Radial Location of Bearings

If the load carrying ability of a bearing is to be fully utilized, its rings or washers must be supported around their complete circumference and across the whole width of the raceway. The support must be firm and even and, for inner rings, can be provided by a cylindrical or tapered seating or, for washers, by a flat (plane) support surface. This means that the seatings must be made with adequate accuracy and that they have a surface which is uninterrupted by grooves, holes or other features. In addition the rings must be reliably secured to prevent them from turning on or in their seatings under load. Inadequately or incorrectly secured bearing rings generally produce damage to the bearings and associated components.

A satisfactory radial location and an adequate support can generally only be obtained when the rings are mounted with an appropriate degree of interference. However, when simple mounting and dismounting are desirable, or when axial displacement is required with a non-locating bearing, interference fits cannot be used.

Selection of fit

When selecting a fit, the factors discussed in the following and the general guidelines in respect of them should be considered.

1. Conditions of rotation

Conditions of rotation refer to the movement of the bearing ring being considered in relation to the direction of the load. Essentially there are three different conditions: ''rotating load'' ''stationary load'' and ''direction of load indeterminate''.

If the bearing ring rotates and the load is stationary, or if the ring is stationary and the load rotates so that all points on the raceway are subjected to load in the course of one revolution, the load is defined as a ''rotating load''. Heavy loads which do not rotate but oscillate (for example, those acting on the outer rings of connecting rod bearings) are generally considered as rotating loads.

''Stationary load'' applies if the bearing ring is stationary and the load is also stationary, or if the ring and load rotate at the same speed so that the load is always directed to the same point on the raceway.

Variable external loads, shock loads, vibrations and unbalance loads in high-speed machines give rise to changes in the direction of load which cannot be accurately described. Such conditions are classified as ''direction of load indeterminate''.

A bearing ring subjected to a rotating load will turn (creep) on its own seating if mounted with a clearance fit, and wear (fretting corrosion) of the contacting surfaces will occur. To prevent this, interference fits must be used. The degree of interference needed is dictated by the operating conditions (see points 2 and 4).

When a stationary load exists, a bearing ring will not normally turn on its seating. Therefore, the ring need not necessarily have an interference fit unless this is required for other reasons.

When the direction of load is indeterminate and particularly where heavy loads are involved, it is desirable that both rings have an interference fit. For the inner ring the fit recommended for rotating load is normally used. However, when the outer ring must be free to move axially in the housing and the load is not heavy, a somewhat looser fit than that recommended for rotating load may be used.

2. Magnitude of the load.

The interference fit of a bearing inner ring on its seating will be loosened with increasing load as the ring will expand. Under the influence of rotating load the ring may begin to creep. The degree of interference must therefore be related to the magnitude of the load: the heavier the load, particularly if it is of shock character, the greater the interference required.

3. Bearing internal clearance

An interference fit of a bearing on the shaft or in the housing means that the ring is elastically deformed (expanded or compressed) and the bearing internal clearance reduced. A certain minimum clearance should remain, however (see also ''Bearing radial clearance'', page 272). The initial clearance and permissible reduction depend on the type and size of the bearing. The reduction in clearance due to the interference fit can be so large that bearings with increased radial clearance have to be used in order to prevent the bearing from becoming preloaded.

4. Temperature conditions

In service, bearing rings normally reach a temperature which is higher than that of the components to which they are fitted. This can result in an easing of the fit of the inner ring on its seating, while outer ring expansion may prevent the desired axial displacement of the ring in its housing. Temperature differentials and the direction of heat flow must therefore be carefully considered.

5. Running accuracy requirements

To reduce resilience and vibration, clearance fits should generally not be used for bearings where high demands are placed on running accuracy. Bearing seatings on the shaft and in the housing should be

Radial Location of Bearings (continued)

made to narrow dimensional tolerances, corresponding at least to ABEC-5 for the shaft and ABEC-3 for the housing as shown in the tables.

6. Design and material of shaft and housing

CAUTION: The fit of a bearing ring on its seating must not lead to uneven distortion of the ring (out-of- round). This can be caused for example by discontinuities in the seating surface. Split housings are therefore not generally suitable where outer rings are to have an interference fit.

To ensure adequate support for bearing rings mounted in thin-walled housings, light alloy housings or on hollow shafts, heavier interference fits than those normally selected for thick-walled steel or cast iron housings or for solid shafts should be used (see also ''Fits for hollow shafts'', page 250).

For stainless steel shafts, reduced shaft interference or increased bearing internal clearance should be considered because of the high coefficient of expansion of stainless steel.

7. Ease of mounting and dismounting

Bearings with clearance fits are usually easier to mount or dismount than those with interference fits. Where operating conditions necessitate interference fits and it is essential that mounting and dismounting can be done easily, separable bearings, or bearings with tapered bore and adapter or withdrawal sleeve may be used.

8. Displacement of non-locating bearing

If non-separable bearings are used as non-locating bearings it is imperative that one of the bearing rings is free to move axially at all times during operation. This is ensured by adopting a clearance fit for that ring which carries a stationary load. When the outer ring is under stationary load so that axial displacement has to take place in the housing bore, a hardened intermediate bushing is often fitted to the outer ring, for example, where light alloy housings are employed. In this way a ''hammering out'' of the housing seating because of the lower material hardness is avoided; it would otherwise result in the axial displacement being restricted or even impossible after a time. If cylindrical or needle roller bearings having one ring without flanges are used, both bearing rings may be mounted with an interference fit because axial displacement will take place within the bearing.

Recommended Fits

The general recommendation for shaft and housing diameters and resulting fits are shown in the tables on pages 252-263, for ABEC-1, 3, 5, and 7 tolerance grades and either rotating or stationary shaft or housing. They apply to single-row, double-row and duplex bearings mounted on steel shafts and in steel or cast iron housings. For special bearing applications and arrangements, other fits may be required as shown in the tables on pages 264-271.

Duplex Bearings

MRC 7000 PJ Series, 40° contact angle, duplex bearings are supplied with axial looseness, or end play, and should be mounted on the shaft with an ISO k5 fit and in the housing with an ISO H6 fit as shown in the tables. These bearings are identified with the suffix letters "DE" and separately by the letters "CA," "CB," "CC" or "CX" and a four-digit MRC specification number. The letters signify specific end play values with "CX" designating special end play. 7000 PJDE bearings are normally stocked with a "CB" end play. The amount of end play per set is shown in the table below.

Bore Diameter (mm)		End Play Per Set			
		Min.		Max.	
Over	Incl	,001 mm	,0001 inch	,001 mm	,0001 inch
—	10	14	**6**	22	**9**
10	18	15	**6**	23	**9**
18	30	18	**7**	26	**10**
30	50	22	**9**	30	**12**
50	80	26	**10**	38	**15**
80	120	32	**13**	44	**17**
120	180	35	**14**	47	**19**
180	250	45	**18**	61	**24**
250	315	52	**21**	68	**27**

Duplex Bearings may also be supplied without end play or preload (free running, no end play) designated on the bearing by the letters ''DU''. Bearings with preload are identified on the bearing by the letters ''DS'' and separately by the letters ''DL'', ''DM'', ''DH'' or ''DX'' and a four digit MRC Specification Code, signifying light, medium, heavy or special preload respectively. These bearings should be mounted on the shaft with an ISO h5 fit and in the housing with an ISO H6 fit. The reduced shaft interference resulting from the ISO h5 fit minimizes the loss of internal clearance caused by expansion of the inner ring. Loss of internal clearance changes the offset, or flushness, of the bearing faces and, in turn, increases bearing preload, which may lead to excessive heating and premature failure. For shaft and housing diameters corresponding to ISO h5 and ISO H6 fits, see pages 266 & 269.

The recommendations described above for general bearing applications are valid for solid steel shafts and cast iron or steel housings. Years of practical experience have shown the recommendations to be correct for a wide range of applications and bearing arrangements.

Tapered Bore Bearings

Bearings with tapered bores are mounted either on tapered shafts or on slotted sleeves having an external taper and mounted on cylindrical shafts. In these cases, the fit of the inner ring is not determined by the selected shaft tolerance but by the distance through which the ring is driven up on the tapered shaft or sleeve. Special precautions with respect to reduction in internal clearance must be observed. For the recommended mounting procedure refer to pages 172 & 173 in the self-aligning ball bearing section.

Fits For Hollow Shafts

If bearings are to be mounted with an interference fit on a hollow shaft it is generally necessary to use a heavier interference fit than that used for a solid shaft in order to achieve the same surface pressure between the inner ring and shaft seating. The following diameter ratios are important when deciding on the fit to be used:

$$c_i = \frac{d_i}{d} \text{ and } c_e = \frac{d}{d_e}$$

where
c_i = diameter ratio of hollow shaft
c_e = diameter ratio of inner ring
d = outside diameter of hollow shaft (= bore diameter of bearing)
d_i = internal diameter of hollow shaft
d_e = mean outside diameter of inner ring

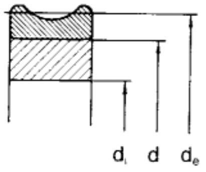
The fit is not appreciably affected until the diameter ratio of the hollow shaft $c_i \geq 0.5$. If the outside diameter of the inner ring is not known, the diameter ratio c_e can be calculated with sufficient accuracy from the equation

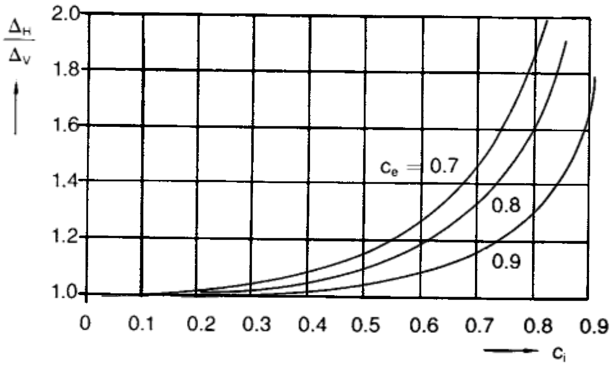
$$c_e = \frac{d}{k\,(D - d) + d}$$

where
d = bore diameter of bearing
D = outside diameter of bearing
k = a factor for the bearing type
k = 0.25 for self-aligning ball bearings of series 22 and 23 and for cylindrical roller bearings
k = 0.3 for all other bearings

To determine the requisite interference fit for a bearing to be mounted on a hollow shaft, use is made of the mean probable interference between shaft diameter and bearing bore obtained for the tolerance recommended for a solid shaft of the same diameter. If the plastic deformation (smoothing) of the mating surfaces produced during mounting is neglected, then the effective interference can be equated to the mean probable interference.

The interference Δ_H needed for a hollow shaft of steel can then be determined in relation to the known inteference Δ_V for the solid shaft from the diagram below. Δ_V equals the mean value of the smallest and largest values of the probable interference given in the tables. The tolerance for the hollow shaft is then selected so that the mean probable inteference is as close as possible to the inteference Δ_V obtained from the diagram.





Example:
A 208S deep groove ball bearing is to be mounted on a hollow shaft having a diameter ratio of $C_i = 0.8$. The recommended mean probable interference for a solid steel shaft is 0.00055 determined from the tables for an ABEC-1 grade bearing with a 40mm bore diameter.

For $C_i = 0.8$ and $C_e = \dfrac{40}{0.3\,(80-40) + 40} = 0.77$,

The ratio $\Delta_H/\Delta_V = 1.7$ from the diagram.
Thus the required interference for the hollow shaft is,
$\Delta_H = 1.7 \times .00055 = .0009$.

Shaft And Housing Surface Finish
For ABEC-1 bearings, finishes should not exceed 32 AA for shafts up to 2 inches in diameter and 63 AA maximum over 2 inches. Housing bores should not exceed 125 AA.