

Table A8. Guide values for the tightening factor α_A

Tightening factor α_A	**Scatter** $\frac{\Delta F_M}{2 \cdot F_{Mm}} = \frac{\alpha_A - 1}{\alpha_A + 1}$	**Tightening method**	**Setting method**	**Comments**
1,1 to 1,2	±5 % to ±9 %	tightening with elongation control or monitoring by ultrasound	sound travel time	• calibration values required • when $l_K/d < 2$ progressive increase in error to be taken into account • smaller error with direct mechanical coupling, larger with indirect coupling
1,1 to 1,3	±5 % to ±13 %	mechanical elongation by means of pressure screws located in the nut or the bolt head	prespecified elongation of the bolt, setting via forcing torque of the pressure screws	• hardened washer for supporting the pressure screws • from approx. M24
1,2 to 1,5	±9 % to ±20 %	mechanical elongation by means of multipartite nuts with threaded bushing	torque of the tightening tool	• largely torsion-free tightening • from approx. M30
1,1 to 1,5	±5 % to ±20 %	tightening with mechanical elongation measurement or monitoring	direct method: setting via elongation measurement indirect method: axial play at monitoring pin used up	• required: precise determination of the proportional axial elastic resiliences of the bolt • The scatter depends to a considerable extent on the accuracy of the measurement method. • For low values calibration is necessary. • when $l_K/d < 2$ progressive increase in error to be taken into account
1,1 to 1,4	±5 % to ±17 %	hydraulic frictionless and torsion-free tightening	setting via pressure or length measurement or further rotation angle of the nut	• when $l_K/d \geq 5$ lower values achievable, with mechanically machined bolts and plates $\alpha_A = 1{,}05$ is possible • with standard bolts and nuts $\alpha_A \geq 1{,}2$ • Smaller clamping length values result in higher α_A values. • Recovery losses occur which are not taken into account in the tightening factor. • application from M20 upwards
1,2 to 2,0	±9 % to ±33 %	impulse driver with hydraulic impulse generator, torque- and/or rotation-angle-controlled	setting via angle of rotation or further torque	• small values only in the case of presetting to the bolting case via rotation angle, compressed air servo valve and impulse counting • In special cases even assembly up to the yield strength point is possible.
1,2 to 1,4	±9 % to ±17 %	yield-point controlled tightening, motorized or manual	presetting of the relative torque-rotation angle coefficient	The preload scatter is determined to a considerable extent by the scatter of the yield point in the installed bolt batch. Here the bolts are dimensioned for F_{Mmin}; a design of the bolts for F_{Mmax} with the tightening factor α_A does not therefore apply with these tightening methods.
1,2 to 1,4	±9 % to ±17 %	rotation-angle controlled tightening, motorized or manual	experimental determination of preliminary tightening moment and rotation angle (stages)	
1,4 to 1,6	±17 % to ±23 %	torque-controlled gradual tightening with hydraulic tool	setting via pressure measurement	from approx. M30

Table A8. Guide values for the tightening factor α_A (continued)

Tightening factor α_A	**Scatter** $\frac{\Delta F_M}{2 \cdot F_{Mm}} = \frac{\alpha_A - 1}{\alpha_A + 1}$	**Tightening method**	**Setting method**	**Comments**	
1,4 to 1,6	±17 % to ±23 %	torque-controlled tightening with torque wrench, signalling wrench or motorized nut-runner with dynamic torque measurement	experimental determination of the setpoint torques at the original joint member, for example, by elongation measurement of the bolt	low values: large number of setting or monitoring attempts required (20, for example); low scatter of the output moment (for example, ±5 %) required	low values for: • small rotation angles, in other words, relatively stiff joints • relatively low hardness of the countersurface[a)] • countersurfaces which do not have a “galling” tendency, for example, phosphated or adequately lubricated
1,6 to 2,0 (coefficient of friction class B) 1,7 to 2,5 (coefficient of friction class A)	±23 % to ±33 % ±26 % to ±43 %	torque-controlled tightening with torque wrench, signalling wrench or motorized nut-runner with dynamic torque measurement	determination of the setpoint tightening moment by estimating the coefficient of friction (surface and lubrication conditions are a great influence)	low values for: measuring torque wrenches with even tightening and for precision nut-runners high values for: signalling or buckling torque wrenches	high values for: • large rotation angle, in other words, relatively resilient joints as well as fine thread • great hardness of the countersurface, combined with a rough surface
2,5 to 4	±43 % to ±60 %	tightening with impact wrench, “stalling driver” or impulse driver; tightening by hand	setting the driver via retightening moment, which is formed from the required tightening moment (for the estimated coefficient of friction) plus a supplement; manual tightening based on subjective assessment	low values for: • large number of setting attempts (retightening moment) • on horizontal branch of the driver characteristic • backlash-free impulse transmission method only suitable for preliminary tightening, in the case of tightening by hand risk of overstretching with M10 and smaller	

[a)] countersurface: clamped joint member whose surface is in contact with the tightening element of the joint (bolt head or nut)

Note: Smaller tightening factors are possible in the specific case. They call for more effort in the setting process, a higher quality of the tool and/or the fasteners and components.