2 and Y_o see the table below.

e	Y_1	Y_2	Y_o	Bearing Number	Mass Kg. (Approx.)
0.28	2.4	3.5	2.3	22208 CA W33	0.47
0.28	2.4	3.5	2.3	22208K CA W33	0.45
0.31	2.2	3.2	2.1	22208 MB W33	0.47
0.31	2.2	3.2	2.1	22208K MB W33	0.47
0.24	2.8	4.1	2.8	21308 CC W33	0.72
0.24	2.8	4.1	2.8	21308 MB W33	0.73
0.24	2.8	4.1	2.8	21308K MB W33	0.70
0.24	2.8	4.1	2.8	21308K CC W33	0.93
0.39	1.7	2.5	1.7	22308 CC W33	1.01
0.39	1.7	2.5	1.7	22308K CC W33	0.95
0.39	1.7	2.5	1.7	22308 MB W33	1.03
0.39	1.7	2.5	1.7	22308K MB W33	1.00
0.37	1.8	2.7	1.8	22209 CA W33	0.61
0.37	1.8	2.7	1.8	22209K CA W33	0.60
0.26	2.6	3.8	2.5	22209 CC W33	0.59
0.26	2.6	3.8	2.5	22209K CC W33	0.58

Spherical Roller Bearing

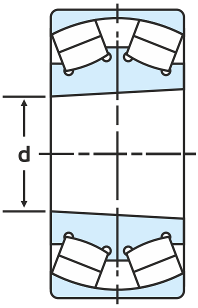


Cylindrical bore



Tapered bore (K)
(1:12)

Boundary Dimensions				Basic Load Rating				Fatigue load limit
				Dynamic	Static	Dynamic	Static	
mm				KN		Kgf		KN
d	D	B	r	Cr	Cor	Cr	Cor	Cu
45	85	23	1.1	82.6	91.3	8423	9310	11.1
45	85	23	1.1	82.6	91.3	8423	9310	11.1
45	100	36	1.5	146	175	14888	17845	21.3
45	100	36	1.5	146	175	14888	17845	21.3
45	100	36	1.5	146	175	14888	17845	21.3
45	100	36	1.5	146	175	14888	17845	21.3
45	100	36	1.5	146	175	14888	17845	21.3
50	90	23	1.1	82.5	95.8	8413	9769	11.7
50	90	23	1.1	82.5	95.8	8413	9769	11.7
50	90	23	1.1	85.9	102	8759	10401	12.4
50	90	23	1.1	85.9	102	8759	10401	12.4
50	90	23	1.1	86.6	103.3	8831	10534	12.6
50	90	23	1.1	86.6	103.3	8831	10534	12.6
50	110	27	2	126	142	12848	14480	17.3
50	110	27	2	126	142	12848	14480	17.3
50	110	27	2	126	142	12848	14480	17.3



Tapered bore (K30)
(1:30)

Equivalent radial load
dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{F_r} \leqq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	Y_1	0.67	Y_2

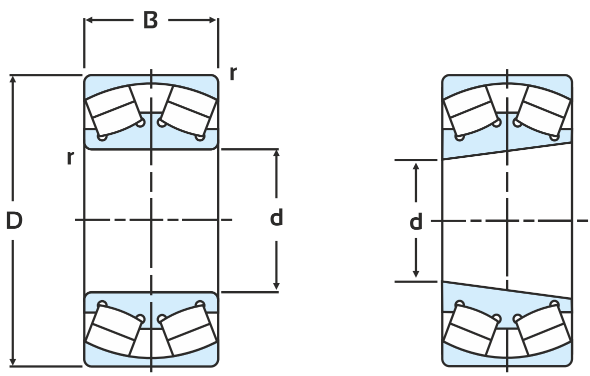
static

$P_{or} = F_r + Y_o F_a$

For values of e, Y_2 and Y_o see the table below.

e	Y_1	Y_2	Y_o	Bearing Number	Mass Kg. (Approx.)
0.28	2.4	3.5	2.3	22209 MB W33	0.61
0.28	2.4	3.5	2.3	22209K MB W33	0.61
0.37	1.8	2.7	1.8	22309 CC W33	1.30
0.37	1.8	2.7	1.8	22309K CC W33	1.10
0.37	1.8	2.7	1.8	22309 CA W33	1.37
0.37	1.8	2.7	1.8	22309 MB W33	1.40
0.37	1.8	2.7	1.8	22309K MB W33	1.38
0.24	2.8	4.1	2.7	22210 CA W33	0.64
0.24	2.8	4.1	2.7	22210K CA W33	0.62
0.24	2.8	4.1	2.7	22210 CC W33	0.62
0.24	2.8	4.1	2.7	22210K CC W33	0.60
0.26	2.6	3.8	2.5	22210 MB W33	0.64
0.26	2.6	3.8	2.5	22210K MB W33	0.63
0.24	2.8	4.2	2.8	21310 CC W33	1.20
0.24	2.8	4.2	2.8	21310K CC W33	1.01
0.24	2.8	4.2	2.8	21310 MB W33	1.50

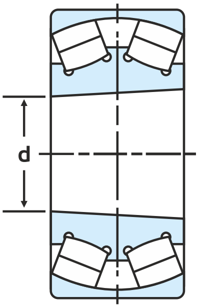
Spherical Roller Bearing



Cylindrical bore

Tapered bore (K) (1:12)

Boundary Dimensions				Basic Load Rating				Fatigue load limit
				Dynamic	Static	Dynamic	Static	
mm				KN		Kgf		KN
d	D	B	r	Cr	Cor	Cr	Cor	Cu
50	110	27	2	126	142	12848	14480	17.3
50	110	40	2	193	227	19680	23147	27.7
50	110	40	2	193	227	19680	23147	27.7
50	110	40	2	193	227	19680	23147	27.7
55	100	25	1.5	98.9	118.9	10085	12124	14.5
55	100	25	1.5	98.9	118.9	10085	12124	14.5
55	100	25	1.5	106	126	10809	12848	15.4
55	100	25	1.5	106	126	10809	12848	15.4
55	100	25	1.5	108	128	11013	13052	15.6
55	100	25	1.5	108	128	11013	13052	15.6
55	120	29	2	145	163	14786	16621	19.9
55	120	29	2	145	163	14786	16621	19.9
55	120	29	2	145	163	14786	16621	19.9
55	120	29	2	145	163	14786	16621	19.9
55	120	43	2	214	258	21822	26308	31.5
55	120	43	2	214	258	21822	26308	31.5



Tapered bore (K30)
(1:30)

Equivalent radial load
dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{F_r} \leqq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	Y_1	0.67	Y_2

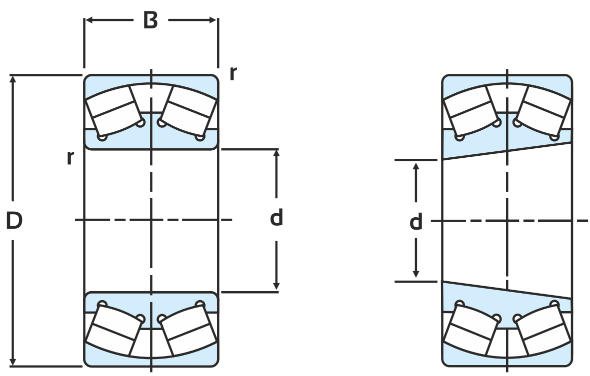
static

$P_{or} = F_r + Y_o F_a$

For values of e, Y_2 and Y_o see the table below.

e	Y_1	Y_2	Y_o	Bearing Number	Mass Kg. (Approx.)
0.24	2.8	4.2	2.8	21310K MB W33	1.30
0.37	1.8	2.7	1.8	22310 CA W33	1.83
0.37	1.8	2.7	1.8	22310 MB W33	1.88
0.37	1.8	2.7	1.8	22310K MB W33	1.84
0.27	2.5	3.7	2.5	22211 MB W33	0.87
0.27	2.5	3.7	2.5	22211K MB W33	0.85
0.24	2.8	4.2	2.8	22211 CA W33	0.83
0.24	2.8	4.2	2.8	22211K CA W33	0.81
0.24	2.8	4.2	2.8	22211 CC W33	0.83
0.24	2.8	4.2	2.8	22211K CC W33	0.83
0.24	2.8	4.2	2.8	21311 CC W33	1.61
0.24	2.8	4.2	2.8	21311K CC W33	1.45
0.24	2.8	4.2	2.8	21311 MB W33	1.66
0.24	2.8	4.2	2.8	21311K MB W33	1.62
0.36	1.9	2.8	1.8	22311 CA W33	2.33
0.36	1.9	2.8	1.8	22311K CA W33	2.30

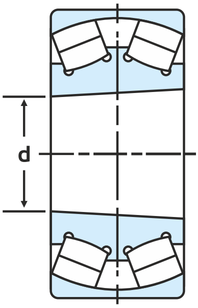
Spherical Roller Bearing



Cylindrical bore

Tapered bore (K) (1:12)

Boundary Dimensions				Basic Load Rating				Fatigue load limit
				Dynamic	Static	Dynamic	Static	
mm				KN		Kgf		KN
d	D	B	r	Cr	Cor	Cr	Cor	Cu
55	120	43	2	214	258	21822	26308	31.5
55	120	43	2	214	258	21822	26308	31.5
60	110	28	1.5	132	156	13460	15907	19.0
60	110	28	1.5	132	156	13460	15907	19.0
60	110	28	1.5	135	157	13766	16009	19.1
60	110	28	1.5	135	157	13766	16009	19.1
60	110	28	1.5	150	182	15296	18559	22.2
60	110	28	1.5	150	182	15296	18559	22.2
60	130	31	2.1	167	191	17029	19476	23.3
60	130	31	2.1	174	202	17743	20598	24.6
60	130	31	2.1	174	202	17743	20598	24.6
60	130	46	2.1	240	310	24473	31611	37.8
60	130	46	2.1	240	310	24473	31611	37.8
60	130	46	2.1	240	310	24473	31611	37.8
60	130	46	2.1	240	310	24473	31611	37.8
60	130	46	2.1	240	310	24473	31611	37.8



Tapered bore (K30)
(1:30)

Equivalent radial load
dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{F_r} \leqq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	Y_1	0.67	Y_2

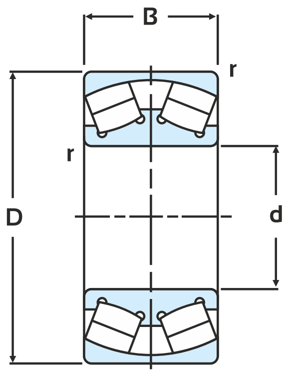
static

$P_{or} = F_r + Y_o F_a$

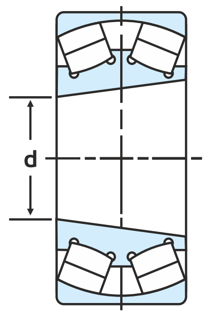
For values of e, Y_2 and Y_o see the table below.

e	Y_1	Y_2	Y_o	Bearing Number	Mass Kg. (Approx.)
0.36	1.9	2.8	1.8	22311 MB W33	2.33
0.36	1.9	2.8	1.8	22311K MB W33	2.30
0.25	2.7	4.0	2.7	22212 MB W33	1.23
0.25	2.7	4.0	2.7	22212K MB W33	1.20
0.24	2.8	4.1	2.7	22212 CA W33	1.18
0.24	2.8	4.1	2.7	22212K CA W33	1.15
0.24	2.8	4.1	2.7	22212 CC W33	1.18
0.24	2.8	4.1	2.7	22212K CC W33	1.15
0.24	2.8	4.2	2.8	21312 CA W33	2.10
0.24	2.8	4.2	2.8	21312 CC W33	1.98
0.24	2.8	4.2	2.8	21312K CC W33	1.93
0.36	1.9	2.8	1.8	22312 CC W33	2.87
0.36	1.9	2.8	1.8	22312 CA W33	2.91
0.38	1.8	2.7	1.8	22312 MB W33	2.93
0.38	1.8	2.7	1.8	22312K MB W33	2.90
0.36	1.9	2.8	1.8	22312K CC W33	2.82

Spherical Roller Bearing

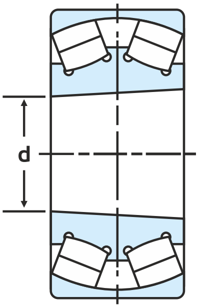


Cylindrical bore



Tapered bore (K)
(1:12)

Boundary Dimensions				Basic Load Rating				Fatigue load limit
				Dynamic	Static	Dynamic	Static	
mm				KN		Kgf		KN
d	D	B	r	Cr	Cor	Cr	Cor	Cu
65	120	31	1.5	112	158	11421	16111	19.3
65	120	31	1.5	147	181	14990	18457	22.1
65	120	31	1.5	157.2	196.8	16030	20068	24.0
65	120	31	1.5	164	197	16723	20088	24.0
65	120	31	1.5	164	197	16723	20088	24.0
65	140	48	2.1	275	327	28042	33344	39.6
65	140	48	2.1	275	327	28042	33344	39.6
65	140	48	2.1	275	327	28042	33344	39.6
65	140	48	2.1	295	353	30081	35995	42.7
65	140	48	2.1	295	353	30081	35995	42.7
65	140	48	2.1	295	353	30081	35995	42.7
70	125	31	1.5	161.4	203.8	16458	20781	25.0
70	125	31	1.5	161.4	203.8	16458	20781	25.0
70	125	31	1.5	170	218	17335	22229	26.6
70	125	31	1.5	170	218	17335	22229	26.6



Tapered bore (K30)
(1:30)

Equivalent radial load
dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{F_r} \leqq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	Y_1	0.67	Y_2

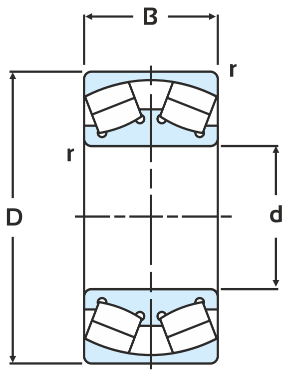
static

$P_{or} = F_r + Y_o F_a$

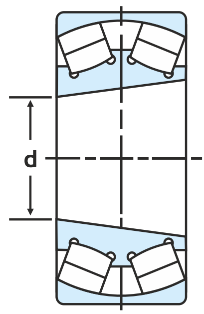
For values of e, Y_2 and Y_o see the table below.

e	Y_1	Y_2	Y_o	Bearing Number	Mass Kg. (Approx.)
0.28	2.4	3.6	2.3	22213K MB W33	1.48
0.28	2.4	3.6	2.3	22213 MB W33	1.54
0.25	2.7	4.0	2.6	22213K CC W33	1.46
0.25	2.7	4.0	2.6	22213 CC W33	1.49
0.25	2.7	4.0	2.6	22213K CA W33	1.52
0.35	1.9	2.9	1.9	22313 CC W33	3.50
0.35	1.9	2.9	1.9	22313K CC W33	3.50
0.35	1.9	2.9	1.9	22313 CC W33	3.42
0.35	1.9	2.9	1.9	22313 CA W33	2.61
0.35	1.9	2.9	1.9	22313 MB W33	3.61
0.35	1.9	2.9	1.9	22313K MB W33	3.54
0.24	2.8	4.2	2.8	22214 CC W33	1.65
0.24	2.8	4.2	2.8	22214K CC W33	1.63
0.24	2.8	4.2	2.8	22214 MB W33	1.64
0.24	2.8	4.2	2.8	22214K MB W33	1.64

Spherical Roller Bearing

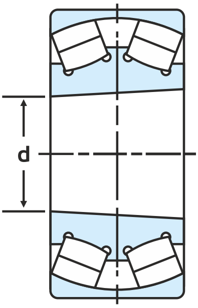


Cylindrical bore



Tapered bore (K)
(1:12)

Boundary Dimensions				Basic Load Rating				Fatigue load limit
				Dynamic	Static	Dynamic	Static	
mm				KN		Kgf		KN
d	D	B	r	Cr	Cor	Cr	Cor	Cu
70	150	35	2.1	204.6	219.6	20863	22393	26.0
70	150	35	2.1	204.6	219.6	20863	22393	26.0
70	150	35	2.1	210	247	21414	25187	29.3
70	150	35	2.1	210	247	21414	25187	29.3
70	150	35	2.1	210	247	21414	25187	29.3
70	150	51	2.1	342	426	34874	43439	50.5
70	150	51	2.1	342	426	34874	43439	50.5
70	150	51	2.1	342	426	34874	43439	50.5
70	150	51	2.1	342	426	34874	43439	50.5
70	150	51	2.1	342	426	34874	43439	50.5
75	130	31	1.5	163	215	16621	21924	26.0
75	130	31	1.5	170	220	17335	22433	26.6
75	130	31	1.5	170.2	220.3	17355	22464	26.7
75	130	31	1.5	170.2	220.3	17355	22464	26.7
75	130	31	1.5	190	240	19374	24473	29.1
75	160	37	2.1	239	287	24371	29265	33.3



Tapered bore (K30)
(1:30)

Equivalent radial load
dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{F_r} \leqq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	Y_1	0.67	Y_2

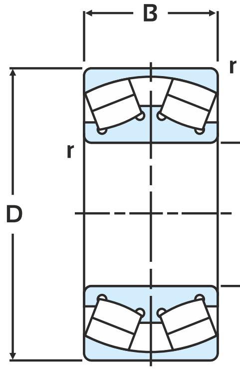
static

$P_{or} = F_r + Y_o F_a$

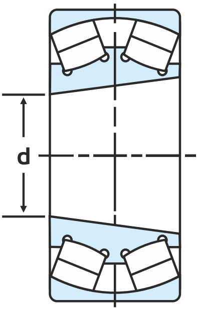
For values of e, Y_2 and Y_o see the table below.

e	Y_1	Y_2	Y_o	Bearing Number	Mass Kg. (Approx.)
0.25	2.7	4.1	2.7	21314 MB W33	3.00
0.25	2.7	4.1	2.7	21314K MB W33	2.67
0.23	2.9	4.3	2.9	21314 CA W33	3.05
0.23	2.9	4.3	2.9	21314 CC W33	3.08
0.23	2.9	4.3	2.9	21314K CC W33	3.06
0.34	2.0	2.9	1.9	22314 CC W33	4.36
0.34	2.0	2.9	1.9	22314K CC W33	4.31
0.34	2.0	2.9	1.9	22314 CA W33	4.39
0.34	2.0	3.0	1.9	22314 MB W33	4.41
0.34	2.0	3.0	1.9	22314K MB W33	4.32
0.24	2.9	4.3	2.8	22215K MB W33	1.80
0.22	3.0	4.5	2.9	22215 CC W33	1.80
0.22	3.0	4.5	2.9	22215K CA W33	1.71
0.22	3.0	4.5	2.9	22215K CC W33	1.71
0.24	2.9	4.3	2.8	22215 MB W33	1.69
0.23	2.9	4.4	2.9	21315 CA W33	3.65

Spherical Roller Bearing

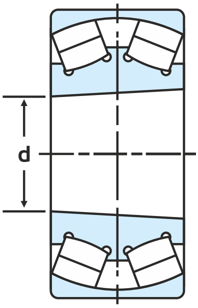


Cylindrical bore



Tapered bore (K) (1:12)

Boundary Dimensions				Basic Load Rating				Fatigue load limit
				Dynamic	Static	Dynamic	Static	
mm				KN		Kgf		KN
d	D	B	r	Cr	Cor	Cr	Cor	Cu
75	160	37	2.1	242	287	24371	29265	33.3
75	160	37	2.1	242	287	24371	29265	33.3
75	160	37	2.1	262	288	26716	29367	33.5
75	160	37	2.1	262	288	26716	29367	33.5
75	160	55	2.1	357	449	36403	45785	52.2
75	160	55	2.1	357	449	36403	45785	52.2
75	160	55	2.1	373	451	38035	45988	52.4
75	160	55	2.1	373	451	38035	45988	52.4
75	160	55	2.1	373	451	38035	45988	52.4
75	160	55	2.1	373	451	38035	45988	52.4
80	140	33	2	174	234	17743	23861	27.7
80	140	33	2	175	234	17845	23861	27.7
80	140	33	2	175	234	17845	23861	27.7
80	140	33	2	175	234	17845	23861	27.7
80	140	33	2	179	240	18253	24473	28.4



Tapered bore (K30)
(1:30)

Equivalent radial load
dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{F_r} \leqq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	Y_1	0.67	Y_2

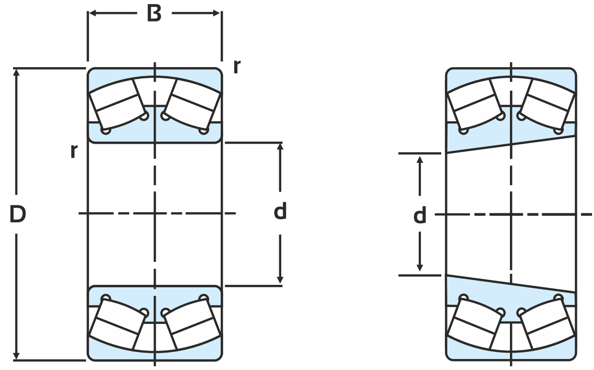
static

$P_{or} = F_r + Y_o F_a$

For values of e, Y_2 and Y_o see the table below.

e	Y_1	Y_2	Y_o	Bearing Number	Mass Kg. (Approx.)
0.23	2.9	4.4	2.9	21315 CC W33	3.80
0.23	2.9	4.4	2.9	21315K CC W33	3.30
0.32	2.1	3.2	2.1	21315 MB W33	3.70
0.32	2.1	3.2	2.1	21315K MB W33	3.65
0.32	2.1	3.2	2.1	22315 CC W33	5.35
0.32	2.1	3.2	2.1	22315K CC W33	5.31
0.35	2.0	2.9	1.9	22315 CA W33	5.85
0.35	2.0	2.9	1.9	22315K CA W33	5.81
0.35	2.0	2.9	1.9	22315 MB W33	5.89
0.35	2.0	2.9	1.9	22315K MB W33	5.85
0.22	3.0	4.5	3.0	22216 MB W33	2.26
0.35	2.0	2.9	2.0	22216K CC W33	2.10
0.22	3.0	4.5	3.0	22216K MB W33	2.26
0.35	2.0	2.9	2.0	22216 CC W33	2.2
0.22	3.0	4.5	3.0	22216 CA W33	2.26

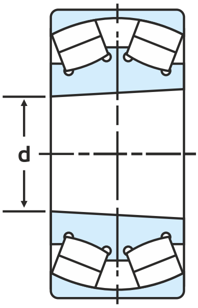
Spherical Roller Bearing



Cylindrical bore

Tapered bore (K) (1:12)

Boundary Dimensions				Basic Load Rating				Fatigue load limit
				Dynamic	Static	Dynamic	Static	
mm				KN		Kgf		KN
d	D	B	r	Cr	Cor	Cr	Cor	Cu
80	140	33	2	179	240	18253	24473	28.4
80	170	39	2.1	256	325	26104	33140	37.1
80	170	39	2.1	256	325	26104	33140	37.1
80	170	58	2.1	436	533	44459	54350	60.8
80	170	58	2.1	436	533	44459	54350	60.8
80	170	58	2.1	436	533	44459	54350	60.8
80	170	58	2.1	436	533	44459	54350	60.8
85	150	36	2	213	282	21720	28756	32.8
85	150	36	2	224	290	22841	29571	33.7
85	150	36	2	224	290	22841	29571	33.7
85	150	36	2	225	293	22943	29877	34.0
85	150	36	2	225	293	22943	29877	34.0
85	180	60	3	433	560	44153	57103	62.8
85	180	60	3	433	560	44153	57103	62.8
85	180	60	3	438	560	44663	57103	62.8
85	180	60	3	446	563	45479	57409	63.1



Tapered bore (K30)
(1:30)

Equivalent radial load
dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{F_r} \leqq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	Y_1	0.67	Y_2

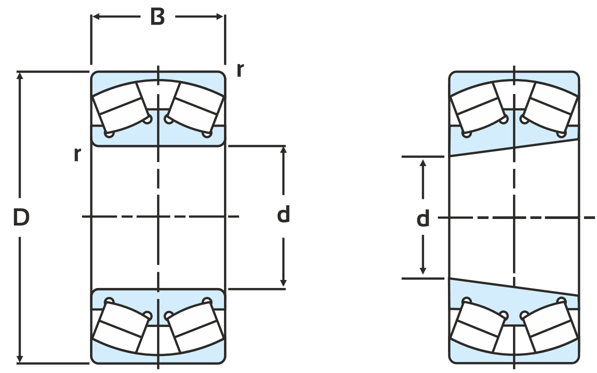
static

$P_{or} = F_r + Y_o F_a$

For values of e, Y_2 and Y_o see the table below.

e	Y_1	Y_2	Y_0	Bearing Number	Mass Kg. (Approx.)
0.22	3.0	4.5	3.0	22216K CA W33	2.24
0.24	2.8	4.2	2.8	21316 CC W33	4.50
0.24	2.8	4.2	2.8	21316K CC W33	4.1
0.34	2.0	2.9	1.9	22316 CA W33	6.19
0.34	2.0	2.9	1.9	22316K CA W33	6.15
0.34	2.0	2.9	1.9	22316 MB W33	6.34
0.34	2.0	2.9	1.9	22316K MB W33	6.2
0.23	3.0	4.4	2.9	22217K CA W33	2.87
0.24	2.8	4.2	2.8	22217 MB W33	2.92
0.24	2.8	4.2	2.8	22217K MB W33	2.88
0.23	3.0	4.4	2.9	22217 CC W33	2.71
0.23	3.0	4.4	2.9	22217K CC W33	2.68
0.34	2.0	3.0	2.0	22317 MB W33	7.31
0.34	2.0	3.0	2.0	22317K MB W33	7.27
0.34	2.0	3.0	2.0	22317 CA W33	7.31
0.34	2.0	3.0	2.0	22317 CC W33	7.25

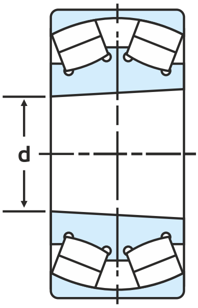
Spherical Roller Bearing



Cylindrical bore

Tapered bore (K) (1:12)

Boundary Dimensions				Basic Load Rating				Fatigue load limit
				Dynamic	Static	Dynamic	Static	
mm				KN		Kgf		KN
d	D	B	r	Cr	Cor	Cr	Cor	Cu
85	180	60	3	446	563	45479	57409	63.1
90	160	40	2	202	286	20598	29163	32.6
90	160	40	2	248	345	25289	35180	39.3
90	160	40	2	254	336	25900	34262	38.3
90	160	40	2	265	353	27022	35995	40.3
90	160	40	2	265	353	27022	35995	40.3
90	160	52.4	2	335	492	34160	50169	56.1
90	160	52.4	2	339	492	34568	50169	56.1
90	160	52.4	2	340	492	34160	50169	56.1
90	160	52.4	2	340	492	34160	50169	56.1
90	190	64	3	489	641	49863	65363	70.7
90	190	64	3	489	641	49863	65363	70.7
95	170	43	2.1	314.4	410.2	32059	41828	46.0
95	170	43	2.1	314.4	410.2	32059	41828	46.0
95	170	43	2.1	317	411	32059	41828	46.0
95	170	43	2.1	317	411	32059	41828	46.0



Tapered bore (K30)
(1:30)

Equivalent radial load
dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{F_r} \leqq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	Y_1	0.67	Y_2

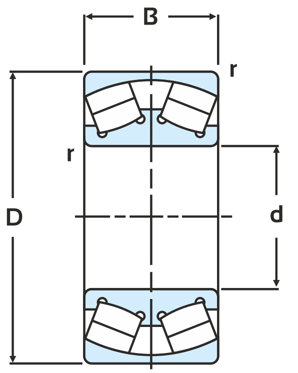
static

$P_{or} = F_r + Y_o F_a$

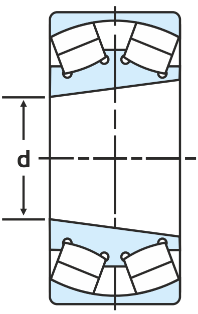
For values of e, Y_2 and Y_o see the table below.

e	Y_1	Y_2	Y_o	Bearing Number	Mass Kg. (Approx.)
0.34	2.0	3.0	2.0	22317K CC W33	7.21
0.25	2.7	4.1	2.7	22218K MB W33	3.32
0.24	2.9	4.3	2.8	22218 CC W33	3.50
0.25	2.7	4.1	2.7	22218 MB W33	3.36
0.24	2.8	4.2	2.8	22218K CC W33	3.42
0.23	3.0	4.4	3.0	22218K CA W33	3.40
0.33	2.1	3.1	2.0	23218 MB W33	4.58
0.33	2.1	3.1	2.0	23218K MB W33	4.54
0.33	2.1	3.1	2.0	23218 CC W33	4.50
0.33	2.1	3.1	2.0	23218K CC W33	4.46
0.34	2.0	3.0	2.0	22318 MB W33	8.35
0.34	2.0	3.0	2.0	22318K MB W33	8.34
0.25	2.7	4.0	2.6	22219 MB W33	4.57
0.25	2.7	4.0	2.6	22219K MB W33	4.52
0.25	2.7	4.0	2.6	22219 CC W33	4.52
0.25	2.7	4.0	2.6	22219K CC W33	4.10

Spherical Roller Bearing

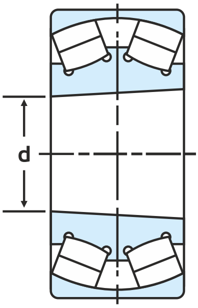


Cylindrical bore



Tapered bore (K)
(1:12)

Boundary Dimensions				Basic Load Rating				Fatigue load limit
				Dynamic	Static	Dynamic	Static	
mm				KN		Kgf		KN
d	D	B	r	Cr	Cor	Cr	Cor	Cu
95	200	67	3	500	615	50985	62712	66.7
95	200	67	3	536	709	54656	72297	76.9
95	200	67	3	536	709	54656	72297	76.9
95	200	67	3	551	714	56185	72807	77.5
95	200	67	3	551	714	56185	72807	77.5
100	180	46	2.1	324	449	33038	45785	49.5
100	180	46	2.1	324	449	33038	45785	49.5
100	165	52	2	335	520	34160	53024	58.3
100	165	52	2	335	520	34160	53024	58.3
100	165	52	2	340	525	34670	53534	58.8
100	165	52	2	340	525	34670	53534	58.8
100	165	52	2	345	530	34670	53534	58.8
100	165	52	2	345	530	34670	53534	58.8
100	180	46	2.1	360	474	36709	48334	52.3
100	180	46	2.1	360	474	36709	48334	52.3



Tapered bore (K30)
(1:30)

Equivalent radial load
dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{F_r} \leqq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	Y_1	0.67	Y_2

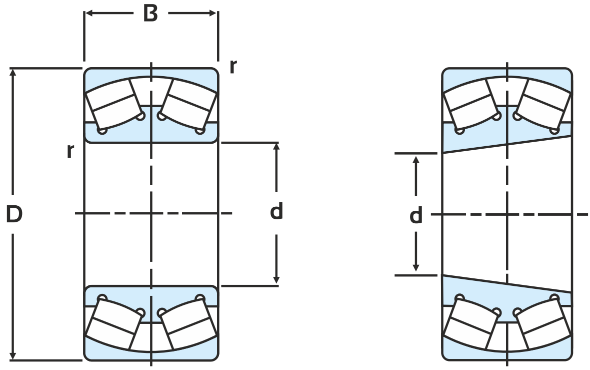
static

$P_{or} = F_r + Y_o F_a$

For values of e, Y_2 and Y_o see the table below.

e	Y_1	Y_2	Y_o	Bearing Number	Mass Kg. (Approx.)
0.34	2.0	3.0	2.0	22319K MB W33	10.11
0.34	2.0	3.0	2.0	22319K CA W33	10.09
0.34	2.0	3.0	2.0	22319 MB W33	10.11
0.34	2.0	3.0	2.0	22319 CC W33	10.28
0.34	2.0	3.0	2.0	22319K CC W33	9.60
0.24	2.8	4.2	2.8	22220 CC W33	4.95
0.24	2.8	4.2	2.8	22220K CC W33	4.90
0.31	2.2	3.2	2.2	23120 MB W33	4.58
0.31	2.2	3.2	2.2	23120K MB W33	4.54
0.30	2.2	3.3	2.2	23120 MB W33	4.34
0.30	2.2	3.3	2.2	23120K MB W33	4.30
0.30	2.2	3.3	2.2	23120 CC W33	4.00
0.30	2.2	3.3	2.2	23120K CC W33	3.90
0.26	2.6	3.9	2.6	22220 MB W33	5.03
0.26	2.6	3.9	2.6	22220K MB W33	4.97

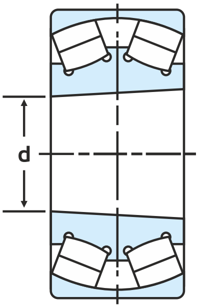
Spherical Roller Bearing



Cylindrical bore

Tapered bore (K)
(1:12)

Boundary Dimensions				Basic Load Rating				Fatigue load limit
				Dynamic	Static	Dynamic	Static	
mm				KN		Kgf		KN
d	D	B	r	Cr	Cor	Cr	Cor	Cu
100	180	60.3	2.1	420	580	42827	59143	63.9
100	180	60.3	2.1	420	580	42827	59143	63.9
100	180	60.3	2.1	437	638	44561	65057	70.3
100	180	60.3	2.1	437	638	44561	65057	70.3
100	215	73	3	626	840	63833	85655	89.4
100	215	73	3	626	840	63833	85655	89.4
100	215	73	3	626	840	63833	85655	89.4
100	215	73	3	626	840	63833	85655	89.4
100	215	73	3	630	840	63833	85655	89.4
100	215	73	3	630	840	63833	85655	89.4
110	170	45	2	282	455	28756	46396	50.2
110	170	45	2	282	455	28756	46396	50.2
110	180	56	2	325	580	33140	59143	63.3
110	180	56	2	325	580	33140	59143	63.3
110	200	53	2.1	424	591	43235	60264	63.2
110	200	53	2.1	424	591	43235	60264	63.2



Tapered bore (K30)
(1:30)

Equivalent radial load
dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{F_r} \leqq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	Y_1	0.67	Y_2

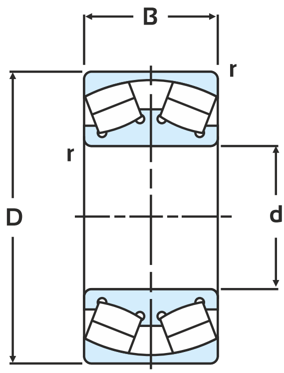
static

$P_{or} = F_r + Y_o F_a$

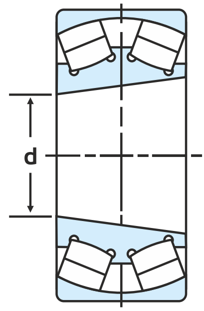
For values of e, Y_2 and Y_o see the table below.

e	Y_1	Y_2	Y_o	Bearing Number	Mass Kg. (Approx.)
0.32	2.1	3.2	2.1	23220 MB W33	6.80
0.32	2.1	3.2	2.1	23220K MB W33	6.68
0.30	2.2	3.3	2.2	23220 CC W33	6.75
0.30	2.2	3.3	2.2	23220K CC W33	6.71
0.24	2.8	4.2	2.8	22320 MB W33	12.95
0.24	2.8	4.2	2.8	22320K MB W33	12.90
0.34	2.0	2.9	1.9	22320 MB W33	12.95
0.34	2.0	2.9	2.0	22320K MB W33	12.88
0.24	2.8	4.2	2.8	22320 CC W33	12.90
0.24	2.8	4.2	2.8	22320K CC W33	11.87
0.24	2.8	4.2	2.8	23022 MB W33	3.63
0.24	2.8	4.2	2.8	23022K MB W33	3.60
0.31	2.2	3.3	2.2	23122 MB W33	5.90
0.31	2.2	3.3	2.2	23122K MB W33	5.87
0.27	2.5	3.7	2.5	22222 MB W33	7.54
0.27	2.5	3.7	2.5	22222K MB W33	6.95

Spherical Roller Bearing

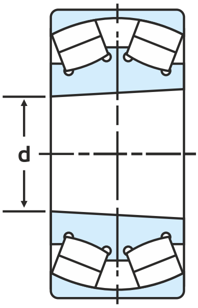


Cylindrical bore



Tapered bore (K)
(1:12)

Boundary Dimensions				Basic Load Rating				Fatigue load limit
				Dynamic	Static	Dynamic	Static	
mm				KN		Kgf		KN
d	D	B	r	Cr	Cor	Cr	Cor	Cu
110	200	69.8	2.1	510	750	52005	76478	80.2
110	200	69.8	2.1	536.5	802.3	54707	81811	85.8
110	200	53	2.1	572	651	58327	66382	69.6
110	200	53	2.1	572	651	58327	66382	69.6
110	240	80	3	723	949	76478	98197	99.3
110	240	80	3	723	949	73724	96770	97.8
110	240	80	3	744	935	75866	95342	96.4
110	240	80	3	744	935	75866	95342	96.4
120	180	46	2	296	495	30183	50475	53.5
120	180	46	2	324.5	513.5	33089	52362	55.4
120	180	60	2	353	638	35995	65057	68.9
120	180	60	2	390	700	39768	71379	75.6
120	180	60	2	390	700	39768	71379	75.6
120	215	58	2.1	396	582	40380	59347	60.8
120	200	62	2	460	705	46906	71889	74.7
120	200	62	2	460	705	46906	71889	74.7



Tapered bore (K30)
(1:30)

Equivalent radial load
dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{F_r} \leqq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	Y_1	0.67	Y_2

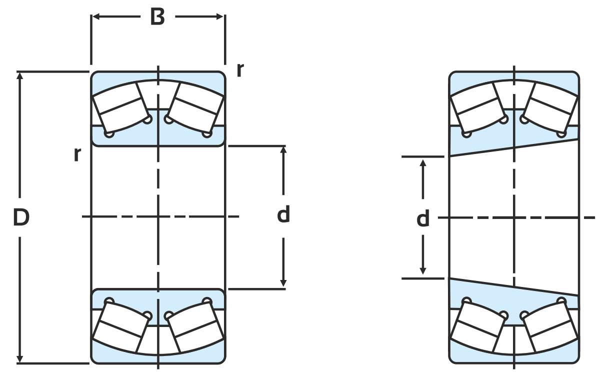
static

$P_{or} = F_r + Y_o F_a$

For values of e, Y_2 and Y_o see the table below.

e	Y_1	Y_2	Y_o	Bearing Number	Mass Kg. (Approx.)
0.35	1.9	2.8	1.9	23222K MB W33	9.50
0.35	1.9	2.8	1.9	23222 MB W33	9.90
0.25	2.7	4.0	2.6	22222 CC W33	7.40
0.25	2.7	4.0	2.6	22222K CC W33	7.37
0.36	1.9	2.8	1.8	22322 MB W33	18.20
0.36	1.9	2.8	1.8	22322K MB W33	17.80
0.35	1.9	2.9	1.9	22322 CC W33	17.90
0.35	1.9	2.9	1.9	22322K CC W33	17.88
0.23	2.9	4.4	2.9	23024 MB W33	4.20
0.23	2.9	4.4	2.9	23024K MB W33	4.06
0.30	2.3	3.4	2.2	24024 CA W33	5.30
0.30	2.3	3.4	2.2	24024 MB W33	5.27
0.30	2.3	3.4	2.2	24024K30 MB W33	5.22
0.28	2.4	3.6	2.4	22224K MB W33	9.14
0.30	2.3	3.4	2.2	23124 MB W33	8.00
0.30	2.3	3.4	2.2	23124K MB W33	7.70

Spherical Roller Bearing

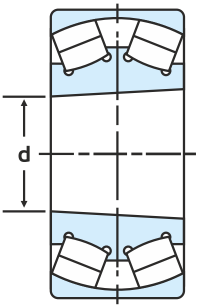


Cylindrical bore

Tapered bore (K)
(1:12)

Boundary Dimensions				Basic Load Rating				Fatigue load limit
				Dynamic	Static	Dynamic	Static	
mm				KN		Kgf		KN
d	D	B	r	Cr	Cor	Cr	Cor	Cu
120	215	58	2.1	507	697	51699	71073	72.8
120	215	76	2.1	595	950	60672	96872	99.2
120	215	76	2.1	595	950	60672	96872	99.2
120	215	58	2.1	652	765	66484	78007	79.9
120	215	58	2.1	652	765	66484	78007	79.9
120	260	86	3	880	1130	89734	115226	113.7
120	260	86	3	880	1130	89734	115226	113.7
120	260	86	3	884	1154	90141	117673	116.1
120	260	86	3	884	1154	90141	117673	116.1
130	200	52	2	375	620	38239	63221	65.1
130	200	52	2	375	620	38239	63221	65.1
130	210	64	2	459	721	46804	73520	75.0
130	210	64	2	459	721	46804	73520	75.0
130	230	64	3	563	832	57409	84839	85.1
130	230	64	3	563	832	57409	84839	85.1
130	230	64	3	570	729	58123	74336	74.5

nbc® flexible solutions



Tapered bore (K30)
(1:30)

Equivalent radial load
dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{F_r} \leqq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	Y_1	0.67	Y_2

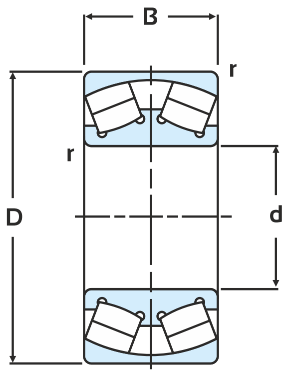
static

$P_{or} = F_r + Y_o F_a$

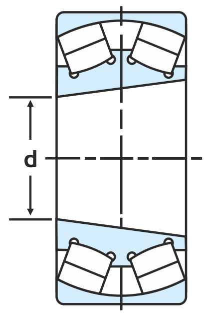
For values of e, Y_2 and Y_o see the table below.

e	Y_1	Y_2	Y_o	Bearing Number	Mass Kg. (Approx.)
0.28	2.4	3.6	2.4	22224 MB W33	9.14
0.35	1.9	2.9	1.9	23224 MB W33	12.30
0.35	1.9	2.9	1.9	23224K MB W33	11.90
0.26	2.6	3.8	2.5	22224 CC W33	9.00
0.26	2.6	3.8	2.5	22224K CC W33	8.86
0.34	2.0	3.0	2.0	22324 CC W33	23.50
0.34	2.0	3.0	2.0	22324K CC W33	22.73
0.35	1.9	2.9	1.9	22324 MB W33	22.67
0.35	1.9	2.9	1.9	22324K MB W33	22.40
0.25	2.7	4.0	2.6	23026 MB W33	6.00
0.25	2.7	4.0	2.6	23026K MB W33	5.87
0.28	2.4	3.6	2.4	23126 MB W33	8.60
0.28	2.4	3.6	2.4	23126K MB W33	8.11
0.26	2.6	3.8	2.5	22226 CC W33	11.10
0.26	2.6	3.8	2.5	22226K CC W33	11.05
0.28	2.4	3.6	2.4	22226 MB W33	11.30

Spherical Roller Bearing

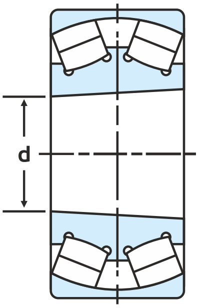


Cylindrical bore



Tapered bore (K)
(1:12)

Boundary Dimensions				Basic Load Rating				Fatigue load limit
				Dynamic	Static	Dynamic	Static	
mm				KN		Kgf		KN
d	D	B	r	Cr	Cor	Cr	Cor	Cu
130	230	64	3	570	729	58123	74336	74.5
130	280	93	4	1020	1377	104009	140413	135.4
130	280	93	4	1020	1377	104009	140413	135.4
130	230	80	3	662	1008	67504	102786	103
130	230	80	3	662	1008	67504	102786	103
140	210	53	2	400	675	40788	68830	69.6
140	210	53	2	400	675	40788	68830	69.6
140	210	53	2	415	695	42318	70869	71.7
140	210	53	2	415	695	42318	70869	71.7
140	210	69	2	510	945	52005	96362	97.4
140	210	69	2	510	945	52005	96362	97.4
140	210	69	2	510	930	52005	94832	95.9
140	210	69	2	510	930	52005	94832	95.9
140	225	68	2.1	540	895	55064	91263	91.1
140	225	68	2.1	540	895	55064	91263	91.1



Tapered bore (K30)
(1:30)

Equivalent radial load
dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{F_r} \leqq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	Y_1	0.67	Y_2

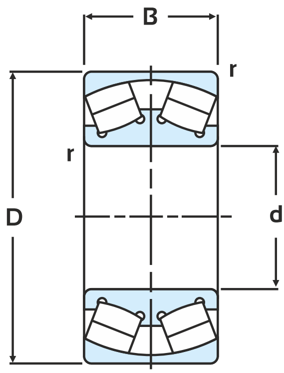
static

$P_{or} = F_r + Y_o F_a$

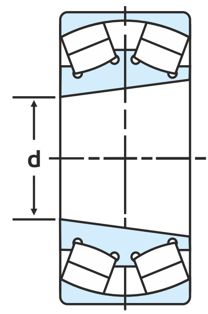
For values of e, Y_2 and Y_o see the table below.

e	Y_1	Y_2	Y_o	Bearing Number	Mass Kg. (Approx.)
0.28	2.4	3.6	2.4	22226K MB W33	11.26
0.33	2.0	3.0	2.0	22326 MB W33	27.50
0.33	2.0	3.0	2.0	22326K MB W33	26.78
0.34	2.0	3.0	2.0	23226 MB W33	14.4
0.34	2.0	3.0	2.0	23226K MB W33	13.8
0.23	3.0	4.4	2.9	23028 CA W33	7.00
0.23	3.0	4.4	2.9	23028K CA W33	6.77
0.23	3.0	4.4	2.9	23028 MB W33	6.66
0.23	3.0	4.4	2.9	23028K MB W33	6.62
0.29	2.3	3.4	2.2	24028 CC W33	8.45
0.29	2.3	3.4	2.2	24028K30 CC W33	8.40
0.32	2.1	3.2	2.1	24028 MB W33	8.50
0.32	2.1	3.2	2.1	24028K30 MB W33	8.47
0.29	2.4	3.5	2.3	23128 MB W33	10.7
0.29	2.4	3.5	2.3	23128K MB W33	10.4

Spherical Roller Bearing

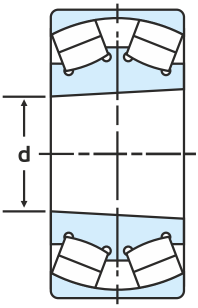


Cylindrical bore



Tapered bore (K)
(1:12)

Boundary Dimensions				Basic Load Rating				Fatigue load limit
				Dynamic	Static	Dynamic	Static	
mm				KN		Kgf		KN
d	D	B	r	Cr	Cor	Cr	Cor	Cu
140	225	68	2.1	550	900	56084	91773	91.6
140	225	68	2.1	550	900	56084	91773	91.6
140	250	68	3	634	924	64649	94220	92.2
140	250	68	3	634	924	64649	94220	92.2
140	250	68	3	639	933	65159	95138	93.1
140	250	68	3	639	933	65159	95138	93.1
140	250	88	3	826	1320	84227	134600	131.7
140	250	88	3	826	1320	84227	134600	131.7
140	280	93	4	830	1250	84635	127463	122.0
140	300	102	4	1154	1620	117673	165191	155.9
140	300	102	4	1154	1620	117673	165191	155.9
150	225	56	2.1	450	795	45887	81066	80.3
150	225	56	2.1	450	795	45887	81066	80.3
150	225	56	2.1	531	820	54146	83615	82.8
150	225	56	2.1	531	820	54146	83615	82.8
150	225	75	2.1	590	1080	60162	110128	109.1



Tapered bore (K30)
(1:30)

Equivalent radial load
dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{F_r} \leqq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	Y_1	0.67	Y_2

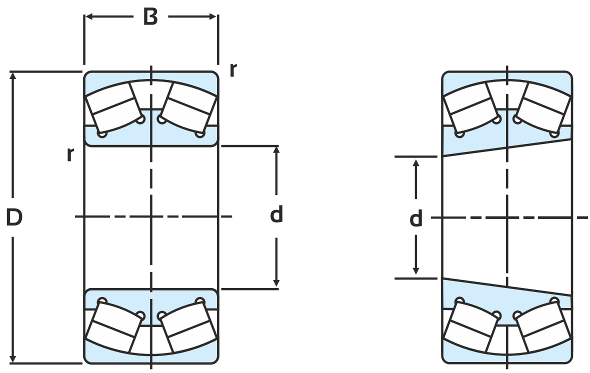
static

$P_{or} = F_r + Y_o F_a$

For values of e, Y_2 and Y_o see the table below.

e	Y_1	Y_2	Y_o	Bearing Number	Mass Kg. (Approx.)
0.28	2.4	3.6	2.4	23128 CC W33	11.8
0.28	2.4	3.6	2.4	23128K CC W33	11.1
0.27	2.5	3.7	2.4	22228 MB W33	14.8
0.27	2.5	3.7	2.4	22228K MB W33	14.0
0.27	2.5	3.7	2.4	22228 CC W33	14.3
0.27	2.5	3.7	2.4	22228K CC W33	14.0
0.34	2.0	3.0	2.0	23228K MB W33	19.3
0.34	2.0	3.0	2.0	23228 MB W33	18.5
0.36	1.9	2.8	1.8	73727	26.0
0.35	1.9	2.9	1.9	22328 MB W33	35.5
0.35	1.9	2.9	1.9	22328K MB W33	35.5
0.23	2.9	4.3	2.8	23030 MB W33	8.10
0.23	2.9	4.3	2.8	23030K MB W33	7.50
0.24	2.8	4.2	2.8	23030K CC W33	7.70
0.24	2.8	4.2	2.8	23030 CC W33	8.35
0.33	2.0	3.0	2.0	24030EK30 MB W33	10.37

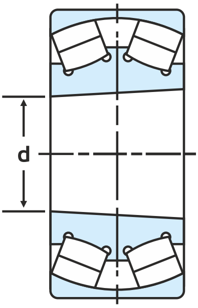
Spherical Roller Bearing



Cylindrical bore

Tapered bore (K)
(1:12)

Boundary Dimensions				Basic Load Rating				Fatigue load limit
				Dynamic	Static	Dynamic	Static	
mm				KN		Kgf		KN
d	D	B	r	Cr	Cor	Cr	Cor	Cu
150	225	75	2.1	607	1116	61896	113799	112.7
150	270	73	3	680	965	69340	98401	94.2
150	250	80	2.1	730	1190	74438	121344	117.9
150	250	80	2.1	745	1244	75968	126851	123.2
150	270	73	3	800	1200	81576	122364	117.1
150	270	96	3	950	1500	96872	152955	146.4
150	270	96	3	960	1520	96872	152955	146.4
150	320	108	4	1270	1750	129502	178448	165.2
150	320	108	4	1270	1750	129502	178448	165.2
150	320	108	4	1270	1750	129502	178448	165.2
160	240	60	2.1	500	875	50985	89224	86.7
160	240	60	2.1	500	875	50985	89224	86.7
160	240	80	2.1	711	1329	72501	135518	131.6
160	240	80	2.1	711	1329	72501	135518	131.6
160	270	86	2.1	837	1362	85349	138883	132.0



Tapered bore (K30)
(1:30)

Equivalent radial load
dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{F_r} \leqq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	Y_1	0.67	Y_2

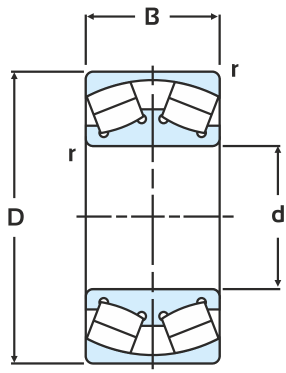
static

$P_{or} = F_r + Y_o F_a$

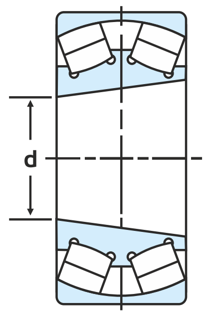
For values of e, Y_2 and Y_o see the table below.

e	Y_1	Y_2	Y_o	Bearing Number	Mass Kg. (Approx.)
0.33	2.0	3.0	2.0	24030E MB W33	10.52
0.27	2.5	3.7	2.4	22230 MB W33	21.1
0.31	2.2	3.2	2.1	23130K MB W33	16.0
0.31	2.2	3.2	2.1	23130 MB W33	16.3
0.27	2.5	3.7	2.4	22230K MB W33	18.6
0.36	1.9	2.8	1.8	23230K MB W33	23.4
0.36	1.9	2.8	1.8	23230 MB W33	24.4
0.36	1.9	2.8	1.8	22330E1 MB W33	43.9
0.36	1.9	2.8	1.8	22330 MB W33	43.9
0.36	1.9	2.8	1.8	22330K MB W33	41.9
0.22	3.0	4.5	2.9	23032 MB W33	9.60
0.22	3.0	4.5	2.9	23032K MB W33	9.57
0.32	2.1	3.1	2.0	24032E MB W33	12.8
0.32	2.1	3.1	2.0	24032EK30 MB W33	11.7
0.31	2.2	3.2	2.1	23132K MB W33	20.5

Spherical Roller Bearing

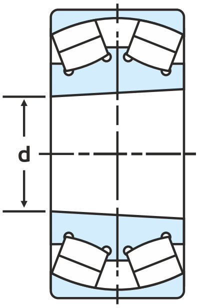


Cylindrical bore



Tapered bore (K)
(1:12)

Boundary Dimensions				Basic Load Rating				Fatigue load limit
				Dynamic	Static	Dynamic	Static	
mm				KN		Kgf		KN
d	D	B	r	Cr	Cor	Cr	Cor	Cu
160	270	86	2.1	839	1350	85553	137660	130.9
160	290	80	3	862	1276	87898	130114	122.0
160	290	80	3	862	1276	87898	130114	122.0
160	290	104	3	1100	1760	112167	179467	168.3
160	290	104	3	1100	1760	112167	179467	168.3
170	260	67	2.1	630	1090	64241	111147	105.7
170	260	67	2.1	640	1080	65261	110128	104.7
170	260	90	2.1	700	1450	71379	147857	140.5
170	260	67	2.1	728	1100	74234	112167	106.6
170	260	67	2.1	728	1100	74234	112167	106.6
170	260	90	2.1	820	1500	83615	152955	145.4
170	280	88	2.1	840	1530	85655	156014	146.3
170	280	88	2.1	895	1550	91263	158054	148.2
170	310	86	4	990	1440	100950	146837	135.0
170	310	86	4	999	1518	101868	154790	142.4
170	280	109	2.1	1020	1800	104009	183546	172.1



Tapered bore (K30)
(1:30)

Equivalent radial load
dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{F_r} \leqq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	Y_1	0.67	Y_2

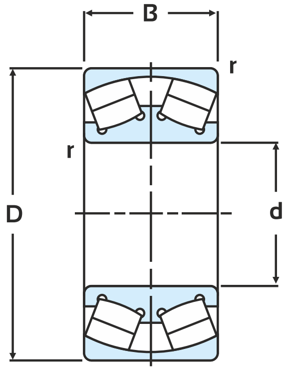
static

$P_{or} = F_r + Y_o F_a$

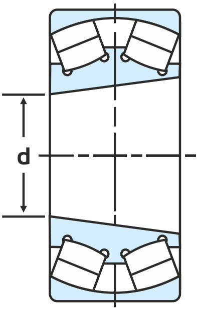
For values of e, Y_2 and Y_o see the table below.

e	Y_1	Y_2	Y_o	Bearing Number	Mass Kg. (Approx.)
0.31	2.2	3.2	2.1	23132 MB W33	20.2
0.28	2.4	3.6	2.4	22232 MB W33	23.5
0.28	2.4	3.6	2.4	22232K MB W33	20.1
0.36	1.9	2.8	1.8	23232 MB W33	30.9
0.36	1.9	2.8	1.8	23232K MB W33	29.6
0.24	2.8	4.2	2.8	23034K MB W33	12.7
0.24	2.8	4.2	2.8	23034 MB W33	13.2
0.34	2.0	3.0	2.0	24034 MB W33	17.9
0.23	2.9	4.3	2.9	23034 CC W33	12.8
0.23	2.9	4.3	2.9	23034K CC W33	11.7
0.34	2.0	3.0	2.0	24034K30 MB W33	17.5
0.30	2.2	3.3	2.2	23134 MB W33	21.9
0.30	2.2	3.3	2.2	23134K MB W33	21.8
0.27	2.5	3.8	2.5	22234K MB W33	27.1
0.27	2.5	3.8	2.5	22234 MB W33	28.5
0.36	1.9	2.8	1.8	24134 MB W33	26.9

Spherical Roller Bearing

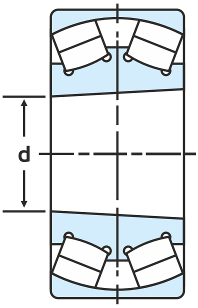


Cylindrical bore



Tapered bore (K)
(1:12)

Boundary Dimensions				Basic Load Rating				Fatigue load limit
				Dynamic	Static	Dynamic	Static	
mm				KN		Kgf		KN
d	D	B	r	Cr	Cor	Cr	Cor	Cu
170	280	109	2.1	1020	1800	104009	183546	172.1
170	280	88	2.1	1086	1519	110739	154892	145.2
170	280	88	2.1	1086	1519	110739	154892	145.2
170	310	110	4	1180	1960	120325	199861	183.8
170	310	110	4	1206	1946	122976	198434	182.5
170	360	120	4	1400	1790	142758	182526	163.0
170	210	110	4	1470	1960	149896	199861	197.2
170	210	110	4	1470	1960	149896	199861	197.2
170	310	110	4	1472	1980	150100	201901	185.7
170	360	120	4	1540	2240	157034	228413	203.9
170	360	120	4	1550	2150	158054	219236	195.7
170	360	120	4	1550	2200	158054	224334	200.3
170	360	120	4	1550	2200	158054	224334	200.3
180	280	74	2.1	756	1308	77089	133377	124.2
180	280	74	2.1	740	129	75458	13154	12.3



Tapered bore (K30)
(1:30)

Equivalent radial load
dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{F_r} \leq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	Y_1	0.67	Y_2

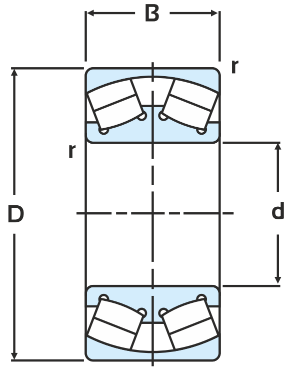
static

$P_{or} = F_r + Y_o F_a$

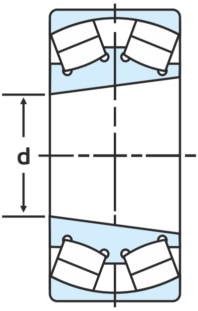
For values of e, Y_2 and Y_o see the table below.

e	Y_1	Y_2	Y_o	Bearing Number	Mass Kg. (Approx.)
0.36	1.9	2.8	1.8	24134K30 MB W33	24.5
0.30	2.2	3.3	2.2	23134 CC W33	21.4
0.30	2.2	3.3	2.2	23134K CC W33	19.1
0.35	1.9	2.9	1.9	23234K MB W33	35.3
0.35	1.9	2.9	1.9	23234 MB W33	37.3
0.36	1.9	2.8	1.8	22334E1 MB W33	63.2
0.35	1.9	2.9	1.9	23234 MB W33	39.0
0.35	1.9	2.9	1.9	23234K MB W33	38.95
0.35	1.9	2.9	1.9	23234 CC W33	37.0
0.36	1.9	2.8	1.8	22334E1 CC W33	58.5
0.35	1.9	2.9	1.9	22334 CA W33	60.0
0.36	1.9	2.8	1.8	22334 MB W33	61.5
0.36	1.9	2.8	1.8	22334K MB W33	59.3
0.25	2.7	4.0	2.6	23036 MB W33	17.5
0.25	2.7	4.0	2.6	23036K MB W33	16

Spherical Roller Bearing

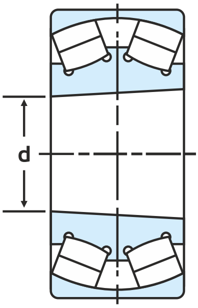


Cylindrical bore



Tapered bore (K) (1:12)

Boundary Dimensions				Basic Load Rating				Fatigue load limit
				Dynamic	Static	Dynamic	Static	
mm				KN		Kgf		KN
d	D	B	r	Cr	Cor	Cr	Cor	Cu
180	280	74	2.1	752.5	1300	76732	132551	123.5
180	280	74	2.1	752.5	1300	76732	132551	123.5
180	280	100	2.1	930	1700	94832	173349	161.5
180	320	86	4	940	1390	95852	141738	128.8
180	280	100	2.1	970	1770	98911	180487	168.1
180	300	96	3	1030	1730	105029	176408	162.2
180	300	96	3	1030	1730	105029	176408	162.2
180	320	86	4	1040	1610	106049	164172	149.2
180	300	96	3	1050	1750	107069	178448	164.1
180	320	112	4	1230	2030	125423	206999	188.1
180	320	112	4	1230	2130	125423	217196	197.3
180	300	118	3	1438	2201	146633	224436	206.4
180	380	126	4	1730	2560	176408	261043	229
180	380	126	4	1730	2560	176408	261043	229
180	280	100	2.1	970	1770	98911	180487	168
180	300	118	3	1110	1890	113187	192723	177



Tapered bore (K30)
(1:30)

Equivalent radial load
dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{F_r} \leqq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	Y_1	0.67	Y_2

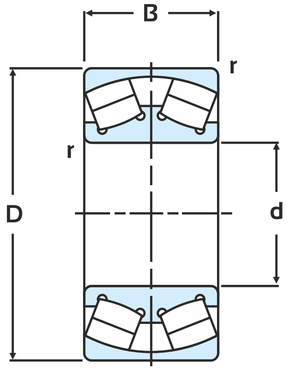
static

$P_{or} = F_r + Y_o F_a$

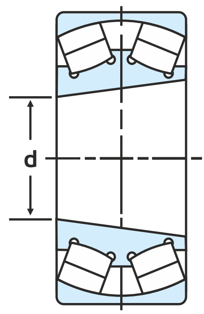
For values of e, Y_2 and Y_o see the table below.

e	Y_1	Y_2	Y_o	Bearing Number	Mass Kg. (Approx.)
0.24	2.8	4.2	2.7	23036 CC W33	17.2
0.24	2.8	4.2	2.7	23036K CC W33	16.8
0.35	1.9	2.9	1.9	24036 CA W33	23.5
0.28	2.4	3.6	2.3	22236 MB W33	30
0.33	2.0	3.0	2.0	24036K30 MB W33	22.5
0.33	2.0	3.0	2.0	23136 MB W33	26
0.33	2.0	3.0	2.0	23136K MB W33	25.9
0.28	2.4	3.6	2.3	22236K MB W33	28.1
0.30	2.3	3.4	2.2	23136K CA W33	26.64
0.35	1.9	2.9	1.9	23236 MB W33	39.4
0.35	1.9	2.9	1.9	23236K MB W33	36.2
0.38	1.8	2.7	1.7	24136 CC W33	33.5
0.36	1.9	2.8	1.9	22336K MB W33	69
0.36	1.9	2.8	1.9	22336 MB W33	70.5
0.35	1.9	2.9	1.9	24036 MB W33	22.9
0.39	1.7	2.5	1.7	24136 MB W33	33.4

Spherical Roller Bearing

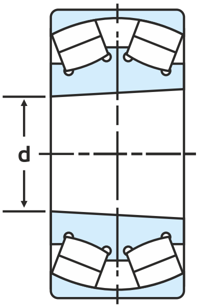


Cylindrical bore



Tapered bore (K)
(1:12)

Boundary Dimensions				Basic Load Rating				Fatigue load limit
				Dynamic	Static	Dynamic	Static	
mm				KN		Kgf		KN
d	D	B	r	Cr	Cor	Cr	Cor	Cu
180	300	118	3	1110	1890	113187	192723	177
190	290	75	2.1	657	1319	66994	134498	123.7
190	290	75	2.1	760	1350	77497	137660	126.6
190	290	75	2.1	760	1350	77497	137660	126.6
190	290	75	2.1	916	1355	93405	138169	127.1
190	340	92	4	1120	1680	114206	171310	152.9
190	340	92	4	1150	1820	117266	185585	165.7
190	320	104	3	1190	2020	121344	205979	186.0
190	320	104	3	1190	2020	121344	205979	186.0
190	320	128	3	1420	2480	144797	252886	228.4
190	340	120	4	1450	2370	147857	241669	215.8
190	340	120	4	1450	2350	147857	239630	213.9
190	320	128	3	1420	2480	144797	252886	228
200	310	82	2.1	910	1614	92793	164580	148.6
200	310	82	2.1	1038	1606	105845	163764	147.9
200	310	82	2.1	1038	1606	105845	163764	147.9



Tapered bore (K30)
(1:30)

Equivalent radial load
dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{F_r} \leqq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	Y_1	0.67	Y_2

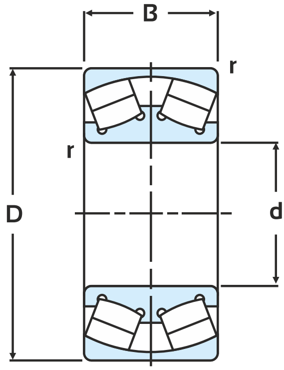
static

$P_{or} = F_r + Y_o F_a$

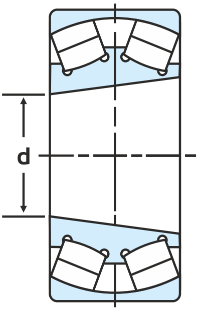
For values of e, Y_2 and Y_o see the table below.

e	Y_1	Y_2	Y_o	Bearing Number	Mass Kg. (Approx.)
0.39	1.7	2.5	1.7	24136K30 MB W33	32.9
0.23	2.9	4.3	2.9	23038 CC W33	17.6
0.23	2.9	4.4	2.9	23038 MB W33	18
0.23	2.9	4.4	2.9	23038K MB W33	17.5
0.23	2.9	4.3	2.8	23038K CC W33	17.4
0.28	2.4	3.6	2.4	22238 MB W33	37
0.27	2.5	3.7	2.4	22238K MB W33	35.6
0.33	2.1	3.1	2.0	23138 MB W33	35.1
0.33	2.1	3.1	2.0	23138K MB W33	34.7
0.39	1.7	2.6	1.7	24138 MB W33	41.6
0.35	1.9	2.9	1.9	23238 MB W33	48.1
0.35	1.9	2.9	1.9	23238K MB W33	47.6
0.39	1.7	2.6	1.7	24138K30 MB W33	41.2
0.25	2.7	4.0	2.6	23040 MB W33	23.7
0.24	2.8	4.2	2.7	23040 CC W33	23.1
0.24	2.8	4.2	2.7	23040K CC W33	22.3

Spherical Roller Bearing

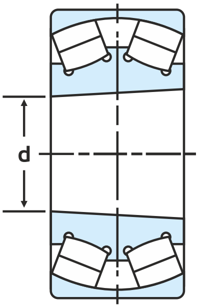


Cylindrical bore



Tapered bore (K)
(1:12)

Boundary Dimensions				Basic Load Rating				Fatigue load limit
				Dynamic	Static	Dynamic	Static	
mm				KN		Kgf		KN
d	D	B	r	Cr	Cor	Cr	Cor	Cu
200	310	109	2.1	1150	2150	117266	219236	198.0
200	360	98	4	1190	1810	121344	184566	162.1
200	360	98	4	1190	1810	121344	184566	162.1
200	310	109	2.1	1310	2090	133581	213117	192.5
200	340	112	3	1340	2220	136640	226373	201.0
200	340	112	3	1355	2280	138169	232492	206.4
200	360	98	4	1500	1950	152955	198842	174.6
200	360	98	4	1500	1950	152955	198842	174.6
200	360	128	4	1620	2630	165191	268181	235.5
200	360	128	4	1620	2640	165191	269201	236.4
200	420	138	5	2040	3050	208019	311009	264.9
200	420	138	5	2040	3050	208019	311009	264.9
200	310	82	2.1	878	1550	89530	158054	143
220	340	90	3	1100	1920	112167	195782	171.9
220	340	90	3	1100	1920	112167	195782	171.9
220	340	118	3	1355	2580	138169	263083	231.0



Tapered bore (K30)
(1:30)

Equivalent radial load
dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{F_r} \leqq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	Y_1	0.67	Y_2

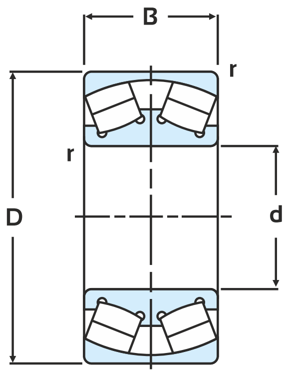
static

$P_{or} = F_r + Y_o F_a$

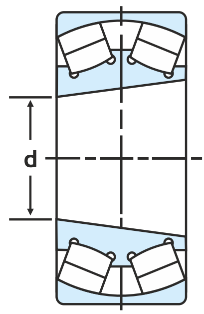
For values of e, Y_2 and Y_o see the table below.

e	Y_1	Y_2	Y_o	Bearing Number	Mass Kg. (Approx.)
0.33	2.0	3.0	2.0	24040K30 MB W33	30
0.28	2.4	3.6	2.4	22240 MB W33	44.5
0.28	2.4	3.6	2.4	22240K MB W33	44.0
0.34	2.0	2.9	1.9	24040 MB W33	30.4
0.32	2.1	3.2	2.1	23140K MB W33	42.0
0.32	2.1	3.2	2.1	23140 MB W33	42.5
0.26	2.6	3.9	2.5	22240K CC W33	42.2
0.26	2.6	3.9	2.5	22240 CC W33	42.7
0.35	1.9	2.8	1.9	23240 MB W33	57.9
0.35	1.9	2.8	1.9	23240K MB W33	57.4
0.35	1.9	2.9	1.9	22340 MB W33	94.5
0.35	1.9	2.9	1.9	22340K MB W33	90.3
0.25	2.7	4.1	2.7	23040K MB W33	22.6
0.25	2.7	4.1	2.7	23044 MB W33	30.1
0.25	2.7	4.1	2.7	23044K MB W33	30.95
0.33	2.1	3.1	2.0	24044K30 MB W33	38.6

Spherical Roller Bearing

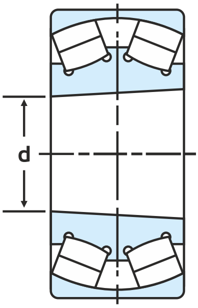


Cylindrical bore



Tapered bore (K) (1:12)

Boundary Dimensions				Basic Load Rating				Fatigue load limit
				Dynamic	Static	Dynamic	Static	
mm				KN		Kgf		KN
d	D	B	r	Cr	Cor	Cr	Cor	Cu
220	340	118	3	1355	2580	138169	263083	231.0
220	400	108	4	1835	2460	187115	250846	213.7
220	400	108	4	1835	2460	187115	250846	213.7
220	370	120	4	1520	2590	154994	264102	228
220	370	120	4	1520	2590	154994	264102	228
220	400	144	4	1870	3020	190684	307949	262
220	400	144	4	1870	3020	190684	307949	262
240	360	92	3	1130	2170	115226	221275	190.3
240	360	92	3	1130	2170	115226	221275	190.3
240	360	118	3	1370	2670	139699	272260	234.2
240	360	118	3	1370	2670	139699	272260	234.2
240	400	128	4	1730	3050	176408	311009	262.4
240	400	128	4	1770	3090	180487	315087	265.8
240	440	120	4	1900	3050	193743	311009	257.7
240	440	120	4	1900	3050	193743	311009	257.7
240	440	120	4	1940	3130	197822	319166	264.4



Tapered bore (K30)
(1:30)

Equivalent radial load
dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{F_r} \leqq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	Y_1	0.67	Y_2

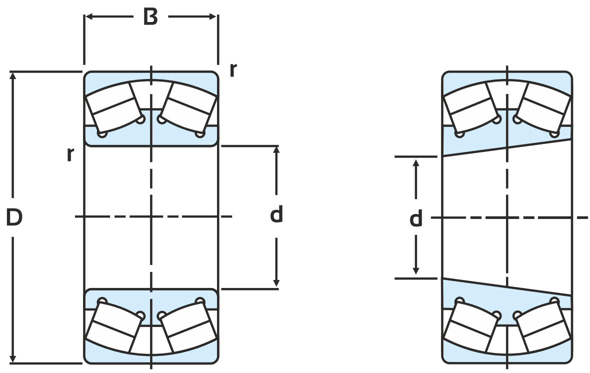
static

$P_{or} = F_r + Y_o F_a$

For values of e, Y_2 and Y_o see the table below.

e	Y_1	Y_2	Y_o	Bearing Number	Mass Kg. (Approx.)
0.33	2.1	3.1	2.0	24044 MB W33	39.3
0.27	2.5	3.7	2.4	22244 MB W33	62.0
0.27	2.5	3.7	2.4	22244K MB W33	59.0
0.32	2.1	3.1	2.1	23144 MB W33	52.7
0.32	2.1	3.1	2.1	23144K MB W33	51.1
0.37	1.8	2.7	1.8	23244 MB W33	79.2
0.37	1.8	2.7	1.8	23244K MB W33	78.0
0.25	2.7	4.0	2.7	23048K MB W33	33.5
0.25	2.7	4.0	2.7	23048 MB W33	33.7
0.31	2.2	3.2	2.1	24048K30 MB W33	40.0
0.31	2.2	3.2	2.1	24048 MB W33	42.0
0.30	2.2	3.3	2.2	23148K MB W33	64.6
0.30	2.2	3.3	2.2	23148 MB W33	67.0
0.27	2.5	3.7	2.4	22248 MB W33	83.0
0.27	2.5	3.7	2.4	22248K MB W33	82.6
0.27	2.5	3.7	2.5	22248 CC W33	81.4

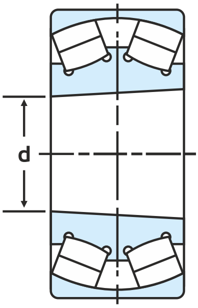
Spherical Roller Bearing



Cylindrical bore

Tapered bore (K)
(1:12)

Boundary Dimensions				Basic Load Rating				Fatigue load limit
				Dynamic	Static	Dynamic	Static	
mm				KN		Kgf		KN
d	D	B	r	Cr	Cor	Cr	Cor	Cu
240	440	120	4	1940	3130	197822	319166	264.4
240	400	128	4	2130	3240	217196	330383	278.7
240	400	128	4	2130	3240	217196	330383	278.7
240	440	160	4	2430	4100	247787	418077	346
240	440	160	4	2430	4100	247787	418077	346
260	360	75	2.1	976	1790	99523	182526	155.5
260	400	104	4	1400	2610	142758	266142	222.5
260	400	104	4	1450	2700	147857	275319	230.1
260	400	104	4	1671	2580	170392	263083	219.9
260	400	104	4	1671	2580	170392	263083	219.9
260	440	144	4	2120	3830	216176	390545	320.7
260	440	144	4	2120	3830	216176	390545	320.7
260	540	165	6	3200	4750	326304	484358	382.2
260	540	165	6	2880	4460	293674	454786	359
260	540	165	6	2880	4460	293674	454786	359
260	480	174	5	2610	4260	266142	434392	351



Tapered bore (K30)
(1:30)

Equivalent radial load
dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{F_r} \leqq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	Y_1	0.67	Y_2

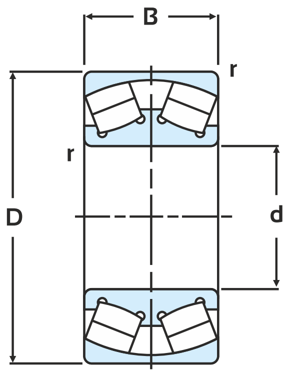
static

$P_{or} = F_r + Y_o F_a$

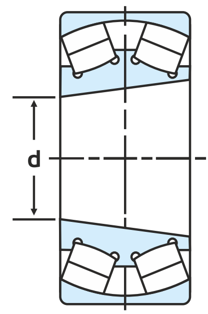
For values of e, Y_2 and Y_o see the table below.

e	Y_1	Y_2	Y_o	Bearing Number	Mass Kg. (Approx.)
0.27	2.5	3.7	2.5	22248K CC W33	79.9
0.30	2.3	3.4	2.2	23148 CC W33	62.2
0.30	2.3	3.4	2.2	23148K CC W33	61.8
0.36	1.9	2.8	1.9	23248 MB W33	110
0.36	1.9	2.8	1.9	23248K MB W33	107
0.18	3.8	5.6	3.8	23952 CA W33	22.9
0.24	2.8	4.2	2.7	23052K MB W33	45
0.24	2.8	4.2	2.7	23052 MB W33	47.2
0.23	2.9	4.3	2.8	23052 CC W33	47.2
0.23	2.9	4.3	2.8	23052K CC W33	46.4
0.32	2.1	3.2	2.1	23152K MB W33	92.0
0.32	2.1	3.2	2.1	23152 MB W33	94.0
0.31	2.1	3.2	2.1	22352 CC W33	181
0.34	2.0	2.9	2.0	22352 MB W33	186
0.34	2.0	2.9	2.0	22352K MB W33	182
0.37	1.8	2.7	1.8	23252 MB W33	139

Spherical Roller Bearing

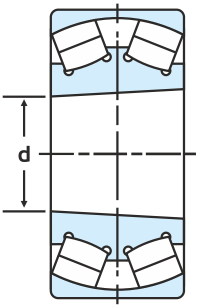


Cylindrical bore



Tapered bore (K)
(1:12)

Boundary Dimensions				Basic Load Rating				Fatigue load limit
				Dynamic	Static	Dynamic	Static	
mm				KN		Kgf		KN
d	D	B	r	Cr	Cor	Cr	Cor	Cu
260	480	174	5	2610	4260	266142	434392	351
260	400	140	4	1830	3550	186605	361994	303
260	400	140	4	1830	3550	186605	361994	303
280	420	106	4	1320	2850	134600	290615	238.7
280	420	106	4	1500	2800	152955	285516	234.5
280	420	106	4	1540	2950	157034	300812	247.1
280	460	146	5	2295	4150	234021	423176	341.8
280	460	146	5	2300	4250	234531	433373	350.0
280	500	130	5	2310	3800	235551	387486	308.1
280	500	130	5	2310	3800	235551	387486	308.1
280	460	180	5	2730	5200	278378	530244	428.3
280	460	180	5	2767	5308	282151	541257	437.2
280	500	176	5	2820	4790	287555	488436	388.3
280	500	176	5	2820	4790	287555	488436	388.3
280	580	175	6	3340	5080	340580	518008	400



Tapered bore (K30)
(1:30)

Equivalent radial load
dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{F_r} \leqq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	Y_1	0.67	Y_2

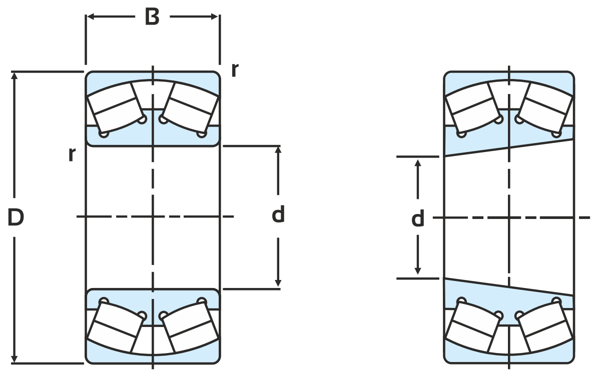
static

$P_{or} = F_r + Y_o F_a$

For values of e, Y_2 and Y_o see the table below.

e	Y_1	Y_2	Y_o	Bearing Number	Mass Kg. (Approx.)
0.37	1.8	2.7	1.8	23252K MB W33	135
0.33	2.0	3.0	2.0	24052 MB W33	65.4
0.33	2.0	3.0	2.0	24052K30 MB W33	64.3
0.24	2.9	4.3	2.8	23056 MB W33	52.5
0.24	2.9	4.3	2.8	23056K CA W33	54
0.23	2.9	4.3	2.8	23056K MB W33	49.8
0.30	2.3	3.4	2.2	23156K MB W33	96.2
0.30	2.3	3.4	2.2	23156E CA W33	97.5
0.26	2.6	3.8	2.5	22256 MB W33	113
0.26	2.6	3.8	2.5	22256K MB W33	111
0.40	1.7	2.5	1.6	24156E CC W33X	121
0.36	1.9	2.8	1.8	24156 CC W33	114
0.36	1.9	2.8	1.8	23256K MB W33	145
0.36	1.9	2.8	1.8	23256 MB W33	148
0.31	2.2	3.2	2.2	22356 MB W33	225

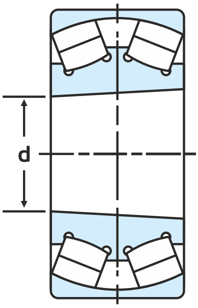
Spherical Roller Bearing



Cylindrical bore

Tapered bore (K) (1:12)

Boundary Dimensions				Basic Load Rating				Fatigue load limit
				Dynamic	Static	Dynamic	Static	
mm				KN		Kgf		KN
d	D	B	r	Cr	Cor	Cr	Cor	Cu
280	580	175	6	3340	5080	340580	518008	400
280	460	146	5	2295	4150	234021	423176	342
280	420	140	4	1800	3570	183546	364033	299
280	420	140	4	1800	3570	183546	364033	299
300	440	105	4	1450	2760	147857	281437	227.3
300	460	118	4	1840	3440	187625	350777	281.1
300	460	118	4	1890	3550	192723	361994	290.1
300	460	118	4	1890	3550	192723	361994	290.1
300	500	160	5	2720	4690	277358	478239	377.3
300	500	160	5	2720	4690	277358	478239	377.3
300	500	200	5	3300	6400	336501	652608	514.9
320	480	121	4	1940	3790	197822	386466	304.9
320	480	160	4	2511	5201	256047	530346	418.5
320	480	160	4	2892	5212	294897	531468	419.3
320	540	176	5	3650	5800	372191	591426	456.6
320	540	176	5	3650	5800	372191	591426	456.6



Tapered bore (K30)
(1:30)

Equivalent radial load
dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{F_r} \leqq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	Y_1	0.67	Y_2

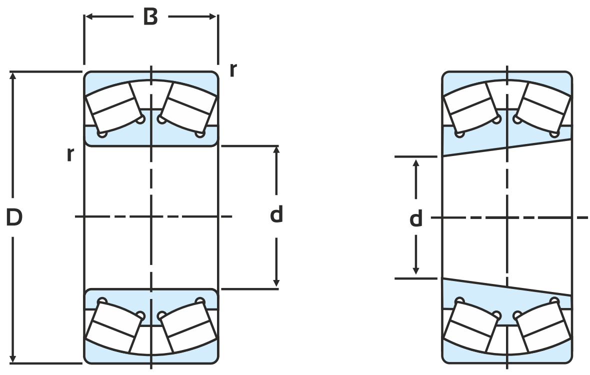
static

$P_{or} = F_r + Y_o F_a$

For values of e, Y_2 and Y_o see the table below.

e	Y_1	Y_2	Y_o	Bearing Number	Mass Kg. (Approx.)
0.31	2.2	3.2	2.2	22356K MB W33	221
0.30	2.3	3.4	2.3	23156 MB W33	99.3
0.32	2.1	3.2	2.1	24056 MB W33	67.8
0.32	2.1	3.2	2.1	24056K30 MB W33	66.7
0.21	3.2	4.7	3.1	3760	55
0.24	2.9	4.3	2.8	23060CK W33	70
0.24	2.9	4.3	2.8	23060K MB W33	70
0.24	2.9	4.3	2.8	23060 MB W33	72.5
0.31	2.2	3.3	2.2	23160K MB W33	127
0.31	2.2	3.3	2.2	23160 MB W33	131
0.40	1.7	2.5	1.7	24160E CC W33X	159
0.23	2.9	4.4	2.9	23064 CA W33	80.1
0.35	1.9	2.9	1.9	24064 CC W33	97.8
0.30	2.3	3.4	2.2	24064 CA W33	103.6
0.32	2.1	3.1	2.1	23164 MB W33	167
0.32	2.1	3.1	2.1	23164K MB W33	164

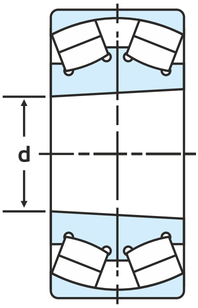
Spherical Roller Bearing



Cylindrical bore

Tapered bore (K) (1:12)

Boundary Dimensions				Basic Load Rating				Fatigue load limit
				Dynamic	Static	Dynamic	Static	
mm				KN		Kgf		KN
d	D	B	r	Cr	Cor	Cr	Cor	Cu
320	580	208	5	4000	7050	407880	718889	547.5
320	580	208	5	4000	7050	407880	718889	547.5
320	580	208	5	4050	7130	412979	727046	553.7
320	580	208	5	4050	7130	412979	727046	553.7
320	480	121	4	1900	3695	193743	376779	297
320	480	121	4	1900	3695	193743	376779	297
340	460	90	3	1290	2720	131541	277358	218.8
340	520	133	5	2310	4450	235551	453767	350.4
340	520	133	5	2310	4450	235551	453767	350.4
340	580	190	5	3600	6600	367092	673002	509.2
340	580	190	5	3600	6600	367092	673002	509.2
340	620	224	6	5128	7980	522851	813761	607.9
340	580	243	5	5168	8950	526981	912632	690.5
340	580	243	5	4620	8620	471101	878981	665
340	580	243	5	4620	8620	471101	878981	665



Tapered bore (K30)
(1:30)

Equivalent radial load
dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{F_r} \leqq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	Y_1	0.67	Y_2

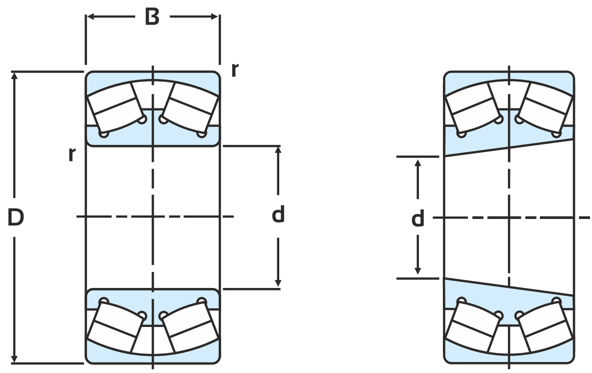
static

$P_{or} = F_r + Y_o F_a$

For values of e, Y_2 and Y_o see the table below.

e	Y_1	Y_2	Y_o	Bearing Number	Mass Kg. (Approx.)
0.36	1.9	2.8	1.8	23264 CA W33X	240
0.36	1.9	2.8	1.8	23264 CA W33	246
0.36	1.9	2.8	1.8	23264K MB W33	243
0.36	1.9	2.8	1.8	23264 MB W33	247
0.24	2.8	4.1	2.8	23064 MB W33	84.8
0.24	2.8	4.1	2.8	23064K MB W33	76.8
0.17	4.0	6.0	3.9	23968 CA W33	44
0.24	2.8	4.2	2.8	23068K MB W33	103
0.24	2.8	4.2	2.8	23068 MB W33	107
0.34	2.0	2.9	1.9	23168 MB W33	211
0.34	2.0	2.9	1.9	23168K MB W33	209
0.36	1.9	2.8	1.8	23268 CA W33	303.4
0.39	1.7	2.6	1.7	24168E CA W33	266.5
0.40	1.7	2.5	1.7	24168 MB W33	259
0.40	1.7	2.5	1.7	24168K30 MB W33	255

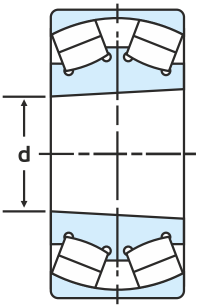
Spherical Roller Bearing



Cylindrical bore

Tapered bore (K) (1:12)

Boundary Dimensions				Basic Load Rating				Fatigue load limit
				Dynamic	Static	Dynamic	Static	
mm				KN		Kgf		KN
d	D	B	r	Cr	Cor	Cr	Cor	Cu
360	540	134	5	2370	4750	241669	484358	368.9
360	540	134	5	2370	4750	241669	484358	368.9
360	540	180	5	3100	6500	316107	662805	504.8
360	540	180	5	3200	6650	326304	678101	516.5
360	600	192	5	3650	6850	372191	698495	522
360	600	192	5	3650	6850	372191	698495	522
360	540	180	5	3200	6650	326304	678101	516
400	590	142	5	2450	5000	249827	509850	377.4
400	600	148	5	2980	6050	303871	616919	455.3
400	650	250	6	5100	10500	520047	1070685	778.6
420	760	272	7.5	6550	12100	667904	1233837	866.4
420	760	272	7.5	6550	12100	667904	1233837	866.4
440	720	226	6	5200	10100	530244	1029897	726.9
440	720	280	6	6450	13100	657707	1335807	942.8
440	720	280	6	6450	13100	657707	1335807	942.8
480	870	310	7.5	8350	15500	851450	1580535	1066



Tapered bore (K30)
(1:30)

Equivalent radial load
dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{F_r} \leqq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	Y_1	0.67	Y_2

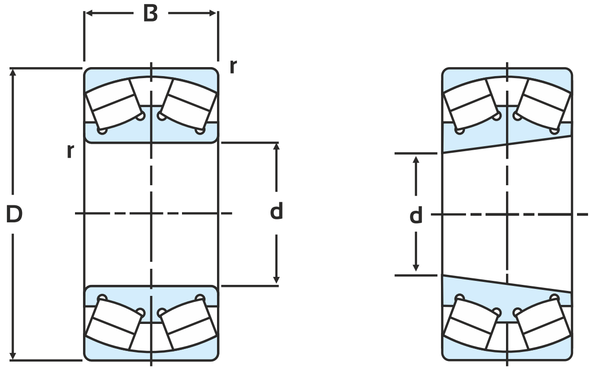
static

$P_{or} = F_r + Y_o F_a$

For values of e, Y_2 and Y_o see the table below.

e	Y_1	Y_2	Y_o	Bearing Number	Mass Kg. (Approx.)
0.22	3.1	4.5	3.0	23072 CC W33	110
0.22	3.1	4.5	3.0	23072K CC W33	107
0.36	1.9	2.8	1.8	24072 CA W33	145
0.31	2.2	3.3	2.2	24072 MB W33	147
0.31	2.2	3.2	2.2	23172 MB W33	227
0.31	2.2	3.2	2.2	23172K MB W33	220
0.36	1.9	2.8	1.9	24072K30 MB W33	145
0.22	3.1	4.6	3.0	3880	134
0.22	3.1	4.6	3.0	23080 CA W33	154
0.36	1.9	2.8	1.8	24180E CA W33	322
0.36	1.9	2.8	1.9	23284K MB W33	526
0.36	1.9	2.8	1.9	23284 MB W33	521
0.30	2.2	3.3	2.2	23188 CA W33	377
0.37	1.8	2.7	1.8	24188 MB W33	473
0.37	1.8	2.7	1.8	24188K30 MB W33	467
0.36	1.9	2.8	1.9	23296K MB W33	784

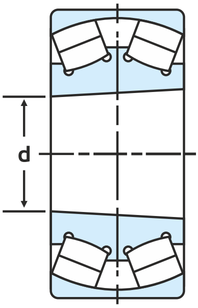
Spherical Roller Bearing



Cylindrical bore

Tapered bore (K) (1:12)

Boundary Dimensions				Basic Load Rating				Fatigue load limit
				Dynamic	Static	Dynamic	Static	
mm				KN		Kgf		KN
d	D	B	r	Cr	Cor	Cr	Cor	Cu
480	650	128	5	2875	5684	293164	579597	412.3
480	790	308	7.5	7450	15300	759677	1560141	1071.6
480	870	310	7.5	8300	15500	846351	1580535	1065.9
480	870	310	7.5	8350	15500	851450	1580535	1065.9
750	920	170	5	3600	11050	367092	1126769	712.9
850	1220	365	7.5	12700	31500	1295019	3212055	1905.5
850	1420	620	12	23300	49260	2375901	5023042	2898.6
1180	1420	180	6	5620	17200	573071	1753884	971.7



Tapered bore (K30)
(1:30)

Equivalent radial load
dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{F_r} \leq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	Y_1	0.67	Y_2

static

$P_{or} = F_r + Y_o F_a$

For values of e, Y_2 and Y_o see the table below.

e	Y_1	Y_2	Y_o	Bearing Number	Mass Kg. (Approx.)
0.18	3.8	5.6	3.7	23996 MB W33	125
0.38	1.8	2.7	1.7	24196E CA W33	587
0.36	1.9	2.8	1.8	23296 CA W33	820
0.36	1.9	2.8	1.8	23296 MB W33	808
0.16	4.2	6.2	4.1	40038/750 (248/750 MB W33)	245
0.27	2.5	3.7	2.5	40031/850 (240/850 CA W33)	1410
0.34	2.0	3.0	1.9	241/900K30 MB W33/AH241_900G_H	3480
0.10	6.4	9.6	6.3	238/1180 CA W33	565

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