SKF

Bearing Installation and Maintenance Guide

Includes Shaft and Housing Fits







140-710

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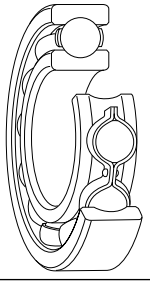
Information Order Form 127

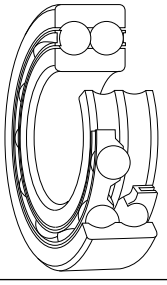
Bearing Types

Each type of bearing has characteristic properties which make it particularly suitable for certain applications. The main factors to be considered when selecting the correct type are:

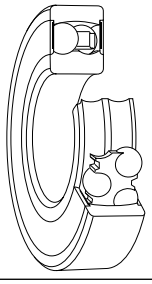
- available space
- magnitude and direction of load (radial, axial, or combined)
- speed
- misalignment
- mounting and dismounting procedures
- precision required
- noise factor
- internal clearance
- materials and cage design
- bearing arrangement
- seals

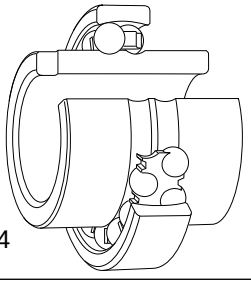
Radial bearings

1 

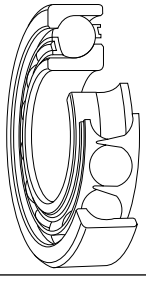
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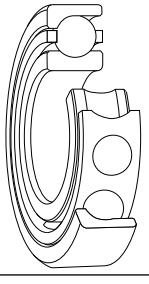
Deep groove ball bearings
single row (1)
with shield(s) or seal(s)
with snap ring groove in outer ring (and snap ring)
double row (2)

3 

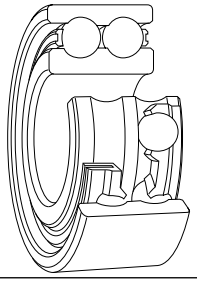
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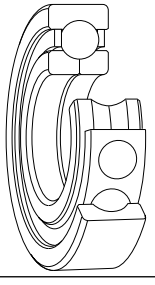
Self-aligning ball bearings
with cylindrical (3) or tapered bore
with seals
with extended inner ring (4)

5 

6 

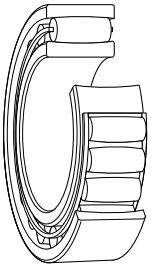
Angular contact ball bearings
single row (5)
for paired mounting
precision bearings (6)

7 

8 

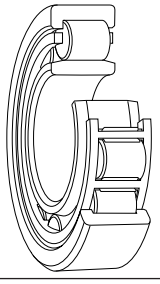
double row (7)
with shields or seals
Four-point contact ball bearings (8)

Radial bearings

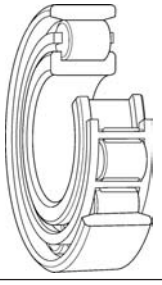


9

CARB™ toroidal roller bearing (9)
caged or full complement version
with or without seals

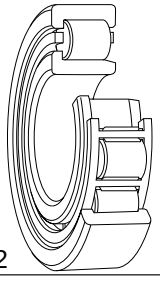


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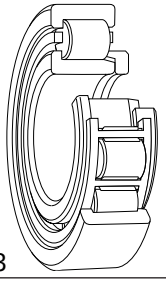


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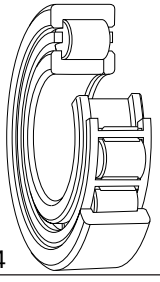
Cylindrical roller bearings
single row
NU type (10)
N type (11)



12

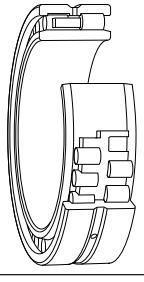


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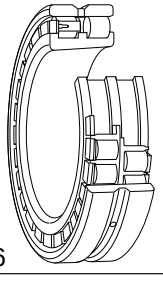


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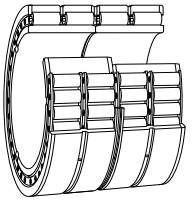
NJ type (12)
NJ type with HJ angle ring (13)
NUP type (14)



15

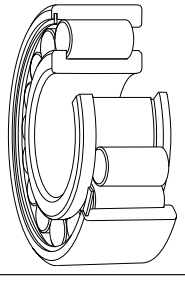


16

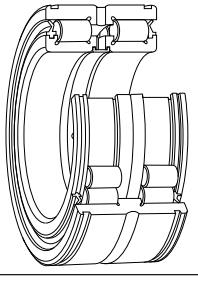


17

double row
NNU type (15)
NN type (16)
four-row
with cylindrical (17) or tapered bore

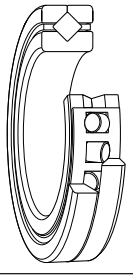


18



19

Full complement cylindrical roller bearings
single row (18)
double row with (19) or without seals
multi-row

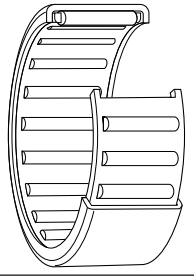


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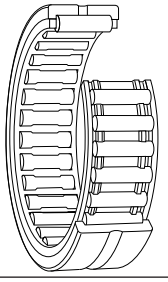
Cross cylindrical roller bearings (20)

Bearing types

Radial bearings

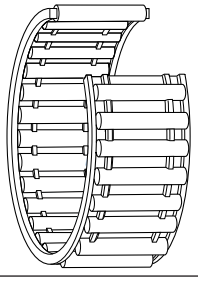


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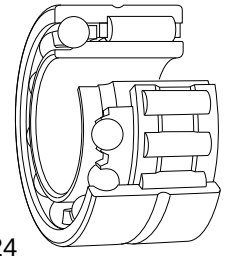


22

Needle roller bearings
Drawn cup needle roller bearings
with open (21) and closed ends
Needle roller bearings with flanges
with or without inner ring (22), with seal(s)
Needle roller bearings without flanges
with or without inner ring

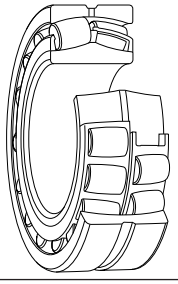


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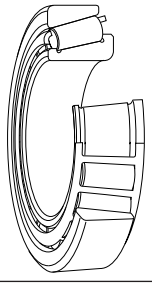
24

Needle roller and cage assemblies (23)
Combined needle roller bearings (24)
Alignment needle roller bearings

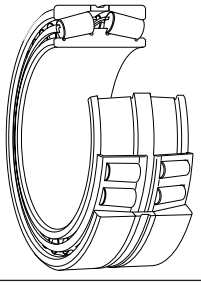


25

Spherical roller bearings
with cylindrical (25) or tapered bore

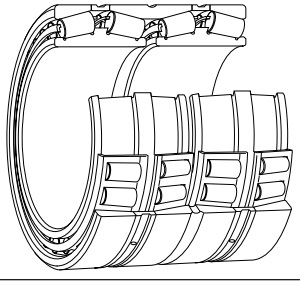


26



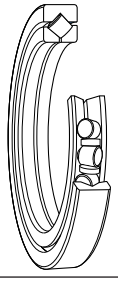
27

Taper roller bearings
single row (26)
double row (27)



28

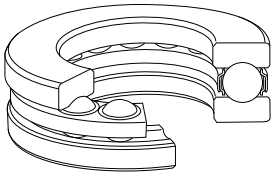
four row (28)



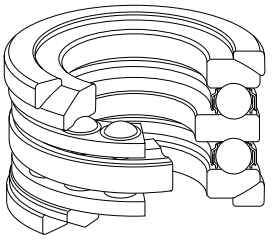
29

Cross taper roller bearings (29)

Thrust bearings



30

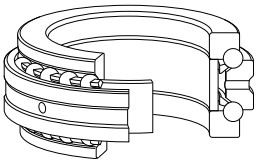


31

Thrust ball bearings
single direction
with flat housing washer (30)
with sphered housing washer and seating ring
double direction
with flat housing washers
with sphered housing washers and seating rings (31)

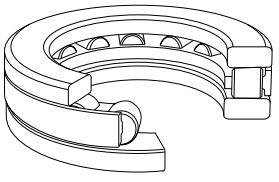


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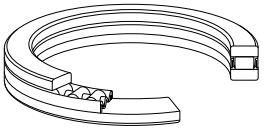
33

Angular contact thrust ball bearings
single direction (32)
double direction (33)



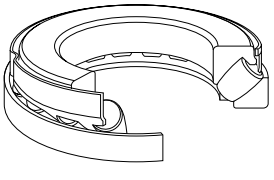
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Cylindrical roller thrust bearings (34)



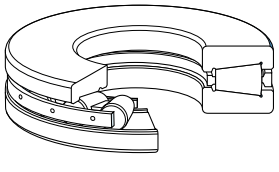
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Needle roller thrust bearings (35)

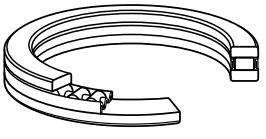


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Spherical roller thrust bearings (36)



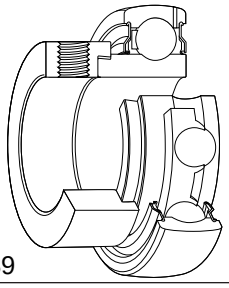
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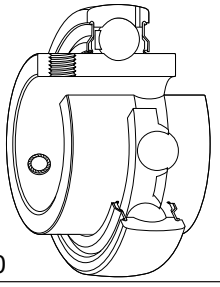
38

Taper roller thrust bearings
single direction (37)
double direction (38)

Bearing types

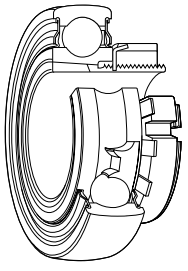


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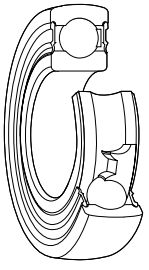


40

Y-bearings
with eccentric locking ring
with inner ring extended at one side (39)
with inner ring extended at both sides with
grub screw locking (40)

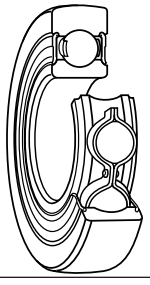


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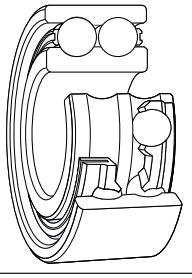


42

with adapter sleeve (41)
with normal inner ring (42)

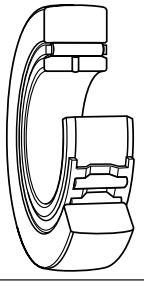


43



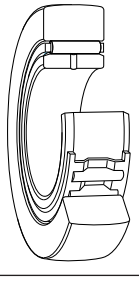
44

Cam rollers
narrow design
with crowned runner surface (43)
wide design
with crowned or cylindrical runner surface (44)

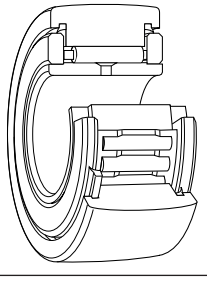


45

Support rollers
without axial guidance
with crowned (45) or cylindrical runner surface
with or without inner ring
with or without seals

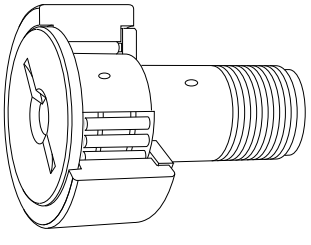


46



47

with axial guidance
with crowned or cylindrical runner surface
separable design (46)
non-separable design with cage (47)
full complement

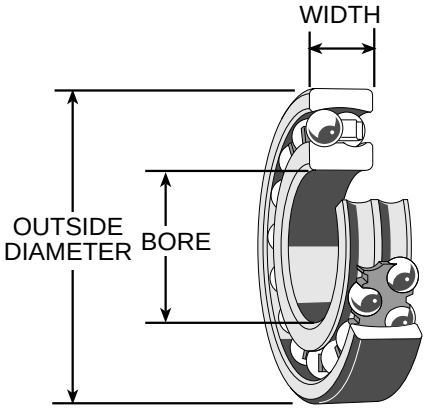


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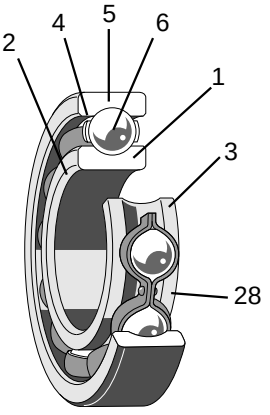
Cam followers
with crowned or cylindrical runner surface
with cage (48)
full complement

Bearing Terminology

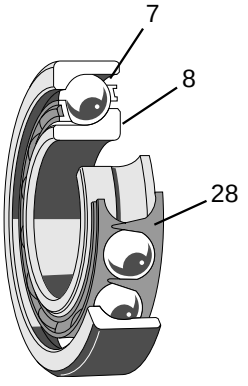
The illustrations below identify the bearing parts of eight SKF® basic bearing types. The terms used conform with the terminology section of the American Bearing Manufacturers Association, Inc. (ABMA) standards, and are generally accepted by anti-friction bearing manufacturers.



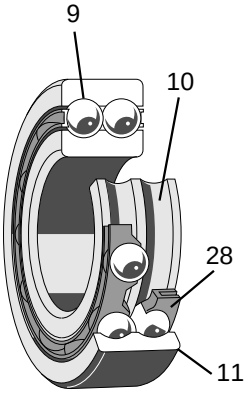
Self-Aligning Ball Bearing



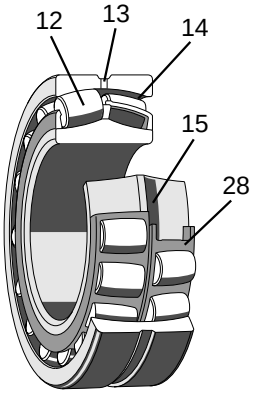
Single Row Deep Groove Ball Bearing



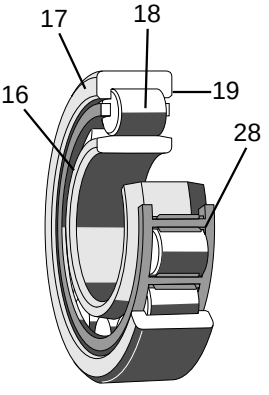
Angular Contact Ball Bearing



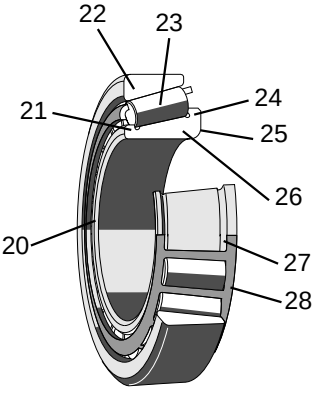
Double Row Deep Groove Ball Bearing



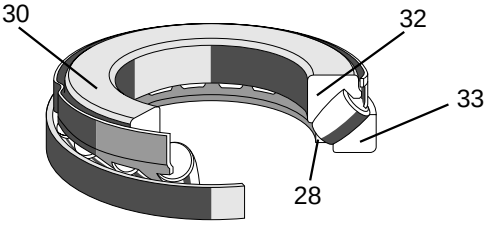
Spherical Roller Bearing



Cylindrical Roller Bearing



Tapered Roller Bearing



Spherical Roller Thrust Bearing

1. Inner Ring
2. Inner Ring Corner
3. Inner Ring Land
4. Outer Ring Land
5. Outer Ring
6. Ball
7. Counter Bore
8. Thrust Face
9. Outer Ring Raceway
10. Inner Ring Raceway
11. Outer Ring Corner
12. Spherical Roller
13. Lubrication Feature (Holes and Groove) (W33)
14. Spherical Outer Ring Raceway
15. Floating Guide Ring
16. Inner Ring Side Face
17. Outer Ring Side Face
18. Cylindrical Roller
19. Outer Ring Flange
20. Cone Front Face
21. Cone Front Face Flange
22. Cup (Outer Ring)
23. Tapered Roller
24. Cone Back Face Flange
25. Cone Back Face
26. Cone (Inner Ring)
27. Undercut
28. Cage
30. Face
32. Shaft Washer (Inner Ring)
33. Housing Washer (Outer Ring)

Mounting and Dismounting of Bearings

Nearly all rolling bearing applications require the use of an interference fit on at least one of the bearing rings, usually the inner. Consequently, all mounting methods are based on obtaining the necessary interferences without undue effort, and with no risk of damage to the bearing.

Fitting Practice

A ball or roller bearing has extremely accurate component parts which fit together with very close clearances. The inner ring bore and the outer ring outside diameter are manufactured within close limits to fit their respective supporting members — the shaft and housing. It follows that the shaft and the housing must also be machined to similar close limits. Only then will the required fits be obtained when the bearing is mounted. Shaft and housing fit tables are shown in a separate chapter beginning on page 32.

Internal Bearing Clearance

It is evident that a press (or interference) fit between the parts will stretch the inner ring. This holds true when mounting the bearing directly on the shaft or by means of an adapter sleeve. Thus, there will be a tendency to reduce the initial internal radial clearance in the bearing.

However, bearings are designed in such a way that if the recommended shaft fits are used and operating temperatures have been taken into account, the internal clearance remaining after mounting the bearing will be sufficient for proper operation.

Mounting Methods

Three basic mounting methods are used, the choice depending on factors such as the number of mountings, bearing type and size, magnitude of the interferences and, possibly, the available tools. SKF supplies tools for all mounting methods described here. For more details, see the SKF Bearing Maintenance Tools Catalog (711-639).

1. Cold Mounting

Mounting of a bearing without heating it first is the most basic and direct mounting method. A pressure force of sufficient magnitude is applied against the face of the ring having the interference fit. This method is most suitable for cylindrical bore bearings up to about 70 mm bore and for tapered bore bearings up to about 240 mm bore.

Sometimes the interference specified for a cylindrical bore bearing of less than 70 mm bore is great enough to warrant the use of one of the other methods to be described. Three other situations may make it impractical or inadvisable to cold mount a bearing:

- When the bearing face against which the pressing force is to be applied, either directly or through an adjacent part, is inaccessible.
- When the distance through which the bearing must be displaced in order to seat is too great.
- When the shaft or housing seating material is so soft that there is risk of permanently deforming it during the mounting process.

2. Temperature Mounting

Temperature mounting is the technique of obtaining an interference fit by first introducing a temperature differential between the parts to be fitted, thus facilitating their assembly. The necessary temperature differential can be obtained in one of three ways:

- Heating one part (most common)
- Cooling one part
- Simultaneously heating one part and cooling the other

Heating the Bearing

Heat mounting is suitable for all medium and large size straight bore bearings, and for small bearings with cylindrical seating arrangements. Normally a bearing temperature of 150°F above shaft temperature (not to exceed 250°F) provides sufficient expansion for mounting. As the bearing cools, it contracts and tightly grips the shaft. It's important to heat the bearing uniformly, and to regulate heat accurately, since excess heat destroys a bearing's metallurgical properties, softening the bearing. Never heat a bearing using an open flame, such as a blowtorch.

Heat mounting reduces the risk of bearing or shaft damage during installation, because the bearing can be slid easily onto the shaft. Appropriate electric-heat bearing mounting devices include induction heaters, ovens, hot plates and heating cones. Of these, induction heaters and ovens are the most convenient, and heaters the fastest, devices to use.

Hot oil baths have traditionally been used to heat bearings, but are no longer recommended except when unavoidable. In addition to health and safety considerations are the environmental issues about oil disposal, which can become costly.

If hot oil bath is used, both the oil and the container must be absolutely clean. Oil previously used for some other purpose should be thoroughly filtered. Quenching oil having a minimum flash point of 300°F, transformer oil, or 10% to 15% water soluble oil, are satisfactory heating mediums. When using an oil bath, temperature monitoring is important not only to prevent bearing damage, but also to prevent the oil from reaching flash point.

The quantity of oil used in a bath should be plentiful in relation to the volume of the bearing. An insufficient quantity heats and cools too rapidly, thus introducing the risk of inadequately or unevenly heating the bearing. It is also difficult in such a case to determine when and if the bearing has reached the same temperature as the oil. To avoid hot spots on the bearing, it is good practice to install a rack at the bottom of the bath. Sufficient time should be allowed for the entire bearing to reach the correct temperature. The bath should cover the bearing.

Heating the Housing

The bearing housing may require heating in cases where the bearing outer ring is mounted with an interference fit in the housing. Since the outer ring is usually mounted with a lighter interference fit, the temperature difference required is usually less than that required for an inner ring.

A bearing housing may be heated in several ways. If the size of the housing bore permits, an inspection lamp can be inserted, the heat from the lamp usually being sufficient to produce the desired expansion. In some cases the shape and size of the housing allow the use of an electric furnace, but in other cases a hot oil bath is necessary.

3. Oil-Injection (Hydraulic) Mounting

This is a refined method for cold mounting a tapered bore bearing. It is based on the injection of oil between the interfering surfaces, thus greatly reducing the required axial mounting force. The pressure is generally supplied with a manually-operated reciprocating pump. The required pressure seldom exceeds 10,000 psi, and is usually much less.

The oil used for oil-injection mounting should be neither too thin nor too viscous. It is difficult to build up pressures with excessively thin oils, while thick oils do not readily drain from between the fitting surfaces and require a little more axial force for positioning the bearing. This method cannot be used unless provided for in the design of the mounting. (Contact SKF for retrofitting details.)

Mounting on the Shaft

Cylindrical Bore Bearings

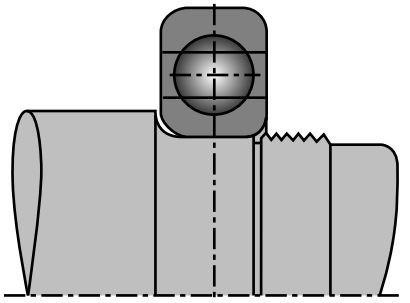
When mounted directly on the shaft, the inner ring should be located against a shaft shoulder of proper height (→ **fig 1**). This shoulder must be machined square with the bearing seat and a shaft fillet should be used. The radius of the fillet must clear the corner radius of the inner ring. Specific values for recommended shoulder heights and fillet radii for each size bearing are given in the dimensional tables of all SKF products catalogs.

If the inner ring is loose on the shaft, creeping will occur. This will result in overheating, excessive wear and contact erosion between the shaft and inner ring. Creep is described as the relative circumferential movement between the bearing bore and shaft surfaces.

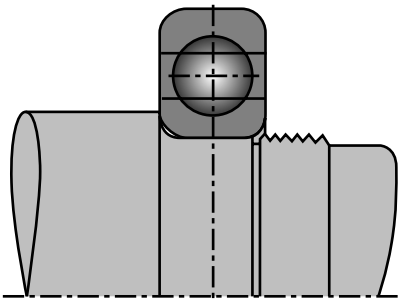
Therefore a preventive measure must be taken to eliminate creeping and its harmful results. Mount the inner ring with a sufficient press fit on the shaft. This will help ensure that both inner ring and shaft act as a unit and rotate at the same speed. It is also desirable to use a locknut to clamp the inner ring against the shaft shoulder.

If the applied load is of a rotating nature (for example, vibrating screens where unbalanced weights are attached to the shaft), then the outer ring becomes the critical member. In

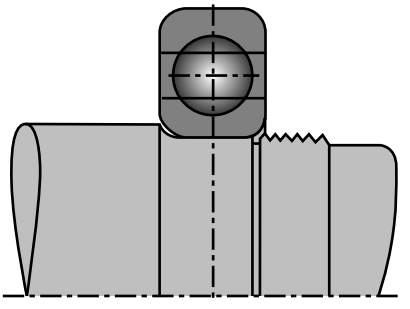
Fig 1



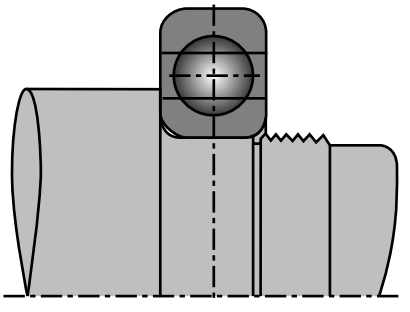
1. Shaft Fillet Too Large



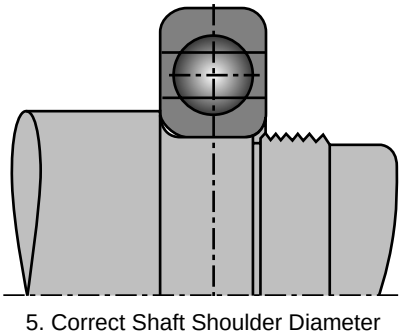
2. Correct Shaft Fillet



3. Shaft Shoulder Too Small



4. Shaft Shoulder Too Large



5. Correct Shaft Shoulder Diameter

order to eliminate creeping in this case, the outer ring must be mounted with a press fit in the housing. The rotating inner ring, when subjected to a rotating load, can be mounted with a slip fit on the shaft.

When the ring rotates in relation to the load, a tight fit is required.

Tapered Bore Bearings

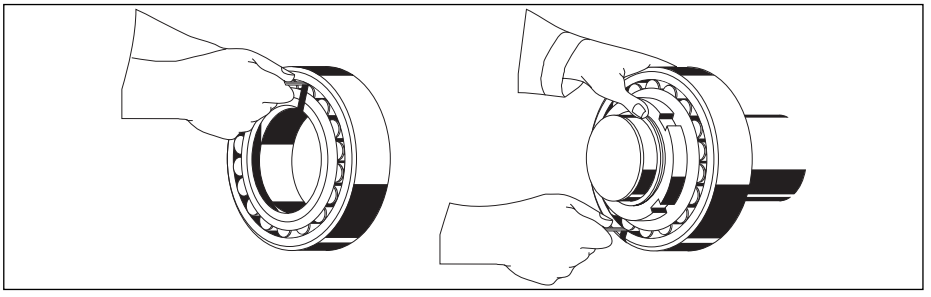
The mounting of any tapered bore bearing is affected by driving the bearing on its seat a suitable amount. This amount may be determined either by measuring the reduction of internal radial clearance or the axial drive-up.

Drive-up is achieved with a force of sufficient magnitude applied directly to the face of the ring with the interference fit. This force is generated with one of the following devices:

1. Threaded lock nut
2. Bolted end plate
3. Hydraulic nut
4. Mounting sleeve

When using the internal radial clearance reduction method on tapered bore spherical roller bearings, establish an initial reference point by measuring the unmounted internal clearance using the instructions shown with chart A.

The absolute values for reduction in clearance are shown in chart B.



How to measure unmounted radial internal clearance of SKF tapered bore spherical roller bearings (in inches)

Oscillate the inner ring in a circumferential direction to properly seat the rollers. Measure the radial internal clearance in the bearing by inserting progressively larger feeler blades the full length of the roller between the most unloaded roller and the outer ring sphere. CAUTION: Do not roll over the feeler blade, slide it through the clearance. Record the measurement on the largest size blade that will slide through. This is the unmounted radial internal clearance.

Repeat this procedure in two or three other locations by resting the bearing on a different spot on its O.D. and measuring over different rollers in one row. Repeat the above procedure for the other row of rollers or measure each row alternately in the procedure described above (See chart A).

Chart A — Unmounted Radial Internal Clearance of SKF Tapered Bore Spherical Roller Bearings (in inches)

Bore Dia. d(m)		Normal (in.)		C3 (in.)		C4 (in.)	
Over	**Incl.**	Min.	Max.	Min.	Max.	Min.	Max.
24	**30**	0.0012	0.0016	0.0016	0.0022	0.0022	0.0030
30	**40**	0.0014	0.0020	0.0020	0.0026	0.0026	0.0033
40	**50**	0.0018	0.0024	0.0024	0.0031	0.0031	0.0039
50	**65**	0.0022	0.0030	0.0030	0.0037	0.0037	0.0047
65	**80**	0.0028	0.0037	0,0037	0.0047	0.0047	0.0059
80	**100**	0.0031	0.0043	0.0043	0.0055	0.0055	0.0071
100	**120**	0.0039	0.0053	0.0053	0.0067	0.0067	0.0087
120	**140**	0.0047	0.0063	0.0063	0.0079	0.0079	0.0102
140	**160**	0.0051	0.0071	0.0071	0.0091	0.0091	0.0118
160	**180**	0.0055	0.0079	0.0079	0.0102	0.0102	0.0134
180	**200**	0.0063	0.0087	0.0087	0.0114	0.0114	0.0146
200	**225**	0.0071	0.0098	0.0098	0.0126	0.0126	0.0161
225	**250**	0.0079	0.0106	0.0106	0.0138	0.0138	0.0177
250	**280**	0.0087	0.0118	0.0118	0.0154	0.0154	0.0193
280	**315**	0.0094	0.0130	0.0130	0.0169	0.0169	0.0213
315	**355**	0.0106	0.0142	0.0142	0.0185	0.0185	0.0232
355	**400**	0.0118	0.0157	0.0157	0.0205	0.0205	0.0256
400	**450**	0.0130	0.0173	0.0173	0.0224	0.0224	0.0283
450	**500**	0.0146	0.0193	0.0193	0.0248	0.0248	0.0311
500	**560**	0.0161	0.0213	0.0213	0.0268	0.0268	0.0343
560	**630**	0.0181	0.0236	0.0236	0.0299	0.0299	0.0386
630	**710**	0.0201	0.0264	0.0264	0.0335	0.0335	0.0429
710	**800**	0.0224	0.0295	0.0295	0.0378	0.0378	0.0480
800	**900**	0.0252	0.0331	0.0331	0.0421	0.0421	0.0539
900	**1000**	0.0280	0.0366	0.0366	0.0469	0.0469	0.0598
1000	**1120**	0.0303	0.0406	0.0406	0.0512	0.0512	0.0657
1120	**1250**	0.0327	0.0441	0.0441	0.0559	0.0559	0.0720

Fig 2

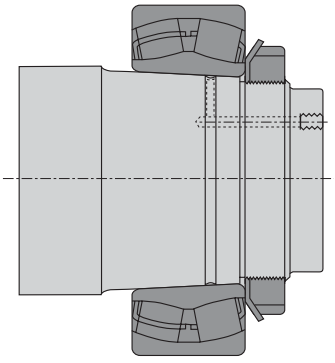


Figure 2. *Tapered Shaft Mounting (with locknut and hydraulic removal)*

Fig 3

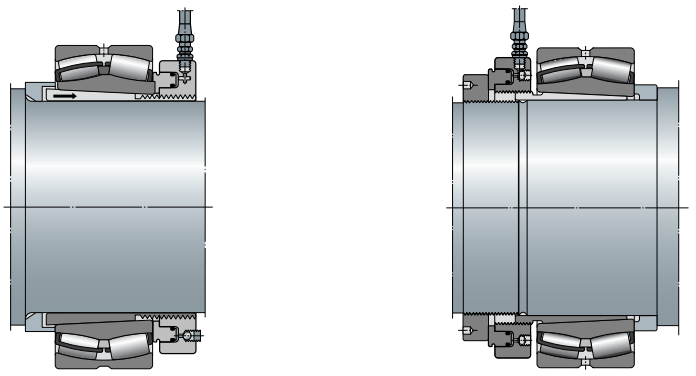
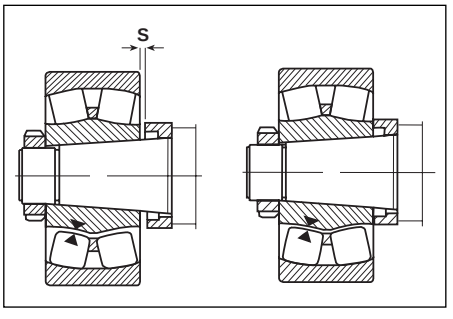


Figure 3. *Tapered Bore Mounting: with adapter sleeve (left); with withdrawal sleeve (right).*

Spherical Roller Bearing Axial Drive-up

The axial drive-up "S" is approximately:

- 16 times the reduction on 1:12 taper for solid steel shafts
- 18 times the reduction on 1:12 taper for sleeve mounting
- 39 times the reduction in 1:30 taper for solid steel shafts
- 42 times the reduction on 1:30 taper for sleeve mounting



CAUTION: Do not use the maximum reduction of radial internal clearance when the initial unmounted radial internal clearance is in the lower half of the tolerance range or where large temperature differentials between the bearing rings can occur in operation. (See chart B).

Tapered Shaft Mounting

Mounting on a tapered shaft requires that the shaft is manufactured with a matching tapered seat.

Chart B — Recommended Clearance Reduction Values of SKF Tapered Bore Bearings (in inches)

Bore Diameter d(mm)		Reduction in Radial Internal Clearance (in.)	
Over	**Incl.**	Min.	Max.(1)
24	**30**	0.0006	0.0008
30	**40**	0.0008	0.0010
40	**50**	0.0010	0.0012
50	**65**	0.0012	0.0015
65	**80**	0.0015	0.0020
80	**100**	0.0018	0.0025
100	**120**	0.0020	0.0028
120	**140**	0.0025	0.0035
140	**160**	0.0030	0.0040
160	**180**	0.0030	0.0045
180	**200**	0.0035	0.0050
200	**225**	0.0040	0.0055
225	**250**	0.0045	0.0060
250	**280**	0.0045	0.0065
280	**315**	0.0050	0.0075
315	**355**	0.0060	0.0085
355	**400**	0.0065	0.0090
400	**450**	0.0080	0.0105
450	**500**	0.0085	0.0110
500	**560**	0.0095	0.0125
560	**630**	0.0100	0.0135
630	**710**	0.0120	0.0155
710	**800**	0.0135	0.0175
800	**900**	0.0145	0.0195
900	**1000**	0.0160	0.0215
1000	**1120**	0.0175	0.0235
1120	**1250**	0.0190	0.0255

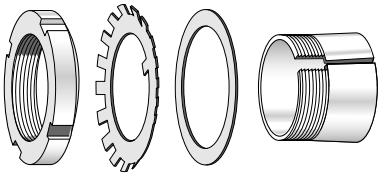
Adapter Mounting

NOTE: Wipe preservative from the adapter O. D. and bore as well as the bearing bore. It may not be necessary to remove the preservative from the internal components of the bearing unless the bearing will be lubricated by a circulating oil or oil mist system.

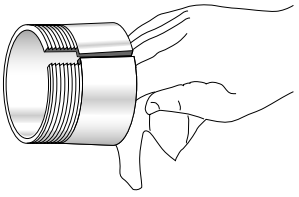
Step 1 —adapter sleeve
Remove oil from the shaft to prevent transfer of oil to the bore of the adapter sleeve. Position adapter sleeve on shaft, thread outboard as indicated, to approximate location with respect to required bearing centerline. Light oil applied to the sleeve outside diameter surface results in easier bearing mounting and removal. (see → **fig** 4)

Step 2 — bearing
Spherical roller radial bearings — Measure the unmounted internal radial clearance in the bearing by inserting progressively larger feeler blades the full length of the roller between the most vertical unloaded roller and the outer ring sphere. DO NOT roll the feeler blade through the clearance; slide it through. Record the measurement of the largest size blade that will slide through. This is the unmounted radial internal clearance. Wipe bearing bore and mount on adapter sleeve, starting with the large bore of the inner ring to match the taper of the adapter. With the bearing hand tight on the adapter sleeve, locate the bearing to the proper axial position on the shaft. (DO NOT apply lockwasher at this time because drive-up procedure may damage lockwasher). Apply the locknut with the

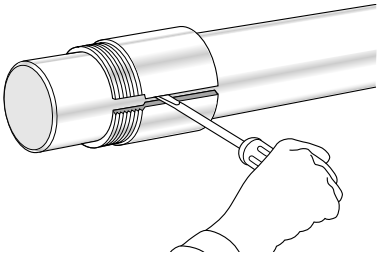
Fig 4



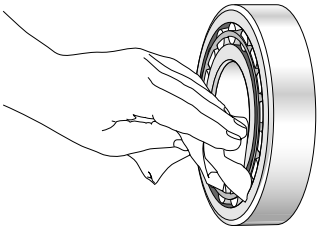
1. Screw off the nut and remove the locking washer.



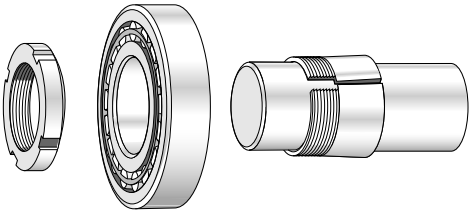
2. Wipe the preservative from the surfaces of the sleeve and then oil the bore surface lightly. Use a thin mineral oil.



3. Open up the sleeve by inserting a screwdriver in the slit; then slide the sleeve along the shaft to the correct position.



4. Wipe the preservative from the bore of the bearing and then oil the surface lightly. Use a thin mineral oil.



5. Place the bearing on the sleeve. Screw on the nut with its chamfer facing the bearing, but do **not** mount the locking washer. Do **not** push the inner ring up on the taper.

Figure 4. *Mounting bearings on adapter sleeves*

chamfered face toward the bearing. Use a lubricant on the face of the locknut where it contacts the inner ring face of the bearing to make easier mounting for large sizes. LARGE SIZE BEARINGS WILL REQUIRE A HEAVY DUTY IMPACT SPANNER WRENCH AND SLEDGE HAMMER TO OBTAIN THE REQUIRED REDUCTION IN RADIAL INTERNAL CLEARANCE. AN SKF HYDRAULIC NUT MAKES MOUNTING OF LARGE SIZE BEARINGS EASIER. Do not attempt to tighten the locknut with hammer and drift. The locknut will be damaged and chips can enter the bearing.

Self-aligning ball bearings* —
Wipe bearing bore and mount on adapter sleeve, starting with the large bore of the inner ring to match the taper of the adapter. With the bearing hand tight on the adapter, locate bearing to the proper axial position on the shaft. (DO NOT apply lockwasher at this time because drive-up procedure may damage lockwasher).

Apply the locknut with chamfered face toward the bearing after lubricating the face of the locknut next to the bearing. Hand tighten the nut with a spanner wrench until the adapter sleeve can neither be moved axially, nor rotated on the shaft. Then with a hammer, drive the spanner wrench until the locknut has been tightened on the adapter sleeve according to the turning angle shown in **tables** 1a, 1b, and 1c on pages 14 and 15.

CAUTION: A loose adapter sleeve can lead to the inner ring turning on the adapter sleeve and/or the adapter sleeve turning on the shaft. To insure that the nut is not excessively tight, make certain the outer ring of the bearing rotates freely. When mounting a normal fit bearing, swiveling the outer ring will result in a slight drag. If the bearing is a C3 fit, the outer ring will swivel freely.

Step 3 — locknut & washer
Remove locknut and mount lockwasher on adapter sleeve with inner prong of lockwasher toward the face of the bearing and located in the slot of the adapter sleeve. Reapply locknut until tight. (DO NOT drive bearing further up the taper, as this will reduce the radial internal clearance previously secured. Check to make certain radial internal

* Method can also be used for Spherical Roller Bearings and CARB™

clearance has not changed). Find the lockwasher tang that is nearest a locknut slot. If the slot is slightly past the tang, don't loosen the nut, but instead tighten it to meet a washer tang.

Mounting in the Housing

There is usually no difficulty encountered when mounting the bearing in the housing. In the case of a split housing, the shaft, with the bearing correctly mounted on it, is simply lowered into the housing, and the other half of the housing is lowered and secured. In the case of straight-through solid housings, the bearing rings generally have a loose fit with the housing, making it possible to push the shaft and bearing assembly into position.

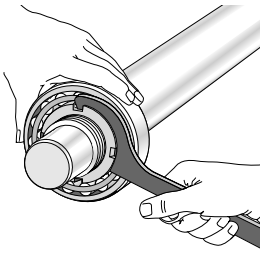
Bearings having a loose fit on the shaft generally have a tight fit in the housing. In this case the bearing is first mounted in the housing either by hammering on a mounting sleeve or by pressing, and the shaft is then inserted into the bearing. If a tight fit is to be used both on the shaft and in the housing, both bearing rings may have to be mounted simultaneously, in which case the force must be applied to both rings so that none of it is carried by the rolling elements. Alternatively, the housing may be heated.

Bearings Requiring Axial Adjustment

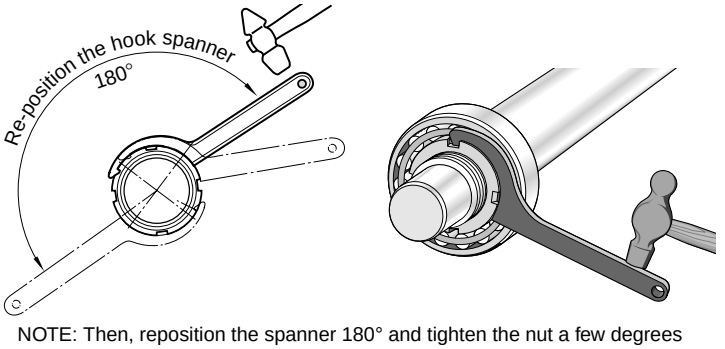
Axial adjustment is necessary when the bearing type dictates it, or when axial movement and location of the shaft must be closely controlled. The types of bearings most frequently requiring this technique are tapered roller bearings, angular contact ball bearings, and thrust bearings.

Tapered roller bearings and angular contact ball bearings are available in arrangements which, when mounted in duplex (side-by-side) with or without spacers, automatically provide the correct adjustment when the bearings are locked together. As a general rule, however, whenever the bearings are separated by a portion or portions of the housing or shaft, adjustment must be made at assembly either by shimming or by controlling the securing of the bearings. For more details, consult SKF.

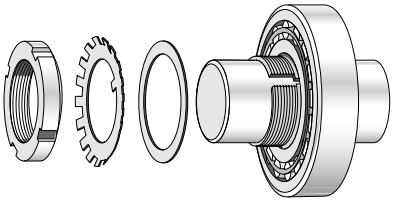
Fig 4



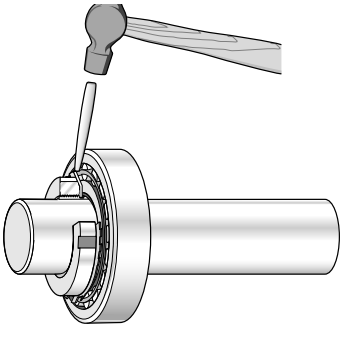
6. Turn the nut sufficiently to ensure that the shaft makes proper contact (self-locking) with the sleeve, but do not drive the bearing any further up the sleeve. Then turn the nut according to the turning angle in tables 1a, 1b, and 1c.



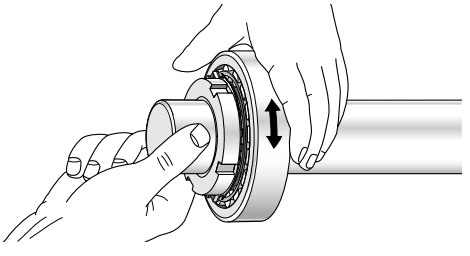
NOTE: Then, reposition the spanner 180° and tighten the nut a few degrees more by tapping the spanner handle lightly with a hammer.



7. Unscrew the nut, place the locking washer and spacer in position, and tighten the nut firmly again. Make sure that the bearing is not driven any further up the sleeve.



8. Lock the nut by bending one of the locking washer tabs down into one of the slots in the nut. Do not bend it to the bottom of the slot.



9. Check that the shaft or outer ring can be rotated easily by hand.

Table 1a

Angular drive-up for self-aligning ball bearings

Bearing Designation	Bore d (mm)	Axial Drive-ups (mm)	Metric Nut Designation	Turning Angle α (degrees)	Inch Nut Designation	Turning Angle α (degrees)
1205 K	25	0.220	KM 5	55	N 05	100
1206 K	30	0.220	KM 6	55	N 06	55
1207 K	35	0.300	KM 7	70	N 07	75
1208 K	40	0.300	KM 8	70	N 08	75
1209 K	45	0.310	KM 9	75	N 09	80
1210 K	50	0.310	KM 10	75	N 10	80
1211 K	55	0.400	KM 11	70	N 11	100
1212 K	60	0.400	KM 12	70	N 12	100
1213 K	65	0.400	KM 13	70	N 13	100
1214 K	70	0.400	KM 14	70	N 14	100
1215 K	75	0.450	KM 15	80	AN 15	75
1216 K	80	0.450	KM 16	80	AN 16	75
1217 K	85	0.580	KM 17	105	AN 17	100
1218 K	90	0.580	KM 18	105	AN 18	100
1219 K	95	0.580	KM 19	105	AN 19	100
1220 K	100	0.580	KM 20	105	AN 20	100
1221 K	105	0.670	KM 21	120	AN 21	115
1222 K	110	0.670	KM 22	120	AN 22	115
1224 K	120	0.670	KM 24	120	AN 24	115
2205 K	25	0.220	KM 5	55	N 05	100
2206 K	30	0.220	KM 6	55	N 06	55
2207 K	35	0.300	KM 7	70	N 07	75
2208 K	40	0.300	KM 8	70	N 08	75
2209 K	45	0.310	KM 9	75	N 09	80
2210 K	50	0.310	KM 10	75	N 10	80
2211 K	55	0.310	KM 11	55	N 11	80
2212 K	60	0.390	KM 12	70	N 12	100
2213 K	65	0.390	KM 13	70	N 13	100
2214 K	70	0.430	KM 14	75	N 14	110
2215 K	75	0.430	KM 15	75	AN 15	75
2216 K	80	0.430	KM 16	75	AN 16	75
2217 K	85	0.540	KM 17	95	AN 17	90
2218 K	90	0.540	KM 18	95	AN 18	90
2219 K	95	0.540	KM 19	95	AN 19	90
2220 K	100	0.540	KM 20	95	AN 20	90
2221 K	105	0.660	KM 21	120	AN 21	110
2222 K	110	0.660	KM 22	120	AN 22	110

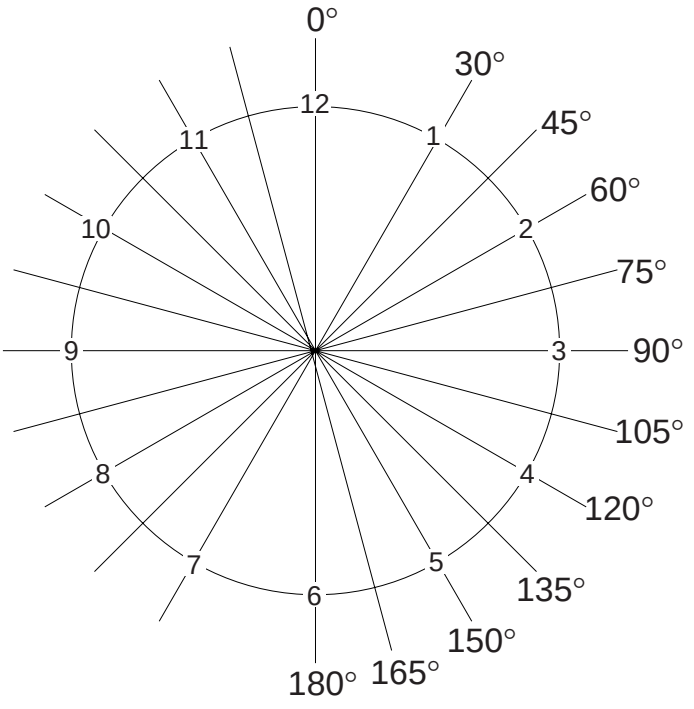


Table 1b

Angular drive-up for spherical roller bearings

Bearing Designation	Bore d (mm)	Axial Drive-up s (mm)	Metric Nut Designation	Turning Angle α (degrees)	Inch Nut Designation	Turning Angle α (degrees)
22206 CCK	30	0.450	KM 6	110	N 06	115
22207 CCK	35	0.480	KM 7	115	N 07	120
22208 CCK	40	0.520	KM 8	125	N 08	135
22209 CCK	45	0.540	KM 9	130	N 09	140
22210 CCK	50	0.580	KM 10	140	N 10	150
22211 CCK	55	0.600	KM 11	110	N 11	155
22212 CCK	60	0.650	KM 12	115	N 12	165
22213 CCK	65	0.670	KM 13	120	N 13	170
22214 CCK	70	0.690	KM 14	125	N 14	175
22215 CCK	75	0.720	KM 15	130	AN 15	120
22216 CCK	80	0.770	KM 16	140	AN 16	130
22217 CCK	85	0.800	KM 17	145	AN 17	135
22218 CCK	90	0.840	KM 18	150	AN 18	145
22219 CCK	95	0.840	KM 19	150	AN 19	145
22220 CCK	100	0.870	KM 20	155	AN 20	150
22221 CCK	105	0.940	KM 21	170	AN 21	160
22222 CCK	110	0.950	KM 22	170	AN 22	160
22224 CCK	120	1.010	KM 24	180	AN 24	170
22306 CCK	30	0.460	KM 6	110	N 06	115
22307 CCK	35	0.480	KM 7	115	N 07	120
22308 CCK	40	0.520	KM 8	125	N 08	135
22309 CCK	45	0.540	KM 9	130	N 09	140
22310 CCK	50	0.580	KM 10	140	N 10	150
22311 CCK	55	0.580	KM 11	105	N 11	150
22312 CCK	60	0.650	KM 12	115	N 12	165
22313 CCK	65	0.700	KM 13	125	N 13	180
22314 CCK	70	0.720	KM 14	130	N 14	185
22315 CCK	75	0.750	KM 15	135	AN 15	130
22316 CCK	80	0.780	KM 16	140	AN 16	135
22317 CCK	85	0.810	KM 17	145	AN 17	140
22318 CCK	90	0.860	KM 18	155	AN 18	145
22319 CCK	95	0.870	KM 19	155	AN 19	150
22320 CCK	100	0.900	KM 20	160	AN 20	155
22321 CCK	105	0.950	KM 21	170	AN 21	160
22322 CCK	110	1.000	KM 22	180	AN 22	170
22324 CCK	120	1.030	KM 24	185	AN 24	175

Drive up and angular rotation values are the same for both CC and E design SKF spherical roller bearings.

For sizes greater than those shown in tables 1a, 1b, and 1c we recommend the use of the SKF Hydraulic drive-up method. Please refer to page 16 for more detailed information.

Table 1c

Angular drive-up for CARB™ toroidal roller bearings

Bearing Designation	Bore d (mm)	Axial Drive-up s (mm)	Metric Nut Designation	Turning Angle α (degrees)	Inch Nut Designation	Turning Angle α (degrees)
C 2205 K	25	0.420	KM 5	100	N 05	190
C 2206 K	30	0.450	KM 6	110	N 06	115
C 2207 K	35	0.480	KM 7	115	N 07	120
C 2208 K	40	0.520	KM 8	125	N 08	135
C 2209 K	45	0.540	KM 9	130	N 09	140
C 2210 K	50	0.580	KM 10	140	N 10	150
C 2211 K	55	0.600	KM 11	110	N 11	155
C 2212 K	60	0.650	KM 12	115	N 12	165
C 2213 K	65	0.670	KM 13	120	N 13	170
C 2214 K	70	0.690	KM 14	125	N 14	175
C 2215 K	75	0.720	KM 15	130	AN 15	120
C 2216 K	80	0.770	KM 16	140	AN 16	130
C 2217 K	85	0.800	KM 17	145	AN 17	135
C 2218 K	90	0.840	KM 18	150	AN 18	145
C 2219 K	95	0.840	KM 19	150	AN 19	145
C 2220 K	100	0.870	KM 20	155	AN 20	150
C 2221 K	105	0.940	KM 21	170	AN 21	160
C 2222 K	110	0.950	KM 22	170	AN 22	160
C 2224 K	120	1.010	KM 24	180	AN 24	170
C 2304 K	20	0.380	KM 4	140	N 04	170
C 2305 K	25	0.420	KM 5	100	N 05	190
C 2306 K	30	0.460	KM 6	110	N 06	115
C 2307 K	35	0.480	KM 7	115	N 07	120
C 2308 K	40	0.520	KM 8	125	N 08	135
C 2309 K	45	0.540	KM 9	130	N 09	140
C 2310 K	50	0.580	KM 10	140	N 10	150
C 2311 K	55	0.620	KM 11	110	N 11	160
C 2312 K	60	0.650	KM 12	115	N 12	165
C 2313 K	65	0.700	KM 13	125	N 13	180
C 2314 K	70	0.720	KM 14	130	N 14	185
C 2315 K	75	0.750	KM 15	135	AN 15	130
C 2316 K	80	0.780	KM 16	140	AN 16	135
C 2317 K	85	0.810	KM 17	145	AN 17	140
C 2318 K	90	0.860	KM 18	155	AN 18	145
C 2319 K	95	0.870	KM 19	155	AN 19	150
C 2320 K	100	0.900	KM 20	160	AN 20	155
C 2321 K	105	0.950	KM 21	170	AN 21	160
C 2322 K	110	1.000	KM 22	180	AN 22	170
C 2324 K	120	1.030	KM 24	185	AN 24	175

For sizes greater than those shown in tables 1a, 1b, and 1c we recommend the use of the SKF Hydraulic drive-up method. Please refer to page 22 for more detailed information.

SKF Hydraulic drive-up method

A new method of accurately achieving the adjustment of spherical roller bearings, mounted on solid tapered seatings, is now available. This method is also used for CARB™ toroidal roller bearings (see p. 21). The correct fit is achieved by controlling the axial drive-up of the bearing from a predetermined position. The method incorporates the use of a hydraulic nut fitted with a dial indicator, and a specially calibrated pressure gauge, mounted on the selected pump.

A special hydraulic pressure table providing the required MPa/psi pressures must be used for each bearing type. (see → **table** 2 for spherical roller bearings; **table** 5 for CARB bearings) This enables accurate positioning of the bearing at the starting point, where the axial drive-up is measured. This method provides:

1. Reduced time to mount bearings.
2. A reliable, safe and accurate method of clearance adjustment.
3. Ideal way to mount sealed spherical roller bearings.

Step by step procedure

1. Ensure that the bearing size is equal to the hydraulic nut. (Otherwise the pressure in the table must be adjusted.)
2. Determine whether one or two surfaces slide during mounting; see → **figures** 6 - 9.
3. Lightly oil all mating surfaces with a thin oil and carefully place the bearing on the shaft.
4. Drive the bearing up to the starting position by applying the hydraulic pressure found in the table. Monitor the pressure by the gauge on the selected pump. As an alternative, SKF mounting gauge 1077587/2 can be screwed directly into the hydraulic nut.
5. Drive the bearing up the taper the required distance S_s.The axial drive-up is best monitored by a dial indicator.

   Normally, the bearing is now mounted with a suitable interference on the shaft and a suitable residual clearance.

For abnormal operating conditions, hollow shaft, very accurate requirements on residual clearance, etc., the drive-up must be adjusted. In such cases please contact SKF.

SKF hydraulic pump 729124 SRB is suitable for hydraulic nuts ≤ HMV(C) 54E.

SKF TMJL 100SRB is suitable for hydraulic nuts ≤ HMV(C) 92E while TMJL 50SRB is suitable for nuts ≤ HMV(C) 200E.

≤ = *less than or equal to*

Instructions and pressure tables

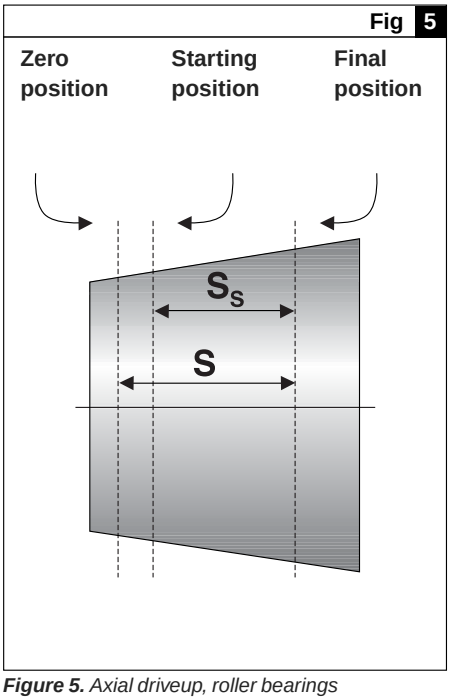


Figure 5. *Axial driveup, roller bearings*

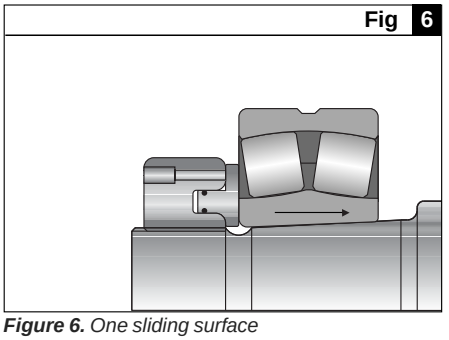


Figure 6. *One sliding surface*

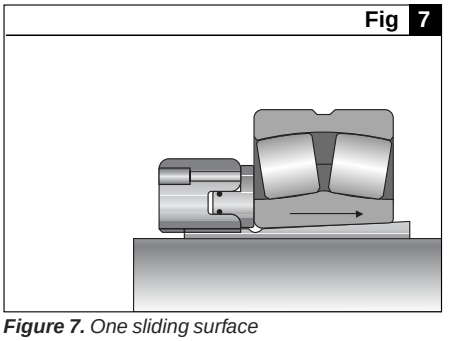


Figure 7. *One sliding surface*

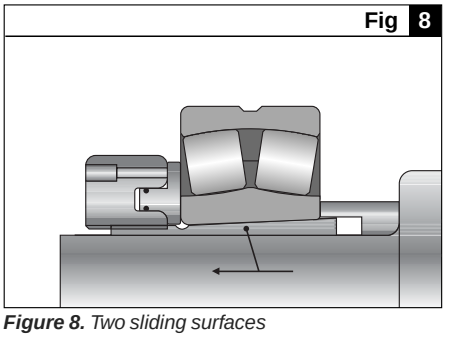


Figure 8. *Two sliding surfaces*

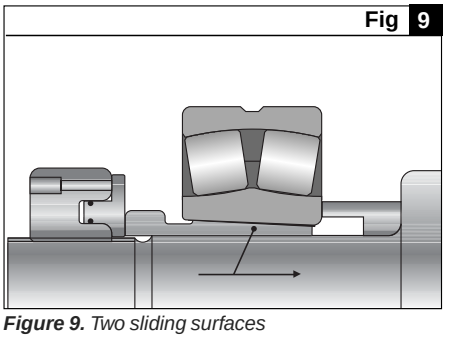


Figure 9. *Two sliding surfaces*

Pressure and axial drive-up table for spherical roller bearings

SKF Bearing designation	Starting position Hydraulic pressure* psi		Final position Radial clearance reduction from zero pos.	Axial drive-up from starting position
	1	2	in	s_s in
213... series				
21310 CCK	230	390	0.0009	0.0150
21310 EK	270	465	0.0009	0.0156
21311 CCK	235	400	0.0010	0.0158
21311 EK	203	341	0.0010	0.0156
21312 CCK	308	523	0.0011	0.0175
21312 EK	352	598	0.0011	0.0181
21313 CCK	314	540	0.0012	0.0186
21313 EK	367	624	0.0012	0.0195
21314 CCK	309	527	0.0012	0.0195
21314 EK	385	656	0.0012	0.0206
21315 CCK	323	551	0.0013	0.0206
21315 EK	319	544	0.0013	0.0206
21316 CCK	356	604	0.0014	0.0217
21316 EK	321	545	0.0014	0.0214
21317 CCK	366	623	0.0015	0.0228
21317 EK	254	432	0.0015	0.0214
21318 CCK	386	660	0.0016	0.0239
21318 EK	268	460	0.0016	0.0225
21319 CCK	426	725	0.0017	0.0253
21319 EK	278	476	0.0017	0.0233
21320 CCK	478	813	0.0018	0.0270
21320 EK	216	367	0.0018	0.0233
21322 CCK	526	896	0.0019	0.0295
222... series				
22210 CCK	105	175	0.0009	0.0136
22210 EK	110	185	0.0009	0.0136
22211 CCK	110	193	0.0010	0.0145
22211 EK	106	180	0.0010	0.0145
22212 CCK	141	237	0.0011	0.0156
22212 EK	127	215	0.0011	0.0156
22213 CCK	161	274	0.0012	0.0170
22213 EK	141	238	0.0012	0.0164
22214 CCK	153	259	0.0012	0.0178
22214 EK	134	233	0.0012	0.0175
22215 CCK	145	246	0.0013	0.0186
22215 EK	127	214	0.0013	0.0183
22216 CCK	152	255	0.0014	0.0195
22216 EK	145	249	0.0014	0.0195
22217 CCK/W33	165	280	0.0015	0.0206
22217 EK	168	287	0.0015	0.0206
22218 CCK/W33	188	324	0.0016	0.0217
22218 EK	173	296	0.0016	0.0214
22219 CCK/W33	204	346	0.0017	0.0225
22219 EK	198	337	0.0017	0.0225
22220 CCK/W33	230	392	0.0018	0.0236
22220 EK	210	361	0.0018	0.0233
22222 CCK/W33	269	461	0.0019	0.0258
22222 EK	251	427	0.0019	0.0256
22224 CCK/W33	283	481	0.0021	0.0275
22224 EK	268	457	0.0021	0.0275
22226 CCK/W33	301	517	0.0023	0.0295
22226 EK	285	485	0.0023	0.0292
22228 CCK/W33	339	578	0.0025	0.0317
22230 CCK/W33	362	617	0.0027	0.0336
22232 CCK/W33	373	637	0.0028	0.0358
22234 CCK/W33	403	686	0.0030	0.0381
22236 CCK/W33	362	617	0.0032	0.0397
22238 CCK/W33	371	633	0.0034	0.0417
22240 CCK/W33	389	664	0.0035	0.0439
22244 CCK/W33	426	727	0.0039	0.0481
22248 CCK/W33	475	811	0.0043	0.0528
22252 CCK/W33	470	801	0.0046	0.0564
22256 CCK/W33	427	729	0.0050	0.0600
22260 CCK/W33	420	716	0.0053	0.0636
22264 CCK/W33	442	754	0.0057	0.0681
223... series				
22310 CCK	255	430	0.0009	0.0142
22310 EK	235	400	0.0009	0.0139
22311 CCK	272	465	0.0010	0.0153
22311 EK	285	488	0.0010	0.0153
22312 CCK	290	497	0.0011	0.0161
22312 EK	343	589	0.0011	0.0167
22313 CCK	310	532	0.0012	0.0175
22313 EK	306	524	0.0012	0.017
222314 CCK/W33	336	572	0.0012	0.0183
22314 EK	374	637	0.0012	0.0189
22315 CCK/W33	363	620	0.0013	0.0195
22315 EK	337	576	0.0013	0.0192
22316 CCK/W33	376	642	0.0014	0.0206
22316 EK	349	594	0.0014	0.0203
22317 CCK/W33	405	692	0.0015	0.0217
22317 EK	428	728	0.0015	0.0217
22318 CCK/W33	413	706	0.0016	0.0225
22318 EK	432	737	0.0016	0.0228
22319 CCK/W33	438	749	0.0017	0.0236
22319 EK	441	752	0.0017	0.0236
22320 CCK/W33	506	861	0.0018	0.0250
22320 EK	594	1015	0.0018	0.0256
22322 CCK/W33	588	1002	0.0019	0.0272
22322 EK	652	1113	0.0019	0.0278
22324 CCK/W33	633	1080	0.0021	0.0295
22326 CCK/W33	686	1171	0.0023	0.0314
22328 CCK/W33	729	1243	0.0025	0.0333
22330 CCK/W33	766	1307	0.0027	0.0356
22332 CCK/W33	747	1273	0.0028	0.0378
22334 CKK/W33	759	1296	0.0030	0.0400
22336 CCK/W33	746	1274	0.0032	0.0420
22338 CCK/W33	738	1258	0.0034	0.0439
22340 CCK/W33	745	1271	0.0035	0.0461
22344 CCK/W33	811	1384	0.0039	0.0511
22348 CCK/W33	808	1379	0.0043	0.0553
22352 CCK/W33	814	1390	0.0046	0.0595
22356 CCK/W33	826	1409	0.0050	0.0636
230... series				
23022 CCK/W33	155	267	0.0019	0.0247
23024 CCK/W33	150	254	0.0021	0.0264
23026 CCK/W33	184	315	0.0023	0.0283
23028 CCK/W33	175	299	0.0025	0.0303
23030 CCK/W33	180	307	0.0027	0.0320
23032 CCK/W33	179	305	0.0028	0.0339
23034 CCK/W33	194	332	0.0030	0.0358
23036 CCK/W33	218	373	0.0032	0.0381
23038 CCK/W33	214	366	0.0034	0.0400

Pressure and axial drive-up table for spherical roller bearings (cont.)

SKF Bearing designation	Starting position Hydraulic pressure* psi		Final position Radial clearance reduction from zero pos.	Final position Axial drive-up from starting position	SKF Bearing designation	Starting position Hydraulic pressure* psi		Final position Radial clearance reduction from zero pos.	Final position Axial drive-up from starting position
	1	2	in	s_s in		1	2	in	s_s in
23040 CCK/W33	235	403	0.0035	0.0422	***239… series***				
23044 CCK/W33	242	413	0.0039	0.0459	**23936 CCK/W33**	121	207	0.0032	0.0372
23048 CCK/W33	215	368	0.0043	0.0495	**23938 CCK/W33**	103	177	0.0034	0.0389
23052 CCK/W33	249	425	0.0046	0.0536	**23940 CCK/W33**	130	222	0.0035	0.0411
23056CCK/W33	225	383	0.0050	0.0570	**23944 CCK/W33**	109	185	0.0039	0.0442
23060 CCK/W33	255	436	0.0053	0.0611	**23948 CCK/W33**	93	159	0.0043	0.0475
23064 CCK/W33	233	397	0.0057	0.0645	**23952 CCK/W33**	132	225	0.0046	0.0520
23068 CCK/W33	267	455	0.0060	0.0689	**23956 CCK/W33**	119	203	0.0050	0.0556
23072 CCK/W33	238	406	0.0064	0.0720	**23960 CCK/W33**	154	263	0.0053	0.0597
23076 CCK/W33	229	392	0.0067	0.0756	**23964 CCK/W33**	139	237	0.0057	0.0634
231… series					**23968 CCK/W33**	129	220	0.0060	0.0667
23120 CCK/W33	205	350	0.0018	0.0231	**23972 CCK/W33**	117	200	0.0064	0.0700
23122 CCK/W33	210	357	0.0019	0.0247	**23976 CCK/W33**	151	259	0.0067	0.0745
23124 CCK/W33	256	437	0.0021	0.0270	***240… series***				
23126 CCK/W33	238	408	0.0023	0.0286	**24024 CCK30/W33**	157	292	0.0021	0.0659
23128 CCK/W33	247	422	0.0025	0.0306	**24026 CCK30/W33**	202	376	0.0023	0.0711
23130 CCK/W33	323	549	0.0027	0.0328	**24028 CCK30/W33**	186	345	0.0025	0.0753
23132 CCK/W33	327	558	0.0028	0.0350	**24030 CCK30/W33**	193	360	0.0027	0.0800
23134 CCK/W33	310	529	0.0030	0.0367	**24032 CCK30/W33**	192	356	0.0028	0.0848
23136 CCK/W33	335	572	0.0032	0.0386	**24034 CCK30/W33**	219	406	0.0030	0.0900
23138 CCK/W33	362	618	0.0034	0.0409	**24036 CCK30/W33**	256	476	0.0032	0.0956
23140 CCK/W33	377	644	0.0035	0.0431	**24038 CCK30/W33**	226	419	0.0034	0.0998
23144 CCK/W33	393	671	0.0039	0.0470	**24040 CCK30/W33**	252	466	0.0035	0.1050
23148 CCK/W33	379	646	0.0043	0.0506	**24044 CCK30/W33**	253	469	0.0039	0.1145
23152 CCK/W33	416	711	0.0046	0.0547	**24048 CCK30/W33**	218	405	0.0043	0.1228
23156 CCK/W33	377	643	0.0050	0.0581	**24052 CCK30/W33**	275	510	0.0046	0.1340
23160 CCK/W33	408	697	0.0053	0.0623	**24056 CCK30/W33**	239	444	0.0050	0.1420
23164 CCK/W33	448	765	0.0057	0.0667	**24060 CCK30/W33**	273	507	0.0053	0.1523
23168 CCK/W33	489	834	0.0060	0.0709	**24064 CCK30/W33**	260	484	0.0057	0.1617
23172 CACK**/W33**	473	807	0.0064	0.0748	**24068 CCK30/W33**	295	548	0.0060	0.1720
23176 CAK/W33	416	710	0.0067	0.0775	**24072 CCK30/W33**	269	500	0.0064	0.1806
232… series					**24076 CCK30/W33**	259	480	0.0067	0.1895
23218 CCK/W33	244	420	0.0016	0.0214	***241… series***				
23220 CCK/W33	279	475	0.0018	0.0233	**24122 CCK30/W33**	225	417	0.0019	0.0625
23222 CCK/W33	342	583	0.0019	0.0256	**24124 CCK30/W33**	280	520	0.0021	0.0678
23224 CCK/W33	365	624	0.0021	0.0275	**24126 CCK30/W33**	272	503	0.0023	0.0723
23226 CCK/W33	372	634	0.0023	0.0295	**24128 CCK30/W33**	273	508	0.0025	0.0767
23228 CCK/W33	439	751	0.0025	0.0317	**24130 CCK30/W33**	342	636	0.0027	0.0825
23230 CCK/W33	450	769	0.0027	0.0336	**24132 CCK30/W33**	369	686	0.0028	0.0881
23232 CCK/W33	477	814	0.0028	0.0358	**24134 CCK30/W33**	315	585	0.0030	0.0917
23234 CCK/W33	498	850	0.0030	0.0378	**24136 CCK30/W33**	358	663	0.0032	0.0975
23236 CCK/W33	460	787	0.0032	0.0395	**24138 CCK30/W33**	385	714	0.0034	0.1031
23238 CCK/W33	472	803	0.0034	0.0417	**24140 CCK30/W33**	409	761	0.0035	0.1081
23240 CCK/W33	503	858	0.0035	0.0439	**24144 CCK30/W33**	408	758	0.0039	0.1176
23244 CCK/W33	549	936	0.0039	0.0481	**24148 CCK30/W33**	411	765	0.0043	0.1276
23248 CCK/W33	626	1068	0.0043	0.0525	**24152 CCK30/W33**	449	834	0.0046	0.1378
23252 CACK**/W33**	666	1137	0.0046	0.0570	**24156 CCK30/W33**	401	746	0.0050	0.1465
23256 CACK**/W33**	599	1021	0.0050	0.0603	**24160 CCK30/W33**	447	831	0.0053	0.1573
23260 CACK**/W33**	629	1073	0.0053	0.0645	**24164 CCK30/W33**	492	913	0.0057	0.1681
23264 CACK**/W33**	678	1156	0.0057	0.0689	**24168 CCK30/W33**	522	969	0.0060	0.1776
23268 CAK/W33	720	1229	0.0060	0.0731	**24172 CCK30/W33**	488	907	0.0064	0.1868
23272 CAK/W33	678	1157	0.0064	0.0767	**24176 CCK30/W33**	467	867	0.0067	0.1959
23276 CAK/W33	685	1170	0.0067	0.0806					

** = Values given valid for HMV(C) E series nut size = Bearing size*

1 = Should be applied when one surface slides during mounting. Surface lightly oiled, with light oil.

2 = Should be applied when two surfaces slide during mounting. Surface lightly oiled, with light oil.

Pressure and axial drive-up table for spherical roller bearings (cont.)

SKF Bearing designation	Starting position Hydraulic pressure* MPa		Final position Radial clearance reduction from zero pos.	Final position Axial drive-up from starting position	SKF Bearing designation	Starting position Hydraulic pressure* MPa		Final position Radial clearance reduction from zero pos.	Final position Axial drive-up from starting position
	1	2	mm	s_s mm		1	2	mm	s_s mm
213... series					**22236 CCK/W33**	2.53	4.32	0.081	1.008
21310 CCK	1.61	2.73	0.023	0.381	**22238 CCK/W33**	2.6	4.43	0.086	1.059
21310 EK	1.89	3.26	0.023	0.396	**22240 CCK/W33**	2.72	4.65	0.089	1.115
21311 CCK	1.65	2.8	0.025	0.401	**22244 CCK/W33**	2.98	5.09	0.099	1.222
21311 EK	1.42	2.39	0.025	0.396	**22248 CCK/W33**	3.33	5.68	0.109	1.341
21312 CCK	2.16	3.66	0.028	0.445	**22252 CCK/W33**	3.29	5.61	0.117	1.433
21312 EK	2.46	4.19	0.028	0.460	**22256 CCK/W33**	2.99	5.1	0.127	1.524
21313 CCK	2.2	3.78	0.030	0.472	**22260 CCK/W33**	2.94	5.01	0.135	1.615
21313 EK	2.57	4.37	0.030	0.495	**22264 CCK/W33**	3.09	5.28	0.145	1.730
21314 CCK	2.16	3.69	0.030	0.495	***223... series***				
21314 EK	2.7	4.59	0.030	0.523	**22310 CCK**	1.79	3.01	0.023	0.361
21315 CCK	2.26	3.86	0.033	0.523	**22310 EK**	1.65	2.8	0.023	0.353
21315 EK	2.23	3.81	0.033	0.523	**22311 CCK**	1.9	3.26	0.025	0.389
21316 CCK	2.49	4.23	0.036	0.551	**22311 EK**	2	3.42	0.025	0.389
21316 EK	2.25	3.82	0.036	0.544	**22312 CCK**	2.03	3.48	0.028	0.409
21317 CCK	2.56	4.36	0.038	0.579	**22312 EK**	2.4	4.12	0.028	0.424
21317 EK	1.78	3.02	0.038	0.544	**22313 CCK**	2.17	3.72	0.030	0.445
21318 CCK	2.7	4.62	0.041	0.607	**22313 EK**	2.14	3.67	0.030	0.432
21318 EK	1.88	3.22	0.041	0.572	**222314 CCK/W33**	2.35	4	0.030	0.465
21319 CCK	2.98	5.08	0.043	0.643	**22314 EK**	2.62	4.46	0.030	0.480
21319 EK	1.95	3.33	0.043	0.592	**22315 CCK/W33**	2.54	4.34	0.033	0.495
21320 CCK	3.35	5.69	0.046	0.686	**22315 EK**	2.36	4.03	0.033	0.488
21320 EK	1.51	2.57	0.046	0.592	**22316 CCK/W33**	2.63	4.49	0.036	0.523
21322 CCK	3.68	6.27	0.048	0.749	**22316 EK**	2.44	4.16	0.036	0.516
222... series					**22317 CCK/W33**	2.84	4.84	0.038	0.551
22210 CCK	0.74	1.23	0.023	0.345	**22317 EK**	3	5.1	0.038	0.551
22210 EK	0.77	1.3	0.023	0.345	**22318 CCK/W33**	2.89	4.94	0.041	0.572
22211 CCK	0.77	1.35	0.025	0.368	**22318 EK**	3.02	5.16	0.041	0.579
22211 EK	0.74	1.26	0.025	0.368	**22319 CCK/W33**	3.07	5.24	0.043	0.599
22212 CCK	0.99	1.66	0.028	0.396	**22319 EK**	3.09	5.26	0.043	0.599
22212 EK	0.89	1.51	0.028	0.396	**22320 CCK/W33**	3.54	6.03	0.046	0.635
22213 CCK	1.13	1.92	0.030	0.432	**22320 EK**	4.16	7.11	0.046	0.650
22213 EK	0.99	1.67	0.030	0.417	**22322 CCK/W33**	4.12	7.01	0.048	0.691
22214 CCK	1.07	1.81	0.030	0.452	**22322 EK**	4.56	7.79	0.048	0.706
22214 EK	0.94	1.63	0.030	0.445	**22324 CCK/W33**	4.43	7.56	0.053	0.749
22215 CCK	1.02	1.72	0.033	0.472	**22326 CCK/W33**	4.8	8.2	0.058	0.798
22215 EK	0.89	1.5	0.033	0.465	**22328 CCK/W33**	5.1	8.7	0.064	0.846
22216 CCK	1.06	1.79	0.036	0.495	**22330 CCK/W33**	5.36	9.15	0.069	0.904
22216 EK	1.02	1.74	0.036	0.495	**22332 CCK/W33**	5.23	8.91	0.071	0.960
22217 CCK/W33	1.16	1.96	0.038	0.523	**22334 CKK/W33**	5.31	9.07	0.076	1.016
22217 EK	1.18	2.01	0.038	0.523	**22336 CCK/W33**	5.22	8.92	0.081	1.067
22218 CCK/W33	1.32	2.27	0.041	0.551	**22338 CCK/W33**	5.17	8.81	0.086	1.115
22218 EK	1.21	2.07	0.041	0.544	**22340 CCK/W33**	5.22	8.9	0.089	1.171
22219 CCK/W33	1.43	2.42	0.043	0.572	**22344 CCK/W33**	5.68	9.69	0.099	1.298
22219 EK	1.39	2.36	0.043	0.572	**22348 CCK/W33**	5.66	9.65	0.109	1.405
22220 CCK/W33	1.61	2.74	0.046	0.599	**22352 CCK/W33**	5.7	9.73	0.117	1.511
22220 EK	1.47	2.53	0.046	0.592	**22356 CCK/W33**	5.78	9.86	0.127	1.615
22222 CCK/W33	1.88	3.23	0.048	0.655	***230... series***				
22222 EK	1.76	2.99	0.048	0.650	**23022 CCK/W33**	1.09	1.87	0.048	0.627
22224 CCK/W33	1.98	3.37	0.053	0.699	**23024 CCK/W33**	1.05	1.78	0.053	0.671
22224 EK	1.88	3.2	0.053	0.699	**23026 CCK/W33**	1.29	2.21	0.058	0.719
22226 CCK/W33	2.11	3.62	0.058	0.749	**23028 CCK/W33**	1.23	2.09	0.064	0.770
22226 EK	2	3.4	0.058	0.742	**23030 CCK/W33**	1.26	2.15	0.069	0.813
22228 CCK/W33	2.37	4.05	0.064	0.805	**23032 CCK/W33**	1.25	2.14	0.071	0.861
22230 CCK/W33	2.53	4.32	0.069	0.853	**23034 CCK/W33**	1.36	2.32	0.076	0.909
22232 CCK/W33	2.61	4.46	0.071	0.909	**23036 CCK/W33**	1.53	2.61	0.081	0.968
22234 CCK/W33	2.82	4.8	0.076	0.968	**23038 CCK/W33**	1.5	2.56	0.086	1.016

Pressure and axial drive-up table for spherical roller bearings (cont.)

SKF Bearing designation	Starting position Hydraulic pressure* MPa		Final position Radial clearance reduction from zero pos.	Final position Axial drive-up from starting position	SKF Bearing designation	Starting position Hydraulic pressure* MPa		Final position Radial clearance reduction from zero pos.	Final position Axial drive-up from starting position
	1	2	mm	s_s mm		1	2	mm	s_s mm
23040 CCK/W33	1.65	2.82	0.089	1.072	***239… series***				
23044 CCK/W33	1.69	2.89	0.099	1.166	**23936 CCK/W33**	0.85	1.45	0.081	0.945
23048 CCK/W33	1.51	2.58	0.109	1.257	**23938 CCK/W33**	0.72	1.24	0.086	0.988
23052 CCK/W33	1.74	2.98	0.117	1.361	**23940 CCK/W33**	0.91	1.55	0.089	1.044
23056 CCK/W33	1.58	2.68	0.127	1.448	**23944 CCK/W33**	0.76	1.3	0.099	1.123
23060 CCK/W33	1.79	3.05	0.135	1.552	**23948 CCK/W33**	0.65	1.11	0.109	1.207
23064 CCK/W33	1.63	2.78	0.145	1.638	**23952 CCK/W33**	0.92	1.58	0.117	1.321
23068 CCK/W33	1.87	3.19	0.152	1.750	**23956 CCK/W33**	0.83	1.42	0.127	1.412
23072 CCK/W33	1.67	2.84	0.163	1.829	**23960 CCK/W33**	1.08	1.84	0.135	1.516
23076 CCK/W33	1.6	2.74	0.170	1.920	**23964 CCK/W33**	0.97	1.66	0.145	1.610
231… series					**23968 CCK/W33**	0.9	1.54	0.152	1.694
23120 CCK/W33	1.44	2.45	0.046	0.587	**23972 CCK/W33**	0.82	1.4	0.163	1.778
23122 CCK/W33	1.47	2.5	0.048	0.627	**23976 CCK/W33**	1.06	1.81	0.170	1.892
23124 CCK/W33	1.79	3.06	0.053	0.686	***240… series***				
23126 CCK/W33	1.67	2.86	0.058	0.726	**24024 CCK30/W33**	1.1	2.04	0.053	1.674
23128 CCK/W33	1.73	2.95	0.064	0.777	**24026 CCK30/W33**	1.41	2.63	0.058	1.806
23130 CCK/W33	2.26	3.84	0.069	0.833	**24028 CCK30/W33**	1.3	2.42	0.064	1.913
23132 CCK/W33	2.29	3.91	0.071	0.889	**24030 CCK30/W33**	1.35	2.52	0.069	2.032
23134 CCK/W33	2.17	3.7	0.076	0.932	**24032 CCK30/W33**	1.34	2.49	0.071	2.154
23136 CCK/W33	2.35	4	0.081	0.980	**24034 CCK30/W33**	1.53	2.84	0.076	2.286
23138 CCK/W33	2.53	4.33	0.086	1.039	**24036 CCK30/W33**	1.79	3.33	0.081	2.428
23140 CCK/W33	2.64	4.51	0.089	1.095	**24038 CCK30/W33**	1.58	2.93	0.086	2.535
23144 CCK/W33	2.75	4.7	0.099	1.194	**24040 CCK30/W33**	1.76	3.26	0.089	2.667
23148 CCK/W33	2.65	4.52	0.109	1.285	**24044 CCK30/W33**	1.77	3.28	0.099	2.908
23152 CCK/W33	2.91	4.98	0.117	1.389	**24048 CCK30/W33**	1.53	2.84	0.109	3.119
23156 CCK/W33	2.64	4.5	0.127	1.476	**24052 CCK30/W33**	1.93	3.57	0.117	3.404
23160 CCK/W33	2.86	4.88	0.135	1.582	**24056 CCK30/W33**	1.67	3.11	0.127	3.607
23164 CCK/W33	3.14	5.36	0.145	1.694	**24060 CCK30/W33**	1.91	3.55	0.135	3.868
23168 CCK/W33	3.42	5.84	0.152	1.801	**24064 CCK30/W33**	1.82	3.39	0.145	4.107
23172 CACK/W33	3.31	5.65	0.163	1.900	**24068 CCK30/W33**	2.07	3.84	0.152	4.369
23176 CAK/W33	2.91	4.97	0.170	1.969	**24072 CCK30/W33**	1.88	3.5	0.163	4.587
232… series					**24076 CCK30/W33**	1.81	3.36	0.170	4.813
23218 CCK/W33	1.71	2.94	0.041	0.544	***241… series***				
23220 CCK/W33	1.95	3.33	0.046	0.592	**24122 CCK30/W33**	1.58	2.92	0.048	1.588
23222 CCK/W33	2.39	4.08	0.048	0.650	**24124 CCK30/W33**	1.96	3.64	0.053	1.722
23224 CCK/W33	2.56	4.37	0.053	0.699	**24126 CCK30/W33**	1.9	3.52	0.058	1.836
23226 CCK/W33	2.6	4.44	0.058	0.749	**24128 CCK30/W33**	1.91	3.56	0.064	1.948
23228 CCK/W33	3.07	5.26	0.064	0.805	**24130 CCK30/W33**	2.39	4.45	0.069	2.096
23230 CCK/W33	3.15	5.38	0.069	0.853	**24132 CCK30/W33**	2.58	4.8	0.071	2.238
23232 CCK/W33	3.34	5.7	0.071	0.909	**24134 CCK30/W33**	2.21	4.1	0.076	2.329
23234 CCK/W33	3.49	5.95	0.076	0.960	**24136 CCK30/W33**	2.51	4.64	0.081	2.477
23236 CCK/W33	3.22	5.51	0.081	1.003	**24138 CCK30/W33**	2.7	5	0.086	2.619
23238 CCK/W33	3.3	5.62	0.086	1.059	**24140 CCK30/W33**	2.86	5.33	0.089	2.746
23240 CCK/W33	3.52	6.01	0.089	1.115	**24144 CCK30/W33**	2.86	5.31	0.099	2.987
23244 CCK/W33	3.84	6.55	0.099	1.222	**24148 CCK30/W33**	2.88	5.36	0.109	3.241
23248 CCK/W33	4.38	7.48	0.109	1.334	**24152 CCK30/W33**	3.14	5.84	0.117	3.500
23252 CACK/W33	4.66	7.96	0.117	1.448	**24156 CCK30/W33**	2.81	5.22	0.127	3.721
23256 CACK/W33	4.19	7.15	0.127	1.532	**24160 CCK30/W33**	3.13	5.82	0.135	3.995
23260 CACK/W33	4.4	7.51	0.135	1.638	**24164 CCK30/W33**	3.44	6.39	0.145	4.270
23264 CACK/W33	4.75	8.09	0.145	1.750	**24168 CCK30/W33**	3.65	6.78	0.152	4.511
23268 CAK/W33	5.04	8.6	0.152	1.857	**24172 CCK30/W33**	3.42	6.35	0.163	4.745
23272 CAK/W33	4.75	8.1	0.163	1.948	**24176 CCK30/W33**	3.27	6.07	0.170	4.976
23276 CAK/W33	4.8	8.19	0.170	2.047					

** = Values given valid for HMV(C) E series nut size = Bearing size*

1 = Should be applied when one surface slides during mounting. Surface lightly oiled, with light oil.

2 = Should be applied when two surfaces slide during mounting. Surface lightly oiled, with light oil.

Mounting CARB™ toroidal roller bearings

The CARB toroidal roller bearing is a standard bearing having high radial load carrying capacity and a unique combination of characteristics including

- the low sectional height of needle roller bearings,
- the properties of cylindrical roller bearings in accommodating axial displacement within the bearing, and
- the ability of spherical roller bearings to accept misalignment

CARB is available with a cage or in a full complement design without cage, with a choice of cylindrical or tapered bore. Brief recommendations for mounting and dismounting and guidelines for grease lubrication are given in the following. The same rules are valid for CARB toroidal roller bearings as for other standard bearings.

Axial location

CARB can accommodate axial displacement within the bearing. This means that the inner ring as well as the roller assembly can be axially displaced in relation to the outer ring. The CARB can be secured with lock nuts KMF .. E or KML. If a standard KM lock nut and an MB locking washer are used instead, a spacer may be needed between the bearing inner ring and the washer to prevent washer contact with the cage, *if axial displacement or misalignment are extreme,* see ➔ **fig** 10.

The spacer dimensions shown in **Figure** 11 will help ensure safe operation with axial offset ±10% of bearing width, and 0.5° misalignment.

Note that both the inner and outer ring must be locked in the axial direction as shown in **Figures** 10 and 11.

Spacer dimensions

For mounting with standard KM lock nut and MB locking washer, as shown in **Figure** 11, spacers with the following dimensions are needed:

d < 35 mm[1)]	B_1 = 2 mm
35 mm < d < 120 mm	B_1 = 3 mm
d > 120 mm	B_1 = 4 mm

Measure d and d_2 as shown in the SKF General Catalog.

Axial mounting position

Initial axial displacement of one ring in relation to the other can be used to increase the available axial clearance for shaft movement in one direction, see ➔ **fig** 11.

It is also possible to accurately adjust the radial clearance or the radial position of the bearing by displacing one of the rings.

Axial and radial clearance are interdependent, i.e. an axial displacement of one ring from the center position reduces the radial clearance. The principle is shown in **Figure** 12 as applied to CARB C 2220.

For example, if the axial displacement is 2.5 mm, the radial clearance is reduced from 100 to 90 µm and the radial position of the bearing changes from –50 to –45 µm, see ➔ **fig** 12. For more information please contact SKF.

Precautions before mounting

Use the same standard mounting precautions for CARB bearings as for any other bearings.

Fig 10

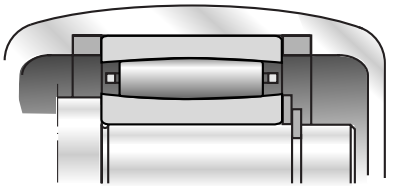


Figure 10. *Axial location and axial displacement*

[1)] < = *less than*
> = *greater than*

Fig 11

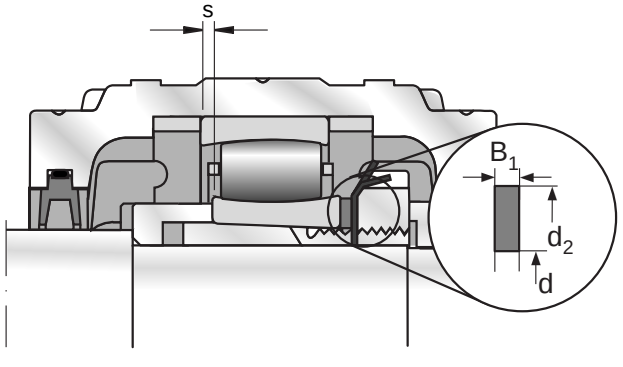


Figure 11*. Initial axial displacements and spacer dimensions*

Fig 12

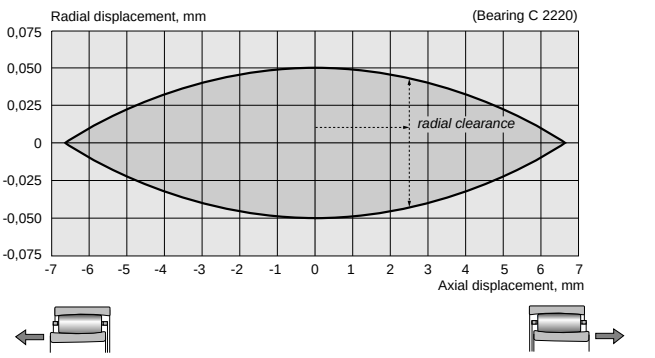


Figure 12. *The clearance window for CARB™*

Mounting of CARB™ toroidal roller bearings with cylindrical bore

The same basic rules for mounting all other bearings with cylindrical bores apply to the CARB bearing. See page 9.

Mounting of CARB™ toroidal roller bearings with tapered bore

CARB toroidal roller bearings, as well as other bearings with a tapered bore, are always mounted with an interference fit on the shaft. As a measure of the degree of interference of the fit, either the reduction in radial internal clearance or the axial displacement of the inner ring on the tapered seat can be used.

Below, three methods for mounting bearings on a tapered seating are described:

1. Axial drive-up on adapter sleeve, angle method

Using the turning angle of the sleeve nut to determine the drive-up needed to achieve correct interference is successfully used on self-aligning ball bearings, and is also suitable for CARB for shaft diameters up to approximately 100 mm. It is important to establish a standard procedure for determining the starting point, “zero turning angle”.

Table 1c shows turning angles and corresponding axial drive-up distances for CARB toroidal roller bearings of series C22 and C23. The sequence described on pages 12 and13 should be followed. The starting point for measuring the turning angle is reached when the nut is tightened sufficiently to make the sleeve just lock on the journal, but not more.

It is advisable to mark the starting point on the nut and on the journal before tightening the nut according to **Table** 1c.

2. Clearance reduction method

For larger bearings the measurement of clearance reduction is often used to establish the required interference fit.

Before mounting, the internal radial clearance of the bearing should be measured with a feeler gauge.

Place the bearing on a clean work surface and rotate the inner ring a few times. Align the rings so they are parallel and center the roller assembly, see → **figs** 14 and 15. Use a blade slightly thinner than the minimum value of the clearance before mounting. Insert it over the uppermost unloaded roller so that it passes the middle of the roller. Move the blade to and fro a few times. Measure with an increasingly thicker blade until, when attempting to pull out the blade, there is a slight resistance. Push the bearing up on to the shaft and check the reduction in internal clearance during drive-up under the lowest roller with the rings parallel and the roller set centered, see → **fig** 16.

The minimum values for internal clearance given in **Table** 4, apply mainly to bearings in which clearance is close to the lower limit. This will give the minimum permissible clearance.

3. SKF hydraulic drive-up method

When measurement of the axial drive-up is used to achieve the required interference fit it can be difficult, for larger bearings, to establish where the drive-up starts. An accurate method for axial drive-up measurements is described below where the correct fit is achieved by controlling the axial drive-up of the bearing from a predetermined position.

The method may incorporate the use of an SKF hydraulic nut, HMV(C) .. E fitted with a dial indicator, and a specially calibrated pressure gauge, mounted on a selected pump. The equipment
is shown in **figure** 17.

The required pressure for each CARB bearing is given in **Table** 5, page 26. This enables accurate positioning of the bearing at the starting point, from where the axial drive-up (S_s) is measured.

Mounting of CARB™ toroidal roller bearings with tapered bore on sleeve

Adapter and withdrawal sleeves are often used and the bearings are in principle mounted in the same way as for a tapered shaft. Detailed information is found in the SKF Bearing Maintenance Handbook.

Dismounting methods

Dismounting of bearings may become necessary when a machine functions improperly or is being overhauled. Many precautions and operations are common to the mounting of bearings. The methods and tools depend on many factors such as bearing design, accessibility, type of fit, etc.

There are three dismounting methods: mechanical, hydraulic and oil injection.

- *When dismounting bearings, never apply the force through the rolling elements.*

Fig 13

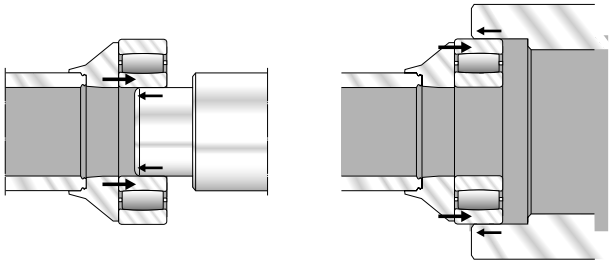


Figure 13. *Mounting CARB with SKF TMFT fitting tool*

Interference fit on the shaft

Bearings, with bore diameters up to 120 mm, mounted with an interference fit on the shaft, can be dismounted using a conventional puller (The CARB toroidal bearing requires a special puller; see → **fig.** 18). The puller should engage the inner ring, and the bearing is then removed with a steady force until the bearing bore completely clears the entire length of the cylindrical seating, see → **fig.** 19.

Larger bearings with an interference fit on the shaft often require considerable dismounting force. In these cases a hydraulic tool is more suitable than a mechanical one.

Interference fit in the housing

A bearing mounted in a housing without shoulders can be removed by hammer blows directed on a sleeve that abuts the outer ring. Larger bearings require greater force to dismount and the use of a press is recommended.

Interference fit both in the housing and on the shaft

For bearings with an interference fit on both rings, the best method is to allow the bearing to be pressed out of the housing with the shaft. If this is not suitable the opposite procedure – allowing the bearing to come off the shaft with the housing – can be used.

Fig 14

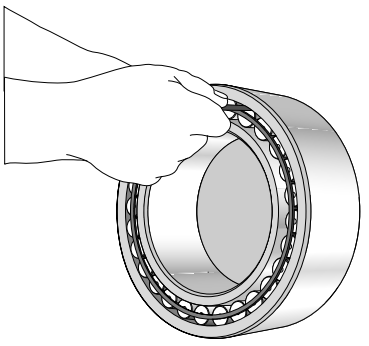


Figure 14. *Measurement of radial clearance*

Fig 15

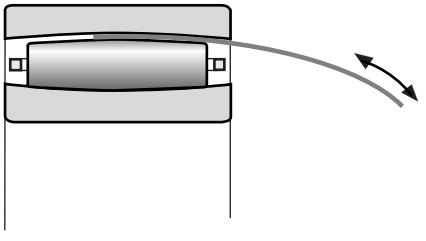


Figure 15*.The feeler gauge should be moved to and fro*

Fig 16

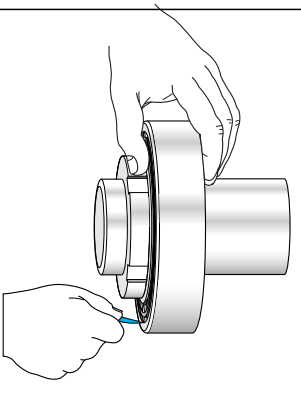


Figure 16. *Measurement of clearance reduction*

Table 3

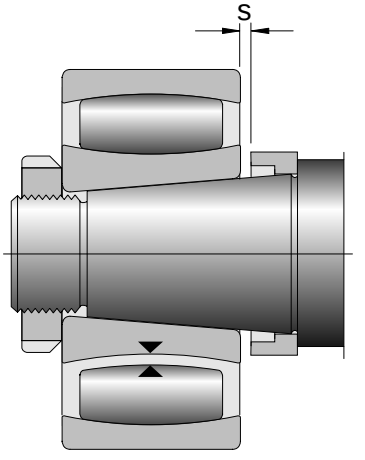
Radial internal clearance of CARB toroidal roller bearings with tapered bore

Bore diameter d		Radial internal clearance C2		Normal		C3		C4	
over	incl.	min	max	min	max	min	max	min	max
mm[1]		µm[2]							
18	**24**	20	30	30	40	40	52	52	67
24	**30**	25	35	35	47	47	65	65	85
30	**40**	30	42	42	57	57	75	75	95
40	**50**	37	52	52	70	70	90	90	115
50	**65**	47	65	65	85	85	107	107	140
65	**80**	60	82	82	107	107	135	135	175
80	**100**	67	95	95	125	125	160	160	205
100	**120**	82	117	117	152	152	195	195	250
120	**140**	100	140	140	180	180	230	230	295
140	**160**	110	155	155	205	205	265	265	340
160	**180**	120	170	170	230	230	300	300	385
180	**200**	135	190	190	255	255	330	330	420
200	**225**	150	215	215	285	285	365	365	465
225	**250**	170	235	235	310	310	400	400	510
250	**280**	185	260	260	345	345	440	440	555
280	**315**	205	285	285	380	380	485	485	610
315	**355**	230	315	315	415	415	530	530	665
355	**400**	255	350	350	460	460	585	585	735
400	**450**	280	385	385	505	505	645	645	815
450	**500**	315	430	430	560	560	710	710	895
500	**560**	350	475	475	610	610	775	775	985
560	**630**	390	530	530	680	680	870	870	1 105
630	**710**	430	590	590	760	760	970	970	1 225
710	**800**	480	660	660	855	855	1 090	1 090	1 360

Table 4

Axial drive-up table for CARB toroidal roller bearings with tapered bore

Bore diameter d		Reduction in radial internal clearance		Axial drive-up s[3] Taper 1:12 on diameter		Taper 1:30 on diameter		Minimum permissible residual radial clearance[4] after mounting bearings with initial clearance		
over	incl.	min	max	min	max	min	max	Normal	C3	C4
mm[1]		mm[1]		mm[1]				mm[1]		
18	**24**	0.009	0.014	0.210	0.290	0.530	0.720	0.021	0.026	0.038
24	**30**	0.012	0.018	0.250	0.340	0.640	0.850	0.023	0.029	0.047
30	**40**	0.015	0.024	0.300	0.420	0.740	1.060	0.027	0.033	0.051
40	**50**	0.020	0.030	0.370	0.510	0.920	1.270	0.032	0.040	0.060
50	**65**	0.025	0.039	0.440	0.640	1.090	1.590	0.040	0.046	0.068
65	**80**	0.033	0.048	0.540	0.760	1.360	1.910	0.044	0.054	0.087
80	**100**	0.040	0.060	0.650	0.930	1.620	2.330	0.055	0.065	0.100
100	**120**	0.050	0.072	0.790	1.100	1.980	2.750	0.067	0.080	0.123
120	**140**	0.060	0.084	0.930	1.270	2.330	3.180	0.080	0.106	0.146
140	**160**	0.070	0.096	1.070	1.440	2.680	3.600	0.085	0.119	0.169
160	**180**	0.080	0.108	1.210	1.610	3.040	4.020	0.090	0.132	0.192
180	**200**	0.090	0.120	1.360	1.780	3.390	4.450	0.100	0.145	0.210
200	**225**	0.100	0.135	1.500	1.990	3.740	4.980	0.115	0.160	0.230
225	**250**	0.113	0.150	1.670	2.200	4.180	5.510	0.122	0.170	0.250
250	**280**	0.125	0.168	1.850	2.460	4.620	6.140	0.135	0.187	0.272
280	**315**	0.140	0.189	2.060	2.750	5.150	6.880	0.145	0.201	0.296
315	**355**	0.158	0.213	2.310	3.090	5.770	7.730	0.158	0.222	0.317
355	**400**	0.177	0.240	2.590	3.470	6.480	8.680	0.172	0.240	0.345
400	**450**	0.200	0.270	2.910	3.900	7.270	9.740	0.185	0.255	0.375
450	**500**	0.225	0.300	3.260	4.320	8.150	10.800	0.205	0.280	0.410
500	**560**	0.250	0.336	3.610	4.830	9.040	12.070	0.225	0.304	0.439
560	**630**	0.280	0.378	4.040	5.420	10.090	13.550	0.250	0.342	0.492
630	**710**	0.315	0.426	4.530	6.100	11.330	15.250	0.275	0.374	0.544
710	**800**	0.355	0.480	5.100	6.860	12.740	17.150	0.305	0.425	0.610



[1] 1 inch = 25.4 mm

[2] 1 µm = 0.001 mm = 0.000039 inches

[3] Valid for solid steel shafts only

[4] The residual clearance must be checked in cases where the initial radial internal clearance is in the lower half of the tolerance range and where large temperature differentials between the bearing rings can arise in operation. The residual clearance must not be less than the minimum values quoted above. When doing so, make sure that the rings and roller assembly are aligned and centered

Dismounting from a tapered journal

Smaller bearings can be dismounted using a conventional puller which engages the inner ring. Center the puller accurately to avoid damage to the bearing seating.

Larger bearings may require considerable force to dismount, so a hydraulic withdrawal tool may be more suitable than a mechanical one.

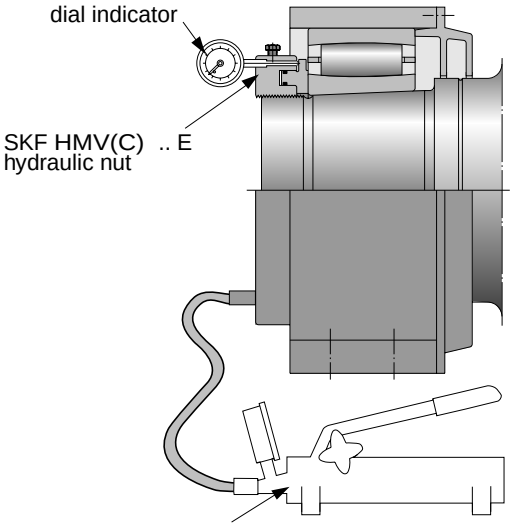
The SKF puller for CARB allows easy dismounting from housings with loose fit after dismounting of the inner ring. The puller arms are inserted between the bearing cage and outer ring and engage on the outer ring, see → **fig. 18**.

The best way to facilitate dismounting of inner rings is to utilize the SKF oil injection method. Detailed information is found in the SKF Bearing Maintenance Handbook.

Dismounting from sleeves

Adapter and withdrawal sleeves are often used. CARB toroidal roller bearings are in principle dismounted in the same way as other bearings. Detailed information is given in the SKF Bearing Maintenance Handbook.

Fig 17



SKF 729124 SRB (for nuts ≤ HMV(C) 54 E) [1)]
SKF TMJL 100 SRB (for nuts ≤ HMV(C) 92 E)
SKF TMJL 50 SRB (for nuts ≤ HMV(C) 200 E)

Figure 17. *The equipment for accurate drive-up*

[1)] ≤ = less than or equal to

Fig 18

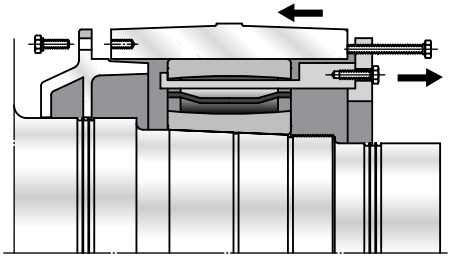


Figure 18. *Puller for CARB™*

Fig 19

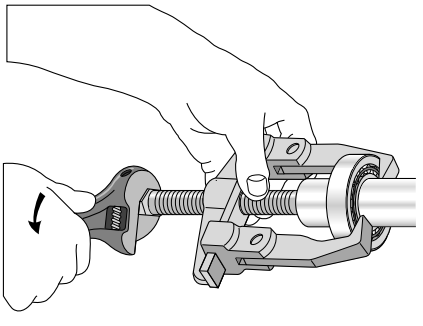


Figure 19. *The puller should engage the inner ring*

Pressure and axial drive-up table for CARB™ toroidal roller bearings with tapered bore

Bearing designation	Starting position		Final position		
	Pressure at start*		Radial clearance reduction from starting position	Axial drive-up s_s from starting position	
	1	2		1	2
	MPa		mm	mm	
22					
C 2210 K	0.7	1.2	0.023	0.340	0.410
C 2211 K	0.6	1.0	0.025	0.350	0.420
C 2212 K	1.1	1.9	0.027	0.390	0.460
C 2213 K	0.8	1.4	0.029	0.400	0.470
C 2214 K	0.8	1.3	0.032	0.430	0.500
C 2215 K	0.7	1.2	0.034	0.440	0.520
C 2216 K	0.8	1.3	0.036	0.460	0.540
C 2217 K	1.1	1.9	0.038	0.500	0.570
C 2218 K	1.4	2.3	0.041	0.550	0.620
C 2219 K	1.0	1.7	0.043	0.540	0.620
C 2220 K	1.1	1.9	0.045	0.560	0.640
C 2221 K	1.9	3.2	0.047	0.620	0.690
C 2222 K	1.5	2.5	0.050	0.630	0.710
C 2224 K	1.6	2.7	0.054	0.670	0.740
C 2226 K	1.4	2.5	0.059	0.710	0.790
C 2228 K	2.4	4.0	0.063	0.790	0.860
C 2230 K	1.8	3.1	0.068	0.820	0.890
C 2232 K	2.6	4.5	0.072	0.900	0.970
C 2234 K	2.6	4.4	0.076	0.940	1.000
C 2236 K	2.5	4.2	0.081	0.990	1.100
C 2238 K	1.8	3.0	0.086	1.000	1.100
C 2240 K	2.8	4.8	0.090	1.100	1.200
C 2244 K	2.0	3.3	0.099	1.200	1.200
23					
C 2310 K	1.4	2.3	0.023	0.340	0.420
C 2311 K	1.7	2.9	0.025	0.370	0.450
C 2312 K	1.8	3.1	0.027	0.390	0.470
C 2313 K	2.5	4.3	0.029	0.440	0.510
C 2314 K	2.0	3.4	0.032	0.450	0.530
C 2315 K	2.3	3.8	0.034	0.480	0.550
C 2316 K	2.1	3.6	0.036	0.490	0.560
C 2317 K	2.4	4.1	0.038	0.520	0.590
C 2318 K	2.9	4.9	0.041	0.570	0.640
C 2319 K	2.2	3.8	0.043	0.570	0.640
C 2320 K	2.6	4.4	0.045	0.590	0.660
C 2321 K	3.3	5.7	0.047	0.630	0.700
C 2322 K	3.9	6.7	0.050	0.690	0.760
C 2324 K	3.2	5.5	0.054	0.700	0.770
C 2326 K	2.7	4.6	0.059	0.730	0.810
C 2328 K	4.9	8.3	0.063	0.830	0.900
C 2330 K	6.8	11.5	0.068	0.950	1.000
30					
C 3010 K	0.4	0.6	0.023	0.320	0.390
C 3011 K	0.5	0.8	0.025	0.340	0.410
C 3012 K	0.5	0.8	0.027	0.360	0.430
C 3013 K	0.5	0.8	0.029	0.380	0.450
C 3014 K	0.6	1.1	0.032	0.420	0.490
C 3015 K	0.5	0.8	0.034	0.430	0.500
C 3016 K	0.6	1.1	0.036	0.460	0.530
C 3017 K	0.5	0.9	0.038	0.470	0.540
C 3018 K	0.8	1.4	0.041	0.520	0.590
C 3019 K	0.7	1.2	0.043	0.530	0.610
C 3020 K	0.6	1.1	0.045	0.550	0.620
C 3021 K	0.8	1.4	0.047	0.580	0.650
C 3022 K	1.0	1.7	0.050	0.610	0.690
C 3024 K	0.9	1.6	0.054	0.650	0.720
C 3026 K	1.2	2.1	0.059	0.720	0.790
C 3028 K	1.3	2.1	0.063	0.760	0.830
C 3030 K	1.0	1.7	0.068	0.800	0.870
C 3032 K	1.3	2.3	0.072	0.860	0.930
C 3034 K	1.5	2.6	0.076	0.900	0.980
C 3036 K	1.4	2.4	0.081	0.950	1.000
C 3038 K	1.6	2.7	0.086	1.000	1.100
C 3040 K	1.6	2.8	0.090	1.100	1.100
C 3044 K	1.6	2.7	0.099	1.200	1.200
C 3048 K	1.3	2.3	0.108	1.200	1.300
C 3052 K	1.8	3.0	0.117	1.400	1.400
C 3056 K	1.7	2.9	0.126	1.500	1.500
C 3060 K	1.9	3.2	0.135	1.600	1.600
C 3064 K	1.8	3.1	0.144	1.700	1.700
C 3068 K	2.0	3.5	0.153	1.800	1.800
C 3072 K	1.7	2.8	0.162	1.800	1.900
C 3076 K	1.4	2.3	0.171	1.900	2.000
C 3080 K	1.5	2.6	0.180	2.000	2.100
31					
C 3110 K	0.7	1.1	0.023	0.330	0.410
C 3111 K	0.7	1.1	0.025	0.350	0.420
C 3112 K	0.8	1.3	0.027	0.370	0.450
C 3113 K	0.8	1.3	0.029	0.390	0.460
C 3114 K	0.6	1.0	0.032	0.420	0.490
C 3115 K	0.8	1.4	0.034	0.440	0.520
C 3116 K	0.7	1.3	0.036	0.460	0.530
C 3117 K	0.8	1.3	0.038	0.480	0.550
C 3118 K	1.2	2.0	0.041	0.530	0.600
C 3119 K	1.3	2.2	0.043	0.550	0.620
C 3120 K	1.3	2.2	0.045	0.570	0.640
C 3121 K	1.3	2.2	0.047	0.580	0.650
C 3122 K	1.3	2.2	0.050	0.620	0.690
C 3124 K	1.8	3.0	0.054	0.670	0.750
C 3126 K	1.5	2.6	0.059	0.720	0.790
C 3128 K	1.8	3.1	0.063	0.770	0.840
C 3130 K	2.4	4.1	0.068	0.840	0.910
C 3132 K	2.1	3.5	0.072	0.870	0.940
C 3134 K	1.8	3.1	0.076	0.900	0.970
C 3136 K	1.7	2.9	0.081	0.940	1.000
C 3138 K	2.3	3.9	0.086	1.000	1.100
C 3140 K	2.7	4.6	0.090	1.100	1.200
C 3144 K	2.8	4.7	0.099	1.200	1.300
C 3148 K	2.0	3.4	0.108	1.200	1.300
C 3152 K	2.8	4.7	0.117	1.400	1.400
C 3156 K	2.6	4.5	0.126	1.500	1.500
C 3160 K	2.8	4.8	0.135	1.600	1.600
32					
C 3210 K	1.0	1.7	0.023	0.340	0.420
C 3211 K	0.7	1.2	0.025	0.350	0.420
C 3212 K	0.9	1.5	0.027	0.370	0.440
C 3213 K	1.1	1.8	0.029	0.400	0.470
C 3214 K	0.9	1.6	0.032	0.430	0.500
C 3215 K	0.9	1.6	0.034	0.450	0.520
C 3216 K	1.3	2.2	0.036	0.480	0.550
C 3217 K	1.2	2.1	0.038	0.490	0.560

Pressure and axial drive-up table for CARB™ toroidal roller bearings with tapered bore

Bearing designation	Starting position		Final position			Bearing designation	Starting position		Final position		
	Pressure at start*		Radial clearance reduction from starting position	Axial drive-up s_s from starting position			Pressure at start*		Radial clearance reduction from starting position	Axial drive-up s_s from starting position	
	1	2		1	2		1	2		1	2
	MPa		mm	mm			MPa		mm	mm	
C 3218 K	1.8	3.1	0.041	0.550	0.620	**C 4013 K30**	0.5	0.9	0.029	0.950	1.100
C 3219 K	1.3	2.2	0.043	0.540	0.610	**C 4014 K30**	0.6	1.1	0.032	1.000	1.200
C 3220 K	2.1	3.6	0.045	0.590	0.660	**C 4015 K30**	0.7	1.3	0.034	1.100	1.300
C 3221 K	2.4	4.1	0.047	0.610	0.690	**C 4016 K30**	0.8	1.4	0.036	1.200	1.300
C 3222 K	2.6	4.4	0.050	0.660	0.730	**C 4017 K30**	0.6	1.2	0.038	1.200	1.400
C 3224 K	2.5	4.2	0.054	0.680	0.760	**C 4018 K30**	0.9	1.7	0.041	1.300	1.500
C 3226 K	2.5	4.3	0.059	0.740	0.810	**C 4019 K30**	0.8	1.5	0.043	1.300	1.500
C 3228 K	2.9	5.0	0.063	0.790	0.860	**C 4020 K30**	0.7	1.3	0.045	1.400	1.600
C 3230 K	2.3	3.9	0.068	0.820	0.890	**C 4021 K30**	1.0	1.9	0.047	1.500	1.600
C 3232 K	2.7	4.6	0.072	0.870	0.940	**C 4022 K30**	0.9	1.6	0.050	1.500	1.700
C 3234 K	3.9	6.6	0.076	0.960	1.000	**C 4024 K30**	0.8	1.5	0.054	1.600	1.800
C 3236 K	3.7	6.3	0.081	1.000	1.100	**C 4026 K30**	1.2	2.2	0.059	1.800	2.000
C 3238 K	2.9	5.0	0.086	1.000	1.100	**C 4028 K30**	1.2	2.3	0.063	1.900	2.100
C 3240 K	2.6	4.4	0.090	1.100	1.100	**C 4030 K30**	1.2	2.2	0.068	2.000	2.200
40						**C 4032 K30**	1.1	2.0	0.072	2.100	2.300
C 4010 K30	0.4	0.8	0.023	0.800	0.990	**C 4034 K30**	1.4	2.5	0.076	2.200	2.400
C 4011 K30	0.7	1.2	0.025	0.870	1.100	**C 4036 K30**	1.2	2.2	0.081	2.300	2.500
C 4012 K30	0.5	0.9	0.027	0.890	1.100	**C 4038 K30**	1.5	2.8	0.086	2.500	2.700
						C 4040 K30	1.4	2.5	0.090	2.600	2.800

** = Values given valid for HMV(C) E series nut size = Bearing size*
1 = Should be applied when one surface slides during mounting. Surface lightly oiled, with light oil.
2 = Should be applied when two surfaces slide during mounting. Surface lightly oiled, with light oil.
The table is only valid for solid steel shafts. For hollow shafts or other materials please contact SKF
For existing and planned range please contact your local SKF sales company

NOTE: to convert values to inches and psi
in = mm/25.4
psi = 145 x MPa

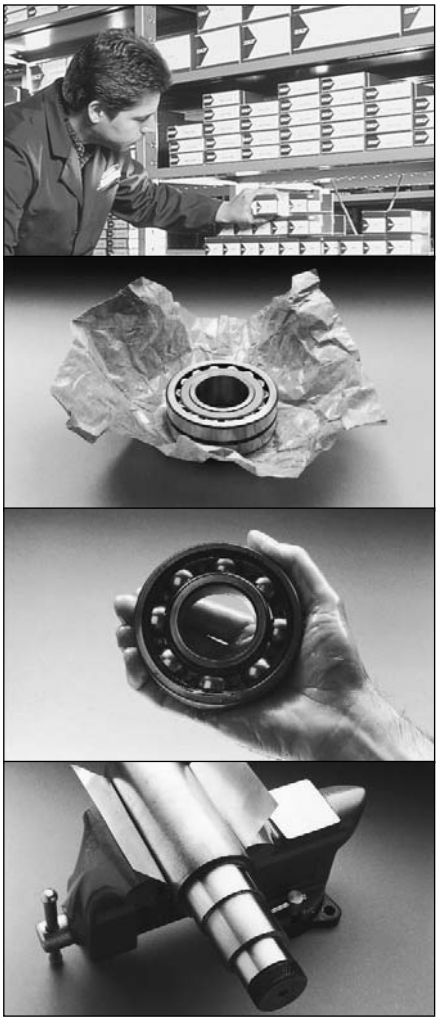
Guidelines for Bearing Assembly, Maintenance and Inspection For Better Bearing Performance



Don't work under the handicap of poor tools, dirt, a rough bench, or cluttered area.



Clean tools and surroundings will help maximize bearing performance.



Proper care begins in the stock room. Store bearings in original unopened packages, in a dry place. The bearing number is plainly shown on the box or wrapping. Before packaging, the manufacturer protected the bearing with a rust preventive slush compound. An unopened package means continued protection. Do not open carton until ready to use.

Open package only when ready to install bearing. Handle bearing with clean, dry hands and with clean rags. Lay bearing on clean paper and keep covered. Never expose bearing on a dirty bench or floor. Never use a bearing as a gauge to check either the housing bore or the shaft fit.

Don't wash a new bearing — it is already clean and the slushing oil should not be removed. Old grease can be washed from a used bearing with a solvent but fluid and container must be clean. After this cleaning, wash the bearing out thoroughly with light oil and then relubricate. Bearings should be washed only when necessary. (See pages 31 and 79).

Before mounting, be sure shaft size is within the specified tolerances recommended for the bearing. The bearing seat should be perfectly round and not tapered. It should be clean and free from nicks and burrs. If a shaft is too worn to properly seat a bearing — don't use it! Support shaft firmly in a clean place; if in a vise, protect it from vice jaws. Protectors can be soft metal, wood, cardboard or paper.



To press bearing on shaft, first apply a thin coating of lightweight oil to the bearing seat and bore. Place fitting tool over the shaft and rest it on inner ring. Be sure bearing is square on shaft, then apply pressure by tapping fitting tool or end of pipe with hammer or using arbor press.

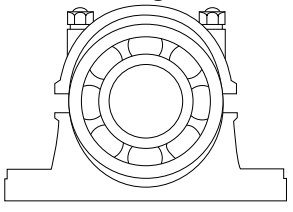


When temperature mounting an open cylindrical bore bearing, three methods are typically used:

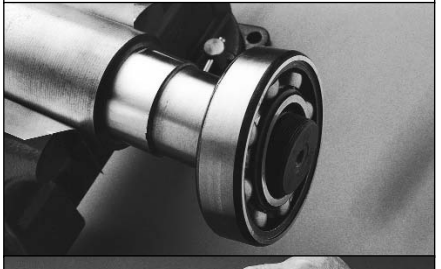
1. Using an induction heater
2. Heating in a clean temperature-controlled electric oven or on a hotplate to a maximum of 121˚C (250˚F) for about 15 minutes.
3. Boiling in emulsion of 10% to 15% soluble oil in water. Be sure to place supports under bearing to isolate it from bottom of container, as contact will overheat bearing. Also be sure that oil is clean. (See p. 9).

Thoroughly heat bearing but do not overheat. This will prevent seizing on the cold shaft. After bearing is in place against shaft shoulder, lock it immediately with a locknut. Otherwise, in shrinking, bearing may move away from its proper position against shaft shoulder.

Danger



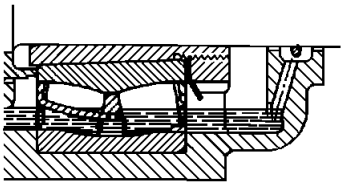
When mounting in a split housing, check bore of housing to see that it is within specified tolerances and is perfectly round. Bearing must not be pinched by a small bore or because of a cocked outer ring. Don’t switch housing caps — they are not interchangeable. An undersized housing bore will pinch the bearing and cause early failure.



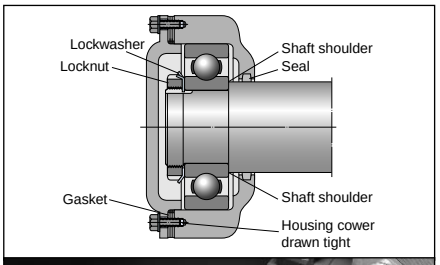
Some precautions must be taken when mounting bearings in a solid housing; i.e., the outer ring should be perfectly square with the housing bore before any pressure is applied. Here again, the housing bore should be within the specified tolerances for the bearing size and should be perfectly round. The housing bore and bearing outside diameter should be coated with a thin coating of lightweight oil.



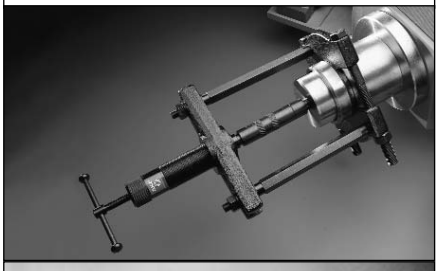
Cover an unfinished job, even if it is left for only a few hours. Rewrap each bearing with greaseproof paper to keep out dirt and moisture.



The type of lubricant used usually depends on operating conditions — follow the machine builder’s instructions. When oil is used, cover about half of bottom ball or roller. It is preferred that an oil sight gage be used and marked to show static and operating oil levels. This helps to determine when additional oil is required. The operating level is different from the static level and can be determined only when the bearing is in operation. For more details, see section on lubrication (page 64).

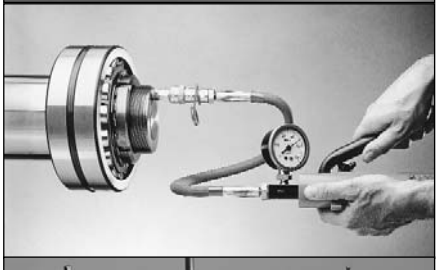


Be sure bearing is square with and held firmly against shaft shoulder. Secure it with a locknut and lockwasher. Housing covers must be tight to keep lubricant in and dirt out. After held bearing has been positioned, the free bearing should be located centrally in its housing to permit expansion and contraction of the shaft.



Small and medium-sized bearings may be dismounted cold using a conventional puller. If the bearing has been mounted with an interference fit on the shaft, the puller should preferably engage the inner ring.

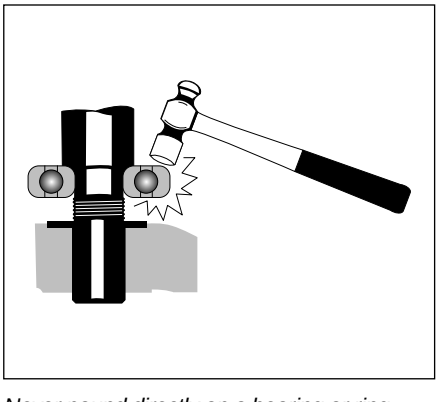
To avoid damage to the bearing seating, the puller must be accurately centered. The use of a 3 jaw or split strong back puller (shown) eliminates the risk of damage, and dismounting is simpler and faster.



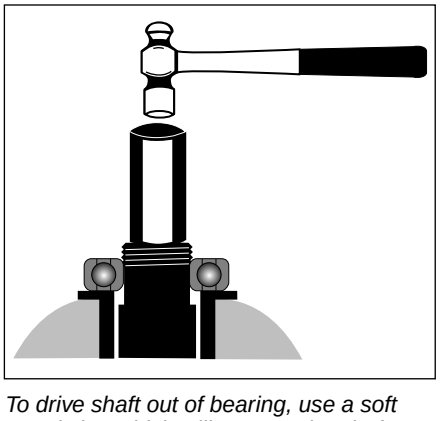
One of the easiest mounting and dismounting procedures, the SKF Oil Injection method is frequently used for larger sized bearings.



Bearing pullers may be used separately or in various combinations to pull or push complete bearings or individual rings.



Never pound directly on a bearing or ring. This may damage both shaft and bearing. WARNING: There is also a danger of the bearing shattering and causing human injury.



To drive shaft out of bearing, use a soft metal slug which will not mar the shaft (available in SKF Fitting Tool Kit).



An arbor press is equally good for both cold mounting and removing bearings.

Can the Bearing Be Used Again?
Always inspect a dismounted bearing, but don't try to judge whether it can be reused until after it has been cleaned. Treat it as new.

Never spin a dirty bearing; instead, rotate it slowly while washing. Wash with a petroleum-based solvent. Dry with a clean, lint-free cloth or compressed clean, moisture-free air, taking care that no bearing part starts rotating. Contact your SKF Authorized Distributor for information on equipment for cleaning and drying.

Larger bearings with badly oxidized lubricant can be cleaned with a strong alkaline solution, for example, a solution containing up to 10% caustic soda. Add 1% of a suitable wetting agent.

Take care when following this cleaning procedure: lye is harmful to skin, clothing and aluminum. Always use protective gloves, goggles and apron.

Examine a used bearing closely to determine whether it is reusable. Use a small mirror and a dental-type probe with a rounded point to inspect raceways, cage and rolling elements.

Be alert for scratches, marks, streaks, cracks, discolorations, mirror-like surfaces and so on. Carefully rotate the bearing and listen to the sound. An undamaged bearing (i.e., one that has no marks or other defects and runs evenly without abnormally large radial internal clearance) can be remounted. Before a large bearing is remounted for a critical application, ask SKF for examination. The cost of such inspection may actually save money.

Bearings with a shield or seal on one side should be cleaned, dried, inspected and handled in the same way as bearings without seals. However, never wash a bearing with seals or shields on both sides. They are sealed and lubricated for life and should be replaced if you suspect bearing or seal damage.

To prevent corrosion, use a rust preventative immediately after cleaning.

Cleaning Bearings

There are two methods of cleaning bearings: hot and cold.

Cold cleaning involves washing the bearing in petroleum based solvents or a similar substance. Always use clean fluid and tools, using one receptacle for the first wash and another for the final rinse. Dry the bearing and grease or oil it immediately after drying. Protect it from dirt until mounting.

When hot cleaning, use a thin, clean oil with a flash point of at least 480˚F (250˚C). Heat the oil to about 250˚F (120˚C). Hot cleaning is generally very effective. The residual oil, moreover, provides temporary protection against rust. See p. 79 for more details about cleaning bearings.

WARNING:

Use protective gloves whenever possible. Regular contact with petroleum products may cause allergic reactions. Follow the Material Safety Data Sheet (MSDS) safety instructions included with the solvent you use to clean bearings.

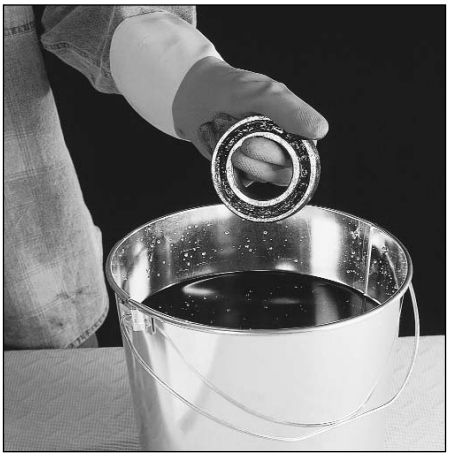
Mounting Used Bearings

Remember: Used bearings should be thoroughly cleaned before mounting, except for bearings with integral shields or seals which should never be washed — just clean the outer surfaces. Replace the bearing if it appears to be damaged.

If a bearing is very dirty or is encrusted with carbonized lubricant, it is generally not worth cleaning. Most often it is more economical to install a new bearing.



Do not spin bearings before cleaning. Dirt can cause serious scratching.



Soak bearings thoroughly in solvent. Then rinse them in clean solvent, light oil or kerosene.



Do not spin by force of air. Hold both rings. Use clean, dry air.

Shaft and Housing Fits

If a rolling bearing is to function satisfactorily, both the fit between the inner ring and the shaft, and the fit between the outer ring and the housing, must be suitable for the application.

Suitable Fits

Although a bearing must satisfy widely varying operating conditions, which determine the choice of fit, the tolerances for the bearing itself are standardized. The desired fits can therefore be obtained only by selecting the proper tolerances for the shaft diameter and the housing bore. The system of limits and fits used by industry for all rolling bearings except tapers (ISO Standard 286) contains a considerable choice of shaft and housing tolerances. When used with standard bearings, these will give any of the desired fits, from the tightest to the loosest required. Each tolerance is designated by a letter and a numeral. The letter (small for shaft diameters and capital for housing bores) locates the tolerance zone in relation to the nominal dimensions, and the numeral gives the magnitude of the tolerance zone. **Figure** 1 illustrates this relation. The rectangles indicate the location and magnitude of the various shaft and housing tolerance zones which are used for rolling bearings, superimposed on the bore and O.D. tolerance.

The selection of fit depends on the character of the load, the bearing dimensions, the temperature conditions in the bearing in operation, the heat expansion of the shaft and other parts, the design, and the requirements for running accuracy.

Fig 1

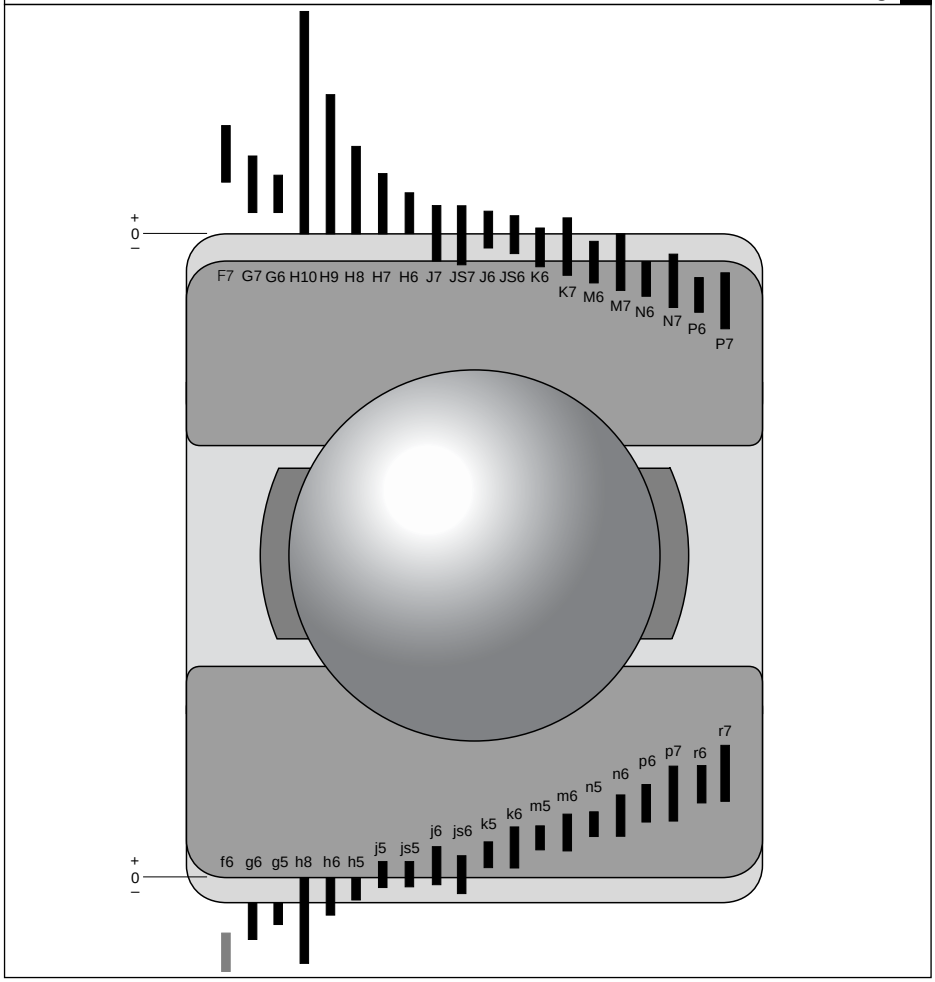


Figure 1:
Location of shaft and housing tolerance grades with respect to bearing bore and O.D. tolerances (exaggerated).

Consideration must also be given to the fact that a solid shaft deforms differently than a hollow one.

In determining suitable fits for the inner ring and the outer ring in any given application, the direction of the load in relation to the respective bearing ring is of prime importance. For the selection of the proper shaft and housing tolerance for radial bearings, refer to **Tables** 1 and 1a respectively. For thrust bearings, see **Tables** 2 and 3 respectively.

The symbols for the shaft and housing tolerances that apply in each case may be determined from the tables by taking into account the conditions of loading, the type and size of the bearing.

For the definitions of “light”, “normal” and “heavy” loads, refer to **Figure 2**. For corresponding maximum and minimum shaft and housing diameters and the resulting maximum and minimum interference of clearance fits, see: **Tables 5a** and **5b** (inch and metric, respectively) for bearing bore and shaft; **Tables 6a** and **6b** (inch and metric, respectively) for bearing O.D. and housing.

For inch dimensioned tapered roller bearings, the recommended shaft diameter and housing bore deviations from nominal diameters and the resulting fits are shown in **Tables 10** – **13**.

Fig 2

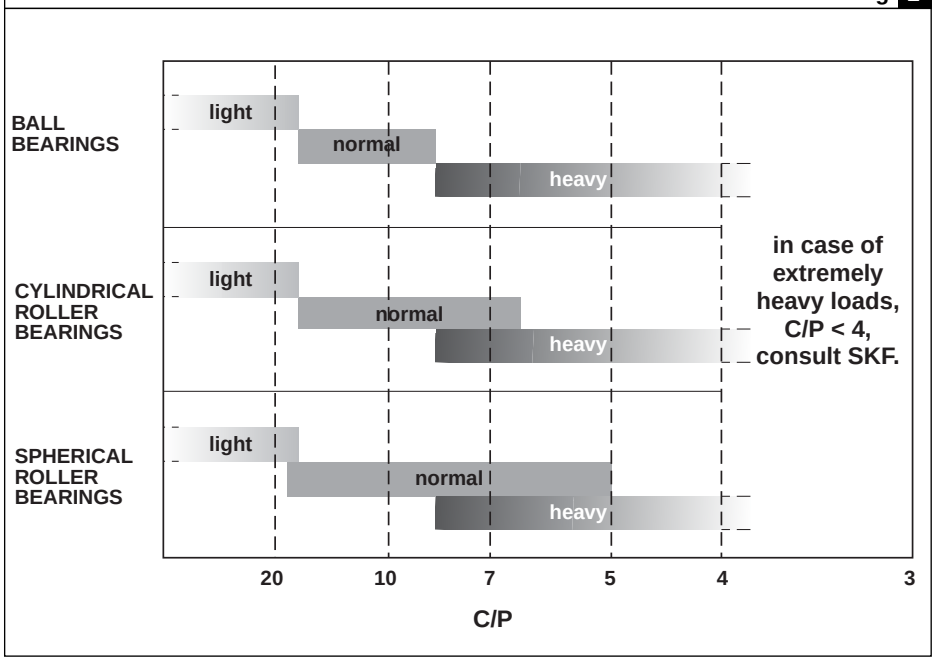


Figure 2:
Classification of “light, medium, and heavy” loading, expressed in C/P.
C = Basic Load Rating as shown in SKF catalogs *(as per ABMA Standards 9 and 11, and modified for improved materials and manufacturing methods).*
P = Equivalent dynamic bearing load *(for definition, see SKF product catalogs).*

Dimensional, form and running accuracy of bearing seatings and abutments

The accuracy of cylindrical bearing seatings on shafts and in housing bores, of seatings for thrust bearing washers and of the support surfaces (abutments) for bearing rings provided by shaft and housing shoulders, etc. should correspond to the accuracy of the bearings used. In the following, guideline values for dimensional, form and running accuracy are given which should be adhered to when machining seatings and abutments.

Dimensional tolerances

For bearings made with normal tolerances, the dimensional accuracy of the cylindrical seatings on the shaft is shown in **Tables 1**, **2**, **5a** and **5b**. For housings, see **Tables 1a**, **3**, **6a** and **6b**. For bearings with higher accuracy, correspondingly higher tolerances should be used; for ABEC 5 bearings see **Tables 14** and **15**.

Where adapter or withdrawal sleeves are used on cylindrical shafts, wider diameter tolerances can be permitted than for bearing seatings; see **Table 4**.

The basic tolerance for the standardized tolerance series to ISO/R286-1962 will be found in **Table 7**.

Tolerances for cylindrical form

The cylindricity tolerance t, as defined in ISO 1101-1983 should be 1 to 2 IT grades better than the prescribed dimensional tolerance, depending on requirements. For example, if a bearing seating on a shaft has been machined to tolerance m6, then the accuracy of form should be to IT5 or IT4. The tolerance value t_1 for cylindricity is obtained for an assumed shaft diameter of 150 mm from t_1 = IT5/2 = 18/2 = 9 μm or from t_1 = IT4/2 = 12/2 = 6 μm. **Table 9** gives guideline values for the cylindrical form tolerance (and for the total runout tolerance t_3 if preferred).

Tolerance for perpendicularity

Abutments for bearing rings should have a rectangularity tolerance as defined in ISO 1101-1983 which is better by at least one IT grade than the diameter tolerance of the associated cylindrical seating. For thrust bearing washer seatings, the perpendicularity tolerance should not exceed the values to IT5. Guideline values for the rectangularity tolerance t_2 (and for the total axial runout t_4) will be found in **Table 9**.

Surface roughness of bearing seatings

The roughness of bearing seating surfaces does not have the same degree of influence on bearing performance as the dimensional, form and running accuracies. However, a desired interference fit is much more accurately obtained the smoother the mating surfaces are. For less critical bearing arrangements relatively large surface roughnesses are permitted. For bearing arrangements where demands in respect to accuracy are high, guideline values for the mean surface roughness R_a are given in **Table 8** for different dimensional accuracies of the bearing seatings. These guideline values apply to ground seatings, which are normally assumed for shaft seatings. For fine turned seatings, the roughness may be a class or two higher.

Selection of Solid Steel Shaft Tolerance Classification for Metric *Radial* Ball and Roller Bearings of Tolerance Classes ABEC-1, RBEC-1 (Except Inch Dimensioned Tapered Roller Bearings)

Conditions	Shaft diameter, mm Ball bearings[1]	Cylindrical roller bearings, metric taper	Spherical roller bearings	Tolerance Symbol
Rotating inner ring load or direction of loading indeterminate				
Light loads	18≤100 100≤140	≤40 40≤100	— —	j6 k6
Normal loads	≤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)[2] m5 (m6)[2] m6 n6 p6 r6 r7
Heavy loads	— — —	50≤140 140≤200 ≤200	50≤100 100≤140 >140	n6[3] p6[3] r6[3]
High demands on running accuracy with light loads	≤18 18≤100 100≤200 —	— ≤40 40≤140 140≤200	— — — —	h5[4] j5[4] k5[4] m5[4]
Stationary inner ring load				
Easy axial displacement of inner ring on shaft desirable	all	all	all	g6
Easy axial displacement of inner ring on shaft unnecessary	all	all	all	h6
Axial loads only				
	≤250 >250	≤250 >250	≤250 >250	j6 js6

[1]Shaft tolerances for Y-bearings (set-screw mounted) are available from SKF.
[2]The tolerances in brackets are generally used for metric taper roller and single row angular ball bearings used individually. They can also be used for other types of bearing where speeds are moderate and the effect of bearing internal clearance is not significant.
[3]Bearings with radial internal clearance greater than Normal are necessary.
[4]For ABCE 5 bearings, use Table 14; for higher precision bearings other recommendations apply. Consult SKF.
≤ less than or equal to.

Selection of Steel or Cast Iron Housing Tolerance Classification for Metric *Radial* Ball and Roller Bearings of Tolerance Classes ABEC-1, RBEC-1 (Except Inch Dimensioned Tapered Roller Bearings)

Conditions	Tolerance Symbol	Displacement of outer ring
SOLID HOUSINGS		
Rotating outer ring load		
Heavy loads on bearings in thin-walled housings, heavy shock loads	P7	Cannot be displaced
Normal loads and heavy loads	N7	Cannot be displaced
Light and variable loads	M7	Cannot be displaced
Direction of load indeterminate		
Heavy shock loads	M7	Cannot be displaced
Normal loads and heavy loads axial displacement of outer ring unnecessary	K7	Cannot be displaced as a rule
Accurate or silent running		
	K6[1]	Cannot be displaced as a rule
	J6[2]	Can be displaced
	H6	Can easily be displaced
SPLIT OR SOLID HOUSING		
Direction of load indeterminate		
Light loads and normal loads axial displacement of outer ring desirable	J7	Can be displaced as a rule
Stationary outer ring load		
Loads of all kinds	H7[3]	Can easily be displaced
Light loads and normal loads with simple working conditions	H8	Can easily be displaced
Heat conduction through shaft	G7[4]	Can easily be displaced

[1]For heavier loads a tighter fit than K6 should be selected, e.g., M6 or N6. For high precision bearings other recommendations apply. Further details on request.
[2]For ABCE 5 bearings, use Table 15; for higher precision bearings other recommendations apply. Consult SKF.
[3]For large bearings (D >250 mm) and temperature differences between outer ring and housing >10°C (>18°F), G7 may be used instead of H7.
[4]For large bearings (D >250 mm) and temperature differences between outer ring and housing >10°C (>18°F), F7 may be used instead of G7.

Table 2

Selection of Shaft Tolerance for *Thrust* Bearings

Conditions	Shaft diameter, mm	Tolerance
Axial loads only		
Thrust ball bearings	all	h6
Cylindrical roller thrust bearings	all	h6
Radial and axial loads on spherical roller thrust bearings		
Stationary load on shaft washer	≤250	j6
	>250	js6
Rotating load on shaft washer or direction of loading indeterminate	<200	k6
	200≤400	m6
	>400	n6

> greater than.
≤ less than or equal to.

Table 3

Selection of Housing Tolerances for *Thrust* Bearings

Conditions	Tolerance	Remarks
Axial loads only		
Thrust ball bearings	H8	For less accurate bearing arrangements there can be radial clearance of up to 0.001 D
Cylindrical roller thrust bearings	H7	
Cylindrical roller and cage thrust assemblies	H10	
Spherical roller thrust bearings, where another bearing is used for radial location	—	Housing washer fitted with radial clearance of up to 0.001 D. Consult SKF.

Table 4

Shaft Tolerance Limits for Adapter Mounting and Pillow Block Seal Seatings[3]

Nominal Dia. inches		Dia. Tolerance Limits inches	
Over	**Including**	**S-1[1]**	**S-2 and S-3[2]**
1/2	1	0.000 – 0.002	
1	2	0.000 – 0.003	0.000 – 0.003
2	4	0.000 – 0.004	0.000 – 0.003
4	6	0.000 – 0.005	0.000 – 0.003
6	10	0.000 – 0.006	0.000 – 0.004
10	15	0.000 – 0.006	0.000 – 0.005
15		0.000 – 0.006	0.000 – 0.006

[1]"S-1" values are deviations from nominal shaft dimensions for mounting via an adapter or sleeve. The out of round (OOR) and cylindrical form tolerance for shaft diameters ≤ 4 inches: OOR ≤ .0005 in; > 4 in. OOR ≤ .001 in.; total indicated runout (TIR) ≤ 1/2 OOR.

[2]"S-2" and "S-3" values are deviations for nominal shaft dimensions for pillow block mountings (except Unit Ball and Unit Roller). The shaft diameter recommendations assure proper operations of the seals, while the recommended shaft tolerance for the cylindrical bearing seat should be taken from **Table 1.**

[3]See Table 7a for metric shaft tolerances.

Shaft Bearing-Seat Diameters (Values in inches)

Bearing Bore Diameters (inches)			f7			g6			h6			h5			j5		
			Shaft Dia.		Fit in	Shaft Dia.		Fit in	Shaft Dia.		Fit in	Shaft Dia.		Fit in	Shaft Dia.		Fit in
(mm)	Max.	Min.	Max.	Min.	0.0000"	Max.	Min.	0.0000"	Max.	Min.	0.0000"	Max.	Min.	0.0000"	Max.	Min.	0.0000"
4	0.1575	0.1572	0.1571	0.1566		0.1573	0.1570		0.1575	0.1572		0.1575	0.1573		0.1576	0.1574	
5	0.1969	0.1966	0.1965	0.1960	9 L	0.1967	0.1964	5 L	0.1969	0.1966	3 L	0.1969	0.1967	2 L	0.1970	0.1968	1 L
6	0.2362	0.2359	0.2358	0.2353	1 L	0.2360	0.2357	1 T	0.2362	0.2359	3 T	0.2362	0.2360	3 T	0.2363	0.2361	4 T
7	0.2756	0.2753	0.2751	0.2745		0.2754	0.2750		0.2756	0.2752		0.2756	0.2754		0.2758	0.2755	
8	0.3150	0.3147	0.3145	0.3139	11 L	0.3148	0.3144	6 L	0.3150	0.3146	4 L	0.3150	0.3148	2 L	0.3152	0.3149	1 L
9	0.3543	0.3540	0.3538	0.3532	2 L	0.3541	0.3538	1 T	0.3543	0.3539	3 T	0.3543	0.3541	3 T	0.3545	0.3542	5 T
10	0.3937	0.3934	0.3932	0.3926		0.3935	0.3931		0.3937	0.3933		0.3937	0.3935		0.3939	0.3936	
12	0.4724	0.4721	0.4718	0.4711		0.4722	0.4717		0.4724	0.4720		0.4724	0.4721		0.4726	0.4723	
15	0.5906	0.5903	0.5900	0.5893	13 L	0.5904	0.5899	7 L	0.5906	0.5902	4 L	0.5906	0.5903	3 L	0.5908	0.5905	1 L
17	0.6693	0.6690	0.6687	0.6680	3 L	0.6691	0.6686	1 T	0.6693	0.6689	3 T	0.6693	0.6690	3 T	0.6695	0.6692	5 T
20	0.7874	0.7870	0.7866	0.7858		0.7871	0.7866		0.7874	0.7869		0.7874	0.7870		0.7876	0.7872	
25	0.9843	0.9839	0.9835	0.9827	16 L	0.9840	0.9835	8 L	0.9843	0.9838	5 L	0.9843	0.9839	4 L	0.9845	0.9841	2 L
30	1.1811	1.1807	1.1803	1.1795	4 L	1.1808	1.1803	1 T	1.1811	1.1806	4 T	1.1811	1.1807	4 T	1.1813	1.1809	6 T
35	1.3780	1.3775	1.3770	1.3760		1.3776	1.3770		1.3780	1.3774		1.3780	1.3776		1.3782	1.3778	
40	1.5748	1.5743	1.5738	1.5728	20 L	1.5744	1.5738	10 L	1.5748	1.5742	6 L	1.5748	1.5744	4 L	1.5750	1.5746	2 L
45	1.7717	1.7712	1.7707	1.7697	5 L	1.7713	1.7707	1 T	1.7717	1.7711	5 T	1.7717	1.7713	5 T	1.7719	1.7716	7 T
50	1.9685	1.9680	1.9675	1.9665		1.9681	1.9675		1.9685	1.9679		1.9685	1.9681		1.9687	1.9683	
55	2.1654	2.1648	2.1642	2.1630		2.1650	2.1643		2.1654	2.1647		2.1654	2.1649		2.1656	2.1651	
60	2.3622	2.3616	2.3610	2.3598		2.3618	2.3611		2.3622	2.3615		2.3622	2.3617		2.3624	2.3619	
65	2.5591	2.5585	2.5579	2.5567	24 L	2.5587	2.5580	11 L	2.5591	2.5584	7 L	2.5591	2.5586	5 L	2.5593	2.5588	3 L
70	2.7559	2.7553	2.7547	2.7535	6 L	2.7555	2.7548	2 T	2.7559	2.7552	6 T	2.7559	2.7554	6 T	2.7561	2.7556	8 T
75	2.9528	2.9522	2.9516	2.9504		2.9524	2.9517		2.9528	2.9521		2.9528	2.9523		2.9530	2.9525	
80	3.1496	3.1490	3.1484	3.1472		3.1492	3.1485		3.1496	3.1489		3.1496	3.1491		3.1498	3.1493	
85	3.3465	3.3457	3.3451	3.3437		3.3460	3.3452		3.3465	3.3456		3.3465	3.3459		3.3467	3.3461	
90	3.5433	3.5425	3.5419	3.5405		3.5428	3.5420		3.5433	3.5424		3.5433	3.5427		3.5435	3.5429	
95	3.7402	3.7394	3.7388	3.7374		3.7397	3.7389		3.7402	3.7393		3.7402	3.7396		3.7404	3.7398	
100	3.9370	3.9362	3.9356	3.9342	28 T	3.9365	3.9357	13 L	3.9370	3.9361	9 L	3.9370	3.9364	6 L	3.9372	3.9366	4 L
105	4.1339	4.1331	4.1325	4.1311	6 L	4.1334	4.1326	3 T	4.1339	4.1330	8 T	4.1339	4.1333	8 T	4.1341	4.1335	10 T
110	4.3307	4.3299	4.3293	4.3279		4.3302	4.3294		4.3307	4.3298		4.3307	4.3301		4.3309	4.3303	
115	4.5276	4.5268	4.5262	4.5248		4.5271	4.5263		4.5276	4.5267		4.5276	4.5270		4.5278	4.5272	
120	4.7244	4.7236	4.7230	4.7216		4.7239	4.7231		4.7244	4.7235		4.7244	4.7238		4.7246	4.7240	
125	4.9213	4.9203	4.9196	4.9180		4.9207	4.9197		4.9213	4.9203		4.9213	4.9206		4.9216	4.9209	
130	5.1181	5.1171	5.1164	5.1148		5.1175	5.1166		5.1181	5.1171		5.1181	5.1174		5.1184	5.1177	
140	5.5118	5.5108	5.5101	5.5085		5.5112	5.5103		5.5118	5.5108		5.5118	5.5111		5.5121	5.5114	
150	5.9055	5.9045	5.9038	5.9022	33 L	5.9049	5.9040	15 L	5.9055	5.9045	10 L	5.9055	5.9048	7 L	5.9058	5.9051	4 L
160	6.2992	6.2982	6.2975	6.2959	7 L	6.2986	6.2977	4 T	6.2992	6.2982	10 T	6.2992	6.2985	10 T	6.2995	6.2988	13 T
170	6.6929	6.6919	6.6912	6.6896		6.6923	6.6914		6.6929	6.6919		6.6929	6.6922		6.6932	6.6925	
180	7.0866	7.0856	7.0849	7.0833		7.0860	7.0851		7.0866	7.0856		7.0866	7.0859		7.0869	7.0862	
190	7.4803	7.4791	7.4783	7.4765		7.4797	7.4786		7.4803	7.4792		7.4803	7.4795		7.4806	7.4798	
200	7.8740	7.8728	7.8720	7.8702	38 L	7.8734	7.8723	17 L	7.8740	7.8729	11 L	7.8740	7.8732	8 L	7.8743	7.8735	5 L
220	8.6614	8.6602	8.6594	8.6576	8 L	8.6608	8.6597	6 T	8.6614	8.6603	12 T	8.6614	8.6606	12 T	8.6617	8.6609	15 T
240	9.4488	9.4476	9.4468	9.4450		9.4482	9.4471		9.4488	9.4477		9.4488	9.4480		9.4491	9.4483	
250	9.8425	9.8413	9.8405	9.8387		9.8419	9.8408		9.8425	9.8414		9.8425	9.8417		9.8428	9.8420	
260	10.2362	10.2348	10.2340	10.2319		10.2355	10.2343		10.2362	10.2349		10.2362	10.2353		10.2365	10.2356	
280	11.0236	11.0222	11.0214	11.0193	43 L	11.0229	11.0217	19 L	11.0236	11.0223	13 L	11.0236	11.0227	9 L	11.0239	11.0230	6 L
300	11.8110	11.8096	11.8088	11.8067	8 L	11.8103	11.8091	7 T	11.8110	11.8097	14 T	11.8110	11.8101	14 T	11.8113	11.8104	17 T
310	12.2047	12.2033	12.2025	12.2004		12.2040	12.2028		12.2047	12.2034		12.2047	12.2038		12.2050	12.2041	
320	12.5984	12.5968	12.5959	12.5937		12.5977	12.5963		12.5984	12.5970		12.5984	12.5974		12.5987	12.5977	
340	13.3858	13.3842	13.3833	13.3811		13.3851	13.3837		13.3858	13.3844		13.3858	13.3848		13.3861	13.3851	
350	13.7795	13.7779	13.7770	13.7748	47 L	13.7788	13.7774	21 L	13.7795	13.7781	14 L	13.7794	13.7785	10 L	13.7798	13.7788	7 L
360	14.1732	14.1716	14.1707	14.1685	9 L	14.1725	14.1711	9 T	14.1732	14.1718	16 T	14.1732	14.1722	16 T	14.1735	14.1725	19 T
380	14.9606	14.9590	14.9581	14.9559		14.9599	14.9585		14.9606	14.9592		14.9606	14.9596		14.9609	14.9599	
400	15.7480	15.7464	15.7455	15.7433		15.7473	15.7459		15.7480	15.7466		15.7480	15.7470		15.7483	15.7473	
420	16.5354	16.5336	16.5327	16.5302		16.5346	16.5330		16.5354	16.5338		16.5354	16.5343		16.5357	16.5346	
440	17.3228	17.3210	17.3201	17.3176	52 L	17.3220	17.3204	24 L	17.3228	17.3212	16 L	17.3228	17.3217	11 L	17.3231	17.3220	8 L
460	18.1102	18.1084	18.1075	18.1050	9 L	18.1094	18.1078	10 T	18.1102	18.1086	18 T	18.1102	18.1091	18 T	18.1105	18.1094	21 T
480	18.8976	18.8958	18.8949	18.8924		18.8968	18.8952		18.8976	18.8960		18.8976	18.8965		18.8979	18.8968	
500	19.6850	19.6832	19.6823	19.6798		19.6842	19.6826		19.6850	19.6834		19.6850	19.6839		19.6853	19.6842	
530	20.8661	20.8641	20.8631	20.8605		20.8652	20.8635		20.8661	20.8644							
560	22.0472	22.0452	22.0442	22.0416	56 L	22.0463	22.0446	26 L	22.0472	22.0455	17 L						
600	23.6220	23.6200	23.6190	23.6164	10 L	23.6211	23.6194	11 T	23.6220	23.6203	20 T						
630	24.8031	24.8011	24.8001	24.7975		24.8022	24.8005		24.8031	24.8014							
660	25.9843	25.9813	25.9811	25.9782		25.9834	25.9814		25.9843	25.9823							
670	26.3780	26.3750	26.3748	26.3719		26.3771	26.3751		26.3780	26.3760							
710	27.9528	27.9498	27.9496	27.9467	61 L	27.9519	27.9499	29 L	27.9528	27.9508	20 L						
750	29.5276	29.5246	29.5244	29.5215	2 L	29.5267	29.5247	21 T	29.5276	29.5256	30 T						
780	30.7087	30.7057	30.7055	30.7026		30.7078	30.7058		30.7087	30.7067							
800	31.4961	31.4931	31.4929	31.4900		31.4952	31.4932		31.4962	31.4941							
850	33.4646	33.4607	33.4611	33.4577		33.4636	33.4614		33.4645	33.4624							
900	35.4331	35.4292	35.4296	35.4262	69 L	35.4321	35.4299	32 L	35.4331	35.4309	22 L						
950	37.4016	37.3977	37.3981	37.3947	4 T	37.4006	37.3984	29 T	37.4016	37.3994	39 T						
1000	39.3701	39.3662	39.3666	39.3632		39.3691	39.3669		39.3701	39.3679							
1060	41.7323	41.7274	41.7284	41.7247		41.7312	41.7286		41.7323	41.7297							
1120	44.0945	44.0896	44.0906	44.0869	76 L	44.0934	44.0908	37 L	44.0945	44.0919	26 L						
1180	46.4567	46.4518	46.4528	46.4491	10 T	46.4556	46.4530	38 T	46.4567	46.4541	49 T						
1250	49.2126	49.2077	49.2087	49.2050		49.2115	49.2089		49.2126	49.2100							

Shaft Bearing-Seat Diameters (Values in inches) (cont.)

Bearing Diameters	Bore (inches)		j6			k5			k6			m5			m6		
			Shaft Dia.		Fit in	Shaft Dia.		Fit in	Shaft Dia.		Fit in	Shaft Dia.		Fit in	Shaft Dia.		Fit in
(mm)	Max.	Min.	Max.	Min.	0.0000"	Max.	Min.	0.0000"	Max.	Min.	0.0000"	Max.	Min.	0.0000"	Max.	Min.	0.0000"
4	0.1575	0.1572	0.1577	0.1574		0.1577	0.1575		0.1579	0.1575		0.1579	0.1577		0.1580	0.1577	
5	0.1969	0.1966	0.1971	0.1968	1 L	0.1971	0.1969	0 T	0.1973	0.1969	0 T	0.1973	0.1971	2 T	0.1974	0.0001	2 T
6	0.2362	0.2359	0.2364	0.2361	5 T	0.2364	0.2362	5 T	0.2366	0.2362	7 T	0.2366	0.2364	7 T	0.2367	0.2364	8 T
7	0.2756	0.2753	0.2759	0.2755		0.2759	0.2756		0.2760	0.2756		0.2761	0.2758		0.2762	0.2758	
8	0.3150	0.3147	0.3153	0.3149	1 L	0.3153	0.3150	0 T	0.3154	0.3150	0 T	0.3155	0.3152	2 T	0.3156	0.3152	2 T
9	0.3543	0.3540	0.3546	0.3542	6 T	0.3546	0.3543	6 T	0.3547	0.3543	7 T	0.3548	0.3545	8 T	0.3549	0.3545	9 T
10	0.3937	0.3934	0.3940	0.3936		0.3940	0.3937		0.3941	0.3937		0.3942	0.3939		0.3943	0.3939	
12	0.4724	0.4721	0.4727	0.4723		0.4728	0.4724		0.4729	0.4724		0.4730	0.4727		0.4731	0.4727	
15	0.5906	0.5903	0.5909	0.5905	1 L	0.5910	0.5906	0 T	0.5911	0.5906	0 T	0.5912	0.5909	3 T	0.5913	0.5909	3 T
17	0.6693	0.6690	0.6696	0.6692	6 T	0.6697	0.6693	7 T	0.6698	0.6693	8 T	0.6699	0.6696	9 T	0.6700	0.6696	10 T
20	0.7874	0.7870	0.7878	0.7872		0.7878	0.7875		0.7880	0.7875		0.7881	0.7877		0.7882	0.7877	
25	0.9843	0.9839	0.9847	0.9841	2 L	0.9847	0.9844	1 T	0.9849	0.9844	1 T	0.9850	0.9846	3 T	0.9851	0.9846	3 T
30	1.1811	1.1807	1.1815	1.1809	8 T	1.1815	1.1812	8 T	1.1817	1.1812	10 T	1.1818	1.1814	11 T	1.1819	1.1814	12 T
35	1.3780	1.3775	1.3784	1.3778		1.3785	1.3781		1.3787	1.3781		1.3788	1.3784		1.3790	1.3784	
40	1.5748	1.5743	1.5752	1.5746	2 L	1.5753	1.5749	1 T	1.5755	1.5749	1 T	1.5756	1.5752	4 T	1.5758	1.5752	4 T
45	1.7717	1.7712	1.7721	1.7715	9 T	1.7722	1.7718	10 T	1.7724	1.7718	12 T	1.7725	1.7721	13 T	1.7727	1.7721	15 T
50	1.9685	1.9680	1.9689	1.9683		1.9690	1.9686		1.9692	1.9686		1.9693	1.9689		1.9695	1.9689	
55	2.1654	2.1648	2.1658	2.1651		2.1660	2.1655		2.1662	2.1655		2.1663	2.1658		2.1666	2.1658	
60	2.3622	2.3616	2.3626	2.3619		2.3628	2.3623		2.3630	2.3623		2.3631	2.3626		2.3634	2.3626	
65	2.5591	2.5585	2.5595	2.5588	3 L	2.5597	2.5592	1 T	2.5599	2.5592	1 T	2.5600	2.5595	4 T	2.5603	2.5595	4 T
70	2.7559	2.7553	2.7563	2.7556	11 T	2.7565	2.7560	12 T	2.7567	2.7560	14 T	2.7568	2.7563	15 T	2.7571	2.7563	18 T
75	2.9528	2.9522	2.9532	2.9525		2.9534	2.9529		2.9536	2.9529		2.9537	2.9532		2.9540	2.9532	
80	3.1496	3.1490	3.1500	3.1493		3.1502	3.1497		3.1504	3.1497		3.1505	3.1500		3.1508	3.1500	
85	3.3465	3.3457	3.3470	3.3461		3.3472	3.3466		3.3475	3.3466		3.3476	3.3470		3.3479	3.3470	
90	3.5433	3.5425	3.5438	3.5429		3.5440	3.5434		3.5443	3.5434		3.5444	3.5438		3.5447	3.5438	
95	3.7402	3.7394	3.7407	3.7398		3.7409	3.7403		3.7412	3.7403		3.7413	3.7407		3.7416	3.7407	
100	3.9370	3.9362	3.9375	3.9366	4 L	3.9377	3.9371	1 T	3.9380	3.9371	1 T	3.9381	3.9375	5 T	3.9384	3.9375	5 T
105	4.1339	4.1331	4.1344	4.1335	13 T	4.1346	4.1340	15 T	4.1349	4.1340	18 T	4.1350	4.1344	19 T	4.1353	4.1344	22 T
110	4.3307	4.3299	4.3312	4.3303		4.3314	4.3308		4.3317	4.3308		4.3318	4.3312		4.3321	4.3312	
115	4.5276	4.5268	4.5281	4.5272		4.5283	4.5277		4.5286	4.5277		4.5287	4.5281		4.5290	4.5281	
120	4.7244	4.7236	4.7249	4.7240		4.7251	4.7245		4.7254	4.7245		4.7255	4.7249		4.7258	4.7249	
125	4.9213	4.9203	4.9219	4.9209		4.9221	4.9214		4.9224	4.9214		4.9226	4.9219		4.9229	4.9219	
130	5.1181	5.1171	5.1187	5.1177		5.1189	5.1182		5.1192	5.1182		5.1194	5.1187		5.1197	5.1187	
140	5.5118	5.5108	5.5124	5.5114		5.5126	5.5119		5.5129	5.5119		5.5131	5.5124		5.5134	5.5124	
150	5.9055	5.9045	5.9061	5.9051	4 L	5.9063	5.9056	1 T	5.9066	5.9056	1 T	5.9068	5.9061	6 T	5.9071	5.9061	6 T
160	6.2992	6.2982	6.2998	6.2988	16 T	6.3000	6.2993	18 T	6.3003	6.2993	21 T	6.3005	6.2998	23 T	6.3008	6.2998	26 T
170	6.6929	6.6919	6.6935	6.6925		6.6937	6.6930		6.6940	6.6930		6.6942	6.6935		6.6945	6.6935	
180	7.0866	7.0856	7.0872	7.0862		7.0874	7.0867		7.0877	7.0867		7.0879	7.0872		7.0882	7.0872	
190	7.4803	7.4791	7.4809	7.4798		7.4812	7.4805		7.4815	7.4805		7.4818	7.4810		7.4821	7.4810	
200	7.8740	7.8728	7.8746	7.8735	5 L	7.8749	7.8742	2 T	7.8753	7.8742	2 T	7.8755	7.8747	7 T	7.8758	7.8747	7 T
220	8.6614	8.6602	8.6620	8.6609	18 T	8.6623	8.6616	21 T	8.6627	8.6616	25 T	8.6629	8.6621	26 T	8.6632	8.6621	30 T
240	9.4488	9.4476	9.4494	9.4483		9.4497	9.4490		9.4501	9.4490		9.4503	9.4495		9.4506	9.4495	
250	9.8425	9.8413	9.8431	9.8420		9.8434	9.8427		9.8438	9.8427		9.8440	9.8432		9.8443	9.8432	
260	10.2362	10.2348	10.2368	10.2356		10.2373	10.2364		10.2376	10.2364		10.2379	10.2370		10.2382	10.2370	
280	11.0236	11.0222	11.0242	11.0230	6 L	11.0247	11.0238	2 T	11.0250	11.0238	2 T	11.0253	11.0244	8 T	11.0256	11.0244	8 T
300	11.8110	11.8096	11.8116	11.8104	20 T	11.8121	11.8112	25 T	11.8124	11.8112	28 T	11.8127	11.8118	31 T	11.8130	11.8118	34 T
310	12.2047	12.2033	12.2053	12.2041		12.2058	12.2049		12.2061	12.2049		12.2064	12.2055		12.2067	12.2055	
320	12.5984	12.5968	12.5991	12.5977		12.5995	12.5986		12.6000	12.5986		12.6002	12.5992		12.6006	12.5992	
340	13.3858	13.3842	13.3865	13.3851		13.3869	13.3860		13.3874	13.3860		13.3876	13.3866		13.3880	13.3866	
350	13.7795	13.7779	13.7802	13.7788	7 L	13.7806	13.7797	2 T	13.7811	13.7797	2 T	13.7813	13.7803	8 T	13.7817	13.7803	8 T
360	14.1732	14.1716	14.1739	14.1725	23 T	14.1743	14.1734	27 T	14.1748	14.1734	32 T	14.1750	14.1740	34 T	14.1754	14.1740	38 T
380	14.9606	14.9590	14.9613	14.9599		14.9617	14.9608		14.9622	14.9608		14.9624	14.9614		14.9628	14.9614	
400	15.7480	15.7464	15.7487	15.7473		15.7491	15.7482		15.7496	15.7482		15.7498	15.7488		15.7502	15.7488	
420	16.5354	16.5336	16.5362	16.5346		16.5367	16.5356		16.5372	16.5356		16.5374	16.5363		16.5379	16.5363	
440	17.3228	17.3210	17.3236	17.3220	8 L	17.3241	17.3230	2 T	17.3246	17.3230	2 T	17.3248	17.3237	9 T	17.3253	17.3237	9 T
460	18.1102	18.1084	18.1110	18.1094	26 T	18.1115	18.1104	31 T	18.1120	18.1104	36 T	18.1122	18.1111	38 T	18.1127	18.1111	43 T
480	18.8976	18.8958	18.8984	18.8968		18.8989	18.8978		18.8994	18.8978		18.8996	18.8985		18.9001	18.8985	
500	19.6850	19.6832	19.6858	19.6842		19.6863	19.6852		19.6868	19.6852		19.6870	19.6859		19.6875	19.6859	
530	20.8661	20.8641	20.8670	20.8653		20.8673	20.8661		20.8678	20.8661		20.8683	20.8671				
560	22.0472	22.0452	22.0481	22.0464	9 L	22.0484	22.0472	0 T	22.0489	22.0472	0 T	22.0494	22.0482	10 T			
600	23.6220	23.6200	23.6229	23.6212	28 T	23.6232	23.6220	32 T	23.6237	23.6220	37 T	23.6242	23.6230	42 T			
630	24.8031	24.8011	24.8040	24.8023		24.8043	24.8031		24.8048	24.8031		24.8053	24.8041				
660	25.9843	25.9813	25.9852	25.9833		25.9855	25.9843		25.9862	25.9843		25.9867	25.9855				
670	26.3780	26.3750	26.3789	26.3770		26.3792	26.3780		26.3799	26.3780		26.3804	26.3792				
710	27.9528	27.9498	27.9537	27.9518	10 L	27.9540	27.9528	0 T	27.9547	27.9528	0 T	27.9552	27.9540	12 T			
750	29.5276	29.5246	29.5285	29.5266	39 T	29.5288	29.5276	42 T	29.5295	29.5276	49 T	29.5300	29.5288	54 T			
780	30.7087	30.7057	30.7096	30.7077		30.7099	30.7087		30.7106	30.7087		30.7111	30.7099				
800	31.4961	31.4931	31.4970	31.4951		31.4973	31.4961		31.4980	31.4961		31.4985	31.4973				
850	33.4646	33.4607	33.4657	33.4635		33.4661	33.4646		33.4668	33.4646		33.4674	33.4659				
900	35.4331	35.4292	35.4342	35.4320	11 L	35.4346	35.4331	0 T	35.4353	35.4331	0 T	35.4359	35.4344	13 T			
950	37.4016	37.3977	37.4027	37.4005	50 T	37.4031	37.4016	54 T	37.4038	37.4016	61 T	37.4044	37.4029	67 T			
1000	39.3701	39.3662	39.3712	39.3690		39.3716	39.3701		39.3723	39.3701		39.3729	39.3714				
1060	41.7323	41.7274	41.7336	41.7310		41.7340	41.7323		41.7349	41.7323		41.7355	41.7339				
1120	44.0945	44.0896	44.0958	44.0932	13 L	44.0962	44.0945	0 T	44.0971	44.0945	0 T	44.0977	44.0961	16 T			
1180	46.4567	46.4518	46.4580	46.4554	62 T	46.4584	46.4567	66 T	46.4593	46.4567	75 T	46.4599	46.4583	81 T			
1250	49.2126	49.2077	49.2139	49.2113		49.2143	49.2126		49.2152	49.2126		49.2158	49.2142				

Shaft Bearing-Seat Diameters (Values in inches) (cont.)

Bearing Diameters	Bore (inches)		n6			p6			r6			r7		
			Shaft Dia.		Fit in	Shaft Dia.		Fit in	Shaft Dia.		Fit in	Shaft Dia.		Fit in
(mm)	Max.	Min.	Max.	Min.	0.0000"	Max.	Min.	0.0000"	Max.	Min.	0.0000"	Max.	Min.	0.0000"
4	**0.1575**	**0.1572**	0.1581	0.1578										
5	**0.1969**	**0.1966**	0.1975	0.1972	3 T									
6	**0.2362**	**0.2359**	0.2368	0.2365	9 T									
7	**0.2756**	**0.2753**	0.2763	0.2760										
8	**0.3150**	**0.3147**	0.3157	0.3154	4 T									
9	**0.3543**	**0.3540**	0.3550	0.3547	10 T									
10	**0.3937**	**0.3934**	0.3944	0.3941										
12	**0.4724**	**0.4721**	0.4733	0.4729										
15	**0.5906**	**0.5903**	0.5915	0.5911	5 T									
17	**0.6693**	**0.6690**	0.6702	0.6698	12 T									
20	**0.7874**	**0.7870**	0.7885	0.7880										
25	**0.9843**	**0.9839**	0.9854	0.9849	6 T									
30	**1.1811**	**1.1807**	1.1822	1.1817	15 T									
35	**1.3780**	**1.3775**	1.3793	1.3787										
40	**1.5748**	**1.5743**	1.5761	1.5755	7 T									
45	**1.7717**	**1.7712**	1.7730	1.7724	18 T									
50	**1.9685**	**1.9680**	1.9698	1.9692										
55	**2.1654**	**2.1648**	2.1669	2.1662										
60	**2.3622**	**2.3616**	2.3637	2.3630										
65	**2.5591**	**2.5585**	2.5606	2.5599	8 T									
70	**2.7559**	**2.7553**	2.7574	2.7567	21 T									
75	**2.9528**	**2.9522**	2.9543	2.9536										
80	**3.1496**	**3.1490**	3.1511	3.1504										
85	**3.3465**	**3.3457**	3.3483	3.3474		3.3488	3.3480							
90	**3.5433**	**3.5425**	3.5451	3.5442		3.5456	3.5448							
95	**3.7402**	**3.7394**	3.7420	3.7411		3.7425	3.7417							
100	**3.9370**	**3.9362**	3.9388	3.9379	9 T	3.9393	3.9385	15 T						
105	**4.1339**	**4.1331**	4.1357	4.1348	26 T	4.1362	4.1354	31 T						
110	**4.3307**	**4.3299**	4.3325	4.3316		4.3330	4.3322							
115	**4.5276**	**4.5268**	4.5294	4.5285		4.5299	4.5291							
120	**4.7244**	**4.7236**	4.7262	4.7253		4.7267	4.7259							
125	**4.9213**	**4.9203**	4.9233	4.9224		4.9240	4.9230		4.9248	4.9239				
130	**5.1181**	**5.1171**	5.1201	5.1192		5.1208	5.1198		5.1216	5.1207				
140	**5.5118**	**5.5108**	5.5138	5.5129		5.5145	5.5135		5.5153	5.5144				
150	**5.9055**	**5.9045**	5.9075	5.9066	11 T	5.9082	5.9072	17 T	5.9090	5.9081	26 T			
160	**6.2992**	**6.2982**	6.3012	6.3003	30 T	6.3019	6.3009	37 T	6.3027	6.3018	45 T			
170	**6.6929**	**6.6919**	6.6949	6.6940		6.6956	6.6946		6.6964	6.6955				
180	**7.0866**	**7.0856**	7.0886	7.0877		7.0893	7.0883		7.0901	7.0892				
190	**7.4803**	**7.4791**	7.4827	7.4815		7.4834	7.4823		7.4845	7.4833	30 T			
200	**7.8740**	**7.8728**	7.8764	7.8752	12 T	7.8771	7.8760	20 T	7.8782	7.8770	54 T			
220	**8.6614**	**8.6602**	8.6638	8.6626	35 T	8.6645	8.6634	43 T	8.6657	8.6645	31/55 T/T	8.6664	8.6645	31/62 T/T
240	**9.4488**	**9.4476**	9.4512	9.4500		9.4519	9.4508		9.4532	9.4521	33 T	9.4539	9.4521	33 T
250	**9.8425**	**9.8413**	9.8449	9.8437		9.8456	9.8445		9.8469	9.8458	56 T	9.8476	9.8458	63 T
260	**10.2362**	**10.2348**	10.2388	10.2375		10.2397	10.2384		10.2411	10.2399	37 T	10.2419	10.2399	37 T
280	**11.0236**	**11.0222**	11.0262	11.0249	13 T	11.0271	11.0258	22 T	11.0285	11.0273	63 T	11.0293	11.0273	71 T
300	**11.8110**	**11.8096**	11.8136	11.8123	40 T	11.8145	11.8132	48 T	11.8161	11.8149	39 T	11.8169	11.8149	39 T
310	**12.2047**	**12.2033**	12.2073	12.2060		12.2082	12.2069		12.2098	12.2086	65 T	12.2106	12.2086	73 T
320	**12.5984**	**12.5968**	12.6013	12.5999		12.6023	12.6009		12.6040	12.6027	43 T	12.6049	12.6027	43 T
340	**13.3858**	**13.3842**	13.3887	13.3873		13.3897	13.3882		13.3914	13.3901	72 T	13.3923	13.3901	81 T
350	**13.7795**	**13.7779**	13.7824	13.7810	15 T	13.7834	13.7819	24 T	13.7851	13.7838		13.7860	13.7838	
360	**14.1732**	**14.1716**	14.1761	14.1747	45 T	14.1771	14.1756	55 T	14.1791	14.1777	45 T	14.1799	14.1777	45 T
380	**14.9606**	**14.9590**	14.9635	14.9621		14.9645	14.9631		14.9665	14.9651	75 T	14.9673	14.9651	83 T
400	**15.7480**	**15.7464**	15.7509	15.7495		15.7519	15.7504		15.7539	15.7525		15.7547	15.7525	
420	**16.5354**	**16.5336**	16.5385	16.5370		16.5397	16.5381		16.5419	16.5404	50 T	16.5428	16.5404	50 T
440	**17.3228**	**17.3210**	17.3259	17.3244	16 T	17.3271	17.3255	27 T	17.3293	17.3278	83 T	17.3302	17.3278	92 T
460	**18.1102**	**18.1084**	18.1133	18.1118	49 T	18.1145	18.1129	61 T	18.1170	18.1154	52 T	18.1179	18.1154	52 T
480	**18.8976**	**18.8958**	18.9007	18.8992		18.9019	18.9003		18.9044	18.9028	86 T	18.9053	18.9028	95 T
500	**19.6850**	**19.6832**	19.6881	19.6866		19.6893	19.6877		19.6918	19.6902		19.6927	19.6902	
530	**20.8661**	**20.8641**	20.8696	20.8678		20.8709	20.8692		20.8737	20.8720	59 T	20.8748	20.8720	59 T
560	**22.0472**	**22.0452**	22.0507	22.0489	17 T	22.0520	22.0503	31 T	22.0548	22.0531	96 T	22.0559	22.0531	107 T
600	**23.6220**	**23.6200**	23.6255	23.6237	55 T	23.6268	23.6251	68 T	23.6298	23.6281	61 T	23.6309	23.6281	61 T
630	**24.8031**	**24.8011**	24.8066	24.8048		24.8079	24.8062		24.8109	24.8092	98 T	24.8120	24.8092	109 T
660	**25.9843**	**25.9813**	25.9882	25.9863		25.9897	25.9878		25.9931	25.9912	69 T	25.9943	25.9911	68 T
670	**26.3780**	**26.3750**	26.3819	26.3800		26.3834	26.3815		26.3868	26.3849	118 T	26.3880	26.3848	130 T
710	**27.9528**	**27.9498**	27.9567	27.9548	20 T	27.9582	27.9563	35 T	27.9616	27.9597		27.9628	27.9596	
750	**29.5276**	**29.5246**	29.5315	29.5296	69 T	29.5330	29.5311	84 T	29.5368	29.5349	73 T	29.5380	29.5348	72 T
780	**30.7087**	**30.7057**	30.7126	30.7107		30.7141	30.7122		30.7179	30.7160	122 T	30.7191	30.7159	134 T
800	**31.4961**	**31.4931**	31.5000	31.4981		31.5015	31.4996		31.5053	31.5034		31.5065	31.5033	
850	**33.4646**	**33.4607**	33.4690	33.4668		33.4707	33.4685		33.4751	33.4729	83 T	33.4764	33.4728	82 T
900	**35.4331**	**35.4292**	35.4375	35.4353	22 T	35.4392	35.4370	39 T	35.4436	35.4414	144 T	35.4449	35.4413	157 T
950	**37.4016**	**37.3977**	37.4060	37.4038	83 T	37.4077	37.4055	100 T	37.4125	37.4103	87 T	37.4138	37.4102	86 T
1000	**39.3701**	**39.3662**	39.3745	39.3723		39.3762	39.3740		39.3810	39.3788	148 T	39.3823	39.3787	161 T
1060	**41.7323**	**41.7274**	41.7375	41.7349		41.7396	41.7370		41.7447	41.7421	98 T	41.7463	41.7421	98 T
1120	**44.0945**	**44.0896**	44.0997	44.0971	26 T	44.1018	44.0992	47 T	44.1069	44.1043	173 T	44.1085	44.1043	189 T
1180	**46.4567**	**46.4518**	46.4619	46.4593	101 T	46.4640	46.4614	122 T	46.4694	46.4669	102 T	46.4711	46.4669	102 T
1250	**49.2126**	**49.2077**	49.2178	49.2152		49.2199	49.2173		49.2253	49.2228	177 T	49.2270	49.2228	193 T

Shaft Bearing-Seat Diameters (Values in mm)

Bearing Bore Diameters (mm)			f7			g6			h6			h5			j5		
			Shaft Dia.		Fit in µm	Shaft Dia.		Fit in µm	Shaft Dia.		Fit in µm	Shaft Dia.		Fit in µm	Shaft Dia.		Fit in µm
(mm)	Max.	Min.	Max.	Min.	(0.001mm)	Max.	Min.	(0.001mm)	Max.	Min.	(0.001mm)	Max.	Min.	(0.001mm)	Max.	Min.	(0.001mm)
4	**4.000**	**3.992**	3.990	3.978		3.996	3.988		4.000	3.992		4.000	3.995		4.003	3.998	
5	**5.000**	**4.992**	4.990	4.978	22 L	4.996	4.988	12 L	5.000	4.992	8 L	5.000	4.995	5 L	5.003	4.998	2 L
6	**6.000**	**5.992**	5.990	5.978	2 L	5.996	5.988	4 T	6.000	5.992	8 T	6.000	5.995	8 T	6.003	5.998	11 T
7	**7.000**	**6.992**	6.987	6.972		6.995	6.986		7.000	6.991		7.000	6.994		7.004	6.998	
8	**8.000**	**7.992**	7.987	7.972	28 L	7.995	7.986	14 L	8.000	7.991	9 L	8.000	7.994	6 L	8.004	7.998	2 L
9	**9.000**	**8.992**	8.972	8.972	20 L	8.995	8.986	3 T	9.000	8.991	8 T	9.000	8.994	8 T	9.004	8.998	12 T
10	**10.000**	**9.992**	9.987	9.972		9.995	9.986		10.000	9.991		10.000	9.994		10.004	9.998	
12	**12.000**	**11.992**	11.984	11.966		11.994	11.983		12.000	11.989		12.000	11.992		12.005	11.997	
15	**15.000**	**14.992**	14.984	14.966	34 L	14.994	14.983	17 L	15.000	14.989	11 L	15.000	14.992	8 L	15.005	14.997	3 L
17	**17.000**	**16.992**	16.984	16.966	8 L	16.994	16.983	2 T	17.000	16.989	8 T	17.000	16.992	8 T	17.005	16.997	13 T
20	**20.000**	**19.990**	19.980	19.959		19.993	19.980		20.000	19.987		20.000	19.991		20.005	19.996	
25	**25.000**	**24.990**	24.980	24.959	41 L	24.993	24.980	20 L	25.000	24.987	13 L	25.000	24.991	9 L	25.005	24.996	4 L
30	**30.000**	**29.990**	29.975	29.950	15 L	29.993	29.980	3 T	30.000	29.987	10 T	30.000	29.991	10 T	30.005	29.996	15 T
35	**35.000**	**34.988**	34.975	34.950		34.991	34.975		35.000	34.984		35.000	34.989		35.006	34.995	
40	**40.000**	**39.988**	39.975	39.950	50 L	39.991	39.975	25 L	40.000	39.984	16 L	40.000	39.989	11 L	40.006	39.995	5 L
45	**45.000**	**44.988**	44.975	44.950	13 L	44.991	44.975	3 T	45.000	44.984	12 T	45.000	44.989	12 T	45.006	44.995	18 T
50	**50.000**	**49.988**	49.975	49.950		49.991	49.975		50.000	49.984		50.000	49.989		50.006	49.995	
55	**55.000**	**54.985**	54.970	54.940		54.990	54.971		55.000	54.981		55.000	54.987		55.006	54.993	
60	**60.000**	**59.985**	59.970	59.940		59.990	59.971		60.000	59.981		60.000	59.987		60.006	59.993	
65	**65.000**	**64.985**	64.970	64.940	60 L	64.990	64.971	29 L	65.000	64.981	19 L	65.000	64.987	13 L	65.006	64.993	7 L
70	**70.000**	**69.985**	69.970	69.940	15 L	69.990	69.971	5 T	70.000	69.981	15 T	70.000	69.987	15 T	70.006	69.993	21 T
75	**75.000**	**74.985**	74.970	74.940		74.990	74.971		75.000	74.981		75.000	74.987		75.006	74.993	
80	**80.000**	**79.985**	79.970	79.940		79.990	79.971		80.000	79.981		80.000	79.987		80.006	79.993	
85	**85.000**	**84.980**	84.964	85.929		84.988	84.966		85.000	84.978		85.000	84.985		85.006	84.991	
90	**90.000**	**89.980**	89.964	89.929		89.988	89.966		90.000	89.978		90.000	89.985		90.006	89.991	
95	**95.000**	**94.980**	94.964	94.929		94.988	94.966		95.000	94.978		95.000	94.985		95.006	94.991	
100	**100.000**	**99.980**	99.964	99.929	71 T	99.988	99.966	34 L	100.000	99.978	22 L	100.000	99.985	15 L	100.006	99.991	9 L
105	**105.000**	**104.980**	104.964	104.929	16 L	104.988	104.966	8 T	105.000	104.978	20 T	105.000	104.985	20 T	105.006	104.991	26 T
110	**110.000**	**109.980**	109.964	109.929		109.988	109.966		110.000	109.978		110.000	109.985		110.006	109.991	
115	**115.000**	**114.980**	114.964	114.929		114.988	114.966		115.000	114.978		115.000	114.985		115.006	114.991	
120	**120.000**	**119.980**	119.964	119.929		119.988	119.966		120.000	119.978		120.000	119.985		120.006	119.991	
125	**125.000**	**124.975**	124.957	124.917		124.986	124.961		125.000	124.975		125.000	124.982		125.007	124.989	
130	**130.000**	**129.975**	129.957	129.917		129.986	129.961		130.000	129.975		130.000	129.982		130.007	129.989	
140	**140.000**	**139.975**	139.957	139.917		139.986	139.961		140.000	139.975		140.000	139.982		140.007	139.989	
150	**150.000**	**149.975**	149.957	149.917	83 L	149.986	149.961	39 L	150.000	149.975	25 L	150.000	149.982	18 L	150.007	149.989	11 L
160	**160.000**	**159.975**	139.957	159.917	20.018 L	159.986	159.961	11 T	160.000	159.975	25 T	160.000	159.982	25 T	160.007	159.989	32 T
170	**170.000**	**169.975**	169.957	169.917		169.986	169.961		170.000	169.975		170.000	169.982		170.007	169.989	
180	**180.000**	**179.975**	179.957	179.917		179.986	179.961		180.000	179.975		180.000	179.982		180.007	179.989	
190	**190.000**	**189.970**	189.950	189.904		189.985	189.956		190.000	189.971		190.000	189.980		190.007	189.987	
200	**200.000**	**199.970**	199.950	199.904	96 L	199.985	199.956	44 L	200.000	199.971	29 L	200.000	199.980	20 L	200.007	199.987	13 L
220	**220.000**	**219.970**	219.950	219.904	20 L	219.985	219.956	15 T	220.000	219.971	30 T	220.000	219.980	30 T	220.007	219.987	37 T
240	**240.000**	**239.970**	239.950	239.904		239.985	239.956		240.000	239.971		240.000	239.980		240.007	239.987	
250	**250.000**	**249.970**	249.950	249.904		249.985	249.956		250.000	249.971		250.000	249.980		250.007	249.987	
260	**260.000**	**259.965**	259.944	259.892		259.983	259.951		260.000	259.968		260.000	259.977		260.007	259.984	
280	**280.000**	**279.965**	279.944	279.892	108 L	279.983	279.951	49 L	280.000	279.968	32 L	280.000	279.977	23 L	280.007	279.984	16 L
300	**300.000**	**299.965**	299.944	299.892	21 L	299.983	299.951	18 T	300.000	299.968	35 T	300.000	299.977	35 T	300.007	299.984	42 T
310	**310.000**	**309.965**	309.944	309.892		309.983	309.951		310.000	309.968		310.000	309.977		310.007	309.984	
320	**320.000**	**319.960**	319.938	319.881		319.982	319.946		320.000	319.964		320.000	319.975		320.007	319.982	
340	**340.000**	**339.960**	339.938	339.881		339.982	339.946		340.000	339.964		340.000	339.975		340.007	339.982	
350	**350.000**	**349.960**	349.938	349.881	119 L	349.982	349.946	54 L	350.000	349.964	36 L	350.000	349.975	25 L	350.007	349.982	18 L
360	**360.000**	**359.960**	359.938	359.881	22 L	359.982	359.946	22 T	360.000	359.964	40 T	360.000	359.975	40 T	360.007	359.982	47 T
380	**380.000**	**379.960**	379.938	379.881		379.982	379.946		380.000	379.964		380.000	379.975		380.007	379.982	
400	**400.000**	**399.960**	399.938	399.881		399.982	399.946		400.000	399.964		400.000	399.975		400.007	399.982	
420	**420.000**	**419.955**	419.932	419.869		419.980	419.940		420.000	419.960		420.000	419.973		420.007	419.980	
440	**440.000**	**439.955**	439.932	439.869	131 L	439.980	439.940	60 L	440.000	439.960	40 L	440.000	439.973	27 L	440.007	439.980	20 L
460	**460.000**	**459.955**	459.932	459.869	23 L	459.980	459.940	25 T	460.000	459.960	45 T	460.000	459.973	45 T	460.007	459.980	52 T
480	**480.000**	**479.955**	479.932	479.869		479.980	479.940		480.000	479.960		480.000	479.973		480.007	479.980	
500	**500.000**	**499.955**	499.932	499.869		499.980	499.940		500.000	499.960		500.000	499.973		500.007	499.980	
530	**530.000**	**529.950**	529.925	529.857		529.978	529.934		530.000	529.956							
560	**560.000**	**559.950**	559.925	559.857	143 L	559.978	559.934	66 L	560.000	559.956	44 L						
600	**600.000**	**599.950**	599.925	599.857	25 L	599.978	599.934	28 T	600.000	599.956	50 T						
630	**630.000**	**629.950**	629.925	629.857		629.978	629.934		630.000	629.950							
660	**660.000**	**659.925**	659.920	659.844		659.976	659.926		660.000	659.950							
670	**670.000**	**669.925**	669.920	669.844		669.976	669.926		670.000	669.950							
710	**710.000**	**709.925**	709.920	709.844	156 L	709.976	709.926	74 L	710.000	709.950	50 L						
750	**750.000**	**749.925**	749.920	749.844	5 L	749.976	749.926	51 T	750.000	749.950	75 T						
780	**780.000**	**779.925**	779.920	779.844		779.976	779.926		780.000	779.950							
800	**800.000**	**799.925**	799.920	799.844		799.976	799.926		800.000	799.950							
850	**850.000**	**849.900**	849.910	849.826		849.974	849.918		850.000	849.944							
900	**900.000**	**899.900**	899.910	899.826	174 L	899.974	899.918	82 L	900.000	899.944	56 L						
950	**950.000**	**949.900**	949.910	949.826	10 T	949.974	949.918	74 T	950.000	949.944	100 T						
1000	**1000.000**	**999.900**	999.910	999.826		999.974	999.918		1000.000	999.944							
1060	**1060.000**	**1059.875**	1059.900	1059.807		1059.972	1059.906		1060.000	1059.934							
1120	**1120.000**	**1119.875**	1119.900	1119.807	193 L	1119.972	1119.906	94 L	1120.000	1119.934	66 L						
1180	**1180.000**	**1179.875**	1179.900	1179.807	25 T	1179.972	1179.906	97 T	1180.000	1179.934	125 T						
1250	**1250.000**	**1249.875**	1249.900	1249.807		1249.972	1249.906		1250.000	1249.934							

Shaft Bearing-Seat Diameters (Values in mm) (cont.)

Bearing Bore Diameters (mm)			j6			k5			k6			m5			m6		
			Shaft Dia.		Fit in µm	Shaft Dia.		Fit in µm	Shaft Dia.		Fit in µm	Shaft Dia.		Fit in µm	Shaft Dia.		Fit in µm
(mm)	Max.	Min.	Max.	Min.	(0.001 mm)	Max.	Min.	(0.001 mm)	Max.	Min.	(0.001 mm)	Max.	Min.	(0.001 mm)	Max.	Min.	(0.001 mm)
4	4.000	3.992	4.006	3.998		4.006	4.001		4.009	4.001		4.009	4.004		4.012	4.004	
5	5.000	4.992	5.006	4.998	2 L	5.006	5.001	1 T	5.009	5.001	1 T	5.009	5.004	4 T	5.012	5.004	4 T
6	6.000	5.992	6.006	5.998	14 T	6.006	6.001	14 T	6.009	6.001	17 T	6.009	6.004	17 T	6.012	6.004	20 T
7	7.000	6.992	7.007	6.998		7.007	7.001		7.010	7.001		7.012	7.006		7.015	7.006	
8	8.000	7.992	8.007	7.998	2 L	8.007	8.001	1 T	8.010	8.001	1 T	8.012	8.006	6 T	8.015	8.006	6 T
9	9.000	8.992	9.007	8.998	15 T	9.007	9.001	15 T	9.010	9.001	18 T	9.012	9.006	20 T	9.015	9.006	23 T
10	10.000	9.992	10.007	9.998		10.007	10.001		10.010	10.001		10.012	10.006		10.015	10.006	
12	12.000	11.992	12.008	11.997		12.009	12.001		12.012	12.001		12.015	12.007		12.018	12.007	
15	15.000	14.992	15.008	14.997	3 L	15.009	15.001	1 T	15.012	15.001	1 T	15.015	15.007	7 T	15.018	15.007	7 T
17	17.000	16.992	17.008	16.997	16 T	17.009	17.001	17 T	17.012	17.001	20 T	17.015	17.007	23 T	17.018	17.007	26 T
20	20.000	19.990	20.009	19.996		20.011	20.002		20.015	20.002		20.017	20.008		20.021	20.008	
25	25.000	24.990	25.009	24.996	4 L	25.011	25.002	2 T	25.015	25.002	2 T	25.017	25.008	8 T	25.021	25.008	8 T
30	30.000	29.990	30.009	29.996	19 T	30.011	30.002	21 T	30.015	30.002	25 T	30.017	30.008	27 T	30.021	30.008	31 T
35	35.000	34.988	35.011	34.995		35.013	35.002		35.018	35.002		35.020	35.009		35.025	35.009	
40	40.000	39.988	40.011	39.995	5 L	40.013	40.002	2 T	40.018	40.002	2 T	40.020	40.009	9 T	40.025	40.009	9 T
45	45.000	44.988	45.011	44.995	23 T	45.013	45.002	25 T	45.018	45.002	30 T	45.020	45.009	32 T	45.025	45.009	37 T
50	50.000	49.988	50.011	49.995		50.013	50.002		50.018	50.002		50.020	50.009		50.025	50.009	
55	55.000	54.985	55.012	54.993		55.015	55.002		55.021	55.002		55.024	55.011		55.030	55.011	
60	60.000	59.985	60.012	59.993		60.015	60.002		60.021	60.002		60.024	60.011		60.030	60.011	
65	65.000	64.985	65.012	64.993	7 L	65.015	65.002	2 T	65.021	65.002	2 T	65.024	65.011	11 T	65.030	65.011	11 T
70	70.000	69.985	70.012	69.993	27 T	70.015	70.002	30 T	70.021	70.002	36 T	70.024	70.011	39 T	70.030	70.011	45 T
75	75.000	74.985	75.012	74.993		75.015	75.002		75.021	75.002		75.024	75.011		75.030	75.011	
80	80.000	79.985	80.012	79.993		80.015	80.002		80.021	80.002		80.024	80.011		80.030	80.011	
85	85.000	84.980	85.013	84.991		85.018	85.003		85.025	85.003		85.028	85.013		85.035	85.013	
90	90.000	89.980	90.013	89.991		90.018	90.003		90.025	90.003		90.028	90.013		90.035	90.013	
95	95.000	94.980	95.013	94.991		95.018	95.003		95.025	95.003		95.028	95.013		95.035	95.013	
100	100.000	99.980	100.013	99.991	9 L	100.018	100.003	3 T	100.025	100.003	3 T	100.028	100.013	13 T	100.035	100.013	13 T
105	105.000	104.980	105.013	104.991	33 T	105.018	105.003	38 T	105.025	105.003	45 T	105.028	105.013	48 T	105.035	105.013	55 T
110	110.000	109.980	110.013	109.991		110.018	110.003		110.025	110.003		110.028	110.013		110.035	110.013	
115	115.000	114.980	115.013	114.991		115.018	115.003		115.025	115.003		115.028	115.013		115.035	115.013	
120	120.000	119.980	120.013	119.991		120.018	120.003		120.025	120.003		120.028	120.013		120.035	120.013	
125	125.000	124.975	125.014	124.989		125.021	125.003		125.028	125.003		125.033	125.015		125.040	125.015	
130	130.000	129.975	130.014	129.989		130.021	130.003		130.028	130.003		130.033	130.015		130.040	130.015	
140	140.000	139.975	140.014	139.989		140.021	140.003		140.028	140.003		140.033	140.015		140.040	140.015	
150	150.000	149.975	150.014	149.989	11 L	150.021	150.003	3 T	150.028	150.003	3 T	150.033	150.015	15 T	150.040	150.015	15 T
160	160.000	159.975	160.014	159.989	39 T	160.021	160.003	46 T	160.028	160.003	53 T	160.033	160.015	58 T	160.040	160.015	65 T
170	170.000	169.975	170.014	169.989		170.021	170.003		170.028	170.003		170.033	170.015		170.040	170.015	
180	180.000	179.975	180.014	179.989		180.021	180.003		180.028	180.003		180.033	180.015		180.040	180.015	
190	190.000	189.970	190.016	189.987		190.024	190.004		190.033	190.004		190.037	190.017		190.046	190.017	
200	200.000	199.970	200.016	199.987	13 L	200.024	200.004	4 T	200.033	200.004	4 T	200.037	200.017	17 T	200.046	200.017	17 T
220	220.000	219.970	220.016	219.987	46 T	220.024	220.004	54 T	220.033	220.004	63 T	220.037	220.017	67 T	220.046	220.017	76 T
240	240.000	239.970	240.016	239.987		240.024	240.004		240.033	240.004		240.037	240.017		240.046	240.017	
250	250.000	249.970	250.016	249.987		250.024	250.004		250.033	250.004		250.037	250.017		250.046	250.017	
260	260.000	259.965	260.016	259.984		260.027	260.004		260.036	260.004		260.043	260.020		260.052	260.020	
280	280.000	279.965	280.016	279.984	16 L	280.027	280.004	4 T	280.036	280.004	4 T	280.043	280.020	20 T	280.052	280.020	20 T
300	300.000	299.965	300.016	299.984	51 T	300.027	300.004	62 T	300.036	300.004	71 T	300.043	300.020	78 T	300.052	300.020	87 T
310	310.000	309.965	310.016	309.984		310.027	310.004		310.036	310.004		310.043	310.020		310.052	310.020	
320	320.000	319.960	320.018	319.982		320.029	320.004		320.040	320.004		320.046	320.021		320.057	320.021	
340	340.000	339.960	340.018	339.982		340.029	340.004		340.040	340.004		340.046	340.021		340.057	340.021	
350	350.000	349.960	350.018	349.982	18 L	350.029	350.004	4 T	350.040	350.004	4 T	350.046	350.021	21 T	350.057	350.021	21 T
360	360.000	359.960	360.018	359.982	58 T	360.029	360.004	69 T	360.040	360.004	80 T	360.046	360.021	86 T	360.057	360.021	97 T
380	380.000	379.960	380.018	379.982		380.029	380.004		380.040	380.004		380.046	380.021		380.057	380.021	
400	400.000	399.960	400.018	399.982		400.029	400.004		400.040	400.004		400.046	400.021		400.057	400.021	
420	420.000	419.955	420.020	419.980		420.032	420.005		420.045	420.005		420.050	420.023		420.063	420.023	
440	440.000	439.955	440.020	439.980	20 L	440.032	440.005	5 T	440.045	440.005	5 T	440.050	440.023	23 T	440.063	440.023	23 T
460	460.000	459.955	460.020	459.980	65 T	460.032	460.005	77 T	460.045	460.005	90 T	460.050	460.023	95 T	460.063	460.023	108 T
480	480.000	479.955	480.020	479.980		480.032	480.005		480.045	480.005		480.050	480.023		480.063	480.023	
500	500.000	499.955	500.020	499.980		500.032	500.005		500.045	500.005		500.050	500.023		500.063	500.023	
530	530.000	529.950	530.022	529.978		530.029	530.000		530.044	530.000		530.055	530.026				
560	560.000	559.950	560.022	559.978	22 L	560.029	560.000	0 T	560.044	560.000	0 T	560.055	560.026	26 T			
600	600.000	599.950	600.022	599.978	72 T	600.029	600.000	79 T	600.044	600.000	94 T	600.055	600.026	105 T			
630	630.000	629.950	630.022	629.978		630.029	630.000		630.044	630.000		630.055	630.026				
660	660.000	659.925	660.025	659.975		660.032	660.000		660.050	660.000		660.062	660.030				
670	670.000	669.925	670.025	669.975		670.032	670.000		670.050	670.000		670.062	670.030				
710	710.000	709.925	710.025	709.975	25 L	710.032	710.000	0 T	710.050	710.000	0 T	710.062	710.030	30 T			
750	750.000	749.925	750.025	749.975	100 T	750.032	750.000	107 T	750.050	750.000	125 T	750.062	750.030	137 T			
780	780.000	779.925	780.025	779.975		780.032	780.000		780.050	780.000		780.062	780.030				
800	800.000	799.925	800.025	799.975		800.032	800.000		800.050	800.000		800.062	800.030				
850	850.000	849.900	850.028	849.972		850.036	850.000		850.056	850.000		850.070	850.034				
900	900.000	899.900	900.028	899.972	28 L	900.036	900.000	0 T	900.056	900.000	0 T	900.070	900.034	34 T			
950	950.000	949.900	950.028	949.972	128 T	950.036	950.000	136 T	950.056	950.000	156 T	950.070	950.034	170 T			
1000	1000.000	999.900	1000.028	999.972		1000.036	1000.000		1000.056	1000.000		1000.070	1000.034				
1060	1060.000	1059.875	1060.033	1059.967		1060.042	1060.000		1060.066	1060.000		1060.082	1060.040				
1120	1120.000	1119.875	1120.033	1119.967	33 L	1120.042	1120.000	0 T	1120.066	1120.000	0 T	1120.082	1120.040	40 T			
1180	1180.000	1179.875	1180.033	1179.967	158 T	1180.042	1180.000	167 T	1180.066	1180.000	191 T	1180.082	1180.040	207 T			
1250	1250.000	1249.875	1250.033	1249.967		1250.042	1250.000		1250.066	1250.000		1250.082	1250.040				

Shaft Bearing-Seat Diameters (Values in mm) (cont.)

Bearing Bore Diameters (mm)			n6			p6			r6			r7		
			Shaft Dia.		Fit in µm	Shaft Dia.		Fit in µm	Shaft Dia.		Fit in µm	Shaft Dia.		Fit in µm
(mm)	Max.	Min.	Max.	Min.	(0.001 mm)	Max.	Min.	(0.001 mm)	Max.	Min.	(0.001 mm)	Max.	Min.	(0.001 mm)
4	**4.000**	**3.992**	4.016	4.008										
5	**5.000**	**4.992**	5.016	5.008	8 T									
6	**6.000**	**5.992**	6.016	6.008	24 T									
7	**7.000**	**6.992**	7.019	7.010										
8	**8.000**	**7.992**	8.019	8.010	10 T									
9	**9.000**	**8.992**	9.019	9.010	27 T									
10	**10.000**	**9.992**	10.019	10.010										
12	**12.000**	**11.992**	12.023	12.012										
15	**15.000**	**14.992**	15.023	15.012	12 T									
17	**17.000**	**16.992**	17.023	17.012	31 T									
20	**20.000**	**19.990**	20.028	20.015										
25	**25.000**	**24.990**	25.028	25.015	15 T									
30	**30.000**	**29.990**	30.028	30.015	38 T									
35	**35.000**	**34.988**	35.033	35.017										
40	**40.000**	**39.988**	40.033	40.017	17 T									
45	**45.000**	**44.988**	45.033	45.017	45 T									
50	**50.000**	**49.988**	50.033	50.017										
55	**55.000**	**54.985**	55.039	55.020										
60	**60.000**	**59.985**	60.039	60.020										
65	**65.000**	**64.985**	65.039	65.020	20 T									
70	**70.000**	**69.985**	70.039	70.020	54 T									
75	**75.000**	**74.985**	75.039	75.020										
80	**80.000**	**79.985**	80.039	80.020										
85	**85.000**	**84.980**	85.045	85.023		85.059	85.037							
90	**90.000**	**89.980**	90.045	90.023		90.059	90.037							
95	**95.000**	**94.980**	95.045	95.023		95.059	95.037							
100	**100.000**	**99.980**	100.045	100.023	23 T	100.059	100.037	37 T						
105	**105.000**	**104.980**	105.045	105.023	65 T	105.059	105.037	79 T						
110	**110.000**	**109.980**	110.045	110.023		110.059	110.037							
115	**115.000**	**114.980**	115.045	115.023		115.059	115.037							
120	**120.000**	**119.980**	120.045	120.023		120.059	120.037							
125	**125.000**	**124.975**	125.052	125.027		125.068	125.043		125.088	125.063				
130	**130.000**	**129.975**	130.052	130.027		130.068	130.043		130.088	130.063				
140	**140.000**	**139.975**	140.052	140.027		140.068	140.043		140.088	140.063				
150	**150.000**	**149.975**	150.052	150.027	27 T	150.068	150.043	43 T	150.090	150.065	65 T			
160	**160.000**	**159.975**	160.052	160.027	77 T	160.068	160.043	93 T	160.090	160.065	115 T			
170	**170.000**	**169.975**	170.052	170.027		170.068	170.043		170.093	170.068				
180	**180.000**	**179.975**	180.052	180.027		180.068	180.043		180.093	180.068				
190	**190.000**	**189.970**	190.060	190.031		190.079	190.050		190.106	190.077	77 T			
200	**200.000**	**199.970**	200.060	200.031	31 T	200.079	200.050	50 T	200.106	200.077	136 T			
220	**220.000**	**219.970**	220.060	220.031	90 T	220.079	220.050	109 T	220.109	220.080	80/139 T/T	220.126	220.080	80/156 T/T
240	**240.000**	**239.970**	240.060	240.031		240.079	240.050		240.113	240.084	84 T	240.130	240.084	84 T
250	**250.000**	**249.970**	250.060	250.031		250.079	250.050		250.113	250.084	143 T	250.130	250.084	160 T
260	**260.000**	**259.965**	260.066	260.034		260.088	260.056		260.126	260.094	94 T	260.146	260.094	94 T
280	**280.000**	**279.965**	280.066	280.034	34 T	280.088	280.056	56 T	280.126	280.094	161 T	280.146	280.094	181 T
300	**300.000**	**299.965**	300.066	300.034	101 T	300.088	300.056	123 T	300.130	300.098	98 T	300.150	300.098	98 T
310	**310.000**	**309.965**	310.066	310.034		310.088	310.056		310.130	310.098	165 T	310.150	310.098	185 T
320	**320.000**	**319.960**	320.073	320.037		320.098	320.062		320.144	320.108	108 T	320.165	320.108	108 T
340	**340.000**	**339.960**	340.073	340.037		340.098	340.062		340.144	340.108	184 T	340.165	340.108	205 T
350	**350.000**	**349.960**	350.073	350.037	37 T	350.098	350.062	62 T	350.144	350.108		350.165	350.108	
360	**360.000**	**359.960**	360.073	360.037	113 T	360.098	360.062	138 T	360.150	360.114	114 T	360.171	360.114	114 T
380	**380.000**	**379.960**	380.073	380.037		380.098	380.062		380.150	380.114	190 T	380.171	380.114	211 T
400	**400.000**	**399.960**	400.073	400.037		400.098	400.062		400.150	400.114		400.171	400.114	
420	**420.000**	**419.955**	420.080	420.040		420.108	420.068		420.166	420.126	126 T	420.189	420.126	126 T
440	**440.000**	**439.955**	440.080	440.040	40 T	440.108	440.068	68 T	440.166	440.126	211 T	440.189	440.126	234 T
460	**460.000**	**459.955**	460.080	460.040	125 T	460.108	460.068	153 T	460.172	460.132	132 T	460.195	460.132	132 T
480	**480.000**	**479.955**	480.080	480.040		480.108	480.068		480.172	480.132	217 T	480.195	480.132	240 T
500	**500.000**	**499.955**	500.080	500.040		500.108	500.068		500.172	500.132		500.195	500.132	
530	**530.000**	**529.950**	530.088	530.044		530.122	530.078		530.194	530.150	150 T	530.220	530.150	150 T
560	**560.000**	**559.950**	560.088	560.044	44 T	560.122	560.078	78 T	560.194	560.150	244 T	560.220	560.150	270 T
600	**600.000**	**599.950**	600.088	600.044	138 T	600.122	600.078	172 T	600.199	600.155	155 T	600.225	600.155	155 T
630	**630.000**	**629.950**	630.088	630.044		630.122	630.078		630.199	630.155	249 T	630.225	630.155	275 T
660	**660.000**	**659.925**	660.100	660.050		660.138	660.088		660.225	660.175	175 T	660.255	660.175	175 T
670	**670.000**	**669.925**	670.100	670.050		670.138	670.088		670.225	670.175	300 T	670.255	670.175	330 T
710	**710.000**	**709.925**	710.100	710.050	50 T	710.138	710.088	88 T	710.225	710.175		710.255	710.175	
750	**750.000**	**749.925**	750.100	750.050	175 T	750.138	750.088	213 T	750.235	750.185	185 T	750.265	750.185	185 T
780	**780.000**	**779.925**	780.100	780.050		780.138	780.088		780.235	780.185	310 T	780.265	780.185	340 T
800	**800.000**	**799.925**	800.100	800.050		800.138	800.088		800.235	800.185		800.265	800.185	
850	**850.000**	**849.900**	850.112	850.056		850.156	850.100		850.266	850.210	210 T	850.300	850.210	210 T
900	**900.000**	**899.900**	900.112	900.056	56 T	900.156	900.100	100 T	900.266	900.210	366 T	900.300	900.210	400 T
950	**950.000**	**949.900**	950.112	950.056	212 T	950.156	950.100	256 T	950.276	950.220	220 T	950.310	950.220	220 T
1000	**1000.000**	**999.900**	1000.112	1000.066		1000.156	1000.100		1000.276	1000.220	376 T	1000.310	1000.250	410 T
1060	**1060.000**	**1059.875**	1060.132	1060.066		1060.186	1060.120		1060.316	1060.260	250 T	1060.355	1060.250	250 T
1120	**1120.000**	**1119.875**	1120.132	1120.066	66 T	1120.186	1120.120	120 T	1120.316	1120.260	441 T	1120.355	1120.250	480 T
1180	**1180.000**	**1179.875**	1180.132	1180.066	257 T	1180.186	1180.120	311 T	1180.326	1180.260	260 T	1180.365	1180.260	260 T
1250	**1250.000**	**1249.875**	1250.132	1250.066		1250.186	1250.120		1250.326	1250.260	451 T	1250.365	1250.260	490 T

Housing Bearing-Seat Diameters (Values in Inches)

Bearing Outside Diameter			F7			G7			H8			H7			H6		
mm	Inches		Housing Bore		Fit in 0.0000"	Housing Bore		Fit in 0.0000"	Housing Bore		Fit in 0.0000"	Housing Bore		Fit in 0.0000"	Housing Bore		Fit in 0.0000"
	Max.	Min.	Min.	Max.		Min.	Max.		Min.	Max.		Min.	Max.		Min.	Max.	
16	**0.6299**	**0.6296**	0.6305	0.6312	16 L 6 L	0.6301	0.6308	12 L 2 L	0.6299	0.6310	14 L 0	0.6299	0.6306	10 L 0	0.6299	0.6303	7 L 0
19	**0.7480**	**0.7476**	0.7488	0.7496		0.7483	0.7491		0.7480	0.7493		0.7480	0.7488		0.7480	0.7485	
22	**0.8661**	**0.8657**	0.8669	0.8677		0.8664	0.8672		0.8661	0.8674		0.8661	0.8669		0.8661	0.8666	
24	**0.9449**	**0.9445**	0.9457	0.9465	20 L	0.9452	0.9460	15 L	0.9449	0.9462	17 L	0.9449	0.9457	12 L	0.9449	0.9454	9 L
26	**1.0236**	**1.0232**	1.0244	1.0252	8 L	1.0239	1.0247	3 L	1.0236	1.0249	0	1.0236	1.0244	0	1.0236	1.0241	0
28	**1.1024**	**1.1020**	1.1032	1.1040		1.1027	1.1035		1.1024	1.1037		1.1024	1.1032		1.1024	1.1029	
30	**1.1811**	**1.1807**	1.1819	1.1827		1.1814	1.1822		1.1811	1.1824		1.1811	1.1819		1.1811	1.1816	
32	**1.2598**	**1.2594**	1.2608	1.2618		1.2602	1.2611		1.2598	1.2613		1.2598	1.2608		1.2598	1.2604	
35	**1.3780**	**1.3776**	1.3790	1.4000		1.3784	1.3793		1.3780	1.3795		1.3780	1.3790		1.3780	1.3786	
37	**1.4567**	**1.4563**	1.4577	1.4587	24 L	1.4571	1.4580	17 L	1.4567	1.4582	19 L	1.4567	1.4577	14 L	1.4567	1.4573	10 L
40	**1.5748**	**1.5744**	1.5758	1.5768	10 L	1.5752	1.5761	4 L	1.5748	1.5763	0	1.5748	1.5758	0	1.5748	1.5754	0
42	**1.6535**	**1.6531**	1.6545	1.6555		1.6539	1.6548		1.6535	1.6550		1.6535	1.6545		1.6535	1.6541	
47	**1.8504**	**1.8500**	1.8514	1.8524		1.8508	1.8517		1.8504	1.8519		1.8504	1.8514		1.8504	1.8510	
52	**2.0472**	**2.0467**	2.0484	2.0496		2.0476	2.0488		2.0472	2.0490		2.0472	2.0484		2.0472	2.0479	
55	**2.1654**	**2.1649**	2.1666	2.1678		2.1658	2.1670		2.1654	2.1672		2.1654	2.1666		2.1654	2.1661	
62	**2.4409**	**2.4404**	2.4421	2.4433	29 L	2.4413	2.4425	21 L	2.4409	2.4427	23 L	2.4409	2.4421	17 L	2.4409	2.4416	12 L
68	**2.6772**	**2.6767**	2.6784	2.6796		2.6776	2.6788		2.6772	2.6790		2.6772	2.6784		2.6772	2.6779	
72	**2.8346**	**2.8341**	2.8358	2.8370	12 L	2.8350	2.8362	4 L	2.8346	2.8364	0	2.8346	2.8358	0	2.8346	2.8353	0
75	**2.9527**	**2.9522**	2.9539	2.9551		2.9532	2.9543		2.9527	2.9545		2.9527	2.9539		2.9527	2.9534	
80	**3.1496**	**3.1491**	3.1508	3.1520		3.1500	3.1512		3.1496	3.1514		3.1496	3.1508		3.1496	3.1503	
85	**3.3465**	**3.3459**	3.3479	3.3493		3.3470	3.3484		3.3465	3.3486		3.3465	3.3479		3.3465	3.3474	
90	**3.5433**	**3.5427**	3.5447	3.5461		3.5438	3.5452		3.5433	3.5454		3.5433	3.5447		3.5433	3.5442	
95	**3.7402**	**3.7396**	3.7416	3.7430		3.7407	3.7421		3.7402	3.7423		3.7402	3.7416		3.7402	3.7411	
100	**3.9370**	**3.9364**	3.9384	3.9398	34 L	3.9375	3.9389	25 L	3.9370	3.9391	27 L	3.9370	3.9384	20 L	3.9370	3.9379	15 L
110	**4.3307**	**4.3301**	4.3321	4.3335	14 L	4.3312	4.3326	5 L	4.3307	4.3328	0	4.3307	4.3321	0	4.3307	4.3316	0
115	**4.5276**	**4.5270**	4.5290	4.5304		4.5281	4.5295		4.5276	4.5297		4.5276	4.5290		4.5276	4.5285	
120	**4.7244**	**4.7238**	4.7258	4.7272		4.7249	4.7263		4.7244	4.7265		4.7244	4.7258		4.7244	4.7253	
125	**4.9213**	**4.9206**	4.9230	4.9246		4.9219	4.9234		4.9213	4.9238		4.9213	4.9229		4.9213	4.9223	
130	**5.1181**	**5.1174**	5.1198	5.1214		5.1187	5.1202		5.1181	5.1206		5.1181	5.1197		5.1181	5.1191	
140	**5.5118**	**5.5111**	5.5135	5.5151	40 L	5.5124	5.5139	28 L	5.5118	5.5143	32 L	5.5118	5.5134	23 L	5.5118	5.5128	17 L
145	**5.7087**	**5.7080**	5.7104	5.7120	17 L	5.7093	5.7108	6 L	5.7087	5.7112	0	5.7087	5.7103	0	5.7087	5.7097	0
150	**5.9055**	**5.9048**	5.9072	5.9088		5.9061	5.9076		5.9055	5.9080		5.9055	5.9071		5.9055	5.9065	
160	**6.2992**	**6.2982**	6.3009	6.3025		6.2998	6.3013		6.2992	6.3017		6.2992	6.3008		6.2992	6.3002	
165	**6.4961**	**6.4951**	6.4978	6.4994		6.4967	6.4982		6.4961	6.4986		6.4961	6.4977		6.4961	6.4971	
170	**6.6929**	**6.6919**	6.6946	6.6962	43 L	6.6935	6.6950	31 L	6.6929	6.6954	35 L	6.6929	6.6945	26 L	6.6929	6.6939	20 L
180	**7.0866**	**7.0856**	7.0883	7.0899	17 L	7.0872	7.0887	6 L	7.0866	7.0891	0	7.0866	7.0882	0	7.0866	7.0876	0
190	**7.4803**	**7.4791**	7.4823	7.4841		7.4809	7.4827		7.4803	7.4831		7.4803	7.4821		7.4803	7.4814	
200	**7.8740**	**7.8728**	7.8760	7.8778		7.8746	7.8764		7.8740	7.8768		7.8740	7.8758		7.8740	7.8751	
210	**8.2677**	**8.2665**	8.2697	8.2715		8.2683	8.2701		8.2677	8.2705		8.2677	8.2695		8.2677	8.2688	
215	**8.4646**	**8.4634**	8.4666	8.4684	50 L	8.4652	8.4670	36 L	8.4646	8.4674	40 L	8.4646	8.4664	30 L	8.4646	8.4657	23 L
220	**8.6614**	**8.6602**	8.6634	8.6652		8.6620	8.6638		8.6614	8.6642		8.6614	8.6632		8.6614	8.6625	
225	**8.8583**	**8.8571**	8.8603	8.8621	20 L	8.8589	8.8607	6 L	8.8583	8.8611	0	8.8583	8.8601	0	8.8583	8.8594	0
230	**9.0551**	**9.0539**	9.0571	9.0589		9.0557	9.0575		9.0551	9.0579		9.0551	9.0569		9.0551	9.0562	
240	**9.4488**	**9.4476**	9.4508	9.4526		9.4494	9.4512		9.4488	9.4516		9.4488	9.4506		9.4488	9.4499	
250	**9.8425**	**9.8413**	9.8445	9.8463		9.8431	9.8449		9.8425	9.8453		9.8425	9.8443		9.8425	9.8436	
260	**10.2362**	**10.2348**	10.2384	10.2405		10.2369	10.2389		10.2362	10.2394		10.2362	10.2382		10.2362	10.2375	
270	**10.6299**	**10.6285**	10.6321	10.6342		10.6306	10.6326		10.6299	10.6331		10.6299	10.6319		10.6299	10.6312	
280	**11.0236**	**11.0222**	11.0258	11.0279	57 L	11.0243	11.0263	41 L	11.0236	11.0268	46 L	11.0236	11.0256	34 L	11.0236	11.0249	27 L
290	**11.4173**	**11.4159**	11.4195	11.4216		11.4180	11.4200		11.4173	11.4205		11.4173	11.4193		11.4173	11.4186	
300	**11.8110**	**11.8096**	11.8132	11.8153	22 L	11.8117	11.8137	7 L	11.8110	11.8142	0	11.8110	11.8130	0	11.8110	11.8123	0
310	**12.2047**	**12.2033**	12.2069	12.2090		12.2054	12.2074		12.2047	12.2079		12.2047	12.2067		12.2047	12.2060	
320	**12.5984**	**12.5968**	12.6008	12.6031		12.5991	12.6014		12.5984	12.6019		12.5984	12.6006		12.5984	12.5998	
340	**13.3858**	**13.3842**	13.3882	13.3905		13.3865	13.3888		13.3858	13.3893		13.3858	13.3880		13.3858	13.3872	
360	**14.1732**	**14.1716**	14.1756	14.1779	63 L	14.1739	14.1762	46 L	14.1732	14.1767	51 L	14.1732	14.1754	38 L	14.1732	14.1746	30 L
370	**14.5670**	**14.5654**	14.5694	14.5717		14.5677	14.5700		14.5670	14.5705		14.5670	14.5692		14.5669	14.5684	
380	**14.9606**	**14.9590**	14.9630	14.9653	24 L	14.9613	14.9636	7 L	14.9606	14.9641	0	14.9606	14.9628	0	14.9606	14.9620	0
400	**15.7480**	**15.7464**	15.7504	15.7527		15.7487	15.7510		15.7480	15.7515		15.7480	15.7502		15.7480	15.7494	
420	**16.5354**	**16.5336**	16.5381	16.5406		16.5362	16.5387		16.5354	16.5392		16.5354	16.5379		16.5354	16.5370	
440	**17.3228**	**17.3210**	17.3255	17.3280	70 L	17.3236	17.3261	51 L	17.3228	17.3266	56 L	17.3228	17.3253	43 L	17.3228	17.3244	34 L
460	**18.1102**	**18.1084**	18.1129	18.1154	27 L	18.1110	18.1135	8 L	18.1102	18.1140	0	18.1102	18.1127	0	18.1102	18.1118	0
480	**18.8976**	**18.8958**	18.9003	18.9028		18.8984	18.9009		18.8976	18.9014		18.8976	18.9001		18.8976	18.8992	
500	**19.6850**	**19.6832**	19.6877	19.6902		19.6858	19.6883		19.6850	19.6888		19.6850	19.6875		19.6850	19.6866	

Housing Bearing-Seat Diameters (Values in Inches) (cont.)

Bearing Outside Diameter			F7			G7			H8			H7			H6		
mm	Inches		Housing Bore		Fit in	Housing Bore		Fit in	Housing Bore		Fit in	Housing Bore		Fit in	Housing Bore		Fit in
	Max.	Min.	Min.	Max.	0.0000"	Min.	Max.	0.0000"	Min.	Max.	0.0000"	Min.	Max.	0.0000"	Min.	Max.	0.0000"
520	**20.4724**	**20.4704**	20.4754	20.4781		20.4733	20.4760		20.4724	20.4767		20.4724	20.4752		20.4724	20.4741	
540	**21.2598**	**21.2578**	21.2628	21.2655		21.2607	21.2634		21.2598	21.2641		21.2598	21.2626		21.2598	21.2615	
560	**22.0472**	**22.0452**	22.0502	22.0529		22.0481	22.0508		22.0472	22.0515		22.0472	22.0500		22.0472	22.0489	
580	**22.8346**	**22.8326**	22.8376	22.8403	77 L	22.8355	22.8382	56 L	22.8346	22.8389	63 L	22.8346	22.8374	48 L	22.8346	22.8363	37 L
600	**23.6220**	**23.6200**	23.6250	23.6277	30 L	23.6229	23.6256	9 L	23.6220	23.6263	0	23.6220	23.6248	0	23.6220	23.6237	0
620	**24.4094**	**24.4074**	24.4124	24.4151		24.4103	24.4130		24.4094	24.4137		24.4094	24.4122		24.4094	24.4111	
	25.5906	**25.5876**	25.5937	25.5969		25.5915	25.5947		25.5906	25.5955		25.5906	25.5937		25.5906	25.5926	
670	**26.3780**	**26.3750**	26.3811	26.3843		26.3789	26.3821		26.3780	26.3829		26.3780	26.3811		26.3780	26.3800	
680	**26.7717**	**26.7687**	26.7748	26.7780		26.7726	26.7758		26.7717	26.7766		26.7717	26.7748		26.7717	26.7737	
700	**27.5591**	**27.5561**	27.5622	27.5654	93 L	27.5600	27.5632	71 L	27.5591	27.5640	79 L	27.5591	27.5622	61 L	27.5591	27.5611	50 L
720	**28.3465**	**28.3435**	28.3496	28.3528	31 L	28.3474	28.3506	9 L	28.3465	28.3514	0	28.3465	28.3496	0	28.3465	28.3485	0
750	**29.5276**	**29.5246**	29.5307	29.5339		29.5285	29.5317		29.5276	29.5325		29.5276	29.5307		29.5276	29.5296	
760	**29.9213**	**29.9183**	29.9244	29.9276		29.9222	29.9254		29.9213	29.9262		29.9213	29.9244		29.9213	29.9233	
780	**30.7087**	**30.7057**	30.7118	30.7150		30.7096	30.7128		30.7087	30.7136		30.7087	30.7118		30.7087	30.7107	
790	**31.1024**	**31.0994**	31.1055	31.1087		31.1033	31.1065		31.1024	31.1073		31.1024	31.1055		31.1024	31.1044	
800	**31.4961**	**31.4931**	31.4992	31.5024		31.4970	31.5002		31.4961	31.5010		31.4961	31.4992		31.4961	31.4981	
820	**32.2835**	**32.2796**	32.2869	32.2904		32.2845	32.2881		32.2835	32.3890		32.2835	32.2870		32.2835	32.2857	
830	**32.6772**	**32.6733**	32.6806	32.6841		32.6782	32.6818		32.6772	32.6827		32.6772	32.6807		32.6772	32.6794	
850	**33.4646**	**33.4607**	33.4680	33.4715		33.4656	33.4692		33.4646	33.4701		33.4646	33.4681		33.4646	33.4668	
870	**34.2520**	**34.2481**	34.2554	34.2589		34.2530	34.2566		34.2520	34.2575		34.2520	34.2555		34.2520	34.2542	
920	**36.2205**	**36.2166**	36.2239	36.2274	108 L	36.2215	36.2251	85 L	36.2205	36.2260	94 L	36.2205	36.2240	74 L	36.2205	36.2227	61 L
950	**37.4016**	**37.3977**	37.4050	37.4085	34 L	37.4026	37.4062	10 L	37.4016	37.4071	0	37.4016	37.4051	0	37.4016	37.4038	0
980	**38.5827**	**38.5788**	38.5861	38.5896		38.5837	38.5873		38.5827	38.5882		38.5827	38.5862		38.5827	38.5849	
1000	**39.3701**	**39.3662**	39.3735	39.3770		39.3711	39.3747		39.3701	39.3756		39.3701	39.3736		39.3701	39.3723	
1150	**45.2756**	**45.2707**	45.2795	45.2836	129 L	45.2767	45.2808	101 L	45.2756	45.2821	114 L	45.2756	45.2797	90 L	45.2756	45.2782	75 L
1250	**49.2126**	**49.2077**	49.2165	49.2206	39 L	49.2137	49.2178	11 L	49.2126	49.2191	0	49.2126	49.2167	0	49.2126	49.2152	0
1400	**55.1181**	**55.1118**	55.1224	55.1274	156 L	55.1193	55.1242	124 L	55.1181	55.1258	140 L	55.1181	55.1230	112 L	55.1181	55.1212	94 L
1600	**62.9921**	**62.9858**	62.9964	63.0014	43 L	62.9933	62.9982	12 L	62.9921	62.9998	0	62.9921	62.9970	0	62.9921	62.9952	0
1800	**70.8661**	**70.8582**	70.8708	70.8767	185 L	70.8674	70.8733	151 L	70.8661	70.8752	170 L	70.8661	70.8720	138 L	70.8661	70.8697	115 L
2000	**78.7402**	**78.7323**	78.7449	78.7508	47 L	78.7415	78.7474	13 L	78.7402	78.7493	0	78.7402	78.7461	0	78.7402	78.7438	0
2300	**90.5512**	**90.5414**	90.5563	90.5632	218 L	90.5525	90.5594	180 L	90.5512	90.5622	208 L	90.5512	90.5581	167 L	90.5512	90.5555	141 L
2500	**98.4252**	**98.4154**	98.4303	98.4372	51 L	98.4265	98.4334	13 L	98.4252	98.4362	0	98.4252	98.4321	0	98.4252	98.4295	0

Housing Bearing-Seat Diameters (Values in Inches) (cont.)

Bearing Outside Diameter			J6			J7			K6			K7			M6		
mm	Inches		Housing Bore		Fit in 0.0000"	Housing Bore		Fit in 0.0000"	Housing Bore		Fit in 0.0000"	Housing Bore		Fit in 0.0000"	Housing Bore		Fit in 0.0000"
	Max.	Min.	Min.	Max.		Min.	Max.		Min.	Max.		Min.	Max.		Min.	Max.	
16	0.6299	0.6296	0.6297	0.6301	5 L 2 T	0.6296	0.6303	7 L 3 T	0.6295	0.6300	4 L 4 T	0.6294	0.6301	5 L 5 T	0.6293	0.6297	1 L 6 T
19	0.7480	0.7476	0.7478	0.7483		0.7476	0.7485		0.7476	0.7481		0.7474	0.7482		0.7473	0.7478	
22	0.8661	0.8657	0.8659	0.8664		0.8657	0.8666		0.8657	0.8662		0.8655	0.8663		0.8654	0.8659	
24	0.9449	0.9445	0.9447	0.9452	7 L	0.9445	0.9454	9 L	0.9445	0.9450	5 L	0.9443	0.9451	6 L	0.9442	0.9447	2 L
26	1.0236	1.0232	1.0234	1.0239	2 T	1.0232	1.0241	4 T	1.0232	1.0237	4 T	1.0230	1.0238	6 T	1.0229	1.0234	7 T
28	1.1024	1.1020	1.1022	1.1027		1.1020	1.1029		1.1020	1.1025		1.1018	1.1026		1.1017	1.1022	
30	1.1811	1.1807	1.1809	1.1814		1.1807	1.1816		1.1807	1.1812		1.1805	1.1813		1.1804	1.1809	
32	1.2598	1.2594	1.2596	1.2602		1.2594	1.2604		1.2593	1.2599		1.2591	1.2601		1.2590	1.2596	
35	1.3780	1.3776	1.3778	1.3784		1.3776	1.3786		1.3775	1.3781		1.3773	1.3783		1.3772	1.3778	
37	1.4567	1.4563	1.4565	1.4571	8 L	1.4563	1.4573	10 L	1.4562	1.4568	5 L	1.4560	1.4570	7 L	1.4559	1.4565	2 L
40	1.5748	1.5744	1.5746	1.5752	2 T	1.5744	1.5754	4 T	1.5743	1.5749	5 T	1.5741	1.5751	7 T	1.5740	1.5746	8 T
42	1.6535	1.6531	1.6533	1.6539		1.6531	1.6541		1.6530	1.6536		1.6528	1.6538		1.6527	1.6533	
47	1.8504	1.8500	1.8502	1.8508		1.8500	1.8510		1.8499	1.8505		1.8497	1.8507		1.8496	1.8502	
52	2.0472	2.0467	2.0470	2.0477		2.0467	2.0479		2.0466	2.0474		2.0464	2.0476		2.0463	2.047	
55	2.1654	2.1649	2.1652	2.1659		2.1649	2.1661		2.1648	2.1656		2.1646	2.1658		2.1645	2.1652	
62	2.4409	2.4404	2.4407	2.4414	10 L	2.4404	2.4416	12 L	2.4403	2.4411	7 L	2.4401	2.4413	9 L	2.4400	2.4407	3 L
68	2.6772	2.6767	2.6770	2.6777		2.6767	2.6779		2.6766	2.6774		2.6764	2.6776		2.6763	2.6770	
72	2.8346	2.8341	2.8344	2.8351	2 T	2.8341	2.8353	5 T	2.8340	2.8348	6 T	2.8338	2.8350	8 T	2.8337	2.8344	9 T
75	2.9527	2.9522	2.9525	2.9532		2.9522	2.9534		2.9521	2.9529		2.9519	2.9531		2.9518	2.9525	
80	3.1496	3.1491	3.1494	3.1501		3.1491	3.1503		3.1490	3.1498		3.1488	3.1500		3.1487	3.1494	
85	3.3465	3.3459	3.3463	3.3471		3.3460	3.3474		3.3458	3.3467		3.3455	3.3469		3.3454	3.3463	
90	3.5433	3.5427	3.5431	3.5439		3.5428	3.5442		3.5426	3.5435		3.5423	3.5437		3.5422	3.5431	
95	3.7402	3.7396	3.7400	3.7408		3.7397	3.7411		3.7395	3.7404		3.7392	3.7406		3.7391	3.7400	
100	3.9370	3.9364	3.9368	3.9376	12 L	3.9365	3.9379	15 L	3.9363	3.9372	8 L	3.9360	3.9374	10 L	3.9359	3.9368	4 L
110	4.3307	4.3301	4.3305	4.3313	2 T	4.3302	4.3316	5 T	4.3300	4.3309	7 T	4.3297	4.3311	10 T	4.3296	4.3305	11 T
115	4.5276	4.5270	4.5274	4.5282		4.5271	4.5285		4.5269	4.5278		4.5266	4.5280		4.5265	4.5274	
120	4.7244	4.7238	4.7242	4.7250		4.7239	4.7253		4.7237	4.7246		4.7234	4.7248		4.7233	4.7242	
125	4.9213	4.9206	4.9210	4.9220		4.9207	4.9223		4.9205	4.9215		4.9202	4.9218		4.9200	4.9210	
130	5.1181	5.1174	5.1178	5.1188		5.1175	5.1191		5.1173	5.1183		5.1170	5.1186		5.1168	5.1178	
140	5.5118	5.5111	5.5115	5.5125	14 L	5.5112	5.5128	17 L	5.5110	5.5120	9 L	5.5107	5.5123	12 L	5.5105	5.5115	4 L
145	5.7087	5.7080	5.7084	5.7094	3 T	5.7081	5.7097	6 T	5.7079	5.7089	8 T	5.7076	5.7092	11 T	5.7074	5.7084	13 T
150	5.9055	5.9048	5.9052	5.9062		5.9049	5.9065		5.9047	5.9057		5.9044	5.9060		5.9042	5.9052	
160	6.2992	6.2982	6.2989	6.2999		6.2986	6.3002		6.2984	6.2994		6.2981	6.2997		6.2979	6.2989	
165	6.4961	6.4951	6.4958	6.4968		6.4955	6.4971		6.4953	6.4963		6.4950	6.4966		6.4948	6.4958	
170	6.6929	6.6919	6.6926	6.6936	17 L	6.6923	6.6939	20 L	6.6921	6.6931	12 L	6.6918	6.6934	15 L	6.6916	6.6926	7 L
180	7.0866	7.0856	7.0863	7.0873	3 T	7.0860	7.0876	6 T	7.0858	7.0868	8 T	7.0855	7.0871	11 T	7.0853	7.0863	13 T
190	7.4803	7.4791	7.4800	7.4812		7.4797	7.4815		7.4794	7.4805		7.4790	7.4808		7.4788	7.4800	
200	7.8740	7.8728	7.8737	7.8749		7.8734	7.8752		7.8731	7.8742		7.8727	7.8745		7.8725	7.8737	
210	8.2677	8.2665	8.2674	8.2686		8.2671	8.2689		8.2668	8.2679		8.2664	8.2682		8.2662	8.2674	
215	8.4646	8.4634	8.4643	8.4655	21 L	8.4640	8.4658	24 L	8.4637	8.4648	14 L	8.4633	8.4651	17 L	8.4631	8.4643	9 L
220	8.6614	8.6602	8.6611	8.6623		8.6608	8.6626		8.6605	8.6616		8.6601	8.6619		8.6599	8.6611	
225	8.8583	8.8571	8.8580	8.8592	3 T	8.8577	8.8595	6 T	8.8574	8.8585	9 T	8.8570	8.8588	13 T	8.8568	8.8580	15 T
230	9.0551	9.0539	9.0548	9.0560		9.0545	9.0563		9.0542	9.0553		9.0538	9.0556		9.0536	9.0548	
240	9.4488	9.4476	9.4485	9.4497		9.4482	9.4500		9.4479	9.4490		9.4475	9.4493		9.4473	9.4485	
250	9.8425	9.8413	9.8422	9.8434		9.8419	9.8437		9.8416	9.8427		9.8412	9.8430		9.8410	9.8422	
260	10.2360	10.2350	10.2360	10.2370		10.2360	10.2380		10.2350	10.2360		10.2350	10.2370		10.2350	10.2360	
270	10.6299	10.6285	10.6296	10.6309		10.6293	10.6313		10.6288	10.6301		10.6285	10.6305		10.6283	10.6295	
280	11.0240	11.0220	11.0230	11.0250	24 L	11.0230	11.0250	28 L	11.0230	11.0240	16 L	11.0220	11.0240	20 L	11.0220	11.0230	10 L
290	11.4173	11.4159	11.4170	11.4183		11.4167	11.4187		11.4162	11.4175		11.4159	11.4179		11.4157	11.4169	
300	11.8110	11.8100	11.8110	11.8120	3 T	11.8100	11.8120	6 T	11.8100	11.8110	11 T	11.8100	11.8120	14 T	11.8090	11.8110	16 T
310	12.2050	12.2030	12.2040	12.2060		12.2040	12.2060		12.2040	12.2050		12.2030	12.2050		12.2030	12.2040	
320	12.5980	12.5970	12.5980	12.6000		12.5980	12.6000		12.5970	12.5990		12.5970	12.5990		12.5970	12.5980	
340	13.3860	13.3840	13.3860	13.3870		13.3850	13.3870		13.3850	13.3860		13.3840	13.3870		13.3840	13.3850	
360	14.1730	14.1720	14.1730	14.1740	27 L	14.1730	14.1750	31 L	14.1720	14.1740	19 L	14.1720	14.1740	23 L	14.1710	14.1730	12 L
370	14.5670	14.5654	14.5667	14.5681		14.5663	14.5685		25.5659	14.5673		14.5654	14.5677		14.5652	14.5666	
380	14.9610	14.9590	14.9600	14.9620	3 T	14.9600	14.9620	7 T	14.9600	14.9610	11 T	14.9590	14.9610	16 T	14.9590	14.9600	18 T
400	15.7480	15.7460	15.7480	15.7490		15.7470	15.7500		15.7470	15.7480		15.7460	15.7490		15.7460	15.7480	
420	16.5350	16.5340	16.5350	16.5370		16.5350	16.5370		16.5340	16.5360		16.5340	16.5360		16.5330	16.5350	
440	17.3230	17.3210	17.3230	17.3240	31 L	17.3220	17.3250	35 L	17.3220	17.3230	21 L	17.3210	17.3240	25 L	17.3210	17.3220	14 L
460	18.1100	18.1080	18.1100	18.1120	3 T	18.1090	18.1120	8 T	18.1090	18.1110	13 T	18.1080	18.1110	18 T	18.1080	18.1100	20 T
480	18.8980	18.8960	18.8970	18.8990		18.8970	18.8990		18.8960	18.8980		18.8960	18.8980		18.8960	18.8970	
500	19.6850	19.6830	19.6850	19.6860		19.6840	19.6870		19.6840	19.6850		19.6830	19.6860		19.6830	19.6850	

Housing Bearing-Seat Diameters (Values in Inches) (cont.)

Bearing Outside Diameter			J6			J7			K6			K7			M6		
mm	Inches		Housing Bore		Fit in 0.0000"	Housing Bore		Fit in 0.0000"	Housing Bore		Fit in 0.0000"	Housing Bore		Fit in 0.0000"	Housing Bore		Fit in 0.0000"
	Max.	Min.	Min.	Max.		Min.	Max.		Min.	Max.		Min.	Max.		Min.	Max.	
520	**20.4720**	**20.4700**	20.4720	20.4740		20.4720	20.4740		20.4710	20.4720		20.4700	20.4720		20.4700	20.4710	
540	**21.2600**	**21.2580**	21.2600	21.2610		21.2590	21.2620		21.2580	21.2600		21.2570	21.2600		21.2570	21.2590	
560	**22.0472**	**22.0452**	22.0442	22.0487		22.0463	22.0491		22.0455	22.0472		22.0444	22.0472		22.0444	22.0462	
580	**22.8350**	**22.8330**	23.8340	22.8360	35 L	22.8340	22.8370	39 L	22.8330	22.8350	20 L	22.8320	22.8350	20 L	22.8320	22.8340	10 L
600	**23.6220**	**23.6200**	23.6220	23.6240	3 T	23.6210	23.6240	9 T	23.6200	23.6220	17 T	23.6190	23.6220	28 T	23.6190	23.6210	28 T
620	**24.4090**	**24.4070**	24.4090	24.4110		24.4090	24.4110		24.4080	24.4090		24.4070	24.4090		24.4070	24.4080	
650	**25.5910**	**25.5880**	25.5900	25.5920		25.5900	25.5930		25.5890	25.5910		25.5880	25.5910		25.5880	25.5890	
670	**26.3780**	**26.3750**	26.3780	26.3800		26.3770	26.3800		26.3760	26.3780		26.3750	26.3780		26.3750	26.3770	
680	**26.7720**	**26.7690**	26.7710	26.7730		26.7710	26.7740		26.7700	26.7720		26.7690	26.7720		26.7690	26.7710	
700	**27.5590**	**27.5560**	27.5590	27.5610	46 L	27.5580	27.5610	52 L	27.5570	27.5590	30 L	27.5560	27.5590	30 L	27.5560	27.5580	18 L
720	**28.3470**	**28.3440**	28.3460	28.3480	4 T	28.3460	28.3490	9 T	28.3450	28.3470	20 T	28.3430	28.3470	31 T	28.3430	28.3450	31 T
750	**29.5280**	**29.5250**	29.5270	29.5290		29.5270	29.5300		29.5260	29.5280		29.5250	29.5280		29.5250	29.5260	
760	**29.9213**	**29.9183**	29.9209	29.9229		29.9204	29.9235		29.9193	29.9213		29.9182	29.9213		29.9182	29.9201	
780	**30.7090**	**30.7060**	30.7080	30.7100		30.7080	30.7110		30.7070	30.7090		30.7060	30.7090		30.7060	30.7080	
790	**31.1020**	**31.0990**	31.1020	31.1040		31.1020	31.1050		31.1000	31.1020		31.0990	31.1020		31.0990	31.1010	
800	**31.4961**	**31.4931**	31.4957	31.4977		31.4952	31.4962		31.4941	31.4961		31.4930	31.4961		31.4930	31.4949	
820	**32.2840**	**32.2800**	32.2830	32.2850		32.2830	32.2860		32.2810	32.2840		32.2800	32.2840		32.2800	32.2820	
830	**32.6772**	**32.6733**	32.6768	32.6790		32.6762	32.6797		32.6750	32.6772		32.6737	32.6772		32.6737	32.6759	
850	**33.4650**	**33.4610**	33.4640	33.4660		33.4640	33.4670		33.4620	33.4650		33.4610	33.4650		33.4610	33.4630	
870	**34.2520**	**34.2480**	34.2520	34.2540		34.2510	34.2550		34.2500	34.2520		34.2490	34.2520		34.2490	34.2510	
920	**36.2210**	**36.2170**	36.2200	36.2220	57 L	36.2200	36.2230	64 L	36.2180	36.2210	39 L	36.2170	36.2210	39 L	36.2170	36.2190	26 L
950	**37.4020**	**37.3980**	37.4010	37.4030	4 T	37.4010	37.4040	10 T	37.3990	37.4020	22 T	37.3980	37.4020	35 T	37.3980	37.4000	35 T
980	**38.5830**	**38.5790**	38.5820	38.5850		38.5820	38.5850		38.5810	38.5830		38.5790	38.5830		38.5790	38.5810	
1000*																	
1150*																	
1250*																	
1400*																	
1600*																	
1800*																	
2000*																	
2300*																	
2500*																	

*** Contact SKF Engineering for >1000 size range fit recommendations.**

Housing Bearing-Seat Diameters (Values in Inches) (cont.)

Bearing Outside Diameter			M7			N6			N7			P6			P7		
mm	Inches		Housing Bore		Fit in 0.0000"	Housing Bore		Fit in 0.0000"	Housing Bore		Fit in 0.0000"	Housing Bore		Fit in 0.0000"	Housing Bore		Fit in 0.0000"
	Max.	Min.	Min.	Max.		Min.	Max.		Min.	Max.		Min.	Max.		Min.	Max.	
16	**0.6299**	**0.6296**	0.6292	0.6299	3 L 7 T	0.6291	0.6295	1 T 8 T	0.6290	0.6297	1 L 9 T	0.6289	0.6293	3 T 10 T	0.6288	0.6295	1 T 11 T
19	**0.7480**	**0.7476**	0.7472	0.7480		0.7471	0.7476		0.7469	0.7477		0.7468	0.7473		0.7466	0.7474	
22	**0.8661**	**0.8657**	0.8653	0.8661		0.8652	0.8657		0.8650	0.8658		0.8649	0.8654		0.8647	0.8655	
24	**0.9449**	**0.9445**	0.9441	0.9449	4 L	0.9440	0.9445	0	0.9438	0.9446	1 L	0.9437	0.9442	3 T	0.9435	0.9443	2 T
26	**1.0236**	**1.0232**	1.0228	1.0236	8 T	1.0227	1.0232	9 T	1.0225	1.0233	11 T	1.0224	1.0229	12 T	1.0222	1.0230	14 T
28	**1.1024**	**1.1020**	1.1016	1.1024		1.1015	1.1020		1.1013	1.1021		1.1012	1.1017		1.1010	1.1018	
30	**1.1811**	**1.1807**	1.1803	1.1811		1.1802	1.1807		1.1800	1.1808		1.1799	1.1804		1.1797	1.1805	
32	**1.2598**	**1.2594**	1.2588	1.2598		1.2587	1.2593		1.2585	1.2595		1.2583	1.2590		1.2581	1.2591	
35	**1.3780**	**1.3776**	1.3770	1.3780	4 L	1.3769	1.3775		1.3767	1.3777		1.3765	1.3772		1.3763	1.3773	
37	**1.4567**	**1.4563**	1.4557	1.4567	10 T	1.4556	1.4562	1 T	1.4554	1.4564	1 L	1.4552	1.4559	4 T	1.4550	1.4560	3 T
40	**1.5748**	**1.5744**	1.5738	1.5748		1.5737	1.5743	11 T	1.5735	1.5745	13 T	1.5733	1.5740	15 T	1.5731	1.5741	17 T
42	**1.6535**	**1.6531**	1.6525	1.6535		1.6524	1.6530		1.6522	1.6532		1.6520	1.6527		1.6518	1.6528	
47	**1.8504**	**1.8500**	1.8494	1.8504		1.8493	1.8499		1.8491	1.8501		1.8489	1.8496		1.8487	1.8497	
52	**2.0472**	**2.0467**	2.0460	2.0472		2.0459	2.0466		2.0457	2.0468		2.0454	2.0462		2.0452	2.0464	
55	**2.1654**	**2.1649**	2.1642	2.1654	5 L	2.1641	2.1648		2.1639	2.1650		2.1636	2.1644		2.1634	2.1646	
62	**2.4409**	**2.4404**	2.4397	2.4409	12 T	2.4396	2.4403	1 T	2.4394	2.4405	1 L	2.4391	2.4399	5 T	2.4389	2.4401	3 T
68	**2.8346**	**2.8341**	2.6760	2.6772		2.6759	2.6766		2.6760	2.6770		2.6750	2.6760		2.6752	2.6763	
72	**2.8346**	**2.8341**	2.8334	2.8346		2.8333	2.8340	13 T	2.8331	2.8342	15 T	2.8328	2.8336	18 T	2.8326	2.8338	20 T
75	**3.1495**	**3.1491**	2.9516	2.9528		2.9515	2.9522		2.9510	2.9520		2.9510	2.9520		2.9507	2.9519	
80	**3.1496**	**3.1491**	3.1484	3.1496		3.1483	3.1490		3.1481	3.1492		3.1478	3.1486		3.1476	3.1488	
85	**3.3465**	**3.3459**	3.3451	3.3465		3.3450	3.3459		3.3447	3.3461		3.3445	3.3453		3.3442	3.3456	
90	**3.5433**	**3.5427**	3.5419	3.5433		3.5418	3.5427		3.5415	3.5429		3.5413	3.5421		3.5410	3.5424	
95	**3.9370**	**3.9364**	3.7388	3.7402		3.7387	3.7395		3.7380	3.7400		3.7380	3.7390		3.7378	3.7392	
100	**3.9370**	**3.9364**	3.9356	3.9370	6 L	3.9355	3.9364	0	3.9352	3.9366	2 L	3.9350	3.9358	6 T	3.9347	3.9361	3 T
110	**4.3307**	**4.3301**	4.3293	4.3307	14 T	4.3292	4.3301	15 T	4.3289	4.3303	18 T	4.3287	4.3295	20 T	4.3284	4.3298	23 T
115	**4.5276**	**4.5270**	4.5262	4.5276		4.5261	4.5270		4.5258	4.5272		4.5256	4.5264		4.5253	4.5267	
120	**4.7244**	**4.7238**	4.7230	4.7244		4.7229	4.7238		4.7226	4.7240		4.7224	4.7232		4.7221	4.7235	
125	**4.9213**	**4.9206**	4.9197	4.9213		4.9195	4.9205		4.9193	4.9208		4.9189	4.9199		4.9186	4.9202	
130	**5.1181**	**5.1174**	5.1165	5.1181	7 L	5.1163	5.1173		5.1161	5.1176		5.1157	5.1167		5.1154	5.1170	
140	**5.5118**	**5.5111**	5.5102	5.5118	16 T	5.5100	5.5110	1 T	5.5098	5.5113	2 L	5.5094	5.5104	7 T	5.5091	5.5107	4 T
145	**5.7087**	**5.7080**	5.7071	5.7087		5.7069	5.7079	18 T	5.7067	5.7082	20 T	5.7063	5.7073	24 T	5.7060	5.7076	27 T
150	**5.9055**	**5.9048**	5.9039	5.9055		5.9037	5.9047		5.9035	5.9050		5.9031	5.9041		5.9028	5.9044	
160	**6.2992**	**6.2982**	6.2976	6.2992	10 L	6.2974	6.2984		6.2972	6.2987		6.2968	6.2978		6.2965	6.2981	
165	**6.6929**	**6.6919**	6.4945	6.4961		6.4943	6.4953		6.4940	6.4960		6.4940	6.4950		6.4934	6.4950	
170	**6.6929**	**6.6919**	6.6913	6.6929	16 T	6.6911	6.6921	2 L	6.6909	6.6924	5 L	6.6905	6.6915	4 T	6.6902	6.6918	1 T
180	**7.0866**	**7.0856**	7.0850	7.0866		7.0848	7.0858	18 T	7.0846	7.0861	20 T	7.0842	7.0852	24 T	7.0839	7.0855	27 T
190	**7.4803**	**7.4791**	7.4785	7.4803		7.4783	7.4794		7.4779	7.4797		7.4775	7.4787		7.4772	7.4790	
200	**7.8740**	**7.8728**	7.8722	7.8740		7.8720	7.8731		7.8716	7.8734		7.8712	7.8724		7.8709	7.8727	
210	**8.2677**	**8.2665**	8.2659	8.2677		8.2657	8.2668		8.2653	8.2671		8.2649	8.2661		8.2646	8.2664	
215	**8.4646**	**8.4634**	8.4628	8.4646	12 L	8.4626	8.4637	3 L	8.4622	8.4640	6 L	8.4618	8.4630	4 T	8.4615	8.4633	1 T
220	**8.8583**	**8.8571**	8.6596	8.6614		8.6594	8.6606		8.6590	8.6610		8.6590	8.6600		8.6583	8.6601	
225	**8.8583**	**9.0539**	9.0571	8.8583	18 T	8.8563	8.8574	20 T	8.8559	8.8577	24 T	8.8555	8.8567	28 T	8.8552	8.8570	31 T
230	**9.4488**	**9.4476**	9.0533	9.0551		9.0531	9.0543		9.0530	9.0550		9.0520	9.0540		9.0520	9.0538	
240	**9.4488**	**9.4476**	9.4470	9.4488		9.4468	9.4479		9.4464	9.4482		9.4460	9.4472		9.4457	9.4475	
250	**9.8425**	**9.8413**	9.8407	9.8425		9.8405	9.8416		9.8401	9.8419		9.8397	9.8409		9.8394	9.8412	
260	**10.2362**	**10.2348**	10.2342	10.2362		10.2340	10.2352		10.2336	10.2356		10.2331	10.2343		10.2327	10.2348	
270	**11.0236**	**11.0222**	10.6279	10.6299		10.6277	10.6289		10.6270	10.6290		10.6270	10.6280		10.6265	10.6285	
280	**11.0236**	**11.0222**	11.0216	11.0236	14 L	11.0214	11.0226	4 L	11.0210	11.0230	8 L	11.0205	11.0217	5 T	11.0201	11.0222	0
290	**11.8110**	**11.8096**	11.4153	11.4173		11.4151	11.4163		11.4150	11.4170		11.4140	11.4150		11.4139	11.4159	
300	**11.8110**	**11.8096**	11.8090	11.8110	20 T	11.8088	11.8100	22 T	11.8084	11.8104	26 T	11.8079	11.8091	31 T	11.8075	11.8096	35 T
310	**12.2047**	**12.2033**	12.2027	12.2047		12.2025	12.2037		12.2021	12.2041		12.2016	12.2028		12.2012	12.2033	
320	**12.5984**	**12.5968**	12.5962	12.5984		12.5960	12.5974		12.5955	12.5978		12.5950	12.5964		12.5945	12.5968	
340	**13.3858**	**13.3842**	12.3836	12.3858	16 L	13.3834	13.3848		13.3829	13.3852		13.3824	13.3838		13.3819	13.3842	
360	**14.1732**	**14.1716**	14.1710	14.1732	22 T	14.1708	14.1722	6 L	14.1703	14.1726	10 L	14.1698	14.1712	4 T	14.1693	14.1716	0
370	**14.9607**	**14.9591**	14.5647	14.5669		14.5645	14.5659		14.5640	14.5660		14.5640	14.5650		14.5631	14.5653	
380	**14.9606**	**14.9590**	14.9584	14.9606		14.9582	14.9596	24 T	14.9577	14.9600	29 T	14.9572	14.9586	34 T	14.9567	14.9590	39 T
400	**15.7480**	**15.7464**	15.7458	15.7480		15.7456	15.7470		15.7451	15.7474		15.7446	15.7460		15.7441	15.7464	
420	**16.5354**	**16.5336**	16.5329	16.5354		16.5328	16.5343		16.5323	16.5347		16.5317	16.5332		16.5311	16.5336	
440	**17.3228**	**17.3210**	17.3203	17.3228	18 L	17.3202	17.3217	7 L	17.3197	17.3221	11 L	17.3191	17.3206	4 T	17.3185	17.3210	0
460	**18.1102**	**18.1084**	18.1077	18.1102	25 T	18.1076	18.1091	26 T	18.1071	18.1095	31 T	18.1065	18.1080	37 T	18.1059	18.1084	43 T
480	**18.8976**	**18.8958**	18.8951	18.8976		18.8950	18.8965		18.8945	18.8969		18.8939	18.8954		18.8933	18.8958	
500	**19.6850**	**19.6832**	19.6825	19.6850		19.6824	19.6839		19.6819	19.6843		19.6813	19.6828		19.6807	19.6832	

Housing Bearing-Seat Diameters (Values in Inches) (cont.)

Bearing Outside Diameter			M7			N6			N7			P6			P7		
mm	Inches		Housing Bore		Fit in 0.0000"	Housing Bore		Fit in 0.0000"	Housing Bore		Fit in 0.0000"	Housing Bore		Fit in 0.0000"	Housing Bore		Fit in 0.0000"
	Max.	Min.	Min.	Max.		Min.	Max.		Min.	Max.		Min.	Max.		Min.	Max.	
520	**20.4724**	**20.4704**	20.4686	20.4714		20.4689	20.4707		20.4679	20.4707		20.4676	20.4693		20.4666	20.4693	
540	**21.2598**	**21.2578**	21.2560	21.2588		21.2563	21.2581		21.2553	21.2581		21.2550	21.2567		21.2540	21.2567	
560	**22.0472**	**22.0452**	22.0435	22.0462		22.0438	22.0455		22.0430	22.0460		22.0420	22.0440		22.0414	22.0442	
580	**22.8346**	**22.8326**	22.8308	22.8336	10 L	22.8311	22.8329	3 L	22.8301	22.8329	3 L	22.8298	22.8315	11 T	22.8288	22.8315	11 T
600	**23.6220**	**23.6200**	23.6182	23.6210	38 T	23.6185	23.6203	35 T	23.6175	23.6203	45 T	23.6172	23.6189	48 T	23.6162	23.6189	58 T
620	**24.4094**	**24.4074**	24.4056	24.4084		24.4059	24.4077		24.4049	24.4077		24.4046	24.4063		24.4036	24.4063	
650	**25.5906**	**25.5876**	25.5863	25.5894		25.5867	25.5886		25.5855	25.5886		25.5852	25.5871		25.5840	25.5871	
670	**26.3780**	**26.3750**	26.3737	26.3768		26.3741	26.3760		26.3729	26.3760		26.3726	26.3745		26.3714	26.3745	
680	**26.7717**	**26.7687**	26.7674	26.7705		26.7678	26.7697		26.7666	26.7697		26.7663	26.7682		26.7651	26.7682	
700	**27.5591**	**27.5561**	27.5548	27.5579	18 L	27.5552	27.5571	10 L	27.5540	27.5571	10 L	27.5537	27.5556	5 T	27.5525	27.5556	5 T
720	**28.3465**	**28.3435**	28.3422	28.3453	43 T	28.3426	28.3445	39 T	28.3414	28.3445	51 T	28.3411	28.3430	54 T	28.3399	28.3430	66 T
750	**29.5276**	**29.5246**	29.5233	29.5264		29.5237	29.5256		29.5225	29.5256		29.5222	29.5241		29.5210	29.5241	
760	**29.9213**	**29.9183**	29.9169	29.9201		29.9173	29.9193		29.9160	29.9190		29.9160	29.9180		29.9146	29.9178	
780	**30.7087**	**30.7057**	30.7044	30.7075		30.7048	30.7067		30.7036	30.7077		30.7033	30.7052		30.7021	30.7052	
790	**31.1024**	**31.0994**	31.0981	31.1012		31.0985	31.1004		31.0973	31.1004		31.0970	31.0989		31.0958	31.0989	
800	**31.4961**	**31.4931**	31.4917	31.4949		31.4921	31.4941		31.4910	31.4940		31.4910	31.4930		31.4894	31.4926	
820	**32.2835**	**32.2796**	32.2786	32.2822		32.2791	32.2813		31.2778	32.2813		32.2774	32.2796		32.2760	32.2796	
830	**32.6772**	**32.6733**	32.6723	32.6758		32.6728	32.6750		32.6710	32.6750		32.6710	32.6730		32.6697	32.6732	
850	**33.4646**	**33.4607**	33.4597	33.4633	26 L	33.4602	33.4624		33.4589	33.4624		33.4585	33.4607		33.4571	33.4607	
870	**34.2520**	**34.2481**	34.2471	34.2507	49 T	34.2476	34.2498	17 L	34.2463	34.2498	17 L	34.2459	34.2481	0	34.2445	34.2481	0
920	**36.2205**	**36.2166**	36.2156	36.2192		36.2161	36.2183	44 T	36.2148	36.2183	57 T	36.2144	36.2166	61 T	36.2130	36.2166	75 T
950	**37.4016**	**37.3977**	37.3967	37.4003		37.3972	37.3994		37.3959	37.3994		37.3955	37.3977		37.3941	37.3977	
980	**38.5827**	**38.5788**	38.5778	38.5814		38.5783	38.5805		38.5770	38.5805		38.5766	38.5788		38.5752	38.5788	
1000	**39.3701**	**39.3662**	39.3652	39.3688		39.3657	39.3679		39.3644	39.3679		39.3640	39.3662		39.3626	39.3662	
1150	**45.2756**	**45.2707**	45.2699	45.2740	33 L	45.2704	45.2730	23 L	45.2689	45.2730	23 L	45.2683	45.2709	2 L	45.2667	45.2709	2 L
1250	**49.2126**	**49.2077**	49.2069	49.2110	57 T	49.2074	49.2100	52 T	49.2059	49.2100	67 T	49.2053	49.2079	73 T	40.2037	49.2079	89 T
1400	**55.1181**	**55.1118**	55.1113	55.1162	44 L	55.1120	55.1150	32 L	55.1101	55.1150	32 L	55.1095	55.1126	8 L	55.1077	55.1126	8 L
1600	**62.9921**	**62.9858**	62.9853	62.9902	68 T	62.9860	62.9890	61 T	62.9841	62.9890	80 T	62.9835	62.9866	86 T	62.9817	62.9866	104 T
1800	**70.8661**	**70.8582**	70.8579	70.8638	56 L	70.8589	70.8625	43 L	70.8566	70.8625	43 L	70.8558	70.8594	12 L	70.8535	70.8594	12 L
2000	**78.7402**	**78.7323**	78.7320	78.7379	82 T	78.7330	78.7366	72 T	78.7307	78.7366	95 T	78.7299	78.7335	103 T	78.7276	78.7335	126 T
2300	**90.5512**	**90.5414**	90.5416	90.5485	71 L	90.5425	90.5469	55 L	90.5400	90.5469	55 L	90.5392	90.5435	21 L	90.5366	90.5435	21 L
2500	**98.4252**	**98.4154**	98.4156	98.4225	96 T	98.4165	98.4209	87 T	98.4140	98.4209	112 T	98.4132	98.4175	120 T	98.4106	98.4175	146 T

Housing Bearing-Seat Diameters (Values in mm)

Bearing Outside Diameter			F7			G7			H8			H7			H6		
mm	mm		Housing Bore		Fit in µm	Housing Bore		Fit in µm	Housing Bore		Fit in µm	Housing Bore		Fit in µm	Housing Bore		Fit in µm
	Max.	Min.	Min.	Max.	(0.001 mm)	Min.	Max.	(0.001 mm)	Min.	Max.	(0.001 mm)	Min.	Max.	(0.001 mm)	Min.	Max.	(0.001 mm)
16	**16.000**	**15.992**	16.016	16.034	42 L 16 L	16.006	16.020	28 L 6 L	16.000	16.027	35 L 0	16.000	16.018	26 L 0	16.000	16.011	19 L 0
19	**19.000**	**18.991**	19.020	19.041		19.007	19.028		19.000	19.033		19.000	19.021		19.000	19.013	
22	**22.000**	**21.991**	22.020	22.041		22.007	22.028		22.000	22.033		22.000	22.021		22.000	22.013	
24	**24.000**	**23.991**	24.020	24.041	50 L	24.007	24.028	37 L	24.000	24.033	42 L	24.000	24.021	30 L	24.000	24.013	22 L
26	**26.000**	**25.991**	26.020	26.041	20 L	26.007	26.028	7 L	26.000	26.033	0	26.000	26.021	0	26.000	26.013	0
28	**28.000**	**27.991**	28.020	28.041		28.007	28.028		28.000	28.033		28.000	28.021		28.000	28.013	
30	**30.000**	**29.991**	30.020	30.041		30.007	30.028		30.000	30.033		30.000	30.021		30.000	30.013	
32	**32.000**	**31.989**	32.025	32.050		32.009	32.034		32.000	32.039		32.000	32.025		32.000	32.016	
35	**35.000**	**34.989**	35.025	35.050		35.009	35.034		35.000	35.039		35.000	35.025		35.000	35.016	
37	**37.000**	**36.989**	37.025	37.050	61 L	37.009	37.034	45 L	37.000	37.039	50 L	37.000	37.025	36 L	37.000	37.016	27 L
40	**40.000**	**39.989**	40.025	40.050	25 L	40.009	40.034	9 L	40.000	40.039	0	40.000	40.025	0	40.000	40.016	0
42	**42.000**	**41.989**	42.025	42.050		42.009	42.034		42.000	42.039		42.000	42.025		42.000	42.016	
47	**47.000**	**46.989**	47.025	47.050		47.009	47.034		47.000	47.039		47.000	47.025		47.000	47.016	
52	**52.000**	**51.987**	52.030	52.060		52.010	52.040		52.000	52.046		52.000	52.030		52.000	52.019	
55	**55.000**	**54.987**	55.030	55.060		55.010	55.040		55.000	55.046		55.000	55.030		55.000	55.019	
62	**62.000**	**61.987**	62.030	62.060	73 L	62.010	62.040	53 L	62.000	62.046	59 L	62.000	62.030	43 L	62.000	62.019	32 L
68	**68.000**	**67.987**	68.030	68.060		68.010	68.040		68.000	68.046		68.000	68.030		68.000	68.019	
72	**72.000**	**71.987**	72.030	72.060	30 L	72.010	72.040	10 L	72.000	72.046	0	72.000	72.030	0	72.000	72.019	0
75	**75.000**	**74.987**	75.030	75.060		75.010	75.040		75.000	75.046		75.000	75.030		75.000	75.019	
80	**80.000**	**79.987**	80.030	80.060		80.010	80.040		80.000	80.046		80.000	80.030		80.000	80.019	
85	**85.000**	**84.985**	85.036	85.071		85.012	85.047		85.000	85.054		85.000	85.035		85.000	85.022	
90	**90.000**	**89.985**	90.036	90.071		90.012	90.047		90.000	90.054		90.000	90.035		90.000	90.022	
95	**95.000**	**94.985**	95.036	95.071		95.012	95.047		95.000	95.054		95.000	95.035		95.000	95.022	
100	**100.000**	**99.985**	100.036	100.071	86 L	100.012	100.047	62 L	100.000	100.054	69 L	100.000	100.035	50 L	100.000	100.022	37 L
110	**110.000**	**109.985**	110.036	110.071	36 L	110.012	110.047	12 L	110.000	110.054	0	110.000	110.035	0	110.000	110.022	0
115	**115.000**	**114.985**	115.036	115.071		115.012	115.047		115.000	115.054		115.000	115.035		115.000	115.022	
120	**120.000**	**119.985**	120.036	120.071		120.012	120.047		120.000	120.054		120.000	120.035		120.000	120.022	
125	**125.000**	**124.982**	125.043	125.083		125.014	125.054		125.000	125.063		125.000	125.040		125.000	125.025	
130	**130.000**	**129.982**	130.043	130.083		130.014	130.054		130.000	130.063		130.000	130.040		130.000	130.025	
140	**140.000**	**139.982**	140.043	140.083	101 L	140.014	140.054	72 L	140.000	140.063	81 L	140.000	140.040	58 L	140.000	140.025	43 L
145	**145.000**	**144.982**	145.043	145.083	43 L	145.014	145.054	14 L	145.000	145.063	0	145.000	145.040	0	145.000	145.025	0
150	**150.000**	**149.982**	150.043	150.083		150.014	150.054		150.000	150.063		150.000	150.040		150.000	150.025	
160	**160.000**	**159.975**	160.043	160.083		160.014	160.054		160.000	160.063		160.000	160.040		160.000	160.025	
165	**165.000**	**164.975**	165.043	165.083		165.014	165.054		165.000	165.063		165.000	165.040		165.000	165.025	
170	**170.000**	**169.975**	170.043	170.083	108 L	170.014	170.054	79 L	170.000	170.063	88 L	170.000	170.040	65 L	170.000	170.025	50 L
180	**180.000**	**179.975**	180.043	180.083	43 L	180.014	180.054	14 L	180.000	180.063	0	180.000	180.040	0	180.000	180.025	0
190	**190.000**	**189.970**	190.050	190.096		190.015	190.061		190.000	190.072		190.000	190.046		190.000	190.029	
200	**200.000**	**199.970**	200.050	200.096		200.015	200.061		200.000	200.072		200.000	200.046		200.000	200.029	
210	**210.000**	**209.970**	210.050	210.096		210.015	210.061		210.000	210.072		210.000	210.046		210.000	210.029	
215	**215.000**	**214.970**	215.050	215.096	126 L	215.015	215.061	91 L	215.000	215.072	102 L	215.000	215.046	76 L	215.000	215.029	59 L
220	**220.000**	**219.970**	220.050	220.096		220.015	220.061		220.000	220.072		220.000	220.046		220.000	220.029	
225	**225.000**	**224.970**	225.050	225.096	50 L	225.015	225.061	15 L	225.000	225.072	0	225.000	225.046	0	225.000	225.029	0
230	**230.000**	**229.970**	230.050	230.096		230.015	230.061		230.000	230.072		230.000	230.046		230.000	230.029	
240	**240.000**	**239.970**	240.050	240.096		240.015	240.061		240.000	240.072		240.000	240.046		240.000	240.029	
250	**250.000**	**249.970**	250.050	250.096		250.015	250.061		250.000	250.072		250.000	250.046		250.000	250.029	
260	**260.000**	**259.965**	260.056	260.108		260.017	260.069		260.000	260.081		260.000	260.052		260.000	260.032	
270	**270.000**	**269.965**	270.056	270.108		270.017	270.069		270.000	270.081		270.000	270.052		270.000	270.032	
280	**280.000**	**279.965**	280.056	280.108	143 L	280.017	280.069	104 L	280.000	280.081	116 L	280.000	280.052	87 L	280.000	280.032	67 L
290	**290.000**	**289.965**	290.056	290.108		290.017	290.069		290.000	290.081		290.000	290.052		290.000	290.032	
300	**300.000**	**299.965**	300.056	300.108	56 L	300.017	300.069	17 L	300.000	300.081	0	300.000	300.052	0	300.000	300.032	0
310	**310.000**	**309.965**	310.056	310.108		310.017	310.069		310.000	310.081		310.000	310.052		310.000	310.032	
320	**320.000**	**319.960**	320.062	320.119		320.018	320.075		320.000	320.089		320.000	320.057		320.000	320.036	
340	**340.000**	**339.960**	340.062	340.119		340.018	340.075		340.000	340.089		340.000	340.057		340.000	340.036	
360	**360.000**	**359.960**	360.062	360.119	159 L	360.018	360.075	115 L	360.000	360.089	129 L	360.000	360.057	97 L	360.000	360.036	76 L
370	**370.000**	**369.960**	370.062	370.119		370.018	370.075		370.000	370.089		370.000	370.057		370.000	370.036	
380	**380.000**	**379.960**	380.062	380.119	62 L	380.018	380.075	18 L	380.000	380.089	0	380.000	380.057	0	380.000	380.036	0
400	**400.000**	**399.960**	400.062	400.119		400.018	400.075		400.000	400.089		400.000	400.057		400.000	400.036	
420	**420.000**	**419.955**	420.068	420.131		420.020	420.083		420.000	420.097		420.000	420.063		420.000	420.040	
440	**440.000**	**439.955**	440.068	440.131	176 L	440.020	440.083	128 L	440.000	440.097	142 L	440.000	440.063	108 L	440.000	440.040	85 L
460	**460.000**	**459.955**	460.068	460.131	68 L	460.020	460.083	20 L	460.000	460.097	0	460.000	460.063	0	460.000	460.040	0
480	**480.000**	**479.955**	480.068	480.131		480.020	480.083		480.000	480.097		480.000	480.063		480.000	480.040	
500	**500.000**	**499.955**	500.068	500.131		500.020	500.083		500.000	500.097		500.000	500.063		500.000	500.040	

Housing Bearing-Seat Diameters (Values in mm) (cont.)

Bearing Outside Diameter			F7			G7			H8			H7			H6		
mm	mm		Housing Bore		Fit in µm	Housing Bore		Fit in µm	Housing Bore		Fit in µm	Housing Bore		Fit in µm	Housing Bore		Fit in µm
	Max.	Min.	Min.	Max.	(0.001 mm)	Min.	Max.	(0.001 mm)	Min.	Max.	(0.001 mm)	Min.	Max.	(0.001 mm)	Min.	Max.	(0.001 mm)
520	**520.000**	**519.950**	520.076	520.146		520.022	520.092		520.000	520.110		520.000	520.070		520.000	520.044	
540	**540.000**	**539.950**	540.076	540.146		540.022	540.092		540.000	540.110		540.000	540.070		540.000	540.044	
560	**560.000**	**559.950**	560.076	560.146		560.022	560.092		560.000	560.110		560.000	560.070		560.000	560.044	
580	**580.000**	**579.950**	580.076	580.146	196 L	580.022	580.092	142 L	580.000	580.110	160 L	580.000	580.070	120 L	580.000	580.044	94 L
600	**600.000**	**599.950**	600.076	600.146	76 L	600.022	600.092	22 L	600.000	600.110	0	600.000	600.070	0	600.000	600.044	0
620	**620.000**	**619.950**	620.076	620.146		620.022	620.092		620.000	620.110		620.000	620.070		620.000	620.044	
650	**650.000**	**649.925**	650.080	650.160		650.024	650.104		650.000	650.125		650.000	650.080		650.000	650.050	
670	**670.000**	**669.925**	670.080	670.160		670.024	670.104		670.000	670.125		670.000	670.080		670.000	670.050	
680	**680.000**	**679.925**	680.080	680.160		680.024	680.104		680.000	680.125		680.000	680.080		680.000	680.050	
700	**700.000**	**699.925**	700.080	700.160	235 L	700.024	700.104	179 L	700.000	700.125	200 L	700.000	700.080	155 L	700.000	700.050	125 L
720	**720.000**	**719.925**	720.080	720.160	80 L	720.024	720.104	24 L	720.000	720.125	0	720.000	720.080	0	720.000	720.050	0
750	**750.000**	**749.925**	750.080	750.160		750.024	750.104		750.000	750.125		750.000	750.080		750.000	750.050	
760	**760.000**	**759.925**	760.080	760.160		760.024	760.104		760.000	760.125		760.000	760.080		760.000	760.050	
780	**780.000**	**779.925**	780.080	780.160		780.024	780.104		780.000	780.125		780.000	780.080		780.000	780.050	
790	**790.000**	**789.925**	790.080	790.160		790.024	790.104		790.000	790.125		790.000	790.080		790.000	790.050	
800	**800.000**	**799.925**	800.080	800.160		800.024	800.104		800.000	800.125		800.000	800.080		800.000	800.050	
820	**820.000**	**819.900**	820.086	820.176		820.026	820.116		820.000	820.140		820.000	820.090		820.000	820.056	
830	**830.000**	**829.900**	830.086	830.176		830.026	830.116		830.000	830.140		830.000	830.090		830.000	830.056	
850	**850.000**	**849.900**	850.086	850.176		850.026	850.116		850.000	850.140		850.000	850.090		850.000	850.056	
870	**870.000**	**869.900**	870.086	870.176		870.026	870.116		870.000	870.140		870.000	870.090		870.000	870.056	
920	**920.000**	**919.900**	920.086	920.176	276 L	920.026	920.116	216 L	920.000	920.140	240 L	920.000	920.090	190 L	920.000	920.056	156 L
950	**950.000**	**949.900**	950.086	950.176	86 L	950.026	950.116	26 L	950.000	950.140	0	950.000	950.090	0	950.000	950.056	0
980	**980.000**	**979.900**	980.086	980.176		980.026	980.116		980.000	980.140		980.000	980.090		980.000	980.056	
1000	**1000.000**	**999.900**	1000.086	1000.176		1000.026	1000.116		1000.000	1000.140		1000.000	1000.090		1000.000	1000.056	
1150	**1150.000**	**1149.875**	1150.098	1150.203	328 L	1150.028	1150.133	258 L	1150.000	1150.165	290 L	1150.000	1150.105	230 L	1150.000	1150.066	191 L
1250	**1250.000**	**1249.875**	1250.098	1250.203	98 L	1250.028	1250.133	28 L	1250.000	1250.165	0	1250.000	1250.105	0	1250.000	1250.066	0
1400	**1400.000**	**1399.840**	1400.110	1400.235	395 L	1400.030	1400.155	315 L	1400.000	1400.195	355 L	1400.000	1400.125	285 L	1400.000	1400.078	238 L
1600	**1600.000**	**1599.840**	1600.110	1600.235	110 L	1600.030	1600.155	30 L	1600.000	1600.195	0	1600.000	1600.125	0	1600.000	1600.078	0
1800	**1800.000**	**1799.800**	1800.120	1800.270	470 L	1800.032	1800.182	382 L	1800.000	1800.230	430 L	1800.000	1800.150	350 L	1800.000	1800.092	292 L
2000	**2000.000**	**1999.800**	2000.120	2000.270	120 L	2000.032	2000.182	32 L	2000.000	2000.230	0	2000.000	2000.150	0	2000.000	2000.092	0
2300	**2300.000**	**2299.750**	2300.130	2300.305	555 L	2300.034	2300.209	459 L	2300.000	2300.280	530 L	2300.000	2300.175	425 L	2300.000	2300.110	360 L
2500	**2500.000**	**2499.750**	2500.130	2500.305	130 L	2500.034	2500.209	34 L	2500.000	2500.280	0	2500.000	2500.175	0	2500.000	2500.110	0

Housing Bearing-Seat Diameters (Values in mm) (cont.)

Bearing Outside Diameter			J6			J7			K6			K7			M6		
mm	mm		Housing Bore		Fit in µm	Housing Bore		Fit in µm	Housing Bore		Fit in µm	Housing Bore		Fit in µm	Housing Bore		Fit in µm
	Max.	Min.	Min.	Max.	(0.001 mm)	Min.	Max.	(0.001 mm)	Min.	Max.	(0.001 mm)	Min.	Max.	(0.001 mm)	Min.	Max.	(0.001 mm)
16	**16.000**	**15.992**	15.995	16.006	14 L 5 T	15.992	16.010	18 L 8 T	15.991	16.002	10 L 9 T	15.988	16.006	14 L 12 T	15.985	15.996	4 L 15 T
19	**19.000**	**18.991**	18.995	19.008		18.991	19.012		18.989	19.002		18.985	19.006		18.983	18.996	
22	**22.000**	**21.991**	21.995	22.008		21.991	22.012		21.989	22.002		21.985	22.006		21.983	21.996	
24	**24.000**	**23.991**	23.995	24.008	17 L	23.991	24.012	21 L	23.989	24.002	11 L	23.985	24.006	15 L	23.983	23.996	5 L
26	**26.000**	**25.991**	25.995	26.008	5 T	25.991	26.012	9 T	25.989	26.002	11 T	25.985	26.006	15 T	25.983	25.996	17 T
28	**28.000**	**27.991**	27.995	28.008		27.991	28.012		27.989	28.002		27.985	28.006		27.983	27.996	
30	**30.000**	**29.991**	29.995	30.008		29.991	30.012		29.989	30.002		29.985	30.006		29.983	29.996	
32	**32.000**	**31.989**	31.994	32.010		31.989	32.014		31.987	32.003		31.982	32.007		31.980	31.996	
35	**35.000**	**34.989**	34.994	35.010		34.989	35.014		34.987	35.003		34.982	35.007		34.980	34.996	
37	**37.000**	**36.989**	36.994	37.010	21 L	36.989	37.014	25 L	36.987	37.003	14 L	36.982	37.007	18 L	36.980	36.996	7 L
40	**40.000**	**39.989**	39.994	40.010	6 T	39.989	40.014	11 T	39.987	40.003	13 T	39.982	40.007	18 T	39.980	39.996	20 T
42	**42.000**	**41.989**	41.994	42.010		41.989	42.014		41.987	42.003		41.982	42.007		41.980	41.996	
47	**47.000**	**46.989**	46.994	47.010		46.989	47.014		46.987	47.003		46.982	47.007		46.980	46.996	
52	**52.000**	**51.987**	51.994	52.013		51.988	52.018		51.985	52.004		51.979	52.009		51.976	51.995	
55	**55.000**	**54.987**	54.994	55.013		54.988	55.018		54.985	55.004		54.979	55.009		54.976	54.995	
62	**62.000**	**61.987**	61.994	62.013	26 L	61.988	62.018	31 L	61.985	62.004	17 L	61.979	62.009	22 L	61.976	61.995	8 L
68	**68.000**	**67.987**	67.994	68.013		67.988	68.018		67.985	68.004		67.979	68.009		67.976	67.995	
72	**72.000**	**71.987**	71.994	72.013	6 T	71.988	72.018	12 T	71.985	72.004	15 T	71.979	72.009	21 T	71.976	71.995	24 T
75	**75.000**	**74.987**	74.994	75.013		74.988	75.018		74.985	75.004		74.979	75.009		74.976	74.995	
80	**80.000**	**79.987**	79.994	80.013		79.988	80.018		79.985	80.004		79.979	80.009		79.976	79.995	
85	**85.000**	**84.985**	84.994	85.016		84.987	85.022		84.982	85.004		84.975	85.010		84.972	84.994	
90	**90.000**	**89.985**	89.994	90.016		89.987	90.022		89.982	90.004		89.975	90.010		89.972	89.994	
95	**95.000**	**94.985**	94.994	95.016		94.987	95.022		94.982	95.004		94.975	95.010		94.972	94.994	
100	**100.000**	**99.985**	99.994	100.016	31 L	99.987	100.022	37 L	99.982	100.004	19 L	99.975	100.010	25 L	99.972	99.994	9 L
110	**110.000**	**109.985**	109.994	110.016	6 T	109.987	110.022	13 T	109.982	110.004	18 T	109.975	110.010	25 T	109.972	109.994	28 T
115	**115.000**	**114.985**	114.994	115.016		114.987	115.022		114.982	115.004		114.975	115.010		114.972	114.994	
120	**120.000**	**119.985**	119.994	120.016		119.987	120.022		119.982	120.004		119.975	120.010		119.972	119.994	
125	**125.000**	**124.982**	124.993	125.018		124.986	125.026		124.979	125.004		124.972	125.012		124.967	124.992	
130	**130.000**	**129.982**	129.993	130.018		129.986	130.026		129.979	130.004		129.972	130.012		129.967	129.992	
140	**140.000**	**139.982**	139.993	140.018	36 L	139.986	140.026	44 L	139.979	140.004	22 L	139.972	140.012	30 L	139.967	139.992	10 L
145	**145.000**	**144.982**	144.993	145.018	7 T	144.986	145.026	14 T	144.979	145.004	21 T	144.972	145.012	28 T	144.967	144.992	33 T
150	**150.000**	**149.982**	149.993	150.018		149.986	150.026		149.979	150.004		149.972	150.012		149.967	149.992	
160	**160.000**	**159.975**	159.993	160.018		159.986	160.026		159.979	160.004		159.972	160.012		159.967	159.992	
165	**165.000**	**164.975**	164.993	165.018		164.986	165.026		164.979	165.004		164.972	165.012		164.967	164.992	
170	**170.000**	**169.975**	169.993	170.018	43 L	169.986	170.026	51 L	169.979	170.004	29 L	169.972	170.012	37 L	169.967	169.992	17 L
180	**180.000**	**179.975**	179.993	180.018	7 T	179.986	180.026	14 T	179.979	180.004	21 T	179.972	180.012	28 T	179.967	179.992	33 T
190	**190.000**	**189.970**	189.993	190.022		189.984	190.030		189.976	190.005		189.967	190.013		189.963	189.992	
200	**200.000**	**199.970**	199.993	200.022		199.984	200.030		199.976	200.005		199.967	200.013		199.963	199.992	
210	**210.000**	**209.970**	209.993	210.022		209.984	210.030		209.976	210.005		209.967	210.013		209.963	209.992	
215	**215.000**	**214.970**	214.993	215.022	52 L	214.984	215.030	60 L	214.976	215.005	35 L	214.967	215.013	43 L	214.963	214.992	22 L
220	**220.000**	**219.970**	219.993	220.022		219.984	220.030		219.976	220.005		219.967	220.013		219.963	219.992	
225	**225.000**	**224.970**	224.993	225.022	7 T	224.984	225.030	16 T	224.976	225.005	24 T	224.967	225.013	33 T	224.963	224.992	37 T
230	**230.000**	**229.970**	229.993	230.022		229.984	230.030		229.976	230.005		229.967	230.013		229.963	229.992	
240	**240.000**	**239.970**	239.993	240.022		239.984	240.030		239.976	240.005		239.967	240.013		239.963	239.992	
250	**250.000**	**249.970**	249.993	250.022		249.984	250.030		249.976	250.005		249.967	250.013		249.963	249.992	
260	**260.000**	**259.965**	259.993	260.025		259.984	260.036		259.973	260.005		259.964	260.016		259.959	259.991	
270	**270.000**	**269.965**	269.993	270.025		269.984	270.036		269.973	270.005		269.964	270.016		269.959	269.991	
280	**280.000**	**279.965**	279.993	280.025	60 L	279.984	280.036	71 L	279.973	280.005	40 L	279.964	280.016	51 L	279.959	279.991	26 L
290	**290.000**	**289.965**	289.993	290.025		289.984	290.036		289.973	290.005		289.964	290.016		289.959	289.991	
300	**300.000**	**299.965**	299.993	300.025	7 T	299.984	300.036	16 T	299.973	300.005	27 T	299.964	300.016	36 T	299.959	299.991	41 T
310	**310.000**	**309.965**	309.993	310.025		309.984	310.036		309.973	310.005		309.964	310.016		309.959	309.991	
320	**320.000**	**319.960**	319.993	320.029		319.982	320.039		319.971	320.007		319.960	320.017		319.954	319.990	
340	**340.000**	**339.960**	339.993	340.029		339.982	340.039		339.971	340.007		339.960	340.017		339.954	339.990	
360	**360.000**	**359.960**	359.993	360.029	69 L	359.982	360.039	79 L	359.971	360.007	47 L	359.960	360.017	57 L	359.954	359.990	30 L
370	**370.000**	**369.960**	369.993	370.029		369.982	370.039		369.971	370.007		369.960	370.017		369.954	369.990	
380	**380.000**	**379.960**	379.993	380.029	7 T	379.982	380.039	18 T	379.971	380.007	29 T	379.960	380.017	40 T	379.954	379.990	46 T
400	**400.000**	**399.960**	399.993	400.029		399.982	400.039		399.971	400.007		399.960	400.017		399.954	399.990	
420	**420.000**	**419.955**	419.993	420.033		419.980	420.043		419.968	420.008		419.955	420.018		419.950	419.990	
440	**440.000**	**439.955**	439.993	440.033	78 L	439.980	440.043	88 L	439.968	440.008	53 L	439.955	440.018	63 L	439.950	439.990	35 L
460	**460.000**	**459.955**	459.993	460.033	7 T	459.980	460.043	20 T	459.968	460.008	32 T	459.955	460.018	45 T	459.950	459.990	50 T
480	**480.000**	**479.955**	479.993	480.033		479.980	480.043		479.968	480.008		479.955	480.018		479.950	479.990	
500	**500.000**	**499.955**	499.993	500.033		499.980	500.043		499.968	500.008		499.955	500.018		499.950	499.990	

Housing Bearing-Seat Diameters (Values in mm) (cont.)

Bearing Outside Diameter			J6			J7			K6			K7			M6		
mm	mm		Housing Bore		Fit in µm	Housing Bore		Fit in µm	Housing Bore		Fit in µm	Housing Bore		Fit in µm	Housing Bore		Fit in µm
	Max.	Min.	Min.	Max.	(0.001 mm)	Min.	Max.	(0.001 mm)	Min.	Max.	(0.001 mm)	Min.	Max.	(0.001 mm)	Min.	Max.	(0.001 mm)
520	**520.000**	**519.950**	519.991	520.037		519.976	520.047		519.956	520.000		519.930	520.000		519.930	519.974	
540	**540.000**	**539.950**	539.991	540.037		539.976	540.047		539.956	540.000		539.930	540.000		539.930	539.974	
560	**560.000**	**559.950**	559.923	560.037		559.976	560.047		559.956	560.000		559.930	560.000		559.930	559.974	
580	**580.000**	**579.950**	605.391	580.037	89 L	579.976	580.047	99 L	579.956	580.000	50 L	579.930	580.000	50 L	579.930	579.974	24 L
600	**600.000**	**599.950**	599.991	600.037	7 T	599.976	600.047	23 T	599.956	600.000	44 T	599.930	600.000	70 T	599.930	599.974	70 T
620	**620.000**	**619.950**	619.991	620.037		619.976	620.047		619.956	620.000		619.930	620.000		619.930	619.974	
650	**650.000**	**649.925**	649.991	650.042		649.978	650.057		649.950	650.000		649.920	650.000		649.920	649.970	
670	**670.000**	**669.925**	669.991	670.042		669.978	670.057		669.950	670.000		669.920	670.000		669.920	669.970	
680	**680.000**	**679.925**	679.991	680.042		679.978	680.057		679.950	680.000		679.920	680.000		679.920	679.970	
700	**700.000**	**699.925**	699.991	700.042	117 L	699.978	700.057	132 L	699.950	700.000	75 L	699.920	700.000	75 L	699.920	699.970	45 L
720	**720.000**	**719.925**	719.991	720.042	10 T	719.978	720.057	23 T	719.950	720.000	50 T	719.920	720.000	80 T	719.920	719.970	80 T
750	**750.000**	**749.925**	749.991	750.042		749.978	750.057		749.950	750.000		749.920	750.000		749.920	749.970	
760	**760.000**	**759.925**	759.991	760.042		759.978	760.057		759.950	760.000		759.920	760.000		759.920	759.970	
780	**780.000**	**779.925**	779.991	780.042		779.978	780.057		779.950	780.000		779.920	780.000		779.920	779.970	
790	**790.000**	**789.925**	789.991	790.042		789.978	790.057		789.950	790.000		789.920	790.000		789.920	789.970	
800	**800.000**	**799.925**	799.991	800.042		799.978	800.003		799.950	800.000		799.920	800.000		799.920	799.970	
820	**820.000**	**819.900**	819.991	820.047		819.976	820.064		819.944	820.000		819.910	820.000		819.910	819.966	
830	**830.000**	**829.900**	829.991	830.047		829.975	830.064		829.944	830.000		829.910	830.000		829.910	829.966	
850	**850.000**	**849.900**	849.991	850.047		849.975	850.064		849.944	850.000		849.910	850.000		849.910	849.966	
870	**870.000**	**869.900**	869.991	870.047		869.975	870.064		869.944	870.000		869.910	870.000		869.910	869.966	
920	**920.000**	**919.900**	919.991	920.046	145 L	919.975	920.064	163 L	919.944	920.000	100 L	919.910	920.000	100 L	919.910	919.966	66 L
950	**950.000**	**949.900**	949.990	950.046	10 T	949.975	950.064	25 T	949.944	950.000	56 T	949.910	950.000	90 T	949.910	949.966	90 T
980	**980.000**	**979.900**	979.990	980.046		979.975	980.064		979.944	980.000		979.910	980.000		979.910	979.966	
1000*																	
1150*																	
1250*																	
1400*																	
1600*																	
1800*																	
2000*																	
2300*																	
2500*																	

*** Contact SKF Engineering for >1000 size range fit recommendations.**

Housing Bearing-Seat Diameters (Values in mm) (cont.)

Bearing Outside Diameter			M7			N6			N7			P6			P7		
mm	mm		Housing Bore		Fit in µm	Housing Bore		Fit in µm	Housing Bore		Fit in µm	Housing Bore		Fit in µm	Housing Bore		Fit in µm
	Max.	Min.	Min.	Max.	(0.001 mm)	Min.	Max.	(0.001 mm)	Min.	Max.	(0.001 mm)	Min.	Max.	(0.001 mm)	Min.	Max.	(0.001 mm)
16	**16.000**	**15.992**	15.982	16.000	8 L 18 T	15.980	15.991	1 T 20 T	15.977	15.995	3 L 23 T	15.974	15.985	7 T 26 T	15.971	15.989	3 T 29 T
19	**19.000**	**18.991**	18.979	19.000		18.976	18.989		18.972	18.993		18.969	18.982		18.965	18.986	
22	**22.000**	**21.991**	21.979	22.000		21.976	21.989		21.972	21.993		21.969	21.982		21.965	21.986	
24	**24.000**	**23.991**	23.979	24.000	9 L	23.976	23.989	2 T	23.972	23.993	2 L	23.969	23.982	9 T	23.965	23.986	5 T
26	**26.000**	**25.991**	25.979	26.000	21 T	25.976	25.989	24 T	25.972	25.993	28 T	25.969	25.982	31 T	25.965	25.986	35 T
28	**28.000**	**27.991**	27.979	28.000		27.976	27.989		27.972	27.993		27.969	27.982		27.965	27.986	
30	**30.000**	**29.991**	29.979	30.000		29.976	29.989		29.972	29.993		29.969	29.982		29.965	29.986	
32	**32.000**	**31.989**	31.975	32.000		31.972	31.988		31.967	31.992		31.963	31.979		31.958	31.983	
35	**35.000**	**34.989**	34.975	35.000		34.972	34.988		34.967	34.992		34.963	34.979		34.958	34.983	
37	**37.000**	**36.989**	36.975	37.000	11 L	36.972	36.988	1 T	36.967	36.992	3 L	36.963	36.979	10 T	36.958	36.983	6 T
40	**40.000**	**39.989**	39.975	40.000	25 T	39.972	39.988	28 T	39.967	39.992	33 T	39.963	39.979	37 T	39.958	39.983	42 T
42	**42.000**	**41.989**	41.975	42.000		41.972	41.988		41.967	41.992		41.963	41.979		41.958	41.983	
47	**47.000**	**46.989**	46.975	47.000		46.972	46.988		46.967	46.992		46.963	46.979		46.958	46.983	
52	**52.000**	**51.987**	51.970	52.000		51.967	51.986		51.961	51.991		51.955	51.974		51.949	51.979	
55	**55.000**	**54.987**	54.970	55.000		54.967	54.986		54.961	54.991		54.955	54.974		54.949	54.979	
62	**62.000**	**61.987**	61.970	62.000	13 L	61.967	61.986	1 T	61.961	61.991	4 L	61.955	61.974	13 T	61.949	61.979	8 T
68	**68.000**	**67.987**	67.970	68.000		67.967	67.986		67.961	67.991		67.955	67.974		67.949	67.979	
72	**72.000**	**71.987**	71.970	72.000	30 T	71.967	71.986	33 T	71.961	71.991	39 T	71.955	71.974	45 T	71.949	71.979	51 T
75	**75.000**	**74.987**	74.970	75.000		74.967	74.986		74.961	74.991		74.955	74.974		74.949	74.979	
80	**80.000**	**79.987**	79.970	80.000		79.967	79.986		79.961	79.991		79.955	79.974		79.949	79.979	
85	**85.000**	**84.985**	84.965	85.000		84.962	84.984		84.955	84.990		84.948	84.970		84.941	84.976	
90	**90.000**	**89.985**	89.965	90.000		89.962	89.984		89.955	89.990		89.948	89.970		89.941	89.976	
95	**95.000**	**94.985**	94.965	95.000		94.962	94.984		94.955	94.990		94.948	94.970		94.941	94.976	
100	**100.000**	**99.985**	99.965	100.000	15 L	99.962	99.984	1 T	99.955	99.990	5 L	99.948	99.970	15 T	99.941	99.976	9 T
110	**110.000**	**109.985**	109.965	110.000	35 T	109.962	109.984	38 T	109.955	109.990	45 T	109.948	109.970	52 T	109.941	109.976	59 T
115	**115.000**	**114.985**	114.965	115.000		114.962	114.984		114.955	114.990		114.948	114.970		114.941	114.976	
120	**120.000**	**119.985**	119.965	120.000		119.962	119.984		119.955	119.990		119.948	119.970		119.941	119.976	
125	**125.000**	**124.982**	124.960	125.000		124.955	124.980		124.948	124.988		124.939	124.964		124.932	124.972	
130	**130.000**	**129.982**	129.960	130.000		129.955	129.980		129.948	129.988		129.939	129.964		129.932	129.972	
140	**140.000**	**139.982**	139.960	140.000	18 L	139.955	139.980	2 T	139.948	139.988	6 L	139.939	139.964	18 T	139.932	139.972	10 T
145	**145.000**	**144.982**	144.960	145.000	40 T	144.955	144.980	45 T	144.948	144.988	52 T	144.939	144.964	61 T	144.932	144.972	68 T
150	**150.000**	**149.982**	149.960	150.000		149.955	149.980		149.948	149.988		149.939	149.964		149.932	149.972	
160	**160.000**	**159.975**	159.960	160.000		159.955	159.980		159.948	159.988		159.939	159.964		159.932	159.972	
165	**165.000**	**164.975**	164.960	165.000		164.955	164.980		164.948	164.988		164.939	164.964		164.932	164.972	
170	**170.000**	**169.975**	169.960	170.000	25 L	169.955	169.980	5 L	169.948	169.988	13 L	169.939	169.964	11 T	169.932	169.972	3 T
180	**180.000**	**179.975**	179.960	180.000	40 T	179.955	179.980	45 T	179.948	179.988	52 T	179.939	179.964	61 T	179.932	179.972	68 T
190	**190.000**	**189.970**	189.954	190.000		189.949	189.978		189.940	189.986		189.930	189.959		189.921	189.967	
200	**200.000**	**199.970**	199.954	200.000		199.949	199.978		199.940	199.986		199.930	199.959		199.921	199.967	
210	**210.000**	**209.970**	209.954	210.000		209.949	209.978		209.940	209.986		209.930	209.959		209.921	209.967	
215	**215.000**	**214.970**	214.954	215.000	30 L	214.949	214.978	8 L	214.940	214.986	16 L	214.930	214.959	11 T	214.921	214.967	3 T
220	**220.000**	**219.970**	219.954	220.000		219.949	219.978		219.940	219.986		219.930	219.959		219.921	219.967	
225	**225.000**	**224.970**	224.954	225.000	46 T	224.949	224.978	51 T	224.940	224.986	60 T	224.930	224.959	70 T	224.921	224.967	79 T
230	**230.000**	**229.970**	229.954	230.000		229.949	229.978		229.940	229.986		229.930	229.959		229.921	229.967	
240	**240.000**	**239.970**	239.954	240.000		239.949	239.978		239.940	239.986		239.930	239.959		239.921	239.967	
250	**250.000**	**249.970**	249.954	250.000		249.949	249.978		249.940	249.986		249.930	249.959		249.921	249.967	
260	**260.000**	**259.965**	259.948	260.000		259.943	259.975		259.934	259.986		259.921	259.953		259.912	259.964	
270	**270.000**	**269.965**	269.948	270.000		269.943	269.975		269.934	269.986		269.921	269.953		269.912	269.964	
280	**280.000**	**279.965**	279.948	280.000	35 L	279.943	279.975	10 L	279.934	279.986	21 L	279.921	279.953	12 T	279.912	279.964	1 T
290	**290.000**	**289.965**	289.948	290.000		289.943	289.975		289.934	289.986		289.921	289.953		289.912	289.964	
300	**300.000**	**299.965**	299.948	300.000	52 T	299.943	299.975	57 T	299.934	299.986	66 T	299.921	299.953	79 T	299.912	299.964	88 T
310	**310.000**	**309.965**	309.948	310.000		309.943	309.975		309.934	309.986		309.921	309.953		309.912	309.964	
320	**320.000**	**319.960**	319.943	320.000		319.938	319.974		319.927	319.984		319.913	319.949		319.902	319.959	
340	**340.000**	**339.960**	339.943	340.000		339.938	339.974		339.927	339.984		339.913	339.949		339.902	339.959	
360	**360.000**	**359.960**	359.943	360.000	40 L	359.938	359.974	14 L	359.927	359.984	24 L	359.913	359.949	11 T	359.902	359.959	1 T
370	**370.000**	**369.960**	369.943	370.000		369.938	369.974		369.927	369.984		369.913	369.949		369.902	369.959	
380	**380.000**	**379.960**	379.943	380.000	57 T	379.938	379.974	62 T	379.927	379.984	73 T	379.913	379.949	87 T	379.902	379.959	98 T
400	**400.000**	**399.960**	399.943	400.000		399.938	399.974		399.927	399.984		399.913	399.949		399.902	399.959	
420	**420.000**	**419.955**	419.937	420.000		419.933	419.973		419.920	419.983		419.905	419.945		419.892	419.955	
440	**440.000**	**439.955**	439.937	440.000	45 L	439.933	439.973	18 L	439.920	439.983	28 L	439.905	439.945	10 T	439.892	439.955	0
460	**460.000**	**459.955**	459.937	460.000	63 T	459.933	459.973	67 T	459.920	459.983	80 T	459.905	459.945	95 T	459.892	459.955	108 T
480	**480.000**	**479.955**	479.937	480.000		479.933	479.973		479.920	479.983		479.905	479.945		479.892	479.955	
500	**500.000**	**499.955**	499.937	500.000		499.933	499.973		499.920	499.983		499.905	499.945		499.892	499.955	

Housing Bearing-Seat Diameters (Values in mm) (cont.)

Bearing Outside Diameter			M7			N6			N7			P6			P7		
mm	mm		Housing Bore		Fit in µm	Housing Bore		Fit in µm	Housing Bore		Fit in µm	Housing Bore		Fit in µm	Housing Bore		Fit in µm
	Max.	Min.	Min.	Max.	(0.001 mm)	Min.	Max.	(0.001 mm)	Min.	Max.	(0.001 mm)	Min.	Max.	(0.001 mm)	Min.	Max.	(0.001 mm)
520	**520.000**	**519.950**	519.904	519.974		519.912	519.956		519.886	519.956		519.878	519.922		519.852	519.922	
540	**540.000**	**539.950**	539.904	539.974		539.912	539.956		539.886	539.956		539.878	539.922		539.852	539.922	
560	**560.000**	**559.950**	559.904	559.974	24 L	559.912	559.956	6 L	559.886	559.956		559.878	559.922		559.852	559.922	
580	**580.000**	**579.950**	579.904	579.974	96 T	579.912	579.956	88 T	579.886	579.956	6 L	579.878	579.922	28 T	579.852	579.922	28 T
600	**600.000**	**599.950**	599.904	599.974		599.912	599.956		599.886	599.956	114 T	599.878	599.922	122 T	599.852	599.922	148 T
620	**620.000**	**619.950**	619.904	619.974		619.912	619.956		619.886	619.956		619.878	619.922		619.852	619.922	
650	**650.000**	**649.925**	649.890	649.970		649.900	649.950		649.870	649.950		649.862	649.912		649.832	649.912	
670	**670.000**	**669.925**	669.890	669.970		669.900	669.950		669.870	669.950		669.862	669.912		669.832	669.912	
680	**680.000**	**679.925**	679.890	679.970		679.900	679.950		679.870	679.950		679.862	679.912		679.832	679.912	
700	**700.000**	**699.925**	699.890	699.970	45 L	699.900	699.950	25 L	699.870	699.950	25 L	699.862	699.912	13 T	699.832	699.912	13 T
720	**720.000**	**719.925**	719.890	719.970	110 T	719.900	719.950	100 T	719.870	719.950	130 T	719.862	719.912	138 T	719.832	719.912	168 T
750	**750.000**	**749.925**	749.890	749.970		749.900	749.950		749.870	749.950		749.862	749.912		749.832	749.912	
760	**760.000**	**759.925**	759.890	759.970		759.900	759.950		759.870	759.950		759.862	759.912		759.832	759.912	
780	**780.000**	**779.925**	779.890	779.970		779.900	779.950		779.870	779.950		779.862	779.912		779.832	779.912	
790	**790.000**	**789.925**	789.890	789.970		789.900	789.950		789.870	789.950		789.862	789.912		789.832	789.912	
800	**800.000**	**799.925**	799.890	799.970		799.900	799.950		799.870	799.950		799.862	799.912		799.832	799.912	
820	**820.000**	**819.900**	819.876	819.966		819.888	819.944		819.854	819.944		819.844	819.902		819.810	819.902	
830	**830.000**	**829.900**	829.876	829.966		829.888	829.944		829.854	829.944		829.844	829.902		829.810	829.902	
850	**850.000**	**849.900**	849.876	849.966	66 L	849.888	849.944	44 L	849.854	849.944		849.844	849.902		849.810	849.902	
870	**870.000**	**869.900**	869.876	869.966	124 T	869.888	869.944	112 T	869.854	869.944		869.844	869.902		869.810	869.902	
920	**920.000**	**919.900**	919.876	919.966		919.888	919.944		919.854	919.944	44 L	919.844	919.902	0	919.810	919.902	0
950	**950.000**	**949.900**	949.876	949.966		949.888	949.944		949.854	949.944	146 T	949.844	949.902	156 T	949.810	949.902	190 T
980	**980.000**	**979.900**	979.876	979.966		979.888	979.944		979.854	979.944		979.844	979.902		979.810	979.902	
1000	**1000.000**	**999.900**	999.876	999.966		999.888	999.944		999.854	999.944		999.844	999.902		999.810	999.902	
1150	**1150.000**	**1149.875**	1149.855	1149.960	85 L	1149.868	1149.934	59 L	1149.829	1149.934	59 L	1149.814	1149.880	5 L	1149.775	1149.880	5 L
1250	**1250.000**	**1249.875**	1249.855	1249.960	145 T	1249.868	1249.934	132 T	1249.829	1249.934	171 T	1249.814	1249.880	186 T	1249.775	1249.880	225 T
1400	**1400.000**	**1399.840**	1399.827	1399.952	112 L	1399.844	1399.922	82 L	1399.797	1399.922	82 L	1399.782	1399.860	20 L	1399.735	1399.860	20 L
1600	**1600.000**	**1599.840**	1599.827	1599.952	173 T	1599.844	1599.922	156 T	1599.797	1599.922	23 T	1599.782	1599.860	218 T	1599.735	1599.860	265 T
1800	**1800.000**	**1799.800**	1799.792	1799.942	142 L	1799.816	1799.908	108 L	1799.758	1799.908	18 L	1799.738	1799.830	30 L	1799.680	1799.830	30 L
2000	**2000.000**	**1999.800**	1999.792	1999.942	208 T	1999.816	1999.908	184 T	1999.758	1999.908	242 T	1999.738	1999.830	262 T	1999.680	1999.830	320 T
2300	**2300.000**	**2299.750**	2299.757	2299.932	182 L	2299.780	2299.890	140 L	2299.715	2299.890	140 L	2299.695	2299.805	55 L	2299.630	2299.805	55 L
2500	**2500.000**	**2499.750**	2499.757	2499.932	243 T	2499.780	2499.890	220 T	2499.715	2499.890	285 T	2499.695	2499.805	305 T	2499.630	2499.805	370 T

Table 7

Limits for ISO Tolerance Grades for Dimensions

Nominal dimension		Tolerance grades												
over	incl.	IT0	IT1	IT2	IT3	IT4	IT5	IT6	IT7	IT8	IT9	IT10	IT11	IT12
mm		µm (0.001 mm)*												
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	—	—	—	—	—	32	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	1,050
1250	1600	—	—	—	—	—	50	78	125	195	310	500	780	1,250
1600	2000	—	—	—	—	—	60	92	150	230	370	600	920	1,500
2000	2500	—	—	—	—	—	70	110	175	280	440	700	1,100	1,750

*For values in inches, divide by 25.4

Table 7a

Shaft Tolerances for Bearings Mounted on Metric Sleeves

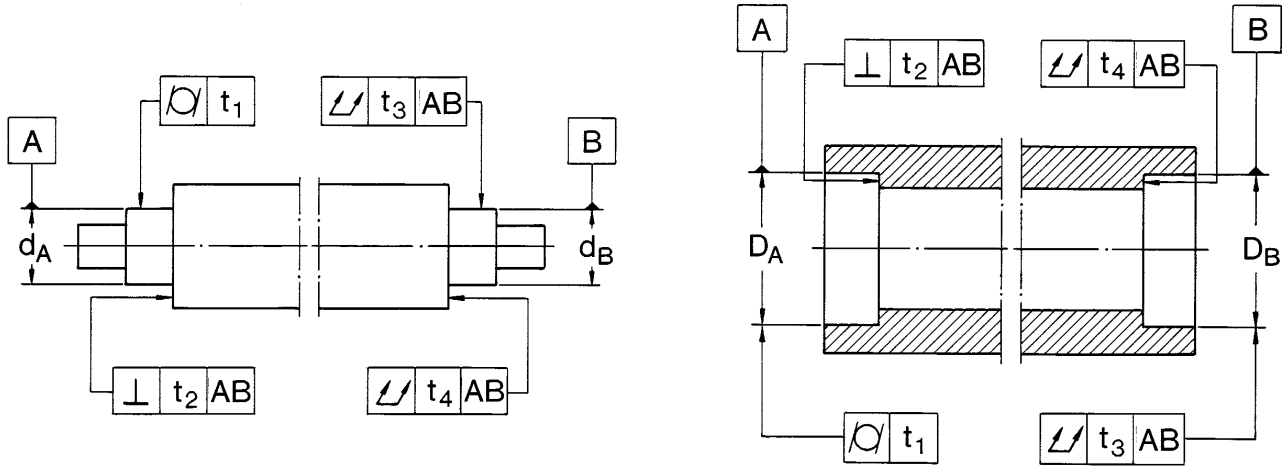
Shaft Diameter		Diameter and form tolerances					
d		h9		IT5/2	h10		IT7/2
Nominal		Deviations			Deviations		
over	incl.	high	low	max	high	low	max
mm		µm					
10	**18**	0	–43	4	0	–70	9
18	**30**	0	–52	4.5	0	–84	10.5
30	**50**	0	–62	5.5	0	–100	12.5
50	**80**	0	–74	6.5	0	–120	15
80	**120**	0	–87	7.5	0	–140	17.5
120	**180**	0	–100	9	0	–160	20
180	**250**	0	–115	10	0	–185	23
250	**315**	0	–130	11.5	0	–210	26
315	**400**	0	–140	12.5	0	–230	28.5
400	**500**	0	–155	13.5	0	–250	31.5
500	**630**	0	–175	14	0	–280	35
630	**800**	0	–200	16	0	–320	40
800	**1 000**	0	–230	18	0	–360	45
1 000	**1 250**	0	–260	21	0	–420	52.2

Table 8

Guideline values for surface roughness of bearing seatings

Diameter of seating d (D)		Recommended R_a value for ground seatings Diameter tolerance to		
over	incl.	IT7	IT6	IT5
mm		microns **micro inches**		
		(.001 mm) **(.000001 in)**	(.001 mm) **(.000001 in)**	(.001 mm) **(.000001 in)**
———	80	1.6 **63**	0.8 **32**	0.4 **16**
80	500	1.6 **63**	1.6 **63**	0.8 **32**
500	1250	3.2 **126**	1.6 **63**	1.6 **63**

Accuracy of form and position for bearing seatings on shafts and in housings



Surface Characteristic	Symbol for characteristic	tolerance zone	**Permissible deviations** Bearings of tolerance class [1] Normal, CLN	P6	P5	
Cylindrical seating						
Cylindricity (or total radial runout)	⌭	t_1	$\frac{IT5}{2}$	$\frac{IT4}{2}$	$\frac{IT3}{2}$	$\frac{IT2}{2}$
	(⌰)	(t_3)				
Flat abutment						
Rectangularity (or total axial runout)	⊥	t_2	IT5	IT4	IT3	IT2
	(⌰)	(t_4)				

[1] For bearings of higher accuracy (tolerance class P4 etc.) please refer to SKF catalog “Precision bearings”.

Explanation

For normal demands

For special demands in respect of running accuracy or even support

Table 10

Shaft Tolerances for Standard Inch Size
Tapered Roller Bearings [1,2]
Sizes and Values in Inches (Classes 4 and 2)

Cone Bore (Inner Ring)			Shaft Seat Deviation from Minimum Cone Bore and the Resultant Fit									
			Rotating Cone				Stationary Cone					
d			moderate loads,[3] no shock		heavy loads,[4] or high speed or shock		heavy loads,[4] or high speed or shock		moderate loads,[3] no shock		wheel spindles	
over	incl.	tolerance	shaft seat deviation	resultant fit	shaft seat deviation	resultant fit	shaft seat deviation	resultant fit	shaft seat deviation	resultant fit	shaft seat deviation	resultant fit
0	3	+0.0005 0	+0.0015 +0.0010	0.0005T 0.0015T	+0.0025 +0.0015	0.0010T 0.0025T	+0.0025 +0.0015	0.0010T 0.0025T	0 – 0.0005	0.0010 L 0	– 0.0002 – 0.0007	0.0012 L 0.0002 L
3	12	+0.0010 0	+0.0025 +0.0015	0.0005T 0.0025T	0.0005"/Inch Bearing Bore Avg. Tight Fit		0.0005"/Inch Bearing Bore Avg. Tight Fit		0 0.0010	0.0020 L 0	– 0.0002 – 0.0012	0.0022 L 0.0002 L
12	24	+0.0020 0	+0.0050 +0.0030	0.0010T 0.0050T					0 – 0.0020	0.0040 L 0	—	—
24	36	+0.0030 0	+0.0075 +0.0045	0.0015T 0.0075T	+0.0150 +0.0120	0.0090T 0.0150T	+0.0150 +0.0120	0.0090T 0.0150T	0 – 0.0030	0.0060 L 0	—	—

[1]For fitting practice for metric and J-prefix part number tapered roller bearings, see Table 12.
[2]These recommendations not applicable to tapered bore cones. For recommendations, consult your SKF representative.
[3]$\frac{C}{P} \geq 8.3$
[4]$\frac{C}{P} < 8.3$
C is the basic load rating, P is the equivalent load.
T indicates tight fit, L indicates loose fit.
≥ equal or greater than
> less than

Table 11

Housing Tolerance for Standard Inch Size
Tapered Roller Bearings[1]
Sizes and Values in Inches

Cup O.D. (Outer Ring)			Housing Seat Deviation from Minimum Cup O.D. and the Resultant Fit									
			Stationary Cup				Rotating Cup					
D			floating or clamped		adjustable		non-adjustable or in carriers		non-adjustable or in carriers, sheaves-clamped		sheaves-unclamped	
over	incl.	tolerance	housing seat deviation	resultant fit	housing seat deviation	resultant fit	housing seat deviation	resultant fit	housing seat deviation	resultant fit	housing seat deviation	resultant fit
0	3	+0.0010 0	+0.0030 +0.0020	0.0030 L 0.0010 L	+0.0010 0	0.0010 L 0.0010T	– 0.0005 – 0.0015	0.0005T 0.0025T	– 0.0005 – 0.0015	0.0005T 0.0025T	– 0.0020 – 0.0030	0.0020T 0.0040T
3	5	+0.0010 0	+0.0030 +0.0020	0.0030 L 0.0010 L	+0.0010 0	0.0010 L 0.0010T	– 0.0010 – 0.0020	0.0010T 0.0030T	– 0.0010 – 0.0020	0.0010T 0.0030T	– 0.0020 – 0.0030	0.0020T 0.0040T
5	12	+0.0010 0	+0.0030 +0.0020	0.0030 L 0.0010 L	+0.0020 0	0.0020 L 0.0010T	– 0.0010 – 0.0020	0.0010T 0.0030T	– 0.0010 – 0.0020	0.0010T 0.0030T	– 0.0020 – 0.0030	0.0020T 0.0040T
12	24	+0.0020 0	+0.0060 +0.0040	0.0060 L 0.0020 L	+0.0030 +0.0010	0.0030 L 0.0010T	– 0.0010 – 0.0030	0.0010T 0.0050T	– 0.0010 – 0.0030	0.0010T 0.0050T	– 0.0020 – 0.0040	0.0020T 0.0060T
24	36	+0.0030 0	+0.0090 +0.0060	0.0090 L 0.0030 L	+0.0050 +0.0020	0.0050 L 0.0010T	– 0.0010 – 0.0040	0.0010T 0.0070T	– 0.0010 – 0.0040	0.0010T 0.0070T	— —	— —

Recommended fits above are for cast iron or steel housing. For housings of light metal, tolerances are generally selected which give a slightly tighter fit than those in the table.
[1]For fitting practice for metric and J-prefix part number tapered roller bearings, see Table 13.
T indicates tight fit.
L indicates loose fit.

Shaft Tolerances for Metric and J-Prefix Inch Series
Tapered Roller Bearings[1]
ISO Class Normal and ABMA Class K and N
Values in Inches

Cone Bore (Inner Ring)			Shaft Seat Deviation from Maximum Cone Bore and the Resultant Fit											
			Rotating Cone						Stationary Cone					
									tension pulley rope sheaves			wheel spindles		
d			constant loads,[2] with moderate shock			heavy loads,[3] or high speed or shock			moderate loads,[2] no shock			moderate loads,[2] no shock		
over in mm	incl. in mm	tolerance (in)	shaft seat deviation	resultant fit	tolerance symbol	shaft seat deviation	resultant fit	tolerance symbol	shaft seat deviation	resultant fit	tolerance symbol	shaft seat deviation	resultant fit	tolerance symbol
0.3937 10	0.7087 18	0 – 0.0005	+0.0004 +0.0001	0.0001T 0.0009T	 k5	+0.0009 +0.0005	0.0005T 0.0014T	 n6	0 – 0.0004	0.0004 L 0.0005T	 h6	– 0.00025 – 0.00065	0.00065 L 0.00025T	 g6
0.7087 18	1.1811 30	0 – 0.0005	+0.0005 +0.0001	0.0001T 0.0010T	 k5	+0.0011 +0.0006	0.0006T 0.0016T	 n6	0 – 0.0005	0.0005 L 0.0005T	 h6	– 0.0003 – 0.0008	0.0008 L 0.0002T	 g6
1.1811 30	1.9685 50	0 – 0.0005	+0.0008 +0.0004	0.0004T 0.0013T	 m5	+0.0013 +0.0007	0.0007T 0.0018T	 n6	0 – 0.0006	0.0006 L 0.0005T	 h6	– 0.0004 – 0.0010	0.0010 L 0.0001T	 g6
1.9685 50	3.1496 80	0 – 0.0006	+0.0010 +0.0005	0.0005T 0.0016T	 m5	+0.0015 +0.0008	0.0008T 0.0021T	 n6	0 – 0.0007	0.0007 L 0.0006T	 h6	– 0.0004 – 0.0011	0.0011 L 0.0002T	 g6
3.1496 80	4.7244 120	0 – 0.0008	+0.0014 +0.0005	0.0005T 0.0022T	 m6	+0.0019 +0.0010	0.0010T 0.0027T	 n6	0 – 0.0009	0.0009 L 0.0008T	 h6	– 0.0005 – 0.0014	0.0014 L 0.0003T	 g6
4.7244 120	7.0866 180	0 – 0.0010	+0.0022 +0.0012	0.0012T 0.0032T	 n6	+0.0034 +0.0018	0.0018T 0.0044T	 p6	0 – 0.0010	0.0010 L 0.0010T	 h6	– 0.0006 – 0.0016	0.0016 L 0.0004T	 g6
7.0866 180	9.8425 250	0 – 0.0012	+0.0026 +0.0014	0.0014T 0.0038T	 n6	+0.0042 +0.0030	0.0030T 0.0054T	 r6	0 – 0.0012	0.0012 L 0.0012T	 h6	– 0.0006 – 0.0018	0.0018 L 0.0006T	 g6
9.8425 250	12.4016 315	0 – 0.0014	+0.0034 +0.0022	0.0022T 0.0048T	 p6	+0.0047 +0.0035	0.0035T 0.0061T	 r6	0 – 0.0012	0.0012 L 0.0014T	 h6	– 0.0007 – 0.0019	0.0019 L 0.0007T	 g6
12.4016 315	15.7480 400	0 – 0.0016	+0.0039 +0.0025	0.0025T 0.0055T	 p6	+0.0059 +0.0045	0.0045T 0.0065T	 r6	0 – 0.0014	0.0014 L 0.0016T	 h6	– 0.0007 – 0.0029	0.0029 L 0.0009T	 g7
15.7480 400	19.6850 500	0 – 0.0018	+0.0044 +0.0028	0.0028T 0.0062T	 p6	+0.0066 +0.0050	0.0050T 0.0084T	 r6	0 – 0.0016	0.0016 L 0.0018T	 h6	– 0.0008 – 0.0033	0.0033 L 0.0010T	 g7

Recommended fits above are for ground shaft seats.
NOTE: Assembly conditions may dictate tighter fits than recommended above. Consult your SKF representative where application conditions call for fitting practices not covered by these recommendations.
[1]These recommendations not applicable to tapered bore cones. For recommendations, consult your SKF representative.
[2]$\frac{C}{P} \geq 8.3$
[3]$\frac{C}{P} < 8.3$
C is the basic load rating.
P is the equivalent load.
T indicates tight fit.
L indicates loose fit.
≥ equal or greater than.
< less than.

Housing Tolerances for Metric and J-Prefix Inch Series
Tapered Roller Bearings
ISO Class Normal and ABMA Class K and N
Values in Inches

Cup O.D. (Outer Ring)			Housing Seat Deviation from Maximum Cup O.D. and the Resultant Fit												
D			Stationary Cup									Rotating Cup			
			floating or clamped			adjustable			non-adjustable or in carriers			sheaves-unclamped			
over in mm	incl. in mm	tolerance (in)	housing seat deviation	resultant fit	tolerance symbol	housing seat deviation	resultant fit	tolerance symbol	housing seat deviation	resultant fit	tolerance symbol	housing seat deviation	resultant fit	tolerance symbol
0.7087	1.1811	0	+ 0.0008	0.0013 L		+ 0.0005	0.0010 L		– 0.0005	0		– 0.0009	0.0004T	
18	30	– 0.0005	0	0	H7	– 0.0003	0.0003T	J7	– 0.0013	0.0013T	P7	– 0.0017	0.0017T	R7
1.1811	1.9685	0	+ 0.0010	0.0016 L		+ 0.0006	0.0012 L		– 0.0006	0		– 0.0010	0.0004T	
30	50	– 0.0006	0	0	H7	– 0.0004	0.0004T	J7	– 0.0016	0.0016T	P7	– 0.0020	0.0020T	R7
1.9685	3.1496	0	+ 0.0012	0.0018 L		+ 0.0008	0.0014 L		– 0.0009	0.0003T		– 0.0011	0.0005T	
50	80	– 0.0006	0	0	H7	– 0.0004	0.0004T	J7	– 0.0021	0.0021T	P7	– 0.0023	0.0023T	R7
3.1496	4.7244	0	+ 0.0014	0.0021 L		+ 0.0009	0.0016 L		– 0.0011	0.0004T		– 0.0015	0.0008T	
80	120	– 0.0007	0	0	H7	– 0.0005	0.0005T	J7	– 0.0025	0.0025T	P7	– 0.0029	0.0029T	R7
4.7244	5.9055	0	+ 0.0016	0.0024 L		+ 0.0010	0.0018 L		– 0.0012	0.0004T		– 0.0019	0.0011T	
120	150	– 0.0008	0	0	H7	– 0.0006	0.0006T	J7	– 0.0028	0.0028T	P7	– 0.0035	0.0035T	R7
5.9055	7.0866	0	+ 0.0016	0.0026 L		+ 0.0010	0.0020 L		– 0.0012	0.0002T		– 0.0019	0.0009T	
150	180	– 0.0010	0	0	H7	– 0.0006	0.0006T	J7	– 0.0028	0.0028T	P7	– 0.0035	0.0035T	R7
7.0866	9.8424	0	+ 0.0018	0.0030 L		+ 0.0011	0.0023 L		– 0.0014	0.0002T		– 0.0024	0.0012T	
180	250	– 0.0012	0	0	H7	– 0.0007	0.0007T	J7	– 0.0032	0.0032T	P7	– 0.0042	0.0042T	R7
9.8425	12.4016	0	+ 0.0027	0.0041 L		+ 0.0013	0.0027 L		– 0.0014	0		– 0.0027	0.0013T	
250	315	– 0.0014	+ 0.0007	0.0007 L	G7	– 0.0007	0.0007T	J7	– 0.0034	0.0034T	P7	– 0.0047	0.0047T	R7
12.4016	15.7480	0	+ 0.0029	0.0045 L		+ 0.0015	0.0031 L		– 0.0017	0.0001T		– 0.0037	0.0021T	
315	400	– 0.0016	+ 0.0007	0.0007 L	G7	– 0.0007	0.0007T	J7	– 0.0039	0.0039T	P7	– 0.0059	0.0059T	R7
15.7480	19.6850	0	+ 0.0033	0.0051 L		+ 0.0016	0.0034 L		– 0.0019	0.0001T		– 0.0041	0.0023T	
400	500	– 0.0018	+ 0.0008	0.0008 L	G7	– 0.0009	0.0009T	J7	– 0.0044	0.0044T	P7	– 0.0066	0.0066T	R7

Recommendations above are for cast iron or steel housing. For housings of light metal, tolerances are generally selected which give a slightly tighter fit than those in the table.
T indicates tight fit. L indicates loose fit.

Bearing Shaft — Seat Diameters[1]
Precision (ABEC 5) Deep Groove Ball Bearings

Bearing Bore Diameter			Shaft/Seat Diameter		
mm	inches		inches		Fit in .0001"
	maximum	minimum	maximum	minimum	
10	.3937	.3935	.3937	.3935	2 L, 2T
12	.4724	.4722	.4724	.4722	2 L, 2T
15	.5906	.5904	.5906	.5904	2 L, 2T
17	.6693	.6691	.6693	.6691	2 L, 2T
20	.7874	.7872	.7875	.7873	1 L, 3T
25	.9843	.9841	.9844	.9842	1 L, 3T
30	1.1811	1.1809	1.1812	1.1810	1 L, 3T
35	1.3780	1.3777	1.3782	1.3779	1 L, 5T
40	1.5748	1.5745	1.5750	1.5747	1 L, 5T
45	1.7717	1.7714	1.7719	1.7716	1 L, 5T
50	1.9685	1.9682	1.9687	1.9684	1 L, 5T
55	2.1654	2.1650	2.1656	2.1652	2 L, 6T
60	2.3622	2.3618	2.3624	2.3620	2 L, 6T
65	2.5591	2.5587	2.5593	2.5589	2 L, 6T
70	2.7559	2.7555	2.7561	2.7557	2 L, 6T
75	2.9528	2.9524	2.9530	2.9526	2 L, 6T
80	3.1496	3.1492	3.1498	3.1494	2 L, 6T
85	3.3465	3.3461	3.3467	3.3463	2 L, 6T
90	3.5433	3.5429	3.5435	3.5431	2 L, 6T
95	3.7402	3.7398	3.7404	3.7400	2 L, 6T
100	3.9370	3.9366	3.9372	3.9368	2 L, 6T
105	4.1339	4.1335	4.1341	4.1337	2 L, 6T
110	4.3307	4.3303	4.3309	4.3305	2 L, 6T
120	4.7244	4.7240	4.7246	4.7242	2 L, 6T

[1]Use this table for ABEC 5 bearings; for higher precision bearings, other recommendations apply. Consult SKF.
*Note — These shaft dimensions are to be used when C/P > = 14.3 and the inner ring rotates in relation to the direction of the radial load. For heavier loads contact SKF.

Bearing Housing — Seat Diameters
Precision (ABEC 5) Deep Groove Ball Bearings

Bearing Outside Diameter			Housing/Seat Diameter		
mm	inches		inches		Fit in .0001"
	maximum	minimum	minimum	maximum	
30	1.1811	1.1809	1.1810	1.1813	4 L, 1T
32	1.2598	1.2595	1.2597	1.2600	5 L, 1T
35	1.3780	1.3777	1.3779	1.3782	5 L, 1T
37	1.4567	1.4564	1.4566	1.4569	5 L, 1T
40	1.5748	1.5745	1.5747	1.5750	5 L, 1T
42	1.6535	1.6532	1.6534	1.6537	5 L, 1T
47	1.8504	1.8501	1.8503	1.8506	5 L, 1T
52	2.0472	2.0468	2.0471	2.0474	6 L, 1T
62	2.4409	2.4405	2.4408	2.4411	6 L, 1T
72	2.8346	2.8342	2.8345	2.8348	6 L, 1T
80	3.1496	3.1492	3.1495	3.1498	6 L, 1T
85	3.3465	3.3461	3.3464	3.3468	7 L, 1T
90	3.5433	3.5429	3.5432	3.5436	7 L, 1T
100	3.9370	3.9366	3.9369	3.9373	7 L, 1T
110	4.3307	4.3303	4.3306	4.3310	7 L, 1T
120	4.7244	4.7240	4.7243	4.7247	7 L, 1T
125	4.9213	4.9209	4.9211	4.9216	7 L, 2T
130	5.1181	5.1177	5.1179	5.1184	7 L, 2T
140	5.5118	5.5114	5.5116	5.5121	7 L, 2T
150	5.9055	5.9051	5.9053	5.9058	7 L, 2T
160	6.2992	6.2987	6.2990	6.2995	8 L, 2T
170	6.6929	6.6924	6.6927	6.6932	8 L, 2T
180	7.0866	7.0861	7.0864	7.0869	8 L, 2T
190	7.4803	7.4797	7.4801	7.4807	10 L, 2T
200	7.8740	7.8734	7.8738	7.8744	10 L, 2T

[1]Use this table for ABEC 5 bearings; for higher precision bearings, other recommendations apply. Consult SKF.
*Note — These housing dimensions are to be used when the outer ring is stationary in relation to the direction of the radial load.
For applications with rotating outer ring loads contact SKF.

Table 16

Conversion of Millimeters Into Inches
Basis 1 mm. = 0.0394 in.

mm	0	1	2	3	4	5	6	7	8	9	mm
0		0.0394	0.0787	0.1181	0.1575	0.1969	0.2362	0.2756	0.3150	0.3543	0
10	0.3937	0.4331	0.4724	0.5118	0.5512	0.5906	0.6299	0.6693	0.7087	0.7480	10
20	0.7874	0.8268	0.8661	0.9055	0.9449	0.9843	1.0236	1.0630	1.1024	1.1417	20
30	1.1811	1.2205	1.2598	1.2992	1.3386	1.3780	1.4173	1.4567	1.4961	1.5354	30
40	1.5748	1.6142	1.6535	1.6929	1.7323	1.7717	1.8110	1.8504	1.8898	1.9291	40
50	1.9685	2.0079	2.0472	2.0866	2.1260	2.1654	2.2047	2.2441	2.2835	2.3228	50
60	2.3622	2.4016	2.4409	2.4803	2.5197	2.5592	2.5984	2.6378	2.6772	2.7165	60
70	2.7559	2.7953	2.8346	2.8740	2.9134	2.9528	2.9921	3.0315	3.0709	3.1102	70
80	3.1496	3.1890	3.2283	3.2677	3.3071	3.3465	3.3858	3.4252	3.4646	3.5039	80
90	3.5433	3.5827	3.6220	3.6614	3.7008	3.7402	3.7795	3.8189	3.8583	3.8976	90
100	3.9370	3.9764	4.0157	4.0551	4.0945	4.1339	4.1732	4.2126	4.2520	4.2913	100

Table 17

Conversion of Inches Into Millimeters
Basis 1 in. = 25.400 mm

in.	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	in.
0		2.540	5.080	7.620	10.160	12.700	15.240	17.780	20.320	22.860	0
1	25.400	27.940	30.480	33.020	35.560	38.100	40.640	43.180	45.720	48.260	1
2	50.800	53.340	55.880	58.420	60.960	63.500	66.040	68.580	71.120	73.660	2
3	76.200	78.740	81.280	83.820	86.360	88.900	91.440	93.980	96.520	99.060	3
4	101.600	104.140	106.680	109.220	111.760	114.300	116.840	119.380	121.920	124.460	4
5	127.000	129.540	132.080	134.620	137.160	139.700	142.240	144.780	147.320	149.860	5
6	152.400	154.940	157.480	160.020	162.560	165.100	167.640	170.180	172.720	175.260	6
7	177.800	180.340	182.880	185.420	187.960	190.500	193.040	195.580	198.120	200.660	7
8	203.200	205.740	208.280	210.820	213.360	215.900	218.440	220.980	223.520	226.060	8
9	228.600	231.140	233.680	236.220	238.760	241.300	243.840	246.380	248.920	251.460	9
10	254.000	256.540	259.080	261.620	264.160	266.700	269.240	271.780	274.320	276.860	10

Lubrication

Adequate lubrication of rolling bearings is essential to achieving L_{na}, the calculated life expectancy. The principles of lubrication of rolling bearings differ considerably from the established practices used for plain or sleeve-type bearings. These principles must be known and applied to correctly design rolling bearing lubrication systems. It is equally important to incorporate them in maintenance procedures, as well as actually applying them in servicing the equipment.

This section presents various successful lubrication arrangements based on SKF's extensive practical experience with all types of rolling element bearings. Examples of both oil and grease lubrication are included. In choosing a particular lubricant, it should be noted, however, that successful performance is not assured on the basis of specifications alone. The lubricant should be produced by a reputable, knowledgeable supplier, and the principles of adequate lubrication actually applied.

The Functions of Lubrication

Rolling bearing lubricants serve the following primary functions:

1. To lubricate all true rolling contacts elastohydrodynamically;
2. To lubricate that part of the contact between the raceways and rolling elements which is not true rolling;
3. To lubricate the sliding contact which exists between the retainer and other parts of the bearing.

Secondary functions are:

4. To protect the highly finished surfaces of rolling elements and rings from corrosion;
5. To help seal housings against external contamination (done with grease pack);
6. In the case of oil to provide a heat transfer medium.

Oil Lubrication

The Annular Bearing Engineers' Committee (ABEC) has, after extensive research, issued the following recommendations:

"The friction torque in a ball bearing lubricated with oil consists essentially of two components. One of these is a function of the bearing design and the load imposed on the bearing, and the other is a function of the viscosity and quantity of the oil and the speed of the bearing.

"It has been found that the friction torque in a bearing is lowest with a very small quantity of oil, just sufficient to form a thin film over the contacting surfaces, and that the friction will increase with greater quantity and with higher viscosity of the oil. With more oil than just enough to make a film, the friction torque will also increase with the speed.

"The energy loss in a bearing is proportional to the product of torque and speed. This energy loss will be dissipated as heat, and cause a rise in the temperature of the bearing and its housing. This temperature rise will be checked by radiation, convection and conduction of the heat generated to an extent depending upon the construction of the housing and the influence of the surrounding atmosphere. The rise in temperature, due to operation of the bearing, will result in a decrease in viscosity of the oil, and therefore, a decrease in friction torque compared with the friction of starting, but soon a balanced condition will be reached.

"With so many factors influencing the friction torque, energy loss, and temperature rise in a bearing lubricated with oil, it is evidently not possible to give definite recommendations for selection of an oil for all bearing applications.

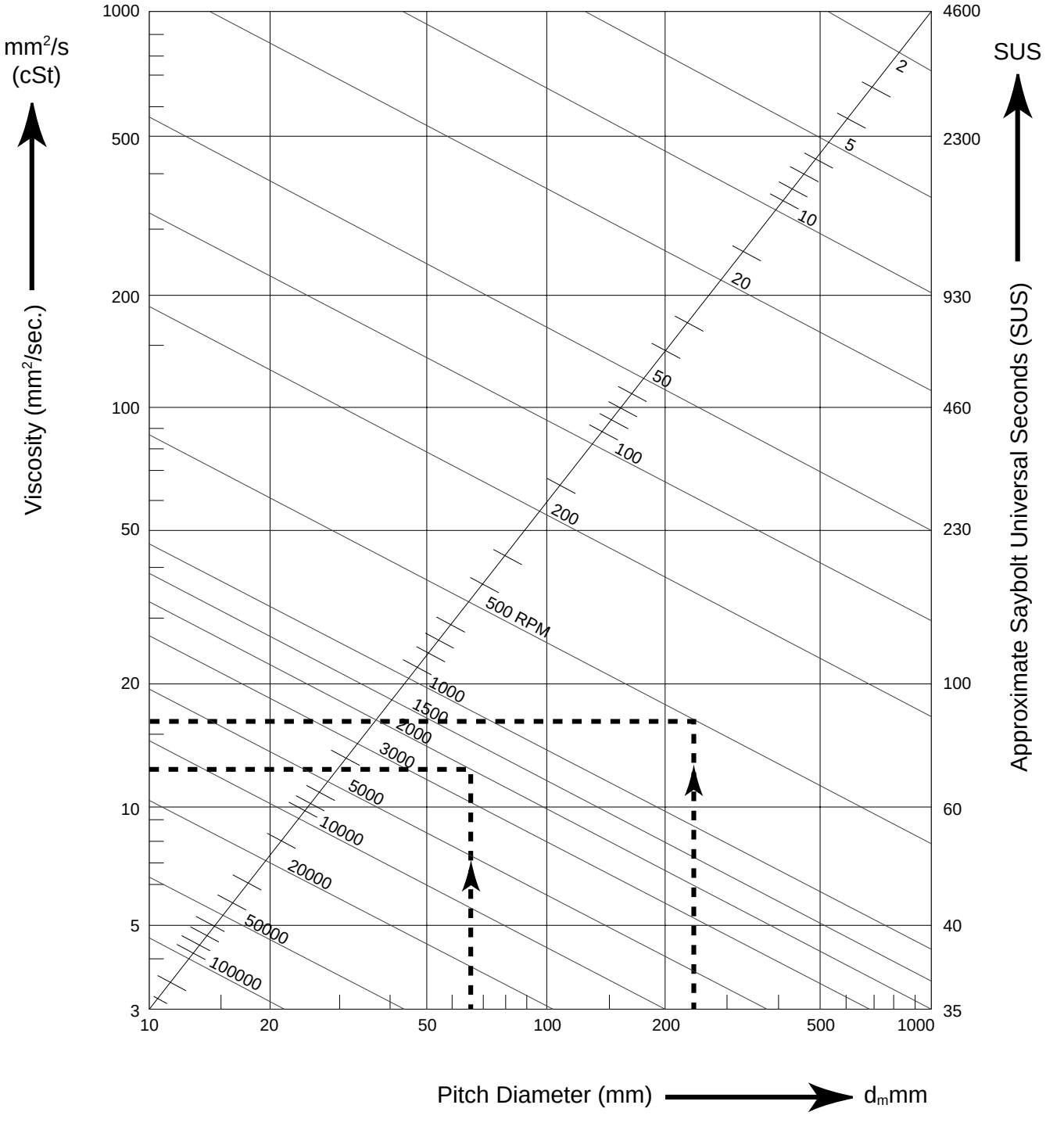
"When bearings have to operate in a wide range of temperatures, an oil that has the least changes with temperature variations, i.e., an oil with high viscosity index, should be selected.

"In the great majority of applications pure mineral oils are most satisfactory, but they should, of course, be free from contamination that may cause wear in the bearing, and they should show high resistance to oxidation, gumming, and to deterioration by evaporation of light distillates, and they must not cause corrosion of any parts of the bearing during standing or operation.

"It is evident that for very low starting temperatures an oil must be selected that has sufficiently low pour-point, so that the bearing will not be locked by oil frozen solid.

"In special applications, various compounded oils may be preferred, and in such cases the recommendation of the lubricant manufacturer should be obtained."

Figure 1 Minimum Required Lubricant Viscosity



d_m = (bearing bore + bearing O.D.) ÷ 2
ν_1 = required lubricant viscosity for adequate lubrication at the operating temperature

Selection of Oil

The most important property of lubricating oil is the viscosity. **Figures** 1 and 2 should be used to assure that the viscosity is adequate in an application to insure proper film forming. **Figure** 1 shows the minimum required viscosity as a function of bearing size and rotational speed. See pages 65 and 67.

The viscosity of a lubricating oil, however, varies with temperature. It decreases with increasing temperature. Therefore, the viscosity at the operating temperature must be used, rather than the viscosity grade (VG) which is based on the viscosity at the internationally standardized reference temperature of 40˚C (104˚F). **Figure** 2 can be used to determine the actual viscosity at the operating temperature.

Example:

A bearing having a bore diameter of 45 mm and an outside diameter of 85 mm is required to operate at a speed of 2000 rpm. The pitch diameter d_m = 0.5 (d + D) = 0.5 (45 + 85) = 65 mm. As shown in **Figure** 1, the intersection of d_m = 65 mm with the oblique line representing 2000 rpm yields a minimum viscosity required of 13 mm^2/s. Now let us assume that the operating temperature is 80˚C (176˚F). In **Figure** 2, the intersection between temperature 80˚C and required viscosity 13 mm^2/s is between the oblique lines for VG46 and VG68. Therefore, a lubricant with the viscosity grade of at least VG68 should be used, i.e. a lubricant of at least 68 mm^2/s viscosity at the standard reference temperature of 40˚C (104˚F).

When determining the operating temperature, it should be kept in mind that the temperature of the oil is usually 3˚ to 11˚C (5˚ to 20˚F) higher than that of the bearing housing. For example, assuming that the temperature of the bearing housing is 77˚C (170˚F), the temperature of the oil will usually be 80˚ to 88˚C (176˚ to 190˚F).

If a lubricant with higher than required viscosity is selected, an improvement in bearing performance (life) can be expected. Contact SKF Application Engineering for more details.

However, since increased viscosity can raise the bearing operating temperature, there is frequently a practical limit to the lubrication improvement which can be obtained by this means. Also only solvent refined mineral oil should be used.

For exceptionally low or high speeds, for critical loading conditions or for unusual lubrication conditions, please consult SKF Applications Engineering.

For all calculations, the viscosity should be expressed in mm^2/s (cSt). See **Figure** 2b for conversion to other viscosity units.

Note: The previous procedure applies to solvent refined mineral oils only.

Relubrication Intervals

The frequency at which the oil must be changed is mainly dependent on the operating conditions and on the quantity of oil used.

Where oil bath lubrication is employed it is normally sufficient to change the oil once a year, provided the bearing temperature does not exceed 50˚C (120˚F) and there is no contamination. Higher temperatures or more arduous running conditions necessitate more frequent changes, e.g. at a temperature of 100˚C (220˚F) the oil should be changed every three months.

For circulating oil systems the period between complete oil changes is dependent on how often the oil is circulated over a given period of time and whether it is cooled, etc. The most suitable period can generally only be determined by trial runs and frequent examination of the oil. The same practice also applies to oil jet lubrication. When in doubt, consult machine manufacturers' recommendations.
In oil mist lubrication, most of the oil is lost, as it is conveyed to the bearing only once.

Oil Supply Systems

Since oils are liquid, suitable enclosures must be provided to prevent leakage and they should receive careful consideration.

Oil Bath

A simple oil bath method (→ **fig** 3) is satisfactory for low and moderate speeds. The oil level at stand-still must not be higher than the center of the lowest ball or roller and, in cases of higher speeds, may lie only ⅛" above the corner at outer ring face and outer ring sphere. Any static oil level must be checked only at standstill. A reliable sight-glass gauge should be provided to permit an easy check.

Circulating Systems

Circulating oil, by forced feed or other means, simplifies maintenance, particularly on large machines, and prolongs the life of the oil where operating conditions are usually severe, such as high ambient temperatures and steadily increasing power inputs and speeds. Entry of oil is best at the center plane of the bearing, at the oil groove, near the top of the housing. Drain for the center feed is best done by two drains, one on each side wall of the housing, leading downward immediately outside the housing. Horizontal drains must be avoided. An alternate method is to have the inlet on one side, below the horizontal center, and drain from the opposite side of the bearing. The outlet should be larger than the inlet to prevent accumulating too much oil in the bearing housing.

The amount of oil retained in the housing is controlled by the location of the outlet. For a "wet sump" the oil level at a standstill must not be higher than the center of the lowest ball or roller. A reliable sight-glass gauge should be provided to permit an easy check. Where there is extreme heat, the lubricant will last longer if the "dry sump" design is used permitting the oil to drain out immediately after it has passed through the bearing. The outlets are then located at the lowest point on both sides of the housing. It has been found that with this arrangement the bearings remain cleaner since

Fig 2a

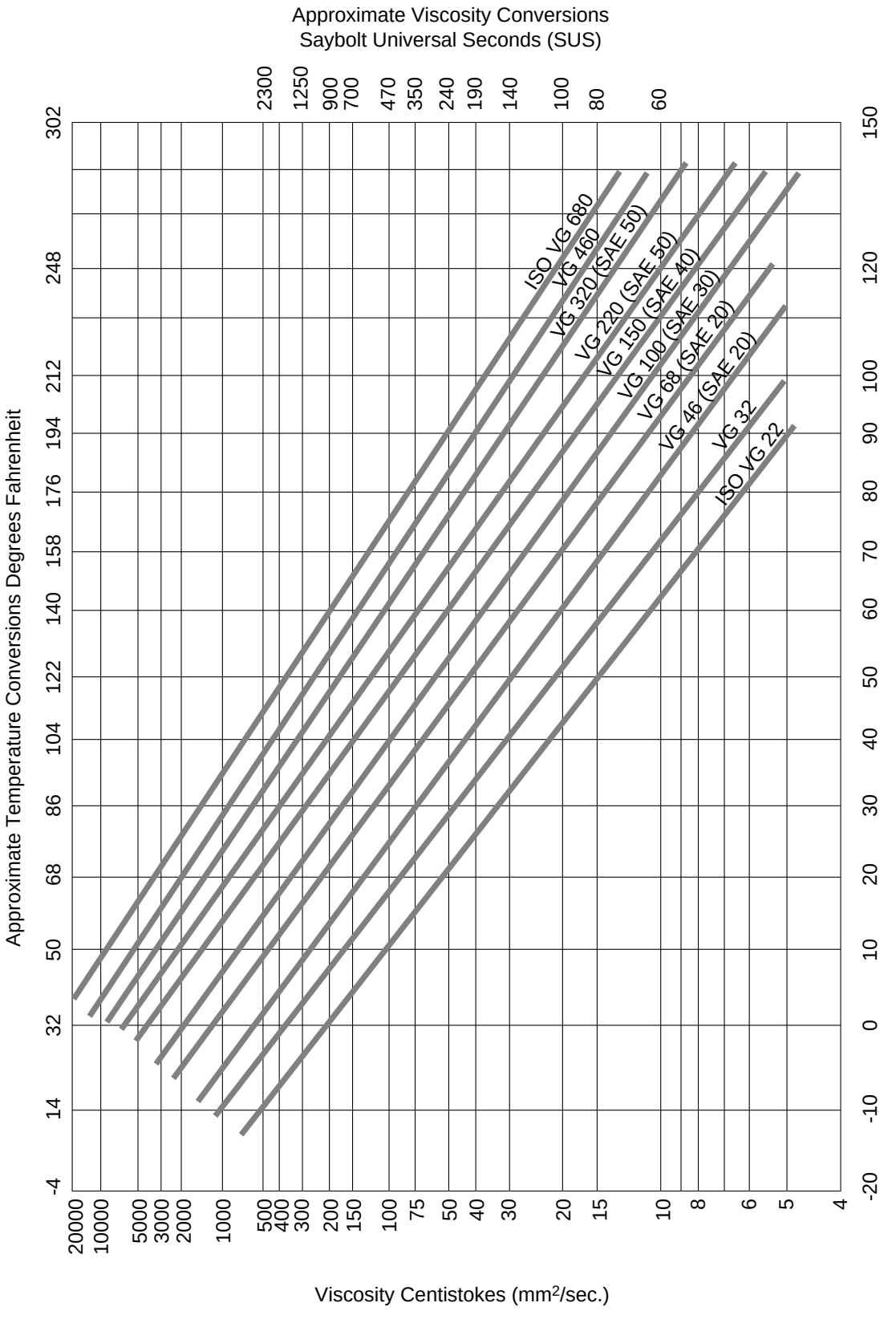
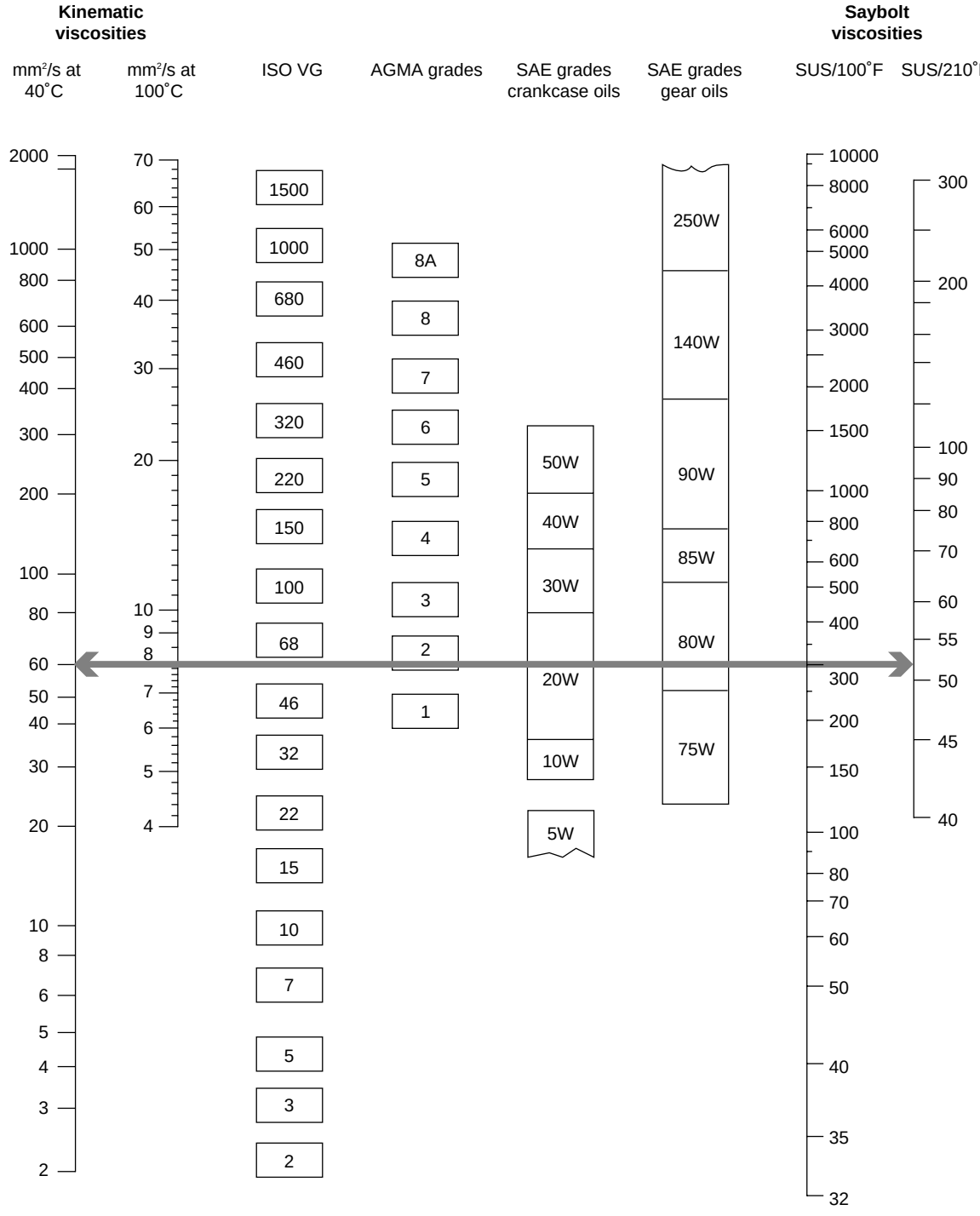


Figure 2. Viscosity-Temperature Chart *Viscosity classification numbers are according to international Standard ISO 3448–1975 for mineral oils having a viscosity index of 95. Approximate equivalent SAE viscosity grades are shown in parentheses.*

Viscosity equivalents



Viscosities based on 95 VI single-grade oils.
ISO grades are specified at 40˚ C.
AGMA grades are specified at 100˚F.
SAE 75W, 80W, 85W, and 5 and 10W
specified at low temperature (below -17˚F = 0˚C).
Equivalent viscosities for 100˚F and 210˚F are shown.
SAE 90 to 250 and 20 to 50 specified at 210˚F (100˚C).

Comparison of various viscosity classification methods

Fig 3

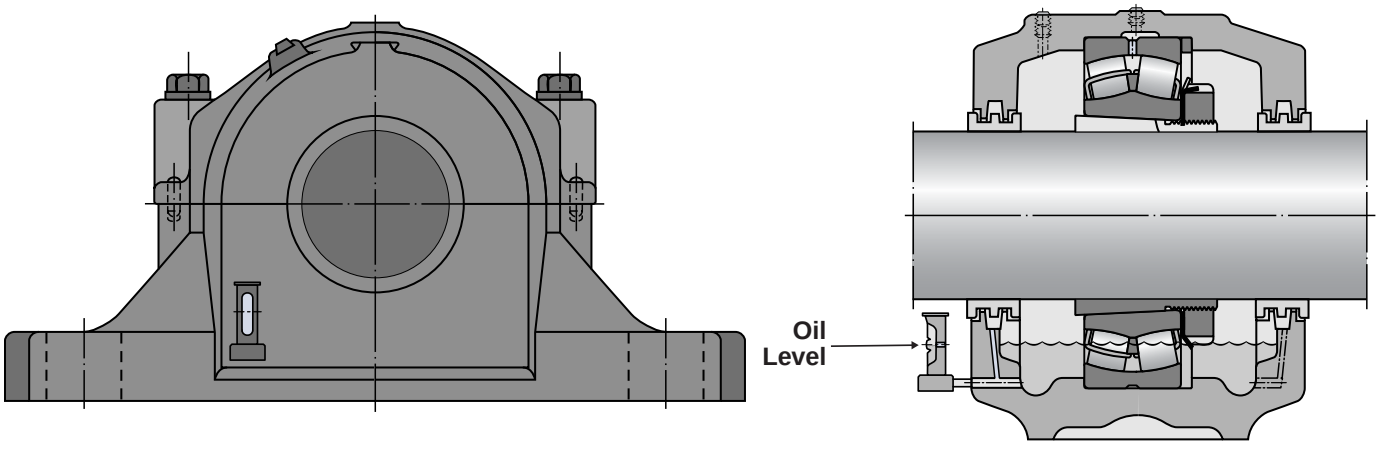


Figure 3. SAF Pillow Block with Oil Sump
The SKF Triple Enclosure Rings are solid rings made with a slip fit on the shaft. The rings can slide along the shaft and adjust their positions with the grooves in the pillow block as governed by the bearing position. Note that the enclosure drains return to the sump below the oil level. This is to prevent oil in mist or splash form from entering the enclosures through these returns.

Fig 4

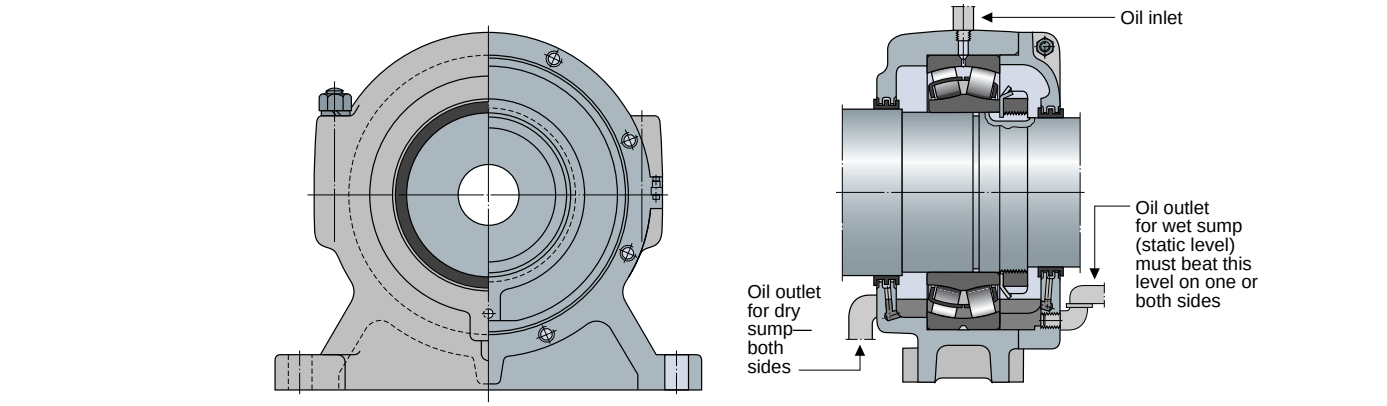


Figure 4. Pillow Block with Oil Circulation for Felt and Paper Dryers in Paper Machines
The drain area (one drain each side of the bearing) should be larger than the inlet area to prevent excess oil from accumulating in the housing. Drains can be located to provide a wet sump (static level) or a dry sump. The cross-section of Figure 4 shows a dry sump example to the left of the bearing and wet sump to the right.

there is little chance of carbonized oil being retained in the housing. When the outlets, or drains, are located at the lowest point on both sides of the housing, an arrangement is necessary to indicate when oil flow is impaired or stopped. Electrically interlocking the oil pump motor with the motor driving the machine can provide this protection. Note that with the SKF bearings the groove or sphere in the outer ring on horizontal mountings will always retain some oil. The bearing will therefore have some oil when it starts to rotate. **Figure** 4 shows a pillow block with oil circulation for felt and paper dryers in paper machines.

Wick Feed

Wick feed is suitable for extreme speeds as a small quantity of filtered oil is supplied to the bearing. Moreover, there is no risk of the lubricant being churned inside the housing. However, some attention must be given to the wicks and they have to be replaced occasionally. They should be dried and thoroughly saturated with oil before mounting, in order to prevent absorption of moisture, which would impair their ability to convey lubricant.

Figure 9 shows a wick feed where the wick siphons the oil into the bearing. With this arrangement, no wear takes place but the wicks will continue to feed oil when the machine has stopped.

Figure 10 shows an arrangement whereby oil is conveyed by a wick by means of capillary attraction to a rotating collar or flinger, where it is thrown off by centrifugal force. This system has the advantage of delivering oil only when it is needed. However, to

Fig 5

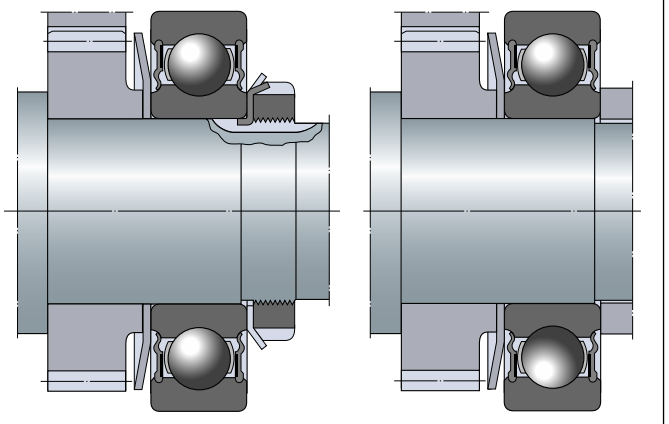


Figure 5. Oil Lubrication of Gears with Small Pitch Diameter
The lubricant squeezed out sideways from the mesh may carry particles worn off the teeth. As foreign matter causes noise and shortens bearing life, a baffle (a) or shield (b) is arranged to deflect the spray. The oil mist inside the housing is generally sufficient for lubrication of the bearings.

Fig 6

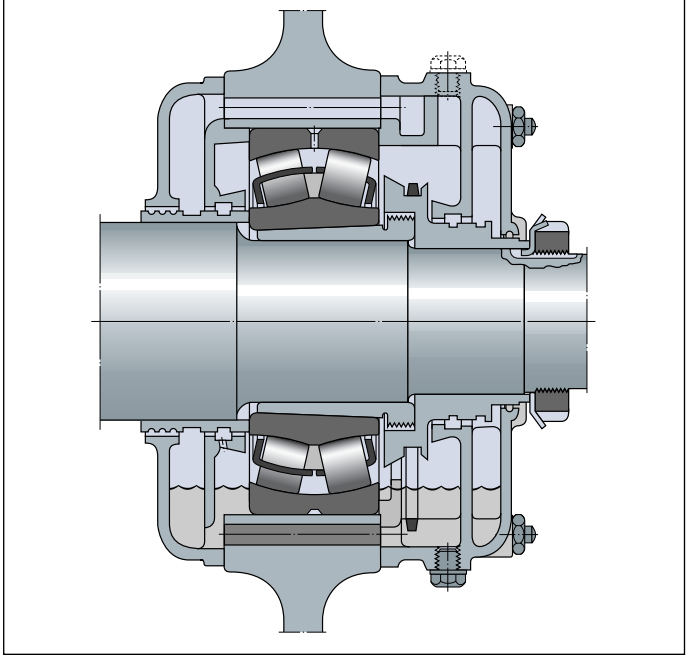


Figure 6. Oil Spray on Fan Motor Bearings
The oil is conveyed to the tapered flinger by an oil ring which dips into the oil bath. An important feature of this application is that the air pressure on both sides of the bearing and enclosures is equalized by connecting ducts. This prevents leakage of the lubricant when the housings are located in an air stream.

function, the wick must be in contact with the rotating flinger.

Oil Mist from Separate Mist Generator

This method consists of a mixture of air and atomized oil being supplied to the bearing housing under suitable pressure. The oil mist is formed in an atomizer. Several manufacturers offer suitable designs and can recommend systems, capacities, and operating temperature and pressures to assure maintaining the required oil viscosity, ν, at the bearings' rolling contacts.

The air, charged with a mist of oil, is introduced in the housing between the bearings so that the air will pass through the bearings before escaping through the housing enclosures or vents. The air from the supply line first passes through a filter then through a reduction valve, which reduces the line pressure to a suitable value. It then passes through an atomizer, where the oil mist is formed. It is important that the air be sufficiently dry, which sometimes makes it necessary to use a dehumidifier before the air is filtered.

This method of lubrication has proven very effective in reducing the operating temperature, not so much by air cooling as by the flow of air preventing excess oil from accumulating in the bearing. Since the air under pressure in the housing escapes through the housing enclosures or vents, the entrance of moisture and grit is retarded. In addition, oil mist lubrication continuously supplies only clean, fresh oil to the bearings. The two factors contribute to full life expectancy. Because the bearings require very little lubricant, the oil consumption is comparatively small.

Air/Oil Lubrication

The air/oil method of lubrication uses compressed air to transport a very precise amount of lubricant directly to a bearing. In contrast to oil mist methods, the air/oil method involves no atomization of the air and oil. Generally, all air oil systems operate on the same principle. A continuous supply of compressed air is used to transport a predetermined amount of oil to a specific point. Oil is metered into the air stream of the supply lines to the bearing housings at set time intervals, monitored by a programmable controller. The oil coats the inside of the supply lines and "spirals" / "creeps" in the direction of the air flow. Through a phenomenon known as the "wall attachment effect," the oil is transported along the inside wall of the feed line by the movement of the air, but never mixes with the air. **Figure** 11 shows a typical air/oil system configuration.

Both the oil mist and air/oil methods of lubrication offer the ability to build and maintain internal bearing pressures, which help to repel contaminants. However, when used in appropriate applications, the air/oil method offers significant advantages. For example, higher base oil viscosity can be more effectively used with the air/oil system. Also, the system does not vent oil mist into the environment. Finally, it uses a lower volume of oil, so it is more cost-efficient.

Fig 7

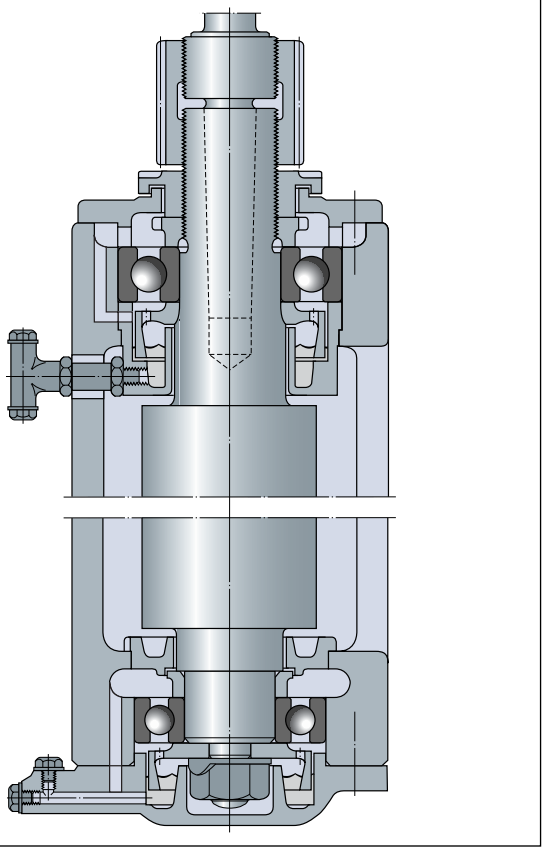


Figure 7. High-Speed Shaper Spindle
Oil is carried upward by the rotating collar under the bearings and passes the latter in the form of a mist. This and Figure 8 are examples of the internally generated mist. Owing to the strong pumping action, space must be available for the oil to accumulate above the bearing. Return channels are often provided to maintain circulation of the lubricant.

Fig 8

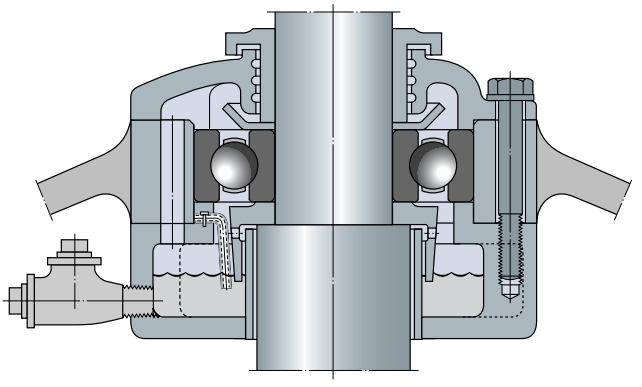


Figure 8. Oil Lubrication for High-Speed Vertical Shaft
Oil climbs upward on the outside taper of the bottom flinger and is blown into a mist where the taper ends. The air circulation, provided by the top flinger and return channels, carries the lubricant into the bearing. The hole in the bottom flinger equalizes the air pressure on both sides of the seal and prevents syphoning of the lubricant. The pin close to the tapered collar counteracts rotation of the oil and therefore contributes towards more efficient lubrication.

Fig 9

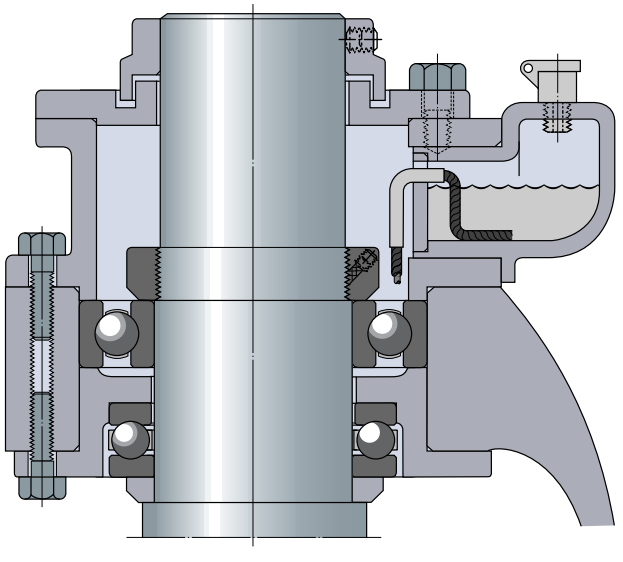


Figure 9. Vertical Milling Machine Spindle
Note the simplicity of design. A small quantity of oil is fed to the bearing by wicks, which syphon the oil from the oil reservoirs.

Fig 10

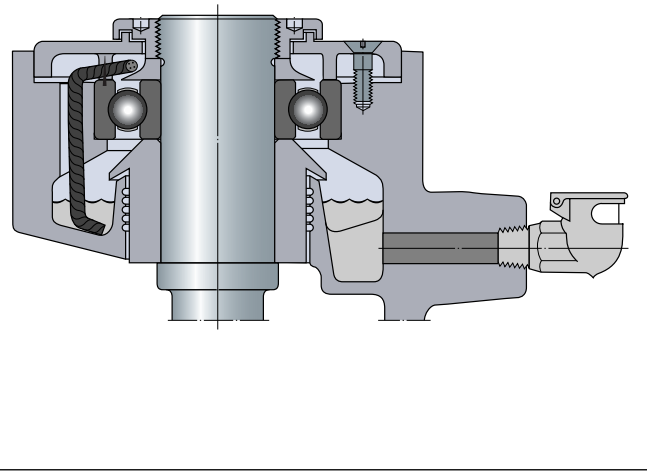
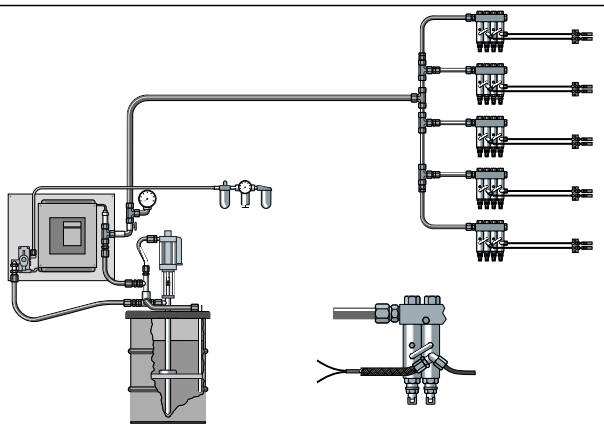
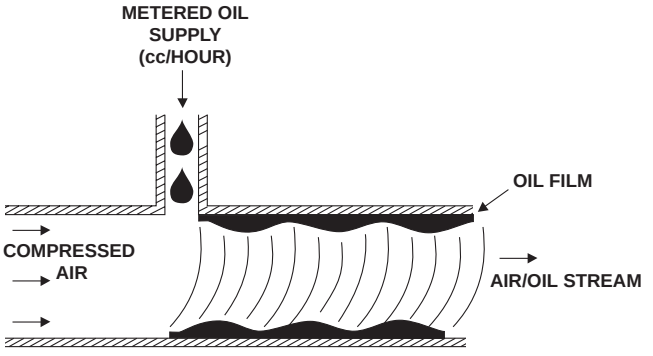


Figure 10. Wick Feed on Vertical Shaper Spindle
The wick conveys the lubricant to a rotating collar, from which it is thrown off and drains back through the bearing. This method circulates and filters the oil, so that clean lubricant is delivered to the bearing.

Fig 11





The oil is transported along the inside wall of a pipe, using a phenomena called the "wall attachment effect".

Figure 11. Typical air/oil configuration

Grease Lubrication

Rolling bearing greases are usually a suspension of oil in a soap or non-soap thickener, plus protective additives. When moving parts of a bearing come in contact with the grease, a small quantity of oil will adhere to the bearing surfaces. Oil is, therefore, removed from the grease near the rotating parts. The oil that is picked up by the bearing is gradually broken down by oxidation or lost by evaporation, centrifugal force, etc. Bleeding of the grease should, therefore, take place to continually supply a quantity of oil sufficient for satisfactory operation. In time, the grease will oxidize or the oil in the grease near the bearing will be depleted. Relubrication is then necessary.

The Ball and Roller Bearing Engineers' Committees of the American Bearing Manufacturers Association, Inc. (ABMA) has been, over a period of years, undertaking laboratory and field research in an effort to obtain a solution to the many problems that are faced by rolling bearing users in obtaining suitable greases for lubricating bearings. In as much as the bearing manufacturers have no control over the manufacture of greases, they cannot be expected to guarantee their performance under all conditions. The guide which follows has been developed from practical experience and careful analysis and its only purpose is to aid the rolling bearing user in the selection of the proper lubricant for the operating conditions of a particular application. The bearing user will appreciate that some lubricants which conform to this guide may not be suitable for all applications, and that some greases that do not conform may sometimes be satisfactory. It is recommended that the bearing user consult with the bearing manufacturer and the grease supplier to determine the lubricant that will be most suitable for the particular application, especially for temperatures below –29˚C (–20˚F) and above 121˚C (250˚F).

There is a trend toward developing a grease sometimes designated as an "all purpose lubricant" covering extremes of temperature. However, until such a grease has been produced and proven by exhaustive tests both in the laboratory and in the field, it will not be recognized in this guide. It has long been felt that the actual temperature of the bearing while running is the most critical factor to be considered in choosing a grease, and for this reason SKF shows the five most frequently encountered grease types and their satisfactory running temperature ranges.

Grease life is not shown since such factors as temperature, speed, load, humidity, type of service and frequency of lubrication would all have to be considered. In applications where elevated temperature, high speed, severe dirt, high humidity or other extreme conditions are encountered, particularly with open type bearings, accelerated deterioration of the grease may ensue. In such cases periodic inspection during the first few weeks of operation will provide the best determination of the required frequency of relubrication.

On the other hand, relubrication of sealed bearings which have been provided with approved greases in the proper amount is not generally considered advisable.

All grease shall be free from dirt, abrasive matter, fillers, excessive amount of moisture, free acid or free alkali.

Grease Classification

1. Group I — General Purpose
   Greases that are expected to give proper lubrication to bearings whose operating temperatures may vary from –40˚C to 121˚C (–40˚F to 250˚F).

2. Group II — High Temperature
   Greases that are expected to give proper lubrication to bearings whose operating temperatures may vary from -18˚C to 149˚C (0˚F to 300˚F).

3. Group III — Medium Temperature
   Greases that are expected to give proper lubrication to bearings whose operating temperatures may vary from 0˚C to 93˚C (32˚F to 200˚F).

4. Group IV — Low Temperature
   Greases that are expected to give proper lubrication to a bearing whose operating temperature may go as low as –55˚C (–67˚F) or as high as 107˚C (225˚F).

5. Group V — Extreme High Temperature
   Greases that are expected to give proper lubrication for comparatively short periods of time where bearing operating temperature may be as high as 232˚C (450˚F).

These five groups of greases cover applications where the lubrication is not affected by extremely heavy loads, high speeds or excessive humidity. The tabulation of test requirements which follows shows those characteristics needed to meet the functional requirements of good rolling bearing greases.

The five groups of greases previously listed along with their test requirements in general apply to both ball and roller bearing greases. Usually roller bearing lubrication requires a somewhat softer grease, and a minimum ASTM worked penetration of 300 is often specified. All of the other requirements such as oxidation stability, dropping point and dirt count apply to greases for roller bearing as well as ball bearing applications.

In greasing rolling bearings the use of high pressure equipment is not only unnecessary but is actually undesirable unless used with great care. High pressure may damage the bearings, cause unnecessary loss of grease, create a danger of overheating due to overgreasing and produce unsightly conditions around the bearing. A ball or roller bearing in most applications is assured of adequate lubrication if the level of grease is maintained at ⅓ to ½ of the volume of the bearing housing space. Any greater amount will, as a rule, be discharged by the seals and be wasted.

There may exist applications where it will be necessary to grease the bearings with either more or less than the recommended ⅓ to ½ of volume. In applications where the speed is high or low torque is a requirement the bearings may be lubricated with a very small amount of grease. Similarly in applications where the speed is very low and the bearing is exposed to excessive amounts of dirt or moisture the bearing may be packed nearly full.

Greases to be used in miniature bearings and instrument bearings may require a lower dirt maximum per cubic cm ratio than listed in the accompanying table.

Methods of Testing

Test Requirements	Method
ASTM Penetration Normal Worked	Method ASTM D-217
Oxidation	Method ASTM D-942
Low Temperature Torque	Method ASTM D-1478
Water Resistance	Method ASTM D-1264
Dropping Point	Method ASTM D-566
Evaporation	Method ASTM D-972
Dirt	Method Federal Test Method Standard No. 791-B Method 3005.3
Consistency, Stability	Method ASTM D-217
Abrasive Matter	Method ASTM D-1404
Free Acid and Free Alkali	Method ASTM D-128
Fillers	Method ASTM D-128
Moisture	Method ASTM D-128

Test Requirements

Tests	Group I	Group II	Group III	Group IV	Group V
ASTM Penetration Normal Worked[1]	250 to 350	200 to 300	220 to 300	260 to 320	250 to 310
Oxidation	10# max. drop in 500 hours	10# max. drop in 500 hours	10# max. drop in 500 hours	5# max. drop in 500 hours	5# max. drop in 100 hours at 121˚C (250˚F)
Low Temperature Torque	1 rev. in max. of 10 sec. at –40˚C (–40˚F)	—	—	1 rev. in max. of 5 sec. at –55˚C (–67˚F)	1 rev. in max. of 10 sec. at –40˚C (–40˚F)
Water Resistance	50% max. loss	-	50% max. loss	20% max. loss	50% max. loss
Dropping Point	149˚C min. (300˚F)	177˚C min. (350˚F)	149˚C min. (300˚F)	149˚C min. (300˚F)	232˚ C min. (450˚F)
Evaporation	—	—	—	1.5% max. in 22 hours at 121˚C (250˚F)	4.0% max. in 22 hours at 204˚C (400˚F)
Dirt Max. Particles per cubic cm	5000/5-20 microns 2000/20-50 microns 50/50-75 microns None over 75 microns	Same as Group I	Same as Group I	Same as Group I	Same as Group I
Consistency Stability: max. ASTM Penetration after 100,000 strokes	Penetration shall not increase more than 100 points and in no case be more than 375	Penetration shall not increase more than 100 points and in no case be more than 350	Penetration shall not increase more than 100 points and in no case be more than 350	Penetration shall not increase more than 100 points and in no case be more than 375	Penetration shall not increase more than 100 points and in no case be more than 375

[1]National Lubricating Grease Institute Code — No. 0: 355-385; No. 1: 310-340; No. 2: 265-295; No. 3: 220-250; No. 4: 175-205

Fig 12

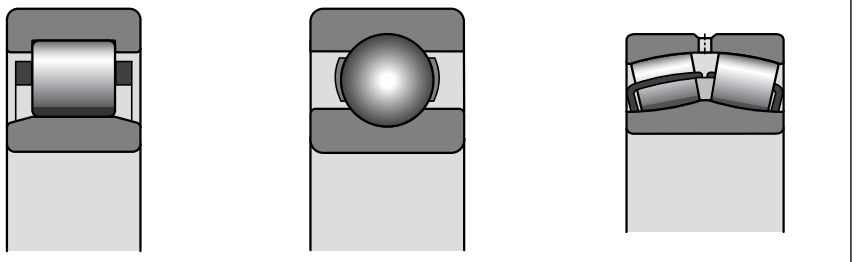


Figure 12. Radial Bearings on Horizontal Shafts
Since the machined retainer in (a) presents flat surfaces to the surrounding lubricant, a stiff grease may soon leave the interior of the bearing dry. The lubricant must therefore, in this case, be rather soft at the operating temperature. A somewhat stiffer grease might, however, be satisfactory with (b) as the interior is more accessible. The position of (c) is intermediate in this respect.

Fig 13

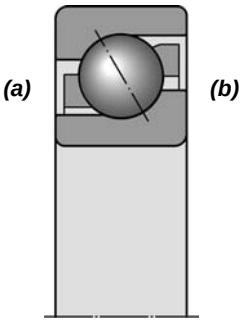


Figure 13. Angular Contact Ball Bearing on Horizontal Shaft
Angular contact bearings tend to pump the lubricant from the side (a) to (b). A grease of soft consistency would pass right through the bearing if applied at (a), whereas, a stiff grease would be more satisfactory if applied from the same side. On the other hand, a soft grease would be more desirable if applied at side (b), since a hard grease would channel and leave the bearing dry.

Fig 14

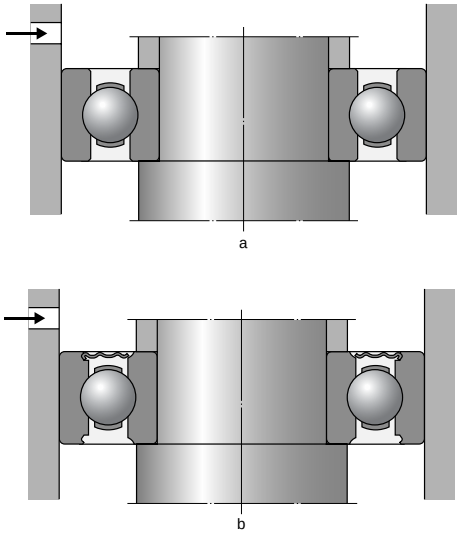


Figure 14. Deep Groove Ball Bearings on Vertical Shaft
On vertical applications where the grease is admitted above the bearing a hard grease is required so that it remains in the bearing (a). Where the grease is resting on a plate, as in (b), a softer consistency is required as otherwise no lubricant would seep into the bearing.

Greases considered satisfactory lubricants for rolling bearings are combinations of soap or non-soap thickening agents, mineral oil, and in many cases ingredients necessary to impart special properties to the grease. Soaps such as sodium, calcium, aluminum, lithium, barium, and non-soap thickening agents such as silica and chemically treated clays are generally used. Rust and oxidation inhibitors and tackiness additives are often added to impart properties not normally present in the grease. Sodium and mixed sodium-calcium soap greases are considered good general purpose greases, while calcium, lithium, and barium soap greases and the non-soap greases are often used when water resistance is necessary. However, calcium base greases are limited to lower operating temperatures. The fluids used in compounding these greases may vary in viscosity from 10 mm^2/s at 38˚C (60 SUS at 100˚F) to over 431 mm^2/s(2000 SUS). Special synthetic oils are used to produce greases that can be used at extremely low and/or extremely high temperatures. Be careful to avoid mixing greases of different soap bases. Since the rust preventive in which SKF bearings are packed is a petroleum product, the only occasion for removing it is when the bearing is to be lubricated with special lubricants.

Operating Conditions

The amount of oil needed by the bearing depends of course, on operating conditions — particularly temperature. Since a temperature rise of 8˚ to 11˚C(14˚ to 20˚F) can double the rate of oxidation, the lubrication problem at the higher temperatures requires more careful consideration. It would however be erroneous to conclude that a grease suitable for a high temperature would also be successful at low temperatures. In all probability, it would be too hard to supply the oil required. On the other hand, a grease which is too soft may have a tendency to flow out of a hot application. The selection of the most suitable consistency of a grease is dependent upon the bearing design as well as its orientation.

In **Figures** 12, 13, and 14 further reference is made to this condition.

It is accordingly advisable to have a competent Lubrication Engineer check all applications before taking any action which is not supported by available experience.

Lubrication and Maintenance

Relubrication

Rolling bearings have to be lubricated if the service life of the grease used is shorter than the expected service life of the bearing. Relubrication should always be undertaken at a time when the lubrication of the bearing is still satisfactory.

The time at which relubrication should be undertaken depends on many factors. These include bearing type and size, speed, operating temperature, grease type, space around the bearing and the bearing environment. The SKF relubrication intervals are defined as the time period, at the end of which 99% of the bearings are still reliably lubricated, and represent L_{01} grease lives. The L_{10} grease lives are approximately twice the L_{01} lives.

The information given in the following does not apply to applications where water and/or solid contaminants can penetrate the bearing arrangement. In such cases it is recommended that the grease is frequently renewed in order to remove contaminants from the bearing.

Relubrication Intervals

The relubrication intervals t_f for normal operating conditions can be read off as a function of bearing speed n and bore diameter d of a specific bearing type from **Figure** 15. The diagram is valid for bearings on horizontal shafts in stationary machines under normal loads. It applies to good quality lithium base greases at a temperature not exceeding +70˚C(+160˚F). To take account of the accelerated ageing of the grease with increasing temperature it is recommended that the intervals obtained from the diagram are halved for every 15˚C(27˚F) increase in bearing temperature above +70˚C(+160˚F), remembering that the maximum operating temperature for the grease should not be exceeded. The intervals may be extended at temperatures lower than +70˚C(+160˚F) but as operating temperatures decrease the grease will bleed oil less readily, and at low temperatures an extension of the intervals by more than two times is not recommended. It is not advisable to use relubrication intervals in excess of 30,000 hours. For bearings on vertical shafts the intervals obtained from the diagram should be halved.

It is also necessary to lubricate more frequently in applications where there is a risk of heavy contamination, e.g.: bearings in papermaking machinery, where housings are washed with water. Large roller bearings having a bore diameter of 300 mm and above, adequate lubrication will be obtained only if the bearing is more frequently relubricated than indicated by the diagram, and the lines are therefore broken. The grease quantity to be supplied can be obtained from the equation below for applications where conditions are otherwise normal, i.e. where external heat is not applied (recommendations for grease quantities for periodic relubrication are given in the following section).

$$G_k = (0.3 \ldots 0.5)\ D\ B \times 10^{-4}$$

where

G_k = grease quantity to be continuously supplied, g/h
D = bearing outside diameter, mm
B = total bearing width (for thrust bearings use total height H),mm

Relubrication procedures

One of the two procedures described below should be used, depending on the relubrication interval t_f obtained:

— If the relubrication interval is shorter than 6 months, then it is recommended that the grease fill in the bearing arrangement be replenished (topped up) at intervals corresponding to 0.5 t_f; the complete grease fill should be replaced after three replenishments.
— When relubrication intervals are longer than 6 months it is recommended as a rough guideline that all used grease be removed from the bearing arrangement and replaced by fresh grease.

Replenishment

By adding small quantities of fresh grease at regular intervals the used grease in the bearing arrangement will only be partially replaced. Suitable quantities to be added can be obtained from

$$G_p\,(g) = .005 \times D\ (mm) \times B\ (mm)$$

$$G_p\,(oz) = \frac{D\ (in) \times B\ (in)}{10}$$

where

G_p = grease quantity to be added when replenishing
D = bearing outside diameter
B = total bearing width (for thrust bearings use total height H)

Grease Supply Systems

Housings without Grease Fittings

For light and medium service, such as line shafts, the original supply of grease will usually last from one to two years or even a longer time at lower ambient temperature. It is, accordingly, advisable to omit grease fittings to discourage over-greasing. The old grease should be removed during overhauls and replaced by new grease, which should be worked into the available space in the bearing by hand. ABMA recommends from ⅓ to ½ of the volume in the housing should be filled with grease for normal applications. An over-supply would only result in churning and breakdown of the lubricant.

Needless to say, care should be taken to keep the bearing and lubricant clean.

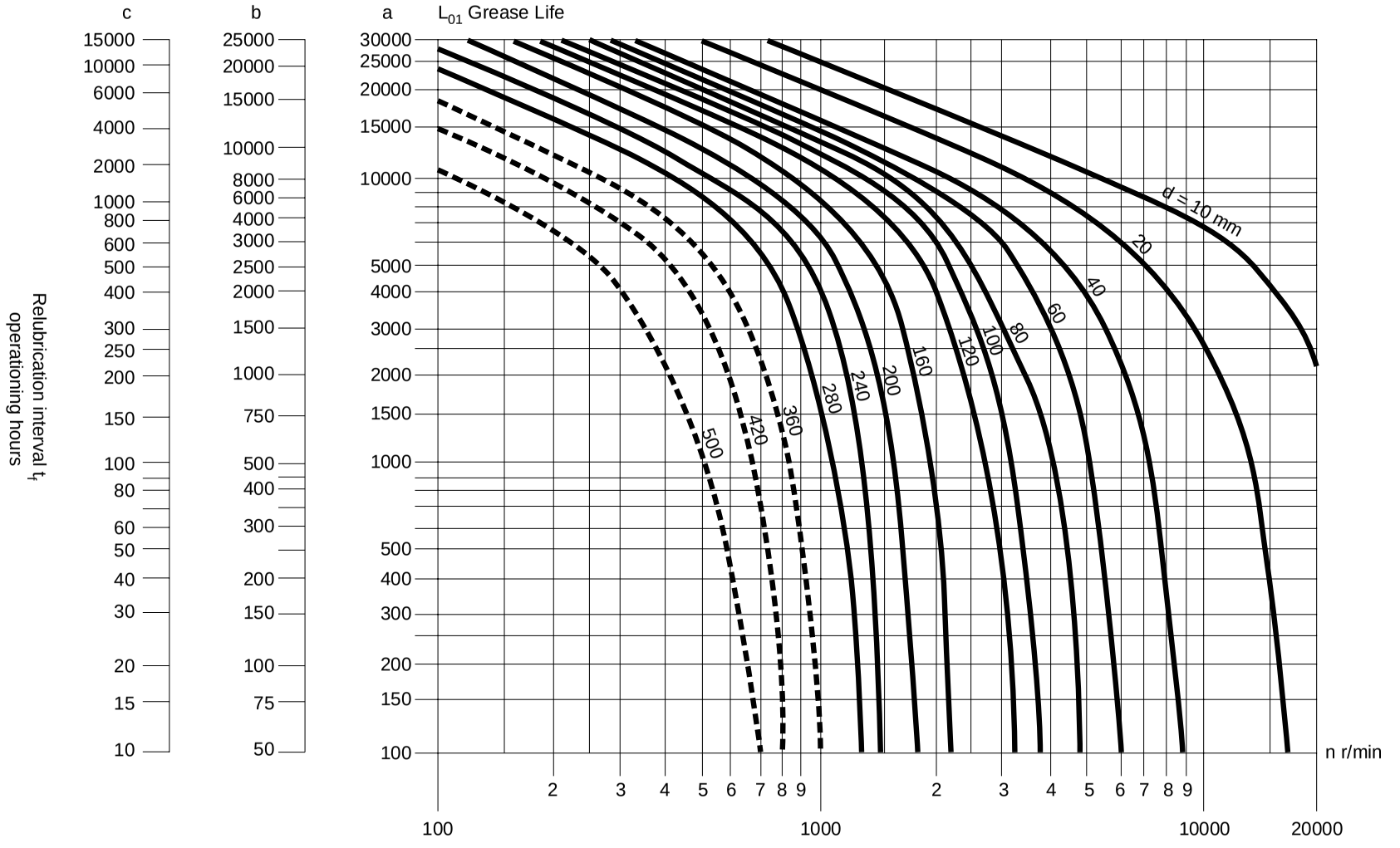
Housings with Grease Fittings

The original filling, and subsequent additions of small amounts of grease after cleaning at major overhauls, should be made as indicated previously.

Adding of lubricant close to the bearing can be effected in several ways.

Figure 16 shows a design which can easily be adapted for this purpose. The lubricant is added using a grease gun at the bottom of the housing, close to the outer ring. The radially placed ribs inside the left-hand end cover tend to deflect the new grease into the bearing without the undesirable effect of first filling the entire space in the

Fig 15



Scale a: radial ball bearings
Scale b: cylindrical roller bearings, needle roller bearings
Scale c: spherical roller bearings, CARB™ toroidal roller bearings, taper roller bearings, thrust ball bearings; cylindrical roller thrust bearings, needle roller thrust bearings, spherical roller thrust bearings ($0.5t_f$); crossed cylindrical roller bearings with cage ($0.3t_f$); full complement cylindrical roller bearings ($0.2t_f$)

d: bearing bore diameter (mm)

Figure 15. See Page 81 for an Example of How to Use This Chart. See pg. 75 (Lubrication and Maintenance) for explanation of L_{01}.

end-cover. These ribs also prevent the grease from being carried around or worked by the rotating shaft, thereby keeping the temperature down and preventing grease leakage. The end-cover on the right-hand side provides ample space to receive the old grease which has passed through the bearing. The cover is split to facilitate removal of the old grease at major overhauls.

Another method which can be used for small and medium size bearings is to force out the old grease with the new. The housing should have a large drain, located on the side opposite the grease fitting, to force all grease to pass through the bearing.

Before adding new grease, make sure that the grease fitting is clean. Clean out any grease which may have caked in the drain hole, so the old grease may be easily expelled. When adding grease, remove the drain plug and force the new grease through the fitting while the shaft is rotating. Continue forcing in new grease until it starts to come out of the drain. The shaft should then be allowed to rotate for about 20 minutes before replacing the drain plug, to give the bearing a chance to expel the excess grease.

Observe cleanliness at all times, whatever method is used, and be sure the new lubricant is clean. Contaminated lubricant will reduce the life of the bearing.

Comparing both methods, the first calls for more skill if the dangers of over-greasing are to be avoided, but has the advantage of being applicable to large bearing sizes, while the latter lends itself readily to small bearings. With large bearings the pressure of the grease gun may not suffice to drive the old grease through the drain to the extent desired. Consequently, the bearings might be left in an over-greased state conducive to hot running.

Grease Chamber Lubrication

The arrangement shown in **Figure** 17 employs the use of a double-shielded bearing, which has been prelubricated. One side of the bearing housing is packed full of an appropriate grease by the usual grease gun method. See grease classifications page 72. Addition of lubricant to the original supply takes place by seepage of oil from the grease as well as a small amount of grease being forced though the clearance in the shield. Care should be taken to ensure that the proper type and amount of grease is injected. See replenishment on page 75. This method does not eliminate the need for care in avoiding overgreasing and its consequent overheating and premature failure. Using double-shielded bearings not only helps prevent over-greasing but also protects the bearing from dust and foreign matter at assembly, or whenever the bearing is exposed. Using the double-shielded bearing does not permit the elimination of the usual housing enclosures.

Prelubricated ball bearings without provisions for adding more grease are used in domestic appliances and other machines where the total number of service hours is small. It should be kept in mind that the life of these “greased for life” bearings may be limited to the time the grease will last.

Grease Quantity Regulator

The grease chamber method described above and the frequency of relubrication needed as relative speeds increase both add to the potential for grease buildup in a housing. SKF developed a Grease Quantity Regulator design that prohibits over-greasing regardless of the frequency of lubrication needed. The Regulator is shown adapted to a horizontal application in **Figure** 18 and to a vertical application in **Figure** 19. The Regulator consists of a regulating disc, which turns with the shaft and maintains a small radial or tapered gap with a stationary part.

If the grease quantity in the bearing housing does not exceed a limit suitable for that bearing and housing, the grease at both sides of the bearing remains nearly stationary and the temperature remains normal. This is the grease reserve from which oil is supplied to the bearing when bearing temperature begins to increase. If the grease quantity is increased beyond the stable limit, part of the grease is thrown about by the rotating bearing and is thrown against the Regulator and ejected through the drain. The process continues until fresh grease is no longer injected and the operating quantity becomes stable again.

Fig 16

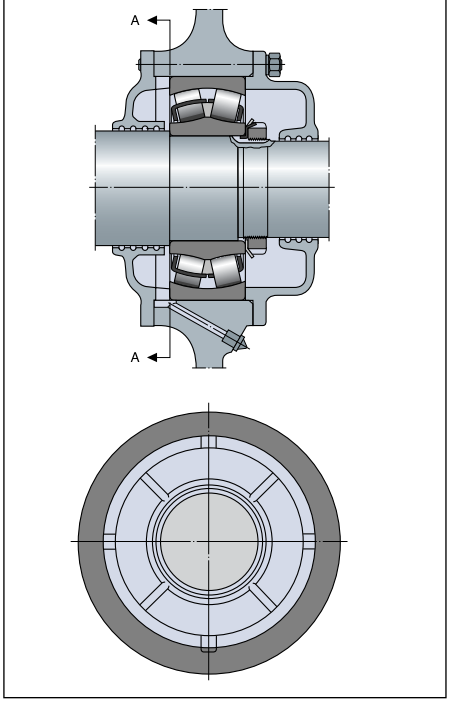


Figure 16. Roller Bearing Arrangement for Large Electric Motor

Fig 17

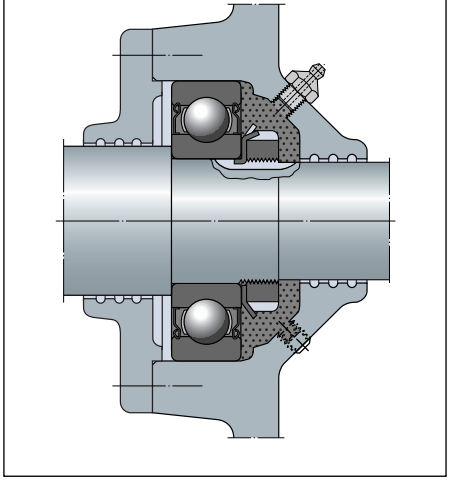


Figure 17. Grease Chamber for Electric Motor
The space between the shield in the bearing and the end-cover is packed with suitable grease.

Comparative Advantages of Oil and Grease

Advantages of oil

1. Oil is easier to drain and refill. This may be more desirable for applications requiring frequent lubricating intervals.
2. The correct amount of lubricant is more easily controlled.
3. Oil lends itself more readily to the lubrication of all parts of a machine.
4. Oil lends itself to applications with higher temperatures and higher operating speeds.

Advantages of grease

1. Maintenance work is ordinarily reduced since there are no oil levels to maintain, and addition of new lubricant is required less frequently.
2. Grease in proper quantity is more easily confined to the housing. Design of enclosures can therefore be simplified.
3. Freedom from excess leakage is readily accomplished in food, textile and chemical industries, and where contamination of products must be avoided.
4. Grease improves the sealing efficiency of enclosures.

A major feature of relubricating bearings with grease quantity regulators is that the inlet is located on the side of the bearing opposite the Regulator. The interior of the cover on the inlet side should have ribs dividing the inboard space into chambers to reduce churning. The chambered cover and regulator disc combine the advantages of introducing fresh grease immediately to where it is needed, effective purging of old grease, and freedom from the dangers of over-greasing.

High Temperature Applications

Where heat is generated in the bearings only, temperature can usually be kept within reasonable limits by means of a suitable selection and quantity of lubricant. The contrary applies to cases where heat also comes from outside sources, such as in hot gas fans, dryers, and so forth. Under such conditions, some method of cooling is usually necessary to avoid excessive bearing temperatures and premature failure of lubrication. The following are some of the methods used for decreasing the bearing temperature:

1. Auxiliary cooling disc for dissipation of heat conducted through the shaft (→ **fig** 20).
2. Water-jacketing the end-covers will also serve to cool the oil. Here again, it is essential to shut off the cooling water when the machine is stationary in order to prevent condensation. The bearing housing extending around the outer ring should not be water-jacketed, since this will introduce complications in maintaining the desired fit of the outer ring in the housing.
3. Circulation of the oil can also be used to advantage, provided that the oil is cooled and filtered. Settling tanks are also used to permit any sludge formation or other foreign matter to settle out. As previously pointed out, the oil should be permitted to drain out as quickly as possible at the lowest point on both sides of the housing after having passed through the bearing. Thus, unnecessary heating of the oil and the settling of sludge inside the housing are prevented.

Minimum Friction Applications

The friction of SKF ball and roller bearings is, in most cases, too small to merit any attention. There are, however, applications such as hand-driven appliances, instruments, etc., where friction must be kept to a minimum. Friction is due not only to the bearing design but also the quantity of lubricant used. Because of the many exacting requirements that are necessary if friction is to be held to a minimum, it is impossible to treat this subject in a general way. Applications of this kind should therefore be given individual consideration. SKF Applications Engineering welcomes the opportunity to make use of experience which has been gained in this field.

Protection Against Moisture

No rolling bearing lubricant has been developed which will completely protect a bearing against moisture. However, rolling bearings are frequently used with success where moisture is present. The design of enclosures and lubrication systems requires careful consideration. Selection of the lubricant is important to minimize effects of some moisture entry.

Compounded oils are more water repellent than straight mineral oils and are therefore better able to keep moisture from the bearing surfaces. If the oil is permitted to oxidize, it will be more destructive to the bearing surfaces when moisture is present.

Lithium-base greases are water-repellent but the grease must completely cover the bearing to protect it. Water-repellent grease is useful also in improving the efficiency of labyrinth seals.

Fig 18

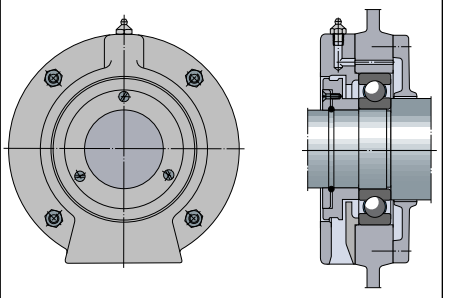


Figure 18. Grease Quantity Regulator Horizontal Shaft

Fig 19

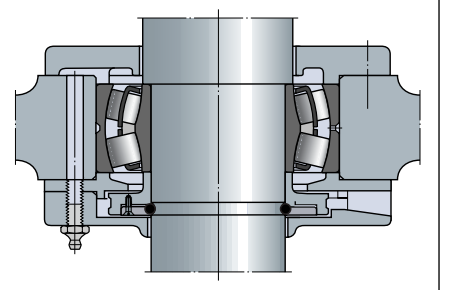


Figure 19. Grease Quantity Regulator Vertical Shaft

Protection of Idle Machinery

Equipment which is idle must be set in motion periodically to spread the lubricant over all bearing surfaces.

Suitable intervals depend on ambient conditions. For storage, assembled bearings should be cleaned and packed full with petrolatum or other suitable anti-rust agents, according to the advice of a reputable supplier. However, storage grease must be removed thoroughly and the proper amount of a suitable lubricant applied before operation.

Cleaning

All lubricants have a tendency to deteriorate in the course of time, but at a greatly different rate. Therefore, sooner or later, it will be necessary to replace the old lubricant with new.

Oils and greases should be removed in the early stages of deterioration so that removal does not become unnecessarily troublesome. Oils can be drained and the bearing flushed and washed, preferably with some solvents, kerosene or even with light oil. The solution should then be drained thoroughly and the bearing and housing flushed with some hot, light oil and again drained before adding new lubricant. Lighter petroleum solvents may be more effective for cleaning but are often objectionable, either because of flammability or because they may have a tendency to become corrosive, particularly in the presence of humidity.

A grease is also more easily replenished in early stages of deterioration, for instance, by displacement with new grease, if the housing is designed so that this can be done.

Bearings which are dismantled are, of course, much more easily cleaned than bearings which must stay assembled in equipment. Solvents can then be used more freely for cleaning.

Badly oxidized oil and grease, however, need a very thorough treatment for their removal; ordinary solvents are usually not satisfactory.

The following methods for cleaning unshielded bearings, as suggested by ABEC (Annular Bearing Engineers' Committee) are recommended.

Fig 20

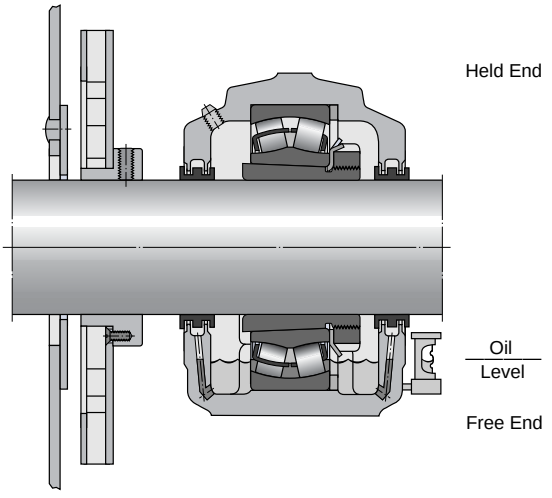


Figure 20. Heat-Dissipating Disc
The disc is located between the bearing and the source of heat, so that any heat traveling through the shaft towards the bearing will be dissipated by radiation. The disc is sometimes provided with vanes to improve the efficiency by circulating the air.

1. Cleaning unmounted bearings which have been in service

"Place bearings in a basket and suspend the basket in a suitable container of clean, cold petroleum solvent or kerosene and allow to soak, preferably overnight. In cases of badly oxidized grease, it may be found expedient to soak bearings in hot, light oil at 93˚ to 116˚ C (200˚ to 240˚F), agitating the basket of bearings slowly through the oil from time to time. In extreme cases, boiling in emulsifiable cleaners diluted with water will usually soften the contaminating sludge. If the hot emulsion solutions are used, the bearings should be drained and spun individually until the water has completely evaporated. The bearings should be immediately washed in a second container of clean petroleum solvent or kerosene. Each bearing should be individually cleaned by revolving by hand with the bearing partly submerged in the solvent... turning slowly at first and working with a brush if necessary to dislodge chips or solid particles. The bearings may be judged for their condition by rotating by hand. After the bearings have been judged as being clean, they should immediately be spun in light oil to completely remove the solvent . . . coated with preservative if they are not to be reassembled immediately and wrapped at once in clean oilproof paper while awaiting reassembly.

"The use of chlorinate solvents of any kind is not recommended in bearing cleaning operations because of the rust hazard involved. Nor is the use of compressed air found desirable in bearing cleaning operations."

2. Cleaning of Bearings as Assembled in an Installation

"For cleaning bearings without dismounting, hot, light oil at 93˚ to 116˚ C (200˚ to 240˚F) may be flushed through the housing while the shaft or spindle is slowly rotated. In cases of badly oxidized grease and oil, hot, aqueous emulsions may be run into the housings, preferably while rotating the bearings until the bearing is satisfactorily cleaned. The solution must then be drained thoroughly, providing rotation if possible, and the bearing and housing flushed with hot, light oil and again drained before adding new lubricant. In some very difficult cases an intermediate flushing with a mixture of alcohol and light mineral solvent after the emulsion treatment may be useful.

"If the bearing is to be relubricated with grease, some of the fresh grease may be forced through the bearing to purge any remaining contamination. This practice cannot be used unless

Fig 21

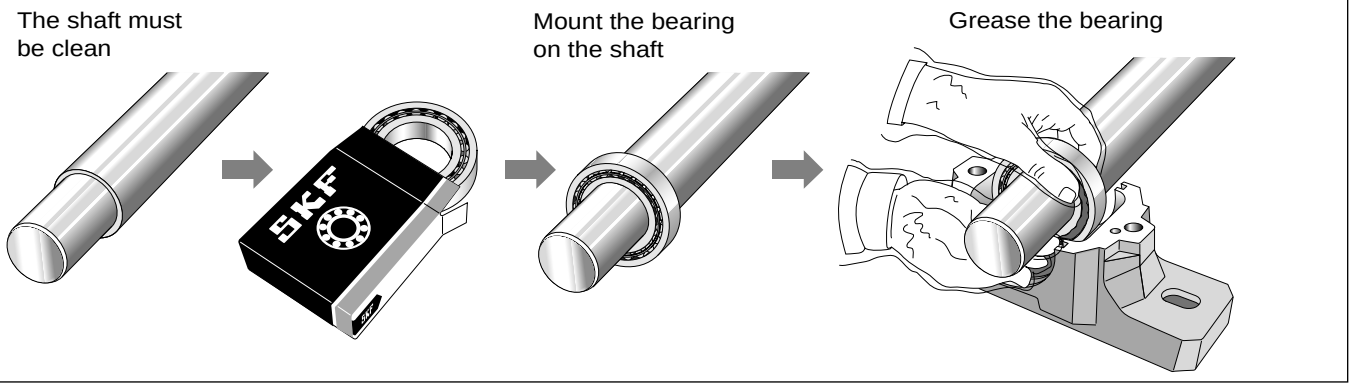


***Figure 21**. Mounting procedure*

there are drain plugs which can be removed so that the old grease may be forced out. Also, bearings should be operated for at least twenty minutes before drain plugs are replaced, as excess lubricant will cause serious overheating of the bearing."

3. Oils Used for Cleaning

"Light transformer oils, spindle oils, or automotive flushing oils are suitable for cleaning bearings, but anything heavier than light motor (SAE 10) is not recommended. An emulsifying solution made with grinding, cutting or floor cleaning compounds, etc., in hot water, has been found effective. Petroleum solvents must be used with the usual precautions associated with fire hazards."

WARNING: Follow the Material Safety Data Sheet (MSDS) safety instructions included with the solvent you use to clean bearings.

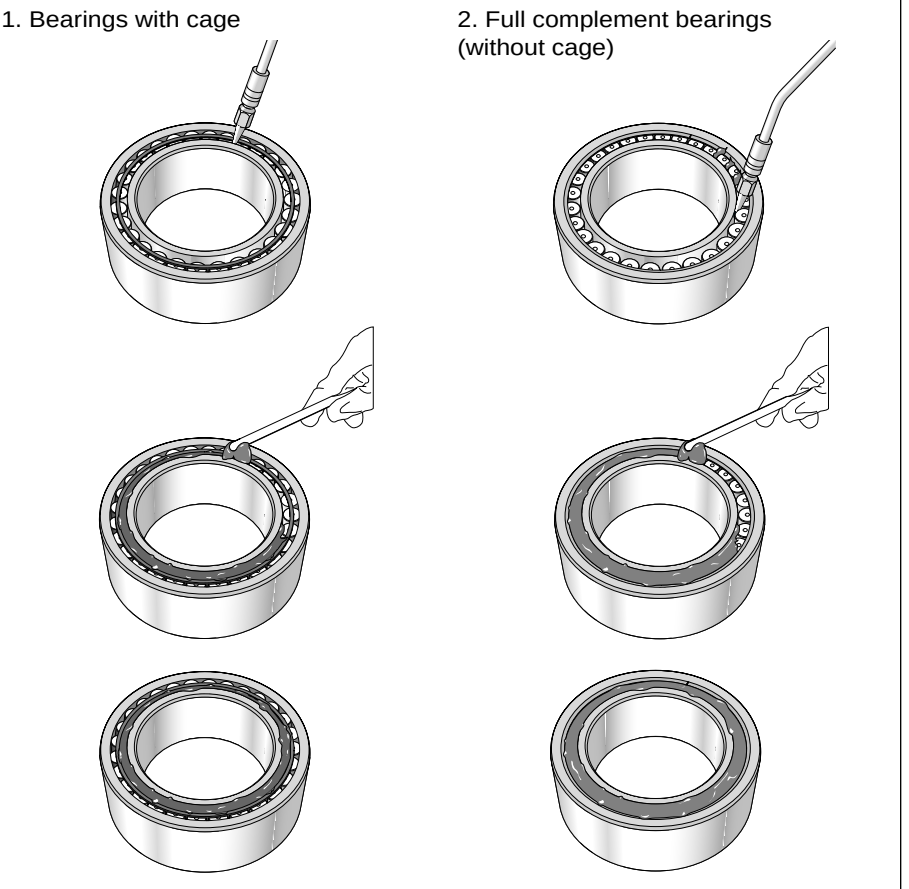
CARB™ Toroidal Roller Bearing Lubrication

Selection of grease

Grease for CARB toroidal roller bearings is selected on the same basis as for other rolling bearings. The grease should normally have a consistency of 2 or possibly 3 to the NLGI Scale and should be rust inhibiting and of good quality. The most important factors to be considered when selecting a grease are

- operating temperature
- speed
- vertical or horizontal shaft

Fig 22



1. **Bearings with cage**
CARB has a relatively large free volume available for grease. If the bearing is run at relatively high speed (greater than ~75% of catalog speed rating for grease) then there is a chance that the temperature will be elevated with a full pack of grease.

The recommendation is therefore to only fill the space between inner ring and cage when initially greasing the bearing for high speed applications.

For low or moderate speeds, the bearing may be fully packed with grease.

2. **Full complement bearings**
All free space in the bearing should be packed with grease.

***Figure 22.** How to grease CARB toroidal roller bearings*

- operating conditions such as vibration
- bearing type and size
- bearing load
- full complement or caged bearing

The viscosity of the base oil of a grease partly determines the thickness of the lubricant film in the rolling contact.

Applying the grease

On delivery, CARB™ toroidal roller bearings are coated with a rust inhibiting compound. There is no need to remove this.

Generally a CARB bearing is first greased when it has been mounted in order to minimize the risk of contamination. Only in cases where it is impossible to apply the grease evenly to the bearing should the grease be applied before the bearing is mounted.

The application of grease to CARB bearings is shown in **figs** → 21 and 22.

Fig 23

Care should be taken when using a grease gun operated by pressurized air. The seals may be damaged by the pressure.

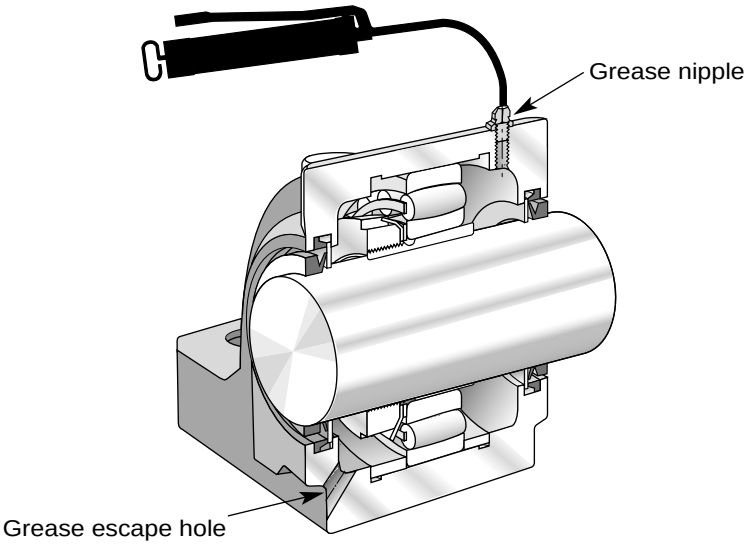
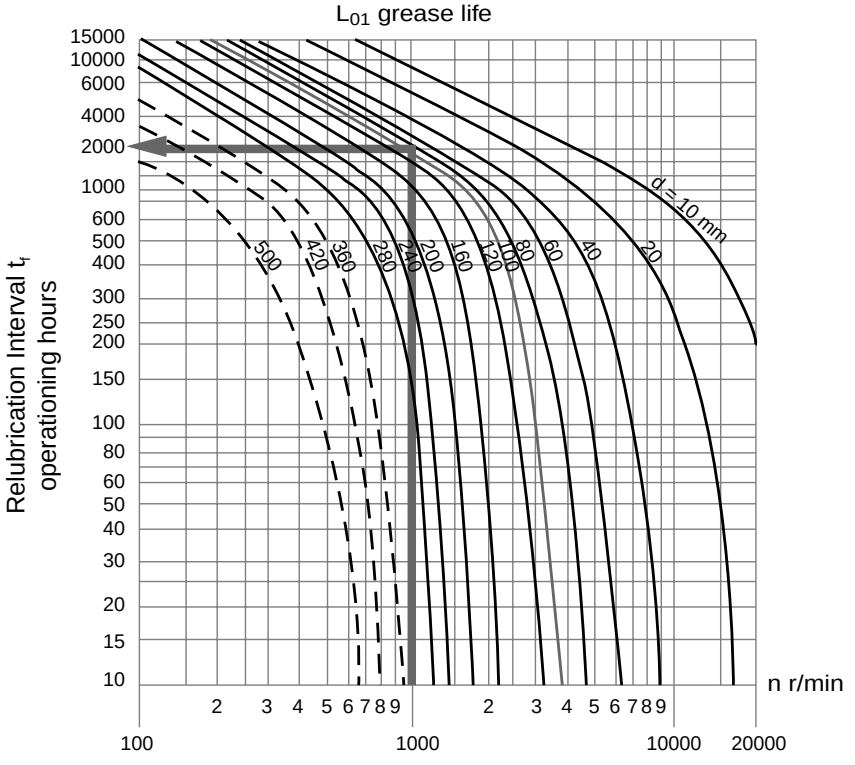


Figure 23. *Grease lubrication of CARB toroidal roller bearing*

Fig 24



Example C 2220 K

The bearing has a bore diameter of d = 100 mm and is to rotate at 1000 r/min.The operating temperature varies between 50 and 70°C (122° and 160°F). What is the recommended relubrication interval?

A line from 1000 r/min on the x axis is followed until it meets the curve for 100 mm bore. A line at right angles is then followed to the y axis where the value is found to be 2000 h. Thus the relubrication interval is 2000 operating hours.

Figure 24. *Relubrication diagram*

How to lubricate CARB™ toroidal roller bearings

Since CARB bearings have one row of rollers they can only be lubricated from the side. The housing should be fitted with a grease nipple at the side opposite to the lock nut (if they are mounted on an adapter sleeve). If they are to be frequently relubricated it is advisable for the housing base to have a grease escape hole at the side of the bearing opposite to the grease nipple, see → **fig** 23.

Experience gained with all roller bearings indicates that a first relubrication after a few days of operation is very beneficial, and may even be a prerequisite if the expected relubrication interval is to be attained when operating speeds are high. For this first relubrication half of the normal quantity recommended for regular relubrication will be sufficient.

Full complement bearings cannot retain grease as well as caged bearings unless the speed is very low. Therefore, full complement bearings should be relubricated much more often than caged bearings, and continuous relubrication may be required if speeds are high.

Relubrication

The length of time during which a grease lubricated bearing will function satisfactorily without relubrication depends on bearing size and speed and on the operating temperature etc., see → **fig** 24.

The grease used for relubrication should be the same as that used for the original greasing. Certain greases lose their lubricating properties when mixed with other greases. For this reason, greases should never be mixed if it is not known whether they are compatible.

Correct amount of grease

The following general rules apply for initial lubrication:

- CARB™ with cages should be filled to approximately 50% except at low speeds when they should be completely filled
- Full complement bearings should be completely filled
- Bearing housings should be partly filled (30% to 50% of the free space)

Fig 25

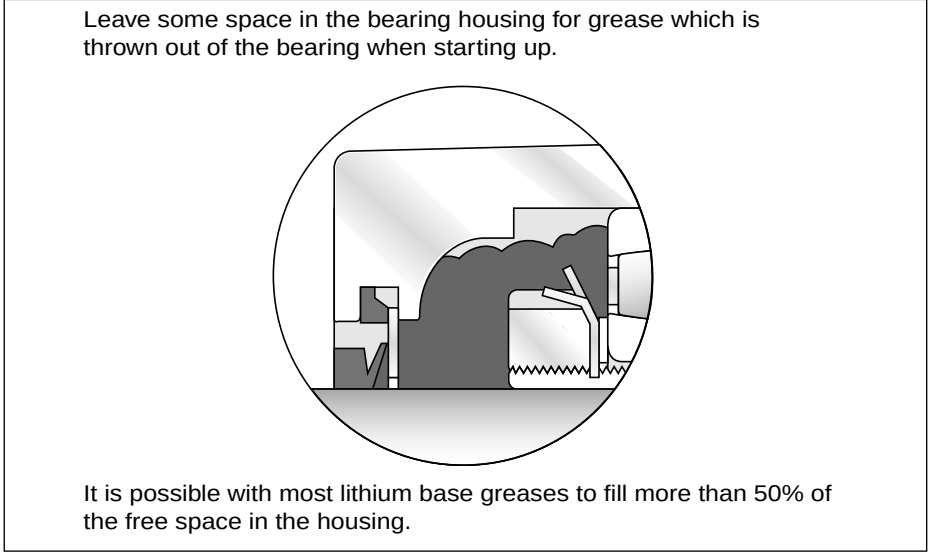


Figure 25. *Grease filling*

Fig 26

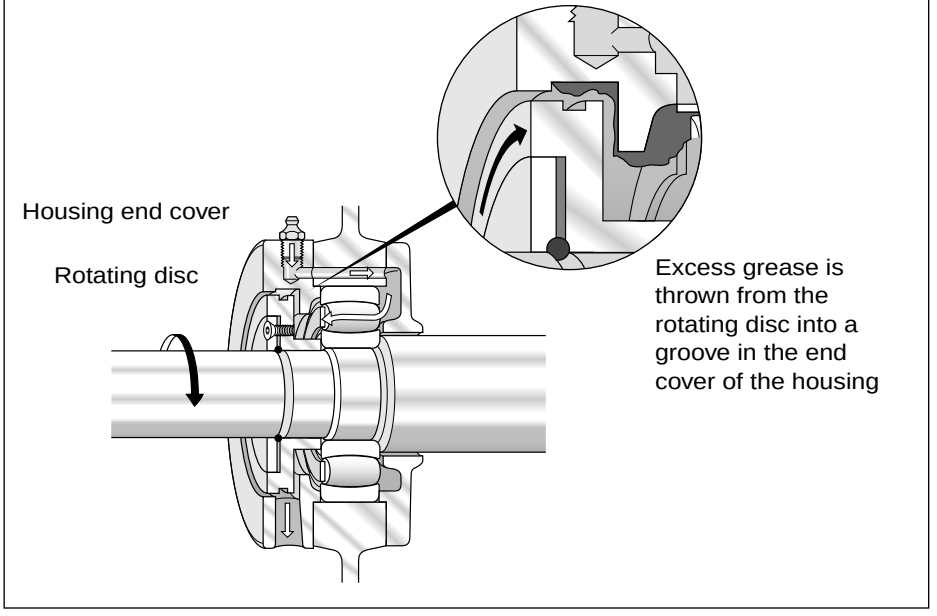


Figure 26. *Grease valve*

- Replenishment quantities should be determined using the methods described on page 75.

In non-vibrating applications it is possible when using most lithium base greases of the “full fill” type to apply more grease to the housing than recommended above, without any risk of increasing the temperature, see → **fig** 25. The increased grease quantity provides greater protection against the penetration of contaminants to the bearing. When a bearing has to be relubricated often, too much grease may collect in the bearing housing. This can be prevented by using a grease valve, see → **fig** 26.

SKF Solid Oil

Formulations	Approximate Oil Viscosity	
W64B/W64C (Standard Product)	140 cSt at 40°C 735 SUS at 100°F	19 cSt at 100°C 96 SUS at 210°F
W64E	385 cSt at 40°C 2000 SUS at 100°F	39 cSt at 100°C 189 SUS at 210°F
W64H	1056 cSt at 40°C 5600 SUS at 100°F	97 cSt at 100°C 470 SUS at 210°F
Food Grade W64 (USDA H1)		
W64F	62 cSt at 40°C 315 SUS at 100°F	10.1 cSt at 100°C 64 SUS at 210°F
W64G	208 cSt at 40°C 1050 SUS at 100°F	25 cSt at 100°C 130 SUS at 210°F

SKF Solid Oil™ — The Unique Lubrication Problem Solver

SKF Solid Oil is a mixture of lubricating oil and polymers, thermally cured to a rigid, sponge-like gel. This solid but elastic mass completely fills the bearing cavity but permits free rotation of the rolling elements. While the bearing operates, a thin film of oil is continuously released from the polymer "sponge" through light rubbing contact — only as much as required. When operation stops, excess oil is reabsorbed into the SKF Solid Oil "sponge", ready to be released again when needed.

The unique characteristics of SKF Solid Oil provide excellent oil lubrication without the problems normally associated with keeping oil or grease in contact with the rolling elements. The thin film of oil released by the surface during rubbing contact with the metal surfaces provides efficient lubrication. There's no waste and no bleeding of excess lubricant from the bearing which could contaminate processes or mechanisms. When operation stops, any excess oil is reabsorbed.

With SKF Solid Oil, environmental restrictions requiring users to account for the greases that have been consumed are more easily met.

SKF Solid Oil is most beneficial in applications with

- Low to moderate speeds
- Moderate temperatures
- Short service life due to:
  - —Orbital centrifugal force throwing grease out
  - —High pressure liquids washing out grease
  - —Particle contamination where frequent regreasing cannot be done
- Where relubrication is inconvenient or in a hazardous area or environment.

In general, the advantages are most cost beneficial in those applications where the current bearing service life is only a few months due to the causes listed above. In these cases, it may substantially increase the bearing service life (and reduce overall costs) even though the (much longer) calculated L_{10} life may still not be achieved.

Consult with your SKF representative especially if one or more of the following conditions apply:

- Bearing service life with grease is three years or longer (without relubrication)
- High moisture levels/condensation is causing internal bearing corrosion
- Speeds and/or ambient temperatures are high
- Grease relubrication at proper intervals is easily done at little extra cost (for example — other parts of the machine are regreased anyway)



SKF bearing type	Maximum Nd_m* with Solid Oil
Single row deep groove ball	300,000
Angular contact ball	150,000
Self-aligning ball	150,000
Cylindrical roller	150,000
Spherical roller-radial	
Excluding "E" type	85,000
"E" type	42,500
Tapered roller	45,000
Ball bearings with nylon cages (including Y-range unit ball bearings)	40,000

$$Nd_m = RPM \times \frac{(Bore + O.D.)\ in\ mm}{2}$$

*Maximum Nd_m values are for open and shielded bearings. For sealed bearings use 80% of the value listed.

Troubleshooting

Bearings that are not operating properly usually exhibit identifiable symptoms. This section presents some useful hints so you can help prevent it from happening again. The listed causes are the most common for the symptoms. Practical solutions are presented wherever possible. Depending on the degree of bearing damage, many misleading symptoms may be present. In most cases these symptoms are the result of secondary damage. To effectively troubleshoot bearing problems, it is necessary to analyze the symptoms according to those first observed in the applications. Additional solutions appear throughout this guide.

Symptoms of bearing trouble can usually be reduced to a few classifications, listed in the chart below.

Common Symptoms

A — Overheated bearing
B — Noisy bearing
C — Replacements are too frequent
D — Vibration
E — Unsatisfactory performance of equipment
F — Bearing is loose on shaft
G — Shaft is difficult to turn

The following table shows:

- The alphabetical codes for symptoms
- Typical conditions that result in bearing failure
- The numerical codes for solutions

NOTE:
Troubleshooting information shown on these pages should be used as guidelines only. Consult your SKF representative or machine manufacturer for specific maintenance information.

Typical Conditions Resulting in Bearing Failures

Common Symptoms	Typical Conditions	Solution Code
A B C G	Inadequate lubrication (Wrong type of grease or oil)	1
A B C G	Insufficient lubrication (Low oil level — loss of lubricant through seals)	2
A G	Excessive lubrication (Housing oil level is too high or housing is packed with grease)	3
A B C E G	Insufficient bearing clearance (Wrong fit selection)	4
B C D E G	Foreign matter acting as an abrasive (Sand, carbon etc.)	5
B C D E G	Foreign matter acting as a corrosive (Water, acids, paints etc.)	6
A B C D E G	Bearing is pinched in the housing (Bore out of round)	7
A B C D E G	Bearing is pinched in the housing (Warped housing)	8
A B C D E G	Uneven shimming of housing base (Distorted housing bore — possible cracking of the base)	9
B C D E G	Foreign matter in bearing housing (Chips, turnings, or dirt left in housing)	10
C	High air velocity over bearings causing pressure differentials (Oil leakage)	11
A G	Seals are too tight (Distorted seals)	12
A B G	Misaligned seals (Rubbing against stationary parts)	13
A	Oil return holes are plugged (Oil leakage)	14
A B C E G	Preloaded bearings (Cross location)	15
A B C G	Preloaded bearings (Two locating bearings on one shaft)	16
B C D E F	Bearing is loose on the shaft (Shaft diameter is too small)	17

Common Symptoms	Typical Conditions	Solution Code
B C D E F	Bearing is loose on shaft (Adapter sleeve is not tightened sufficiently)	18
A B C E G	Bearing is too tight internally (Adapter sleeve is tightened excessively)	19
C	Split plummer (pillow) block with uneven surfaces (Oil leakage)	20
A B C D E	Outer ring spins in housing (Unbalanced load)	21
B D E	Noisy bearing (Flattened surface on rolling element due to skidding)	22
C D E	Tapered shaft seating (Concentration of load in the bearing)	23
C D E	Tapered housing bore (Concentration of load in the bearing)	24
B C D E G	Shaft shoulder is too small (Inadequate shoulder support — bending of shaft)	25
A B C G	Shaft shoulder is too large (Rubbing against bearing seals)	26
B C D E G	Housing shoulder too small (Inadequate shoulder support)	27
B C G	Housing shoulder is too large (Bearing seals are distorted)	28
B C D E G	Shaft fillet is too large (Bending of shaft, bearing not properly seated)	29
B C D E G	Housing fillet is too large (Inadequate support)	30
A B C G	Insufficient clearance in labyrinth seals (Rubbing)	31
A C	Oil gauge breather hole is clogged (Indicates incorrect oil level)	32
A C D E G	Linear misalignment of shaft	33
A C D E G	Angular misalignment of shaft	34
A C	Constant oil level cups (Incorrect level)	35
A C	Constant oil level cups (Incorrect location)	36
A B E G	Lock washer prongs are bent (Rubbing against the bearing)	37
A B C G	Incorrect positioning of flingers (Rubbing against covers)	38
A B C D E G	Supporting surface is uneven (Bent housing is causing the bearing to be pinched)	39
B C D E	Rolling element is dented (Caused by blows to the bearing)	40
B	Bearing noise (Caused by other components)	41
A B C	Lubricant leakage and entry of dirt into the bearing (Worn out seals)	42
B D E	Vibration (Excessive clearance in the bearing)	43
B D E	Vibration (Unbalanced load)	44
C E G	Hard-turning shaft (Shaft or housing shoulders are out of square with the bearing seating)	45
B	Bearing is discolored (Blow torch was used to remove the bearing)	46
A B C E G	Oversized shaft (Bearing overheats)	47
A B C E G	Undersized housing bore (Bearing overheats)	48
A B C D E	Oversized housing bore (Outer ring spins; Bearing overheats)	49
A B C D E	Enlarged housing bore (Excessive peening of non-ferrous housing)	50
B E	Bearing noise (False brinelling)	51

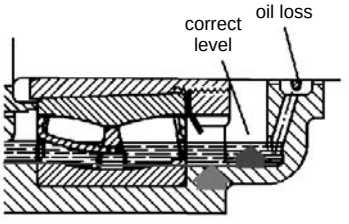
"Symptoms" refers back to the table on page 84.
"Typical conditions" provides the causes of each symptom.
"Solution code" provides the practical solution.
The following pages offer practical solutions to bearing symptoms.

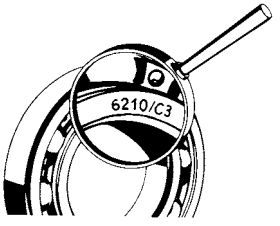
Trouble Conditions and their Solutions

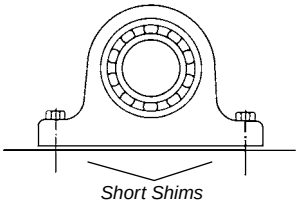
A — Overheated Bearing

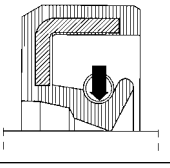
Solution Code	Reason For Condition	Practical Solution
1	Grease or oil is breaking down because it is the wrong type for operating conditions.	Consult lubricant manufacturer to determine proper type of lubricant. Check compatibility if grease or oil has been changed from one type to another.
2	Low oil level. Lubricant is being lost through the seal.	Static oil level should be at the center of the lowest rolling element in the bearing.
	Insufficient grease in the housing.	Pack housing 1/3 to 1/2 with grease.
3	Housing is fully packed with grease, or the oil level is too high. This causes excessive lubricant churning, high operating temperature or oil leakage.	Purge bearing until the housing is 1/2 filled with grease. For oil lubricated bearings, reduce the oil level to just below the center of the lowest rolling element.
4	Bearing has inadequate internal clearance for conditions where external heat is conducted through the shaft. This causes the inner ring to expand excessively.	Check whether overheated bearing had clearance according to original design specification. If so, then change to bearing with increased radial clearance, i.e. Normal to C3 or C3 to C4. If not, order to specification. Check with SKF if the bearing designation has become illegible.
7 8 9 39 48	Housing bore is out of round. Housing is warped or distorted. Supporting surface uneven. Housing bore is undersized.	Check the housing bore for size and roundness. If necessary remachine the housing bore to the correct dimension. Ensure that the supporting surface is flat and that the shims cover the entire area of the housing base. Housing bore is undersized if non-locating bearing is changed from cylindrical roller bearings to deep groove ball bearings.
12	Contact (rubbing) seals are dried out or have excessive spring tension.	Replace contact (rubbing) seals with seals having correct spring tension. Lubricate seals.
13 31 38	Rotating seals or flingers are rubbing against stationary parts.	Check the running clearance of the rotating seal or flinger to eliminate rubbing. Correct the alignment.

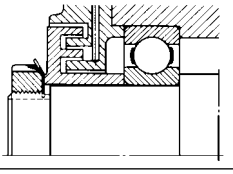


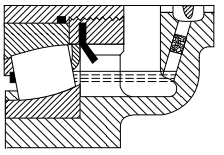
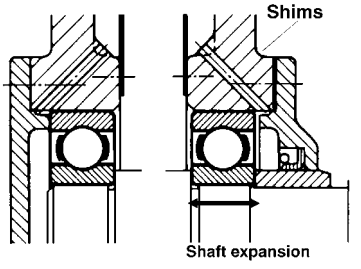
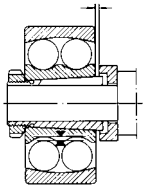
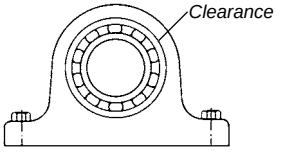
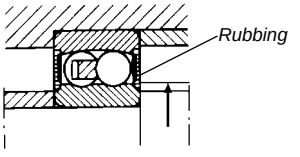
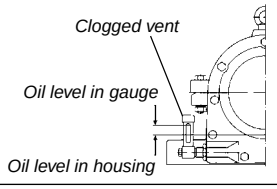
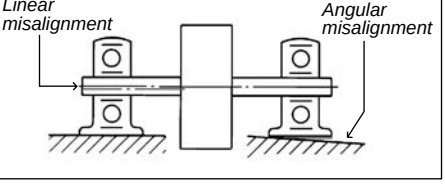




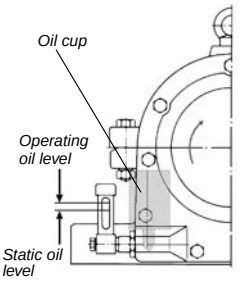
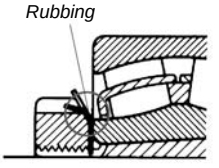
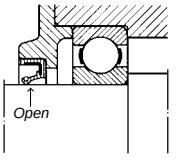
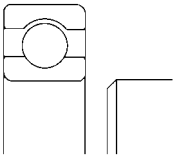
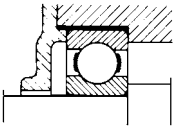




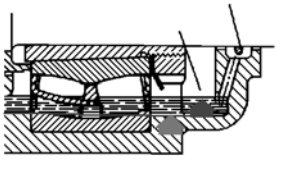


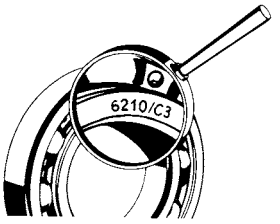
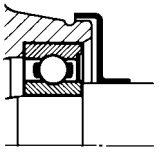
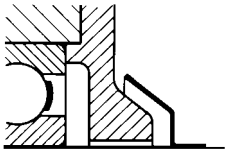
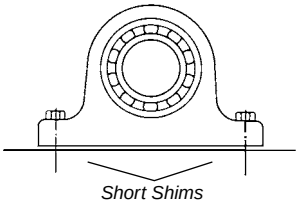
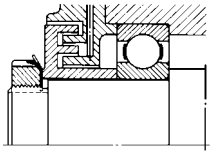
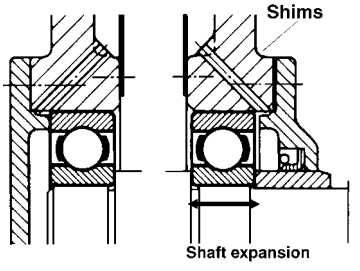
Solution Code	Reason For Condition	Practical Solution
14	Oil return holes are blocked. Pumping action of the seals causes oil leakage.	Clear the holes. Drain used oil and refill the proper level with fresh lubricant. 
15	Cross location	Insert shim between housing and cover flange to relieve axial preloading of bearing. 
16	Two locating bearings on one shaft. Insufficient clearance in bearing caused by excessive shaft expansion.	Move the covers in one of the housings outwards. Use shims to obtain adequate clearance between the housing and the outer ring. Apply axial spring load on the outer ring, if possible, to reduce axial play of the shaft.
19	Adapter sleeve is tightened excessively.	Loosen the locknut and sleeve assembly. Retighten it sufficiently to clamp the sleeve on to the shaft, but be sure the bearing turns freely. Use the clearance reduction method for spherical roller bearings. 
21 49	Unbalanced load. Housing bore is too large.	Rebalance the machine. Replace the housing with one having the proper bore. 
26	Shaft shoulder is rubbing against bearing seals.	Remachine the shaft shoulder to clear the seals. Check that the shoulder diameter is in accordance with SKF recommendations. 
32	No lubricant in bearing due to incorrect oil level.	Clear out the clogged oil hole to vent the oil gauge. 
33 34	Incorrect linear or angular alignment of two or more coupled shafts with two or more bearings.	Correct alignment by shimming the housings. Ensure that the shafts are coupled in a straight line, especially when three or more bearings operate on one shaft. Be sure to use full support shims. 

A — Overheated Bearing (cont.)

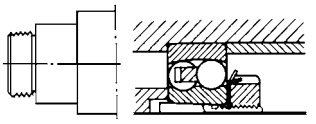
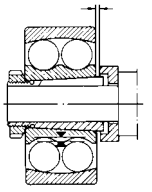
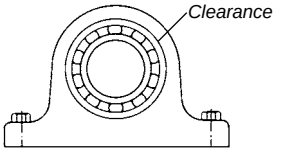
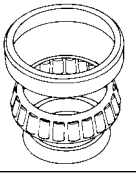
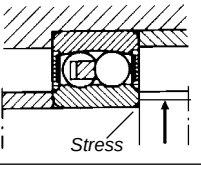
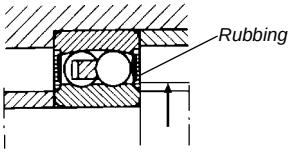
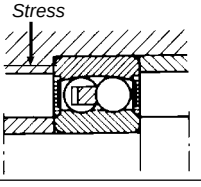
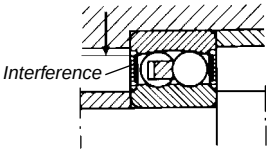
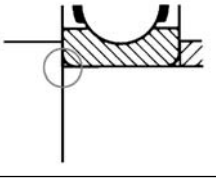
Solution Code	Reason For Condition	Practical Solution	
35 36	Constant oil level cup is mounted too high or low. The cup is located opposite to the bearing's direction of rotation.	The static oil level must not be higher than the center of the lowermost rolling element. Replace the constant level oiler with a sight gauge. Locate cup with rotation of bearing. Sketch illustrates correct position of constant level oil cup with respect to rotation.	
37	Washer prong is rubbing against the bearing.	Remove the lockwasher. Straighten the prong or replace with a new washer.	
42	Contact seals are excessively worn, causing lubricant loss or permitting dirt to enter the bearing.	Replace seals after thoroughly flushing bearing and refilling with fresh lubricant.	
47	Bearing seating diameter is oversized, causing excessive inner ring expansion. This reduces bearing clearance.	Grind shaft to get a proper fit between the shaft and the bearing inner ring. If regrinding is not possible change to bearing with larger radial clearance.	
50	"Pounding out" of housing bore due to too soft metal. The resulting enlarged bore causes the outer ring to spin in the housing.	Rebore the housing and press a steel bushing in the bore. Machine the bushing bore to the correct size.	

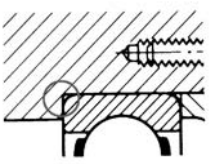
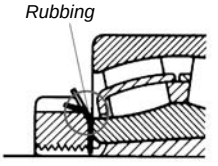
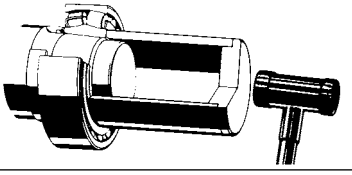
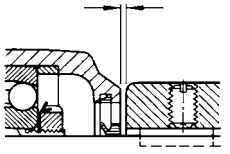
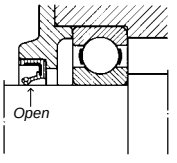
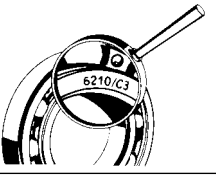
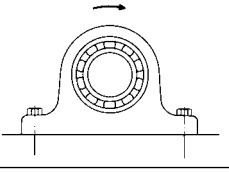
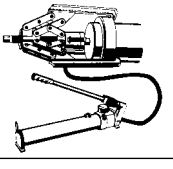
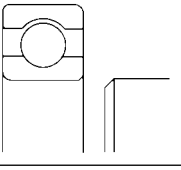
B — Noisy bearing

1	Grease or oil is breaking down because it is the wrong type for operating conditions.	Consult lubricant manufacturer to determine proper type of lubricant. Check compatibility if grease or oil has been changed from one type to another.	
2	Low oil level. Lubricant is being lost through the seal. Insufficient grease in the housing.	Oil level should be at the center of the lowest rolling element in the bearing. Pack housing 1/3 to 1/2 with grease.	

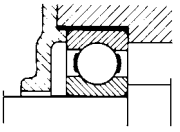
Solution Code	Reason For Condition	Practical Solution
4	Bearing has inadequate internal clearance for conditions where external heat is conducted through the shaft. This causes the inner ring to expand excessively.	Check whether overheated bearing had clearance according to original design specification. If so, then change to bearing with increased radial clearance, i.e. Normal to C3 or C3 to C4. If not, order to specification. Check with SKF if the bearing designation has become illegible. 
5	Dirt, sand, carbon, or other contaminants are entering the bearing housing.	Clean the bearing housing. Replace worn seals or improve the seal design to obtain adequate bearing protection. 
6	Water, acids, paints or other corrosives are entering the bearing housing.	Install a protective shield and/or flinger to guard against foreign matter. Improve seals. 
7 8 9 39 48	Housing bore is out of round. Housing is warped or distorted. Supporting surface is uneven. Housing bore is undersized.	Check the housing bore for size and roundness. If necessary remachine the housing bore to the correct dimension. Ensure that the supporting surface is flat and that the shims cover the entire area of the housing base. Housing bore is undersized if non-locating bearing is changed from cylindrical roller bearings to deep groove ball bearings. 
10	Chips, dirt etc. were not removed from housing before assembling the bearing unit.	Carefully clean and install fresh lubricant.
13 31 38	Rotating seals or flingers are rubbing against stationary parts.	Check the running clearance of the rotating seal or flinger to eliminate rubbing. Correct the alignment. 
15	Cross location.	Insert shim between housing and cover flange to relieve axial preloading of bearing. 
16	Two locating bearings on one shaft. Insufficient clearance in bearing caused by excessive shaft expansion.	Move the covers in one of the housings outwards. Use shims to obtain adequate clearance between the housing and the outer ring. Apply axial spring load on the outer ring, if possible, to reduce axial play of the shaft.

B — Noisy bearing (cont.)

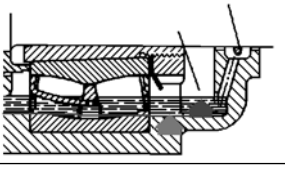
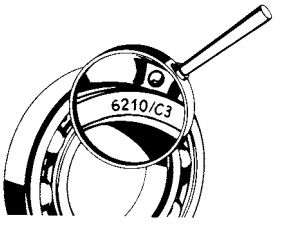
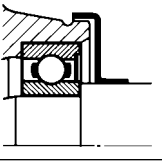
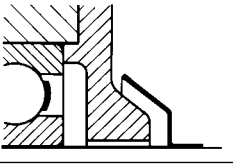
Solution Code	Reason For Condition	Practical Solution
17 18	Shaft diameter is too small. Adapter is not sufficiently tightened.	Restore shaft diameter using appropriate technique and regrind the shaft to obtain the proper fit. Retighten the adapter for a firm grip on shaft. 
19	Adapter sleeve is tightened excessively.	Loosen the locknut and sleeve assembly. Retighten it sufficiently to clamp the sleeve on to the shaft but be sure the bearing turns freely. Use the clearance reduction method for spherical roller bearings. 
21 49	Unbalanced load. Housing bore is too large.	Rebalance the machine. Replace the housing with one having the proper bore. 
22	Flat spot on rolling element due to skidding. (Caused by fast starts).	Visually check the rolling elements and replace the bearing if a rolling element has a flat spot. Make sure that the requisite minimum load is applied to the bearing. 
25	Shaft is bending due to incorrect shoulder diameter.	Remachine the shaft fillet to relieve stress. The application may require a shoulder collar. Check that abutment dimensions is in accordance with SKF recommendations. 
26	Shaft shoulder is rubbing against bearing seals.	Remachine the shaft shoulder to clear the seals. Check that shoulder diameter is in accordance with SKF recommendations. 
27	Inadequate support in the housing is causing the outer ring to distort.	Remachine the housing fillet to relieve stress. Check that abutment dimensions is in accordance with SKF recommendations. The application may require a shoulder collar. 
28	Distorted bearing seals.	Remachine the housing shoulder to clear the seals. 
29	Shaft and inner ring are distorted.	Remachine shaft fillet to obtain the proper support. 

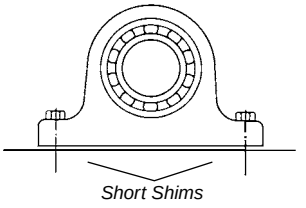
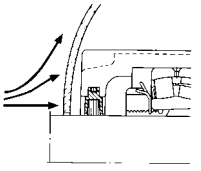
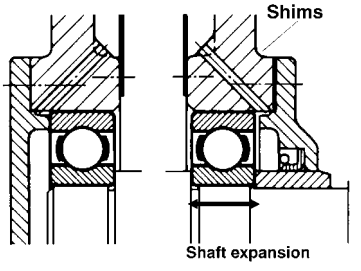
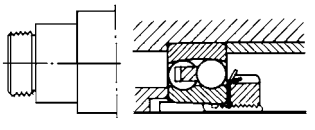
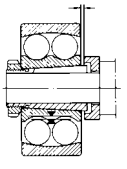
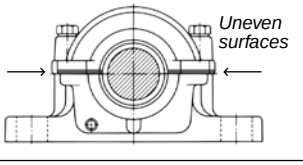
Solution Code	Reason For Condition	Practical Solution
30	Housing and outer ring are distorted.	Remachine the housing fillet to obtain the proper support. 
37	Washer prong is rubbing against the bearing.	Remove the lockwasher. Straighten the prong or replace with a new washer. 
40	Incorrect mounting method. Hammer blows on bearing.	Replace the bearing with a new one. Never hammer any part of a bearing when mounting. Always use a mounting sleeve. 
41	Moving components in the machine are interfering with bearing operation.	Carefully check every moving component in the machine. Clear whatever is interfering. 
42	Contact seals are excessively worn, causing lubricant loss or permitting dirt to enter the bearing.	Replace seals after thoroughly flushing bearing and refilling with fresh lubricant. 
43	Excessive clearance in the bearing is causing vibration.	Use a bearing with recommended internal clearance. Apply spring load to the outer ring of the non-locating bearing to eliminate axial and radial play. 
44	Equipment is vibrating	Check the balance of the rotating parts. Rebalance the equipment. 
46	Distortion of the shaft and other bearing assembly components, probably due to heat.	Use a torch to remove a bearing only under extreme circumstances. Avoid high heat concentration at any one point to avoid distortion. Replace discolored bearings. 
47	Bearing seating diameter is oversized, causing excessive inner ring expansion. This reduces bearing clearance.	Grind shaft to get a proper fit between the shaft and the bearing inner ring. If regrinding is not possible change to bearing with larger radial clearance. 

B — Noisy bearing (cont.)

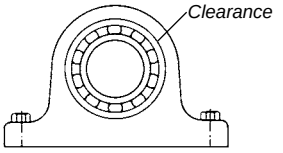
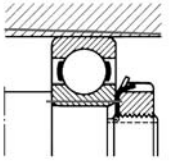
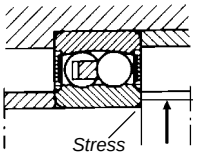
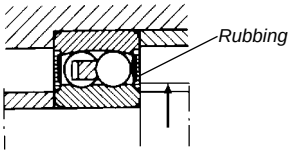
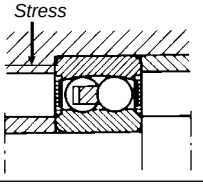
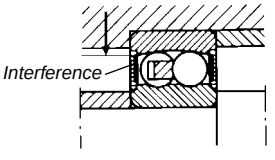
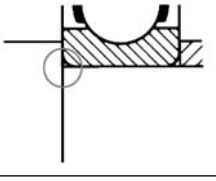
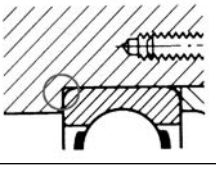
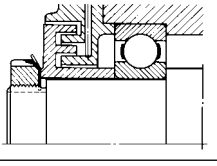
Solution Code	Reason For Condition	Practical Solution
50	"Pounding out" of housing bore due to too soft metal. The resulting enlarged bore causes the outer ring to spin in the housing.	Rebore the housing and press a steel bushing in the bore. Machine the bushing bore to the correct size. 
51	Bearing is exposed to vibration while the machine is idle.	Carefully examine the bearing for wear spots corresponding to the spacing of the rolling elements.

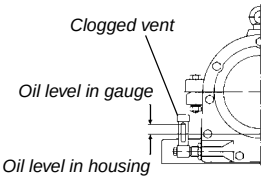
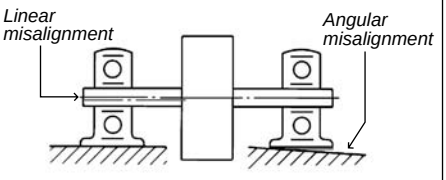
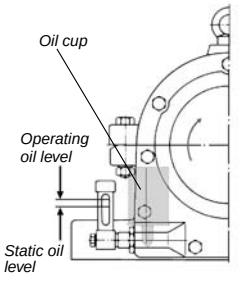
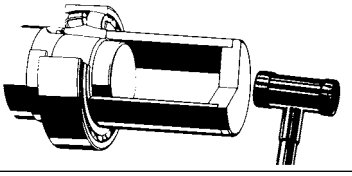
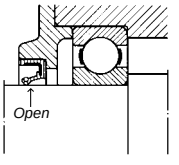
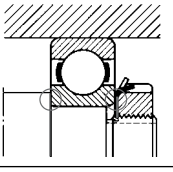
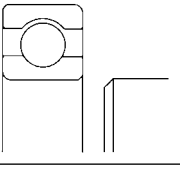
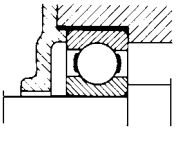
C — Replacements are too frequent

1	Grease or oil is breaking down because it is the wrong type for operating conditions.	Consult lubricant manufacturer to determine proper type of lubricant. Check compatibility if grease or oil has been changed from one type to another. 
2	Low oil level. Lubricant is being lost through the seal. Insufficient grease in the housing.	Static oil level should be at the center of the lowest rolling element in the bearing. Pack housing 1/3 to 1/2 with grease. 
4	Bearing has inadequate internal clearance for conditions where external heat is conducted through the shaft. This causes the inner ring to expand excessively.	Check whether overheated bearing had clearance according to original design specification. If so, then change to bearing with increased radial clearance, i.e. Normal to C3 or C3 to C4. If not, order to specification. Check with SKF if the bearing designation has become illegible. 
5	Dirt, sand, carbon, or other contaminants are entering the bearing housing.	Clean the bearing housing. Replace worn seals or improve the seal design to obtain adequate bearing protection. 
6	Water, acids, paints or other corrosives are entering the bearing housing.	Install a protective shield and/or flinger to guard against foreign matter. Improve seals. 

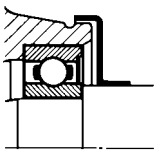
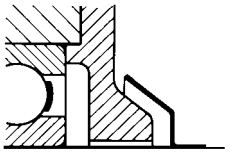
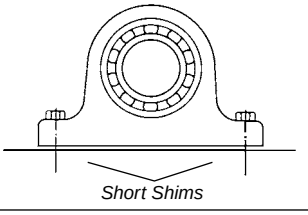
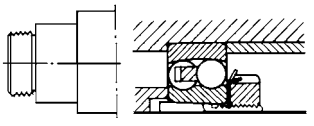
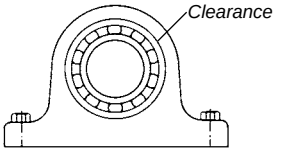
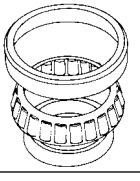
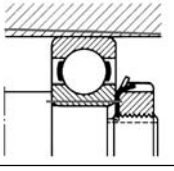
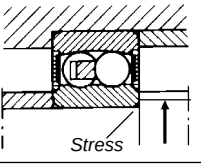
Solution Code	Reason For Condition	Practical Solution
7 8 9 39 48	Housing bore is out of round. Housing is warped or distorted. Supporting surface uneven. Housing bore is undersized.	Check the housing bore for size and roundness. If necessary remachine the housing bore to the correct dimension. Ensure that the supporting surface is flat and that the shins cover the entire area of the housing base. Housing bore is undersized if non-locating bearing is changed from cylindrical roller bearings to deep groove ball bearings. 
10	Chips, dirt etc. were not removed from housing before assembling the bearing unit.	Carefully clean and install fresh lubricant.
11	Air flowing over the bearing is causing an oil leak. (Example: Forced draft fan with air inlet over the bearing.)	Install baffles to divert the air flow. Avoid pressure difference over the bearing. Use grease lubrication if possible. 
15	Cross location.	Insert shim between housing and cover flange to relieve axial preloading of bearing. 
16	Two locating bearings on one shaft. Insufficient clearance in bearing caused by excessive shaft expansion.	Move the covers in one of the housings outwards. Use shims to obtain adequate clearance between the housing and the outer ring. Apply axial spring load on the outer ring, if possible, to reduce axial play of the shaft.
17 18	Shaft diameter is too small. Adapter is not sufficiently tightened.	Restore shaft diameter using appropriate technique to obtain the proper fit. Retighten the adapter for a firm grip on shaft. 
19	Adapter sleeve is tightened excessively.	Loosen the locknut and sleeve assembly. Retighten it sufficiently to clamp the sleeve on to the shaft but be sure the bearing turns freely. 
20	Oil is leaking at the housing split. Excessive loss of lubricant.	A thin layer of gasket cement will stop minor leaks. Do not use shims. Replace the housing if necessary. 

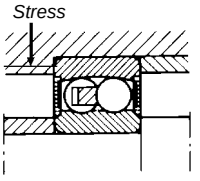
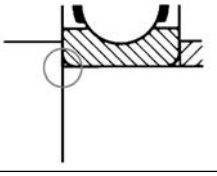
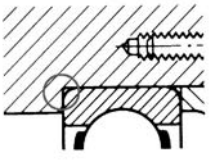
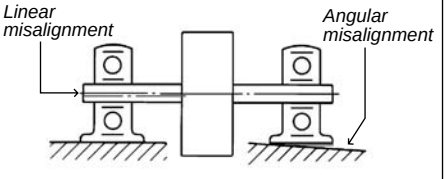
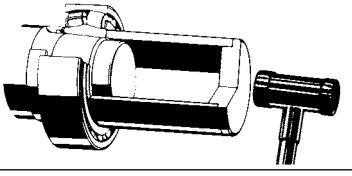
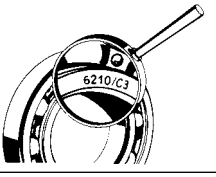
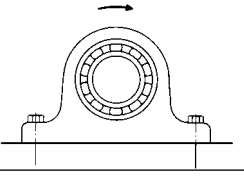
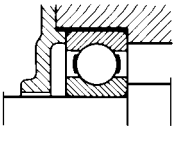
C — Replacements are too frequent (cont.)

Solution Code	Reason For Condition	Practical Solution	
21 49	Unbalanced load. Housing bore is too large.	Rebalance the machine. Replace the housing with one having the proper bore.	
23 24	Unequal load distribution on the bearing due to poor geometry or shape of shaft seating or housing bore.	Rework the shaft, housing, or both, to obtain the proper form and fit. The application may require a new shaft or housing.	
25	Shaft is bending due to incorrect shoulder diameter.	Remachine the shaft fillet to relieve stress. The application may require a shoulder collar. Check that abutment dimensions are in accordance with SKF recommendations.	
26	Shaft shoulder is rubbing against bearing seals.	Remachine the shaft shoulder to clear the seals. Check that the shoulder diameter is in accordance with SKF recommendations.	
27	Inadequate support in the housing is causing the outer ring to distort.	Remachine the housing fillet to relieve stress. Check that abutment dimensions are in accordance with SKF recommendations. The application may require a shoulder collar.	
28	Distorted bearing seals.	Remachine the housing shoulder to clear the seals.	
29	Shaft and inner ring are distorted.	Remachine shaft fillet to obtain the proper support.	
30	Housing and outer ring are distorted.	Remachine the housing fillet to obtain the proper support.	
31 38	Rotating seals or flingers are rubbing against stationary parts.	Check the running clearance of the rotating seal or flinger to eliminate rubbing. Correct the alignment.	

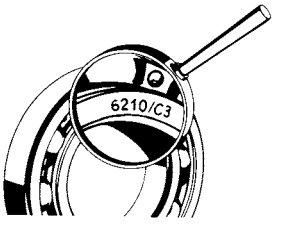
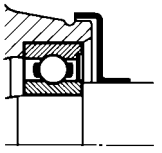
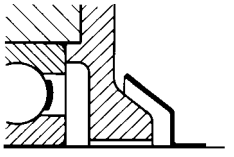
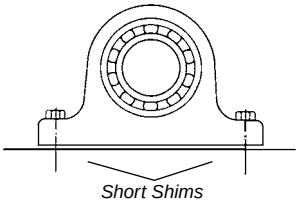
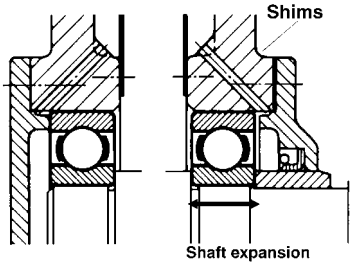
Solution Code	Reason For Condition	Practical Solution
32	No lubricant in bearing due to incorrect oil level.	Clear out the clogged oil hole to vent the oil gauge. 
33 34	Incorrect linear or angular alignment of two or more coupled shafts with two or more bearings.	Correct alignment by shimming the housings. Ensure that the shafts are coupled in a straight line, especially when three or more bearings operate on one shaft. Be sure to use full support shims. 
35 36	Constant oil level cup is mounted too high or low. The cup is located opposite to the bearing's direction of rotation.	The static oil level must not be higher than the center of the lowermost rolling element. Replace the constant level oiler with a sight gauge. Locate cup with rotation of bearing. Sketch illustrates correct position of constant level oil cup with respect to rotation. 
40	Incorrect mounting method. Hammer blows on bearing.	Replace the bearing with a new one. Never hammer any part of a bearing when mounting. Always use a mounting sleeve. 
42	Contact seals are excessively worn, causing lubricant loss or permitting dirt to enter the bearing.	Replace seals after thoroughly flushing bearing and refilling with fresh lubricant. 
45	Shaft or housing shoulders or locknut face out-of-square with the bearing seat.	Remachine parts to obtain squareness. 
47	Bearing seating diameter is oversized, causing excessive inner ring expansion. This reduced bearing clearance.	Grind shaft to get a proper fit between the shaft and the bearing inner ring. If regrinding is not possible change to bearing with larger radial clearance. 
50	"Pounding out" of housing bore due to too soft metal. The resulting enlarged bore causes the outer ring to spin in the housing.	Rebore the housing and press a steel bushing in the bore. Machine the bushing bore to the correct size. 

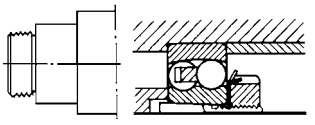
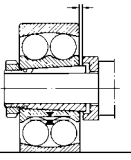
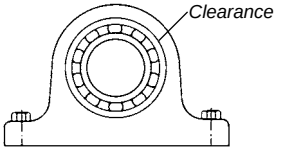
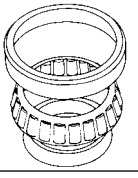
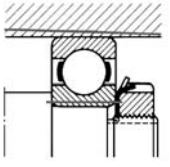
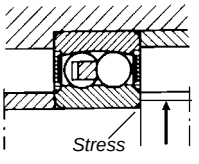
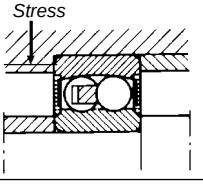
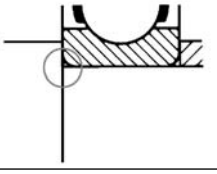
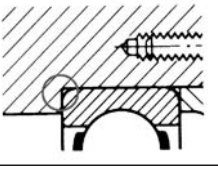
D — Vibration

Solution Code	Reason For Condition	Practical Solution
5	Dirt, sand, carbon, or other contaminants are entering the bearing housing.	Clean the bearing housing. Replace worn seals or improve the seal design to obtain adequate bearing protection. 
6	Water, acids, paints or other corrosives are entering the bearing housing.	Install a protective shield and/or flinger to guard against foreign matter. 
7 8 9 39	Housing bore is out of round. Housing is warped or distorted. Supporting surface is uneven.	Check the housing bore for size and roundness. If necessary remachine the housing bore to the correct dimension. Ensure that the supporting surface is flat and that the shims cover the entire area of the housing base. 
10	Chips, dirt etc. were not removed from housing before assembling the bearing unit.	Carefully clean and install fresh lubricant.
17 18	Shaft diameter is too small. Adapter is not sufficiently tightened.	Restore shaft diameter using appropriate technique to obtain the proper fit. Retighten the adapter for a firm grip on shaft. 
21 49	Unbalanced load. Housing bore is too large.	Rebalance the machine. Replace the housing with one having the proper bore. 
22	Flat spot on rolling element due to skidding. (Caused by fast starts.)	Visually check the rolling elements and replace the bearing if a rolling element has a flat spot. Make sure that the requisite minimum load is applied to the bearing. 
23 24	Unequal load distribution on the bearing due to poor geometry or shape of shaft seating or housing bore.	Rework the shaft, housing, or both, to obtain the proper form and fit. The application may require a new shaft or housing. 
25	Shaft is bending due to incorrect shoulder diameter.	Remachine the shaft fillet to relieve stress. The application may require a shoulder collar. Check that abutment dimensions are in accordance with SKF recommendations. 

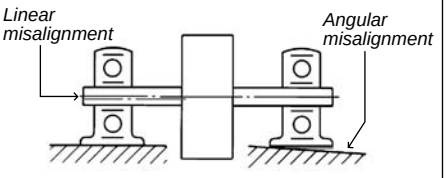
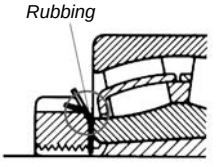
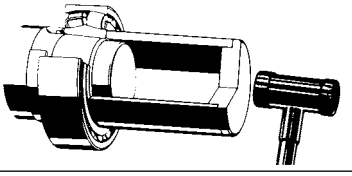
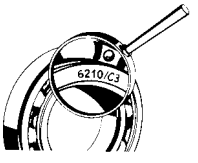
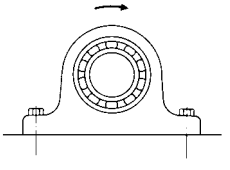
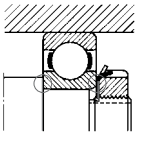
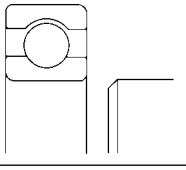
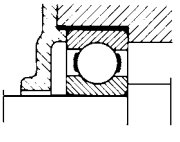
Solution Code	Reason For Condition	Practical Solution
27	Inadequate support in the housing is causing the outer ring to distort.	Remachine the housing fillet to relieve stress. Check that abutment dimensions are in accordance with SKF recommendations. The application may require a shoulder collar. 
29	Shaft and inner ring are distorted.	Remachine shaft fillet to obtain the proper support. 
30	Housing and outer ring are distorted.	Remachine the housing fillet to obtain the proper support. 
33 34	Incorrect linear or angular alignment of two or more coupled shafts with two or more bearings.	Correct the alignment by shimming the housings. Ensure that the shafts are coupled in a straight line, especially when three or more bearings operate on one shaft. Be sure to use full support shims. 
40	Incorrect mounting method. Hammer blows on bearing.	Replace the bearing with a new one. Never hammer any part of a bearing when mounting. Always use a mounting sleeve. 
43	Excessive clearance in the bearing is causing vibration.	Use a bearing with recommended internal clearance. Apply spring load to the outer ring of the non-locating bearing to eliminate axial and radial play. 
44	Equipment is vibrating	Check the balance of the rotating parts. Rebalance the equipment. 
50	“Pounding out” of housing bore due to too soft metal. The resulting enlarged bore causes the outer ring to spin in the housing.	Rebore the housing and press a steel bushing in the bore. Machine the bushing bore to the correct size. 

E — Unsatisfactory equipment performance

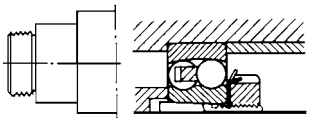
Solution Code	Reason For Condition	Practical Solution
4	Bearing has inadequate internal clearance for conditions where external heat is conducted through the shaft. This causes the inner ring to expand excessively.	Check whether overheated bearing had clearance according to original design specification. If so, then change to bearing with increased radial clearance, i.e. Normal to C3 or C3 to C4. If not, order to specification. Check with SKF if the bearing designation has become illegible. 
5	Dirt, sand, carbon, or other contaminants are entering the bearing housing.	Clean the bearing housing. Replace worn seals or improve the seal design to obtain adequate bearing protection. 
6	Water, acids, paints or other corrosives are entering the bearing housing.	Install a protective shield and/or flinger to guard against foreign matter. Improve seals. 
7 8 9 39 48	Housing bore is out of round. Housing is warped or distorted. Supporting surface uneven. Housing bore is undersized.	Check the housing bore for size and roundness. If necessary remachine the housing bore to the correct dimension. Ensure that the supporting surface is flat and that the shims cover the entire area of the housing base. Housing bore is undersized if non-locating bearing is changed from cylindrical roller bearings to deep groove ball bearings. 
10	Chips, dirt etc. were not removed from housing before assembling the bearing unit.	Carefully clean and install fresh lubricant.
15	Cross location.	Insert shim between housing and cover flange to relieve axial preloading of bearing.
16	Two locating bearings on one shaft. Insufficient clearance in bearing caused by excessive shaft expansion.	Move the covers in one of the housings outwards. Use shims to obtain adequate clearance between the housing and the outer ring. Apply axial spring load on the outer ring, if possible, to reduce axial play of the shaft. 

Solution Code	Reason For Condition	Practical Solution
17 18	Shaft diameter is too small. Adapter is not sufficiently tightened.	Restore shaft diameter using appropriate technique to obtain the proper fit. Retighten the adapter for a firm grip on shaft. 
19	Bearing is driven too far up the adapter sleeve.	Loosen the locknut and sleeve assembly. Retighten it sufficiently to clamp the sleeve on to the shaft, but be sure the bearing turns freely. 
21 49	Unbalanced load. Housing bore is too large.	Rebalance the machine. Replace the housing with one having the proper bore. 
22	Flat spot on rolling element due to skidding. (Caused by fast starts).	Visually check the rolling elements and replace the bearing if a rolling element has a flat spot. Make sure that the requisite minimum load is applied to the bearing. 
23 24	Unequal load distribution on the bearing due to poor bearing seat geometry.	Rework the shaft, housing, or both, to obtain the proper form and fit. The application may require a new shaft or housing. 
25	Shaft is bending due to incorrect shoulder diameter.	Remachine the shaft fillet to relieve stress. The application may require a shoulder collar. Check that abutment dimensions is in accordance with SKF recommendations. 
27	Inadequate support in the housing is causing the outer ring to distort.	Remachine the housing fillet to relieve stress. Check that abutment dimensions is in accordance with SKF recommendations. The application may require a shoulder collar. 
29	Shaft and inner ring are distorted.	Remachine shaft fillet to obtain the proper support. 
30	Housing and outer ring are distorted.	Remachine the housing fillet to obtain the proper support. 

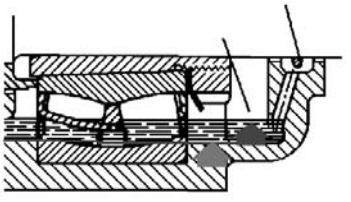
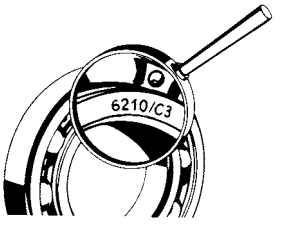
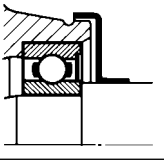
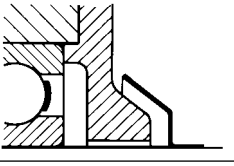
E — Unsatisfactory equipment performance (cont.)

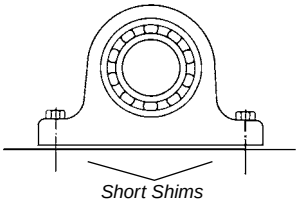
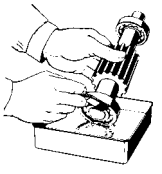
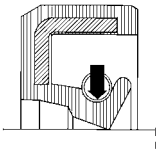
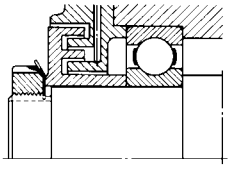
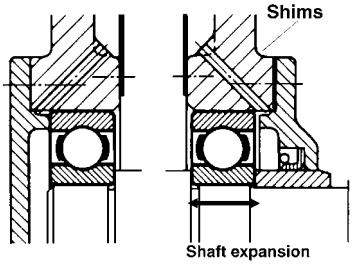
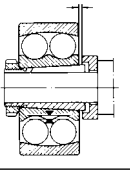
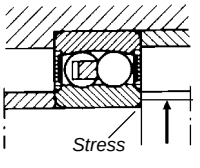
Solution Code	Reason For Condition	Practical Solution
33 34	Incorrect linear or angular alignment of two or more coupled shafts with two or more bearings.	Correct alignment by shimming the housings. Ensure that the shafts are coupled in a straight line, especially when three or more bearings operate on one shaft. Be sure to use full support shims. 
37	Washer prong is rubbing against the bearing.	Remove the lockwasher. Straighten the prong or replace with a new washer. 
40	Incorrect mounting method. Hammer blows on bearing.	Replace the bearing with a new one. Never hammer any part of a bearing when mounting. Always use a mounting sleeve. 
43	Excessive clearance in the bearing is causing vibration.	Use a bearing with recommended internal clearance. Apply spring load to the outer ring of the non-locating bearing to eliminate axial and radial play. 
44	Equipment is vibrating	Check the balance of the rotating parts. Rebalance the equipment. 
45	Shaft or housing shoulders or locknut face out-of-square with the bearing seat.	Remachine parts to obtain squareness. 
47	Bearing seating diameter is oversized, causing excessive inner ring expansion. This reduces bearing clearance.	Grind shaft to get a proper fit between the shaft and the bearing inner ring. If regrinding is not possible change to bearing with larger radial clearance. 
50	“Pounding out” of housing bore due to too soft metal. The resulting enlarged bore causes the outer ring to spin in the housing.	Rebore the housing and press a steel bushing in the bore. Machine the bushing bore to the correct size. 
51	Bearing is exposed to vibration while the machine is idle.	Carefully examine the bearing for wear spots corresponding to the spacing of the rolling elements.

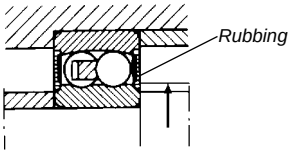
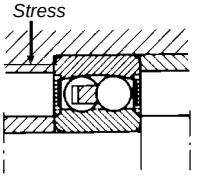
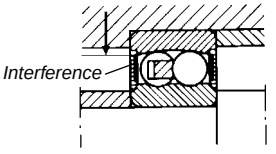
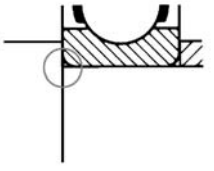
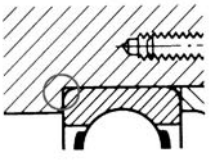
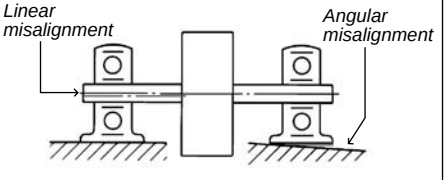
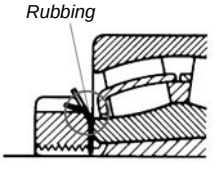
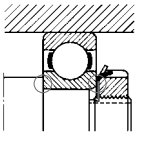
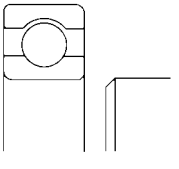
F — Bearing is loose on the shaft

Solution Code	Reason For Condition	Practical Solution
17 18	Shaft diameter is too small. Adapter is not sufficiently tightened.	Restore shaft diameter using appropriate technique to obtain the proper fit. Retighten the locknut for a firm grip on shaft. 

G — Shaft is difficult to turn

1	Grease or oil is breaking down because it is the wrong type for operating conditions.	Consult lubricant manufacturer to determine proper type of lubricant. Check compatibility if grease or oil has been changed from one type to another. 
2	Low oil level. Lubricant is being lost through the seal. Insufficient grease in the housing.	Static oil level should be just below the center of the lowest rolling element in the bearing (when the bearing is not running). Pack housing 1/3 to 1/2 with grease. 
3	Housing is fully packed with grease, or the oil level is too high. This causes excessive lubricant churning, high operating temperature or oil leakage.	Purge bearing until the housing is 1/2 filled with grease. For oil lubricated bearings, reduce the oil level to the center of the lowest rolling element.
4	Bearing has inadequate internal clearance for conditions where external heat is conducted through the shaft. This causes the inner ring to expand excessively.	Check whether overheated bearing had clearance according to original design specification. If so, then change to bearing with increased radial clearance, i.e. Normal to C3 or C3 to C4. If not, order to specification. Check with SKF if the bearing designation has become illegible. 
5	Dirt, sand, carbon, or other contaminants are entering the bearing housing.	Clean the bearing housing. Replace worn seals or improve the seal design to obtain adequate bearing protection. 
6	Water, acids, paints or other corrosives are entering the bearing housing.	Install a protective shield and/or flinger to guard against foreign matter. Improve seals. 

Solution Code	Reason For Condition	Practical Solution
7 8 9 39 48	Housing bore is out of round. Housing is warped or distorted. Supporting surface is uneven. Housing bore is undersized.	Check the housing bore for size and roundness. If necessary remachine the housing bore to the correct dimension. Ensure that the supporting surface is flat and that the shims cover the entire area of the housing base. 
10	Chips, dirt etc. were not removed from housing before assembling the bearing unit.	Carefully clean and install fresh lubricant. 
12	Contact (rubbing) seals are dried out or have excessive spring tension.	Replace contact (rubbing) seals with seals having correct spring tension. Lubricate seals. 
13 31 38	Rotating seals or flingers are rubbing against stationary parts.	Check the running clearance of the rotating seal or flinger to eliminate rubbing. Correct the alignment. 
15	Cross location	Insert shim between housing and cover flange to relieve axial preloading of bearing. 
16	Two locating bearings on one shaft. Insufficient clearance in bearing caused by excessive shaft expansion.	Move the covers in one of the housings outwards. Use shims to obtain adequate clearance between the housing and the outer ring side face. Apply axial spring load on the outer ring, if possible, to reduce axial play of the shaft.
19	Bearing is driven too far up the adapter sleeve.	Loosen the locknut and sleeve assembly. Retighten it sufficiently to clamp the sleeve on to the shaft, but be sure the bearing turns freely. 
25	Shaft is bending due to incorrect shoulder diameter.	Remachine the shaft fillet to relieve stress. The application may require a shoulder collar. Check that abutment dimensions are in accordance with SKF recommendations. 

Solution Code	Reason For Condition	Practical Solution
26	Shaft shoulder is rubbing against bearing seals.	Remachine the shaft shoulder to clear the seals. Check that shoulder diameter is in accordance with SKF recommendations. 
27	Inadequate support in the housing is causing the outer ring to distort.	Remachine the housing fillet to relieve stress. Check that abutment dimensions is in accordance with SKF recommendations. The application may require a shoulder collar. 
28	Distorted bearing seals.	Remachine the housing shoulder to clear the seals. 
29	Shaft and inner ring are distorted.	Remachine shaft fillet to obtain the proper support. 
30	Housing and outer ring are distorted.	Remachine the housing fillet to obtain the proper support. 
33 34	Incorrect linear or angular alignment of two or more coupled shafts with two or more bearings.	Correct alignment by shimming the housings. Ensure that the shafts are coupled in a straight line, especially when three or more bearings operate on one shaft. Be sure to use full support shims. 
37	Washer prong is rubbing against the bearing.	Remove the lockwasher. Straighten the prong or replace with a new washer. 
45	Shaft or housing shoulders or locknut face out-of-square with the bearing seat.	Remachine parts to obtain squareness. 
47	Bearing seating diameter is oversized, causing excessive inner ring expansion. This reduced bearing clearance.	Grind shaft to get a proper fit between the shaft and the bearing inner ring. If regrinding is not possible change to bearing with larger radial clearance. 

Bearing Failures and Their Causes

Since the bearings of a machine are among its most vital components, the ability to learn as much as possible from bearing failures is of utmost importance.

In designing the bearing mounting the first step is to decide which type and size of bearings should be used. The choice is usually based on a certain desired life for the bearing. The next step is to design the application with allowance for the prevailing service conditions. Unfortunately, too many of the ball and roller bearings installed never attain their calculated life expectancy because of something done or left undone in handling, installation and maintenance.

The calculated life expectancy of any bearing is based on four assumptions:

1. Good lubrication in proper quantity will always be available to the bearing.
2. The bearing will be mounted without damage.
3. Dimensions of parts related to the bearing will be correct.
4. There are no defects inherent in the bearing.

However, even when properly applied and maintained, the bearing will be subjected to one cause of failure: fatigue of the bearing material. Fatigue is the result of shear stresses cyclically applied immediately below the load carrying surfaces and is observed as spalling away of surface metal, as seen in **Figures** 1 through 3. Although spalling can be readily observed, it is necessary to discern between spalling produced at the normal end of a bearing's useful life and that triggered by causes found in the three major classifications of premature spalling: lubrication, mechanical damage, and material defects. Most bearing failures can be attributed to one or more of the following causes:

1. Defective bearing seats on shafts and in housings.
2. Misalignment.
3. Faulty mounting practice.
4. Incorrect shaft and housing fits.
5. Inadequate lubrication.
6. Ineffective sealing.
7. Vibration while the bearing is not rotating.
8. Passage of electric current through the bearing.
9. Transportation, storage and handling.

Spalling

The actual beginning of spalling (or flaking) is invisible because its origin is usually below the surface. The first visible sign is a small crack, which cannot be seen nor can its effects be heard while the machine operates. **Figures** 1-3 illustrate the progression of spalling. The spot on the inner ring in **Figure** 1 will gradually spread to the condition seen in the ring of **Figure** 3 where spalling extends around the ring. By the time spalling reaches proportions shown in **Figure** 2, the condition should make itself known by noise. If the surrounding noise level is too great, a bearing's condition can be evaluated by using a monitoring device. The time between incipient and advanced spalling varies with speed and load, but in any event it is not a sudden condition that will cause destructive failure within a matter of hours. Complete bearing failure and consequent damage to

Fig 1

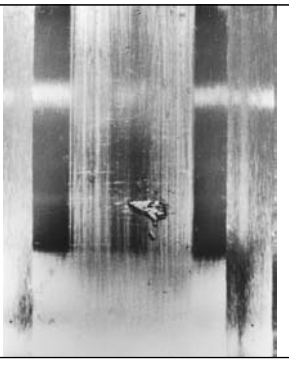


Figure 1: *Early fatigue spalling.*

Fig 2

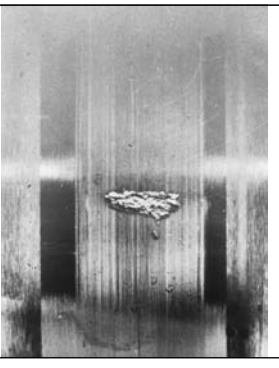


Figure 2: *More advanced spalling.*

Fig 3

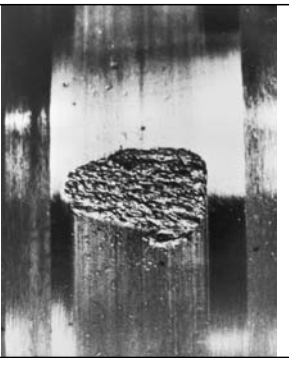


Figure 3: *Greatly advanced spalling.*

machine parts is usually avoided because of the noise the bearing will produce and the erratic performance of the shaft supported by the bearing.

The patterns of load zones and their meaning in bearing damage

There are many ways bearings can be damaged before and during mounting and in service. The pattern or load zone produced by the action of the applied load and the rolling elements on the internal surfaces of the bearing is a clue to the cause of failure.

To benefit from a study of load zones, one must be able to differentiate between normal and abnormal patterns. **Figure 4** illustrates how an applied load of constant direction is distributed among the rolling elements of a bearing. The large arrow indicates the applied load and the series of small arrows show the share of this load that is supported by each ball or roller in the bearing. The rotating ring will have a continuous 360˚ zone while the stationary ring will show a pattern of approximately 150˚. **Figure 5** illustrates the load zone found inside a ball bearing when the inner ring rotates and the load has a constant direction. **Figure 6** illustrates the load zone resulting if the outer ring rotates relative to a load of constant direction, or where the inner ring rotates and the load also rotates in phase with the shaft. **Figure 7** illustrates the pattern we find in a deep groove ball bearing carrying an axial load and **Figure 8** shows pattern from excessive axial load. This is one condition where the load zones are the full 360˚ on both rings. Combined thrust and radial load will produce a pattern somewhere between the two as shown in **Figure 9**. With combined load, the loaded area of the inner ring is slightly off-center and the length in the outer is greater than that produced by radial load, but not necessarily 360˚. In a double-row bearing, a combined load will produce load zones of unequal length. The thrust carrying row will have a longer stationary load zone. If the thrust is of sufficient magnitude, one row of rolling elements can be completely unloaded.

When an interference fit is required, it must be sufficient to prevent the

Fretting Corrosion Fretting corrosion is the mechanical wearing of material which occurs from movement between two surfaces resulting in oxidation or rust colored appearance. Usually found on the inner ring bore or outer ring OD, and corresponds to load zone areas.
Spalling Spalling is the flaking away of material which occurs after fatigue of the rolling contact surfaces.
Smearing Smearing is the transfer of material which occurs when one hardened steel surface slides against another without the benefit of proper lubrication.
Fragment Denting Indentations which result from the compression of solid foreign particles trapped between two rolling surfaces under load.
Brinelling Brinells are indentations which are caused by balls or rollers in a bearing receiving an excessive static load such as an impact/shock. The grinding pattern is still visible in the bottom of the dent when viewed under a microscope.
False Brinelling False brinelling is the localized wearing, arising when rolling elements of the bearing move back and forth against the raceway surface, in a stationary bearing subjected to vibrations. The distinguishing feature of false brinelling from true brinelling is the absence of grinding marks at the bottom of the indentations and/or rust colored appearance at each location.
Parasitic Loads Unexpected loads which occur due to improper set-up, changing operating conditions or environment.
Fatigue Failure Failure due to material fatigue or spalling.

Fig 4

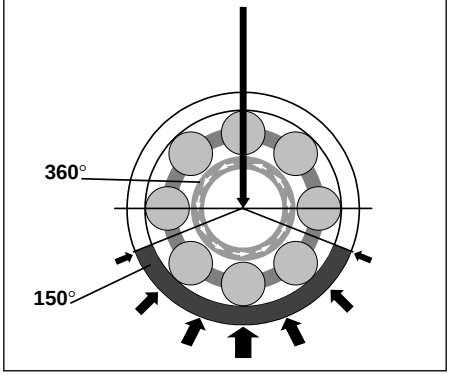


Figure 4: *Load distribution within a bearing.*

Fig 5

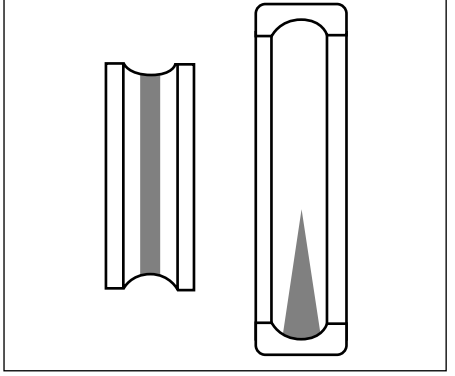


Figure 5: *Normal load zone inner ring rotating relative to load.*

Fig 6

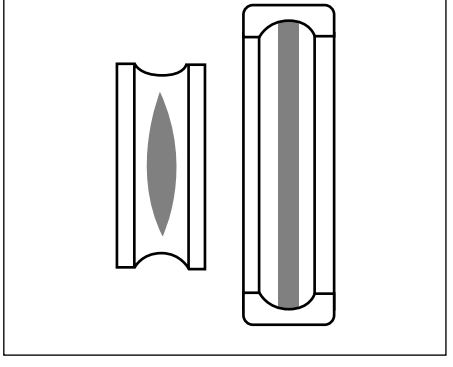


Figure 6: *Normal load zone outer ring rotating relative to load or load rotating in phase with inner ring.*

Fig 7

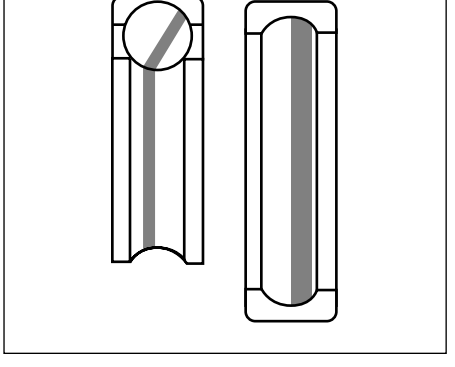


Figure 7: *Normal load zone. Axial load.*

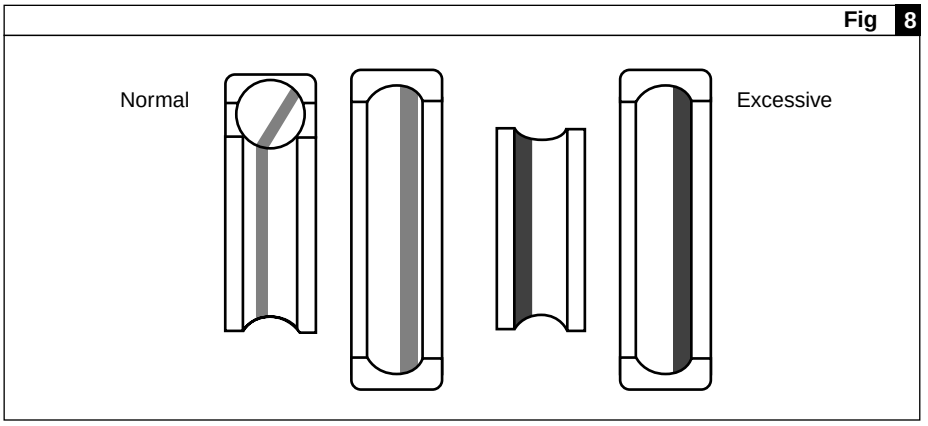


Figure 8: *Load zone when thrust loads are excessive.*

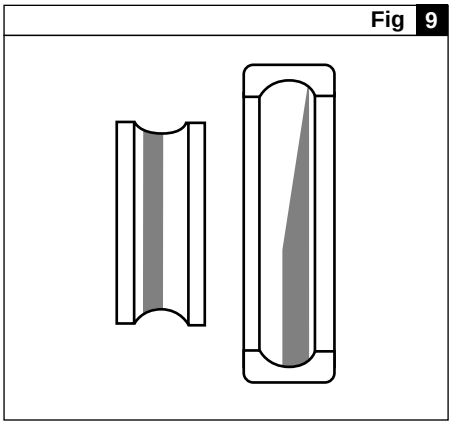


Figure 9: *Normal load zone combined thrust and radial load.*

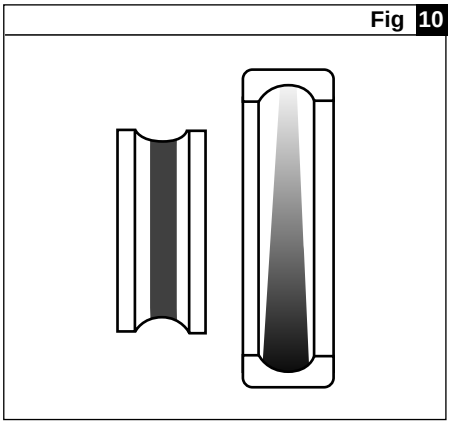


Figure 10: *Load zone from internally preloaded bearing supporting radial load.*

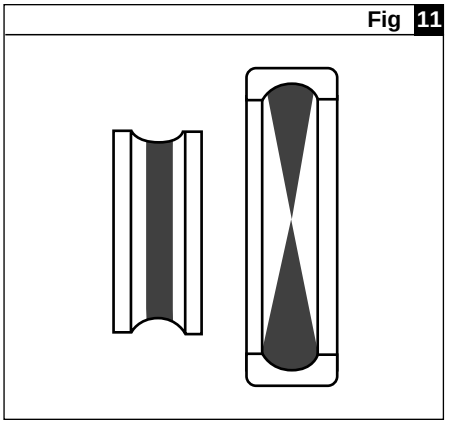


Figure 11: *Load zones produced by out-of-round housing pinching outer ring.*

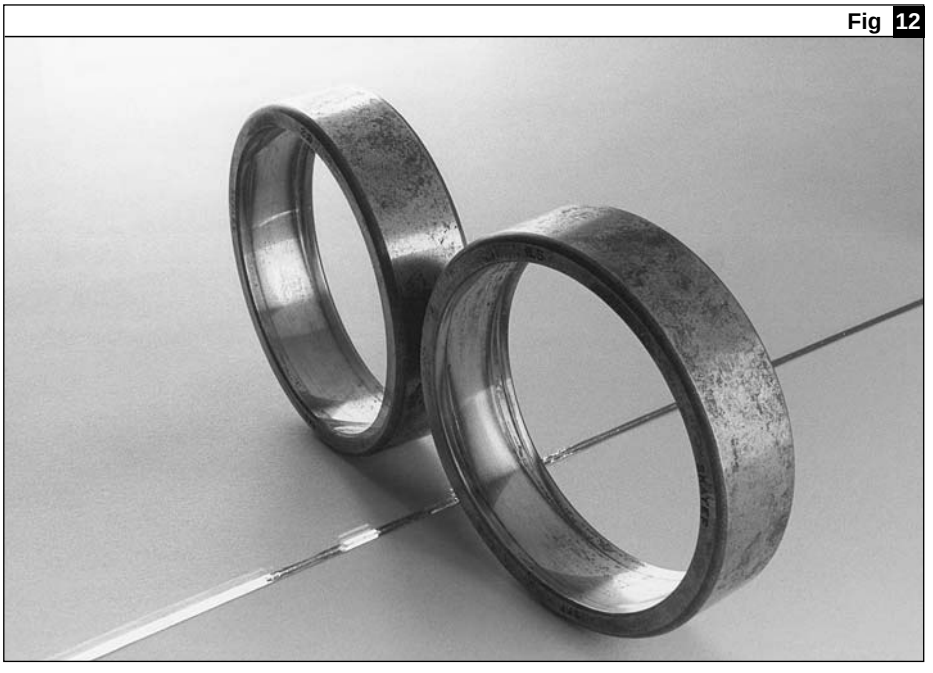


Figure 12: *Mirror view shows how raceway is affected by out-of-round housing (see Fig. 11).*

inner ring from slipping on the shaft. There are ISO/ABMA standards defining just what this fit should be for any application and bearing type. A discussion of fitting practice appears on page 32. If the fit is too tight, the bearing can be internally preloaded by compressing the rolling elements between the two rings. In this case, the load zones observed in the bearing indicate that this is not a normal life failure as **Figure** 10 shows. Both rings are loaded through 360°, but the pattern will usually be wider in the stationary ring where the applied load is superimposed most on the internal preload.

Distorted or out-of-round housing bores can radially pinch an outer ring. **Figure** 11 illustrates the load zone found in a bearing where the housing bore was initially out-of-round or became out-of-round by bolting the housing to a concave or convex surface. In this case, the outer ring will show two or more load zones depending on the type of distortion. **Figure** 12 is a picture of a bearing that had been mounted in an out-of-round housing that pinched the stationary outer ring. This is a mirror view and shows both sides of the outer ring raceway. Certain types of bearings can tolerate only very limited amounts of misalignment. A deep groove ball bearing when misaligned will produce load zones not parallel to the ball groove on one or both rings depending on which ring is misaligned. **Figure** 13 illustrates the load zone when the outer ring is misaligned relative to the shaft. **Figure** 14

Fig 13

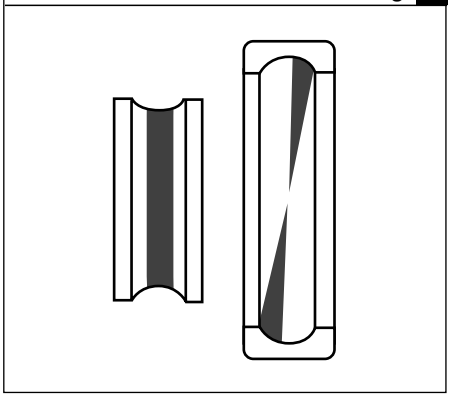


Figure 13: *Load zone produced when outer ring is misaligned relative to shaft axis (e.g.: shaft deflection).*

Fig 14

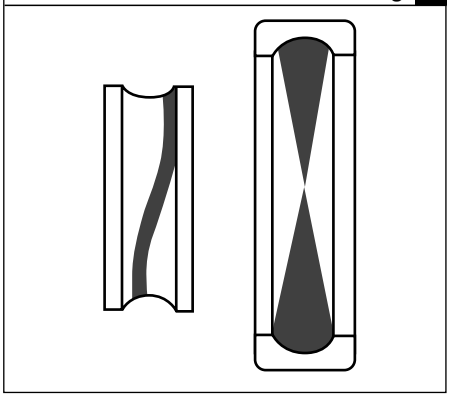


Figure 14: *Load zones when inner ring is misaligned relative to shaft axis (e.g.: bent shaft).*

Fig 15

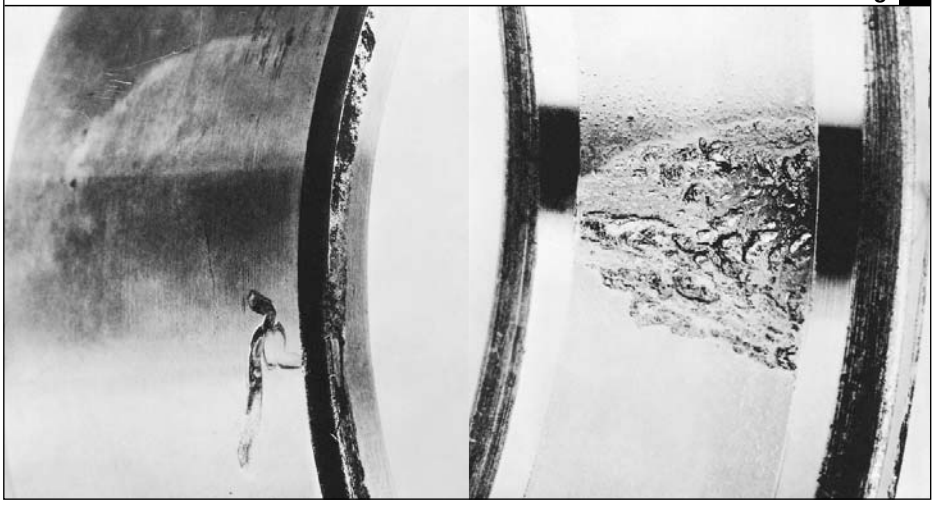


Figure 15: *Fatigue from chip in housing bore.*

Fig 16



Figure 16: *Wear due to fretting corrosion.*

illustrates the patterns that appear when the inner ring is misaligned relative to the housing. Cylindrical roller bearings and angular contact ball bearings are also sensitive to misalignments but it is more difficult to detect this condition from the load zones. With this background of failure patterns, the following failure descriptions should be meaningful.

1. Failure due to defective bearing seats on shafts and in housings

The calculated life expectancy of a roller bearing presupposes that its comparatively thin rings will be fitted on shafts or in housings that are as geometrically true as modern machine shop techniques can produce. Unfortunately, there are factors that produce shaft seats and housing bores that are oversized or undersized, tapered or oval.

Figure 15 shows the condition resulting when a bearing outer ring is not fully supported. The impression made on the bearing O.D. by a turning chip left in the housing when the bearing was installed is seen in the left hand view. This outer ring was subsequently supported by the chip alone with the result that the entire load was borne buy a small portion of the roller path. The heavy specific load imposed on that part of the ring immediately over the turning chip produced the premature spalling seen in the illustration. On both sides of the spalled area there is a condition called fragment denting, which occured when fragments from the flaked surface were trapped between the rollers and the raceway.

Fretting corrosion is the mechanical wearing of surfaces other than rolling contact, resulting from movement which produces oxidation or a rust colored appearance. When the contact between a bearing and its seat is not perfect, small movements can produce fretting corrosion (➔ **figs** 16 and 17). Fretting started the crack which in turn triggered the spalling.

Fretting corrosion can also be found in applications such as railroad journal boxes, where machining of the seats is accurate but where, because of service conditions, the seats deform under load. This type of fretting corrosion on the outer ring does not as a rule detrimentally affect the life of the bearing. Shaft seats or journals as well as housing bores can yield and produce fretting corrosion. **Figure** 18 illustrates damage by movement on a shaft. The fretting corrosion covers a large portion of the surface of both the inner ring bore and the journal.

Bearing damage is also caused by bearing seats that are concave, convex, or tapered. On such a seat, a bearing ring can not make contact throughout its width. The ring therefore deflects under the loads and fatigue cracks commonly appear axially along the raceway. Cracks caused by faulty contact between a ring and its housing are shown in **Figure** 19.

2. Misalignment

Misalignment is a common source of premature spalling. It occurs when an

Fig 17



Figure 17: *Advanced wear and cracking due to fretting corrosion.*

Fig 18

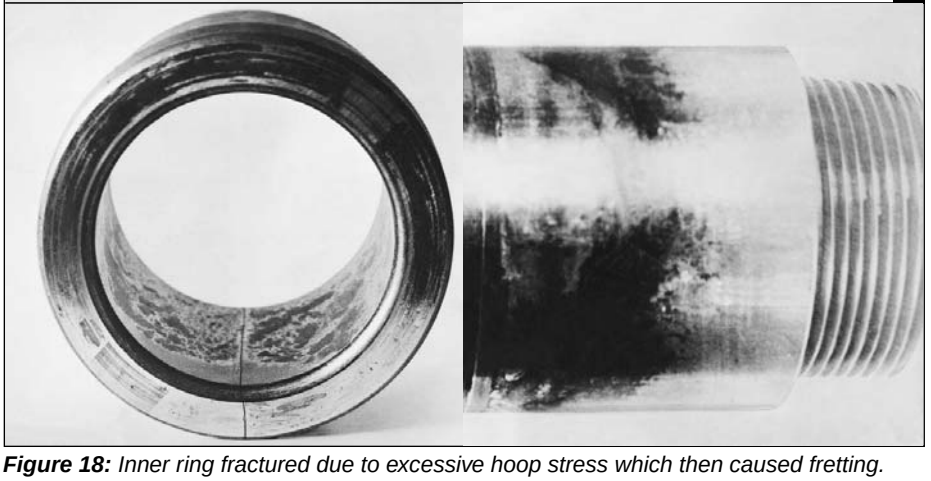


Figure 18: *Inner ring fractured due to excessive hoop stress which then caused fretting.*

Fig 19



Figure 19: *Cracks caused by faulty housing fit.*

Fig 20

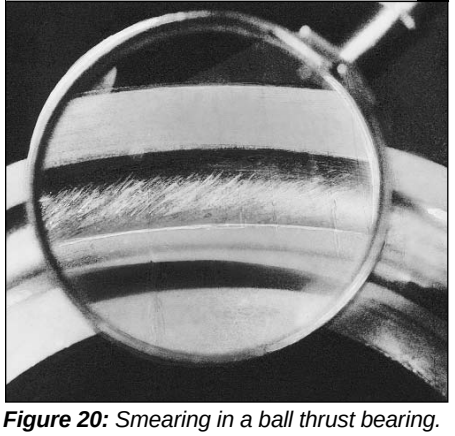


Figure 20: *Smearing in a ball thrust bearing.*

inner ring is seated against a shaft shoulder that is not square with the journal, or where a housing shoulder is out-of-square with the housing bore. Misalignment arises when two housings are not on the same center line. A bearing ring can be misaligned even though it is mounted on a tight fit but is not pressed against its shoulder and so left cocked on its seat. Bearing outer rings in slip-fitted housings that are cocked across their opposite corners can also result in misalignment.

Some of the foregoing misalignment faults are not cured by using self-aligning bearings. When the inner ring of a self-aligning bearing is not square with its shaft seat the inner ring is required to wobble as it rotates. This results in smearing and early fatigue. Where an outer ring is cocked in its housing across corners, a normally floating outer ring can become axially held as well as radially pinched in its housing. The effect of a pinched outer ring was shown in **Figure** 12.

Ball thrust bearings suffer early fatigue when mounted on supports that are not perpendicular to the shaft axis, because one short load zone of the stationary ring carries all of the load. When the rotating ring of the ball thrust bearing is mounted on an out-of-square shaft shoulder, the ring wobbles as it rotates. The wobbling rotating ring loads only a small portion of the stationary ring and causes early fatigue.

Figure 20 illustrates smearing within a ball thrust bearing when either one of two conditions occurs: first, the two rings may not be parallel to each other during operation, and secondly, the load may not be sufficient at the operating speed to hold the bearing in its designed operational attitude. If the condition arises from non-parallelism of the rings, the smearing seen in **Figure** 20 occurs when the balls pass from the loaded into the unloaded zone. Secondly, if the rings are parallel to each other but the speed is too high in relation to the load, centrifugal force causes each ball to spin instead of roll at its contact with the raceway. Smearing results. Smearing from misalignment will be localized in one zone of the stationary ring whereas smearing from gyral forces will be general around both rings.

Where two housings supporting the same shaft do not have a common centerline, only self-aligning ball or roller bearings will be able to function without inducing bending moments. Cylindrical and tapered roller bearings can accommodate only very small misalignments, even if crowned. If misalignment is appreciable, edge-loading results, a source of premature fatigue. Edge-loading from misalignment was responsible for the spalling in the bearing ring shown in **Figure** 21. Advanced spalling due to the same cause can be seen on the inner ring and a roller of a tapered roller bearing in **Figure** 22.

3. Faulty mounting practice

Premature fatigue and other failures are often due to abuse and neglect before and during mounting. Prominent among causes of early fatigue is the presence of foreign matter in the bearing and its housing during operation. The effect of trapping a chip between the O.D. of the bearing and the bore of the housing was shown in **Figure** 15. **Figure** 23 shows the inner ring of a bearing where foreign matter has been trapped between the raceway and the rollers causing brinelled depressions. This condition is called fragment denting. Each of these small dents is the potential start of premature fatigue. Small particles of foreign matter cause wear, and when the original internal geometry is changed, the calculated life expectancy cannot be achieved.

Impact damage during handling or mounting results in brinelled depressions that become the start of premature fatigue. An example of this is shown in **Figure** 24, where the spacing of flaked areas correspond to the distance between the balls. The bearing has obviously suffered impact, and if it has been installed, the fault should be apparent by noise of vibration during operation.

Cylindrical roller bearings are easily damaged in mounting, especially when the rotating part with the inner ring mounted on it is assembled into a stationary part with its outer ring and roller set assembled. **Figure** 25 shows the inner ring of a cylindrical roller bearing that has been damaged because the rollers had to slide forceably across the inner ring during assembly. Here again the spacing of the damage marks on the inner ring is the same as the distance between rollers. The smeared streak in **Figure** 25 is shown enlarged eight times in **Figure** 26.

If a bearing is subjected to loads greater than those calculated to arrive at the life expectancy, premature fatigue results. Unanticipated or parasitic loads can arise from faulty mounting practice. An example of parasitic load can be found in the procedure of mounting the front wheel of an automobile. If the locknut is not backed off after the specific torque to seat the bearing is applied, parasitic load may result. Another example would be any application where a bearing should be free in its housing, but because of pinching or cocking, it cannot move with thermal expansion. **Figure** 27 shows the effect of a parasitic thrust load. The damaged area is not in the center of the ball groove as it should be, but is high on the shoulder of the groove. The ring shown in **Figure** 28 is of a self-aligning ball bearing subjected to an abnormally heavy thrust load. Usually in such cases, evidence of axial restraint will appear either as the imprint of a housing shoulder on the

Fig 21



Figure 21: *Fatigue caused by edge-loading.*

Fig 23



Figure 23: *Fragment denting.*

Fig 25

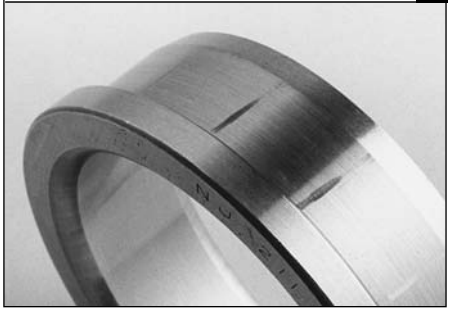


Figure 25: *Smearing caused by excessive force in mounting.*

Fig 22

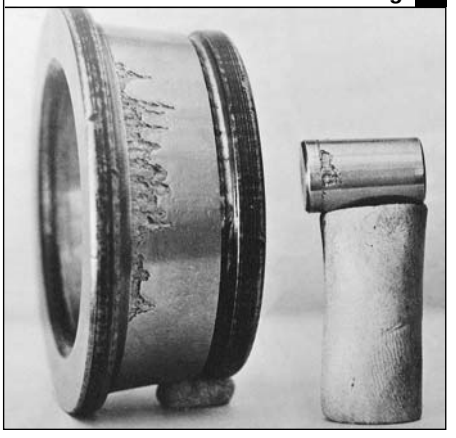


Figure 22: *Advanced spalling caused by edge-loading.*

Fig 24



Figure 24: *Fatigue caused by impact damage during handling or mounting.*

Fig 26

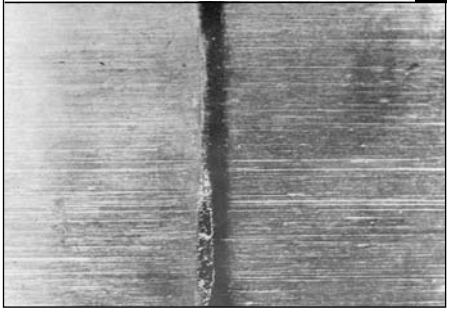


Figure 26: *Smearing, enlarged 8X from Figure 25.*

Fig 27



Figure 27: *Spalling from excessive thrust.*

Fig 28



Figure 28: *Spalling from parasitic thrust.*

Fig 29

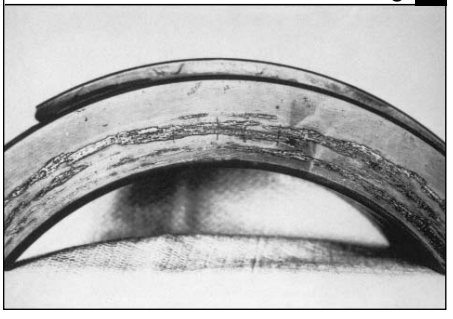


Figure 29: *Smearing caused by contact with the shaft shoulder while bearing ring rotated.*

Fig 30



Figure 30: *Scoring of inner ring bore caused by "creep".*

Fig 31

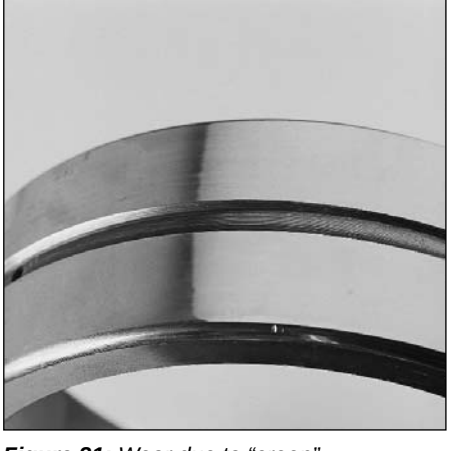


Figure 31: *Wear due to "creep".*

outer ring face, or as areas of fretting on the O.D. of the bearing.

Interference between rotating and stationary parts can result in destructive cracks in the rotating bearing ring. The roller bearing inner ring in **Figure** 29 shows the effect of contact with the shaft shoulder while the bearing ring rotated.

4. Damage due to improper fit

To decide if a bearing ring, either inner or outer, should be mounted with an interference or a slip fit on its shaft or in its housing, it must be determined whether the ring rotates or is stationary with reference to the direction of the load. The degree of tightness or looseness is governed by the magnitude of the load and the speed. If a bearing ring rotates relative to the load direction, an interference fit is required. If the ring is stationary with reference to the load, it is fitted with some clearance and is called a loose fit. The degree of fit is governed by the concept that heavier loads require greater interference. The presence of shock or continuous vibration calls for heavier interference fit of the ring that rotates relative to the load. Lightly loaded rings or rings with considerable load but which operate at extremely slow speeds that rotate relative to the load, may use a lighter fit or, in some cases, a slip fit.

Consider two examples. In an automobile front wheel, the direction of the load is constant — the pavement is always exerting an upward force on the wheel. In this case, the outer rings or cups are rotating and are press-fitted into the wheel hub while the inner rings or cones are stationary and are slip fitted on the spindle. On the other hand, the bearings of a conventional gear drive have their outer rings stationary relative to the load and are slip fitted but the inner rings rotate relative to the load and are mounted with an interference fit. There are some cases where it appears necessary to mount both inner and outer rings of a bearing with interference fits due to a combination of stationary and rotating loads or loads of undetermined amounts. Such cases are designed with bearings that can allow axial expansion at the rollers rather than at a slip-fitted ring. Such a mounting would consist of a cylindrical roller bearing or CARB™ at one end of the shaft and a self-contained bearing (deep groove ball or spherical roller bearing) at the other end.

Some examples of the effects of incorrect fitting follow. **Figure** 30 shows the bore surface of an inner ring that has been damaged by relative movement between it and its shaft while rotating under a constant direction load. This relative movement, called creep, can result in the scoring shown in **Figure** 30. When a normally press fitted inner ring does creep, the damage is not confined to the bore surface but can have its effect on the faces of the ring. Contact with shaft shoulders or spacers can result in either wear or severe rubbing cracks (→ **Figure** 29). Wear between a press fitted ring and its seat is an accumulative damage. The initial wear accelerates the creep which in turn produces more wear. The ring loses adequate supports, develops cracks, and the products of wear become foreign matter to fragment dent and internally wear the bearing.

Excessive fits also result in bearing damage by internally preloading the bearing as shown in **Figure** 10 or inducing dangerously high hoop stresses in the inner ring. **Figure** 32 illustrates an inner ring that cracked because of excessive interference fit.

Housing fits that are unnecessarily loose allow the outer ring to fret, creep or even spin. Examples of fretting were seen in **Figures** 16 and 17. Lack of support to the outer ring results from excessive looseness as well as from faulty housing bore contact. A cracked outer ring was shown in **Figure** 19.

Movement between surfaces can cause the bright polished appearance shown in **Figure** 31.

5. Inadequate or unsuitable lubricants

All bearings need lubricants for reliable operation. The curvature of the contact areas between rolling element and raceway in normal operation results in minute amounts of sliding motion in addition to the rolling. Also, the cage must be carried on either the rolling elements or some surface of the bearing rings, or a combination of these. In most types of roller bearings, there are roller end faces which slide against a flange or a cage. For these reasons, adequate lubrication is even more important at all times.

The term “lubrication failure” is too often taken to imply that there was no oil or grease in the bearing. While this does happen occasionally, the failure analysis is normally not that simple. Many cases require a thorough examination of the lubricant’s properties, the amount of lubricant applied to the bearing and the operating conditions. If any one of these factors does not meet requirements, the bearing can be said to have failed from inadequate lubrication.

Viscosity of the oil — either as oil itself or as the oil in grease — is the primary characteristic of adequate lubrication. The nature of the soap base of a grease and its consistency, along with the viscosity of the oil, are the main quality points when considering a grease. The quantity of lubricant required in a bearing at any one time is usually rather small, but the supply must be constant and consistent.

Fig 32



Figure 32: *Axial cracks caused by an excessive interference fit.*

If the lubricant is oil, and it is being used for heat removal as well as for lubrication, then a larger quantity is required.

An insufficient quantity of grease at medium to high speeds generates a temperature rise and usually a whistling sound. An excessive amount of grease results in churning, which produces a temperature rise in all but exceptionally slow speed bearings. A lubricant that is adequate under normal conditions can be made inadequate when operational conditions produce abnormally high temperatures.

When lubrication is inadequate, surface damage results. This damage progresses rapidly to failures that are often difficult to differentiate from a failure due to material fatigue or spalling. Spalling will occur and often destroy the evidence of inadequate lubrication. However, if caught soon enough, indications that pinpoint the real cause of the short bearing life can be found.

One form of surface damage is shown in stages in **Figures** 33 a, b, c, and d. The first visible indication of trouble is usually a fine roughening or waviness on the surface. Later, fine cracks develop, followed by spalling. If there is insufficient heat removal, the temperature may rise high enough to cause discoloration and softening of the hardened bearing steel. This happened to the bearing shown in **Figure** 34. In some cases, inadequate lubrication initially appears as a highly glazed or glossy surface which, as damage progresses, takes on a frosty appearance and eventually spalls. The highly glazed surface is shown in **Figure** 35.

In the frosty stage, it is sometimes possible to feel the “nap” of fine slivers of metal pulled from the bearing raceway by the rolling element. The frosted area will feel smooth in one direction, but have distinct roughness in the other. As metal is pulled from the surface, pits appear and frosting advances to pulling (**Figure** 36).

Another form of surface damage is called smearing. It appears when two surfaces slide and the lubricant cannot prevent adhesion of the surfaces.

Fig 33



Figure 33: *a,b,c,d. Progressive stages of spalling caused by inadequate lubrication.*

Fig 34



Figure 34: *Discoloration and softening of metal caused by inadequate lubrication and excessive heat.*

Fig 35



Figure 35: *Glazing caused by inadequate lubrication.*

Fig 36

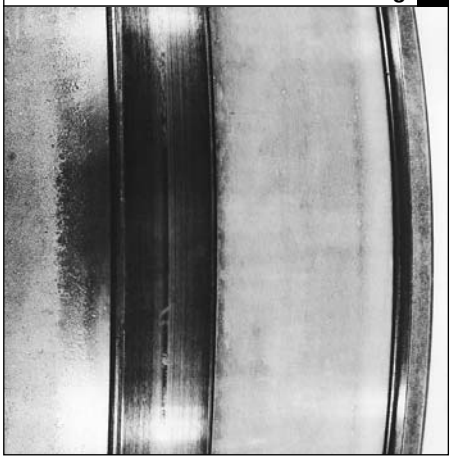


Figure 36: *Effect of rollers pulling metal from the bearing raceway (frosting)*

Fig 37

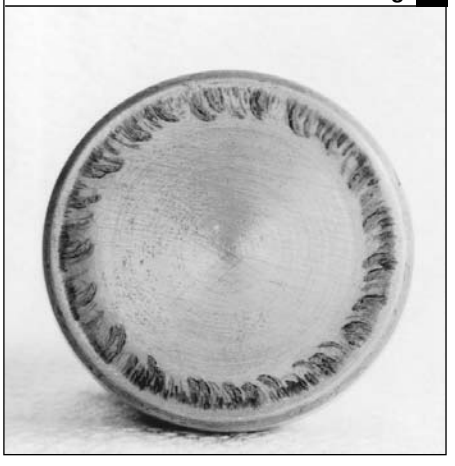


Figure 37: *Smearing on spherical roller end.*

Fig 38

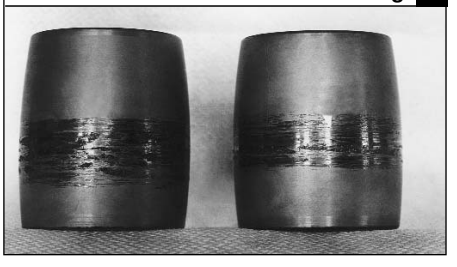


Figure 38: *Smearing on spherical rollers caused by ineffective lubrication.*

Fig 39

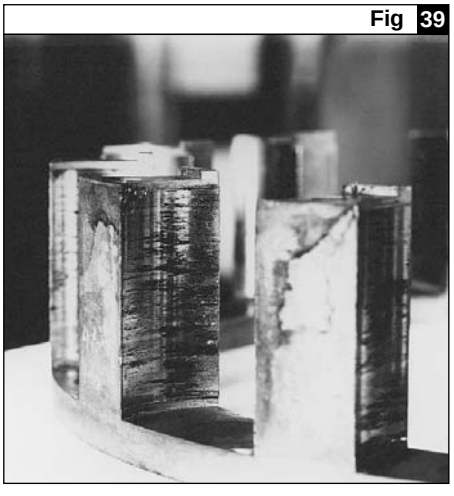


Figure 39: *Smearing on cage pockets caused by ineffective lubrication.*

Fig 40

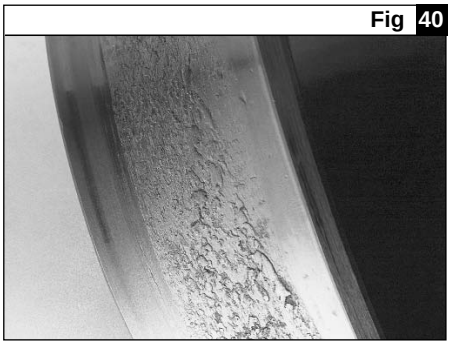


Figure 40: *Smearing on inner ring of spherical roller bearing.*

Minute pieces of one surface are torn away and rewelded to either surface. Examples are shown in **Figures** 37 through 40. A peculiar type of smearing occurs when rolling elements slide as they pass from the unloaded to the loaded zone. **Figure** 41 illustrates the patches of skid smearing, one in each row. Insufficient load, a lubricant that is too stiff, excessive clearance and insufficient lubrication in load zone, can all contribute to smearing.

Wear of the bearing as a whole also results from inadequate lubrication. The areas subject to sliding friction such as locating flanges and the ends of rollers in a roller bearing are the first parts to be affected. **Figures** 43 and 44 illustrate the damage done and the extent of the wear.

Figure 42 shows a large bore tapered roller bearing failure due to an insufficient amount of lubricant resulting from too low a flow rate in a circulating oil system. The area between the guide flange and the large end of the roller is subject to sliding motion.

Where high speeds are involved, inertial forces and lubrication become especially important. **Figure** 45 shows an advanced case of damage from high speed with inadequate lubrication. Inertia forces acting on the rolling elements at high speed and with sudden starting or stopping can result in high forces between rolling elements and the cage.

Fig 41



Figure 41: *Skid smearing on spherical outer raceway.*

Fig 42

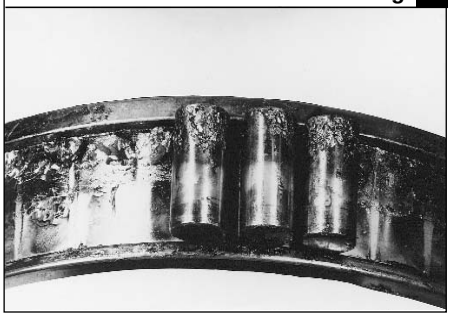


Figure 42: *Roller welded to rib because of ineffective lubrication.*

Fig 43

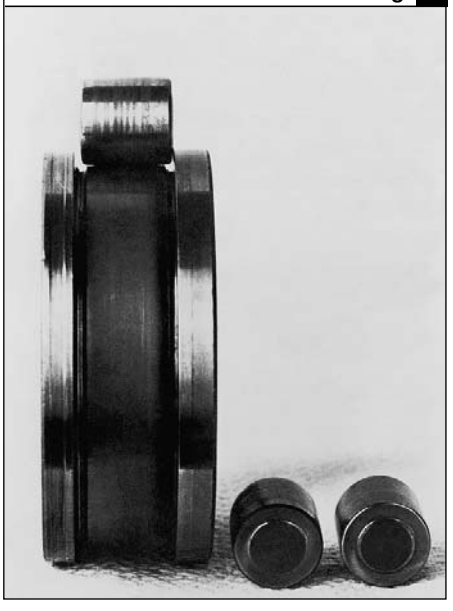


Figure 43: *Grooves caused by wear due to inadequate lubrication.*

Fig 44

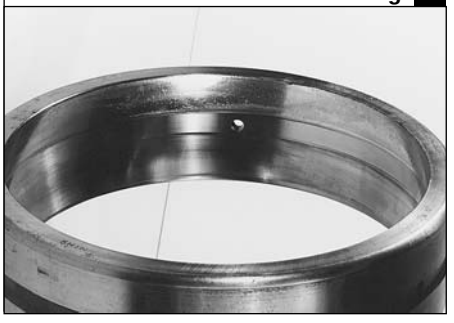


Figure 44: *Grooves caused by wear due to inadequate lubrication.*

Fig 45



Figure 45: *Broken cage caused by ineffective lubrication.*

Fig 46



Figure 46: *Advanced abrasive wear.*

This area is more difficult to lubricate than those areas of rolling motion, accounting for the discoloration starting at the flange contact area. The heat generated at the flange caused the discoloration of the bearing and resulted in some of the rollers being welded to the guide flange.

To avoid lubrication-related surface failures, be aware of the following:

a) Sufficient elastohydrodynamic film prevents surface distress (glazing, frosting).

b) Proper lubrication guards against smearing and sliding surface wear.

c) Clean lubricants prevent significant wear of rolling surfaces.

d) Sufficient lubricant flow keeps bearing from overheating.

As long as the rolling element and raceway surfaces in rolling contact can be separated by an elastohydro dynamic oil film, surface distress is avoided. The continuous presence of the film depends on contact area, the load it carries, the speed, operating temperature, the surface finish, and the oil viscosity.

In unusual applications, when viscosity selection must be governed by the sliding areas, experience has proven that the viscosity chosen is capable of maintaining the necessary elastohydrodynamic film in the rolling contacts.

SKF research has developed a procedure for determining the required oil viscosity when the bearing size, load, and speed are known and operating temperature can be reasonably estimated. Refer to the lubrication section of this catalog.

6. Ineffective Sealing

Although foreign matter can enter a bearing during mounting, its most direct and sustained area of entry can be the housing seals. The result of gross change in bearing internal geometry has been pointed out. Bearing manufacturers realize the damaging effect of dirt and take extreme precautions to deliver clean bearings. Not only assembled bearings, but also parts in process are washed and cleaned. Freedom from abrasive matter is so important that some bearings are assembled in air conditioned white rooms. Dramatic examples of combined abrasive particle and corrosive wear, both due to the defective sealing, are shown in **Figures** 46 and 47. **Figure** 48 shows a deep groove ball bearing which has operated with abrasive in it. The balls have worn to such an extent that they no longer support the cage and the latter has been rubbing on the lands of both rings.

In addition to abrasive matter, corrosive agents should be excluded from bearings. Water, acid and those agents that deteriorate lubricants result in corrosion. **Figure** 49 illustrates how moisture in the lubricant can rust the

Fig 47



Figure 47: *Advanced abrasive wear.*

Fig 48

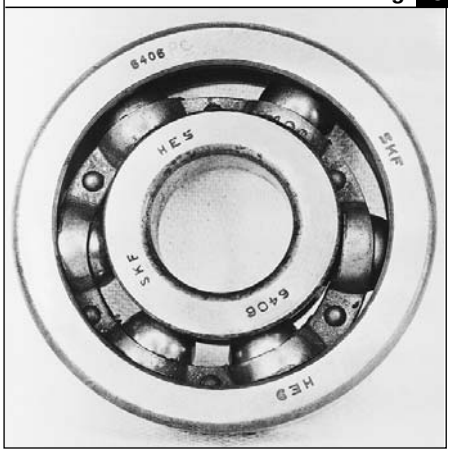


Figure 48: *Advanced abrasive wear.*

Fig 49



Figure 49: *Rust on end of roller caused by moisture in lubricant.*

Fig 50



Figure 50: *Corrosion on roller surface caused by water in lubricant while bearing was standing still.*

Fig 51



Figure 51: *Corrosion of roller surface caused by formation of acids in lubricant with some moisture present.*

Fig 52



Figure 52: *Corrosion streaks caused by water in the lubricant while the bearing rotated.*

end of a roller. The corroded areas on the rollers of **Figure** 50 occurred while the bearing was not rotating. Acids forming in the lubricant with water present etches the surface as shown in **Figure** 51. The streaks of corrosion seen in **Figure** 52 are caused by water in the lubricant as the bearing rotates.

7. Vibration

Rolling bearings exposed to vibration while the shafts are not rotating are subject to damage called false brinelling. The evidence can be either bright polished depressions or the characteristic red-brown stain of fretting. The oxidation rate at the point of contact determines the appearance. Variation in the vibration load causes minute sliding in the area of contact between rolling elements and raceways. Small particles of material are set free from the contact surfaces and may or may not be immediately oxidized. The debris thus formed acts as a lapping agent and accelerates the wear.

Another identification of damage of this type is the spacing of the marks on the raceway. The spacing of false brinelling will be equal to the distance between the rolling elements, just as it is in some types of true brinelling. If the bearing has rotated slightly between periods of vibration, more than one pattern of false brinelling damage may be seen.

A type of false brinelling with abrasive present is seen in **Figure** 53. There was no rotation between the two rings of the bearing for considerable periods of time, but while they were static they were subject to severe vibration. False brinelling developed with a production of iron oxide, which in turn acted as a lapping compound.

A combination of vibration and abrasion in a rotating bearing is seen in the wavy pattern shown in **Figure** 54. When these waves are more closely spaced, the pattern is called fluting and appears similar to cases shown in the section under Passage of Electric Current. Metallurgical examination is often necessary to distinguish between fluting caused solely by abrasive and vibration or by vibration and passage of electric current.

Fig 53



Figure 53: *False brinelling caused by vibration with bearing stationary.*

Fig 55

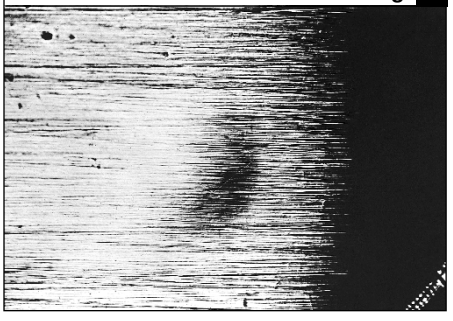


Figure 55: *Example of true brinelling — 100X*

Fig 57

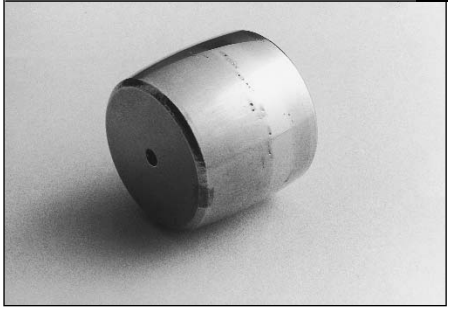


Figure 57: *Electric pitting on surface of spherical roller caused by passage of relatively large current.*

Since false brinelling is a true wear condition, such damage can be observed even though the forces applied during vibration are much smaller than those corresponding to the static carrying capacity of the bearing. However, the damage is more extensive as the contact load on the rolling elements increases.

Fig 54

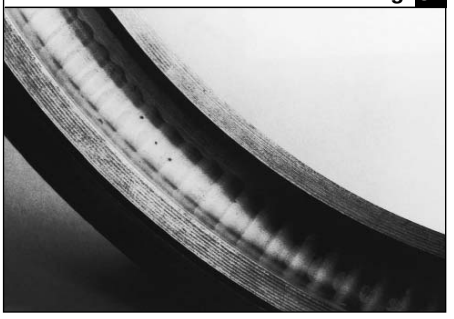


Figure 54: *False brinelling caused by vibration in presence of abrasive dirt while bearing was rotating.*

Fig 56

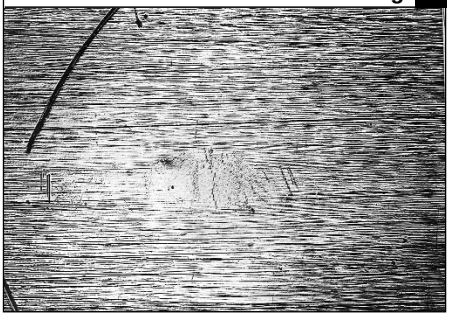


Figure 56: *Example of false brinelling — 100X*

Fig 58



Figure 58: *Electric pitting on surface of spherical outer raceway caused by passage of relatively large current.*

False brinelling occurs most frequently during transportation of assembled machines. Vibration fed through a foundation can generate false brinelling of a shaft that is not rotating. False brinelling during transportation can always be minimized and usually eliminated by temporary structures that will prevent any rotation or axial movement of the shaft.

It is necessary to distinguish between false and true brinelling. **Figures** 55 and 56 are 100X photomicrographs of true and false brinelling in a raceway respectively. In **Figure** 55, true brinelling, there is a dent produced by plastic flow of the raceway material. The grinding marks are not noticeably disturbed and can be seen over the whole dented area. However, false brinelling, **Figure** 56, does not involve flow of metal but rather a removal of surface metal by attrition. Notice that the grinding marks are removed. To further understand false brinelling, which is very similar to fretting corrosion, one should remember that a rolling element squeezes the lubricant out of its contact with the raceway, and the angular motion from vibration is so small that the lubricant is not replenished at the contact. Metal to metal contact becomes inevitable, resulting in submicroscopic particles being torn from high points. If protection by lubricant is absent, these minute particles oxidize and account for the red-brown color usually associated with fretting. If there is a slower oxidation rate, the false brinelling depression can remain bright, thereby adding to the difficulty in distinguishing true from false brinelling.

8. Passage of Electric Current Through the Bearing

In certain electrical machinery applications, there is the possibility that electric current will pass through a bearing. Current that seeks ground through the bearing can be generated from stray magnetic fields in the machinery. It can also be caused by welding on some part of the machine with the ground attached so that the circuit is required to pass through the bearing.

An electric current can be generated by static electricity, emanating from charged belts or from manufacturing processes involving leather, paper, cloth or rubber. This current can pass through the shaft to the bearing and then to ground. When the current is broken at the contact surfaces between rolling elements and raceways, arcing results. This produces very localized high temperature and consequent damage. The overall damage to the bearing is in proportion to the number and size of individual damage points.

Figure 57 shows a series of electrical pits in a roller; **Figure** 58 shows the same type of damage in an enlarged

view of a spherical roller bearing raceway. The pit was formed each time the current broke in its passage between raceway and roller.

Another type of electrical damage occurs when current passes during prolonged periods and the number of individual pits accumulate drastically. The result is fluting, shown in **Figures** 59 through 63. This condition can occur in ball or roller bearings. Flutes can develop considerable depth, producing noise and vibration during operation and eventual fatigue from local overstressing. The formation of flutes rather than a homogeneous dispersion of pits cannot be clearly explained. It is possible that it is related to initial synchronization of shocks or vibrations and the breaking of the current. Once the fluting has started, it is probably a self-perpetuating phenomenon.

Individual electric marks, pits, and fluting have been produced in test bearings. Both alternating and direct current can cause the damage. Amperage rather than voltage governs the amount of damage. When a bearing is under radial load, greater internal looseness in the bearing appears to result in greater electrical damage for the same current. In a double-row bearing loaded in thrust, little if any damage results in the thrust carrying row, although the opposite row may be damaged.

Fig 59



Figure 59: *Fluting on surface of spherical roller caused by prolonged passage of electric current.*

Fig 60



Figure 60: *Fluting on inner raceway of spherical roller bearing caused by prolonged passage of electric current.*

Fig 61

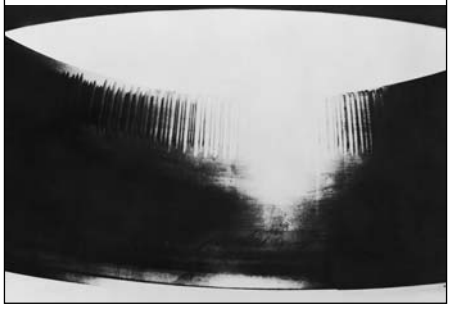


Figure 61: *Fluting on raceway of spherical roller bearing.*

Fig 62

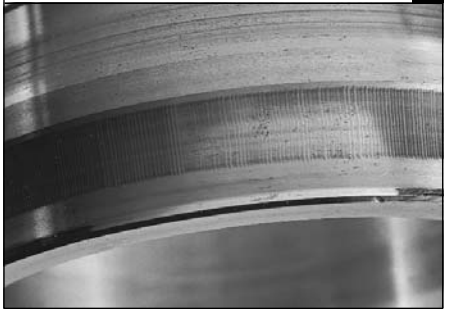


Figure 62: *Fluting on inner raceway.*

Fig 63



Figure 63: *Fluting on raceway of ball bearing caused by prolonged passage of relatively small electric current.*

SKF Bearing Maintenance Products

SKF bearings are precision products, manufactured from high quality steels, machined, hardened and ground to extremely fine finishes and close tolerances. But what treatment do these precision products get when they are mounted and dismounted?

Precision products require precision tools for mounting and dismounting. That is why SKF offers a comprehensive range of tools for the job.

Contact your local SKF Authorized Distributor or SKF sales office for more information about our complete line of bearing maintenance products, or request SKF catalog 711-639 on the order sheet shown on page 123.



PULLERS

—Standard jaw pullers
—Reversible jaw pullers
—Hydraulically-assisted heavy duty jaw pullers and kits
—Strong back pullers
—Internal Bearing puller kits
—Blind housing puller kit
—Hydraulic ram



FITTING TOOLS

—Hook spanner
—Axial lock nut sockets
—Impact spanners
—Bearing fitting tools
—Precut machinery shims
—Feeler gauges



HEATERS

—"Scorpio" Induction Heater
—Small and medium induction heaters
—Large induction heater
—Electric hot plate



OIL POWER

—Hydraulic nuts
—Air-driven hydraulic pumps
—Hydraulic pump
—Oil injector
—Supporting adapter block
—Oil injection kits
—Mounting and dismounting fluid



INSTRUMENTS

—Thermo-Pen
—High-accuracy single and dual probe function thermometers
—Multi function optical tachometer
—OilCheck monitor
—Vibration pen
—MARLIN™ data management system
—Microlog



GREASES

—Grease packer
—Grease gun
—SKF SYSTEM 24 automatic lubricator
—Anti-fretting agent
—Rust inhibitor

Bearing Mounting and Dismounting Methods

Bearing arrangements	Mounting tools				Dismounting tools			
	Mechanical	Hydraulic	Oil injection	Heaters	Mechanical	Hydraulic	Oil injection	Heaters
Cylindrical seating								
Small bearings								
Medium bearings								
Large bearings								
Cylindrical roller bearing types NU, NJ, NUP, all sizes								
Tapered seating								
Small bearings								
Medium bearings								
Large bearings								
Adapter sleeve								
Small bearings	*							
Medium bearings								
Large bearings								
Withdrawal sleeve								
Small bearings					*			
Medium bearings								
Large bearings								

Small bearings: Bore diameter < 80 mm • Medium bearings: Bore diameter 80 - 200 mm • Large bearings: Bore diameter > 200 mm
** Only for self-aligning ball bearings.*

Key

Jaw puller	Bearing separator	Hydraulic puller	Fitting tool	Hook spanner	Impact spanner	Hydraulic nut and pump	Oil injection method	Hot plate Induction heater	Aluminium ring EAZ heater

SKF Reliability Maintenance Institute

Covering every aspect of machine reliability

The Reliability Maintenance Institute™ is a comprehensive offering of training courses designed to help plants eliminate machinery problems and achieve maximum reliability and productivity by utilizing the very latest in precision maintenance techniques.

Some of these courses involve the use of highly sophisticated diagnostic equipment. Others are more basic in nature and cover such topics as bearing fundamentals and proper lubrication.

Each course is designed to address a specific machine installation or maintenance problem and help you correct it. And unlike other "maintenance training programs," the Reliability Maintenance Institute offers training to all plant levels that impact machine reliability.

Nobody knows more about machine performance than SKF

No matter what industry you're in or what type of machinery you use, the Reliability Maintenance Institute can help you maintain your equipment more productively and compete in your market more effectively.
To achieve these aims, training



courses are divided into three main groups: Bearing Maintenance Reliability, Proactive Reliability Maintenance™ Skills and Condition Monitoring.

Bearing Maintenance and Reliability

These courses make up the well-known SKF Bearing Maintenance Institute and they address every factor that impacts bearing service life. The emphasis of these courses is on improving bearing performance, which in turn improves the reliability of rotating equipment in which they are installed. Bearing Maintenance and Service courses include:

- **Bearing Maintenance and Service** – A three-day course that covers rolling bearing basics, mounting and dismounting, shaft and housing fits, bearing care, fundamentals of lubrication and an overview of applications for various types of bearings and industries.
- **Bearing Reliability in Continuous Casters** – An application-specific course that offers in-depth coverage of such topics as bearing functions, bearing designs and arrangements, ladle turrets, slewing rings, segment rolls and rollout tables. Bearing failure analysis and rework processes are also discussed.
- **Bearing Reliability in Centrifugal Pumps** – This course is designed to provide a clear understanding of the design, installation and maintenance of centrifugal pumps. The course will focus on bearings in pumps; from care and handling to bearing selection, internal clearances, shaft and housing fits and lubrication.
- **Root Cause Bearing Failure Analysis** – Attendees learn how to "read" the various signs of stress, strain and wear on a bearing that has failed prematurely to determine–and eliminate–the root cause of the failure.
- **Machine Tool Reliability** – This course teaches the precision skills necessary to keep machine tool spindles running at peak productivity. A hands-on demonstration of spindle rebuilding is also included.
- **Practical Applications in Bearing Lubrication** – This course covers real-world bearing lubrication in a dynamic, skills-based learning approach. Upon course completion, students will have learned the skills needed to choose, apply and maintain lubricants in bearing applications plant wide.







Proactive Reliability Maintenance Skills

Proactive Reliability Maintenance Skills courses focus on recent advances in machine maintenance technology and show how these new tools and techniques can help plants achieve greater machine reliability. Three levels of training are offered – for upper-level management, plant managers and supervisors, and technicians. Courses range from two-day workshops and seminars to five-day, intensive hands-on training sessions. Proactive Reliability Maintenance Skills courses include:

- **Proactive Reliability Maintenance Skills** – For mechanics and technicians. Participants learn how to assemble to precision standards, identify the most common causes of premature machine failure and prevent these failures from recurring.
- **Principles of Proactive Reliability Maintenance** – A two-day course that covers the latest in machine maintenance techniques and shows supervisors and managers how to assemble an effective machine reliability program utilizing these techniques.
- **Proactive Reliability Maintenance for Industry Leaders** – A one-day executive summary of the above two courses. Explains how reliability maintenance positively affects the bottom line. Held at customer location–for upper-level management and staff.
- **Precision Shaft Alignment – Laser Systems**
- **Field and Shop Balancing**

Condition Monitoring

Condition monitoring plays a vital role in ensuring the availability of plant machinery. With the proper skills and equipment, plant maintenance technicians not only detect problems before they result in a major machine malfunction or breakdown, but they also perform root cause failure analysis to prevent problems from recurring. Highly trained condition monitoring technicians can have a significant impact on a plant's bottom line profitability. The Reliability Maintenance Institute focuses on providing comprehensive training to assist technicians in utilizing the right technology, obtaining the greatest benefit from SKF products and software, and effectively communicating program results to plant management. Condition Monitoring courses include:

- **Product Training Courses** – These courses offer expert instruction in the application and proper use of advanced condition monitoring tools such as:
  - MicrologTMCMVA60 Portable Data Collector/Analyzer
  - Prism⁴ for Windows™
  - Machine Reliability Inspection (Marlin®) Data Management System
  - SKFmachine™ software
  - Machine Analyst™
- **Technology Courses** – Individual courses include:
  - Fundamentals of Machine Condition
  - Balancing with Microlog
  - Machinery Inspection & Evaluation
  - Machinery Analysis (three levels)
  - Advanced Machinery Diagnostics
  - Lubricant Analysis in Condition Monitoring
  - Airborne Ultrasound – 2 levels

Increased machine reliability starts here

The Reliability Maintenance Institute offers a mix of course types and venues to meet virtually any training need.

Reliability Maintenance Institute courses are held at various SKF and other off-site locations. On-site training is available at any time, at any customer location. In addition, regional seminars are available periodically, bringing the subject matter closer to your part of the country. Courses are continually being added and updated.

To find out more information or for the latest schedule, contact your SKF Service representative or the Reliability Maintenance Institute:

Phone: **717-751-2900**
Fax: **717-751-2901**
E-mail: **rmi@skf.com**
Web: **www.skfusa.com/rmi/**



Maintenance Road Show

The SKF Maintenance Road Show brings the latest in SKF bearing maintenance tools and techniques right to your location! With the SKF Maintenance Road Show, the emphasis is on “hands-on” demonstrations.

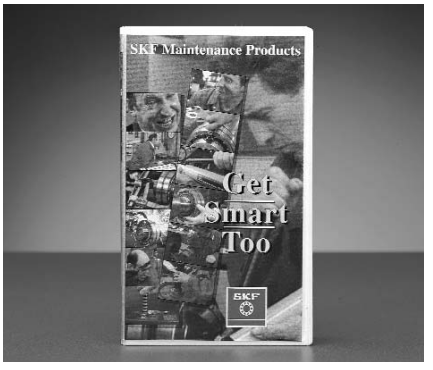
You’ll learn by doing how to use a variety of SKF bearing maintenance tools. And you’ll see the difference quality maintenance can make in terms of decreased downtime and increased productivity.



“Bearing Time” Video

Two amusing yet informative videos describe the advantages of unit pillow blocks and split pillow blocks—for convenient at-home or in-plant study.

Both videos are presented in the form of a fictional television show for do-it-yourselfers called “Bearing Time,” and step-by-step pillow block mounting, dismounting and maintenance procedures are demonstrated.



“Get Smart Too” Video

“Get Smart Too” provides an entertaining look at the right and wrong way to maintain bearings. This video follows two bearing maintenance engineers (who also happen to be next door neighbors) through a typical work day. One of these engineers uses a variety of SKF maintenance tools—Induction Heater, Hydraulic Pump, Bearing Puller Kit and the like—while the other engineer uses “traditional” maintenance methods, with less-than-satisfying results. Anyone involved in bearing maintenance would be smart not to miss this video!

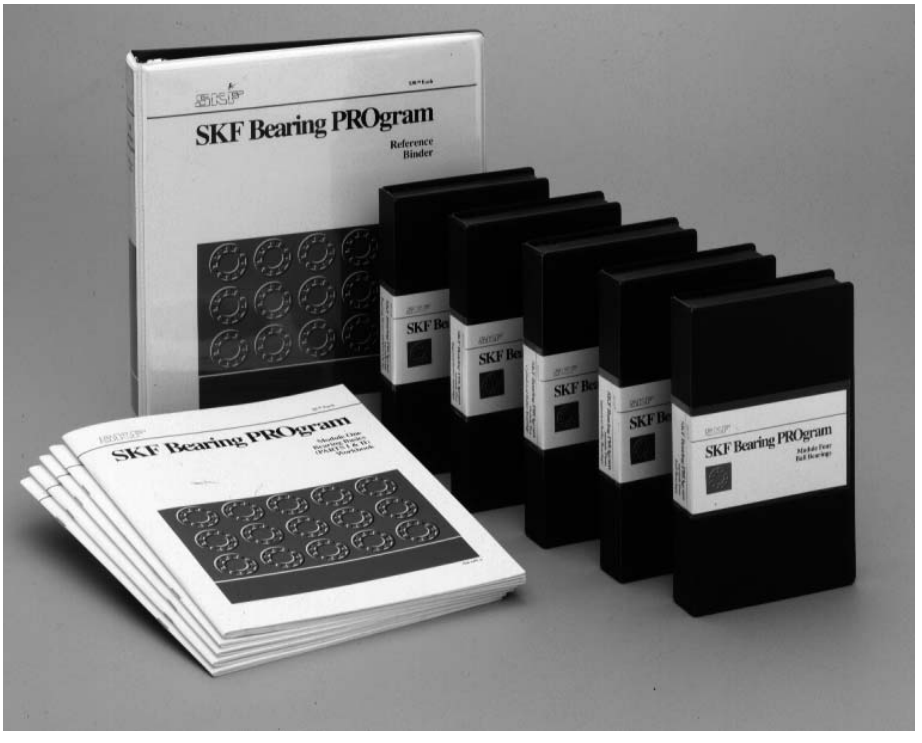
For SKF Authorized Distributors Only

Bearing selection, installation and maintenance is a precise science. And it's important that bearing distributors have a thorough understanding of how bearings work, how they should be maintained, and how they fit into their customers' operations.

To that end, SKF offers a variety of training programs just for distributors. So when customers see that SKF Authorized Distributor sign, they know they're getting not only the highest quality bearings and related products, but also the highest quality distributor sales support.

Bearing PROgram

Seven videotape modules cover various aspects of rolling bearings and their operation. Topics include how bearings work, where they are used and SKF nomenclature. Modules average ten to twenty minutes in length, and can be completed all at once or at a more leisurely pace, depending in the needs of the branch. Workbooks accompany each module, and form a handy reference manual when completed.



Distributor Technology Program—Foundations

An intensive, 2-1/2 day seminar for distributor branch personnel that builds on the basic bearing information provided in the Bearing PROgram.

Topics include bearing types, applications, shaft and housing fits, lubrication, mounting and bearing failures.

Distributor Technology Program—Solutions

The next step in developing your bearing product knowledge and maintenance expertise. Completion of DTP "Foundations" preferred. Learn about design life vs. service life, determining safe loads and speeds, how to select proper dimensions for shafts and housings, how to calculate drive up, and more. Train with the best, and graduate an expert at serving the industrial marketplace.

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