

# Mechanical Properties of Fasteners Made of Carbon Steel and Alloy Steel

Excerpt from JIS B 1051:2000

## Mechanical property for the tensile strength ranking

Mechanical property		Tensile strength ranking											
		3.6	4.6	4.8	5.6	5.8	6.8	8.8 <sup>(1)</sup> d ≤ 16		d > 16 <sup>(3)</sup>	9.8 <sup>(2)</sup>	10.9	12.9
Nominal tensile strength Rm and nom	N/mm <sup>2</sup>	300	400		500		600	800	800	900	1,000	1,200	
Minimum tensile strength Rm and min <sup>(4)</sup>	N/mm <sup>2</sup>	330	400	420	500	520	600	800	830	900	1,040	1,220	
Vickers hardness HV F ≥ 98N	Min.	95	120	130	155	160	190	250	255	290	320	385	
	Max.	220 <sup>(5)</sup>						250	320	335	360	380	435
Brinell hardness HB F = 30D <sup>2</sup> /0.102	Min.	90	114	124	147	152	181	238	242	276	304	366	
	Max.	209 <sup>(5)</sup>						238	304	318	342	361	414
Rockwell hardness	Min.	HRB	52	67	71	79	82	89	–	–	–	–	
		HRC	–	–	–	–	–	–	22	23	28	32	39
	Max.	HRB	95.0 <sup>(5)</sup>						99.5	–	–	–	–
		HRC	–	–	–	–	–	–	32	34	37	39	44
Surface hardness HV0.3	Max.	– <sup>(6)</sup>											
Lower yield point Rel <sup>(7)</sup> N/mm <sup>2</sup>	Nominal Diameter	180	240	320	300	400	480	–	–	–	–	–	
	Min.	190	240	340	300	420	480	–	–	–	–	–	
0.2% durability Rp0.2 <sup>(8)</sup> N/mm <sup>2</sup>	Nominal Diameter	–						640	640	720	900	1,080	
	Min.	–						640	660	720	940	1,100	
Guarantee load stress Sp	Sp/Rel or Sp/Rp0.2	0.94	0.94	0.91	0.93	0.9	0.92	0.91	0.91	0.9	0.88	0.88	
	N/mm <sup>2</sup>	180	225	310	280	380	440	580	600	650	830	970	
Rupture elongation %	Min.	25	22	–	20	–	–	12	12	10	9	8	

Notes: (1) If a bolt of tensile strength ranking 8.8 and d ≤ 16mm is tightened exceeding its guarantee load, the nut thread may be sheared.

(2) Tensile strength ranking 9.8 only applies to those with nominal diameter of thread smaller than 16mm.

(3) Steel structure bolt of tensile strength ranking 8.8 is categorized into nominal diameter of thread 12mm.

(4) The minimum tensile strength only applies to those with nominal length of 2.5 d or above. The minimum hardness applies to those of nominal length below 2.5 d or those that cannot go through the tensile test (e.g. those with special head shape).

(5) Hardness of thread tip surface of bolts, screws and implant bolts shall be 250HV, 238HB or 99.5HRB or below.

(6) The surface hardness of products of tensile strength ranking 8.8 - 12.9 must have no difference from the internal hardness by over 30 points with the Vickers hardness HV0.3.

However, the surface hardness of products of tensile strength ranking 10.9 must not exceed 390HV.

(7) For those that cannot go through the lower yield point Rel measurement, durability Rp0.2 of 0.2% applies. Rel values for the tensile strength ranking 4.8, 5.8 and 6.8 are only for calculation, not for testing.

(8) The yield stress ratio and minimum 0.2% durability Rp0.2 according to the tensile strength ranking indication manners apply to testing with shaved test samples, so obtained values may vary due to differences in manufacturing methods or nominal screw diameter.

## Lower yield point or ratio of durability and tensile strength

Value after decimal point of tensile strength symbol	.6	.8	.9
$\frac{\text{Nominal lower yield point } R_{eL}}{\text{Nominal tensile strength } R_m \text{ and nom}} \times 100\%$ or $\frac{\text{Nominal lower yield point } R_{p0.2}}{\text{Nominal tensile strength } R_m \text{ and nom}} \times 100\%$	60	80	90

## Lower yield point or durability at temperature above normal temperature

Tensile strength ranking	Temperature				
	20°C	100°C	200°C	250°C	300°C
	Lower yield point Rel or 0.2% durability Rp0.2 N/mm <sup>2</sup>				
5.6	300	270	230	215	195
8.8	640	590	540	510	480
10.9	940	875	790	745	705
12.9	1100	1020	925	875	825

The mechanical property of bolts, screws and implant bolts varies as the temperature increases. The left table indicates rough values of lower yield point 0.2% durability at high temperature.

These data may not be used as test requirements.

If high temperature continues, relaxation that must be focused may occur. As a representative case, when 300°C ambient temperature is retained for 100 hours, the initial tightening force is thought to decrease by 25% to lower the yield points.

## Mechanical property of hex socket head cap screw and maximum tightening torque (Tensile strength ranking 10.9 and 12.9 for coarse screws)

Nominal Diameter of Thread	Effective sectional area (mm <sup>2</sup> )	Minimum tensile load (N)		0.2% durability load (N)		Maximum allowed axial force (N)		Maximum tightening torque (N·m)			
		10.9	12.9	10.9	12.9	10.9	12.9	K=0.25		K=0.4	
		10.9	12.9	10.9	12.9	10.9	12.9	10.9	12.9	10.9	12.9
M1.6	1.27	1,320	1,550	1,140	1,370	790	950	0.32	0.38	0.5	0.6
M2	2.07	2,150	2,530	1,860	2,230	1,300	1,560	0.65	0.78	1.0	1.2
M2.5	3.39	3,530	4,140	3,050	3,660	2,130	2,560	1.33	1.6	2.1	2.6
M3	5.03	5,230	6,140	4,520	5,430	3,160	3,800	2.37	2.85	3.8	4.6
M4	8.78	9,130	10,700	7,900	9,480	5,530	6,630	5.53	6.63	8.8	10.6
M5	14.2	14,800	17,300	12,700	15,300	8,930	10,700	11.2	13.3	17.9	21.4
M6	20.1	20,900	24,500	18,000	21,700	12,600	15,200	18.9	22.8	30.2	36.5
M8	36.6	38,100	44,600	32,900	39,500	23,000	27,600	46.0	55.2	73.6	88.2
M10	58	60,300	70,800	52,100	62,600	36,500	43,800	91.3	109	146	175
M12	84.3	87,700	103,000	75,800	91,000	53,000	63,700	159	191	254	305
M14	115	120,000	140,000	103,000	124,000	72,700	87,200	254	305	407	488
M16	157	163,000	192,000	141,000	169,000	98,700	118,000	394	472	631	755
M18	192	200,000	234,000	173,000	207,000	121,000	145,000	544	652	871	1,040
M20	245	255,000	299,000	220,000	264,000	154,000	185,000	770	925	1,230	1,480
M22	303	315,000	370,000	273,000	327,000	191,000	229,000	1,050	1,250	1,680	2,010
M24	353	367,000	431,000	317,000	380,000	222,000	266,000	1,330	1,590	2,130	2,550
M27	459	477,000	560,000	413,000	496,000	289,000	347,000	1,950	2,340	3,120	3,740
M30	561	583,000	684,000	504,000	605,000	353,000	423,000	2,640	3,170	4,230	5,070

Remarks: 1. The minimum tensile load in the above table is according to JIS B 1051:2000.

2. 0.2% durability load = 0.2% durability × Effective sectional area

3. Maximum allowed axial force = 0.7 × 0.2% durability load

4. Maximum tightening torque = Torque coefficient [K] × Maximum allowed axial force × Nominal diameter

5. Torque coefficient: In case of lubricant K=0.25; in case of non-lubricant (plated product, etc.) K=0.4

Minimum tensile strength for 12.9 is 1220N/mm<sup>2</sup>, and 0.2% durability is 1080N/mm<sup>2</sup>

Minimum tensile strength for 10.9 is 1040N/mm<sup>2</sup>, and 0.2% durability is 900N/mm<sup>2</sup>

The torque coefficient varies depending on use conditions. Please use as a reference value.

## Mechanical property of hex socket head cap screw and maximum tightening torque (A2-50 and A2-70 for coarse screws)

Nominal Diameter of Thread	Effective sectional area (mm <sup>2</sup> )	Minimum tensile load (N)		0.2% durability load (N)		Maximum allowed axial force (N)		Maximum tightening torque (N·m)					
		A2-50	A2-70	A2-50	A2-70	A2-50	A2-70	K=0.1		K=0.3		K=0.5	
		A2-50	A2-70	A2-50	A2-70	A2-50	A2-70	A2-50	A2-70	A2-50	A2-70	A2-50	A2-70
M2	2.07	1,030	1,450	430	930	300	650	0.06	0.13	0.18	0.39	0.3	0.7
M2.5	3.39	1,690	2,370	710	1,520	490	1,060	0.12	0.27	0.37	0.80	0.6	1.3
M3	5.03	2,510	3,520	1,050	2,260	730	1,580	0.22	0.47	0.66	1.42	1.1	2.4
M4	8.78	4,380	6,140	1,840	3,940	1,280	2,750	0.51	1.1	1.54	3.30	2.6	5.5
M5	14.2	7,090	9,920	2,970	6,380	2,070	4,460	1.04	2.23	3.11	6.69	5.2	11.2
M6	20.1	10,000	14,000	4,220	9,050	2,950	6,330	1.77	3.8	5.31	11.3	8.9	19
M8	36.6	18,300	25,600	7,680	16,400	5,370	11,500	4.3	9.2	12.8	27.6	21.5	46
M10	58	28,900	40,500	12,100	26,000	8,510	18,200	8.5	18.2	25.5	54.6	42.6	91
M12	84.3	42,100	58,900	17,600	37,900	12,300	26,500	14.7	31.8	44.2	95.4	74	159
M14	115	57,700	80,800	24,200	51,900	16,900	36,300	23.6	50.8	70.9	152	118	254
M16	157	78,300	109,000	32,900	70,500	23,000	49,300	36.8	79	110	236	184	394
M20	245	122,000	171,000	51,400	110,000	35,900	77,100	72	154	215	462	359	771

Remarks: 1. 0.2% durability load = 0.2% durability × Effective sectional area

2. Maximum allowed axial force = 0.7 × 0.2% durability load

3. Maximum tightening torque = Torque coefficient [K] × Maximum allowed axial force × Nominal diameter

4. Torque coefficient: With surface treatment: K=0.1, Without surface treatment: K=0.3, and Clean wash product: K=0.5

Minimum tensile strength of A2 - 70 is 700N/mm<sup>2</sup> and 0.2% durability is 450N/mm<sup>2</sup>

Minimum tensile strength of A2 - 50 is 500N/mm<sup>2</sup> and 0.2% durability is 210N/mm<sup>2</sup>

The torque coefficient varies depending on use conditions. Please use as a reference value.