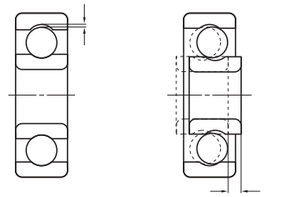
Internal clearance

INTERNAL CLEARANCE AND STANDARD VALUES

Internal clearance is the play between outer ring, inner ring and rolling element. Generally, the amount of up and down movement of the outer ring with respect to the fixed inner ring is called the radial internal clearance and its right and left movement the axial internal clearance. Bearing internal clearance in operation is an important factor that has a significant influence on other factors such as noise, vibration, heat and fatigue life. Radial ball bearings are usually classified by their internal radial clearance. When measuring the internal clearance, the bearing is subjected to a standard load in order to ensure full contact between all bearing components. Under such a load, the measured value is larger than the actual value stated for radial clearance; this is due to elastic deformation. The difference is compensated by the factors given in the tables below.

BEARING INTERNAL CLEARANCE



RADIAL INTERNAL CLEARANCE　　AXIAL INTERNAL CLEARANCE

●RADIAL INTERNAL CLEARANCE OF SMALL AND MINIATURE BEARINGS

Unit μm

CLEARANCE SYMBOL		MC1	MC2	MC3	MC4	MC5	MC6
CLEARANCE	min	0	3	5	8	13	20
	max	5	8	10	13	20	28

NOTE: 1.STANDARD CLEARANCE IS MC3.
2.FOR MEASURING CLEARANCE, OFFSET BY COMPENSATION FACTOR LISTED BELOW.

Unit μm

CLEARANCE SYMBOL	MC1	MC2	MC3	MC4	MC5	MC6
COMPENSATION FACTOR	1	1	1	1	2	2

MEASURING LOAD IS AS FOLLOWS.
MINIATURE BEARINGS 2.5N (0.25kgf)
SMALL BEARINGS 4.4N (0.45kgf)

●RADIAL INTERNAL CLEARANCE OF STANDARD RADIAL BALL BEARINGS

Unit μm

NOMINAL BORE DIAMETER d(mm)		CLEARANCE									
		C2		CN(C0)		C3		C4		C5	
OVER	INCL.	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
10(ONLY)		0	7	2	13	8	23	14	29	20	37
10	18	0	9	3	18	11	25	18	33	25	45
18	24	0	10	5	20	13	28	20	36	28	48
24	30	1	11	5	20	13	28	23	41	30	53
30	40	1	11	6	20	15	33	28	46	40	64
40	50	1	11	6	23	18	36	30	51	45	73

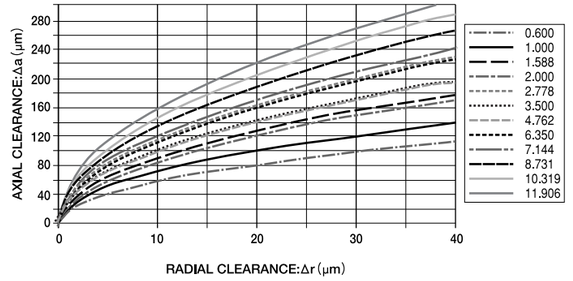
NOTE: 1.FOR MEASURING CLEARANCE, OFFSET BY COMPENSATION FACTOR LISTED BELOW.

Unit μm

BORE DIAMETER OF NOMINAL BEARING d(mm)		MEASURING LOAD	COMPENSATION FACTOR				
OVER	INCL.	N (kgf)	C2	CN(C0)	C3	C4	C5
10(INCLUDED)	18	24.5(2.5)	3～4	4	4	4	4
18	50	49(5)	4～5	6	6	6	6

RELATIONSHIP BETWEEN RADIAL INTERNAL CLEARANCE AND AXIAL INTERNAL CLEARANCE

The axial internal clearance is established from the ball diameter, outer and inner ring raceway radius and the radial internal clearance. Usually it is about 10 times the value of the internal radial clearance. Selection of a small internal radial clearance or an extra large interference fit in order to reduce the internal axial clearance after mounting is not recommended.



$$\Delta a=2\sqrt{\Delta r(r_o+r_i-Da)}\quad(mm)$$

Δa:AXIAL INTERNAL CLEARANCE(mm)
r_o:OUTER RING RACEWAY RADIUS(mm)
Da:BALL DIAMETER(mm)
Δr:RADIAL INTERNAL CLEARANCE(mm)
r_i:INNER RING RACEWAY RADIUS(mm)

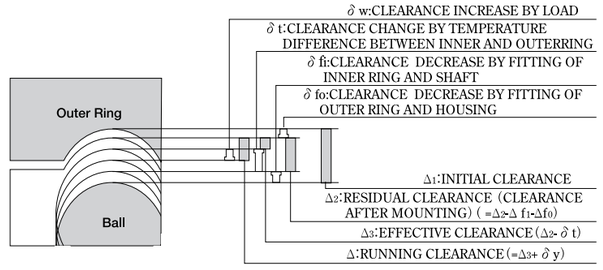
SELECTION OF BEARING CLEARANCE

Theoretically, maximum bearing life is with very slight preload. However, even a slight increase in this theoretical preload can have a considerably detrimental effect on the bearing life. Positive clearance should therefore be selected. MC3 is usually used for miniature or small bearings, standard clearance for general bearings and the clearance for thin section bearings should never be greater than "standard".

●SELECTION OF RADIAL INTERNAL CLEARANCE

Operating Condition	Clearance
Clearance fit for inner and outer ring. Low axial load. No axial load carrying requirement. Select bearing with reduced radial clearance. Lower vibration and noise. Low speeds.	MC1、MC2、C2
Lower frictional torque. Standard axial load. Average axial load carrying requirements. Slight interference fit for inner ring. Clearance fit for outer ring. Average/low speeds.	MC3、MC4、CN(C0)
Extremely low frictional torque. High axial load. High axial load carrying requirements. Heavy interfence fit to support high loads or shock loads. Large temperature gradient from inner ring to outer ring. High degree of shaft deflection.	MC5、MC6、C3、C4、C5

CALCULATION OF CLEARANCE



(1) RUNNING CLEARANCE

Running clearance is the resultant clearance after load, temperature difference and fitting are taken into consideration.

$$\Delta=\Delta_1-(\partial t+\delta f)+\delta w\,(mm)$$

(2) CLEARANCE REDUCTION BY TEMPERATURE DIFFERENCE BETWEEN INNER AND OUTER RING

In a bearing, the highest temperature is generated in the rolling element followed by the inner ring, with the outer ring having the lowest temperature. Since it is impossible to measure the temperature of a rolling element, in practice, the temperature of the inner ring is used.

$$\partial t\fallingdotseq a\times\Delta T\times Do\,(mm)$$

(3) CLEARANCE REDUCTION BY FITTING

When a bearing is fitted onto a shaft or into a housing with an interference fit, the internal clearance of the bearing reduces.

$$\delta f = \delta fi + \delta fo =$$
$$\Delta db \times d/db \times ((1-(do/d)^2))/(1-(do/db)^2)) +$$
$$\Delta Da \times Da/D \times ((1-(D/Dh)^2)/(1-(Da/Dh)^2)) \quad (mm)$$

(4) CLEARANCE INCREASE BY LOAD

Load on a bearing deforms it elastically and increases the internal clearance.

$$\delta w = C \times ((5 \times Fr)/(Z \times \cos \alpha))^{(2/3)} \times (1/dw)^{(1/3)} \quad (mm)$$

The initial contact angle α_0 is calculated from the following two formulae:

$$\cos \alpha_0 / \cos \alpha = 1 + C/(2 \times m-1) \times (Fa/(9.8 \times Z \times Dw^2 \times \sin \alpha)^{(2/3)}$$
$$1-\cos \alpha_0 = \Delta r/(2 \times DW \times (2 \times m-1))$$

SYMBOLS

ΔT : TEMPERATURE DIFFERENCE BETWEEN INNER AND OUTER RING
D₀ : OUTER RING RACEWAY DIAMETER
Δdb : CLEARANCE OF INNER RING ON SHAFT
do : BORE DIAMETER OF HOLLOW SHAFT
Dn : OUTSIDE DIAMETER OF HOUSING SEAT
ΔDa : CLEARANCE OF OUTER RING IN HOUSING
db : AVERAGE OUTSIDE DIAMETER OF INNER RING
Da : AVERAGE OUTSIDE DIAMETER OF OUTER RING
a : COEFFICENT OF THERMAL EXPANSION FOR BEARING STEEL

m : OSCULATION
Z : NUMBER OF BALLS
Dw : BALL DIAMETER
α : CONTACT ANGLE
α₀ : INITIAL CONTACT ANGLE
Fa : AXIAL LOAD
Fr : RADIAL LOAD
Δr : RADIAL INTERNAL CLEARANCE
C : MATERIAL ELASTICITY FACTOR

General Bearing	C=0.00218	m=0.525
Instrument Bearing	C=0.00287	m=0.560