Stainless Steel Bolt and Machine Screw Torque Reference

To construct a securely assembled joint using bolts or machine screws, the fasteners must be tightened to develop the proper amount of clamping force. Therefore, using the correct installation torque is imperative. For carbon steel fasteners, installation torques can be easily calculated using a common torque/fastener tension equation,

Torque = Nut Factor x Thread Diameter x Clamp Load

where the nut factor, also called torque coefficient or friction factor, is based on the surface finish of the fastener; and the clamp load is a function of the material's elastic stress/strain behavior and yield strength. For carbon steel the stress versus strain relationship remains linear and repeatable from A to B with a clearly measurable yield point at C, ***Figure 1***. However, stainless steel fasteners undergo changes in surface friction during installation, the materials' stress/strain is curved and inelastic, and yield points are undefinable. Thus, the standard torque equation is not suitable and potential fastener reusability affected.

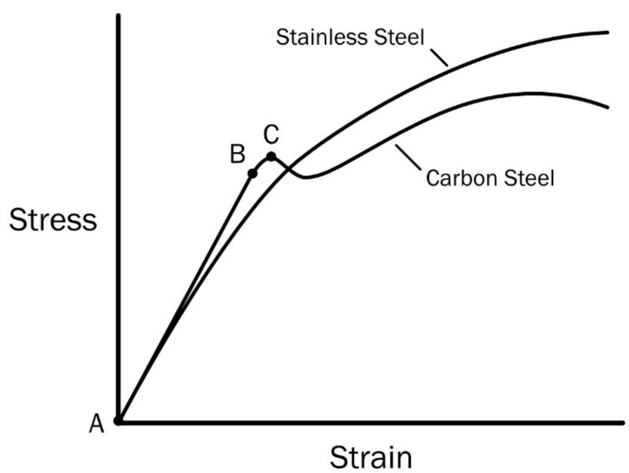

Figure 1

Two methods described herein are industry-recommended for determining torques accurate enough for most applications without performing sophisticated calculations or requiring complicated and expensive torque/tension measuring equipment.

EMPIRICAL SOURCES

The values shown in ***Table 1*** and ***Table 2*** are publicly available and described as being derived through independent testing. They may provide a suitable basis for preliminary installation torques.

Table 1

INCH	Thread Size	18-8 Stainless Steel Torque (in-lbs)		316 Stainless Steel Torque (in-lbs)	
		Dry	Lubricated	Dry	Lubricated
	2-56	2.5	2.3	2.6	2.3
	4-40	5.2	4.7	5.5	5.0
	6-32	9.6	8.6	10.1	9.1
	8-32	19.8	17.8	20.7	18.6
	10-24	22.8	20.5	23.8	21.4
	10-32	31.7	28.5	33.1	29.8
	1/4-20	75.2	67.6	78.8	70.9
	5/16-18	132	119	138	124
	3/8-16	236	212	247	222

Values are suggested maximum installation torques based on publicly available testing results. Data is not endorsed, nor was witnessed, by PENCOM. Source: Fastenal Engineering & Design Support, 2023.

Table 2

METRIC	Thread Size	A2 or A4 Stainless Steel Torque (N-m)	
		Dry	Lubricated
	M3 x 0.5	1.0	0.9
	M4 x 0.7	2.6	2.3
	M5 x 0.8	5.1	4.6
	M6 x 1	8.7	7.8
	M8 x 1.25	21	19
	M10 x 1.5	42	38

Values are suggested maximum installation torques based on publicly available testing results. Data is not endorsed, nor was witnessed, by PENCOM. Source: Fastenal Engineering & Design Support, 2023.

In some applications non-metallic elements are added to screw threads to produce frictional resistance that prevents or reduces loosening due to vibration, *Figure 2*. The amount of torque required to overcome the resistance of the frictional element is known as prevailing torque, ***Table 3,*** and should be added to the installation torques in the preceding tables if used.

Figure 2

Table 3

Thread Size	Prevailing Torque
2-56	9.0 in-oz
4-40	1.5 in-lbs
6-32	3.0 in-lbs
8-32	4.0 in-lbs
10-32	6.0 in-lbs
1/4-20	12.0 in-lbs
5/16-18	24.0 in-lbs
3/8-16	32.0 in-lbs

Source: Long-Lok-Fasteners.

APPLICATION TESTING

A more accurate method of determining installation torque for stainless steel bolts and machine screws is to perform a torque-to-failure test using the actual application conditions. The recommended steps are,

1. Construct at least 10 assemblies of the application joint.
2. Using a calibrated torque wrench, tighten the bolts or machine screws until failure and record the maximum torque achieved in each failure.
3. Calculate the average torque from the tests.
4. Multiply the average torque by .5 to obtain the tightening torque for that particular joint. There will be some variation during actual assembly so applying a tolerance to the installation torque spec is recommended. A ±10-20% range is common and depends on the accuracy of the operators, equipment, installation rpm and torque magnitude.

REUSABILITY

In general as long as a carbon steel bolt or machine screw has not been torqued beyond the material's yield strength, it can be considered for re-use on non-critical joints or applications. However testing has shown that with successive re-installations, more torque may be required to achieve similar clamp loads (Source: Fastenal Engineering, 2023). Stainless steel is prone to adhesive wear called galling where friction between surfaces causes microscopic loosening and transfer of material particles. Therefore, reusability of stainless steel fasteners may have additional limitations and/or require special considerations beyond that of carbon steel fasteners, and should be well evaluated in advance of re-use. For more information on stainless steel galling see PENCOM technical bulletin "Galling of Stainless Steel Fasteners".

Using the correct installation torque is critical for achieving a properly fastened joint with bolt or machine screws. As explained, a common torque calculation can be used for carbon steel fasteners. However due to differences in material behavior, this calculation is not suitable for stainless steel threaded fasteners. Two alternative methods were presented that may provide suitable installation torques. Additionally, stainless steel fasteners have unique material properties and undergo changes in surface friction during installation. Therefore, they may not be not suitable for re-use without appropriate precautions.

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