

# [TECHNICAL DATA] PROPER BOLT AXIAL TIGHTENING FORCE / TORQUE

## ■Axial tightening force and fatigue limit when fastening with bolts

- When calculating the suitable axial tightening force for bolt tightening, the maximum force shall be 70% of the standard proof strength using the torque control method, and the force shall be within the elastic range.
- Bolt fatigue strength under repeated load must not exceed the maximum allowable value.
- The bolt and nut seat must not cause any depression in the fastened part.
- Tightening must not cause any damage to the fastened part.

Methods of bolt tightening include the torque control method, torque gradient control method, rotation angle control method, and extension measurement method. The torque control method is most commonly used, due to its simplicity.

## ■Calculation of axial tightening force and tightening torque

The relationship of axial tightening force  $F_f$  is shown by Formula(1).  $k$  : Torque coefficient

$$F_f = 0.7 \times \sigma_y \times A_s \quad \dots \quad (1)$$

$d$  : Bolt nominal diameter [cm]

Tightening torque  $T_{IA}$  is found from Formula (2).

$$T_{IA} = 0.35k(1+1/Q) \times \sigma_y \times A_s \times d \quad \dots \quad (2)$$

$Q$  : Tightening coefficient

$$\sigma_y : \text{Proof strength } (112 \text{ kgf/mm}^2 \text{ for strength class 12.9})$$

$A_s$  : Bolt effective cross-section area [ $\text{mm}^2$ ]

## ■Sample calculation

Find the suitable torque and axial force when using an M6 hexagon socket head cap screw (strength class 12.9) to fasten soft steel to soft steel, and tightening with oil lubrication.

- The suitable torque is found by Formula (2), as shown below.
- Axial force  $F_f$  is found from Formula (1), as shown below.

$$\begin{aligned} T_{IA} &= 0.35k(1+1/Q) \times \sigma_y \times A_s \times d \\ &= 0.35 \cdot 0.17(1+1/4) \cdot 112 \cdot 20.1 \cdot 0.6 \\ &= 138 [\text{kgf} \cdot \text{cm}] \end{aligned}$$

$$\begin{aligned} F_f &= 0.7 \times \sigma_y \times A_s \\ &= 0.7 \times 112 \times 20.1 \\ &= 1576 [\text{kgf}] \end{aligned}$$

## ■Torque coefficient based on the combination of bolt surface treatment, tightened parts, and internal thread material

Bolt Surface treatment Lubrication	Torque coefficient $k$	Combination		
		Tightened part material	Female screw material	
Steel bolt Black oxide coating Not lubricated	0.145	SCM-FC	FC-SUS-FC	(a)
	0.155	S10C-FC	SCM-S10C	(b)
	0.165	SCM-SUS	AL-FC	
	0.175	S10C-S10C	S10C-SCM	
	0.185	SCM-AL	FC-AL	
	0.195	S10C-AL	SUS-AL	
Steel bolt Black oxide coating Not lubricated	0.215	AL-AL		
	0.25	S10C-FC	SCM-FC	
	0.35	S10C-FC	SCM-S10C	
	0.45	S10C-S10C	SCM-S10C	
	0.55	SCM-AL	FC-AL	
	0.55	SCM-AL	AL-AL	

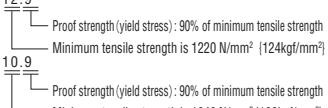
S10C: Non-heattreated soft steel  
SCM: Heat treated steel (35HRc)  
FC: Cast iron (FC200)  
AL: Aluminum  
SUS: Stainless steel (sus304)

## ■Standard value for tightening coefficient Q

Tightening coefficient $Q$	Tightening method	Surface condition		Lubrication
		Bolt	Nut	
1.25	Torque wrench	Manganese phosphate	Untreated or phosphate	Untreated or MoS <sub>2</sub> paste
1.4	Torque wrench			
1.6	Impact wrench	Untreated or phosphate	Untreated	Untreated
1.8	Torque wrench			
10.9	Torque wrench with torque limiter			

Indicating the strength class

Example: 12.9



## ■Initial tightening force and tightening torque

Nominal thread size	Effective cross-section area $A_s$ mm <sup>2</sup>	Strength class					
		12.9		10.9		8.8	
Yield load kgf	Initial tightening force kgf	Tightening torque kgf · cm	Yield load kgf	Initial tightening force kgf	Tightening torque kgf · cm	Yield load kgf	Initial tightening force kgf
M 3×0.5	5.03	563	394	17	482	338	15
M 4×0.7	8.78	983	688	40	842	589	34
M 5×0.8	14.2	1590	1113	81	1362	953	69
M 6×1	20.1	2251	1576	138	1928	1349	118
M 8×1.25	36.6	4099	2869	334	3510	2457	286
M10×1.5	58	6496	4547	663	5562	3894	567
M12×1.75	84.3	9442	6609	1160	8084	5659	990
M14×2	115	12880	9016	1840	11029	7720	1580
M16×2	157	17584	12039	2870	15056	10539	2460
M18×2.5	192	21504	15053	3950	18413	12889	3380
M20×2.5	245	27440	19208	5600	23496	16447	4790
M22×2.5	303	33936	23755	7620	29058	20340	6520
M24×3	353	39536	27675	9680	33853	23697	8290

Note: • Tightening condition: Tightened by torque wrench. (Surface oil lubrication) Torque coefficient  $k=0.17$  Tightening coefficient  $Q=1.4$ )

• Because the torque coefficient varies depending on the conditions of use, use this table only as an approximate guide.

• This table consists of edited excerpts from the Catalog of Kyokuto MFG Co Ltd.