THE IMPORTANCE OF CORRECT FITTING

A bearing can only perform to its full capacity when it is correctly fitted on the shaft and in the housing. Insufficient interference on fitting surfaces could cause bearing rings to creep in a circumferential direction. Once this happens, considerable wear occurs on the fitting surface and both shaft and housing are damaged. Furthermore, abrasive particles may enter the bearing causing vibration, excessive heat and damage to raceways. It is therefore necessary to provide bearing rings under rotating load with an adequate interference fit to prevent creep. When using thin-type bearings under low load, the bearings should be fastened by a nut. Statically loaded bearings generally do not need to be fitted with an interference fit. Only when subject to a high degree of vibration do both inner and outer rings require fitting with an interference fit.

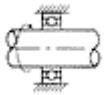
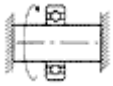
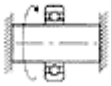
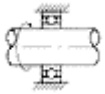
FITTING OF BEARING AND SHAFT

CONDITION (STEEL SHAFT)		SHAFT BORE DIAMETER	SHAFT TOLERANCE CLASS	
			THIN-TYPE	OTHERS
INNER RING ROTATING LOAD OR INDETERMINATE LOAD DIRECTION	LIGHT LOAD<=0.06Cr OR FLUCTUATING LOAD	10≦d≦18 18≦d≦30 30≦d≦50	h5 h5 h5	js5 js5 js5
	STANDARD LOAD=0.06~0.12Cr	10≦d≦18 18≦d≦30 30≦d≦50	js5 js5 js5	j5 k5 k5
OUTER RING ROTATING LOAD	NECESSARY FOR INNER RING TURNING EASILY AROUND SHAFT	ALL BORE DIAMETERS	g5	g6
	UNNECESSARY FOR INNER RING TURNING EASILY AROUND	ALL BORE DIAMETERS	h5	h6

FITTING OF BEARING AND HOUSING

CONDITION (ONE-PIECE HOUSING)		AXIAL DIRECTIONAL MOVEMENT OF OUTER RING	TOLERANCE CLASS OF SHAFT HOUSING SEATS	
			THIN-TYPE	OTHERS
INNER RING ROTATING LOAD	VARYING LOADS	EASY TO MOVE	H6	H7
	LIGHT OR STANDARD LOAD	EASY TO MOVE	H7	H8
	HIGH TEMPERATURE OF INNER RING AND SHAFT	EASY TO MOVE	G6	G7
	LIGHT OR STANDARD LOAD	AS A RULE, IMPOSSIBLE TO MOVE	K5	K6
	PRECISE ROTATION	POSSIBLE TO MOVE	JS6	J6
	QUIET OPERATION	EASY TO MOVE	H6	H6
INDETERMINATE LOAD DIRECTION	LIGHT OR STANDARD LOAD	IN GENERAL, POSSIBLE TO MOVE	JS6	J7
	STANDARD OR HEAVY LOAD	AS A RULE, IMPOSSIBLE TO MOVE	K5	K7
	LARGE SHOCK LOAD	IMPOSSIBLE TO MOVE	M5	M7
	LIGHT OR FLUCTUATING LOAD	IMPOSSIBLE TO MOVE	M5	M7
OUTER RING ROTATING LOAD	STANDARD OR HEAVY LOAD	IMPOSSIBLTE TO MOVE	N5	N7
	THIN-TYPE HOUSING SEATS HEAVY LOAD OR LARGE SHOCK LOAD	IMPOSSIBLE TO MOVE	P6	P7

CHARACTERISTICS OF LOAD AND FITTING

ROTATING RING	LOAD	LOAD CONDITION	FITTING
 INNER RING	 STATIC	INNER RING ROTATING LOAD	INTERFERENCE FIT FOR INNER RING
 OUTER RING	 ROTATING	OUTER RING STATIC LOAD	CLEARANCE FIT FOR OUTER RING
 OUTER RING	 STATIC	OUTER RING ROTATING LOAD	CLEARANCE FIT FOR INNER RING
 INNER RING	 ROTATING	INNER RING STATIC LOAD	INTERFERENCE FIT FOR OUTER RING
IN THE CASE OF FLUCTUATING LOAD DIRECTION OR UNBALANCED LOAD	ROTATING OR STATIC	INDETERMINATE LOAD DIRECTION	INTERFERENCE FIT FOR INNER AND OUTER RING

CALCULATIONS OF FITS

(1) FITTING PRESSURE AND DIMENSIONAL CHANGES OF INNER AND OUTER RING

The right fit for each application is established taking various conditions into consideration such as load, speed, temperature, mounting dismounting of the bearing. The interference fit should be greater than normal in thin housings, housings of soft material or on hollow shafts.

(2) LOAD OF INTERFERENCE

The interference fit of shaft and inner ring decreases under radial load. The decrease in fit of shaft and inner ring is calculated by the following formula:

$$\Delta d_F = 0.08 \times \sqrt{d/B \cdot F_r} \times 10^{-3} (N)$$

(3) INFLUENCE OF TEMPERATURE ON BEARINGS, SHAFTS AND HOUSINGS

Each inner ring, outer ring or rolling element of a bearing rotating under load

generates heat which will affect the interference fits of the shaft and the housing. Assuming a temperature difference within the bearing and the housing of ΔT(℃), that of the mating surface of the shaft and of the bearing is (0.10~0.15) ΔT. Consequently, Δdr, the decrease of the inner ring interference fit due to temperature change, is calculated from the following formula:

$$\Delta dr = (0.10 \sim 0.15) \times \Delta T \cdot a \cdot d \fallingdotseq 0.0015 \times \Delta T \cdot d \times 10^{-3} (mm)$$

Δdr : DECREASE OF INTERFERENCE DUE TO TEMPERATURE DIFFERENCE(mm)

ΔT : TEMPERATURE DIFFERENCE BETWEEN BEARING AND SUROUNDING HOUSING()

a : COEFFICIENT OF THERMAL EXPANSION FOR BEARING STEEL $\fallingdotseq 12.5 \times 10.6^{-6}$(l/℃)

: COEFFICIENT OF THERMAL EXPANSION FOR STAINLESS STEEL $\fallingdotseq 10.3 \times 10.6^{-6}$(l/℃)

d : NOMINAL BORE DIAMETER OF BEARING(mm)

It should also be noted that fit can increase due to temperature changes.

(4) EFFECTIVE INTERFERENCE, SURFACE ROUGHNESS AND ACCURACY

The surface is smoothed during fitting and the effective interference becomes smaller than the theoretical interference. The surface quality of a mating surface has an influence on how much this theoretical interference decreases. Effective interference can usually be calculated as follows:

Ground Shaft : $\Delta d = d/(d+2) \cdot \Delta da (mm)$

Turned Shaft : $\Delta d = d/(d+3) \cdot \Delta da (mm)$

Δd : EFFECTIVE INTERFERENCE(mm)

Δda : THEORETICAL INTERFERENCE(mm)

d : NOMINAL BORE DIAMETER OF BEARING(mm)

By combining these factors, the theoretical interference fit required for inner ring and shaft where the inner ring is subjected to rotating load is calculated as follows:

$$\Delta da \geqq (\Delta df + \Delta dt)\ ((d+3)/d \text{ or } (d+2)/d)\ (mm)$$

Normally, shaft and housing seats have to meet the accuracy and roughness requirements as given below.

ACCURACY AND ROUGHNESS OF SHAFT AND HOUSING SEATS

	SHAFT	HOUSING
ROUNDNESS	BELOW 50% OF SHAFT DIAMETER TOLERANCE	BELOW 50% OF HOUSING BORE DIAMETER TOLERANCE
CYLINDRICITY	BELOW 50% OF SHAFT DIAMETER TOLERANCE WITHIN BEARING WIDTH	BELOW 50% OF HOUSING BORE DIAMETER TOLERANCE WITHIN BEARING WIDTH
SQUARENESS	≦3/1000(0.17)	
ROUGHNESS OF MATING SURFACE	Rmax 3.2	Rmax 6.3

Mountings bearing with extra tight or light interference fits can lead to early bearing failure. In order to ensure safe operating conditions the tolerance variations of shaft seats, housing bores and bearing bore and outside diameter need to be reduced. We recommend the tolerance zones are divided into two bands and selective assembly is applied. Bearings sorted into two tolerance bands for inner and outer rings are available on request. These bearings are marked as follows:

SELECTIVE CLASSIFICATION OF OUTER AND BORE DIAMETER TOLERANCES AND INDICATION MARK

TOLERANCE OF OUTER DIAMETER		0～D／2	−D／2～D	0～−D
TOLERANCE OF BORE DIAMETER	MARK	1	2	0
0～−d／2	1	C11	C12	C10
−d／2～d	2	C21	C22	C20
0～−d	0	C01	C02	

ZC3 (spans C11, C12, C21, C22)

ZC1 (spans C10, C20)

ZC2 (spans C01, C02)

NOTE: 1.THIS IS APPLIED TO BOTH BEARINGS OF ABEC 5P AND P5.

2.UPON YOUR REQUEST, PLEASE SPECIFY THE MARK LISTED BELOW.

ZC1.... 2 SELECTIVE CLASSIFICATIONS FOR BORE DIAMETER TOLERANCE (0～-d/2,-d/2～-d)
1 SELECTIVE CLASSIFICATIONS FOR OUTER DIAMETER TOLERANCE (0～-D)

ZC2... 1 SELECTIVE CASSIFICATION FOR BORE DIAMETER TOLERANCE (0～-d)
2 SELECTIVE CASSIFICATION FOR OUTER DIAMETER TOLERANCE (0～-D/2,-D/2～-D)

ZC3... 4 SELECTIVE CASSIFICATION FOR BOTH BORE DIAMETER TOLERANCE (0～-d/2～,-d/2～-d,0～-D/2,-D/2～-D)

D... MINIMUM VALUE OF OUTER DIAMETER TOLERANCE

d...