9. FITS AND INTERNAL CLEARANCES

9.1 Fits

9.1.1 Importance of Proper Fits

In the case of a rolling bearing with the inner ring fitted to the shaft with only slight interference, a harmful circumferential slipping may occur between the inner ring and shaft. This slipping of the inner ring, which is called "creep", results in a circumferential displacement of the ring relative to the shaft if the interference fit is not sufficiently tight. When creep occurs, the fitted surfaces become abraded, causing wear and considerable damage to the shaft. Abnormal heating and vibration may also occur due to abrasive metallic particles entering the interior of the bearing.

It is important to prevent creep by having sufficient interference to firmly secure that ring which rotates to either the shaft or housing. Creep cannot always be eliminated using only axial tightening through the bearing ring faces. Generally, it is not necessary, however, to provide interference for rings subjected only to stationary loads. Fits are sometimes made without any interference for either the inner or outer ring, to accommodate certain operating conditions, or to facilitate mounting and dismounting. In this case, to prevent damage to the fitting surfaces due to creep, lubrication of other applicable methods should be considered.

9.1.2 Selection of Fit

(1) Load Conditions and Fit

The proper fit may be selected from Table 9.1 based on the load and operating conditions.

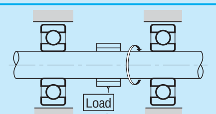
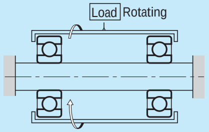
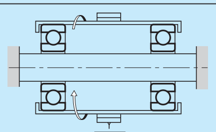
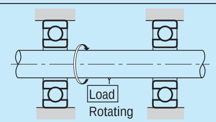
(2) Magnitude of Load and Interference

The interference of the inner ring is slightly reduced by the bearing load; therefore, the loss of interference should be estimated using the following equations:

$$\left.\begin{aligned}\Delta d_F &= 0.08\sqrt{\frac{d}{B}F_r}\times 10^{-3} \;\ldots\ldots\; (\mathrm{N})\\ \Delta d_F &= 0.25\sqrt{\frac{d}{B}F_r}\times 10^{-3} \;\ldots\; \{\mathrm{kgf}\}\end{aligned}\right\}\;\ldots\;\mathbf{(9.1)}$$

where Δd_F : Interference decrease of inner ring (mm)
d : Bearing bore diameter (mm)
B : Nominal inner ring width (mm)
F_r : Radial load applied on bearing (N), {kgf}

Table 9.1 Loading Conditions and Fits

Load Application	Bearing Operation: Inner Ring	Bearing Operation: Outer Ring	Load Conditions	Fitting: Inner Ring	Fitting: Outer Ring
	Rotating	Stationary	Rotating Inner Ring Load	Tight Fit	Loose Fit
	Stationary	Rotating	Stationary Outer Ring Load	Tight Fit	Loose Fit
	Stationary	Rotating	Rotating Outer Ring Load	Loose Fit	Tight Fit
	Rotating	Stationary	Stationary Inner Ring Load	Loose Fit	Tight Fit
Direction of load indeterminate due to variation of direction or unbalanced load	Rotating or Stationary	Rotating or Stationary	Direction of Load Indeterminate	Tight Fit	Tight Fit

Therefore, the effective interference Δd should be larger than the interference given by Equation (9.1).

However, in the case of heavy loads where the radial load exceeds 20% of the basic static load rating C_{0r}, under the operating condition, interference often becomes shortage. Therefore, interference should be estimated using Equation (9.2):

$$\left.\begin{aligned}\Delta d &\geqq 0.02\,\frac{F_r}{B}\times 10^{-3} \;\ldots\ldots\; (\mathrm{N})\\ \Delta d &\geqq 0.2\,\frac{F_r}{B}\times 10^{-3} \;\ldots\ldots\; \{\mathrm{kgf}\}\end{aligned}\right\}\;\ldots\ldots\;\mathbf{(9.2)}$$

where Δd : Effective interference (mm)
F_r : Radial load applied on bearing (N), {kgf}
B : Nominal inner ring width (mm)

(3) Interference Variation Caused by Temperature Difference between Bearing and Shaft or Housing

The effective interference decreases due to the increasing bearing temperature during operation. If the temperature difference between the bearing and housing is ΔT (°C), then the temperature difference between the fitted surfaces of the shaft and inner ring is estimated to be about (0.1~0.15) ΔT in case that the shaft is cooled. The decrease in the interference of the inner ring due to this temperature difference Δd_T may be calculated using Equation (9.3):

$$\begin{aligned}\Delta d_T &= (0.10\text{ to }0.15)\times\Delta T\cdot\alpha\cdot d\\ &\fallingdotseq 0.0015\,\Delta T\cdot d\times 10^{-3}\;\ldots\ldots\ldots\ldots\;\mathbf{(9.3)}\end{aligned}$$

where Δd_T : Decrease in interference of inner ring due to temperature difference (mm)
ΔT : Temperature difference between bearing interior and surrounding parts (°C)
α : Coefficient of linear expansion of bearing steel=12.5×10^{-6} (1/°C)
d : Bearing nominal bore diameter (mm)

In addition, depending on the temperature difference between the outer ring and housing, or difference in their coefficients of linear expansion, the interference may increase.

(4) Effective Interference and Finish of Shaft and Housing

Since the roughness of fitted surfaces is reduced during fitting, the effective interference becomes less than the apparent interference. The amount of this interference decrease varies depending on the roughness of the surfaces and may be estimated using the following equations:

For ground shafts $\Delta d = \dfrac{d}{d+2}\Delta d_a\;\ldots\ldots\ldots\;\mathbf{(9.4)}$

For machined shafts $\Delta d = \dfrac{d}{d+3}\Delta d_a\;\ldots\ldots\ldots\;\mathbf{(9.5)}$

where Δd : Effective interference (mm)
Δd_a : Apparent interference (mm)
d : Bearing nominal bore diameter (mm)

According to Equations (9.4) and (9.5), the effective interference of bearings with a bore diameter of 30 to 150 mm is about 95% of the apparent interference.

(5) Fitting Stress and Ring Expansion and Contraction

When bearings are mounted with interference on a shaft or in a housing, the rings either expand or contract and stress is produced. Excessive interference may damage the bearings; therefore, as a general guide, the maximum interference should be kept under approximately 7/10 000 of the shaft diameter.

The pressure between fitted surfaces, expansion or contraction of the rings, and circumferential stress may be calculated using the equations in Section **15.2**, Fitting(1) (Pages A130 and A131).

9.1.3 Recommended Fits

As described previously, many factors, such as the characteristics and magnitude of bearing load, temperature differences, means of bearing mounting and dismounting, must be considered when selecting the proper fit.

If the housing is thin or the bearing is mounted on a hollow shaft, a tighter than usual fit is necessary. A split housing often deforms the bearing into an oval shape; therefore, a split housing should be avoided when a tight fit with the outer ring is required.

The fits of both the inner and outer rings should be tight in applications where the shaft is subjected to considerable vibration.

The recommended fits for some common applications are shown in Table 9.2 to 9.7. In the case of unusual operating conditions, it is advisable to consult NSK. For the accuracy and surface finish of shafts and housings, please refer to Section **11.1** (Page A100).

Table 9.2 Fits of Radial Bearings with Shafts

Load Conditions		Examples	Shaft Diameter (mm) Ball Brgs	Shaft Diameter (mm) Cylindrical Roller Brgs, Tapered Roller Brgs	Shaft Diameter (mm) Spherical Roller Brgs	Tolerance of Shaft	Remarks
Radial Bearings with Cylindrical Bores							
Rotating Outer Ring Load	Easy axial displacement of inner ring on shaft desirable.	Wheels on Stationary Axles	All Shaft Diameters			g6	Use g5 and h5 where accuracy is required. In case of large bearings, f6 can be used to allow easy axial movement.
	Easy axial displacement of inner ring on shaft unnecessary	Tension Pulleys Rope Sheaves				h6	
Rotating Inner Ring Load or Direction of Load Indeterminate	Light Loads or Variable Loads (<0.06C_r(1))	Electrical Home Appliances Pumps, Blowers, Transport Vehicles, Precision Machinery, Machine Tools	<18	—	—	js5	
			18 to 100	<40	—	js6(j6)	
			100 to 200	40 to 140	—	k6	
			—	140 to 200	—	m6	
	Normal Loads (0.06 to 0.13C_r(1))	General Bearing Applications, Medium and Large Motors(3), Turbines, Pumps, Engine Main Bearings, Gears, Woodworking Machines	<18	—	—	js5 or js6 (j5 or j6)	k6 and m6 can be used for single-row tapered roller bearings and single-row angular contact ball bearings instead of k5 and m5.
			18 to 100	<40	<40	k5 or k6	
			100 to 140	40 to 100	40 to 65	m5 or m6	
			140 to 200	100 to 140	65 to 100	m6	
			200 to 280	140 to 200	100 to 140	n6	
			—	200 to 400	140 to 280	p6	
			—	—	280 to 500	r6	
			—	—	over 500	r7	
	Heavy Loads or Shock Loads (>0.13C_r(1))	Railway Axleboxes, Industrial Vehicles, Traction Motors, Construction Equipment, Crushers	—	50 to 140	50 to 100	n6	More than CN bearing internal clearance is necessary.
			—	140 to 200	100 to 140	p6	
			—	over 200	140 to 200	r6	
			—	—	200 to 500	r7	
Axial Loads Only			All Shaft Diameters			js6 (j6)	—
Radial Bearings with Tapered Bores and Sleeves							
All Types of Loading		General bearing Applications, Railway Axleboxes	All Shaft Diameters			h9/IT5(2)	IT5 and IT7 mean that the deviation of the shaft from its true geometric form, e. g. roundness and cylindricity should be within the tolerances of IT5 and IT7 respectively.
		Transmission Shafts, Woodworking Spindles				h10/IT7(2)	

Notes (1) C_r represents the basic load rating of the bearing.
(2) Refer to Appendix Table 11 on page C22 for the values of standard tolerance grades IT.
(3) Refer to Tables 9.13.1 and 9.13.2 for the recommended fits of shafts used in electric motors for deep groove ball bearings with bore diameters ranging from 10 mm to 160 mm, and for cylindrical roller bearings with bore diameters ranging from 24 mm to 200 mm.

Remarks This table is applicable only to solid steel shafts.

Table 9.3 Fits of Thrust Bearings with Shafts

Load Conditions		Examples	Shaft Diameter (mm)	Tolerance of Shaft	Remarks
Central Axial Load Only		Main Shafts of Lathes	All Shaft Diameters	h6 or js6 (j6)	—
Combined Radial and Axial Loads (Spherical Thrust Roller Bearings)	Stationary Inner Ring Load	Cone Crushers	All Shaft Diameters	js6 (j6)	
	Rotating Inner Ring Load or Direction of Load Indeterminate	Paper Pulp Refiners, Plastic Extruders	<200	k6	
			200 to 400	m6	
			over 400	n6	

Table 9.4 Fits of Radial Bearings with Housings

Load Conditions			Examples	Tolerances for Housing Bores	Axial Displacement of Outer Ring	Remarks
Solid Housings	Rotating Outer Ring Load	Heavy Loads on Bearing in Thin-Walled Housing or Heavy Shock Loads	Automotive Wheel Hubs (Roller Bearings) Crane Travelling Wheels	P7	Impossible	—
		Normal or Heavy Loads	Automotive Wheel Hubs (Ball Bearings) Vibrating Screens	N7		
		Light or Variable Loads	Conveyor Rollers Rope Sheaves Tension Pulleys	M7		
	Direction of Load Indeterminate	Heavy Shock Loads	Traction Motors			
		Normal or Heavy Loads	Pumps Crankshaft Main Bearings Medium and Large Motors(1)	K7	Generally Impossible	If axial displacement of the outer ring is not required.
Solid or Split Housings		Normal or Light Loads		JS7 (J7)	Possible	Axial displacement of outer ring is necessary.
	Rotating Inner Ring Load	Loads of All kinds	General Bearing Applications, Railway Axleboxes	H7	Easily possible	—
		Normal or Light Loads	Plummer Blocks	H8		
		High Temperature Rise of Inner Ring Through Shaft	Paper Dryers	G7		
Solid Housing		Accurate Running Desirable under Normal or Light Loads	Grinding Spindle Rear Ball Bearings High Speed Centrifugal Compressor Free Bearings	JS6 (J6)	Possible	—
	Direction of Load Indeterminate		Grinding Spindle Front Ball Bearings High Speed Centrifugal Compressor Fixed Bearings	K6	Generally Impossible	For heavy loads, interference fit tighter than K is used. When high accuracy is required, very strict tolerances should be used for fitting.
	Rotating Inner Ring Load	Accurate Running and High Rigidity Desirable under Variable Loads	Cylindrical Roller Bearings for Machine Tool Main Spindle	M6 or N6	Impossible	
		Minimum noise is required.	Electrical Home Appliances	H6	Easily Possible	—

Note (1) Refer to Tables 9.13.1 and 9.13.2 for the recommended fits of housing bores of deep groove ball bearings and cylindrical roller bearings for electric motors.

Remarks 1. This table is applicable to cast iron and steel housings. For housings made of light alloys, the interference should be tighter than those in this table.
2. Refer to the introductory section of the bearing dimension tables (blue pages) for special fits such as drawn cup needle roller bearings.

Table 9.5 Fits of Thrust Bearings with Housings

Load Conditions		Bearing Types	Tolerances for Housing Bores	Remarks
Axial Loads Only		Thrust Ball Bearings	Clearance over 0.25mm	For General Applications
			H8	When precision is required
		Spherical Thrust Roller Bearings Steep Angle Tapered Roller Bearings	Outer ring has radial clearance.	When radial loads are sustained by other bearings.
Combined Radial and Axial Loads	Stationary Outer Ring Loads	Spherical Thrust Roller Bearings	H7 or JS7 (J7)	—
	Rotating Outer Ring Loads or Direction of Load Indeterminate		K7	Normal Loads
			M7	Relatively Heavy Radial Loads

Table 9.6 Fits of Inch Design Tapered Roller Bearings with Shafts

(1) Bearings of Precision Classes 4 and 2

Units : μm

Operating Conditions		Nominal Bore Diameters d over (mm)	over 1/25.4	incl. (mm)	incl. 1/25.4	Bore Diameter Tolerances Δ_{ds} high	low	Shaft Diameter Tolerances high	low	Remarks
Rotating Inner Ring Loads	Normal Loads	—		76.200	3.0000	+13	0	+ 38	+ 25	For bearings with $d \leqq 152.4$ mm, clearance is usually larger than CN.
		76.200	3.0000	304.800	12.0000	+25	0	+ 64	+ 38	
		304.800	12.0000	609.600	24.0000	+51	0	+127	+ 76	
		609.600	24.0000	914.400	36.0000	+76	0	+190	+114	
	Heavy Loads Shock Loads High Speeds	—		76.200	3.0000	+13	0	+ 64	+ 38	In general, bearings with a clearance larger than CN are used. ※ means that the average interference is about 0.0005 d.
		76.200	3.0000	304.800	12.0000	+25	0	※		
		304.800	12.0000	609.600	24.0000	+51	0	※		
		609.600	24.0000	914.400	36.0000	+76	0	+381	+305	
Rotating Outer Ring Loads	Normal Loads without Shocks	—		76.200	3.0000	+13	0	+ 13	0	The inner ring cannot be displaced axially. When heavy or shock loads exist, the figures in the above (Rotating inner ring loads, heavy or shock loads) apply.
		76.200	3.0000	304.800	12.0000	+25	0	+ 25	0	
		304.800	12.0000	609.600	24.0000	+51	0	+ 51	0	
		609.600	24.0000	914.400	36.0000	+76	0	+ 76	0	
		—		76.200	3.0000	+13	0	0	− 13	The inner ring can be displaced axially.
		76.200	3.0000	304.800	12.0000	+25	0	0	− 25	
		304.800	12.0000	609.600	24.0000	+51	0	0	− 51	
		609.600	24.0000	914.400	36.0000	+76	0	0	− 76	

(2) Bearings of Precision Classes 3 and 0 (1)

Units : μm

Operating Conditions		Nominal Bore Diameters d over (mm)	over 1/25.4	incl. (mm)	incl. 1/25.4	Bore Diameter Tolerances Δ_{ds} high	low	Shaft Diameter Tolerances high	low	Remarks
Rotating Inner Ring Loads	Precision Machine-Tool Main Spindles	—		76.200	3.0000	+13	0	+ 30	+18	—
		76.200	3.0000	304.800	12.0000	+13	0	+ 30	+18	
		304.800	12.0000	609.600	24.0000	+25	0	+ 64	+38	
		609.600	24.0000	914.400	36.0000	+38	0	+102	+64	
	Heavy Loads Shock Loads High Speeds	—		76.200	3.0000	+13	0	—		A minimum interference of about 0.00025 d is used.
		76.200	3.0000	304.800	12.0000	+13	0	—		
		304.800	12.0000	609.600	24.0000	+25	0	—		
		609.600	24.0000	914.400	36.0000	+38	0	—		
Rotating Outer Ring Loads	Precision Machine-Tool Main Spindles	—		76.200	3.0000	+13	0	+ 30	+18	—
		76.200	3.0000	304.800	12.0000	+13	0	+ 30	+18	
		304.800	12.0000	609.600	24.0000	+25	0	+ 64	+38	
		609.600	24.0000	914.400	36.0000	+38	0	+102	+64	

Note (1) For bearings with d greater than 304.8 mm, Class 0 does not exist.

Table 9.7 Fits of Inch Design Tapered Roller Bearings with Housings

(1) Bearings of Precision Classes 4 and 2

Units : μm

Operating Conditions		Nominal Outside Diameters D over (mm)	over 1/25.4	incl. (mm)	incl. 1/25.4	Outside Diameter Tolerances Δ_{Ds} high	low	Housing Bore Diameter Tolerances high	low	Remarks
Rotating Inner Ring Loads	Used either on free-end or fixed-end	—		76.200	3.0000	+25	0	+ 76	+ 51	The outer ring can be easily displaced axially.
		76.200	3.0000	127.000	5.0000	+25	0	+ 76	+ 51	
		127.000	5.0000	304.800	12.0000	+25	0	+ 76	+ 51	
		304.800	12.0000	609.600	24.0000	+51	0	+152	+102	
		609.600	24.0000	914.400	36.0000	+76	0	+229	+152	
	The outer ring position can be adjusted axially.	—		76.200	3.0000	+25	0	+ 25	0	The outer ring can be displaced axially.
		76.200	3.0000	127.000	5.0000	+25	0	+ 25	0	
		127.000	5.0000	304.800	12.0000	+25	0	+ 51	0	
		304.800	12.0000	609.600	24.0000	+51	0	+ 76	+ 25	
		609.600	24.0000	914.400	36.0000	+76	0	+127	+ 51	
	The outer ring position cannot be adjusted axially.	—		76.200	3.0000	+25	0	− 13	− 38	Generally, the outer ring is fixed axially.
		76.200	3.0000	127.000	5.0000	+25	0	− 25	− 51	
		127.000	5.0000	304.800	12.0000	+25	0	− 25	− 51	
		304.800	12.0000	609.600	24.0000	+51	0	− 25	− 76	
		609.600	24.0000	914.400	36.0000	+76	0	− 25	−102	
Rotating Outer Ring Loads	Normal Loads The outer ring position cannot be adjusted axially.	—		76.200	3.0000	+25	0	− 13	− 38	The outer ring is fixed axially.
		76.200	3.0000	127.000	5.0000	+25	0	− 25	− 51	
		127.000	5.0000	304.800	12.0000	+25	0	− 25	− 51	
		304.800	12.0000	609.600	24.0000	+51	0	− 25	− 76	
		609.600	24.0000	914.400	36.0000	+76	0	− 25	−102	

(2) Bearings of Precision Classes 3 and 0 (1)

Units : μm

Operating Conditions		Nominal Outside Diameters D over (mm)	over 1/25.4	incl. (mm)	incl. 1/25.4	Outside Diameter Tolerances Δ_{Ds} high	low	Housing Bore Diameter Tolerances high	low	Remarks
Rotating Inner Ring Loads	Used on free-end	—		152.400	6.0000	+13	0	+38	+25	The outer ring can be easily displaced axially.
		152.400	6.0000	304.800	12.0000	+13	0	+38	+25	
		304.800	12.0000	609.600	24.0000	+25	0	+64	+38	
		609.600	24.0000	914.400	36.0000	+38	0	+89	+51	
	Used on fixed-end	—		152.400	6.0000	+13	0	+25	+13	The outer ring can be displaced axially.
		152.400	6.0000	304.800	12.0000	+13	0	+25	+13	
		304.800	12.0000	609.600	24.0000	+25	0	+51	+25	
		609.600	24.0000	914.400	36.0000	+38	0	+76	+38	
	The outer ring position can be adjusted axially.	—		152.400	6.0000	+13	0	+13	0	Generally, the outer ring is fixed axially.
		152.400	6.0000	304.800	12.0000	+13	0	+25	0	
		304.800	12.0000	609.600	24.0000	+25	0	+25	0	
		609.600	24.0000	914.400	36.0000	+38	0	+38	0	
	The outer ring position cannot be adjusted axially.	—		152.400	6.0000	+13	0	0	−13	The outer ring is fixed axially.
		152.400	6.0000	304.800	12.0000	+13	0	0	−25	
		304.800	12.0000	609.600	24.0000	+25	0	0	−25	
		609.600	24.0000	914.400	36.0000	+38	0	0	−38	
Rotating Outer Ring Loads	Normal Loads The outer ring position cannot be adjusted axially.	—		76.200	3.0000	+13	0	−13	−25	The outer ring is fixed axially.
		76.200	3.0000	152.400	6.0000	+13	0	−13	−25	
		152.400	6.0000	304.800	12.0000	+13	0	−13	−38	
		304.800	12.0000	609.600	24.0000	+25	0	−13	−38	
		609.600	24.0000	914.400	36.0000	+38	0	−13	−51	

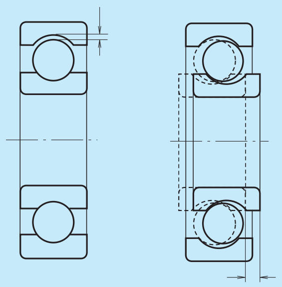
Note (1) For bearings with D greater than 304.8 mm, Class 0 does not exist.

9.2 Bearing Internal Clearances

9.2.1 Internal Clearances and Their Standards

The internal clearance in rolling bearings in operation greatly influences bearing performance including fatigue life, vibration, noise, heat-generation, etc. Consequently, the selection of the proper internal clearance is one of the most important tasks when choosing a bearing after the type and size have been determined.

This bearing internal clearance is the combined clearances between the inner/outer rings and rolling elements. The radial and axial clearances are defined as the total amount that one ring can be displaced relative to the other in the radial and axial directions respectively (Fig. 9.1).



Radial Clearance　　Axial Clearance

Table 9.8 Bearing Internal Clearance

To obtain accurate measurements, the clearance is generally measured by applying a specified measuring load on the bearing; therefore, the measured clearance (sometimes called “measured clearance” to make a distinction) is always slightly larger than the theoretical internal clearance (called “geometrical clearance” for radial bearings) by the amount of elastic deformation caused by the measuring load.

Therefore, the theoretical internal clearance may be obtained by correcting the measured clearance by the amount of elastic deformation. However, in the case of roller bearings this elastic deformation is negligibly small.

Usually the clearance before mounting is the one specified as the theoretical internal clearance.

In Table 9.8, reference table and page numbers are listed by bearing types.

Table 9.8 Index for Radial Internal Clearances by Bearing Types

Bearing Types		Table Number	Page Number
Deep Groove Ball Bearings		9.9	A89
Extra Small and Miniature Ball Bearings		9.10	A89
Magneto Bearings		9.11	A89
Self-Aligning Ball Bearings		9.12	A90
Deep Groove Ball Bearings	For Motors	9.13.1	A90
Cylindrical Roller Bearings	For Motors	9.13.2	A90
Cylindrical Roller Bearings	With Cylindrical Bores With Cylindrical Bores (Matched) With Tapered Bores (Matched)	9.14	A91
Spherical Roller Bearings	With Cylindrical Bores With Tapered Bores	9.15	A92
Double-Row and Combined Tapered Roller Bearings		9.15	A93
Combined Angular Contact Ball Bearings (1)		9.17	A94
Four-Point Contact Ball Bearings (1)		9.18	A94

Note (1) Values given are axial clearances.

Table 9.9 Radial Internal Clearances in Deep Groove Ball Bearings

Units : μm

Nominal Bore Diameter *d* (mm)		Clearance									
		C2		CN		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
50	**65**	1	15	8	28	23	43	38	61	55	90
65	**80**	1	15	10	30	25	51	46	71	65	105
80	**100**	1	18	12	36	30	58	53	84	75	120
100	**120**	2	20	15	41	36	66	61	97	90	140
120	**140**	2	23	18	48	41	81	71	114	105	160
140	**160**	2	23	18	53	46	91	81	130	120	180
160	**180**	2	25	20	61	53	102	91	147	135	200
180	**200**	2	30	25	71	63	117	107	163	150	230
200	**225**	2	35	25	85	75	140	125	195	175	265
225	**250**	2	40	30	95	85	160	145	225	205	300
250	**280**	2	45	35	105	90	170	155	245	225	340
280	**315**	2	55	40	115	100	190	175	270	245	370
315	**355**	3	60	45	125	110	210	195	300	275	410
355	**400**	3	70	55	145	130	240	225	340	315	460
400	**450**	3	80	60	170	150	270	250	380	350	510
450	**500**	3	90	70	190	170	300	280	420	390	570
500	**560**	10	100	80	210	190	330	310	470	440	630
560	**630**	10	110	90	230	210	360	340	520	490	690
630	**710**	20	130	110	260	240	400	380	570	540	760
710	**800**	20	140	120	290	270	450	430	630	600	840

Remarks To obtain the measured values, use the clearance correction for radial clearance increase caused by the measuring load in the table below.

For the C2 clearance class, the smaller value should be used for bearings with minimum clearance and the larger value for bearings near the maximum clearance range.

Units : μm

Nominal Bore Dia. *d* (mm)		Measuring Load		Radial Clearance Correction Amount				
over	incl.	(N)	{kgf}	C2	CN	C3	C4	C5
10 (incl)	**18**	24.5	{2.5}	3 to 4	4	4	4	4
18	**50**	49	{5}	4 to 5	5	6	6	6
50	**280**	147	{15}	6 to 8	8	9	9	9

Remarks For values exceeding 280 mm, please contact NSK.

Table 9.10 Radial Internal Clearances in Extra Small and Miniature Ball Bearings

Units : μm

Clear-ance Symbol	MC1		MC2		MC3		MC4		MC5		MC6	
	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.
Clear-ance	0	5	3	8	5	10	8	13	13	20	20	28

Remarks
1. The standard clearance is MC3.
2. To obtain the measured value, add correction amount in the table below.

Units : μm

Clearance Symbol	MC1	MC2	MC3	MC4	MC5	MC6
Clearance Correction Value	1	1	1	1	2	2

The measuring loads are as follows :

For miniature ball bearings∗ 2.5N {0.25kgf}

For extra small ball bearings∗ 4.4N {0.45kgf}

∗For their classification, refer to Table 1 on Page B 31.

Table 9.11 Radial Internal Clearances in Magneto Bearings

Units : μm

Nominal Bore Diameter *d* (mm)		Bearing Series	Clearance	
over	incl.		min.	max.
2.5	**30**	EN	10	50
		E	30	60

Table 9.12 Radial Internal Clearances in Self-Aligning Ball Bearings

Units : µm

Nominal Bore Dia. *d* (mm)		Clearance in Bearings with Cylindrical Bores										Clearance in Bearings with Tapered Bores									
		C2		CN		C3		C4		C5		C2		CN		C3		C4		C5	
over	incl.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.
2.5	**6**	1	8	5	15	10	20	15	25	21	33	—	—	—	—	—	—	—	—	—	—
6	**10**	2	9	6	17	12	25	19	33	27	42	—	—	—	—	—	—	—	—	—	—
10	**14**	2	10	6	19	13	26	21	35	30	48	—	—	—	—	—	—	—	—	—	—
14	**18**	3	12	8	21	15	28	23	37	32	50	—	—	—	—	—	—	—	—	—	—
18	**24**	4	14	10	23	17	30	25	39	34	52	7	17	13	26	20	33	28	42	37	55
24	**30**	5	16	11	24	19	35	29	46	40	58	9	20	15	28	23	39	33	50	44	62
30	**40**	6	18	13	29	23	40	34	53	46	66	12	24	19	35	29	46	40	59	52	72
40	**50**	6	19	14	31	25	44	37	57	50	71	14	27	22	39	33	52	45	65	58	79
50	**65**	7	21	16	36	30	50	45	69	62	88	18	32	27	47	41	61	56	80	73	99
65	**80**	8	24	18	40	35	60	54	83	76	108	23	39	35	57	50	75	69	98	91	123
80	**100**	9	27	22	48	42	70	64	96	89	124	29	47	42	68	62	90	84	116	109	144
100	**120**	10	31	25	56	50	83	75	114	105	145	35	56	50	81	75	108	100	139	130	170
120	**140**	10	38	30	68	60	100	90	135	125	175	40	68	60	98	90	130	120	165	155	205
140	**160**	15	44	35	80	70	120	110	161	150	210	45	74	65	110	100	150	140	191	180	240

Table 9.13 Radial Internal Clearances in Bearings for Electric Motors

Table 9.13. 1 Deep Groove Ball Bearings for Electric Motors

Units : µm

Nominal Bore Dia. *d* (mm)		Clearance		Remarks	
		CM		Recommended fit	
over	incl.	min.	max.	Shaft	Housing Bore
10 (incl)	**18**	4	11	js5 (j5)	H6, H7(1) or JS6, JS7 (J6, J7)(2)
18	**30**	5	12	k5	
30	**50**	9	17		
50	**80**	12	22		
80	**100**	18	30		
100	**120**	18	30	m5	
120	**160**	24	38		

Notes (1) Applicable to outer rings that require movement in the axial direction.
(2) Applicable to outer rings that do not require movement in the axial direction.

Remarks The radial clearance increase caused by the measuring load is equal to the correction amount for CN clearance in the remarks under Table 9.9.

Table 9.13.2 Cylindrical Roller Bearings for Electric Motors

Units : µm

Nominal Bore Dia. *d* (mm)		Clearance				Remarks	
		Interchangeable CT		Non-Interchangeable CM		Recommended Fit	
over	incl.	min.	max.	min.	max.	Shaft	Housing Bore
24	**40**	15	35	15	30	k5	JS6, JS7 (J6, J7)(1) or K6, K7(2)
40	**50**	20	40	20	35	m5	
50	**65**	25	45	25	40		
65	**80**	30	50	30	45		
80	**100**	35	60	35	55		
100	**120**	35	65	35	60		
120	**140**	40	70	40	65		
140	**160**	50	85	50	80		
160	**180**	60	95	60	90	n6	
180	**200**	65	105	65	100		

Notes (1) Applicable to outer rings that require movement in the axial direction.
(2) Applicable to outer rings that do not require movement in the axial direction.

Table 9.14 Radial Internal Clearances in Cylindrical Roller Bearings and Solid-Type Needle Roller Bearings

Units : µm

Nominal Bore Dia. *d* (mm)		Clearances in Bearings with Cylindrical Bores										Clearances in Non-Interchangeable Bearings with Cylindrical Bores											
		C2		CN		C3		C4		C5		CC1		CC2		CC (1)		CC3		CC4		CC5	
over	incl.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.
—	**10**	0	25	20	45	35	60	50	75	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10	**24**	0	25	20	45	35	60	50	75	65	90	5	15	10	20	20	30	35	45	45	55	65	75
24	**30**	0	25	20	45	35	60	50	75	70	95	5	15	10	25	25	35	40	50	50	60	70	80
30	**40**	5	30	25	50	45	70	60	85	80	105	5	15	12	25	25	40	45	55	55	70	80	95
40	**50**	5	35	30	60	50	80	70	100	95	125	5	18	15	30	30	45	50	65	65	80	95	110
50	**65**	10	40	40	70	60	90	80	110	110	140	5	20	15	35	35	50	55	75	75	90	110	130
65	**80**	10	45	40	75	65	100	90	125	130	165	10	25	20	40	40	60	70	90	90	110	130	150
80	**100**	15	50	50	85	75	110	105	140	155	190	10	30	25	45	45	70	80	105	105	125	155	180
100	**120**	15	55	50	90	85	125	125	165	180	220	10	30	25	50	50	80	95	120	120	145	180	205
120	**140**	15	60	60	105	100	145	145	190	200	245	10	35	30	60	60	90	105	135	135	160	200	230
140	**160**	20	70	70	120	115	165	165	215	225	275	10	35	35	65	65	100	115	150	150	180	225	260
160	**180**	25	75	75	125	120	170	170	220	250	300	10	40	35	75	75	110	125	165	165	200	250	285
180	**200**	35	90	90	145	140	195	195	250	275	330	15	45	40	80	80	120	140	180	180	220	275	315
200	**225**	45	105	105	165	160	220	220	280	305	365	15	50	45	90	90	135	155	200	200	240	305	350
225	**250**	45	110	110	175	170	235	235	300	330	395	15	50	50	100	100	150	170	215	215	265	330	380
250	**280**	55	125	125	195	190	260	260	330	370	440	20	55	55	110	110	165	185	240	240	295	370	420
280	**315**	55	130	130	205	200	275	275	350	410	485	20	60	60	120	120	180	205	265	265	325	410	470
315	**355**	65	145	145	225	225	305	305	385	455	535	20	65	65	135	135	200	225	295	295	360	455	520
355	**400**	100	190	190	280	280	370	370	460	510	600	25	75	75	150	150	225	255	330	330	405	510	585
400	**450**	110	210	210	310	310	410	410	510	565	665	25	85	85	170	170	255	285	370	370	455	565	650
450	**500**	110	220	220	330	330	440	440	550	625	735	25	95	95	190	190	285	315	410	410	505	625	720

Note (1) CC denotes normal clearance for non-Interchangeable cylindrical roller bearings and solid-type needle roller bearings.

Units : µm

Nominal Bore Dia. *d* (mm)		Clearances in Non-Interchangeable Bearings with Tapered Bores															
		CC9 (1)		CC0		CC1		CC2		CC (2)		CC3		CC4		CC5	
over	incl.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.
10	**24**	5	10	—	—	10	20	20	30	35	45	45	55	55	65	75	85
24	**30**	5	10	8	15	10	25	25	35	40	50	50	60	60	70	80	95
30	**40**	5	12	8	15	12	25	25	40	45	55	55	70	70	80	95	110
40	**50**	5	15	10	20	15	30	30	45	50	65	65	80	80	95	110	125
50	**65**	5	15	10	20	15	35	35	50	55	75	75	90	90	110	130	150
65	**80**	10	20	15	30	20	40	40	60	70	90	90	110	110	130	150	170
80	**100**	10	25	20	35	25	45	45	70	80	105	105	125	125	150	180	205
100	**120**	10	25	20	35	25	50	50	80	95	120	120	145	145	170	205	230
120	**140**	15	30	25	40	30	60	60	90	105	135	135	160	160	190	230	260
140	**160**	15	35	30	50	35	65	65	100	115	150	150	180	180	215	260	295
160	**180**	15	35	30	50	35	75	75	110	125	165	165	200	200	240	285	320
180	**200**	20	40	30	50	40	80	80	120	140	180	180	220	220	260	315	355
200	**225**	20	45	35	60	45	90	90	135	155	200	200	240	240	285	350	395
225	**250**	25	50	40	65	50	100	100	150	170	215	215	265	265	315	380	430
250	**280**	25	55	40	70	55	110	110	165	185	240	240	295	295	350	420	475
280	**315**	30	60	—	—	60	120	120	180	205	265	265	325	325	385	470	530
315	**355**	30	65	—	—	65	135	135	200	225	295	295	360	360	430	520	585
355	**400**	35	75	—	—	75	150	150	225	255	330	330	405	405	480	585	660
400	**450**	40	85	—	—	85	170	170	255	285	370	370	455	455	540	650	735
450	**500**	45	95	—	—	95	190	190	285	315	410	410	505	505	600	720	815

Notes (1) Clearance CC9 is applicable to cylindrical roller bearings with tapered bores in ISO Tolerance Classes 5 and 4.
(2) CC denotes normal clearance for non-Interchangeable cylindrical roller bearings and solid-type needle roller bearings.

Table 9.15 Radial Internal Clearances in Spherical Roller Bearings

Units : μm

Nominal Bore Dia. *d* (mm)		Clearance in Bearings with Cylindrical Bores										Clearance in Bearings with Tapered Bores									
		C2		CN		C3		C4		C5		C2		CN		C3		C4		C5	
over	incl.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.
24	**30**	15	25	25	40	40	55	55	75	75	95	20	30	30	40	40	55	55	75	75	95
30	**40**	15	30	30	45	45	60	60	80	80	100	25	35	35	50	50	65	65	85	85	105
40	**50**	20	35	35	55	55	75	75	100	100	125	30	45	45	60	60	80	80	100	100	130
50	**65**	20	40	40	65	65	90	90	120	120	150	40	55	55	75	75	95	95	120	120	160
65	**80**	30	50	50	80	80	110	110	145	145	180	50	70	70	95	95	120	120	150	150	200
80	**100**	35	60	60	100	100	135	135	180	180	225	55	80	80	110	110	140	140	180	180	230
100	**120**	40	75	75	120	120	160	160	210	210	260	65	100	100	135	135	170	170	220	220	280
120	**140**	50	95	95	145	145	190	190	240	240	300	80	120	120	160	160	200	200	260	260	330
140	**160**	60	110	110	170	170	220	220	280	280	350	90	130	130	180	180	230	230	300	300	380
160	**180**	65	120	120	180	180	240	240	310	310	390	100	140	140	200	200	260	260	340	340	430
180	**200**	70	130	130	200	200	260	260	340	340	430	110	160	160	220	220	290	290	370	370	470
200	**225**	80	140	140	220	220	290	290	380	380	470	120	180	180	250	250	320	320	410	410	520
225	**250**	90	150	150	240	240	320	320	420	420	520	140	200	200	270	270	350	350	450	450	570
250	**280**	100	170	170	260	260	350	350	460	460	570	150	220	220	300	300	390	390	490	490	620
280	**315**	110	190	190	280	280	370	370	500	500	630	170	240	240	330	330	430	430	540	540	680
315	**355**	120	200	200	310	310	410	410	550	550	690	190	270	270	360	360	470	470	590	590	740
355	**400**	130	220	220	340	340	450	450	600	600	750	210	300	300	400	400	520	520	650	650	820
400	**450**	140	240	240	370	370	500	500	660	660	820	230	330	330	440	440	570	570	720	720	910
450	**500**	140	260	260	410	410	550	550	720	720	900	260	370	370	490	490	630	630	790	790	1 000
500	**560**	150	280	280	440	440	600	600	780	780	1 000	290	410	410	540	540	680	680	870	870	1 100
560	**630**	170	310	310	480	480	650	650	850	850	1 100	320	460	460	600	600	760	760	980	980	1 230
630	**710**	190	350	350	530	530	700	700	920	920	1 190	350	510	510	670	670	850	850	1 090	1 090	1 360
710	**800**	210	390	390	580	580	770	770	1 010	1 010	1 300	390	570	570	750	750	960	960	1 220	1 220	1 500
800	**900**	230	430	430	650	650	860	860	1 120	1 120	1 440	440	640	640	840	840	1 070	1 070	1 370	1 370	1 690
900	**1 000**	260	480	480	710	710	930	930	1 220	1 220	1 570	490	710	710	930	930	1 190	1 190	1 520	1 520	1 860
1 000	**1 120**	290	530	530	780	780	1 020	1 020	1 330	—	—	530	770	770	1 030	1 030	1 300	1 300	1 670	—	—
1 120	**1 250**	320	580	580	860	860	1 120	1 120	1 460	—	—	570	830	830	1 120	1 120	1 420	1 420	1 830	—	—
1 250	**1 400**	350	640	640	950	950	1 240	1 240	1 620	—	—	620	910	910	1 230	1 230	1 560	1 560	2 000	—	—

Table 9.16 Radial Internal Clearances in Double-Row and Combined Tapered Roller Bearings

Units : μm

Nominal Bore Dia. *d* (mm)		Clearance											
Cylindrical Bore		C1		C2		CN		C3		C4		C5	
Tapered Bore		—		C1		C2		CN		C3		C4	
over	incl.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.
—	**18**	0	10	10	20	20	30	35	45	50	60	65	75
18	**24**	0	10	10	20	20	30	35	45	50	60	65	75
24	**30**	0	10	10	20	20	30	40	50	50	60	70	80
30	**40**	0	12	12	25	25	40	45	60	60	75	80	95
40	**50**	0	15	15	30	30	45	50	65	65	80	95	110
50	**65**	0	15	15	35	35	55	60	80	80	100	110	130
65	**80**	0	20	20	40	40	60	70	90	90	110	130	150
80	**100**	0	25	25	50	50	75	80	105	105	130	155	180
100	**120**	5	30	30	55	55	80	90	115	120	145	180	210
120	**140**	5	35	35	65	65	95	100	130	135	165	200	230
140	**160**	10	40	40	70	70	100	110	140	150	180	220	260
160	**180**	10	45	45	80	80	115	125	160	165	200	250	290
180	**200**	10	50	50	90	90	130	140	180	180	220	280	320
200	**225**	20	60	60	100	100	140	150	190	200	240	300	340
225	**250**	20	65	65	110	110	155	165	210	220	270	330	380
250	**280**	20	70	70	120	120	170	180	230	240	290	370	420
280	**315**	30	80	80	130	130	180	190	240	260	310	410	460
315	**355**	30	80	80	130	140	190	210	260	290	350	450	510
355	**400**	40	90	90	140	150	200	220	280	330	390	510	570
400	**450**	45	95	95	145	170	220	250	310	370	430	560	620
450	**500**	50	100	100	150	190	240	280	340	410	470	620	680
500	**560**	60	110	110	160	210	260	310	380	450	520	700	770
560	**630**	70	120	120	170	230	290	350	420	500	570	780	850
630	**710**	80	130	130	180	260	310	390	470	560	640	870	950
710	**800**	90	140	150	200	290	340	430	510	630	710	980	1 060
800	**900**	100	150	160	210	320	370	480	570	700	790	1 100	1 200
900	**1 000**	120	170	180	230	360	410	540	630	780	870	1 200	1 300
1 000	**1 120**	130	190	200	260	400	460	600	700	—	—	—	—
1 120	**1 250**	150	210	220	280	450	510	670	770	—	—	—	—
1 250	**1 400**	170	240	250	320	500	570	750	870	—	—	—	—

Remarks Axial internal clearance $\Delta_a = \Delta_r \cot\alpha \fallingdotseq \frac{1.5}{e}\Delta_r$

where Δ_r : Radial internal clearance

α : Contact angle

e : Constant (Listed in bearing tables)

Table 9.17 Axial Internal Clearances in Combined Angular Contact Ball Bearings (Measured Clearance)

Units : μm

Nominal Bore Diameter. d (mm)		Axial Internal Clearance											
		Contact Angle 30°						Contact Angle 40°					
		CN		C3		C4		CN		C3		C4	
over	incl.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.
—	**10**	9	29	29	49	49	69	6	26	26	46	46	66
10	**18**	10	30	30	50	50	70	7	27	27	47	47	67
18	**24**	19	39	39	59	59	79	13	33	33	53	53	73
24	**30**	20	40	40	60	60	80	14	34	34	54	54	74
30	**40**	26	46	46	66	66	86	19	39	39	59	59	79
40	**50**	29	49	49	69	69	89	21	41	41	61	61	81
50	**65**	35	60	60	85	85	110	25	50	50	75	75	100
65	**80**	38	63	63	88	88	115	27	52	52	77	77	100
80	**100**	49	74	74	99	99	125	35	60	60	85	85	110
100	**120**	72	97	97	120	120	145	52	77	77	100	100	125
120	**140**	85	115	115	145	145	175	63	93	93	125	125	155
140	**160**	90	120	120	150	150	180	66	96	96	125	125	155
160	**180**	95	125	125	155	155	185	68	98	98	130	130	160
180	**200**	110	140	140	170	170	200	80	110	110	140	140	170

Remarks This table is applicable to bearings in Tolerance Classes Normal and 6. For internal axial clearances in bearings in tolerance classes better than 5 and contact angles of 15° and 25°, it is advisable to consult NSK.

Table 9.18 Axial Internal Clearance in Four-Point Contact Ball Bearings (Measured Clearances)

Units : μm

Nominal Bore Dia. d (mm)		Axial Internal Clearance							
		C2		CN		C3		C4	
over	incl.	min.	max.	min.	max.	min.	max.	min.	max.
10	**18**	15	55	45	85	75	125	115	165
18	**40**	26	66	56	106	96	146	136	186
40	**60**	36	86	76	126	116	166	156	206
60	**80**	46	96	86	136	126	176	166	226
80	**100**	56	106	96	156	136	196	186	246
100	**140**	66	126	116	176	156	216	206	266
140	**180**	76	156	136	196	176	246	226	296
180	**220**	96	176	156	226	206	276	256	326
220	**260**	115	196	175	245	225	305	285	365
260	**300**	135	215	195	275	255	335	315	395
300	**350**	155	235	215	305	275	365	345	425
350	**400**	175	265	245	335	315	405	385	475
400	**500**	205	305	285	385	355	455	435	525

9.2.2 Selection of Bearing Internal Clearances

Among the bearing internal clearances listed in the tables, the CN Clearance is adequate for standard operating conditions. The clearance becomes progressively smaller from C2 to C1 and larger from C3 to C5.

Standard operating conditions are defined as those where the inner ring speed is less than approximately 50% of the limiting speed listed in the bearing tables, the load is less than normal ($P \fallingdotseq 0.1C_r$), and the bearing is tight-fitted on the shaft.

As a measure to reduce bearing noise for electric motors, the radial clearance range is narrower than the normal class and the values are somewhat smaller for deep groove ball bearings and cylindrical roller bearings for electric motors. (Refer to Table 9.13.1 and 9.13.2)

Internal clearance varies with the fit and temperature differences in operation. The changes in radial clearance in a roller bearing are shown in Fig. 9.2.

(1) Decrease in Radial Clearance Caused by Fitting and Residual Clearance

When the inner ring or the outer ring is tight-fitted on a shaft or in a housing, a decrease in the radial internal clearance is caused by the expansion or contraction of the bearing rings. The decrease varies according to the bearing type and size and design of the shaft and housing. The amount of this decrease is approximately 70 to 90% of the interference (refer to Section **15.2**, Fits (1), Pages A130 to A133). The internal clearance after subtracting this decrease from the theoretical internal clearance Δ_0 is called the residual clearance, Δ_f.

(2) Decrease in Radial Internal Clearance Caused by Temperature Differences between Inner and Outer Rings and Effective Clearance

The frictional heat generated during operation is conducted away through the shaft and housing. Since housings generally conduct heat better than shafts, the temperature of the inner ring and the rolling elements is usually higher than that of the outer ring by 5 to 10°C. If the shaft is heated or the housing is cooled, the difference in temperature between the inner and outer rings is greater. The radial clearance decreases due to the thermal expansion caused by the temperature difference between the inner and outer rings. The amount of this decrease can be calculated using the following equations:

$$\delta_t \fallingdotseq \alpha \Delta_t D_e \qquad \textbf{(9.6)}$$

where δ_t : Decrease in radial clearance due to temperature difference between inner and outer rings (mm)
α : Coefficient of linear expansion of bearing steel $\fallingdotseq 12.5 \times 10^{-6}$ (1/°C)
Δ_t : Temperature difference between inner and outer rings (°C)
D_e : Outer ring raceway diameter (mm)

For ball bearings

$$D_e \fallingdotseq \frac{1}{5}(4D+d) \qquad \textbf{(9.7)}$$

For roller bearings

$$D_e \fallingdotseq \frac{1}{4}(3D+d) \qquad \textbf{(9.8)}$$

The clearance after substracting this δ_t from the residual clearance, Δ_f is called the effective clearance, Δ. Theoretically, the longest life of a bearing can be expected when the effective clearance is slightly negative. However, it is difficult to achieve such an ideal condition, and an excessive negative clearance will greatly shorten the bearing life. Therefore, a clearance of zero or a slightly positive amount, instead of a negative one, should be selected. When single-row angular contact ball bearings or tapered roller bearings are used facing each other, there should be a small effective clearance, unless a preload is required. When two cylindrical roller bearings with a rib on one side are used facing each other, it is necessary to provide adequate axial clearance to allow for shaft elongation during operation.

The radial clearances used in some specific applications are given in Table9.19. Under special operating conditions, it is advisable to consult NSK.

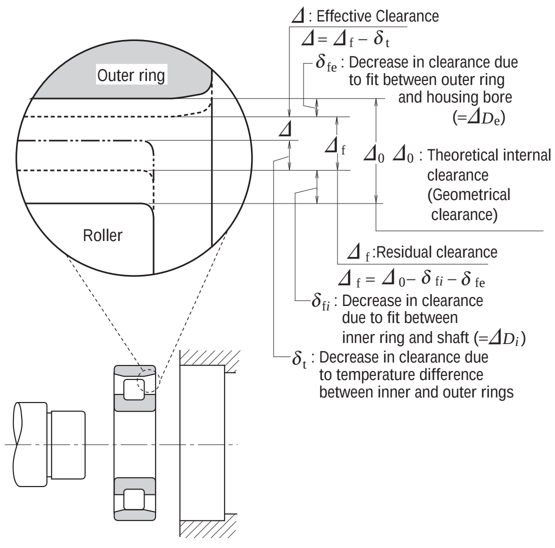


Fig. 9.2 Changes in Radial Internal Clearance of Bearings

Table 9. 19 Examples of Clearances for Specific Applications

Operating Conditions	Examples	Internal Clearance
When shaft deflection is large.	Semi-floating rear wheels of automobiles	C5 or equivalent
When steam passes through hollow shafts or roller shafts are heated.	Dryers in paper making machines	C3, C4
	Table rollers for rolling mills	C3
When impact loads and vibration are severe or when both the inner and outer rings are tight-fitted.	Traction motors for railways	C4
	Vibrating screens	C3, C4
	Fluid couplings	C4
	Final reduction gears for tractors	C4
When both the inner and outer rings are loose-fitted	Rolling mill roll necks	C2 or equivalent
When noise and vibration restrictions are severe	Small motors with special specifications	C1, C2, CM
When clearance is adjusted after mounting to prevent shaft deflection, etc.	Main shafts of lathes	CC9, CC1