



Assembly of screwed fastenings

**Table 1: Accuracy classes of the tightening methods
 Influence of the friction ratios, spread of the preloads**

Accuracy class	Spread of the preload %	Tightening factor	Influence of the friction coefficient?	Tightening method (tools)	Adjustment/Inspection method
–	± 2 to +10 ± 5 to ±20	1.05 to 1.2 1.1 to 1.5	no	<ul style="list-style-type: none"> elongation-controlled (ultrasound) elongation measurement (mechanical) 	Ultrasound sensor (→ PMT system) Setup and length measurement
I	± 9 to ±17	1.2 to 1.4	no	<ul style="list-style-type: none"> yield-controlled angle-controlled (power-assisted or manually) 	Empirical specification of pre-tightening torque/rotation angle
II	± 9 to ±23	1.2 – 1.6	no	<ul style="list-style-type: none"> hydraulic tightening 	Length/pressure measurement
III	± 17 to ±23	1.4 – 1.6	yes	<ul style="list-style-type: none"> torque-controlled (torque wrench, extension measurement, precision screwdriver) 	Empirical specification of the reference tightening torque/dynamic torque measurement
IV	± 23 to ±33	1.6 – 2.0	yes	<ul style="list-style-type: none"> torque-controlled 	Reference tightening torque according to estimated friction coefficient
V	± 26 to ±43	1.7 – 2.5	yes	<ul style="list-style-type: none"> torque-controlled (screwdriver) impulse-controlled (impact wrench) 	with post-tightening torque, taken from reference tightening torque (according to estimated friction coefficient) + extra
VI	± 43 to ±60	2.5 – 4.0	yes	<ul style="list-style-type: none"> impulse-controlled (impact wrench) manually (wrench) 	without (via post-tightening torque if necessary)

Table 2: Friction coefficients μ_{total} for steel screws/nuts*

Surface condition		μ_{total} for condition		
Male thread (screw)	Internal thread (nut/component)	non-lubricated	oiled	MoS _{2p} lubricated
without coating (black)	without coating	0.12 – 0.18	0.10 – 0.17	0.06 – 0.12
Mn-phosphated		0.14 – 0.18	0.14 – 0.15	0.06 – 0.11
Zn-phosphated		0.14 – 0.21	0.14 – 0.17	0.06 – 0.12
zinc plated		0.12 – 0.20	0.10 – 0.18	Attention! The friction coefficient can considerably differ depending on the type/extent of the lubrication! Protection with screw connect test recommended!
cadmium plated		0.08 – 0.14	0.08 – 0.11	
zinc plated	zinc plated	0.12 – 0.20	0.10 – 0.18	
cadmium plated	cadmium plated	0.12 – 0.16	0.12 – 0.14	

Table 3: Friction coefficients μ_a and μ_k for screws/nuts* from stainless steel

Screw/bolt and material of screwed part	nut material	lubricants		Resilience of the joint	Friction coefficients	
		in the thread	under the head		in the thread μ_a	under the head μ_k
A2 (~ A4)	A2 (~ A4)	without	without	very big	0.26 – 0.50	0.35 – 0.50
		Special lubricating agent (chlorine-paraffin basis)			0.12 – 0.23	0.08 – 0.12
		Corrosion protection grease			0.26 – 0.45	0.25 – 0.35
		without	without	small	0.23 – 0.35	0.08 – 0.12
	Special lubricating agent (chlorine-paraffin basis)		0.10 – 0.16		0.08 – 0.12	
	AlMgSi	AlMgSi	without		very big	0.32 – 0.43
Special lubricating agent (chlorine-paraffin basis)			0.32 – 0.43	0.08 – 0.11		
			0.28 – 0.35	0.08 – 0.11		

* Typical values according to VDI 2230-1, issue 07.86, tab. 5–6 for screws/nuts with standard contact surfaces, e.g. according to DIN 912, 931, 933, 934 / ISO 4762, 4014, 4017, 4032