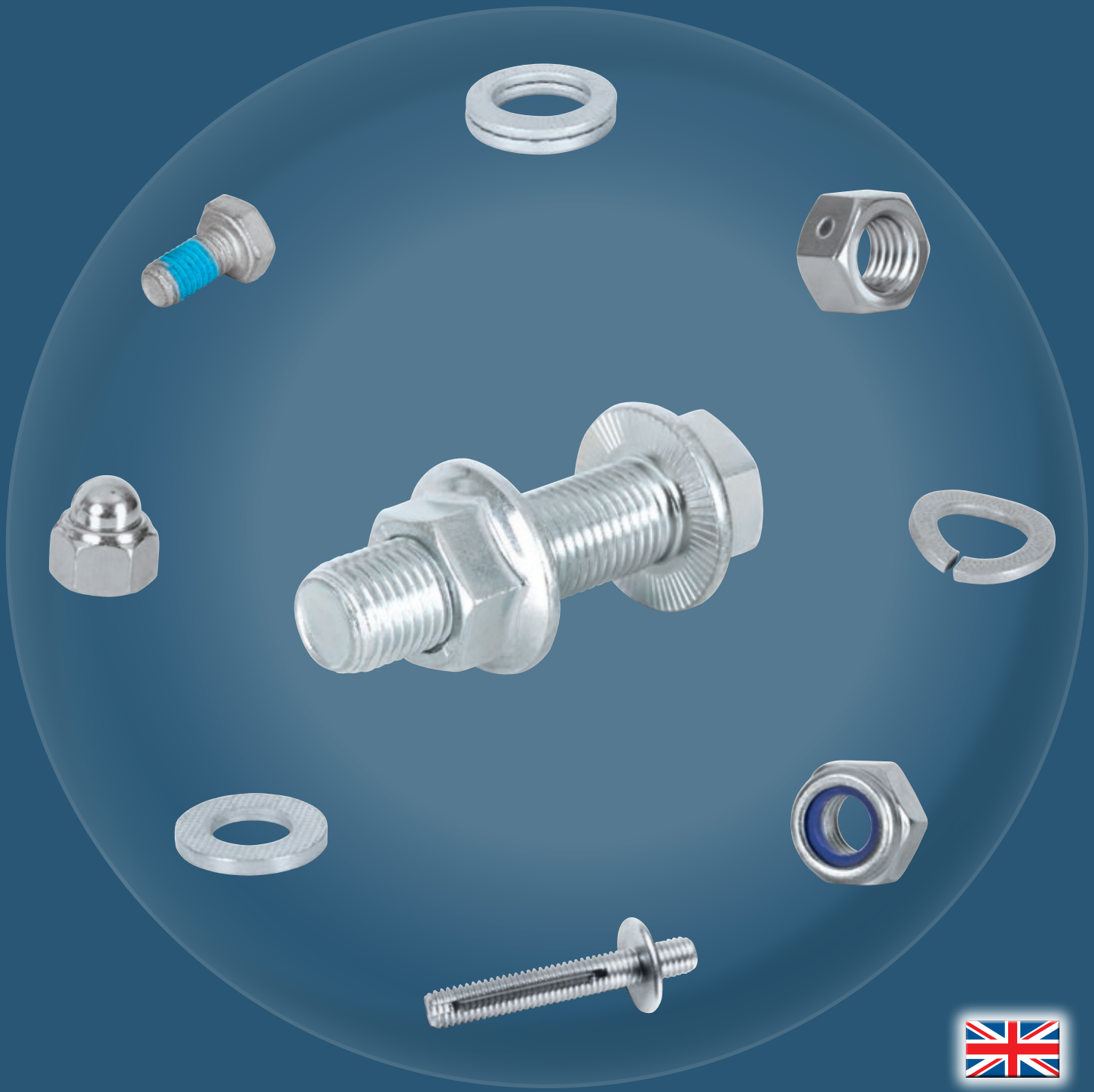
REYHER®

LOCKING OF BOLTED JOINTS



Locking of bolted joints

How can bolted joints be locked? This question is asked regularly in everyday construction and assembly. Through the years many products that meet the requirements as locking devices have been established. Continuing product developments ensure availability of a wide range of possibilities to lock bolted joints.

A bolted joint should be designed in a way, that the preload force remains constant under operational conditions. Depending on the locking devices used considerable loss of preloads cannot always be prevented, but a complete failure of the bolted joint can be avoided. According to the type of requirements and the type of constructional design the danger that the connection will loosen itself is present. The loads are subdivided into static and dynamic loads. Due to this it is advisable to use different safety methods for various objectives.

REYHER can provide suitable solutions to meet all requirements. This includes both standard and non-standard items from stock, or customer-specific items sourced by REYHER on request.

Our experienced engineers and technicians are ready to advise on the right solution for you with their comprehensive specialist knowledge: our dedicated REM – REYHER Engineering Management.

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REM® REYHER ENGINEERING MANAGEMENT

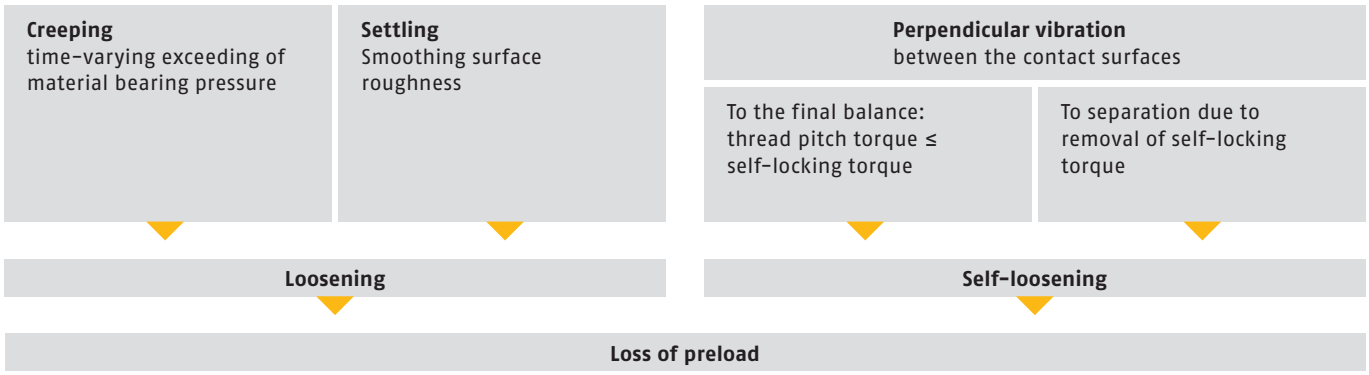
Help for selecting the correct locking fasteners

Design objectives	Locking devices
Multiple use	Form-fitting locking devices
Defined/constant friction co-efficients	Wedge lock washers, adhesive locking
Low assembly costs	Flange screws and nuts with locking serrations/ribs, adhesive locking
Readjustability of the fastenings	Form-fitting locking devices
Assembly conditions	If oil and grease can't be removed from mating threads, form-fitting locks are advisable
Temperature	Adhesive locking can, according to the product, be used for a maximum load of between 110 and 200 °C – see overview on page 13. Otherwise metal locking devices that create form or friction are advisable.

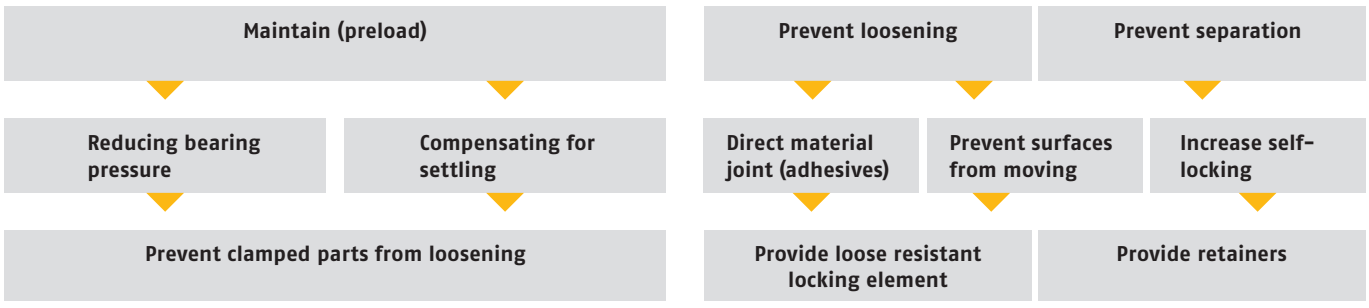
Locking of bolted joints

Presentation of the relationships of self-loosening

Self-loosening mechanism



Actions



Source: DIN 25201-4

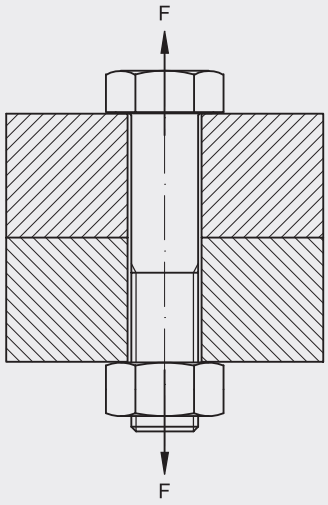
Contents

Loosening and locking of a bolted joint with static loads

■ Risks

Static loads in an axial direction caused by assembly forces and/or initial operating loads can lead to settling phenomena. Under certain circumstances this can lead to complete loss of preload in the bolted joint.

Settling phenomena are not only dependent on forces but also on the number of parting joints in the stressed components and the surface coatings of the joint material, for example roughness or layers of paint. Also limited component stability can lead to settling phenomena, which can be caused by creeping in weaker materials.



Static load

■ Actions

Use of spring type locking washers or suitable design actions can counteract preload loss. To keep settling losses in a bolted joint as low as possible, minimise the number of parting joints between the components.

Every unnecessary flat washer creates an extra parting joint. Also use of 'soft' washers in accordance with DIN 125, with hardness of 140 HV, should be avoided in a high-strength bolted joint with screws in the property class ≥ 8.8.

By the choice of a larger clamping length of the screw, for example use of expansion sleeves, the preload loss can be counteracted with greater elasticity. The same effect can be achieved with expansion bolts and screws with fully threaded shafts or higher preloads using screws of a higher property class.

If these actions cannot be used, settling can be compensated with a conical spring washer in accordance with DIN 6796. It should be noted that the component under the conical spring washer should have a suitably higher hardness, does not flow when stressed and the conical spring washer does not damage the surface.

■ Ineffective products

Withdrawn standards:

- Spring lock washers in accordance with DIN 127 and DIN 128
- Spring washers in accordance with DIN 137

Even when using screws in property class 5.6 and smaller, as stated within the scope of the product standards, these products will only be 'squashed flat' and cannot compensate the settling rate.

Using austenitic stainless steels

Austenitic steels of the steel types A 1 to A 5 have no spring-hard properties. This is why locking elements of these steel types cannot compensate settling with a spring effect. Alternatives are 1.4310 and 1.4568 steels.

Compared to steel types A 1 to A 5 they have limited spring properties, which do not meet the requirements of spring steel. Therefore, locking devices from these stainless steels can only partially meet the spring properties of steel products.

Actions against loosening

Action	Effective action	
	Settling	Creeping
Create connections with high resilience ratio	yes	yes
Reduce surface pressure by increasing contact surface areas	–	yes
Reduce number of parting joints	yes	TBD
Use screws with higher hardness to increase the tension (preload)	yes	no
Increase clamping length	yes	no
Use spring fasteners, but under the following conditions: ▶ The effective spring force of the element is suitable for the required preload of the bolted joint ▶ The part inserted does not cause risk of additional settling ▶ The elasticity of the fasteners remain during the whole lifetime of the connection	yes*	no
Reduced the roughness	yes	no
Appropriate form and position tolerances chosen	yes	yes
Avoidance of thick coatings	yes	no

*Only to equalise surface roughness.

Source: DIN 25201-4

Spring type locking washers

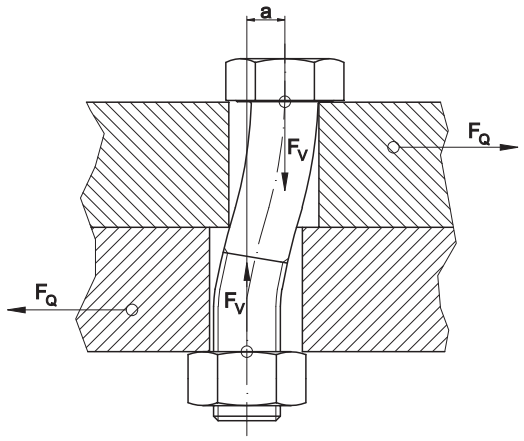
DIN 6796
Conical spring washers for bolted joints

REYHER range on stock – *ready for immediate delivery!*

Self-loosening and locking of a bolted joint with dynamic

■ Risks

If dynamic perpendicular loads exceed grip in the contact face of the joint materials, lateral motions can occur. These motions can create a self-loosening torque. Depending on the frequency of load changes, loosening and final complete separation of the connection could occur.



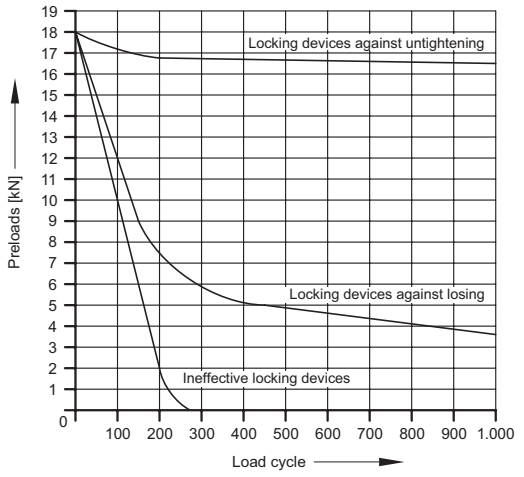
Dynamic load

■ Actions

If the design of the joint allows changes, these can be made, otherwise locking devices should be used. The following actions can be used (see also DIN 25201-4).

Actions against self-loosening

- Increasing preload force
- Increasing screw elasticity
- Increasing friction on the contact surfaces of screws and nuts and/or threads
- Limiting possible perpendicular slip (use of dowel screws/pins or rods)
- Use of locking devices to prevent relative movement of screws or nuts
- Chemical joint (liquid or microencapsulated adhesive)



■ Locking devices against losing

The term locking device against losing is understood to means nuts and screws with a clamping part or locking coating as well as thread-forming screws.

Locking devices against losing do not prevent serious preload loss, but they do prevent the joint from separating. Roughly about 20% of the preload is maintained. The locking is based on the principle of clamping the thread using friction. Circumferential coatings, strip coatings or spot coatings are used in practice.

The requirements for locking coatings for screws are laid down in DIN 267-28. Function properties for nuts with clamping part are defined in ISO 2320.

Product overview of clamping protections

Selection of product and brand names for clamping protections	
TufLok®	Klemm-tight®
S-Lok	Thermo-tight®
Long-Lok	Bio-Tec®
Hot-Lok	

Locking devices against untightening

Locking devices against untightening are understood to be elements and methods to prevent a bolted joint, despite high dynamic load, from self-loosening and to maintain preloads. As a rule the preloads do not fall below 80% of the assembly preload. Basically the following securing methods are suitable:

- Form-fitting locking device against untightening
- Securing with higher preloads
- Adhesive locking device against untightening

Serrated fasteners against untightening

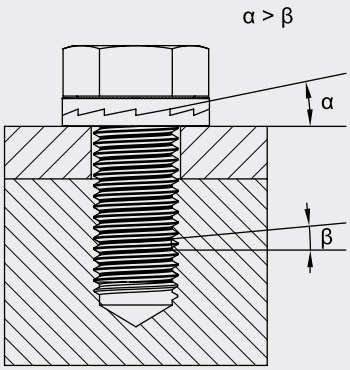
Serrated tooth fasteners have teeth that are shaped in a way that during tightening the teeth bite into the surface. This creates a ratchet-type of resistance to removal. Also the use of washers with locking teeth or ribs is possible. Above all the surface hardness of the teeth or ribs must be considerably higher than the component it is to be connected to, so that it can work into the surface. It is to be noted that the locking teeth and ribs strongly influence the friction.

With softer mating material such as aluminium alloys and structural steel, where the teeth interlock, considerably higher friction rates (0.2 – 0.3) are to be expected. Accordingly, tightening torques are to be sized so as to reach the desired preload. Ultimately, optimal values can only be given in actual situations. Benchmark values for tightening torque are illustrated on pages 14 and 15.

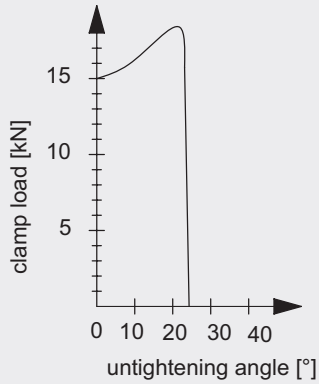
Securing with higher preloads

This securing method is characterised by tightening the outer radial teeth/ribs of the wedge lock washers fit in the respective mating surface. Under dynamic loads and the associated attempt at loosening the bolted joint, movement is only possible between the inner wedge surfaces.

Due to the higher wedge angle of the washer, in comparison to the pitch of the screw thread, preloads in the connection are increased, which is easy to see in both of the following diagrams.



Angles for wedge lock washers



Unlocking at a wedge lock washer

Ineffective products and processes

Withdrawn standards:

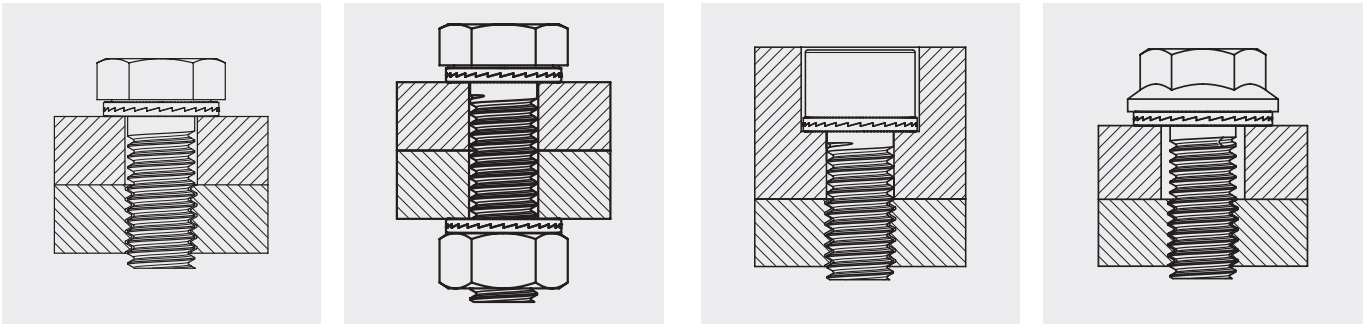
- Serrated lock washers in accordance with DIN 6798
- Toothed lock washers in accordance with DIN 6797
- Washers with a tap in accordance with DIN 93, DIN 432 and DIN 463
- Locking plates in accordance with DIN 526
- Self-locking counter nuts in accordance with DIN 7967
- Countering of bolted joints

Self-loosening and locking of a bolted joint with dynamic loads

Assembly notes for wedge type locking devices

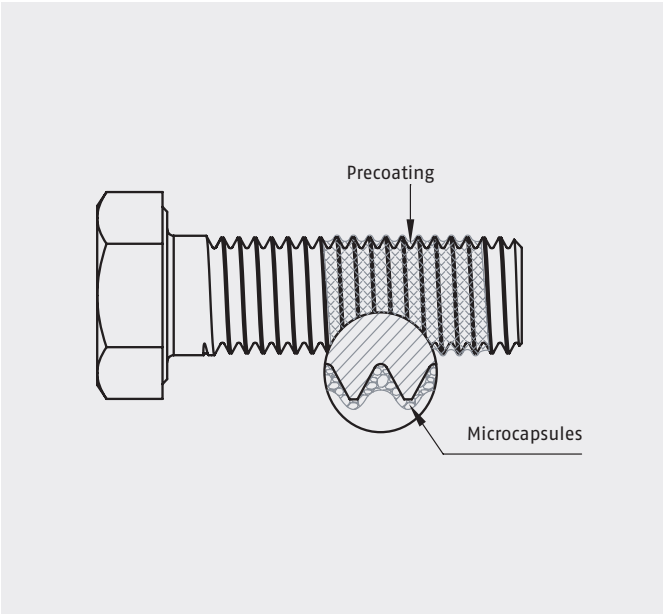
The locking devices must be under the screw head and the nut to prevent loosening.

The illustrations show possible methods.



Installation examples

Adhesive locking against untightening



For adhesive locking against untightening, microcapsules with a carrier material are applied to the thread. This contains adhesive and hardener, the capsule breaks as the screw is tightened, the materials mix and then harden. Usually after 24 hours the bolted joint is secured against vibration and loosening and at the same time sealed. The adhesive produces a material bond that prevents loosening just as well as serrations. DIN 267-27 describes the adhesive lock with microcapsule adhesive.

Microcapsules are recommended for large numbers of units, as a special coating process can be applied to the threads. When using zinc laminated coating, sealing and/or coating with lubricant additives can reduce the breakaway torque as determined in DIN 267-27. In this case the application trials under operating conditions are to be carried out prior to standard use.

The lifetime of microcapsule coatings, in line with DIN 267-27, is determined as at least 4 years.

For smaller numbers of items for universal use, anaerobic hardened liquid adhesives are suitable. They are applied to the threads during mounting and harden when adhesive and metal come into contact (iron and copper ions). Adhesive coatings have temperature resistance limitations. More information on page 13.

Product overview of adhesive locking against untightening

Selection of product and brand names for adhesive locking devices against unscrewing	
LOCTITE®	METAFLUX®
INBUS-Plus	OKS®
DELO	SCOTCH GRIP®
WEICONLOCK®	Klemm-tight®
PRECOTE®	Heat-tight®
Vibra-TITE®	ALU-tight®

Locking devices against losing
REYHER range on stock – *ready for immediate delivery!*

Locking nuts – nuts with metallic and non-metallic inserts

ISO 7040/ISO 10512 (DIN 982/DIN 6924)
Prevailing torque type hexagon nuts, with non-metallic insert, high type

ISO 7042/ISO 10513 (DIN 980/DIN 6925)
Prevailing torque type hexagon nuts, all-metal nuts
- **also in stock with hot dip galvanized surface**

ISO 10511/ISO 10512 (DIN 985)
Prevailing torque type hexagon nuts, with non-metallic insert, low type

DIN 986
Prevailing torque type hexagon domed cap nuts with non-metallic insert

EN 1663
Prevailing torque type hexagon nuts with flange, with non-metallic insert

EN 1664
Prevailing torque type hexagon nuts with flange, all-metal nuts

REYHER article 13023
Prevailing torque type hexagon nuts with flange, all-metal nuts

REYHER article 84032
BILOC clamping nuts

REYHER article 88081
Locknuts with non-metallic insert

Locking devices against losing
REYHER range on stock – *ready for immediate delivery!*

■ **DIN 7500**
Thread rolling screws

Locking devices against losing – *available on request!*

■ **Screws with clamping coatings/prevailing torque**

Form-fitting locking devices against untightening
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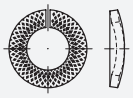
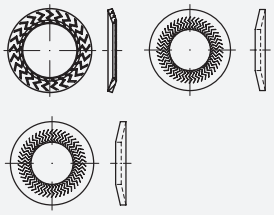
REYHER article 88130/88131
Lock ring



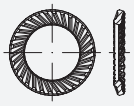
Due to the duplex structured surface and bulging also balances out the small intrusions of parts into materials.

REYHER article 88123-88126
TECKENTRUP lock washers



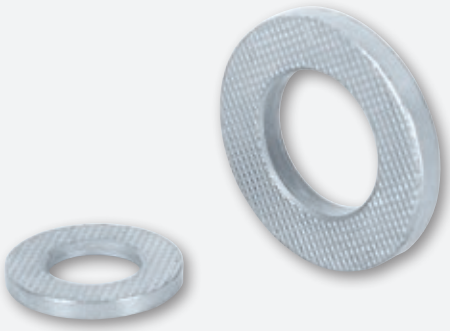
Due to the bulging also balances out the small intrusions of parts into materials.

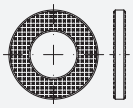
REYHER article 88120/88121
SCHNORR safety washers



Due to the duplex serrated surface and bulging also balances out the small intrusions of parts into materials.

REYHER article 88119
LOCKTIX washers

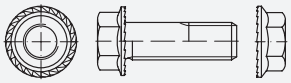




These washers have double-sided surfaces and a large contact surface.

REYHER article 88933
Hexagon head locking screws with serrations and flange

REYHER article 88934
Hexagon locking nuts with serrations and flange



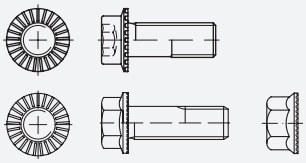
The assembly process is easier thanks to the cold-forged flange with serrations as individual washers do not need to be used. The special design of the flange balances out intrusions of parts into materials to a limited degree.

Form-fitting locking devices against untightening
REYHER range on stock – *ready for immediate delivery!*

■ **REYHER article 88912**
RIPP hexagon socket cap screws with flange

■ **REYHER article 88913**
RIPP hexagon head locking screws with flange

■ **REYHER article 88914**
RIPP hexagon nuts with flange



The assembly process is easier thanks to the cold-forged flange with ribs as individual washers do not need to be used. The special design of the flange balances out intrusions of parts into materials to a limited degree.

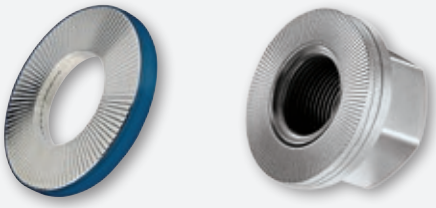
■ **REYHER article 88132**
Nord-Lock washers

- ▸ Standard – with normal bearing surface
- ▸ SP – with enlarged bearing surface
- ▸ SC – for HV connections (German approval Z14.4-629)
- ▸ X-series – arched

Assembled Nord-Lock washers bite with their outer ribs into the joint material. When dynamic stress and the associated attempt to self-loosen the screw connection is present, movement is only possible between the inner wedge surfaces, which leads to an increase of the preload force. All washers are supplied in glued pairs, so that during initial mounting the pairs are easier to handle. The wedge lock washers in the X series are additionally arched, compensating settling.

■ **REYHER article 88033**
HEICO ring lock washers

■ **REYHER article 88034**
HEICO wedge lock nuts



Assembled HEICO ring lock washers and HEICO wedge lock nuts bite with their outer ribs into the joint material. When dynamic stress and the associated attempt to self-loosen the screw connection is present, only movement between the inner wedge surfaces is possible. This leads to an increase in the preload force. The paired washers are held together by a plastic ring, so that when the connection is loosened frequently the washers will remain in the mounting orientation and can simply be reused. Wedge lock washers offer a further simplification in the mounting process. Here there is a flange nut with a non-detachable pair of wedge lock washers integrated.

Adhesive locking against untightening – *available on request!*

Adhesive locking against unthightening are made of microcapsules, with a carrier material that is applied to the thread. This material contains the adhesive and a hardener. Tightening the screw breaks the capsule, adhesive and hardener mix together and harden. Differentiation by colour between the various products and properties can be seen in the illustration.

Technical information

Comparison of clamp and adhesive locking chemicals

Adhesive

Product/designation	Colour	Temperature resistance, braced [°C]	Thread friction coefficient µ	Hardening time [h]	Characteristic
precote 30	yellow	-60 to +150	0.10 - 0.15	6	medium-tight, sealing
precote 80	red/green	-60 to +170	> 0.25	6	high-tight, sealing
precote 85	turquoise	-60 to +170	0.10 - 0.15	6	high-tight, sealing
Scotch-Grip 2353	blue	-30 to +110	0.13 - 0.19	24	high-tight, sealing
Scotch-Grip 2510	orange	-30 to +200	0.13 - 0.19	72	high-tight, sealing

All information are manufacturer specifications. We do not assume any liability for the correctness of these specifications.

Clamp and seal

Product/designation	Colour	Temperature resistance, braced [°C]	Thread friction coefficient µ	Characteristic
Polyamid-Fleck (GESI)	blue, red	-60 to +120	-	Clamp
Polyamid-Rundum (GESI)	blue, red	-60 to +120	0.12 - 0.14	Clamp and seal
TUFLOK-Fleck (NYLOK)	blue, red	-56 to +121	-	Clamp
TUFLOK-Rundum (NYLOK)	blue, red	-56 to +121	-	Clamp and seal
Long-Lok Polycap Nylon	green	-51 to +121	-	Clamp
Long-Lok Kel-F	blue	-196 to +199	-	Clamp
Long-Lok Vespel	brown	-268 to +260	-	Clamp
Hot-Lok	silver	-240 to +649	-	Clamp
Klemm-tight	-	-60 to +200	-	Clamp
Alu-tight	-	-60 to +500	-	Clamp
Heat-tight	-	to +1,000	-	Clamp
Thermo-tight	-	-240 to +220	-	Clamp
precote 2	blue	-60 to +90	0.10 - 0.15	Clamp
precote 6	white	-60 to +110	0.25 - 0.30	Clamp
precote 9	white/red-brown	-60 to +180	0.10 - 0.15	Clamp
precote 10	grey/green/blue	-60 to +130	0.16 - 0.20	Clamp and seal
precote 10-1	green	-60 to +150	0.18 - 0.23	Clamp and seal
precote 19-2	red/colourless	-60 to +90	0.18 - 0.23	Clamp
precote 19-7	yellow/colourless	-60 to +150	0.10 - 0.15	Clamp

All information are manufacturer specifications. We do not assume any liability for the correctness of these specifications.

Technical information

Preloads and tightening torques of bolted joints from steel with locking devices

Typical values for preloads F_V and tightening torques M_A for screws and nuts with lock ribs under the flange
(REYHER articles 88913 and 88914)

Material of screwed part	Property class 100/10													
	M 5		M 6		M 8		M 10		M 12		M 14 x 1.5		M 16	
	F_V [N]	M_A [Nm]	F_V [N]	M_A [Nm]	F_V [N]	M_A [Nm]	F_V [N]	M_A [Nm]	F_V [N]	M_A [Nm]	F_V [N]	M_A [Nm]	F_V [N]	M_A [Nm]
Steel R_m < 800 MPa	9000	11	12600	19	23200	42	37000	85	54000	130	74000	250	102000	330
Steel R_m ≥ 800 MPa	9000	10	12600	18	23200	37	37000	80	54000	120	74000	240	102000	310
Malleable cast iron	9000	9	12600	16	23200	35	37000	75	54000	115	74000	230	102000	300

Typical values for preloads F_V and tightening torques M_A for hexagon socket cap screws with lock ribs under the flange
(REYHER article 88912)

Material of screwed part	Property class 100/10									
	M 5		M 6		M 8		M 10		M 12	
	F_V [N]	M_A [Nm]	F_V [N]	M_A [Nm]	F_V [N]	M_A [Nm]	F_V [N]	M_A [Nm]	F_V [N]	M_A [Nm]
Steel R_m < 800 MPa	9000	13	12600	24	23200	45	37000	90	54000	150
Steel R_m ≥ 800 MPa	9000	11	12600	20	23200	42	37000	85	54000	140
Malleable cast iron	9000	10	12600	19	23200	39	37000	80	54000	120

Typical values for preloads and tightening torques of locking screws and nuts
(REYHER articles 88933 and 88934)

Material of screwed part	Property class 90/8											
	M 5		M 6		M 8		M 10		M 12		M 16	
	F_V [N]	M_A [Nm]	F_V [N]	M_A [Nm]	F_V [N]	M_A [Nm]	F_V [N]	M_A [Nm]	F_V [N]	M_A [Nm]	F_V [N]	M_A [Nm]
Steel	6350	9	9000	16	16500	34	26200	58	54000	120	102000	280
Malleable cast iron	6350	7	9000	13	16500	28	26200	49	54000	105	102000	260

Typical values for tightening torques and preloads of bolted joints used with wedge-lock washers or wedge-lock nuts
(REYHER articles 88132, 88033, 88034)

NL washers for threads	Preloads F_V (kN) for property class					Tightening torque M_A (Nm) for property class				
	8.8[1]	10.9[2]	12.9[3]	A 4-70[4]	A 4-80[4]	8.8[1]	10.9[2]	12.9[3]	A 4-70[4]	A 4-80[4]
M 4	3.5	5.9	7.1	2.6	3.4	3.1	4.1	4.6	2.0	2.7
M 5	5.6	9.6	11.5	4.1	5.5	6.0	8.1	9.1	3.9	5.3
M 6	8.0	13.6	16.3	5.9	7.8	10.2	14.1	15.8	6.9	9.2
M 8	15.0	25.0	30.0	11.0	14.0	25.0	34.0	38.0	17.0	22.0
M 10	23.0	39.0	47.0	17.0	23.0	50.0	67.0	75.0	33.0	43.0
M 12	33.0	57.0	68.0	25.0	33.0	85.0	115.0	128.0	56.0	75.0
M 14	46.0	78.0	94.0	34.0	45.0	136.0	183.0	204.0	89.0	119.0
M 16	62.0	106.0	127.0	46.0	61.0	208.0	279.0	311.0	136.0	181.0
M 18	76.0	130.0	156.0	56.0	75.0	291.0	391.0	437.0	191.0	254.0
M 20	97.0	165.0	198.0	72.0	95.0	408.0	547.0	610.0	267.0	356.0
M 22	120.0	205.0	246.0	89.0	118.0	557.0	745.0	831.0	364.0	485.0
M 24	140.0	238.0	286.0	103.0	137.0	703.0	942.0	1052.0	460.0	613.0
M 27	182.0	310.0	372.0	134.0	179.0	1028.0	1375.0	1533.0	671.0	895.0
M 30	222.0	378.0	454.0	164.0	219.0	1401.0	1875.0	2091.0	915.0	1220.0
M 33	275.0	468.0	562.0	–	–	1889.0	2526.0	2815.0	–	–
M 36	324.0	551.0	662.0	239.0	319.0	2436.0	3259.0	3633.0	1591.0	2121.0
M 39	387.0	659.0	790.0	–	–	3145.0	4203.0	4683.0	–	–
M 42	445.0	757.0	908.0	–	–	3890.0	5202.0	5799.0	–	–

Source: www.nordlock.com

[1] Screw zinc plated, dry, thread friction μ_G = 0.15, friction coefficient of the lock washer μ_W = 0.18, utilisation of the minimum yield strength = 62%
[2] Screw uncoated, oiled, thread friction μ_G = 0.13, friction coefficient of the lock washer μ_W = 0.14, utilisation of the minimum yield strength = 71%
[3] Screw uncoated, oiled, thread friction μ_G = 0.13, friction coefficient of the lock washer μ_W = 0.12, utilisation of the minimum yield strength = 71%
[4] Screw lubricated with graphite paste, thread friction μ_G = 0.14, friction coefficient of the lock washer μ_W = 0.15, utilisation of the minimum yield strength = 65%

Preloads and tightening torques of bolted joints from steel with locking elements

Typical values for tightening torques of bolted joints with lock washers

REYHER articles	Property class Screws	Tightening torque M_A in Nm													
		M 4	M 5	M 6	M 8	M 10	M 12	M 14	M 16	M 18	M 20	M 22	M 24	M 27	M 30
88123 type S	5.8	2.0	4.0	7.0	16.5	32	57	–	–	–	–	–	–	–	–
88124 type M	8.8	3.3	6.7	11.5	27	54	92	145	225	320	460	620	790	1160	1550
	10.9	4.9	9.8	16.5	40	79	135	215	330	460	650	890	1120	1650	2250
88125 type B	10.9	–	–	16.5	40	79	135	–	–	–	–	–	–	–	–
	12.9	–	–	19.5	47	92	158	–	–	–	–	–	–	–	–

Source: www.teckentrup.de

Typical values for bolted joints with SCHNORR washers for screws with regular thread

Dimensions		Stress area AS (mm²)	Tightening torque M_A (Nm) for property class	
	P		8.8	10.9
M 4	0.7	8.78	3.6	5.3
M 5	0.8	14.2	7.2	10.5
M 6	1.0	20.1	12.4	18.2
M 8	1.25	36.6	30.0	44.1
M 10	1.5	58.0	59.0	87.0
M 12	1.75	84.3	102.0	151.0
M 14	2.0	115.0	163.0	240.0
M 16	2.0	157.0	253.0	372.0
M 18	2.5	193.0	362.0	516.0
M 20	2.5	245.0	510.0	727.0
M 22	2.5	303.0	697.0	994.0
M 24	3.0	353.0	878.0	1250.0
M 27	3.0	459.0	1294.0	1841.0
M 30	3.5	561.0	1757.0	2501.0
M 33	3.5	694.0	2377.0	3386.0
M 36	4.0	817.0	3056.0	4353.0

Typical values for bolted joints with SCHNORR washers for screws with fine pitch thread

Dimensions		Stress area AS (mm²)	Tightening torque M_A (Nm) for property class	
	P		8.8	10.9
M 8	1.0	39.2	32	47
M 10	1.25	61.2	63	91
M 12	1.25	92.1	111	164
M 12	1.5	88.1	107	157
M 14	1.5	125.0	175	257
M 16	1.5	167.0	268	395
M 18	1.5	216.0	405	575
M 20	1.5	272.0	562	801
M 22	1.5	333.0	761	1084
M 24	2.0	384.0	952	1355
M 27	2.0	469.0	1388	1977
M 30	2.0	621.0	1932	2752
M 33	2.0	761.0	2587	3685
M 36	2.0	915.0	3390	4829

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