2

Bolt Tightening

2-1 Various Tightening Methods

2-2 Screw and Torque

2-3 Torque Coefficient

2-4 Method for Determining Tightening Torque

2-5 Tolerance of Tightening Torque

2-6 Tightening of Tension Stability

Torque and Tension

Why tighten screws?

Screw tightening is carried out in order to stop objects from moving (to fix them). Followings are major objectives of the screw tightening.

1. For fixing and jointing objects
2. For transmitting driving force and braking force
3. For sealing drain bolts, gas and liquid

The fixing force at this time is called the axial tension (tightening force), and the target of screw tightening is to “apply an appropriate axial tension.”

Although axial tension control should normally be carried out, because axial tension is difficult to measure, torque control is used for its substitute characteristics that allow tightening administration and operations to be carried out easily.

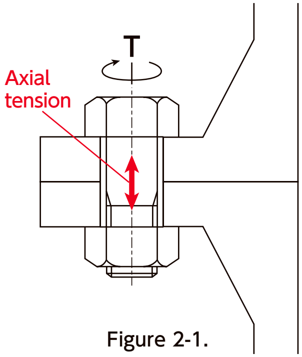


Figure 2-1.

Enhance reliability with combination of fixing, transmitting, preventing leakage and others.

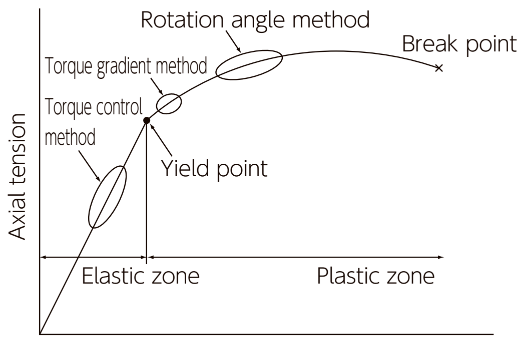
2-1 Various Tightening Methods

Various tightening methods

Table 2-1. Various tightening methods

Tightening method	Description	Advantages and disadvantages
Torque control method	Bolt tightening is controlled by specific torque value. This is the most widely used method.	It is reasonable way for tightening control and operation. Tightening torque is not influenced by the bolt length so easy to standardize. The Bolt efficiency will be low due to wide tolerance of the tension.
Rotation angle method	The tightening is managed by rotting angle which start from the seating point of the bolt head. Tightening is conducted by specific angle from the snug torque.	Tightening within plastic zone gives lower dispersion of axial tension and easy the operation. Since tightening conducts beyond the yield point, there is limitation for additive load to the joint or difficulty for re-tightening. It is difficult to define the tightening angle.
Torque gradient method	The tightening is managed by the variation of the torque gradient against rotating angle at the yield point. The variation is monitored and carried out arithmetic process by an electronic device.	Since the dispersion of the axial tension is small, it is possible to design the bolt efficiency large. Inspection for the bolt itself is possible even after tightening. Tightening is conducted beyond the yield point and the tightening device is expensive, so it is hard to adopt the same method in the service field.
Elongation measurement method	Tightening is controlled by the elongation of the bolt, generated by bolt tightening. Elongation is measured by a micrometer, ultrasonic, or an embedded gauge sensor in a bolt.	The dispersion of the bolt is very small. Tightening within the elastic zone is available. The efficiency of the bolted joint is large. Additive loading and bolt re-tightening are possible. The bolt end faces must be finished. The tightening cost is high.
Loading method	By tightening the nut while tensile load is applied to the bolt, tightening is controlled by the generated tensile force after releasing the load.	Axial tension can be directly controlled. Torsion stress of the bolt is not generated. The tightening device and bolts are specially made. High cost.
Heating method	Tightening is controlled by the variation of the elongation before and after heating the bolt.	Space and force are not required for tightening. There is no clear relation between the heat and axial tension. Temperature setting control is difficult.

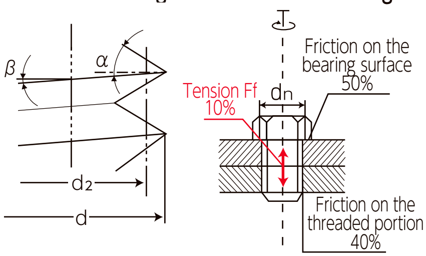
Figure 2-2. Tightening control methods



2-2 Screw and Torque

Relation formula between screw and torque

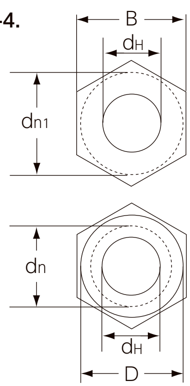
Figure 2-3.
Detail drawing   Relational drawing



T : Torque ········[N·m]
F : Axial tension··· [N]
d_2 : Pitch diameter [mm] (See P.132 Table 8-1)
d_n : Pitch diameter of bearing surface ·················[mm] (See P.132 Table 8-1)
μ : Friction coefficient of threaded portion ················· (See P.36 Table 2-2)
μn : Friction coefficient of bearing potion ··················(See P.36 Table 2-2)
α : Half angle of screw thread · ISO Screw 30°
β : Lead angle [tan β] · (See P.132 Table 8-1)

Formula of pitch diameter of bearing surface (d_{n1}, d_n)

Figure 2-4.



Formula of screw (1)

Reference literature: "Theory and calculation of threaded fasteners" Akira Yamamoto (Yokendo Co., Ltd.)

$$T = Ff\left\{\underbrace{\frac{d_2}{2}\left(\frac{\mu}{\cos\alpha}+\underbrace{\tan\beta}_{\text{Tension Ff}}\right)}_{\text{Friction on the threaded portion}}+\underbrace{\mu_n\frac{d_n}{2}}_{\text{Friction on the bearing surface}}\right\}\div 1000$$

Example: For a M8 bolt at Ft = 8000 [N], the tightening torque is

From P.132 Table 8-1. $d_2 = 7.188$ [mm]
$dn_1 = 11.96$ [mm] (Hexagon nut style)
$\tan\beta = 0.0554$

From P.36 Table 2-2.

$\mu = \mu n = 0.15 \quad \alpha = 30^\circ$

$$T = 8000\{\frac{7.188}{2}(\frac{0.15}{\cos 30^\circ} + 0.0554) + 0.15(\frac{11.96}{2})\} \div 1000$$
$$= 13.8 \ [N\cdot m]$$

a. Hexagon bearing surface (first type nut, bolt)

$$d_{n1} = \frac{0.608B^3 - 0.524d_H^3}{0.866B^2 - 0.785d_H^2}$$

B: Hexagon width across flats [mm] d_H: Bearing surface inside diameter [mm]

b. Round shape bearing surface (second, third type nut)

$$d_n = \frac{2}{3}\cdot\frac{D^3 - d_H^3}{D^2 - d_H^2}$$

D: Bearing surface outside diameter [mm] d_H: Bearing surface inside diameter [mm]

Formula of screw (2)

$$T = K \cdot d \cdot Ff \text{ or } Ff = \frac{T}{K\cdot d}$$

K: Torque coefficient (See P.36 Table 2-2)
d: Nominal size of screw [mm]

Example: Axial tension to tighten a M20 screw to T = 400 [N·m]

d =20 [mm] K = 0.2 (See P.36 Table 2-2)

$$F = \frac{400}{0.2 \times 20 \div 1000} = 100000 \ [N]$$

2-3 Bolt Tightening — Torque Coefficient

(1) Formula of torque coefficient

$$K=\frac{1}{2d}\left[d_2\left(\frac{\mu}{\cos\alpha}+\tan\beta\right)+\mu_n\cdot d_n\right]$$

d is the nominal screw diameter [mm]

(2) Variable Torque Coefficient

Table 2-2. Torque coefficient and friction coefficient

Lubrication	Torque coefficient Min. - Avg. - Max.	Friction coefficient Min. - Avg. - Max.
General machine oil Spindle oil Machine oil Turbine oil Cylinder oil	0.14~0.20~0.26	0.10~0.15~0.20
Low friction oil Double sulfurous molybdenum Wax based oil	0.10~0.15~0.20	0.067~0.10~0.14
Fcon Bolt tension stabilization (See P.482)	0.16~0.18~0.20	0.12~0.135~0.15

Note: The values in this table are for standard screw joints. They are not applicable for special conditions.

$K \approx 1.3\mu + 0.025$

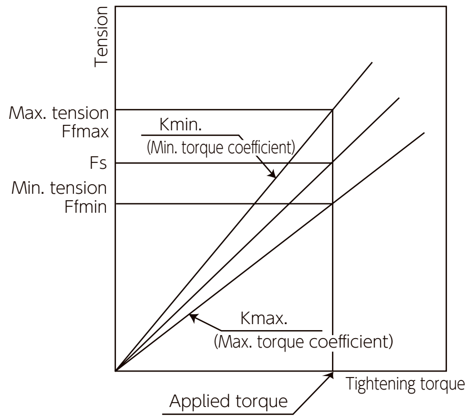
Min. and max. indicate the width of dispersion ($\pm 3\sigma$). The variation width will be smaller if the conditions are limited. (by lubrication oil, shape, etc.)

(3) Fluctuated axial tension with same applied torque

Factors of fluctuated axial tension

- Lubrication
- Machine factors of the bolted Joint
- Environment
- Tightening speed
- Reutilization screw

Figure 2-5. Relation between tightening torque and tightening axial tension



Example: Applying same torque value, how the axial tension varies when the torque coefficient is changed.

F = T / (K.d)

Nominal diameter: d = 10 [mm] = 0.01 [m]
Tightening torque: T = 24 [N·m]
Torque coefficient: Kmin. = 0.14, K = 0.2, Kmax. = 0.26

Kmin. = 0.14

Fmax=24 / (0.14×0.01) =17140 [N]

Kmax. = 0.26

Fmin=24 / (0.26×0.01) =9230 [N]

K = 0.2

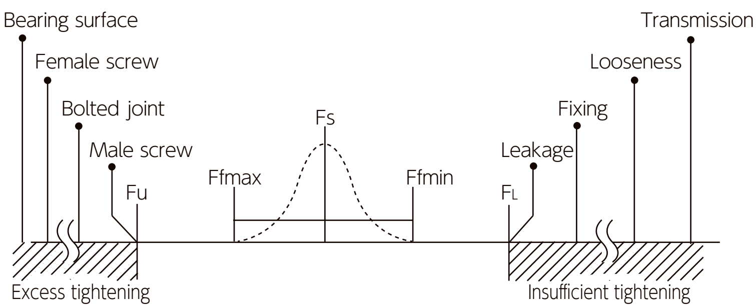
Fs=24 / (0.2×0.01) =12000 [N]

2-4 Bolt Tightening
Method for Determining Tightening Torque

(1) Applying appropriate tightening torque

Male screw strength Female screw strength Strength of bolted joint Bearing surface strength	Fu > Fmax ~ Ffs ~ Ffmin > F_L	Fixing Sealing Transmission Looseness

Figure 2-6. Applying appropriate tightening torque



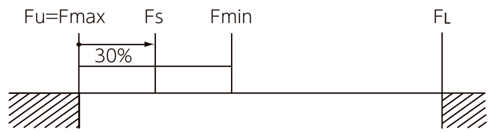
(2) Methods for determining tightening torque

Table 2-3. Methods for determining tightening torque

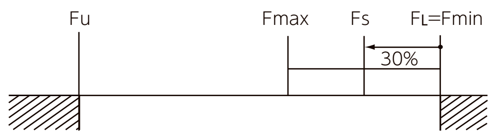
1. Standardization	To establish company standardization of tightening torque. (See P.38 Figure 2-8)
2. Confirmation of the present tightening torque	To establish the present tightening torque and confirm it.
3. Method based on breaking torque (Determination of upper limit)	To adopt 70% of the breaking torque as the tightening torque for screw joints. (Ffmax = Fu)
4. Method based on axial tension (Determination of lower limit)	To adopt 130% of the minimum required tightening torque, the level that prevents loosening, as the tightening torque. (Ffmin = F_L)
5. Method based on axial tension measurement	To specify the tightening torque as the optimal axial tension by measuring with an axial tension meter.

Figure 2-7. Various defective joints

Method based on breaking torque point



Method based on minimum required torque



2-4 Bolt Tightening
Method for Determining Tightening Torque

(3) Standardization of Tightening Torque

Relation between Screw and Torque

Calculation formula

$T = K \cdot d \cdot F$ (JIS B 1083)

$As = \frac{\pi}{4}\left(\frac{d_2+d_3}{2}\right)^2$ (JIS B 1082)

$d_3 = d_1 - \frac{H}{6}$

$H = 0.866025P$

$\sigma = \frac{F}{As}$

T : Tightening torque [N·m]

K : Torque coefficient 0.2 ($\mu \approx 0.15$)

d : Nominal diameter of bolt [mm]

F : Axial tension [N]

As: Stress area of bolt [mm²] (JIS B 1082)

d_2 : Effective diameter of bolt [mm] (JIS B 0205)

d_3 : Value of 1/6 of fundamental triangle height subtracted from root diameter of bolt (d_1) [mm]

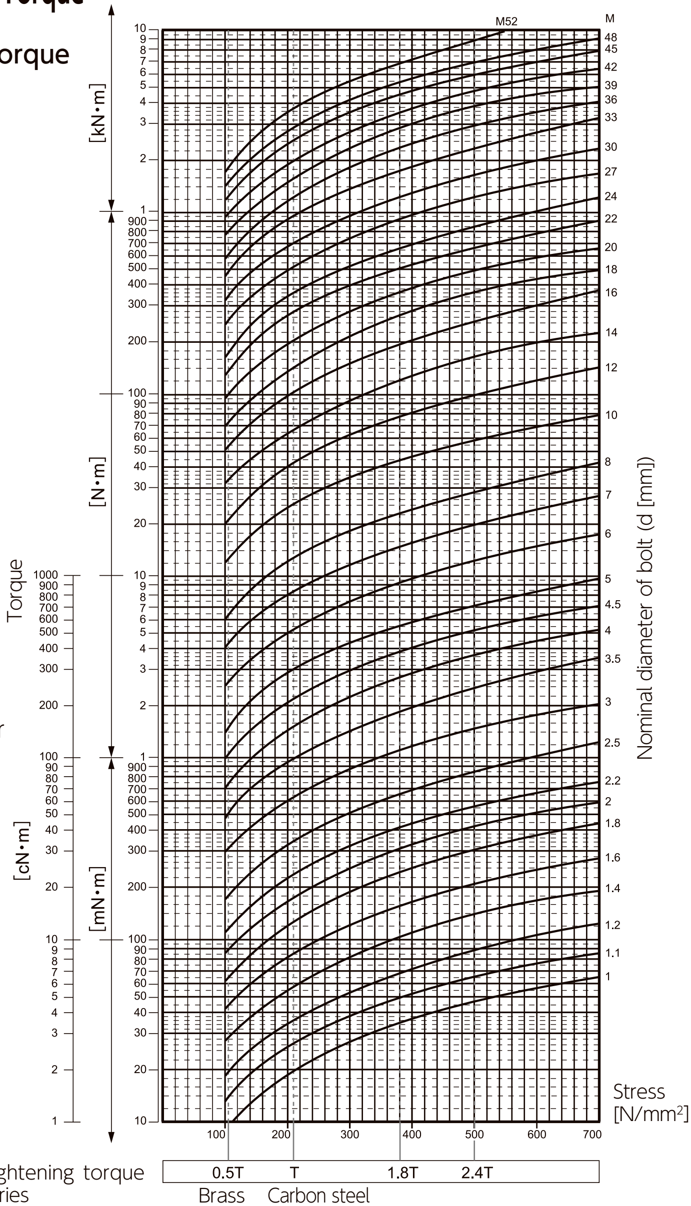
d_1 : Root diameter of bolt [mm] (JIS B 0205)

H : Fundamental triangle height [mm]

P : Pitch [mm]

σ : Tensile stress of bolt [N/mm²]

Figure 2-8. Relation between screw and torque



Standard tightening torque

Table 2-4. Standard tightening torque [N・m] (Reference value)

Nominal diameter	T [N•m]	0.5T series [N•m]	1.8T series [N•m]	2.4T series [N•m]
M1	0.0193	0.00965	0.0347	0.0463
(M1.1)	0.0272	0.0136	0.0490	0.0653
(M1.2)	0.0369	0.0185	0.0664	0.0886
(M1.4)	0.0578	0.0289	0.104	0.139
M1.6	0.0853	0.0427	0.154	0.204
(M1.8)	0.129	0.0645	0.230	0.310
M2	0.174	0.0870	0.310	0.418
(M2.2)	0.229	0.115	0.410	0.550
M2.5	0.356	0.178	0.640	0.854
M3	0.634	0.317	1.14	1.52
(M3.5)	0.997	0.499	1.79	2.39
M4	1.48	0.740	2.66	3.55
(M4.5)	2.14	1.07	3.85	5.14
M5	2.98	1.49	5.36	7.15
M6	5.07	2.55	9.18	12.2
(M7)	8.50	4.25	15.3	20.4
M8	12.3	6.15	22.1	29.5
M10	24.4	12.2	43.9	58.6
M12	42.5	21.3	76.5	102
M14	67.6	33.8	122	162
M16	106	53.0	190	254
(M18)	145	73.0	263	350
M20	206	102	367	490
(M22)	280	140	504	672
M24	356	178	641	854
(M27)	521	261	938	1250
M30	707	354	1270	1700
(M33)	962	481	1730	2310
M36	1240	620	2230	2980
(M39)	1600	800	2880	3840
M42	1980	990	3560	4750
(M45)	2480	1240	4460	5950
M48	2960	1480	5330	7100
(M52)	3840	1920	6910	9220
M56	4780	2390	8600	11500
(M60)	5950	2950	10700	14300
M64	7200	3600	13000	17300
(M68)	8740	4400	15700	21000

Standard bolt stress: 210 [N/mm^2] Stress area of bolt
Round the digit to effective 3 digits.

Table 2-5. Standard tightening torque [kgf・cm] (Reference value)

Nominal diameter	T [kgf•cm]	0.5T series [kgf•cm]	1.8T series [kgf•cm]	2.4T series [kgf•cm]
M1	0.197	0.0984	0.354	0.472
(M1.1)	0.277	0.139	0.500	0.666
(M1.2)	0.376	0.187	0.677	0.903
(M1.4)	0.589	0.293	1.06	1.42
M1.6	0.870	0.435	1.57	2.08
(M1.8)	1.32	0.658	2.37	3.16
M2	1.77	0.887	3.19	4.26
(M2.2)	2.34	1.17	4.20	5.61
M2.5	3.63	1.82	6.53	8.71
M3	6.47	3.23	11.6	15.5
(M3.5)	10.2	5.09	18.3	24.4
M4	15.1	7.55	27.1	36.2
(M4.5)	21.8	10.9	39.3	52.4
M5	30.4	15.2	54.7	72.9
M6	51.7	26.0	93.6	124
(M7)	86.7	43.3	156	208
M8	125	62.7	225	301
M10	249	124	448	598
M12	433	217	780	1040
M14	689	345	1240	1650
M16	1080	540	1940	2590
(M18)	1480	744	2680	3570
M20	2100	1040	3740	5000
(M22)	2860	1430	5140	6850
M24	3630	1820	6540	8710
(M27)	5310	2660	9560	12700
M30	7210	3610	13000	17300
(M33)	9810	4900	17600	23600
M36	12600	6320	22700	30400
(M39)	16300	8160	29400	39200
M42	20200	10100	36300	48400
(M45)	25300	12600	45500	60700
M48	30200	15100	54400	72400
(M52)	39200	19600	70500	94000
M56	48700	24400	87700	117000
(M60)	60700	30100	109000	146000
M64	73400	36700	133000	176000
(M68)	89100	44900	160000	214000

Multiply the table(N・m) on the left by 10.1972 and rounded to effective 3 digits.

Screws and applicable “T” series

Table 2-6. Screws and applicable “T” series

	Standard T series	0.5T series	1.8T series	2.4T series
Applicable screws (Strengths) (Material)	4.6 ～ 6.8 SS, SC, SUS	- Brass, Copper, Aluminum	8.8 ～ 12.9 SCr, SNC, SCM	10.9 ～ 12.9 SCr, SNC, SCM, SNCM
Axial tension standard value [N/mm^2] Min - Max	210 160 ～ 300	105 80 ～ 150	380 290 ～ 540	500 380 ～ 710
Application	To be applied to ordinary screws, unless otherwise specified	Male and female screws with copper, aluminum or plastic, for die-cast plastic products	Durable screw joints made of special steel including those affected by additional dynamic loads (Friction clamping)	
Applicable products	Ordinary products	Electronic products	Vehicles, Engines	Construction products

＊The maximum to the minimum of the axial stress is considered as the dispersion of the torque coefficient.
Example: σ max = 210 × (0.2 ÷ 0.14) = 300 [N/mm^2]
Torque coefficient: 0.14 (minimum)～0.2 (average) ～ 0.26 (maximum)

2-4 Bolt Tightening
Method for Determining Tightening Torque

(4) Standard tightening torque

Table 2-7. Standard tightening torque and bolt axial tension

Nominal diameter	Stress area of bolt [mm²]	T series				0.5T series			
		Std. tightening torque [N•m]	Std. axial tension Fs [N]	Max. axial tension Fmax [N]	Min. axial tension Fmin [N]	Std. tightening torque [N•m]	Std. axial tension Fs [N]	Max. axial tension Fmax [N]	Min. axial tension Fmin [N]
M1	0.460	0.0193	96.5	137	74.2	0.00965	48.3	68.9	37.1
(M1.1)	0.588	0.0272	124	177	95.1	0.0136	61.8	88.3	47.6
(M1.2)	0.732	0.0369	154	220	118	0.0185	77.1	110	59.3
(M1.4)	0.983	0.0578	206	295	159	0.0289	103	147	79.4
M1.6	1.27	0.0853	267	381	205	0.0427	133	191	103
(M1.8)	1.70	0.129	358	512	277	0.0645	179	256	138
M2	2.07	0.174	435	621	335	0.0870	218	311	167
(M2.2)	2.48	0.229	520	744	400	0.115	261	373	201
M2.5	3.39	0.356	712	1020	548	0.178	356	509	274
M3	5.03	0.634	1060	1510	813	0.317	528	755	406
(M3.5)	6.78	0.997	1420	2040	1100	0.499	713	1020	548
M4	8.78	1.48	1850	2640	1430	0.740	925	1320	712
(M4.5)	11.3	2.14	2380	3400	1830	1.07	1190	1700	915
M5	14.2	2.98	2980	4260	2290	1.49	1490	2130	1150
M6	20.1	5.07	4230	6040	3250	2.55	2130	3040	1640
(M7)	28.9	8.50	6070	8670	4670	4.25	3040	4340	2340
M8	36.6	12.3	7690	11000	5910	6.15	3840	5490	2960
M10	58.0	24.4	12200	17400	9390	12.2	6100	8710	4690
M12	84.3	42.5	17700	25300	13600	21.3	8880	12700	6830
M14	115	67.6	24100	34500	18600	33.8	12100	17200	9290
M16	157	106	33100	47300	25500	53.0	16600	23700	12700
(M18)	192	145	40300	57500	31000	73.0	20300	29000	15600
M20	245	206	51500	73600	39600	102	25500	36400	19600
(M22)	303	280	63600	90900	49000	140	31800	45500	24500
M24	353	356	74200	106000	57100	178	37100	53000	28500
(M27)	459	521	96500	138000	74200	261	48300	69000	37200
M30	561	707	118000	168000	90600	354	59000	84300	45400
(M33)	694	962	146000	208000	112000	481	72900	104000	56100
M36	817	1240	172000	246000	132000	620	86100	123000	66200
(M39)	976	1600	205000	293000	158000	800	103000	147000	78900
M42	1120	1980	236000	337000	181000	990	118000	168000	90700
(M45)	1310	2480	276000	394000	212000	1240	138000	197000	106000
M48	1470	2960	308000	440000	237000	1480	154000	220000	119000
(M52)	1760	3840	369000	527000	284000	1920	185000	264000	142000
M56	2030	4780	427000	610000	328000	2390	213000	305000	164000
(M60)	2360	5950	496000	708000	381000	2950	246000	351000	189000
M64	2680	7200	563000	804000	433000	3600	281000	402000	216000
(M68)	3060	8740	643000	918000	494000	4400	324000	462000	249000

Nominal diameter	Stress area of bolt [mm²]	1.8T series				2.4T series			
		Std. tightening torque [N•m]	Std. axial tension Fs [N]	Max. axial tension Fmax [N]	Min. axial tension Fmin [N]	Std. tightening torque [N•m]	Std. axial tension Fs [N]	Max. axial tension Fmax [N]	Min. axial tension Fmin [N]
M1	0.460	0.0347	174	248	134	0.0463	232	331	178
(M1.1)	0.588	0.0490	223	318	171	0.0653	297	424	228
(M1.2)	0.732	0.0664	277	395	213	0.0886	369	527	284
(M1.4)	0.983	0.104	371	531	286	0.139	496	709	382
M1.6	1.27	0.154	481	688	370	0.204	638	911	490
(M1.8)	1.70	0.230	644	921	496	0.310	861	1230	662
M2	2.07	0.310	783	1120	602	0.418	1050	1490	804
(M2.2)	2.48	0.410	936	1340	720	0.550	1250	1790	962
M2.5	3.39	0.640	1280	1830	985	0.854	1710	2440	1310
M3	5.03	1.14	1900	2710	1460	1.52	2530	3620	1950
(M3.5)	6.78	1.79	2560	3650	1970	2.39	3410	4880	2630
M4	8.78	2.66	3330	4750	2560	3.55	4440	6340	3410
(M4.5)	11.3	3.85	4280	6110	3290	5.14	5710	8160	4390
M5	14.2	5.36	5360	7660	4120	7.15	7150	10200	5500
M6	20.1	9.18	7650	10900	5890	12.2	10200	14500	7820
(M7)	28.9	15.3	10900	15600	8410	20.4	14600	20800	11200
M8	36.6	22.1	13800	19700	10600	29.5	18400	26300	14200
M10	58.0	43.9	22000	31400	16900	58.6	29300	41900	22500
M12	84.3	76.5	31900	45500	24500	102	42500	60700	32700
M14	115	122	43600	62200	33500	162	57900	82700	44500
M16	157	190	59400	84800	45700	254	79400	113000	61100
(M18)	192	263	73100	104000	56200	350	97200	139000	74800
M20	245	367	91800	131000	70600	490	123000	175000	94200
(M22)	303	504	115000	164000	88100	672	153000	218000	117000
M24	353	641	134000	191000	103000	854	178000	254000	137000
(M27)	459	938	174000	248000	134000	1250	231000	331000	178000
M30	561	1270	212000	302000	163000	1700	283000	405000	218000
(M33)	694	1730	262000	374000	202000	2310	350000	500000	269000
M36	817	2230	310000	442000	238000	2980	414000	591000	318000
(M39)	976	2880	369000	527000	284000	3840	492000	703000	379000
M42	1120	3560	424000	605000	326000	4750	565000	808000	435000
(M45)	1310	4460	496000	708000	381000	5950	661000	944000	509000
M48	1470	5330	555000	793000	427000	7100	740000	1060000	569000
(M52)	1760	6910	664000	949000	511000	9220	887000	1270000	682000
M56	2030	8600	768000	1100000	591000	11500	1030000	1470000	790000
(M60)	2360	10700	892000	1270000	686000	14300	1190000	1700000	917000
M64	2680	13000	1020000	1450000	781000	17300	1350000	1930000	1040000
(M68)	3060	15700	1150000	1650000	888000	21000	1540000	2210000	1190000

Bolt Tightening

2-5 Tolerance of Tightening Torque

Tolerance of Tightening Torque

For threaded joints, sometimes more definite tightening control is necessary, while at other times relatively rough control is adequate just so that joints will not loosen. The axial tension will be influenced by the dispersion of the torque coefficient and the tolerance of the tightening torque. In order to limit the axial tension dispersion, it will be meaningless simply to limit the tightening torque tolerance without also limiting the torque coefficient dispersion.

Tolerance of tightening torque

Table 2-8.

Class	Tightening torque		Torque coefficient		Axial tension	
	Torque value	Tolerance	Coefficient	Tolerance	Dispersion	Upper/lower limit (Ratio)
Special	Measured value	±5%	Measured value	±15%	±15% 115～85%	0.75
1st class	Measured value	±10%	Measured value	±20%	±20% 120～80%	0.65
2nd class	Standard torque (measured value)	±20%	0.14～0.26※ (0.10～0.20)	±30%	±35% 135～65%	0.50
3rd class	Standard torque	±30%	0.12～0.28※ (0.09～0.20)	±40%	±50% 150～50%	0.35

※( ) Values in brackets are when using disulfide molybdenum or wax as lubrication.

Relation formula of standard deviation

When you require strict bolt management, the following formulas express the relationships using the standard deviation (%) of the dispersion of the tightening torque and the torque coefficient.

Dispersion in axial tension (σn), torque coefficient (σk), and tightening torque (σt) relation

$$\sigma n = \sqrt{\sigma k^2 + \sigma t^2}$$

In order to make σ_n smaller, it is necessary to make σ_k and σ_t smaller, respectively. Since it is easy to manage the tightening torque, $\sigma_k \approx \sigma_t$ will be set if $\sigma_k = 1/3\ \sigma_t$ is approximately controlled.

Example:

$$K = 0.2 \pm 0.06 (3\sigma)$$

$$\sigma K = \frac{0.06}{3 \times 0.2} \times 100(\%) = 10(\%)$$

$$\sigma t = 3\%$$

$$\sigma n = \sqrt{10^2 + 3^2} = 10.4\%$$

$$(3\sigma n = 31.2\%)$$

2-6 Tightening of Tension Stability

Tightening Procedures

Various tightening methods for stabilizing the initial axial tension have been devised.

(1) Zigzag tightening

It is recommended to tighten nuts in a diagonal sequence as shown in the drawing.

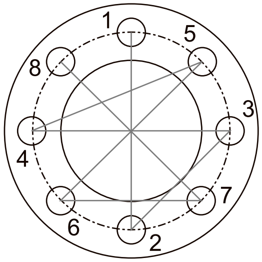


Figure 2-9.

First time…Tighten to around 50% of the specified torque in turns.
Second time…Tighten to around 75% of the specified torque in turns.
Third time…Tighten to 100% of the specified torque in turns.

It is recommended to tighten all the bolts equally, and to avoid applying torque to one or several bolts on one side.

(2) Two steps tightening

The tightening sequence will not follow this drawing if tightening will be done using multiple automatic nutrunners. In the first step the nuts should be tightened provisionally. (50% of the tightening torque)
Next the final tightening should be done with 100% torque. The method consists of tightening in two steps.

(3) Two times tightening

In the case where there will be a delay for axial tension transmission and adequate initial axial tension will not be obtained, such as due to an existing soft part such as packing or rubber in the flap tightened, this is a method of securing initial axial tension by first tightening the nuts with 100% torque and then tightening them once more with 100% torque.

(4) Stabilized tightening

When the bearing will be deformed (including burr and surface roughness) by the tightening, this is a method of preventing initial axial tension drop by tightening the nuts with 100% torque, then loosening them and tightening them once more with 100% torque.