4. Fits

4.1 Interference

Bearing rings are fixed on the shaft or in the housing so that slip or movement does not occur between the mated surface during operation or under load.
This relative movement, creep, between the fitted surfaces of the bearing and the shaft or housing can ocur in a radial direction, or in an axial direction, or in the direction of rotation. This creeping movement under load causes damage to the bearing rings, shaft or housing in the form of abrasive wear, fretting corrosionor friction crack. This can also lead to abrasive particles getting into the bearing, which can cause vibration, excessive heat, and lowered rotational efficiency. To insure that slip does not occur between the fitted surfaces of the bearing rings and the shaft or housing, the bearing is usually installed with an interference fit.

Most effective interference fit is called a tight fit or shrink fit. The advantage of this tight fit for thin walled bearings is that it provides uniform load support over the entire ring circumference without any loss in load carrying capacity.

However, with a tight interference-fit, ease of mounting and dismounting the bearing is lost; and when using a non-separable bearing as a non-fixing bearing, axial displacement is impossible.

4.2 Calculation

Load and interference

The minimum required amount of interference for the inner rings mounted on solid shafts when acted on lby radial load, is found by formulae 4.1 and 4.2.

When $F_r \leq 0.3\,C_{or}$

$$\Delta_{dF} = 0.08\sqrt{\frac{d \cdot F_r}{B}} \quad \text{......} \quad 4.1$$

When $F_r > 0.3\,C_{or}$

$$\Delta_{dF} = 0.02\frac{F_r}{B} \quad \text{......} \quad 4.2$$

Where,

Δ_{dF} : Required effective interference (for load) μm
d : Nominal bore diameter mm
B : Inner ring width mm
F_r : Radial load N
C_{or} : Basic static rated load N

Temperature rise and interference

To prevent loosening of the inner ring on steel shafts due to temperature increases (difference between bearing temperature and ambient temperature) caused by bearing roatation, and interference fit must be given. The required amount of interference can be found by formula (4.3).

$$\Delta_{dT} = 0.0015 \cdot d \cdot \Delta T \quad \text{......} \quad 4.3$$

Where,

Δ_{dT} : Required effective interference (for temperature) μm
ΔT : Difference between bearing temperature and ambient temperature ºC
d : Bearing bore diameter mm

Effective interference and apparent interference

The effective interference (the actual interference after fitting) is different from the apparent interference derived from the dimensions measured value. This differenct is due to the roughness or slight variations of the mating surfaces, and this slight flattening of the uneven surfaces at the time of fitting is taken into consideration.
The relation between the effective and apparent interference, which varies according to the finish given to the mating surfaces, is expressed by formula (4.4).

$$\Delta d_{eff} = \Delta d_f - G \quad \text{......} \quad 4.4$$

Where,

Δd_{eff} : Effective interference μm
Δd_f : Apparent interference μm
G = 1.0 ~ 2.5 μm for ground shaft
= 5.0 ~ 7.0 μm for turned shaft

Maximum interference

When bearing rings are installed with an interference fit on shafts or in housings, tension or compression stree may occur. If the interference is too large, it may cause damage to the bearing rings and reduce the fatigut life of the bearing. For these reasons, the maximum amount of interference should be less than 1/1 000 of the shaft diameter, or

4.3 Selection

Selection of the proper fit is generally based on the following factors: 1) the direction and nature of the bearing load 2) whether the inner ring or outer ring rotates 3) whether the load on teh inner or outer ring rotates or not 4) whether there is static load or direction indeterminate load or not.

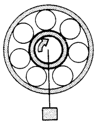
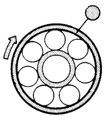
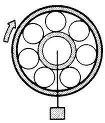
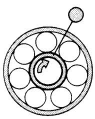
For bearings under rotating loads or direction indeterminate loads, a tight fit is recommended; but for static loads, a transition fit or loose fit should be sufficient.

The interference should be tighter for heavy bearing loads or vibration and shock load conditions. Also, a tighter than normal fit should be given when the bearing is installed on hollow shafts or in housings with thin walls, or housingsa made of light alloys or plastic.

In applications where high rotational accuracy must be maintained, high precision bearings and high tolerance shafts and housing should be employed instead of a tighter interference fit to ensure bearing stability. High interference fits should be avoided if possible as they cause shaft or housing deformities to be induced into the bearing rings, and thus reduce bearing rotational accuracy.

Because mounting and dismounting become very difficult when both the inner ring and outer ring of a non-separable bearing (for example a deep groove ball bearing) are given tight interference fits, one or the other ring should be given a loose fit.

Table 4.1 Radial Load and bearing fit

Bearing rotation and load	Illustration	Ring load	Fit
Inner ring : Rotating Outer ring : Stationery Load direction: Constant	 Static Load	Rotating inner ring load	Inner ring : Tight Fit
Inner ring : Stationery Outer ring : Rotating Load direction : Rotates with outer ring	 Unbalanced Load	Static outer	Outer ring : Loose fit ring load
Inner ring : Stationery Outer ring : Rotating Load direction : Constant	 Static Load	Static inner ring load	Inner ring : Loose fit
Inner ring : Rotating Outer ring : Stationery Loan direction : Rotates with inner ring	 Unbalanced Load	Rotating outer ring load	Outer ring : Tight fit

4.4 Recommended fits

Metric size standard dimension tolerances for bearing shaft diameters and housing bore diameters are governed by ISO 286.

Accordingly, bearing fits are determined by the precision (dimensional tolerance0 of the shaft diameter and housing bore diameter. Widely used fits for various shaft and housing bore diameter tolerances, and bearing bore and outside diameters are shon in Fig. 4.1.

Generally, recommended fits relating to the primary factors of bearing shape, dimensions, and load conditions are listed in Tables 4.2 and 4.3.

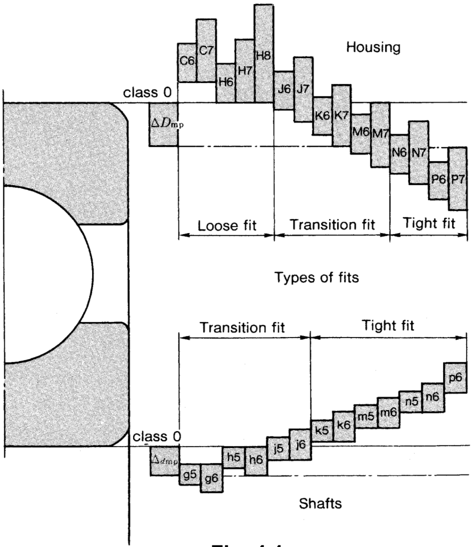


Fig. 4.1

Table 4.2 General standards for radial bearing fits
Housing fit

Housing type	Load condition		Housing fits
Solid or split housing	Outer ring static load	all load conditions	H7
		Heat conducted throuh shaft	G7
	Direction indeterminate load	Light to normal	JS7
Solid housing		Normal to heavy	K7
		Heavy shock	M7
	Outer ring rotating load	Light or variable	M7
		Normal to heavy	N7
		Heavy (thin wall housing)	P7
		Heavy shock	P7

Note : Fits apply to cast iron or steel housings. For light alloy housings, a tighter fit than listed is required.

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Table 4.2 Cylindrical bore radial bearings, Shaft fit

Type of Load	Bearing type	Shaft diameter	Load Type	Shaft Fit
Point load on inner ring	Ball bearings Roller bearings	All sizes	Floating bearings with sliding inner ring	g6 (g5)
			Angular contact ball bearings and tapered roller bearings with adjusted inner ring	h6 (j6)
Circumferential load on inner ring or indeterminate load	Ball bearings	up to 40 mm	normal load	j6 (j5)
		up to 100 mm	low load	j6 (j5)
			normal and high load	k6 (k5)
		up to 200 mm	low load	k6 (k5)
			normal and high load	m6 (m5)
		over 200 mm	normal load	m6 (m5)
			high load, shocks	n6 (n5)
	Roller bearings	up to 60 mm	low load	j6 (j5)
			normal and high load	k6 (k5)
		up to 200 mm	low load	k6 (k5)
			normal load	m6 (m5)
			high load	n6 (n5)
		up to 500 mm	normal load	m6 (n5)
			high load, shocks	p6
		over 500 mm	normal load	n6 (p6)
			high load	p6

Table 4.3 for electric motor bearings, Shaft / Housing fit

Shaft or housing	Deep groove ball bearings			Cylindrical roller bearings		
	Shaft or housing bore diameter mm		Fits	Shaft or housing bore diameter mm		Fits
	over	incl.		over	incl.	
Shaft	-	18	j5	-	40	k5
	18	100	k5	40	160	m5
	100	160	m5	160	200	n5
Housing	All sizes		H6 or J6	All sizes		H6 or J6