

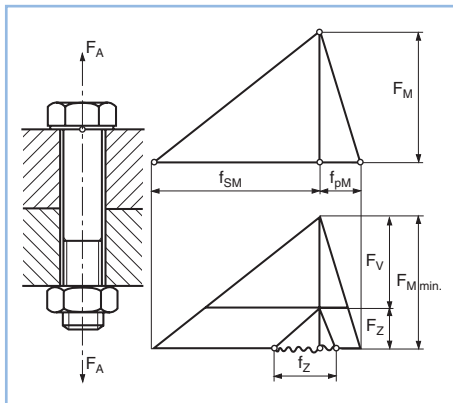
Securely fastened joints

Summary of constructive measures for locking screw joints

In principle, there are two reasons why bolted connections may need locking

Loosening due to seating

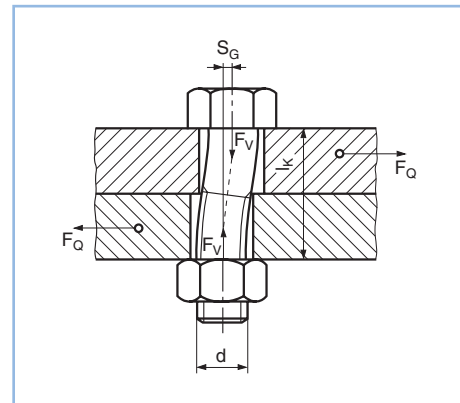
Loosening of bolted joints results in preload loss. This loss is caused by seating of the joint members or by a permanent elongation of the screw after tightening or under the operation force F_A .



- F_M = assembly preload
- f_{SM} = elongation of screw through F_M
- f_{PM} = shortening of compressed parts through F_M
- F_V = final preload
- F_Z = loss of preload due to seating
- f_Z = amount of seating
- F_A = operation force
- $F_{Mmin} = F_V + F_Z$

Rotational loosening

Dynamic shear forces F_Q acting upon the bolted joint can cause the joint members to slip back and forth. This will prompt screws and nuts to rotate, this reducing the preload until it is zero.



- F_V = preload
- F_Q = shear force
- l_K = clamping length
- S_G = displacement of clamped parts
- d = nominal diameter

The following locking methods are possible:
Locking against loosening due to seating

Measures	Effect achieved
Clean, smooth joint interfaces minimum number of interfaces No soft, plastically deformable joint members	Reduction of seating possibilities
Long screws ($l_K \geq 5 \cdot d$) Screws with reduced shank Spring washers	High elasticity, compensation of preload loss
Fasteners with flange	A larger bearing surface prevents the permitted limiting value of surface pressure from being exceeded Larger tolerance for hole-Ø
Special washers with 200 HV hardness	The same advantages as above Use up to property class 8.8

The following locking methods are possible:
Locking against rotational loosening

Measures	Effect achieved
Bigger screws-Ø Higher property classes	Lateral movement of the joint member can be prevented by a higher preload
Shoulder screws Parallel or dowel pins	No possibility for lateral movements
Long screws ($l_K \geq 5 \cdot d$) Screws with reduced shank	Flexible joint Better fatigue resistance
Ribbed screws or ribbed washers	Rolling effect leads to compression of the surface with the embedding of the grooves

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Overview of effectiveness for bolted joint locking solutions and solutions for prevention of loss

Note

The following elements are designed to prevent loosening, rotations loosening and loss (complete separation of bolt and nut). The effectiveness levels are based on typical industrial applications.

Conditions may vary so the user should make its own tests to check the suitability of the locking element in his / her application.

Locking feature / Locking element	Locking against Loosening up to										Loss	Notes
						Rotational loosening up to						
	div.	5.6	8.8	10.9	12.9	div.	5.6	8.8	10.9	12.9		
Screws and nuts w/ corrugated bearing area (VERBUS RIPP®)				○					●			Increased breakaway torque, because of corrugated bearing area
Screws and nuts with serrated bearing area (VERBUS TENSILOCK®)								●				Serrated bearing area prevents rotational loosening
Screws with serrated flange (ecosyn®-grip)			○					●				Increased breakaway torque, because of corrugated bearing area
Screws with integrated spring washers (ecosyn®-fix)		●					●					Increased breakaway torque, because of concave flange
Precote® type 30/80/85, Scotch-Grip® 2353, Loctite®, DELO®, Three Bond®						●	●	●	●	●	●	Chemical safety agents neutralise the play in the thread and seal it off
Screws with Tuflok® polyamide coating											●	Locking against separating of bolt and nut – max. temp. 120 °C
Thread-forming screws for metals DIN 7500 (ecosyn®-IMX)	●					●					●	Total security through, play-free thread fitting
Screws for thread forming into plastics ecosyn®-plast, PT® and DELTA PT®	●					●					●	Total security through, play-free thread fitting
Hex nuts with rotating captive washer (ecosyn® SEF)			●					●			●	Operationally safe contact screw connection combines a self-locking nut Spiralock® with an integrated captive conical spring washer and flat washer
Prevailing torque type hex lock nuts with clamping part – all-metal (ISO 7042, DIN 980, etc.) and non-metallic insert (DIN 982, DIN 985, DIN 6924, DIN 6926, etc.)								●			●	Loss prevention with polyamide insert up to max. 120 °C.; Loss prevention through metallic clamping principle for more demanding applications
Sealing lock nuts (Seal-Lok®) etc.											●	Sealing and protection against loss with polyamide locking element, max. 120 °C
DIN 935 castle nuts etc.						●	●	●			●	Cotter pin prevents loss, limited loosening is possible
Hexagon nuts with attached spring washer (BN 80175, BN 1365)			●									Attached lock washer compensates for seating
Hexagon nuts with toothed lock washer (BN 1364)								○				Increased loosening torque due to integrated, rotatable toothed lock washer
Flange nuts/flange screws (EN1661/EN1662/EN1665)			○					○				Increased bearing area reduces surface pressure, increased effective diameter reduces rotational loosening
Spring lock washers DIN 127/128/7980 etc.		●					○					Slight increase of breakaway torque through its spring action
Toothed and serrated lock washers DIN 6798/6797 etc.							●					Increased breakaway torque on soft surfaces
Rip-Lock™ Ribbed spring washers			●	○				●	○			Ribbed universal spring washer, increased loosening torque with unhardened components
Ribbed lock washers (doubled-sided ribbed)			○					●	○			Springy doubled sided ribbed lock washer, increases breakaway torque on unhardened material
Ribbed lock washers SCHNORR VS									●			
Conical spring lock washers DIN 6796 etc.			●	●								Spring washer with high spring force
NORD-LOCK® washers Bolt securing system								●	●	●		The NORD-LOCK® bolt securing system uses the different angle ratios between wedge surfaces and bolt threads for the effective securing of bolted joints in critical applications, which prevents loosening caused by vibration and dynamic load.

Locking effect: ● very good ● good ○ fair

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Screws which should be locked

Grip length L_k Thread- $\varnothing d$	Loading			
	static in the direction of the axis	transverse to the axis	dynamic in the direction of the axis	transverse to the axis
short $L_k < 2 d$	no locking necessary	clarify locking effect	clarify locking effect	Locking required
medium $5 d > L_k \geq 2 d$	no locking necessary	no locking necessary	depends on the conditions clarify locking effect	Locking required
long $L_k \geq 5 d$	no locking necessary	no locking necessary	no locking necessary	depends on the conditions clarify locking effect