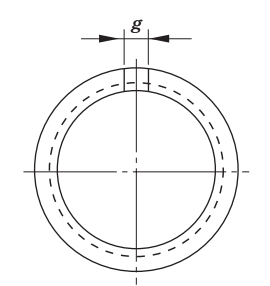
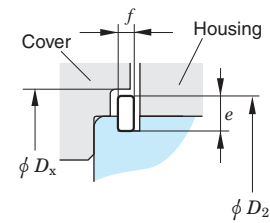
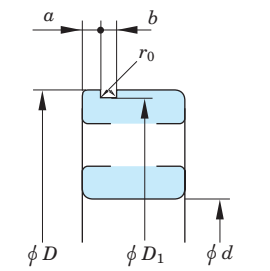


Supplementary table 4 (1) Dimension of snap ring grooves and locating snap rings

- diameter series 18, 19 -

Unit : mm

Applicable bearing			Snap ring groove								Locating snap ring						Housing				
Bore dia. <i>d</i>	Outside dia. <i>D</i>	Snap ring groove dia. <i>D</i> ₁	Position of snap ring groove <i>a</i>				Snap ring groove width <i>b</i>		Fillet radius of snap ring groove <i>r</i> ₀	No.	Section height <i>e</i>		Thickness <i>f</i>		Mounted state		Shoulder bore dia. <i>D</i> _x				
			Dimension series 18		Dimension series 19		max.	min.			max.	min.	max.	min.	max.	min.		Distance between cut ends <i>g</i>	Locating snap ring O.D. <i>D</i> ₂		
18	19	max.	min.	max.	min.	max.	min.	max.		max.	min.	max.	min.	max.	max.						
-	10	22	20.8	20.5	-	-	1.05	0.9	1.05	0.8	0.2			NR 1022	2.0	1.85	0.7	0.6	2	24.8	25.5
-	12	24	22.8	22.5	-	-	1.05	0.9	1.05	0.8	0.2			NR 1024	2.0	1.85	0.7	0.6	2	26.8	27.5
-	15	28	26.7	26.4	-	-	1.3	1.15	1.2	0.95	0.25			NR 1028	2.05	1.9	0.85	0.75	3	30.8	31.5
-	17	30	28.7	28.4	-	-	1.3	1.15	1.2	0.95	0.25			NR 1030	2.05	1.9	0.85	0.75	3	32.8	33.5
20	-	32	30.7	30.4	1.3	1.15	-	-	1.2	0.95	0.25			NR 1032	2.05	1.9	0.85	0.75	3	34.8	35.5
22	-	34	32.7	32.4	1.3	1.15	-	-	1.2	0.95	0.25			NR 1034	2.05	1.9	0.85	0.75	3	36.8	37.5
25	20	37	35.7	35.4	1.3	1.15	1.7	1.55	1.2	0.95	0.25			NR 1037	2.05	1.9	0.85	0.75	3	39.8	40.5
-	22	39	37.7	37.4	-	-	1.7	1.55	1.2	0.95	0.25			NR 1039	2.05	1.9	0.85	0.75	3	41.8	42.5
28	-	40	38.7	38.4	1.3	1.15	-	-	1.2	0.95	0.25			NR 1040	2.05	1.9	0.85	0.75	3	42.8	43.5
30	25	42	40.7	40.4	1.3	1.15	1.7	1.55	1.2	0.95	0.25			NR 1042	2.05	1.9	0.85	0.75	3	44.8	45.5
32	-	44	42.7	42.4	1.3	1.15	-	-	1.2	0.95	0.25			NR 1044	2.05	1.9	0.85	0.75	4	46.8	47.5
-	28	45	43.7	43.4	-	-	1.7	1.55	1.2	0.95	0.25			NR 1045	2.05	1.9	0.85	0.75	4	47.8	48.5
35	30	47	45.7	45.4	1.3	1.15	1.7	1.55	1.2	0.95	0.25			NR 1047	2.05	1.9	0.85	0.75	4	49.8	50.5
40	32	52	50.7	50.4	1.3	1.15	1.7	1.55	1.2	0.95	0.25			NR 1052	2.05	1.9	0.85	0.75	4	54.8	55.5
-	35	55	53.7	53.4	-	-	1.7	1.55	1.2	0.95	0.25			NR 1055	2.05	1.9	0.85	0.75	4	57.8	58.5
45	-	58	56.7	56.4	1.3	1.15	-	-	1.2	0.95	0.25			NR 1058	2.05	1.9	0.85	0.75	4	60.8	61.5
-	40	62	60.7	60.3	-	-	1.7	1.55	1.2	0.95	0.25			NR 1062	2.05	1.9	0.85	0.75	4	64.8	65.5
50	-	65	63.7	63.3	1.3	1.15	-	-	1.2	0.95	0.25			NR 1065	2.05	1.9	0.85	0.75	4	67.8	68.5
-	45	68	66.7	66.3	-	-	1.7	1.55	1.2	0.95	0.25			NR 1068	2.05	1.9	0.85	0.75	5	70.8	72
55	50	72	70.7	70.3	1.7	1.55	1.7	1.55	1.2	0.95	0.25			NR 1072	2.05	1.9	0.85	0.75	5	74.8	76
60	-	78	76.2	75.8	1.7	1.55	-	-	1.6	1.3	0.4			NR 1078	3.25	3.1	1.12	1.02	5	82.7	84
-	55	80	77.9	77.5	-	-	2.1	1.9	1.6	1.3	0.4			NR 1080	3.25	3.1	1.12	1.02	5	84.4	86
65	60	85	82.9	82.5	1.7	1.55	2.1	1.9	1.6	1.3	0.4			NR 1085	3.25	3.1	1.12	1.02	5	89.4	91
70	65	90	87.9	87.5	1.7	1.55	2.1	1.9	1.6	1.3	0.4			NR 1090	3.25	3.1	1.12	1.02	5	94.4	96
75	-	95	92.9	92.5	1.7	1.55	-	-	1.6	1.3	0.4			NR 1095	3.25	3.1	1.12	1.02	5	99.4	101
80	70	100	97.9	97.5	1.7	1.55	2.5	2.3	1.6	1.3	0.4			NR 1100	3.25	3.1	1.12	1.02	5	104.4	106
-	75	105	102.6	102.1	-	-	2.5	2.3	1.6	1.3	0.4			NR 1105	4.04	3.89	1.12	1.02	5	110.7	112
85	80	110	107.6	107.1	2.1	1.9	2.5	2.3	1.6	1.3	0.4			NR 1110	4.04	3.89	1.12	1.02	5	115.7	117
90	-	115	112.6	112.1	2.1	1.9	-	-	1.6	1.3	0.4			NR 1115	4.04	3.89	1.12	1.02	5	120.7	122
95	85	120	117.6	117.1	2.1	1.9	3.3	3.1	1.6	1.3	0.4			NR 1120	4.04	3.89	1.12	1.02	7	125.7	127
100	90	125	122.6	122.1	2.1	1.9	3.3	3.1	1.6	1.3	0.4			NR 1125	4.04	3.89	1.12	1.02	7	130.7	132
105	95	130	127.6	127.1	2.1	1.9	3.3	3.1	1.6	1.3	0.4			NR 1130	4.04	3.89	1.12	1.02	7	135.7	137
110	100	140	137.6	137.1	2.5	2.3	3.3	3.1	2.2	1.9	0.6			NR 1140	4.04	3.89	1.7	1.6	7	145.7	147
-	105	145	142.6	142.1	-	-	3.3	3.1	2.2	1.9	0.6			NR 1145	4.04	3.89	1.7	1.6	7	150.7	152
120	110	150	147.6	147.1	2.5	2.3	3.3	3.1	2.2	1.9	0.6			NR 1150	4.04	3.89	1.7	1.6	7	155.7	157
130	120	165	161.8	161.3	3.3	3.1	3.7	3.5	2.2	1.9	0.6			NR 1165	4.85	4.7	1.7	1.6	7	171.5	173
140	-	175	171.8	171.3	3.3	3.1	-	-	2.2	1.9	0.6			NR 1175	4.85	4.7	1.7	1.6	10	181.5	183
-	130	180	176.8	176.3	-	-	3.7	3.5	2.2	1.9	0.6			NR 1180	4.85	4.7	1.7	1.6	10	186.5	188
150	140	190	186.8	186.3	3.3	3.1	3.7	3.5	2.2	1.9	0.6			NR 1190	4.85	4.7	1.7	1.6	10	196.5	198
160	-	200	196.8	196.3	3.3	3.1	-	-	2.2	1.9	0.6			NR 1200	4.85	4.7	1.7	1.6	10	206.5	208



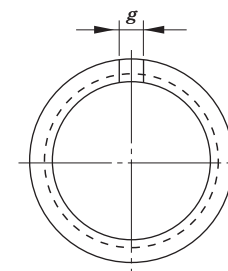
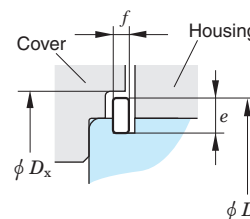
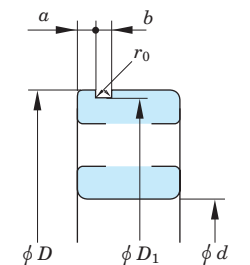
[Remark] Minimum chamfer dimension tolerances on snap ring groove-side outer ring are as follows :
 Bearings belonging to dimension series 18 : 0.3 mm for those with nominal outside diameter not more than 78 mm ; 0.5 mm for those with nominal diameter over 78 mm.
 Bearings belonging to dimension series 19 : 0.3 mm for those with nominal outside diameter not more than 47 mm ; 0.5 mm for those with nominal diameter over 47 mm.

Supplementary table 4 (2) Dimension of snap ring grooves and locating snap rings

- diameter series 0, 2, 3, 4 -

Unit : mm

Applicable bearing				Snap ring groove									Locating snap ring						Housing		
Bore dia. <i>d</i>				Outside dia. <i>D</i>	Snap ring groove dia. <i>D</i> ₁		Position of snap ring groove <i>a</i>				Snap ring groove width <i>b</i>		Fillet radius of snap ring groove <i>r</i> ₀	No.	Section height <i>e</i>		Thickness <i>f</i>		Mounted state		Shoulder bore dia. <i>D</i> _x
							Diameter series												Distance between cut ends <i>g</i>	Locating snap ring O.D. <i>D</i> ₂	
0	2	3	4	max.	min.	0		2, 3, 4		max.	min.	max.	min.	max.	min.	max.	min.	max.			
-	10	9	8	30	28.17	27.91	-	-	2.06	1.9	1.65	1.35	0.4	NR 30	3.25	3.1	1.12	1.02	3	34.7	35.5
15	12	-	9	32	30.15	29.9	2.06	1.9	2.06	1.9	1.65	1.35	0.4	NR 32	3.25	3.1	1.12	1.02	3	36.7	37.5
17	15	10	-	35	33.17	32.92	2.06	1.9	2.06	1.9	1.65	1.35	0.4	NR 35	3.25	3.1	1.12	1.02	3	39.7	40.5
-	-	12	10	37	34.77	34.52	-	-	2.06	1.9	1.65	1.35	0.4	NR 37	3.25	3.1	1.12	1.02	3	41.3	42
-	17	-	-	40	38.1	37.85	-	-	2.06	1.9	1.65	1.35	0.4	NR 40	3.25	3.1	1.12	1.02	3	44.6	45.5
20	-	15	12	42	39.75	39.5	2.06	1.9	2.06	1.9	1.65	1.35	0.4	NR 42	3.25	3.1	1.12	1.02	3	46.3	47
22	-	-	-	44	41.75	41.5	2.06	1.9	-	-	1.65	1.35	0.4	NR 44	3.25	3.1	1.12	1.02	3	48.3	49
25	20	17	-	47	44.6	44.35	2.06	1.9	2.46	2.31	1.65	1.35	0.4	NR 47	4.04	3.89	1.12	1.02	4	52.7	53.5
-	22	-	-	50	47.6	47.35	-	-	2.46	2.31	1.65	1.35	0.4	NR 50	4.04	3.89	1.12	1.02	4	55.7	56.5
28	25	20	15	52	49.73	49.48	2.06	1.9	2.46	2.31	1.65	1.35	0.4	NR 52	4.04	3.89	1.12	1.02	4	57.9	58.5
30	-	-	-	55	52.6	52.35	2.08	1.88	-	-	1.65	1.35	0.4	NR 55	4.04	3.89	1.12	1.02	4	60.7	61.5
-	-	22	-	56	53.6	53.35	-	-	2.46	2.31	1.65	1.35	0.4	NR 56	4.04	3.89	1.12	1.02	4	61.7	62.5
32	28	-	-	58	55.6	55.35	2.08	1.88	2.46	2.31	1.65	1.35	0.4	NR 58	4.04	3.89	1.12	1.02	4	63.7	64.5
35	30	25	17	62	59.61	59.11	2.08	1.88	3.28	3.07	2.2	1.9	0.6	NR 62	4.04	3.89	1.7	1.6	4	67.7	68.5
-	32	-	-	65	62.6	62.1	-	-	3.28	3.07	2.2	1.9	0.6	NR 65	4.04	3.89	1.7	1.6	4	70.7	71.5
40	-	28	-	68	64.82	64.31	2.49	2.29	3.28	3.07	2.2	1.9	0.6	NR 68	4.85	4.7	1.7	1.6	5	74.6	76
-	35	30	20	72	68.81	68.3	-	-	3.28	3.07	2.2	1.9	0.6	NR 72	4.85	4.7	1.7	1.6	5	78.6	80
45	-	32	-	75	71.83	71.32	2.49	2.29	3.28	3.07	2.2	1.9	0.6	NR 75	4.85	4.7	1.7	1.6	5	81.6	83
50	40	35	25	80	76.81	76.3	2.49	2.29	3.28	3.07	2.2	1.9	0.6	NR 80	4.85	4.7	1.7	1.6	5	86.6	88
-	45	-	-	85	81.81	81.31	-	-	3.28	3.07	2.2	1.9	0.6	NR 85	4.85	4.7	1.7	1.6	5	91.6	93
55	50	40	30	90	86.79	86.28	2.87	2.67	3.28	3.07	3	2.7	0.6	NR 90	4.85	4.7	2.46	2.36	5	96.5	98
60	-	-	-	95	91.82	91.31	2.87	2.67	-	-	3	2.7	0.6	NR 95	4.85	4.7	2.46	2.36	5	101.6	103
65	55	45	35	100	96.8	96.29	2.87	2.67	3.28	3.07	3	2.7	0.6	NR100	4.85	4.7	2.46	2.36	5	106.5	108
70	60	50	40	110	106.81	106.3	2.87	2.67	3.28	3.07	3	2.7	0.6	NR110	4.85	4.7	2.46	2.36	5	116.6	118
75	-	-	-	115	111.81	111.3	2.87	2.67	-	-	3	2.7	0.6	NR115	4.85	4.7	2.46	2.36	5	121.6	123
-	65	55	45	120	115.21	114.71	-	-	4.06	3.86	3.4	3.1	0.6	NR120	7.21	7.06	2.82	2.72	7	129.7	131.5
80	70	-	-	125	120.22	119.71	2.87	2.67	4.06	3.86	3.4	3.1	0.6	NR125	7.21	7.06	2.82	2.72	7	134.7	136.5
85	75	60	50	130	125.22	124.71	2.87	2.67	4.06	3.86	3.4	3.1	0.6	NR130	7.21	7.06	2.82	2.72	7	139.7	141.5
90	80	65	55	140	135.23	134.72	3.71	3.45	4.9	4.65	3.4	3.1	0.6	NR140	7.21	7.06	2.82	2.72	7	149.7	152
95	-	-	-	145	140.23	139.73	3.71	3.45	-	-	3.4	3.1	0.6	NR145	7.21	7.06	2.82	2.72	7	154.7	157
100	85	70	60	150	145.24	144.73	3.71	3.45	4.9	4.65	3.4	3.1	0.6	NR150	7.21	7.06	2.82	2.72	7	159.7	162
105	90	75	65	160	155.22	154.71	3.71	3.45	4.9	4.65	3.4	3.1	0.6	NR160	7.21	7.06	2.82	2.72	7	169.7	172
110	95	80	-	170	163.65	163.14	3.71	3.45	5.69	5.44	3.8	3.5	0.6	NR170	9.6	9.45	3.1	3	10	182.9	185
120	100	85	70	180	173.66	173.15	3.71	3.45	5.69	5.44	3.8	3.5	0.6	NR180	9.6	9.45	3.1	3	10	192.9	195
-	105	90	75	190	183.64	183.13	-	-	5.69	5.44	3.8	3.5	0.6	NR190	9.6	9.45	3.1	3	10	202.9	205
130	110	95	80	200	193.65	193.14	5.69	5.44	5.69	5.44	3.8	3.5	0.6	NR200	9.6	9.45	3.1	3	10	212.9	215



[Remark] 1. Snap ring groove dimension does not apply to bearings of dimension series 00, 82 and 83.
 2. The minimum permissible chamfer dimension for snap ring groove-side outer ring is 0.5 mm, except 0.3 mm for bearings belonging to diameter series 0 with nominal outside diameter not more than 35 mm.

Supplementary table 5 Shaft tolerances (deviation from nominal dimensions)

Unit : μm (Refer.)

Nominal shaft dia. (mm)		Deviation classes of shaft dia.																				Nominal shaft dia. (mm)		$\Delta_{dmp}^{(1)}$ of bearing (class 0)							
over	up to	d 6	e 6	f 6	g 5	g 6	h 5	h 6	h 7	h 8	h 9	h 10	js 5	js 6	js 7	j 5	j 6	k 5	k 6	k 7	m 5	m 6	m 7		n 5	n 6	p 6	r 6	r 7	over	up to
3	6	-30 -38	-20 -28	-10 -18	-4 -9	-4 -12	-0 -5	-0 -8	0 -12	0 -18	0 -30	0 -48	± 2.5	± 4	± 6	+3 -2	+6 -2	+6 +1	+9 +1	+13 +1	+9 +4	+12 +4	+16 +4	+13 +8	+16 +8	+20 +12	+23 +15	+27 +15	3	6	0 -8
6	10	-40 -49	-25 -34	-13 -22	-5 -11	-5 -14	-0 -6	-0 -9	0 -15	0 -22	0 -36	0 -58	± 3	± 4.5	± 7.5	+4 -2	+7 -2	+7 +1	+10 +1	+16 +1	+12 +6	+15 +6	+21 +6	+16 +10	+19 +10	+24 +15	+28 +19	+34 +19	6	10	0 -8
10	18	-50 -61	-32 -43	-16 -27	-6 -14	-6 -17	-0 -8	0 -11	0 -18	0 -27	0 -43	0 -70	± 4	± 5.5	± 9	+5 -3	+8 -3	+9 +1	+12 +1	+19 +1	+15 +7	+18 +7	+25 +9	+20 +12	+23 +12	+29 +18	+34 +23	+41 +23	10	18	0 -8
18	30	-65 -78	-40 -53	-20 -33	-7 -16	-7 -20	-0 -9	0 -13	0 -21	0 -33	0 -52	0 -84	± 4.5	± 6.5	± 10.5	+5 -4	+9 -4	+11 +2	+15 +2	+23 +2	+17 +8	+21 +8	+29 +8	+24 +15	+28 +15	+35 +22	+41 +28	+49 +28	18	30	0 -10
30	50	-80 -96	-50 -66	-25 -41	-9 -20	-9 -25	0 -11	0 -16	0 -25	0 -39	0 -62	0 -100	± 5.5	± 8	± 12.5	+6 -5	+11 -5	+12 +2	+18 +2	+27 +2	+20 +9	+25 +9	+34 +9	+28 +17	+33 +17	+42 +26	+50 +34	+59 +34	30	50	0 -12
50	80	-100 -119	-60 -79	-30 -49	-10 -23	-10 -29	0 -13	0 -19	0 -30	0 -46	0 -74	0 -120	± 6.5	± 9.5	± 15	+6 -7	+12 -7	+15 +2	+21 +2	+32 +2	+24 +11	+30 +11	+41 +11	+33 +20	+39 +20	+51 +32	+60 +41	+71 +41	50	80	0 -15
80	120	-120 -142	-72 -94	-36 -58	-12 -27	-12 -34	0 -15	0 -22	0 -35	0 -54	0 -87	0 -140	± 7.5	± 11	± 17.5	+6 -9	+13 -9	+18 +3	+25 +3	+38 +3	+28 +13	+35 +13	+48 +13	+38 +23	+45 +23	+59 +37	+73 +51	+86 +51	80	120	0 -20
120	180	-145 -170	-85 -110	-43 -68	-14 -32	-14 -39	0 -18	0 -25	0 -40	0 -63	0 -100	0 -160	± 9	± 12.5	± 20	+7 -11	+14 -11	+21 +3	+28 +3	+43 +3	+33 +15	+40 +15	+55 +15	+45 +27	+52 +27	+68 +43	+88 +63	+103 +63	120	180	0 -25
180	250	-170 -199	-100 -129	-50 -79	-15 -35	-15 -44	0 -20	0 -29	0 -46	0 -72	0 -115	0 -185	± 10	± 14.5	± 23	+7 -13	+16 -13	+24 +4	+33 +4	+50 +4	+37 +17	+46 +17	+63 +17	+51 +31	+60 +31	+79 +50	+106 +80	+123 +80	180	250	0 -30
250	315	-190 -222	-110 -142	-56 -88	-17 -40	-17 -49	0 -23	0 -32	0 -52	0 -81	0 -130	0 -210	± 11.5	± 16	± 26	+7 -16	+16 -16	+27 +4	+36 +4	+56 +4	+43 +20	+52 +20	+72 +20	+57 +34	+66 +34	+88 +56	+126 +94	+146 +94	250	315	0 -35
315	400	-210 -246	-125 -161	-62 -98	-18 -43	-18 -54	0 -25	0 -36	0 -57	0 -89	0 -140	0 -230	± 12.5	± 18	± 28.5	+7 -18	+18 -18	+29 +4	+40 +4	+61 +4	+46 +21	+57 +21	+78 +21	+62 +37	+73 +37	+98 +62	+144 +108	+165 +108	315	400	0 -40
400	500	-230 -270	-135 -175	-68 -108	-20 -47	-20 -60	0 -27	0 -40	0 -63	0 -97	0 -155	0 -250	± 13.5	± 20	± 31.5	+7 -20	+20 -20	+32 +5	+45 +5	+68 +5	+50 +23	+63 +23	+86 +23	+67 +40	+80 +40	+108 +68	+166 +126	+189 +126	400	500	0 -45
500	630	-260 -304	-145 -189	-76 -120	-22 -54	-22 -66	0 -32	0 -44	0 -70	0 -110	0 -175	0 -280	± 16	± 22	± 35	-	-	+32 0	+44 0	+70 0	+58 +26	+70 +26	+96 +26	+76 +44	+88 +44	+122 +78	+194 +150	+220 +150	500	630	0 -50
630	800	-290 -340	-160 -210	-80 -130	-24 -60	-24 -74	0 -36	0 -50	0 -80	0 -125	0 -200	0 -320	± 18	± 25	± 40	-	-	+36 0	+50 0	+80 0	+66 +30	+80 +30	+110 +30	+86 +50	+100 +50	+138 +88	+225 +175	+255 +175	630	800	0 -75
800	1000	-320 -376	-170 -226	-86 -142	-26 -66	-26 -82	0 -40	0 -56	0 -90	0 -140	0 -230	0 -360	± 20	± 28	± 45	-	-	+40 0	+56 0	+90 0	+74 +34	+90 +34	+124 +34	+96 +56	+112 +56	+156 +100	+266 +210	+300 +210	800	1000	0 -100

[Note] 1) Δ_{dmp} : single plane mean bore diameter deviation

Supplementary table 6 Housing bore tolerances (deviation from nominal dimensions)

Unit : μm (Refer.)

Nominal Bore dia. (mm)		Deviation classes of housing bore																				Nominal Bore dia. (mm)		$\Delta D_{mp}^{(1)}$ of bearing (class 0)							
over	up to	E 6	F 6	F 7	G 6	G 7	H 6	H 7	H 8	H 9	H 10	JS 5	JS 6	JS 7	J 6	J 7	K 5	K 6	K 7	M 5	M 6	M 7	N 5		N 6	N 7	P 6	P 7	R 7	over	up to
10	18	+43 +32	+27 +16	+34 +16	+17 +6	+24 +6	+11 0	+18 0	+27 0	+43 0	+70 0	± 4	± 5.5	± 9	+6 -5	+10 -8	+2 -6	+2 -9	+6 -12	-4 -12	-4 -15	0 -18	-9 -17	-9 -20	-5 -23	-15 -26	-11 -29	-16 -34	10	18	0 -8
18	30	+53 +40	+33 +20	+41 +20	+20 +7	+28 +7	+13 0	+21 0	+33 0	+52 0	+84 0	± 4.5	± 6.5	± 10.5	+8 -5	+12 -9	+1 -8	+2 -11	+6 -15	-5 -14	-4 -17	0 -21	-12 -21	-11 -24	-7 -28	-18 -31	-14 -35	-20 -41	18	30	0 -9
30	50	+66 +50	+41 +25	+50 +25	+25 +9	+34 +9	+16 0	+25 0	+39 0	+62 0	+100 0	± 5.5	± 8	± 12.5	+10 -6	+14 -11	+2 -9	+3 -13	+7 -18	-5 -16	-4 -20	0 -25	-13 -24	-12 -28	-8 -33	-21 -37	-17 -42	-25 -50	30	50	0 -11
50	80	+79 +60	+49 +30	+60 +30	+29 +10	+40 +10	+19 0	+30 0	+46 0	+74 0	+120 0	± 6.5	± 9.5	± 15	+13 -6	+18 -12	+3 -10	+4 -15	+9 -21	-6 -19	-5 -24	0 -30	-15 -28	-14 -33	-9 -39	-26 -45	-21 -51	-30 -60	50	65	0 -13
		+65 +50	+35 +25	+45 +25	+25 +9	+35 +9	+15 0	+25 0	+35 0	+50 0	+90 0	+150 0	± 6.5	± 9.5	± 15	+13 -6	+18 -12	+3 -10	+4 -15	+9 -21	-6 -19	-5 -24	0 -30	-15 -28	-14 -33	-9 -39	-26 -45	-21 -51	-30 -60	65	80
80	120	+94 +72	+58 +36	+71 +36	+34 +12	+47 +12	+22 0	+35 0	+54 0	+87 0	+140 0	± 7.5	± 11	± 17.5	+16 -6	+22 -13	+2 -13	+4 -18	+10 -25	-8 -23	-6 -28	0 -35	-18 -33	-16 -38	-10 -45	-30 -52	-24 -59	-38 -73	80	100	0 -15
		+100 +85	+68 +43	+83 +43	+39 +14	+54 +14	+25 0	+40 0	+63 0	+100 0	+160 0	± 7.5	± 11	± 17.5	+16 -6	+22 -13	+2 -13	+4 -18	+10 -25	-8 -23	-6 -28	0 -35	-18 -33	-16 -38	-10 -45	-30 -52	-24 -59	-38 -73	100	120	0 -15
120	180	+110 +85	+68 +43	+83 +43	+39 +14	+54 +14	+25 0	+40 0	+63 0	+100 0	+160 0	± 9	± 12.5	± 20	+18 -7	+26 -14	+3 -15	+4 -21	+12 -28	-9 -27	-8 -33	0 -40	-21 -39	-20 -45	-12 -52	-36 -61	-28 -68	-48 -88	120	140	(up to 150) 0
		+140 +110	+78 +53	+93 +53	+47 +14	+62 +14	+27 0	+42 0	+65 0	+105 0	+165 0	± 9	± 12.5	± 20	+18 -7	+26 -14	+3 -15	+4 -21	+12 -28	-9 -27	-8 -33	0 -40	-21 -39	-20 -45	-12 -52	-36 -61	-28 -68	-48 -88	140	160	-18 (over to 150) 0
180	250	+129 +100	+79 +50	+96 +50	+44 +15	+61 +15	+29 0	+46 0	+72 0	+115 0	+185 0	± 10	± 14.5	± 23	+22 -7	+30 -16	+2 -18	+5 -24	+13 -33	-11 -31	-8 -37	0 -46	-25 -45	-22 -51	-14 -60	-41 -70	-33 -79	-60 -106	180	200	0 -30
		+150 +120	+67 +43	+87 +43	+47 +14	+62 +14	+27 0	+42 0	+65 0	+105 0	+165 0	± 10	± 14.5	± 23	+22 -7	+30 -16	+2 -18	+5 -24	+13 -33	-11 -31	-8 -37	0 -46	-25 -45	-22 -51	-14 -60	-41 -70	-33 -79	-60 -106	200	225	0 -30
250	315	+142 +110	+88 +56	+108 +56	+49 +17	+69 +17	+32 0	+52 0	+81 0	+130 0	+210 0	± 11.5	± 16	± 26	+25 -7	+36 -16	+3 -20	+5 -27	+16 -36	-13 -36	-9 -41	0 -52	-27 -50	-25 -57	-14 -66	-47 -79	-36 -88	-74 -126	250	280	0 -35
		+160 +130	+78 +53	+93 +53	+47 +14	+62 +14	+27 0	+42 0	+65 0	+105 0	+165 0	± 11.5	± 16	± 26	+25 -7	+36 -16	+3 -20	+5 -27	+16 -36	-13 -36	-9 -41	0 -52	-27 -50	-25 -57	-14 -66	-47 -79	-36 -88	-74 -126	280	315	0 -35
315	400	+161 +125	+98 +62	+119 +62	+54 +18	+75 +18	+36 0	+57 0	+89 0	+140 0	+230 0	± 12.5	± 18	± 28.5	+29 -7	+39 -18	+3 -22	+7 -29	+17 -40	-14 -39	-10 -46	0 -57	-30 -55	-26 -62	-16 -73	-51 -87	-41 -98	-87 -144	315	355	0 -40
		+180 +145	+78 +53	+93 +53	+47 +14	+62 +14	+27 0	+42 0	+65 0	+105 0	+165 0	± 12.5	± 18	± 28.5	+29 -7	+39 -18	+3 -22	+7 -29	+17 -40	-14 -39	-10 -46	0 -57	-30 -55	-26 -62	-16 -73	-51 -87	-41 -98	-87 -144	355	400	0 -40
400	500	+175 +135	+108 +68	+131 +68	+60 +20	+83 +20	+40 0	+63 0	+97 0	+155 0	+250 0	± 13.5	± 20	± 31.5	+33 -7	+43 -20	+2 -25	+8 -32	+18 -45	-16 -43	-10 -50	0 -63	-33 -60	-27 -67	-17 -80	-55 -95	-45 -108	-103 -172	400	450	0 -45
		+190 +155	+78 +53	+93 +53	+47 +14	+62 +14	+27 0	+42 0	+65 0	+105 0	+165 0	± 13.5	± 20	± 31.5	+33 -7	+43 -20	+2 -25	+8 -32	+18 -45	-16 -43	-10 -50	0 -63	-33 -60	-27 -67	-17 -80	-55 -95	-45 -108	-103 -172	450	500	0 -45
500	630	+189 +145	+120 +76	+146 +76	+66 +22	+92 +22	+44 0	+70 0	+110 0	+175 0	+280 0	± 16	± 22	± 35	-	-	0 -32	0 -44	0 -70	-26 -58	-26 -70	-26 -96	-44 -76	-44 -88	-44 -114	-78 -122	-78 -148	-150 -220	500	560	0 -50
		+200 +165	+78 +53	+93 +53	+47 +14	+62 +14	+27 0	+42 0	+65 0	+105 0	+165 0	± 16	± 22	± 35	-	-	0 -32	0 -44	0 -70	-26 -58	-26 -70	-26 -96	-44 -76	-44 -88	-44 -114	-78 -122	-78 -148	-150 -220	560	630	0 -50
630	800	+210 +160	+130 +80	+160 +80	+74 +24	+104 +24	+50 0	+80 0	+125 0	+200 0	+320 0	± 18	± 25	± 40	-	-	0 -36	0 -50	0 -80	-30 -66	-30 -80	-30 -110	-50 -86	-50 -100	-50 -130	-88 -138	-88 -168	-175 -255	630	710	0 -75
		+220 +185	+78 +53	+93 +53	+47 +14	+62 +14	+27 0	+42 0	+65 0	+105 0	+165 0	± 18	± 25	± 40	-	-	0 -36	0 -50	0 -80	-30 -66	-30 -80	-30 -110	-50 -86	-50 -100	-50 -130	-88 -138	-88 -168	-175 -255	710	800	0 -75
800	1000	+226 +170	+142 +86	+176 +86	+82 +26	+116 +26	+56 0	+90 0	+140 0	+230 0	+360 0	± 20	± 28	± 45	-	-	0 -40	0 -56	0 -90	-34 -74	-34 -90	-34 -124	-56 -96	-56 -112	-56 -146	-100 -156	-100 -190	-210 -300	800	900	0 -100
		+240 +205	+78 +53	+93 +53	+47 +14	+62 +14	+27 0	+42 0	+65 0	+105 0	+165 0	± 20	± 28	± 45	-	-	0 -40	0 -56	0 -90	-34 -74	-34 -90	-34 -124	-56 -96	-56 -112	-56 -146	-100 -156	-100 -190	-210 -300	900	1000	0 -100
1000	1250	+261 +195	+164 +98	+203 +98	+94 +28	+133 +28	+66 0	+105 0	+165 0	+260 0	+420 0	± 23.5	± 33	± 52.5	-	-	0 -47	0 -66	0 -105	-40 -87	-40 -106	-40 -145	-66 -113	-66 -132	-66 -171	-120 -186	-120 -225	-250 -355	1000	1120	0 -125
		+280 +245	+78 +53	+93 +53	+47 +14	+62 +14	+27 0	+42 0	+65 0	+105 0	+165 0	± 23.5	± 33	± 52.5	-	-	0 -47	0 -66	0 -105	-40 -87	-40 -106	-40 -145	-66 -113	-66 -132	-66 -171	-120 -186	-120 -225	-250 -355	1120	1250	0 -125

[Note] 1) ΔD_{mp} : single plane mean outside diameter deviation

Supplementary table 7 Numerical values for standard tolerance grades IT

Basic size (mm)		Standard tolerance grades (IT)																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14 ¹⁾	15 ¹⁾	16 ¹⁾	17 ¹⁾	18 ¹⁾
over	up to	Tolerances (μm)										Tolerances (mm)							
–	3	0.8	1.2	2	3	4	6	10	14	25	40	60	0.10	0.14	0.26	0.40	0.60	1.00	1.40
3	6	1	1.5	2.5	4	5	8	12	18	30	48	75	0.12	0.18	0.30	0.48	0.75	1.20	1.80
6	10	1	1.5	2.5	4	6	9	15	22	36	58	90	0.15	0.22	0.36	0.58	0.90	1.50	2.20
10	18	1.2	2	3	5	8	11	18	27	43	70	110	0.18	0.27	0.43	0.70	1.10	1.80	2.70
18	30	1.5	2.5	4	6	9	13	21	33	52	84	130	0.21	0.33	0.52	0.84	1.30	2.10	3.30
30	50	1.5	2.5	4	7	11	16	25	39	62	100	160	0.25	0.39	0.62	1.00	1.60	2.50	3.90
50	80	2	3	5	8	13	19	30	46	74	120	190	0.30	0.46	0.74	1.20	1.90	3.00	4.60
80	120	2.5	4	6	10	15	22	35	54	87	140	220	0.35	0.54	0.87	1.40	2.20	3.50	5.40
120	180	3.5	5	8	12	18	25	40	63	100	160	250	0.40	0.63	1.00	1.60	2.50	4.00	6.30
180	250	4.5	7	10	14	20	29	46	72	115	185	290	0.46	0.72	1.15	1.85	2.90	4.60	7.20
250	315	6	8	12	16	23	32	52	81	130	210	320	0.52	0.81	1.30	2.10	3.20	5.20	8.10
315	400	7	9	13	18	25	36	57	89	140	230	360	0.57	0.89	1.40	2.30	3.60	5.70	8.90
400	500	8	10	15	20	27	40	63	97	155	250	400	0.63	0.97	1.55	2.50	4.00	6.30	9.70
500	630	–	–	–	–	–	44	70	110	175	280	440	0.70	1.10	1.75	2.80	4.40	7.00	11.00
630	800	–	–	–	–	–	50	80	125	200	320	500	0.80	1.25	2.00	3.20	5.00	8.00	12.50
800	1000	–	–	–	–	–	56	90	140	230	360	560	0.90	1.40	2.30	3.60	5.60	9.00	14.00
1000	1250	–	–	–	–	–	66	105	165	260	420	660	1.05	1.65	2.60	4.20	6.60	10.50	16.50
1250	1600	–	–	–	–	–	78	125	195	310	500	780	1.25	1.95	3.10	5.00	7.80	12.50	19.50
1600	2000	–	–	–	–	–	92	150	230	370	600	920	1.50	2.30	3.70	6.00	9.20	15.00	23.00
2000	2500	–	–	–	–	–	110	175	280	440	700	1100	1.75	2.80	4.40	7.00	11.00	17.50	28.00
2500	3150	–	–	–	–	–	135	210	330	540	860	1350	2.10	3.30	5.40	8.60	13.50	21.00	33.00

[Note] 1) Standard tolerance grades IT 14 to IT 18 (incl.) shall not be used for basic sizes less than or equal to 1 mm.

Supplementary table 8 Greek alphabet list

Name	Roman type		Italic type		Name	Roman type		Italic type	
	Capital		Capital	Lowercase		Capital		Capital	Lowercase
alpha	A		<i>A</i>	<i>α</i>	nu	N		<i>N</i>	<i>ν</i>
beta	B		<i>B</i>	<i>β</i>	xi	Ξ		<i>Ξ</i>	<i>ξ</i>
gamma	Γ		<i>Γ</i>	<i>γ</i>	omicron	O		<i>O</i>	<i>ο</i>
delta	Δ		<i>Δ</i>	<i>δ</i>	pi	Π		<i>Π</i>	<i>π</i>
epsilon	E		<i>E</i>	<i>ε</i>	rho	Ρ		<i>Ρ</i>	<i>ρ</i>
zeta	Z		<i>Z</i>	<i>ζ</i>	sigma	Σ		<i>Σ</i>	<i>σ</i>
eta	H		<i>H</i>	<i>η</i>	tau	T		<i>T</i>	<i>τ</i>
theta	Θ		<i>Θ</i>	<i>θ</i>	upsilon	Υ		<i>Υ</i>	<i>υ</i>
iota	I		<i>I</i>	<i>ι</i>	phi	Φ		<i>Φ</i>	<i>φ</i>
kappa	K		<i>K</i>	<i>κ</i>	chi	X		<i>X</i>	<i>χ</i>
lambda	Λ		<i>Λ</i>	<i>λ</i>	psi	Ψ		<i>Ψ</i>	<i>ψ</i>
mu	M		<i>M</i>	<i>μ</i>	omega	Ω		<i>Ω</i>	<i>ω</i>

Supplementary table 9 Prefixes used with SI units

Factor	Prefix		Factor	Prefix	
	Name	Symbol		Name	Symbol
10 ¹⁸	exa	E	10 ⁻¹	deci	d
10 ¹⁵	peta	P	10 ⁻²	centi	c
10 ¹²	tera	T	10 ⁻³	milli	m
10 ⁹	giga	G	10 ⁻⁶	micro	μ
10 ⁶	mega	M	10 ⁻⁹	nano	n
10 ³	kilo	k	10 ⁻¹²	pico	p
10 ²	hecto	h	10 ⁻¹⁵	femto	f
10	deka	da	10 ⁻¹⁸	atto	a

Supplementary table 10 (1) SI units and conversion factors

Mass	SI units	Other units ¹⁾	Conversion into SI units	Conversion from SI units
Angle	rad [radian(s)]	° [degree(s)] ' [minute(s)] " [second(s)]	* 1° = π/180 rad * 1' = π/10 800 rad * 1" = π/648 000 rad	1 rad = 57.295 78°
Length	m [meter(s)]	Å [Angstrom unit] μ [micron(s)] in [inch(es)] ft [foot(feet)] yd [yard(s)] mile [mile(s)]	1Å = 10 ⁻¹⁰ m = 0.1nm = 100pm 1μ = 1 μm 1in = 25.4 mm 1ft = 12 in = 0.304 8 m 1yd = 3 ft = 0.914 4 m 1mile = 5 280 ft = 1 609.344 m	1m = 10 ¹⁰ Å 1m = 39.37 in 1m = 3.280 8 ft 1m = 1.093 6 yd 1km = 0.621 4 mile
Area	m ²	a [are(s)] ha [hectare(s)] acre [acre(s)]	1a = 100 m ² 1ha = 10 ⁴ m ² 1acre = 4 840 yd ² = 4 046.86 m ²	1km ² = 247.1 acre
Volume	m ³	ℓ, L [liter(s)] cc [cubic centimeters] gal(US) [gallon(s)] floz(US) [fluid ounce(s)] barrel(US) [barrels(US)]	* 1ℓ = 1 dm ³ = 10 ⁻³ m ³ * 1cc = 1 cm ³ = 10 ⁻⁶ m ³ 1gal(US) = 231 in ³ = 3.785 41dm ³ 1floz(US) = 29.573 5 cm ³ 1barrel(US) = 158.987 dm ³	1m ³ = 10 ³ ℓ 1m ³ = 10 ⁶ cc 1m ³ = 264.17 gal 1m ³ = 33 814 floz 1m ³ = 6.289 8 barrel
Time	s [second(s)]	min [minute(s)] h [hour(s)] d [day(s)]	* * *	
Angular velocity	rad/s			
Velocity	m/s	kn [knot(s)] m/h	* *	1kn = 1 852 m/h 1km/h = 0.539 96 kn
Acceleration	m/s ²	G		1G = 9.806 65 m/s ² 1m/s ² = 0.101 97 G
Frequency	Hz [hertz]	c/s [cycle(s)/second]		1c/s = 1s ⁻¹ = 1 Hz
Rotational frequency	s ⁻¹	rpm [revolutions per minute] min ⁻¹ r/min	*	1rpm = 1 / 60 s ⁻¹ 1s ⁻¹ = 60 rpm
Mass	kg [kilogram(s)]	t [ton(s)] lb [pound(s)] gr [grain(s)] oz [ounce(s)] ton (UK) [ton(s)(UK)] ton (US) [ton(s)(US)] car [carat(s)]	* * * * * * *	1t = 10 ³ kg 1lb = 0.453 592 37 kg 1gr = 64.798 91 mg 1oz = 1/16 lb = 28.349 5 g 1ton(UK) = 1 016.05 kg 1ton(US) = 907.185 kg 1car = 200 mg 1kg = 2.204 6 lb 1g = 15.432 4 gr 1kg = 35.274 0 oz 1t = 0.984 2 ton(UK) 1t = 1.102 3 ton(US) 1g = 5 car

[Note] * : Unit can be used as an SI unit.
No asterisk : Unit cannot be used.

Supplementary table 10 (2) SI units and conversion factors

Mass	SI units	Other units ¹⁾	Conversion into SI units	Conversion from SI units
Density	kg/m ³			
Linear density	kg/m			
Momentum	kg·m/s			
Moment of momentum, angular momentum	kg·m ² /s			
Moment of inertia		kg·m ²		
Force	N [newton(s)]	dyn [dyne(s)] kgf [kilogram-force] gf [gram-force] tf [ton-force] lbf [pound-force]	1dyn = 10 ⁻⁵ N 1kgf = 9.806 65 N 1gf = 9.806 65×10 ⁻³ N 1tf = 9.806 65×10 ³ N 1lbf = 4.448 22 N	1N = 10 ⁵ dyn 1N = 0.101 97 kgf 1N = 0.224 809 lbf
Moment of force	N·m [Newton meter(s)]	gf·cm kgf·cm kgf·m tf·m lbf·ft	1gf·cm = 9.806 65×10 ⁻⁵ N·m 1kgf·cm = 9.806 65×10 ⁻² N·m 1kgf·m = 9.806 65 N·m 1tf·m = 9.806 65×10 ³ N·m 1lbf·ft = 1.355 82 N·m	1N·m = 0.101 97 kgf·m 1N·m = 0.737 56 lbf·ft
Pressure, Normal stress	Pa [Pascal(s)] or N/m ² { 1 Pa = 1 N/m ² }	gf/cm ² kgf/mm ² kgf/m ² lbf/in ² bar [bar(s)] at [engineering air pressure] mH ₂ O, mAq [meter water column] atm [atmosphere] mHg [meter mercury column] Torr [torr]	1gf/cm ² = 9.806 65×10 Pa 1kgf/mm ² = 9.806 65×10 ⁶ Pa 1kgf/m ² = 9.806 65 Pa 1lbf/in ² = 6 894.76 Pa 1bar = 10 ⁵ Pa 1at = 1kgf/cm ² = 9.806 65×10 ⁴ Pa 1mH ₂ O = 9.806 65×10 ³ Pa 1atm = 101 325 Pa 1mHg = $\frac{101\ 325}{0.76}$ Pa 1Torr = 1 mmHg = 133.322 Pa	1MPa = 0.101 97 kgf/mm ² 1Pa = 0.101 97 kgf/m ² 1Pa = 0.145×10 ⁻⁵ lbf/in ² 1Pa = 10 ⁻² mbar 1Pa = 7.500 6×10 ⁻³ Torr
Viscosity	Pa·s [pascal second]	P [poise] kgf·s/m ²	10 ⁻² P = 1 cP = 1 mPa·s 1kgf·s/m ² = 9.806 65 Pa·s	1Pa·s = 0.101 97 kgf·s/m ²
Kinematic viscosity	m ² /s	St [stokes]	10 ⁻² St = 1 cSt = 1 mm ² /s	
Surface tension	N/m			

Supplementary table 10 (3) SI units and conversion factors

Mass	SI units	Other units ¹⁾	Conversion into SI units	Conversion from SI units
Work, energy	J [joule(s)] {1 J=1 N·m}	eV [electron volt(s)] * erg [erg(s)] kgf·m lbf·ft	1eV = (1.602 189 2± 0.000 004 6)×10 ⁻¹⁹ J 1 erg = 10 ⁻⁷ J 1 kgf·m = 9.806 65 J 1 lbf·ft = 1.355 82 J	1 J = 10 ⁷ erg 1 J = 0.101 97 kgf·m 1 J = 0.737 56 lbf·ft
Power	W [watt(s)]	erg/s [ergs per second] kgf·m/s PS [French horse-power] HP [horse-power (British)] lbf·ft/s	1 erg/s = 10 ⁻⁷ W 1 kgf·m/s = 9.806 65 W 1 PS = 75 kgf·m/s = 735.5 W 1 HP = 550 lbf·ft/s = 745.7 W 1 lbf·ft/s = 1.355 82 W	1 W = 0.101 97 kgf·m/s 1 W = 0.001 36 PS 1 W = 0.001 34 HP
Thermo-dynamic temperature	K [kelvin(s)]			
Celsius temperature	°C [Celsius(s)] {t°C = (t+273.15)K}	°F [degree(s) Fahrenheit]	t °F = $\frac{5}{9}(t-32)°C$	t °C = $(\frac{9}{5}t+32)°F$
Linear expansion coefficient	K ⁻¹	°C ⁻¹ [per degree]		
Heat	J [joule(s)] {1 J=1 N·m}	erg [erg(s)] kgf·m cal _{IT} [I. T. calories]	1 erg = 10 ⁻⁷ J 1 cal _{IT} = 4.186 8 J 1 Mcal _{IT} = 1.163 kW·h	1 J = 10 ⁷ erg 1 J = 0.238 85 cal _{IT} 1 kW·h = 0.86 × 10 ⁶ cal _{IT}
Thermal conductivity	W/(m·K)	W/(m·°C) cal/(s·m·°C)	1 W/(m·°C) = 1 W/(m·K) 1 cal/(s·m·°C) = 4.186 05 W/(m·K)	
Coefficient of heat transfer	W/(m ² ·K)	W/(m ² ·°C) cal/(s·m ² ·°C)	1 W/(m ² ·°C) = 1 W/(m ² ·K) 1 cal/(s·m ² ·°C) = 4.186 05 W/(m ² ·K)	
Heat capacity	J/K	J/°C	1 J/°C = 1 J/K	
Massic heat capacity	J/(kg·K)	J/(kg·°C)		

[Note] * : Unit can be used as an SI unit.
No asterisk : Unit cannot be used.

Supplementary table 10 (4) SI units and conversion factors

Mass	SI units	Other units ¹⁾	Conversion into SI units	Conversion from SI units
Electric current	A [ampere(s)]			
Electric charge, quantity of electricity	C [coulomb(s)] {1 C = 1 A·s}	A·h *	1 A·h = 3.6 kC	
Tension, electric potential	V [volt(s)] {1 V = 1 W/A}			
Capacitance	F [farad(s)] {1 F = 1 C/V}			
Magnetic field strength	A/m	Oe [oersted(s)]	1 Oe = $\frac{10^3}{4\pi}$ A/m	1 A/m = 4π × 10 ⁻³ Oe
Magnetic flux density	T [tesla(s)] $\left\{ \begin{array}{l} 1T=1N/(A\cdot m) \\ =1Wb/m^2 \\ =1V\cdot s/m^2 \end{array} \right\}$	Gs [gauss(es)] γ [gamma(s)]	1 Gs = 10 ⁻⁴ T 1 γ = 10 ⁻⁹ T	1 T = 10 ⁴ Gs 1 T = 10 ⁹ γ
Magnetic flux	Wb [weber(s)] {1 Wb = 1 V·s}	Mx [maxwell(s)]	1 Mx = 10 ⁻⁸ Wb	1 Wb = 10 ⁸ Mx
Self inductance	H [henry(-ries)] {1 H = 1 Wb/A}			
Resistance (to direct current)	Ω [ohm(s)] {1 Ω = 1 V/A}			
Conductance (to direct current)	S [siemens] {1 S = 1 A/V}			
Active power	W $\left\{ \begin{array}{l} 1W=1J/s \\ =1A\cdot V \end{array} \right\}$			

Supplementary table 11 Inch/millimeter conversion

Inch	Inches										
	0	1	2	3	4	5	6	7	8	9	10
	mm										
0	0	25.4000	50.8000	76.2000	101.6000	127.0000	152.4000	177.8000	203.2000	228.6000	254.0000
1/64	0.015625	0.3969	25.7969	51.1969	76.5969	101.9969	127.3969	152.7969	178.1969	203.5969	228.9969
1/32	0.03125	0.7938	26.1938	51.5938	76.9938	102.3938	127.7938	153.1938	178.5938	203.9938	229.3938
3/64	0.046875	1.1906	26.5906	51.9906	77.3906	102.7906	128.1906	153.5906	178.9906	204.3906	229.7906
1/16	0.0625	1.5875	26.9875	52.3875	77.7875	103.1875	128.5875	153.9875	179.3875	204.7875	230.1875
5/64	0.078125	1.9844	27.3844	52.7844	78.1844	103.5844	128.9844	154.3844	179.7844	205.1844	230.5844
3/32	0.09375	2.3812	27.7812	53.1812	78.5812	103.9812	129.3812	154.7812	180.1812	205.5812	230.9812
7/64	0.109375	2.7781	28.1781	53.5781	78.9781	104.3781	129.7781	155.1781	180.5781	205.9781	231.3781
1/8	0.125	3.1750	28.5750	53.9750	79.3750	104.7750	130.1750	155.5750	180.9750	206.3750	231.7750
9/64	0.140625	3.5719	28.9719	54.3719	79.7719	105.1719	130.5719	155.9719	181.3719	206.7719	232.1719
5/32	0.15625	3.9688	29.3688	54.7688	80.1688	105.5688	130.9688	156.3688	181.7688	207.1688	232.5688
11/64	0.171875	4.3656	29.7656	55.1656	80.5656	105.9656	131.3656	156.7656	182.1656	207.5656	232.9656
3/16	0.1875	4.7625	30.1625	55.5625	80.9625	106.3625	131.7625	157.1625	182.5625	207.9625	233.3625
13/64	0.203125	5.1594	30.5594	55.9594	81.3594	106.7594	132.1594	157.5594	182.9594	208.3594	233.7594
7/32	0.21875	5.5562	30.9562	56.3562	81.7562	107.1562	132.5562	157.9562	183.3562	208.7562	234.1562
15/64	0.234375	5.9531	31.3531	56.7531	82.1531	107.5531	132.9531	158.3531	183.7531	209.1531	234.5531
1/4	0.25	6.3500	31.7500	57.1500	82.5500	107.9500	133.3500	158.7500	184.1500	209.5500	234.9500
17/64	0.265625	6.7469	32.1469	57.5469	82.9469	108.3469	133.7469	159.1469	184.5469	209.9469	235.3469
9/32	0.28125	7.1438	32.5438	57.9438	83.3438	108.7438	134.1438	159.5438	184.9438	210.3438	235.7438
19/64	0.296875	7.5406	32.9406	58.3406	83.7406	109.1406	134.5406	159.9406	185.3406	210.7406	236.1406
5/16	0.3125	7.9375	33.3375	58.7375	84.1375	109.5375	134.9375	160.3375	185.7375	211.1375	236.5375
21/64	0.328125	8.3344	33.7344	59.1344	84.5344	109.9344	135.3344	160.7344	186.1344	211.5344	236.9344
11/32	0.34375	8.7312	34.1312	59.5312	84.9312	110.3312	135.7312	161.1312	186.5312	211.9312	237.3312
23/64	0.359375	9.1281	34.5281	59.9281	85.3281	110.7281	136.1281	161.5281	186.9281	212.3281	237.7281
3/8	0.375	9.5250	34.9250	60.3250	85.7250	111.1250	136.5250	161.9250	187.3250	212.7250	238.1250
25/64	0.390625	9.9219	35.3219	60.7219	86.1219	111.5219	136.9219	162.3219	187.7219	213.1219	238.5219
13/32	0.40625	10.3188	35.7188	61.1188	86.5188	111.9188	137.3188	162.7188	188.1188	213.5188	238.9188
27/64	0.421875	10.7156	36.1156	61.5156	86.9156	112.3156	137.7156	163.1156	188.5156	213.9156	239.3156
7/16	0.4375	11.1125	36.5125	61.9125	87.3125	112.7125	138.1125	163.5125	188.9125	214.3125	239.7125
29/64	0.453125	11.5094	36.9094	62.3094	87.7094	113.1094	138.5094	163.9094	189.3094	214.7094	240.1094
15/32	0.46875	11.9062	37.3062	62.7062	88.1062	113.5062	138.9062	164.3062	189.7062	215.1062	240.5062
31/64	0.484375	12.3031	37.7031	63.1031	88.5031	113.9031	139.3031	164.7031	190.1031	215.5031	240.9031
1/2	0.5	12.7000	38.1000	63.5000	88.9000	114.3000	139.7000	165.1000	190.5000	215.9000	241.3000
33/64	0.515625	13.0969	38.4969	63.8969	89.2969	114.6969	140.0969	165.4969	190.8969	216.2969	241.6969
17/32	0.53125	13.4938	38.8938	64.2938	89.6938	115.0938	140.4938	165.8938	191.2938	216.6938	242.0938
35/64	0.546875	13.8906	39.2906	64.6906	90.0906	115.4906	140.8906	166.2906	191.6906	217.0906	242.4906
9/16	0.5625	14.2875	39.6875	65.0875	90.4875	115.8875	141.2875	166.6875	192.0875	217.4875	242.8875
37/64	0.578125	14.6844	40.0844	65.4844	90.8844	116.2844	141.6844	167.0844	192.4844	217.8844	243.2844
19/32	0.59375	15.0812	40.4812	65.8812	91.2812	116.6812	142.0812	167.4812	192.8812	218.2812	243.6812
39/64	0.609375	15.4781	40.8781	66.2781	91.6781	117.0781	142.4781	167.8781	193.2781	218.6781	244.0781
5/8	0.625	15.8750	41.2750	66.6750	92.0750	117.4750	142.8750	168.2750	193.6750	219.0750	244.4750
41/64	0.640625	16.2719	41.6719	67.0719	92.4719	117.8719	143.2719	168.6719	194.0719	219.4719	244.8719
21/32	0.65625	16.6688	42.0688	67.4688	92.8688	118.2688	143.6688	169.0688	194.4688	219.8688	245.2688
43/64	0.671875	17.0656	42.4656	67.8656	93.2656	118.6656	144.0656	169.4656	194.8656	220.2656	245.6656
11/16	0.6875	17.4625	42.8625	68.2625	93.6625	119.0625	144.4625	169.8625	195.2625	220.6625	246.0625
45/64	0.703125	17.8594	43.2594	68.6594	94.0594	119.4594	144.8594	170.2594	195.6594	221.0594	246.4594
23/32	0.71875	18.2562	43.6562	69.0562	94.4562	119.8562	145.2562	170.6562	196.0562	221.4562	246.8562
47/64	0.734375	18.6531	44.0531	69.4531	94.8531	120.2531	145.6531	171.0531	196.4531	221.8531	247.2531
3/4	0.75	19.0500	44.4500	69.8500	95.2500	120.6500	146.0500	171.4500	196.8500	222.2500	247.6500
49/64	0.765625	19.4469	44.8469	70.2469	95.6469	121.0469	146.4469	171.8469	197.2469	222.6469	248.0469
25/32	0.78125	19.8438	45.2438	70.6438	96.0438	121.4438	146.8438	172.2438	197.6438	223.0438	248.4438
51/64	0.796875	20.2406	45.6406	71.0406	96.4406	121.8406	147.2406	172.6406	198.0406	223.4406	248.8406
13/16	0.8125	20.6375	46.0375	71.4375	96.8375	122.2375	147.6375	173.0375	198.4375	223.8375	249.2375
53/64	0.828125	21.0344	46.4344	71.8344	97.2344	122.6344	148.0344	173.4344	198.8344	224.2344	249.6344
27/32	0.84375	21.4312	46.8312	72.2312	97.6312	123.0312	148.4312	173.8312	199.2312	224.6312	250.0312
55/64	0.859375	21.8281	47.2281	72.6281	98.0281	123.4281	148.8281	174.2281	199.6281	225.0281	250.4281
7/8	0.875	22.2250	47.6250	73.0250	98.4250	123.8250	149.2250	174.6250	200.0250	225.4250	250.8250
57/64	0.890625	22.6219	48.0219	73.4219	98.8219	124.2219	149.6219	175.0219	200.4219	225.8219	251.2219
29/32	0.90625	23.0188	48.4188	73.8188	99.2188	124.6188	150.0188	175.4188	200.8188	226.2188	251.6188
59/64	0.921875	23.4156	48.8156	74.2156	99.6156	125.0156	150.4156	175.8156	201.2156	226.6156	252.0156
15/16	0.9375	23.8125	49.2125	74.6125	100.0125	125.4125	150.8125	176.2125	201.6125	227.0125	252.4125
61/64	0.953125	24.2094	49.6094	75.0094	100.4094	125.8094	151.2094	176.6094	202.0094	227.4094	252.8094
31/32	0.96875	24.6062	50.0062	75.4062	100.8062	126.2062	151.6062	177.0062	202.4062	227.8062	253.2062
63/64	0.984375	25.0031	50.4031	75.8031	101.2031	126.6031	152.0031	177.4031	202.8031	228.2031	253.6031

Supplementary table 12 Steel hardness conversion

Rockwell C-scale 1 471.0 N	Vicker's	Brinell		Rockwell		Shore
		Standard ball	Tungsten carbide ball	A-scale 588.4 N	B-scale 980.7 N	
68	940			85.6		97
67	900			85.0		95
66	865			84.5		92
65	832		739	83.9		91
64	800		722	83.4		88
63	772		705	82.8		87
62	746		688	82.3		85
61	720		670	81.8		83
60	697		654	81.2		81
59	674		634	80.7		80
58	653		615	80.1		78
57	633		595	79.6		76
56	613		577	79.0		75
55	595	-	560	78.5		74
54	577	-	543	78.0		72
53	560	-	525	77.4		71
52	544	500	512	76.8		69
51	528	487	496	76.3		68
50	513	475	481	75.9		67
49	498	464	469	75.2		66
48	484	451	455	74.7		64
47	471	442	443	74.1		63
46	458	432	432	73.6		62
45	446		421	73.1		60
44	434		409	72.5		58
43	423		400	72.0		57
42	412		390	71.5		56
41	402		381	70.9		55
40	392		371	70.4	-	54
39	382		362	69.9	-	52
38	372		353	69.4	-	51
37	363		344	68.9	-	50
36	354		336	68.4	(109.0)	49
35	345		327	67.9	(108.5)	48
34	336		319	67.4	(108.0)	47
33	327		311	66.8	(107.5)	46
32	318		301	66.3	(107.0)	44
31	310		294	65.8	(106.0)	43
30	302		286	65.3	(105.5	

Supplementary table 13 Surface roughness comparison

Arithmetical mean deviation of the profile R _a	Maximum height of the profile R _{max}	Ten-point height of irregularities R _z	Roughness grade numbers N
0.013 a	0.05 S	0.05 Z	-
0.025 a	0.1 S	0.1 Z	N 1
0.05 a	0.2 S	0.2 Z	N 2
0.10 a	0.4 S	0.4 Z	N 3
0.20 a	0.8 S	0.8 Z	N 4
0.40 a	1.6 S	1.6 Z	N 5
0.80 a	3.2 S	3.2 Z	N 6
1.6 a	6.3 S	6.3 Z	N 7
3.2 a	12.5 S	12.5 Z	N 8
6.3 a	25 S	25 Z	N 9
12.5 a	50 S	50 Z	N 10
25 a	100 S	100 Z	N 11
50 a	200 S	200 Z	N 12
100 a	400 S	400 Z	-

[Note] Above table is applicable only when processed surface peaks are of equal height.
 Above table is roughly applicable to processed surface for general use.
 Numbers are combined only for convenience in deciding surface roughness.

Supplementary table 14 Viscosity conversion

Kinematic viscosity mm ² /s	Saybolt SUS (second)		Redwood R (second)		Engler E (degree)
	100°F	210°F	50°C	100°C	
2	32.6	32.8	30.8	31.2	1.14
3	36.0	36.3	33.3	33.7	1.22
4	39.1	39.4	35.9	36.5	1.31
5	42.3	42.6	38.5	39.1	1.40
6	45.5	45.8	41.1	41.7	1.48
7	48.7	49.0	43.7	44.3	1.56
8	52.0	52.4	46.3	47.0	1.65
9	55.4	55.8	49.1	50.0	1.75
10	58.8	59.2	52.1	52.9	1.84
11	62.3	62.7	55.1	56.0	1.93
12	65.9	66.4	58.2	59.1	2.02
13	69.6	70.1	61.4	62.3	2.12
14	73.4	73.9	64.7	65.6	2.22
15	77.2	77.7	68.0	69.1	2.32
16	81.1	81.7	71.5	72.6	2.43
17	85.1	85.7	75.0	76.1	2.54
18	89.2	89.8	78.6	79.7	2.64
19	93.3	94.0	82.1	83.6	2.76
20	97.5	98.2	85.8	87.4	2.87
21	102	102	89.5	91.3	2.98
22	106	107	93.3	95.1	3.10
23	110	111	97.1	98.9	3.22
24	115	115	101	103	3.34
25	119	120	105	107	3.46
26	123	124	109	111	3.58
27	128	129	112	115	3.70
28	132	133	116	119	3.82
29	137	138	120	123	3.95
30	141	142	124	127	4.07
31	145	146	128	131	4.20
32	150	150	132	135	4.32
33	154	155	136	139	4.45
34	159	160	140	143	4.57
35	163	164	144	147	4.70
36	168	170	148	151	4.83
37	172	173	153	155	4.96
38	177	178	156	159	5.08
39	181	183	160	164	5.21
40	186	187	164	168	5.34
41	190	192	168	172	5.47
42	195	196	172	176	5.59
43	199	201	176	180	5.72
44	204	205	180	185	5.85
45	208	210	184	189	5.98
46	213	215	188	193	6.11
47	218	219	193	197	6.24
48	222	224	197	202	6.37
49	227	228	201	206	6.50
50	231	233	205	210	6.63
55	254	256	225	231	7.24
60	277	279	245	252	7.90
65	300	302	266	273	8.55
70	323	326	286	294	9.21
75	346	349	306	315	9.89
80	371	373	326	336	10.5
85	394	397	347	357	11.2
90	417	420	367	378	11.8
95	440	443	387	399	12.5
100	464	467	408	420	13.2
120	556	560	490	504	15.8
140	649	653	571	588	18.4
160	742	747	653	672	21.1
180	834	840	734	757	23.7
200	927	933	816	841	26.3
250	1159	1167	1020	1051	32.9
300	1391	1400	1224	1241	39.5

[Remark] 1mm²/s = 1 cSt (centi stokes)