1. TECHNICAL INFORMATION

1.1 BEARING HISTORY

Hundred of years ago, when man lacked strength and endurance to carry loads, such heavy loads to be transported were put on simple skids and dragged to the place of destination. The dragging heavy load on dry ground requires considerable force. These forces can be reduced by using lubricants between the sledge runners and the ground. This lubricant-probably water – was poured to reduce the friction and thereby reducing the volume of force. As the time passed on, these forces were further reduced when man learnt to insert wooden rollers between the ground and the object. THUS SLIDING MOTION WAS CONVERTED INTO ROLLING MOTION, which is the basic principle of bearing. However, things were not much changed for years, till the concept of BALL was conceived, as the application of rollers was not practical everywhere. In 17th century, stone balls were produced and were in use for variety of applications to minimize the friction. Since the stone balls were not suitable for many applications, cast iron balls were also produced, but that was also not suitable. In 19th century, the concept of steel balls was conceived and steel balls were produced. During this era, on lathe machines, balls of remarkable accuracy were cut off from a steel rod and the ends were machined to form a sphere. At the end of 19th century, balls manufactured by this method in England were within the tolerance of 0.025 to 0.050 mm. In the year 1883, Friedric Fischer, instrument maker in Scheweinfurt – W. Germany, after numerous experiments, developed a method of grinding wheel balls, turned between the centers on the centre less principle. For this purpose, he designed ball grinding machine called "BALL MILL". In 1898 taper roller bearing unit developed in USA by H. Timken. During 1913-1914 Roller bearings were put on use.

1.2 GENERAL

The choice of a bearing depends on many factors that need to be examined in order to obtain the most successful results at the lowest cost.
In most cases the selection should be made when the overall design of the machine has been decided. Dimensional limits are then known, as well as the speeds and loads. At this stage the choice can be made from the many types of bearings offered from the Galaxy Bearing Ltd. standard ranges and the notes given in this section will generally permit selection of the most suitable bearing for each application. When calculating the cost of the

assembly, not only should the price of the bearing be considered, but also cost for heat treatment, machining and handling and fitting of ancillary items (snap rings, locking devices, tools etc.) and the eventual quantities required. Large economies can be made on these items if the correct bearings are selected. Something it is more advantageous to choose a bearing of slightly higher cost, which will however, when all criteria are taken into consideration, provide the most economic solution. The result obtained from bearings depends to a large extent on the design and method of assembly, loading, and alignment between inner and outer rings. The introduction of 'Anti-friction' or 'Rolling Contact Bearing' proved far superior to plain Bearings because of their classic advantages, Such as

- Low friction – particularly low starting friction.
- Their ability to support both radial and thrust load and speed.
- Accurate performance under changing load and speed.
- High load carrying capacity.
- Operating ability under extreme conditions of speed and temperature.

These bearings vary in size, from 'tiny pin-head' to 'giant sized' Bearings for Cement/Rolling Mills/Radars etc.

Bearings are so widely used that today, we find their application in objects like the charkha, chairs, doors, filling-cabinets, children's toys, as well as in the most sensitive instruments like computers, data processing machines, rockets and aerospace instruments.

1. 3 BEARING STANDARDS

Galaxy Bearing Ltd standard metric and Inch bearings conforms to International standards (ISO) for boundary dimensions, tolerances and internal clearances. They also comply with the associated DIN, AFBMA AND British Standards. Galaxy Bearing Ltd has comprehensive specifications for materials, heat treatment and quality control to ensure high precision products made from clean bearings steels.

1. 4 MATERIAL

The process of manufacturing Bearing Steel does not start at a Bearing Plant but at the steel mill. The SAE-52100 standard Bearing Steel contains varying amount of carbon, iron, chromium, manganese, phosphorus, sulphur, silicon, etc. Each of these elements plays a vital role in making the final steel suitable for Bearings. Chromium and carbon allow deep hardening. Where as the combination of Carbon, Chromium and Iron helps to minimize Bearing failures as they increase the surface resistance to abrasion and wear & tear. A proper combination of all these elements make the final Bearing Steel tough enough to withstand shocks & heavy loads and hard enough to resist fatigue.

Generally Bearings are made from tubes or bars, but nowadays, many Bearings manufacturers are inclined to make Bearings from forged rings. Large-sized Bearings are manufactured from forged rings. It is filet that Forged Bearing Rings have makes them more durable.

ROLLING ELEMENTS, CAGES SHIELD AND SEALS.

Moreover, balls characteristically minimize the friction to a greater extent than any other rolling elements. This is why 'Ball Bearings' are more versatile than any other type of Bearings. Other rolling elements used in Bearings are Cylindrical Rollers, Taper Rollers, and Spherical Rollers, Needle rollers, Concave Rollers and a combination of Ball & Needle etc.

Basically, every Anti-friction Bearing consists of four basic parts, an outer ring, rolling element and a cage.

The cages are made in various designs and out of various materials, But there are two main types of cages:-

- Pressed Steel Cage made from Strip Steel and
- Turning & Drilling Machine Cage made from Carbon Steel.

The cages keep rolling elements properly spaced out between two rings. The cage may be of steel, brass, etc. depending upon the type and application of the Bearings. Rolling elements can be balls, cylindrical rollers, spherical rollers or taper rollers. Standard bearings are made using high quality carbon-chrome through hardening steel of similar composition of the following specifications: SAE 52100 OR 100Cr6

1.5 SELECTION OF BEARINGS

1. After knowing all about bearings the important thing is the proper selection of bearing for any moving vehicle or machine.
2. The selection of ball & roller bearings for a given installation depends upon the following factors.

- The load carrying capacity & the nature of the load.

- The type of service under given conditions such as temperature, humidity, dustiness, acidity, etc.
- The anticipated life of the bearing.
- Magnitude and direction of loads.
- The proportion of thrust to radial load.

3. Cylindrical Roller Bearings are suitable for those shafts which have been allowed to move freely longitudinally within certain limits, and for far larger and heavily loaded applications.

- Taper Roller Bearings are suitable where radial and thrust loads or any combination of both are required to be handled and in dealing with heavy composite loads as in case of automobile parts.
- In very high speed spindles and machines only, bearings with precision tolerances are used.

4. The capacity of the bearings decreases as the speed increases. If a bearing operates continuously, its life expectancy measured in hours will obviously be shorter than if operated intermittently. Some types of bearings can carry only radial loads or thrust loads while some types of bearings can carry both radial as well as thrust loads. So if a bearing which can carry only thrust loads is put under radial loads, it will either break or damage the machine into which it is fitted. So, a proper selection is necessary. One major cause for bearing failure depends on selection of bearings.

In short the proper selection of bearings is most essential and will ensure the longer life of the bearings as well as the life of the machine in which it is used.

If the bearing loads with its directions of the ratio of radial and thrust capacity and speed is accurately determined, its life span can also be established. The necessary bearings size can also be determined. However the selection is so complex that general rules can hardly be drawn up.

1.6 CALCULATION FOR RADIAL ROLLING BEARINGS

The calculations for radial rolling bearings must take account of the following principal factors:

- Actual supported loads and possible shock loads
- Speed of rotation
- Operating temperature
- Hardness of the bearing raceways

Other features such as lubrication, sealing and alignment do not enter directly into life calculations but they must be considered in order to avoid introducing unfavorable factors.

The life calculation of a radial bearing or a thrust bearing under rotation is established from the dynamic capacity C indicated in the tables of dimensions. The static capacity Co enables one to determine the maximum load under certain conditions.

1.6.1 DYNAMIC CAPACITY C

The dynamic capacity of a bearing is the constant radial load which it can support during 1 000 000 revolutions before the first signs of fatigue appear on a bearing race or rolling element.

1.6.2 NOMINAL LIFE

The life of a radial bearing is the number of revolutions (or the number of hours at constant speed) that it will maintain before showing the first signs of material fatigue.

The relationship between the life is millions of revolutions L_{10}, the dynamic capacity C and the supported load P, is given by the formula:

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

In which :

L_{10}	-	Basic rating life (10^6 Revolutions)
C	-	Basic dynamic load rating (Newton)
P	-	Equivalent dynamic load (Newton)
P	-	is equal to 10/3 for needle or roller bearings and 3 for ball bearings.

The formula above is independent of speed of rotation, which must not exceed the recommended limit in respect of the radial bearing or the thrust bearing used and the method of lubrication.

If the speed of rotation n (rpm) is constant, the life is given in hours by the function:

$L_{10\,h} = (L_{10} \times 10^6)/60\,n$ hours

The life in hours is then inversely proportional to the speed.

The above formulae will ensure that 90% of the bearings operating under the same conditions will attain at least the calculated L_{10} life, known as the nominal life (the figure being the percentage of bearings which may not attain this life). The formulae are based on the use of standard quality bearing steel and assume a satisfactory method of lubrication.

1.6.3 MODIFIEDL LIFE L_{na}

In various conditions modified life can be determined (in millions of revolutions) following the general formula:

$$L_{na} = a_1 a_2 a_3 L_{10}$$

Lna = adjusted rating life, millions of revolutions

In which a1, a2 and a3 are correction factors linked to reliability, material and lubrication respectively.

1.6.4 Reliability correction factor a_1

A reliability factor in excess of 90% may be required in certain industries, such as aviation, for reasons of security and to reduce the risk of very costly immobilization.

The table below indicates the values of the correction factor a1 as a function of reliability:

Reliability %	**Factor a1**	**Corrected Life L_{na1}**
90	1	L_{10}
95	0.62	L_5
96	0.53	L_4
97	0.44	L_3
98	0.33	L_2
99	0.21	L_1

In order to select as an example a bearing of L_4 life (reliability 96%) it is necessary to consider a theoretical L_{10} life (reliability 90%), equal to $L_4/0.53$ applied in the formula $L_{10} = (C/P)^p$ using the dynamic capacity C given in this catalogue.

1.6.5 EQUIVALENT LOAD AND SPEEDS

1.6.5.1 Overload factors

The load on a radial or thrust bearing is established from the characteristics of the machine together with the working loads prevailing. However, account should also be taken as far as possible of the supplementary loads which arises due to imperfections in transmission, etc. or due to overloads, shocks and vibration. For

conventional machines and equipment experience is the best guide but in general the coefficients listed below may be applied to determine the equivalent load used in the life calculations:
– 1.2 machinery or mechanisms operating smoothly without repeated shocks,
– 1.3 geared transmissions according to gear quality,
1.4 – 3.0 machinery or equipment operating under repeated shocks or vibration.
As far as belt drive transmissions are considered, the calculated tangential load should be multiplied by the following coefficients:
2.0 – 2.5 for v belts,
2.5– 5.0 for flat belts according to drive tension.

1.6.5.2 Variable loads and speeds

When the loads and speeds are variable, the life calculation can only be made by first establishing an assumed constant load and constant speed equivalent in their effect on the fatigue life of the radial bearing.

This type of operating condition is frequently met and the possible variations although cyclical are numerous. One encounters this feature in particular, in variable speed drives.

1.7 LUBRICATION

Lubrication of the bearing has got such a great importance, as raw material from which from which they are made. Anticipated life of the bearing largely depends on the quality and quantity of the lubricant and its method of application. Rare lubrication and improper lubrication of a bearing result in the reduced bearing life and its premature failure. It is therefore, very essential to make a proper choice of lubricant.
The advantages derived from the correct choice of lubricant are:

1. It protects the bearing from corrosion.
2. It protects the bearing to a certain extent, from the entrance of foreign matter in to the bearing.
3. It minimizes the friction between the races and rolling elements.
4. It reduces the friction arising due to elastic deformation of rolling elements when under load.
5. It facilities the smooth running of bearing by minimizing noise.
6. It creates the lubricant film on the raceway of the bearing and thereby protects the raceway from blows of the rolling elements.
7. It dissipates the heat from the bearing and also helps distribute uniformly the frictional heat throughout bearing, which is generated during operation.

8. Power losses can be saved, as internal friction can be prevented.
9. It also helps the bearing to attain the required speed.
10. It helps to attain the anticipated life of the bearing.

There are TWO types of lubricants used for bearing lubrication. OIL and GREASE

1.7.1 OIL

Oil lubrication is considered to be the most efficient than Grease, provided proper sealing methods are employed to prevent the leakage. Only highly refined OIL should be used as bearing lubricant.
OIL is preferred when…

1. Bearing speed is very high.
2. Operating temperature is consistently high.
3. Sealing methods can be easily employed.
4. Bearing application demands that Grease is not suitable.

Then during operational condition, most of the lubricant will be forced out of the bearing which can never come back into the bearing, and such lubricant is not suitable for reuse.

1.7.2 GREASE

For many applications, grease is considered to be more convenient than oil. Grease used as lubricant should be of smooth texture and non-fibrous. It must be free from chemically or mechanically active ingredients. For bearing lubricants, general-purpose sodium-soap petroleum grease is preferred. It is suitable for variety of speed and temperature conditions and has rust preventive character under humid conditions.

For specific working conditions and operational requirements special type of Greases are used which are…

1. Lithium soap petroleum oil grease.
2. Lithium soap di-ester grease.
3. Lithium soap silicon grease.
4. Special quality grease to withstand temperature conditions from minus 20^0 to 300^0 F.

Generally Grease lubrication is preferred when…

1. Temperature is not excessive (Not over 200 F).
2. Speeds are moderate.
3. Extra protection from Dirt, Fumes, and other foreign matter is required.
4. Long time operations without maintenance are the requirement.

1.7.3 SELECTION OF LUBRICANT

1. For small size bearing operating at high speed, low viscosity oil is used.
2. Large bearings carrying heavy loads, lubricant with higher viscosity and additional adhesive properties may be used.

3. For any application, the lubricant must have sufficient lubricating capacity at prevailing temperature.
4. It must from a load sustaining lubricating film for prevailing load conditions.
5. It must have the capacity to absorb water to a certain extent, without affecting the lubricating capacity, wherever the application demands.

Thus one should ascertain the correct type of lubricant, which is suitable for operating conditions. When the lubricant quantity is inadequate, it results in the cage failure, and inadequate lubrication may heat up cage, may breakdown the ball pocket, and progressively break the whole cage. Even non-metallic cage also becomes brittle, dry and crack apart under heat and stress. Due to break down of the lubricating film on raceway and rolling element surfaces, they may also develop scoring marks, gradually resulting in bearing failure. This condition may also result in the deformation of parts, and when the bearing with deformed parts rotate under load, it will have sliding motion instead of rolling motion, and it ends up in bearing failure. Normally a medium size bearing running at the speed of 2000-6000 RPM can be sufficient lubricated with only few drops of oil per hour.

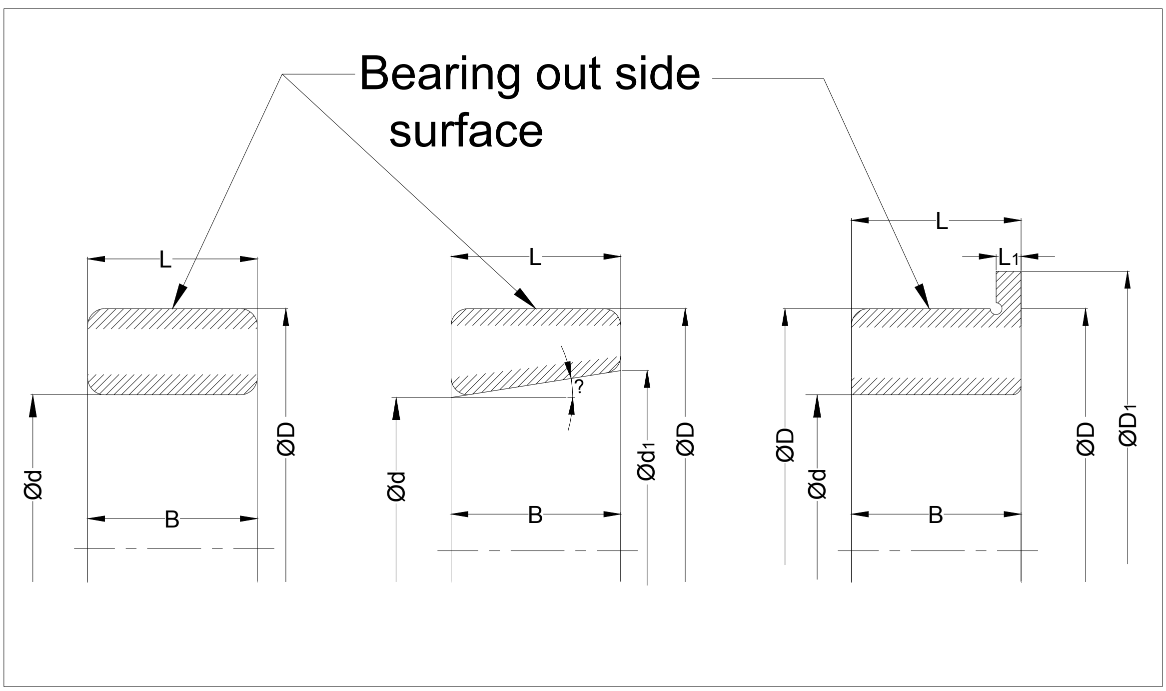
1.8 BEARING TOLERANCES

1.8.1 SYMBOLS

GBL tolerances for bearings conform to values for normal class bearings to ISO Standards. Bearings of other tolerance classes (closer tolerances) can be supplied at extra cost provided the quantity is sufficient.

d	=	bearing bore diameter, nominal
d_1	=	basic diameter at the theoretical large end of a basically tapered bore
Δd_s	=	deviation of a single bore diameter
Δd_{mp}	=	single plane mean bore diameter deviation
Δd_{1mp}	=	mean bore diameter deviations at the theoretical large end of a basically tapered bore
V_{dp}	=	bore diameter variation in a single radial plane
V_{dmp}	=	mean bore diameter variation
D	=	bearing outside diameter, nominal
D_1	=	outside diameter of outer ring flange
ΔD_s	=	deviation of a single outside diameter
ΔD_{1s}	=	deviation of a single outside diameter of outer ring flange.
ΔD_{mp}	=	single plane mean outside diameter deviation
V_{DP}	=	outside diameter variation in a single radial plane
V_{DMP}	=	mean outside diameter variation
B	=	Inner ring width, nominal
ΔB_s	=	deviation of a single width of inner ring
V_{BS}	=	Inner ring width variation
C	=	outer ring width, nominal
C_1	=	outer ring flange width
ΔC_s	=	deviation of a single width of outer ring
ΔC_{1s}	=	deviation of a single width of outer ring flange
V_{CS}	=	outer ring width variation

VC_{1S} = variation of outer ring flange width
K_{ia} = radial run out of assembled bearing inner ring
K_{ea} = radial run out of assembled bearing outer ring
S_d = runout of inner ring reference face (back face, where applicable) with respect to the bore
S_D = variation of outer ring outside surface generatrix inclination with respect to the outer ring reference face (back face)
S_{D1} = variation of outer ring outside surface generatrix inclination with respect to the outer ring flange back face
S_{ia} = runout of inner ring face (back face) with respect to the raceway of assembled bearing
S_{ea} = runout of outer ring face (back face) with respect to the raceway of assembled bearing
S_{ea1} = runout of outer ring flange back face with respect to the raceway of assembled bearing
‘α = taper angle (half the cone angle) of inner ring bore



1.8.2 ADDITIONAL SYMBOLS FOR TAPERED ROLLER BEARINGS

T = bearing width
ΔT_s = deviation of the actual bearing width
T_1 = effective inner subunit width
ΔT_{1s} = deviation of the actual effective inner subunit width
T_2 = effective outer subunit width
ΔT_{2s} = deviation of the actual bearing width

1.8.3 NORMAL TOLERANCE CLASS

(Radial bearings except tapered roller bearings)

Bore diameter tolerances given in the table apply basically to cylindrical bores.

Inner ring (Tolerance values in micrometers)

d mm		**Δ_{dmp}**		**V_{dp} Dia series**			**V_{dmp}**	**K_{ia}**	**ΔB_s**		**V_{BS}**
				7,8,9	**0,1**	**2,3,4**					
Over	**Incl**	**High**	**Low**	**Max**			**Max**	**Max**	**High**	**Low**	**max**
2.5	**10**	**0**	**-8**	**10**	**8**	**6**	**6**	**10**	**0**	**-120**	**15**
10	**18**	**0**	**-8**	**10**	**8**	**6**	**6**	**10**	**0**	**-120**	**20**
18	**30**	**0**	**-10**	**13**	**10**	**8**	**8**	**13**	**0**	**-120**	**20**
30	**50**	**0**	**-12**	**15**	**12**	**9**	**9**	**15**	**0**	**-120**	**20**
50	**80**	**0**	**-15**	**19**	**19**	**11**	**11**	**20**	**0**	**-150**	**25**
80	**120**	**0**	**-20**	**25**	**25**	**15**	**15**	**25**	**0**	**-200**	**25**
120	**180**	**0**	**-25**	**31**	**31**	**19**	**19**	**30**	**0**	**-250**	**30**

Outer ring (Tolerance values in micrometers)

D mm		**Δ_{Dmp}**		**V_{DP} Dia series**			**V_{DMP}**	**K_{ea}**	**ΔC_a**		**V_{cs}**
				7,8,9	**0,1**	**2,3,4**					
Over	**Incl**	**High**	**Low**	**Max**			**Max**	**Max**	**High**	**Low**	**max**
6	**18**	**0**	**-8**	**10**	**8**	**6**	**6**	**15**	**Identical to ΔB_S and V_{BS} of inner ring of same bearing.**		
18	**30**	**0**	**-9**	**12**	**9**	**7**	**7**	**15**			
30	**50**	**0**	**-11**	**14**	**11**	**8**	**8**	**20**			
50	**80**	**0**	**-13**	**16**	**13**	**10**	**10**	**25**			
80	**120**	**0**	**-15**	**19**	**19**	**11**	**11**	**35**			
120	**150**	**0**	**-18**	**23**	**23**	**14**	**14**	**40**			
150	**180**	**0**	**-25**	**31**	**31**	**19**	**19**	**45**			
180	**250**	**0**	**-30**	**38**	**38**	**23**	**23**	**50**			

1.8.4 NORMAL TOLERANCE CLASS

(Tapered roller bearings)

Inner Ring

d mm		Δ_{dmp}		V_{dp}	V_{dmp}	K_{ia}
Over	Incl	High	Low	Max	Max	Max

10	18	0	-12	12	9	15
18	30	0	-12	12	9	18
30	50	0	-12	12	9	20.
50	80	0	-15	15	11	25
80	120	0	-20	20	15	30
120	180	0	-25	25	19	35

Outer Ring

D mm		Δ_{Dmp}		V_{Dp}	V_{Dmp}	K_{ea}
Over	Incl	High	Low	Max	Max	Max
18	30	0	-12	12	9	18
30	50	0	-14	14	11	20
50	80	0	-16	16	12	25
80	120	0	-18	18	14	35
120	150	0	-20	20	15	40
150	180	0	-25	25	19	45
180	250	0	-30	30	23	50

Width – Inner and outer rings, single row bearings and single row subunits

Tolerance values in micrometers

d mm		ΔB_s		ΔC_s		ΔT_s		ΔT_{1s}		ΔT_{2s}	
over	incl	High	Low	high	low	high	low	high	low	high	low
10	18	0	-120	0	-120	+200	0	+100	0	+100	0
18	30	.0	-120	0	-120	+200	0	+100	0	+100	0
30	50	0	-120	0	-120	+200	0	+100	0	+100	0
50	80	0	-150	0	-150	+200	0	+100	0	+100	0
80	120	0	-200	0	-200	+200	-200	+100	-100	+100	-100
120	180	0	-250	0	-250	+350	-250	+150	-150	+200	-100
180	250	0	-300	0	-300	+350	-250	+150	-150	+200	-100

1.8.5 TOLERANCES FOR TAPERED ROLLER BEARINGS (INCH SERIES):

Tolerance values in microns

Inner Ring					Tolerances for inner ring width (ΔB_s)		Tolerances for outer ring width (ΔC_s)		Assembled bearings		Outer Ring				
Tolerances for bore dia. and running accuracy									Tolerances for actual bearing width (ΔT_s)		Tolerances for OD and running accuracy				
Nominal bore diameter d (mm)		Δ_{dmp}		Radial runout (Kie)							Nominal outside diameter D (mm)		Normal class (Δ_{Dmp})		Radial runout (Kea)
over	Incl.	high	low	Max.	high	low	high	low	high	low	over	incl	high	low	Max.
-	76.200	+13	0	51	+76	-254	+51	-254	+203	0	-	304.800	+25	0	51

76.200	266.700	+25	0	51					+356	-254						

1.8.6 TAPERED BORE TOLERANCES – NORMAL TOLERANCE CLASS

Basically tapered bores, tapers 1:12 and 1:30

a) For taper 1:12

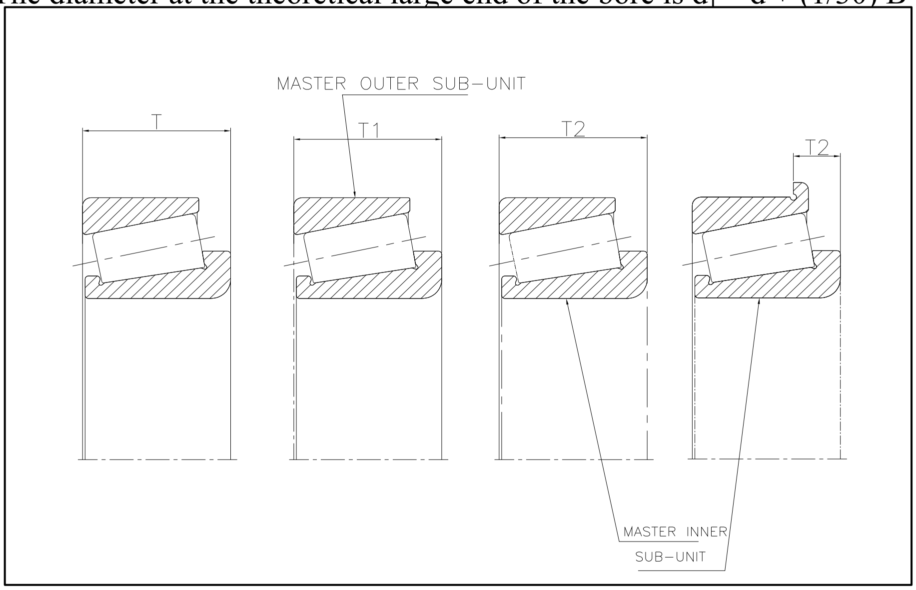
The taper angle (half the cone angle) is $\alpha = 2° 23' 9.4'' = 2.385\ 94° = 0.041\ 643$ rad

The diameter at the theoretical large end of the bore is $d_1 = d + (1/12)\ B$

b) For taper 1:30

The taper angle (half the cone angle) is $\alpha = 0° 57' 17.4'' = 0.954\ 84° = 0.016\ 665$ rad

The diameter at the theoretical large end of the bore is $d_1 = d + (1/30)\ B$



The tolerances for a tapered bore comprise:

- A mean diameter tolerance, given by limits for the mean diameter deviation at the theoretical small end of the bore Δd_{mp} ;
- A taper tolerance, given by limits for the difference between the mean diameter deviations at the two ends of the bore, $\Delta d_{1mp} - \Delta_{dmp}$;
- A tolerance for the diameter variation, $V_{dp,}$ given by a maximum value applying in any radial plane of the bore.

Tapered bore, taper 1:12 Tolerance values in micrometers

d mm		Δ_{dmp}		V_{dp}	$\Delta d_{1mp} - \Delta_{dmp}$	
over	Incl	High	low	max	high	low
18	30	+21	0	13	+21	0
30	50	+25	0	15	+25	0
50	80	+30	0	19	+30	0
80	120	+35	0	25	+35	0

120	180	+40	0	31	+40	0

Tapered bore, taper 1:30   Tolerance values in micrometers

d mm		Δ_{dmp}		V_{dp}	$\Delta d_{1mp} - \Delta_{dmp}$	
over	Incl	High	low	max	high	low
80	120	+20	0	25	+40	0
120	180	+25	0	31	+50	0
180	250	+30	0	38	+55	0

1.9 CHAMFER DIMENSION LIMITS

Limit dimensions of chamfar

Symbol

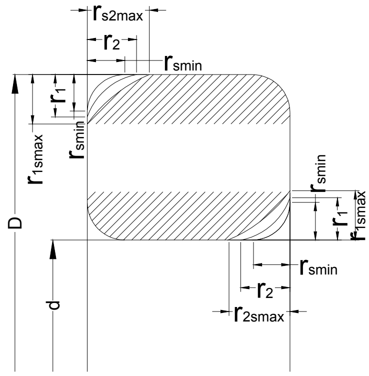
r_1, r_3 Chamfar in radial direction

r_2, r_4 Chamfar in axial direction

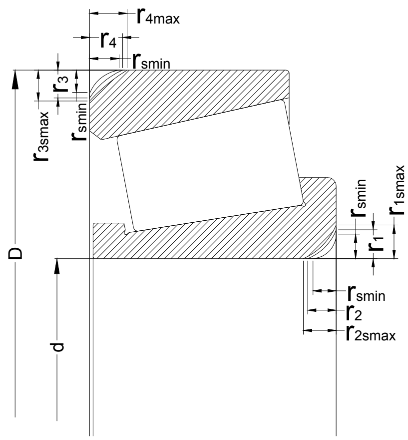
r_{smin} General symbol for the minimum chamfar r_{1smin},r_{2smin},r_{3smin},r_{4smin}

r_{1smax}, r_{3smax} maximum chamfar in radial direction

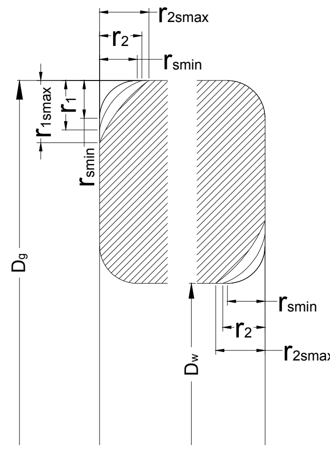
r_{2smax}, r_{4smax} maximum chamfar in axial direction



r_{s2max}
r_2
r_{smin}
r_1
r_{1smax}
r_{smin}
D
d
r_{smin}
r_1
r_{1smax}
r_{smin}
r_2
r_{2smax}



r_{4max}
r_4
r_{smin}
r_3
r_{3smax}
r_{smin}
D
d
r_{smin}
r_{1smax}
r_1
r_{smin}
r_2
r_{2smax}



r_{2smax}
r_2
r_{smin}
r_{1smax}
r_1
r_{smin}
D_g
D_w
r_{smin}
r_2
r_{2smax}

Chamfar of radial bearings

Dimension in mm

rsmin	0,1	0,15	0,2	0,3		0,6		1		1,1		1,5		2		
Nominal diameter over					40		40		50		120		120		80	220
Nominal diameter to				40		40		50		120		120		80	220	
r1max	0.2	0.3	0.5	0.6	0.8	1	1.3	1.5	1.9	2	2.5	2.3	3	3	3.5	3.8
r1max	0.4	0.6	0.8	1	1	2	2	3	3	3.5	4	4	5	4.5	5	6

rsmin	2,1		2,5			3		4	5	6	7,5	9,5	12	15	19
Nominal diameter over		280		100	280		280								
Nominal diameter to	280		100	280		280									
r1max	4	4.5	3.8	4.5	5	5	5.5	6.5	8	10	12.5	15	18	21	25
r1max	6.5	7	6	6	7	8	8	9	10	13	17	19	24	30	38

Cup

Dimension in mm

r_{smin}	0,3		0,6		1		1,5			2			2,5			3				4				5		6	
Nominal over outside diameter D		40		40		50		120	250		120	250		120	250		120	250	400		120	250	400		180		180
	40		40		50		120	250		120	250		120	250		120	250	400		120	250	400		180		180	
r_{3max}	0.7	0.9	1.1	1.3	1.6	1.9	2.3	2.8	3.5	2.8	3.5	4	3.5	4	4.5	4	4.5	5	5.5	5	5.5	6	6.5	6.5	7.5	7.5	9
r_{4max}	1.4	1.6	1.7	2	2.5	3	3	3.5	4	4	4.5	5	5	5.5	6	5.5	6.5	7	7.5	7	7.5	8	8.5	8	9	10	11

2. BEARING MOUNTINGS

Bearing is a precision machine member and is very sensitive to improper treatment. Therefore, while mounting the bearing, utmost care is necessary:

1. Mounting of a bearing should be done in clean, dry, dust free room.
2. While mounting, never remove the preservative coating of thee bearing.
3. If the bearing becomes DIRTY, then clean it with suitable solvents.
4. Never wash NEW bearing with kerosene etc. before mounting.
5. Never remove bearing from its packing, till it is ready for mounting.
6. Bearing seating and other components should be thoroughly cleaned.
7. Check thoroughly dimensional and form accuracy of seating and shaft.
8. Prescribed FITS must be maintained on the shaft and housing.
9. While mounting the smaller bearing onto the shaft, transmit the force thru inner ring only and NOT thru outer ring or thru cage.
10. While mounting the bearing in the housing, force must be transmitted through outer ring only and not thru inner ring or the cage.
11. Never blow hammer directly on thee bearing. Instead, use a suitable size of mounting bush thru which uniform force can be transmitted over the entire ring surface.

12. For mounting the large size bearing it is preferable to heat the bearing up to 80^0 to 100^0 C. While heating the bearing, make sure that accurate temperature control is maintained, because excessive heat may cause the reduction in the hardness of the bearing.

Oil bath, Hot plate, Temperature controlled electric oven etc. are suitable means to heat the bearing. At last see that mounting of the bearing is done by a skilled person, who has through knowledge of the job procedures, tools, knowledge of the force to be applied etc. Any ignorance of these factors may result in damage of the bearing and reduced service life. Experience shows that the amount of shrinkage required for easy fitting is barely depending upon the interference fit tolerance.

As a general rule, the following temperature value can be used.

Bore	Temperature
Below 100 mm	90^0 C (195^0 F)
From 100 mm to 150 mm	120^0 C (250^0 F)
Above 150 mm	130^0 C (265^0 F)

2.1 HOW TO PREPARE ROLLING BEARING FOR MOUNTING

2.1.1 Working Planning

Know in advance what you are going to do so that the mounting work can proceed in a straightforward manner. Study the shop drawing to acquaint you with the design details of the application and the assembly sequence. Phase the individual operations and get reliable information on heating temperatures, mounting forces and the type and the amount of greases to be packed into the bearing. Whenever the installation and removal of rolling bearing necessitates special measures the fitter should be provided with comprehensive instructions on mounting details, including topics such as the means of transport for the bearing, the mounting equipment, measuring devices, heating facilities and type and quantity of lubricant.

2.1.2 Before starting mounting

Before starting mounting the fitter should satisfy himself that bearing number stamped on the package agrees with the designation given on the drawing and in part list. He should therefore be familiar with the bearing numbering and identification system.

2.1.3 Handling of rolling bearings before mounting:

Before being packed, the bearings are coated with preservative oil, which prevents corrosion. The oil does not need to be washed out when mounting the bearing. In service, the oil combines with the bearing lubricant. Do not perform any modifications on the bearings. Subsequent drilling of lubricating holes, machining of grooves, flats and the like will disturb the stress distributions in the ring resulting in premature bearing failure. There is also the risk of chips or grit entering the bearing.

2.1.4 Cleanliness in mounting

An absolute "must" for the proper fitting of roller bearings is working in clean surroundings. The tools to be used should be free from dirt & fillings. In the room where the fittings of the bearings are carried out it is absolutely essential to avoid machining with metal cutting tools. If, despite these precautions, bearings get dirty by improper handling, they must not be rotated because even the smallest particles penetrating into the bearing will damage the races and in this way the service life of the bearing will be considerably reduced.

Attention should also be given to the cleanliness of shaft, housing and any other mating parts. Castings must be free from sand. After cleaning the housing bore should receive a protective coating. Bearing seats on the shaft and in housing bore should be carefully cleaned from antirust components and residual paint. Turned parts must be free from burr and sharp edges.

2.1.5 Surrounding parts

All surrounding parts should be carefully checked for dimensional and geometrical accuracy before starting mounting. Non-observance of the tolerances for shaft and housing seat diameters, out of roundness of these parts, out of square of abutment shoulders etc. impair bearing performances and lead to premature failure is not always easy to establish and much time can be lost in looking for the cause of failure.

2.2 Fits

Good bearing performance is largely depending on adherence to the fits specified for the two rings in the drawing. No one can give a straight answer to the questions of the "right" fit. Indeed the selection of fits is determined by the operating conditions of the machines and the design characteristics of the bearing mounting.

Basically, both rings should be well supported over their seating areas and should therefore be tight fits. This, however, can not be used in all cases, since other factors, such as axial freedom of the floating bearing or easy mounting must also be taken into consideration. The interference produced by tight fits expends the inner ring and contracts the outer ring resulting in a reduction of redial clearance. Hence the radial clearance should be adapted to the fits. The shaft and housing tolerances should be checked. A too loose fit causes the ring to creep on the shaft, which tends to damage both ring and shaft. It also affects the working accuracy of the machine or causes premature raceway fatigue from poor support. On the other hand, to tight a fit leads to a reduction in radial clearance, which might result in detrimental preload and hot running of the bearing. The seating areas must, moreover, be checked for out of round in addition to diameter. As the walls of the rolling bearings are relatively thin, possible poor geometry of shaft or housing is transmitted to the raceways. Out of round and deviation from true parallelism and taper should not exceed half the specified diameter tolerance.

For Radial bearings with cylindrical bore of normal precision class. (Tapered & Cylindrical Bearings)

Several factors like the type and magnitude of bearing load, temperature difference, method of bearing mounting and dismounting should be taking into consideration while selecting the proper fit.

The recommended tolerances for shaft and housing for common applications are given below as general guide lines:

Operating Condition	**Type of rotation**		**Load Conditions**	**Type of fitting**	
	Inner Ring	**Outer Ring**		**Inner Ring**	**Outer Ring**
	Rotation	Stationary	Rotating inner ring load Stationary outer ring load	Tight Fit	Loose Fit
	Stationary	Rotation			
	Stationary	Rotation	Rotating inner ring load Stationary outer ring load	Tight Fit	Loose Fit
	Rotation	Stationary			
Direct of load indeterminate due to variation of direction	Rotating or Stationary	Rotating or Stationary	Direction of load indeterminate	Tight Fit	Tight Fit

TABLE – RECOMMENDED SEATING FITS FOR SHAFTS*

Load Conditions		**Examples**	**Shaft Diameter (mm)**	**Shaft Tolerances**
			Cylindrical Roller & Taper Roller Bearings	
Rotating Outer Ring Load	**Easy axial displacement of inner ring on shaft desirable**	**Wheels on Stationary Axles**	**All Shaft Diameters**	**‘g6**
	Easy axial displacement of inner ring on shaft unnecessary	**Tension Pulleys and Rope Sheaves**		**‘h6**

Rotating inner Ring Load or Direction of Load Indeterminate	Light Load (<0.06 C [1]) Variable Load	Electrical Appliances, Pumps, Blowers, Transport Vehicles, Precision Machinery, Machine Tools	< 40	‘js6 (j6)
			40 ~ 140	‘k6
			140 ~ 200	‘m6
	Normal Loads (0.06 to 0.13 C[1])	General Bearing Applications, Medium & Large Motors, Turbines, Pumps, Engine Main Bearings, Gears, Woodworking Machines	< 40	‘k5~6
			40 ~ 100	‘m5~6
			100 ~ 140	‘m6
			140 ~ 200	‘n6
			200 ~ 400	‘p6
	Heavy Loads (>0.13 C[1]) Shock Loads	Railway Axle boxes, Industrial Vehicles, Traction Motors, Construction Equipment, Crushers	50 ~ 140	‘n6
			140 ~ 200	‘p6
			Over 200	‘r6
Axial Loads Only			All Shaft Diameters	‘js6(j6)
Note [1] C represents the basic dynamic capacity of the bearing				
* Applicable only to solid steel shafts				

TABLE – RECOMMENDED SEATING FITS FOR HOUSING*

Load Conditions			Examples	Housing bore Tolerances	Axial Displacement of Outer Ring
Solid Housing	Rotating Outer Ring Load	Heavy Loads on Bearing in Thin-Walled Housing Heavy Shock Loads	Automotive Wheel Hubs (Roller Bearings) Crane Travelling Wheels	P7	Impossible
		Normal and Heavy loads	Automotive Wheel Hubs (Ball Bearings) Vibrating Screens	N7	
		Light and variable load	Conveyor Rollers, Rope Sheaves, Tension Pulleys	M7	
	Direction of Load indeterminate	Heavy shock loads	Traction Motors		
		Normal and Heavy Loads	Pumps, Crankshaft Main Bearings Medium Large Motors	K7	Generally Impossible
Solid or Split Housings		Normal and Light loads		JS7 (J7)	Possible
	Rotating Inner Ring Load	Loads of all kinds	General Bearing Application, Railway Axle boxes	H7	Easy Displacement

		Normal and Light Loads	**Plummer Blocks**	**H8**	
		High temperature rise of inner Ring Through Shaft	**Papers Dryers**	**G7**	
Solid Housing		**Accurate Running Desirable under Normal and Light Loads**	**Grinding Spindle Rear Ball Bearings, High Speed Centrifugal Compressor Fixed Bearings**	**JS6(J6)**	**Possible**
	Direction of Load indeterminate		**Grinding Spindle Front Ball Bearings, High Speed centrifugal compressor fixed Bearings**	**K6**	**Generally Impossible**
	Rotating Ringing Load	**Accurate Running and High rigidity Desirable under Normal and Light Loads**	**Cylindrical Roller Bearings for Machine Tool Main Spindle**	**M6 / N6**	**Impossible**
		Minimum Noise is required	**Electrical Home appliances**	**H6**	**Easily Possible**

*** Applicable for cast iron and steel housings. For housings made of light alloy, the interference should be tighter than those in this table.**

3. BEARING HANDLING

When handling bearings.......

DO	DON'T
1. Remove all outside dirt from housing before exposing bearing	**1**. Don't work in dirty surrounding.
2. Treat a used bearing as carefully as you would a new one.	**2**. Don't use dirty, brittle or chipped tools.
3. Work with clean tools in clean surroundings.	**3**. Don't use wooden mallets or work on wooden bench tops.
4. Handle with clean, dry hands, or better,	**4**. Don't handle with dirty, moist hands.

clean canvas gloves.	
5. Use clean solvents and flushing oils.	**5**. Don't use gasoline containing tetraethyl lead, as they may be injurious to health.
6. Lay bearings out on clean newspaper.	**6**. Don't spin uncleaned bearings.
7. Protect disassembled bearings from rust and dirt.	**7**. Don't spin bearings with compressed air.
8. Use clean rags to wipe bearings.	**8**. Don't use cotton waste or dirty cloth to wipe bearings.
9. Keep bearings wrapped in oil proof paper when not in use.	**9**. Don't expose bearings to rust or dirt.
10. Clean inside of housing before replacing bearing.	**10**. Don't nick or scratch bearing surfaces.

BEARING FITTMENT