1. Bearing materials

1.1 Raceway and rolling element materials

1.1.1 High/mid carbon alloy steel

In general, steel varieties which can be hardened not just on the surface but also deep hardened by the so-called "through hardening method" are used for the raceways and rolling elements of bearings. Foremost among these is high carbon chromium bearing steel, which is widely used.

1.1.2 Mid-carbon chromium steel

Mid-carbon chromium steel incorporating silicone and manganese, which gives it hardening properties comparable to high carbon chromium steel.

1.2 Cage materials

Bearing cage materials must have the strength to withstand rotational vibrations and shock loads. These materials must also have a low friction coefficient, be light weight, and be able to withstand bearing operation temperatures.

1.2.1 Pressed cages

For small and medium sized bearings, pressed cages of cold or hot rolled steel with a low carbon content of approx. 0.1% are used. However, depending on the application, austenitic stainless steel is also used.

1.2.2 Plastic cages

Injection molded plastic cages are now widely used: most are made from fiber glass reinforced heat resistant polyamide resin. Plastic cages are light weight, corrosion resistant and have excellent dampening and sliding properties. Heat resistant polyamide resins now enable the production of cages that perform well in applications ranging between -40°C - 120°C. However, they are not recommended for use at temperatures exceeding 120°C.

2. Bearing tolerances

2.1 Standard of tolerances

Ball bearing "tolerances" or dimensional accuracy and running accuracy, are regulated by ISO and JIS standards (rolling bearing tolerances). For dimensional accuracy, these standards prescribe the tolerances necessary when installing bearings on shafts or in housings. Running accuracy is defined as the allowable limits for bearing runout during operation.

Table 2.1 Bearings types and applicable tolerance

Bearing type		Applicable standard	Applicable tolerance class				Applicable table
Needle roller bearing		JIS B 1514 ISO 492 (NIKO standard)	class change	class 6	class 5	class 4	Table 3.2
Complex bearing	Radial bearing		class 0	class 6	class 5	—	Table 3.2
	Thrust bearing		NIKO class 0	NIKO class 6	NIKO class 5	NIKO class 4	Table 3.3
Needle roller bearing with double-direction thrustf roller bearing	Radial bearing		—	—	class 5	class 4	Table 3.2
	Thrust bearing		—	—	NIKO class 5	NIKO class 4	Table 3.3
Thrust roller bearings			NIKO class 0	NIKO class 6	NIKO class 5	NIKO class 4	Table 3.3
Roller follower/cam follower			class 0	—	—	—	Table 3.2

Note: JIS B 1514 and ISO 492 have the same specification level.

Table 2.2 Tolerance for radial bearings
Table 2.2.1 Inner rings

Nominal bore diameter d mm		Single plane mean bore diameter deviation $\triangle_{dmp}$								Single radial plane bore diameter variation V_{dp}				Mean single plane bore diameter variation V_{dmp}				Inner ring radial runout K_{ia}			
		class 0		class 6		class 5		class 4❶		class 0	class 6	class 5	class 4	class 0	class 6	class 5	class 4	class 0	class 6	class 5	class 4
over	incl.	high	low	high	low	high	low	high	low	max.				max.				max.			
2.5❷	10	0	-8	0	-7	0	-5	0	-4	10	9	5	4	6	5	3	2.0	10	6	4	2.5
10	18	0	-8	0	-7	0	-5	0	-4	10	9	5	4	6	5	3	2.0	10	7	4	2.5
18	30	0	-10	0	-8	0	-6	0	-5	13	10	6	5	8	6	3	2.5	13	8	4	3.0
30	50	0	-12	0	-10	0	-8	0	-6	15	13	8	6	9	8	4	3.0	15	10	5	4.0
50	80	0	-15	0	-12	0	-9	0	-7	19	15	9	7	11	9	5	3.5	20	10	5	4.0
80	120	0	-20	0	-15	0	-10	0	-8	25	19	10	8	15	11	5	4.0	25	13	6	5.0
120	150	0	-25	0	-18	0	-13	0	-10	31	23	13	10	19	14	7	5.0	30	18	8	6.0
150	180	0	-25	0	-18	0	-13	0	-10	31	23	13	10	19	14	7	5.0	30	18	8	6.0
180	250	0	-30	0	-22	0	-15	0	-12	38	28	15	12	23	17	8	6.0	40	20	10	8.0
250	315	0	-35	0	-25	0	-18	—	—	44	31	18	—	26	19	9	—	50	25	13	—
315	400	0	-40	0	-30	0	-23	—	—	50	38	23	—	30	23	12	—	60	30	15	—
400	500	0	-45	0	-35	—	—	—	—	56	44	—	—	34	26	—	—	65	35	—	—

Note: ❶ The dimensional difference $\triangle_{ds}$ of the bore diameter to be applied for class 4 is the same as the tolerance of dimensional difference $\triangle_{dmp}$ of the average bore diameter
❷ Nominal bore diameter of bearings of 2.5 mm is included in this dimensional division.

(Unit: μm)

Nominal bore diameter d mm		Face runout with bore S_d			Inner ring axial runout (with side) S_{ia}❸			Inner ring width deviation $\triangle_{Bs}$				Inner ring width variation V_{Bs}			
		class 0	class 6	class 5	class 0	class 6	class 5	class 0,6		class 5,4		class 0	class 6	class 5	class 4
over	incl.	max.			max.			high	low	high	low	max.			
2.5❷	10	7	3	1.5	7	3	1.5	0	-120	0	-40	15	15	5	2.5
10	18	7	3	1.5	7	3	1.5	0	-120	0	-80	20	20	5	2.5
18	30	8	4	1.5	8	4	2.5	0	-120	0	-120	20	20	5	2.5
30	50	8	4	1.5	8	4	2.5	0	-120	0	-120	20	20	5	3.0
50	80	8	5	1.5	8	5	2.5	0	-150	0	-150	25	25	6	4.0
80	120	9	5	2.5	9	5	2.5	0	-200	0	-200	25	25	7	4.0
120	150	10	6	2.5	10	7	2.5	0	-250	0	-250	30	30	8	5.0
150	180	10	6	4.0	10	7	5.0	0	-250	0	-250	30	30	8	5.0
180	250	11	7	5.0	13	8	5.0	0	-300	0	-300	30	30	10	6.0
250	315	13	—	—	15	—	—	0	-350	0	-350	35	35	13	—
315	400	15	—	—	20	—	—	0	-400	0	-400	40	40	15	—
400	500	—		—	—	—	—	0	-450	—	—	50	45	—	—

Note: ❸ To be applied for deep groove ball bearing.

Note: $\triangle$dmp: deviation of the mean bore diameter from the nominal ($\triangle dmp = dmp - d$).
Vdp: bore diameter variation; difference between the largest and smallest single bore diameters in one plane.
Vdmp: mean bore diameter variation; difference between the largest and smallest mean bore diameters of one ring or washer.
Kia: radial runout of assembled bearing inner ring and assembled bearing outer ring, respectively.
Sd: side face runout with reference to bore (of inner ring).
Sia: side face runout of assembled bearing inner ring and assembled bearing outer ring, respectively.
$\triangle$Bs: deviation of single inner ring width or single outer ring width from the nominal ($\triangle Bs = Bs - B$ etc.)
VBs: ring width variation; difference between the largest and smallest single widths of inner ring and of outer ring, respectively.

Table 2.2.2 Outer rings

Nominal outside diameter D mm		Single plane mean outside diameter deviation ΔD_{mp}								Single radial plane outside diameter variation V_{Dp}				Mean single plane outside diameter variation V_{Dmp}				Outer ring radial runout K_{ea}			
		class 0		class 6		class 5		class 4 ❹		class 0	class 6	class 5	class 4	class 0	class 6	class 5	class 4	class 0	class 6	class 5	class 4
over	incl.	high	low	high	low	high	low	high	low	max.				max.				max.			
6 ❺	18	0	-8	0	-7	0	-5	0	-4	10	9	5	4	6	5	3	2.0	15	8	5	3
18	30	0	-9	0	-8	0	-6	0	-5	12	10	6	5	7	6	3	2.5	15	9	6	4
30	50	0	-11	0	-9	0	-7	0	-6	14	11	7	6	8	7	4	3.0	20	10	7	5
50	80	0	-13	0	-11	0	-9	0	-7	16	14	9	7	10	8	5	3.5	25	13	8	5
80	120	0	-15	0	-13	0	-10	0	-8	19	16	10	8	11	10	5	4.0	35	18	10	6
120	150	0	-18	0	-15	0	-11	0	-9	23	19	11	9	14	11	6	5.0	40	20	11	7
150	180	0	-25	0	-18	0	-13	0	-10	31	23	13	10	19	14	7	5.0	45	23	13	8
180	250	0	-30	0	-20	0	-15	0	-11	38	25	15	11	23	15	8	6.0	50	25	15	10
250	315	0	-35	0	-25	0	-18	0	-13	44	31	18	13	26	19	9	7.0	60	30	18	11
315	400	0	-40	0	-28	0	-20	0	-15	50	35	20	15	30	21	10	8.0	70	35	20	13
400	500	0	-45	0	-33	0	-23	—	—	56	41	23	—	34	25	12	—	80	40	23	—
500	630	0	-50	0	-38	0	-28	—	—	63	48	28	—	38	29	14	—	100	50	25	—

Note: ❹ The dimensional difference ΔD_s of the outer diameter to be applied for class 4 is the same as the tolerance of dimensional difference ΔD_{mp} of the average outer diameter.
❺ Nominal outer diameter of bearings of 6 mm is included in this dimensional division.

(Unit μm)

Nominal outside diameter D mm		Outside surface inclination S_D		Outside ring axial runout S_{ea} ❻		Outer ring width deviation ΔC_s	Outer ring width variation V_{Cs}		
		class 5	class 4	class 5	class 4		class 0,6	class 5	class 4
over	incl.	max.		max.		all type	max.		
6 ❺	18	8	4	8	5	Identical to ΔB_s of inner ring of same bearing	Identical to ΔB_s and V_{Bs} of inner ring of same bearing	5	2.5
18	30	8	4	8	5			5	2.5
30	50	8	4	8	5			5	2.5
50	80	8	4	10	5			6	3.0
80	120	9	5	11	6			8	4.0
120	150	10	5	13	7			8	5.0
150	180	10	5	14	8			8	5.0
180	250	11	7	15	10			10	7.0
250	315	13	8	18	10			11	7.0
315	400	13	10	20	13			13	8.0
400	500	15	—	23	—			15	—
500	630	18	—	25	—			18	—

Note: ❻ To be applied for deep groove ball bearings.

Note: ΔD_{mp}: deviation of the mean outside diameter from the nominal ($\Delta D_{mp} = D_{mp} - D$).
V_{Dp}: outside diameter variation; difference between the largest and smallest single outside diameters in one plane.
V_{dmp}: mean bore diameter variation; difference between the largest and smallest mean bore diameters of one ring or washer.
K_{ea}: radial runout of assembled bearing inner ring and assembled bearing outer ring, respectively.
S_d: side face runout with reference to bore (of inner ring).
S_{ia}: side face runout of assembled bearing inner ring and assembled bearing outer ring, respectively.
ΔC_s: deviation of single inner ring width or single outer ring width from the nominal ($\Delta B_s = B_s - B$ etc.)
V_{Cs}: ring width variation; difference between the largest and smallest single widths of inner ring and of outer ring, respectively.

Table 2.3 Tolerance of thrust roller bearings
Table 2.3.1 Inner rings (Unit: μm)

Nominal outer diameter *d* mm		Single plane mean bore diameter deviation △*dmp*				Single radial plane bore diameter variation *Vdp*		Thrust bearing shaft washer raceway (or center washer raceway) thickness variation *Si*			
		class 0,6,5		class 4		class 0,6,5	class 4	class 0	class 6	class 5	class 4
over	incl.	high	low	high	low	max.		max.			
—	18	0	-8	0	-7	6	5	10	5	3	2
18	30	0	-10	0	-8	8	6	10	5	3	2
30	50	0	-12	0	-10	9	8	10	6	3	2
50	80	0	-15	0	-12	11	9	10	7	4	3
80	120	0	-20	0	-15	15	11	15	8	4	3
120	180	0	-25	0	-18	19	14	15	9	5	4
180	250	0	-30	0	-22	23	17	20	10	5	4
250	315	0	-35	0	-25	26	19	25	13	7	5
315	400	0	-40	0	-30	30	23	30	15	7	5
400	500	0	-45	0	-35	34	26	30	18	9	6
500	630	0	-50	0	-40	38	30	35	21	11	7

Table 2.3.2 Outer rings (Unit: μm)

Nominal outside diameter *D* mm		Single plane mean outside diameter deviation △*Dmp*				Single radial plane outside diameter variation *VDp*		Thrust bearing housing washer raceway thickness variation *Se*			
		class 0,6,5		class 4		class 0,6,5	class 4	class 0	class 6	class 5	class 4
over	incl.	high	low	high	low	max.		max.			
10	18	0	-11	0	-7	8	5	According to the tolerance of *Si* against "*d*" or "*d2*" of the same bearings			
18	30	0	-13	0	-8	10	6				
30	50	0	-16	0	-9	12	7				
50	80	0	-19	0	-11	14	8				
80	120	0	-22	0	-13	17	10				
120	180	0	-25	0	-15	19	11				
180	250	0	-30	0	-20	23	15				
250	315	0	-35	0	-25	26	19				
315	400	0	-40	0	-28	30	21				
400	500	0	-45	0	-33	34	25				
500	630	0	-50	0	-38	38	29				
630	800	0	-75	0	-45	55	34				

Note: △dmp: deviation of the mean bore diameter from the nominal (△dmp = dmp − d).
Vdp: bore diameter variation: difference between the largest and smallest single bore diameters in one plane.
Si: thickness variation measured from middle of raceway to back (seating) face of shaft washer and of housing washer, respectively (axial runout).
△Dmp: deviation of the mean outside diameter from the nominal (△Dmp=Dmp − D).
VDp: outside diameter variation: difference between the largest and smallest single outside diameters in one plane.
Se: thickness variation, measured from middle of raceway to back (seating) face of shaft washer and of housing washer, respectively (axial runout).