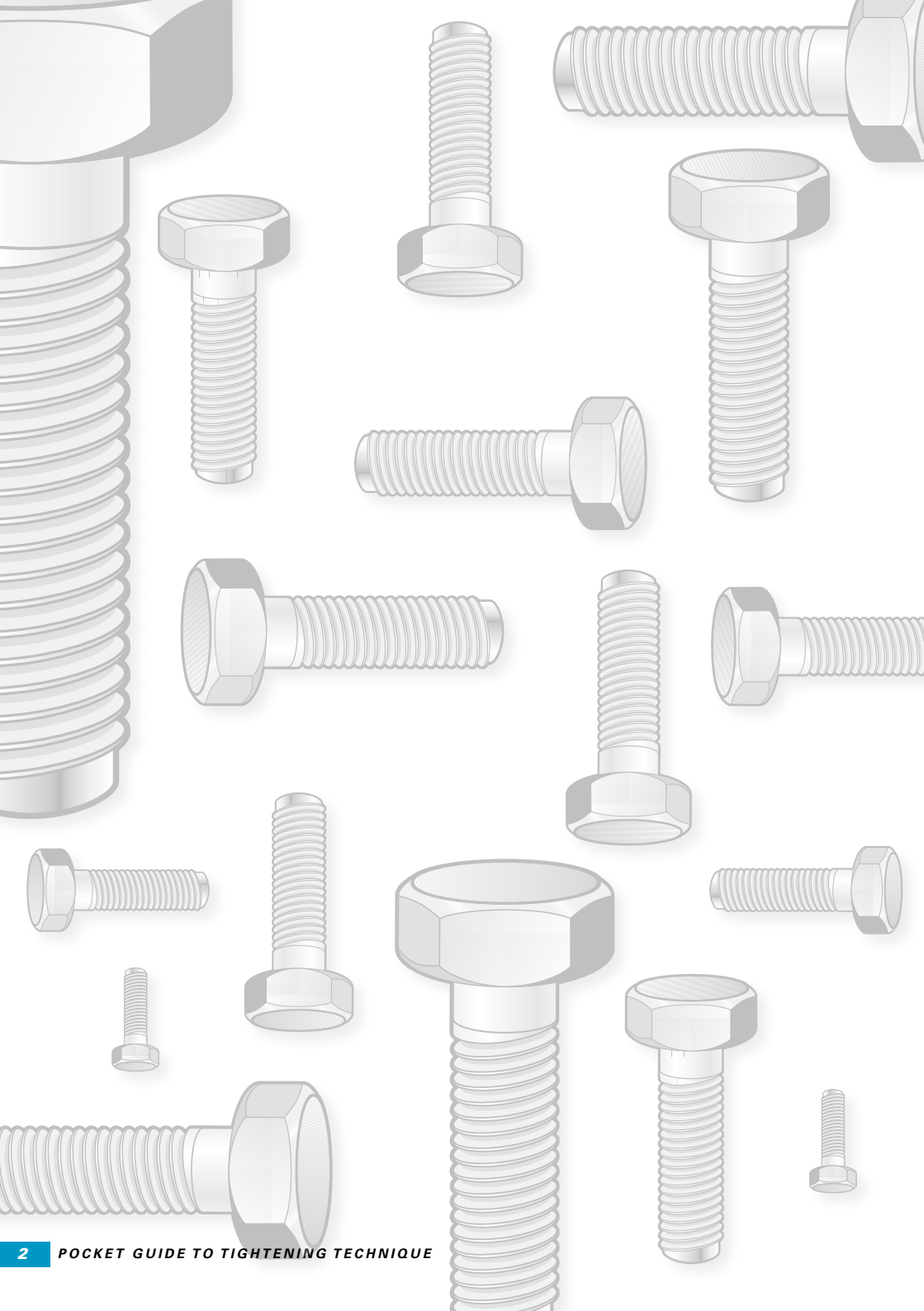




POCKET GUIDE TO TIGHTENING TECHNIQUE

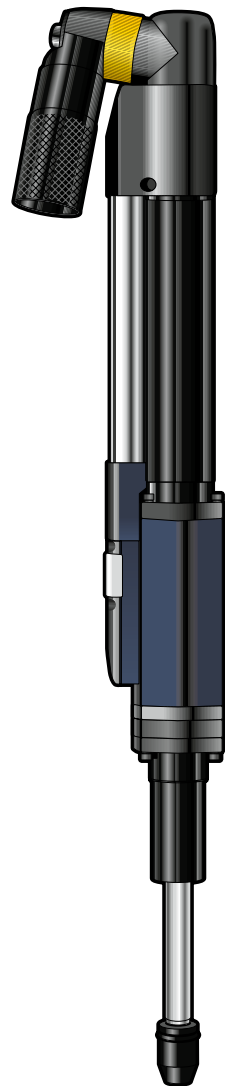
Chapter 1-6

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POCKET GUIDE TO TIGHTENING TECHNIQUE

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POCKET GUIDE TO TIGHTENING TECHNIQUE

This booklet provides an introduction to the technique of using threaded fasteners for assembling components, the application of power tools for the assembly and the influence of tool selection on the quality of the joint.

1. WHY THREADED FASTENERS?

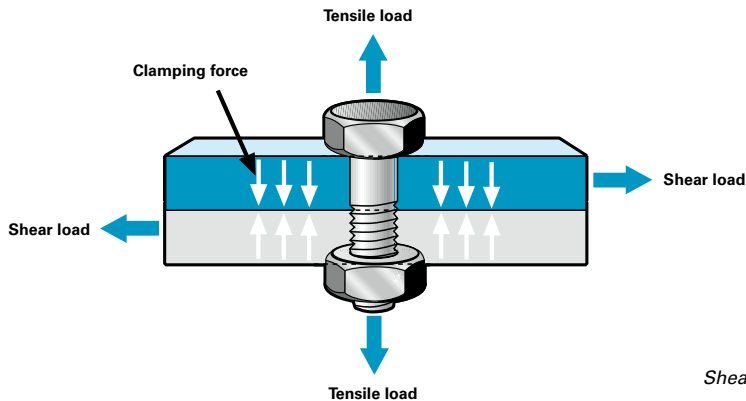
There are several ways of securing parts and components to each other, e.g. gluing, riveting, welding and soldering. However, by far the most common method of joining components is to use a screw to clamp the joint members with a nut or directly to a threaded hole in one of the components. The advantages of this method are the simplicity of design and assembly, easy disassembly, productivity and in the end – cost.

2. THE SCREW JOINT

A screw is exposed to tensile load, to torsion and sometimes also to a shear load.

The stress in the screw when the screw has been tightened to the design extent is known as the pre-stress.

The tensile load corresponds to the force that clamps the joint members together. External loads which are less than the clamping force will not change the tensile load in the screw. On the other hand, if the joint is exposed to higher external loads than the pre-stress in the bolt the joint will come apart and the tensile load in the screw will naturally increase until the screw breaks.



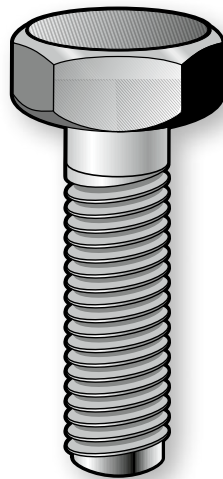
Shear load and tensile load.

Torsion in the screw results from friction between the threads in the screw and the nut.

Some screws are also exposed to shear loads which occur when the external force slides the members of the joint in relation to each other perpendicular to the clamping force. In a properly designed joint the external shear force should be resisted by the friction between the components. A joint of this kind is called a friction joint. If the clamping force is not sufficient to create the friction needed, the screw will also be exposed to the shear load. Joints are frequently designed for a combination of tensile and shear loads.

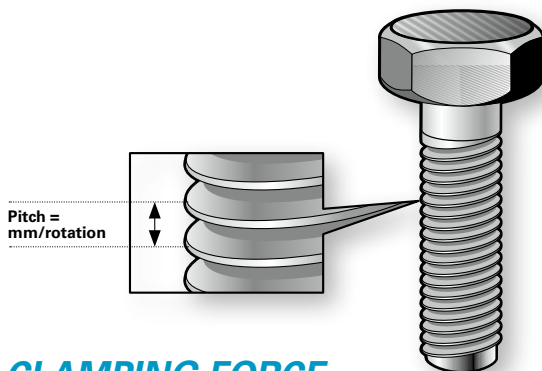
The screw is made up of the shank and the head. The shank is threaded, either for part of its length or for the full length from the end to the head. Longer screws are usually only partly threaded. There is no need to make a thread longer than is necessary to tighten the joint as this will only make the screw more expensive and reduce the tensile strength.

The dimensions of threads, the shape of the thread and the pitch, i.e. the distance between successive threads, have been standardized. In practice there are only two different standards used today in industry; the Unified standard UN, originally used in the Anglo-Saxon countries, and the European Metric standard M.



Basic screw design.

Apart from the basic dimensional differences the UN and M standards have different angles and depths of thread. Both standards include separate specifications for fine threads. The UN fine thread standard UNF is quite common parallel to the normal UNC type.



3. CLAMPING FORCE

In general it is desirable that the screw is the weakest member of the joint. An over-dimensioned screw makes the product both heavier and unnecessarily expensive. As a standard screw is usually comparatively inexpensive it is preferable that the screw should be the first part to break.

Furthermore, in most cases the dimensions of the screw are not critical for the quality of the joint. What is decisive is the clamping force, i.e. whether it is sufficient to carry all the load for which the joint is designed, and whether the joint will remain tight enough to prevent loosening if exposed to pulse loads.

The problem is that there is no practical way to measure the clamping force in normal production situations. Consequently the value of the clamping force is usually referred to as the tightening torque.

As the clamping force is a linear function of both the turning angle of the screw and the pitch of the thread, there is a direct relation between the clamping force and the tightening torque within the elastic range of the screw elongation. However, only about 10% of the torque applied is transferred into clamping force. The remaining tightening force is consumed in friction in the screw joint – 40% of the torque to overcome the friction in the thread and 50% in friction under the screw head.

4. EFFECT OF LUBRICATION

If a screw is lubricated, the friction in the threads and under the head is decreased and the relation between tightening torque and clamping force is changed. If the same torque is applied as before lubrication, a lot more torque will be transformed into clamping force. At worst this might lead to the tension in the screw exceeding the tensile strength and breaking of the screw.

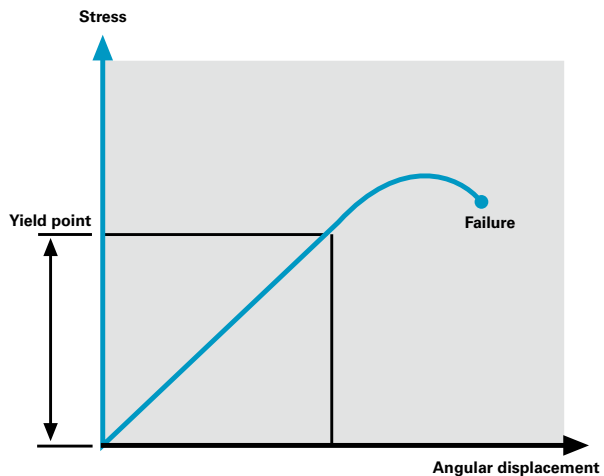
On the other hand, if the screw is completely dry of lubricant the clamping force might be too small to withstand the forces for which the joint is designed, with the risk that the screw becomes loose.

Bolt material	Nut material	Dry	Lightly oiled
Untreated	Untreated	0.18-0.35	0.14-0.26
Phosphorous coated	Untreated	0.25-0.40	0.17-0.30
Electro Zinc plated	Untreated	0.11-0.36	0.11-0.20
Phosphorous coated	Phosphorous coated	0.13-0.24	0.11-0.17
Electro Zinc plated	Electro Zinc plated	0.18-0.42	0.13-0.22

Table 1. Friction in threads of different material.

5. SCREW QUALITY CLASSIFICATION

When a screw is tightened and the clamping force starts to build up, the material of the screw is stressed. After a short time when the thread settles the material will stretch in proportion to the force. In principle, this elongation will continue until the stress in the screw is equal to the tensile strength at which the screw will break. However, as long as the elongation is proportional to the stress the screw will regain its original length when the load is removed. This is known as the elastic area.



At a certain stress, known as the yield point, plastic deformation of the material in the screw will occur. However, the screw will not break immediately. Torque will continue to increase but at a lower torque rate during the deformation above the yield point. The plastic deformation will result in a permanent elongation of the screw if the joint is loosened. For very accurate clamping force requirements this area is sometimes deliberately specified for the tightening process. Beyond the plastic area breakage occurs.

M-Threaded screwbolts

Tightening torque Nm, according to ISO 898/1

The material qualities of screws are standardized, i.e. the amount of tensile stress they can be exposed to before the yield point is reached and before breakage occurs. All screws should be marked according to their Bolt Grade – a classification standard in a two-digit system where the first digit refers to the minimum tensile strength in 100 N/mm² and the second digit indicates the relation between the yield point and the minimum tensile strength. For example: Bolt Grade 8.8 designates a screw with 800 N/mm² minimum tensile strength and a yield point of $0.8 \times 800 = 640$ N/mm².

Table 2. Table for different classes of screws.

Thread	Bolt grade						
	3.6	4.6	4.8	5.8	8.8	10.9	12.9
	Nm						
M1.6	0.05	0.065	0.086	0.11	0.17	0.24	0.29
M2	0.10	0.13	0.17	0.22	0.35	0.49	0.58
M2.2	0.13	0.17	0.23	0.29	0.46	0.64	0.77
M2.5	0.20	0.26	0.35	0.44	0.70	0.98	1.20
M3	0.35	0.46	0.61	0.77	1.20	1.70	2.10
M3.5	0.55	0.73	0.97	1.20	1.90	2.70	3.30
M4	0.81	1.10	1.40	1.80	2.90	4.00	4.90
M5	0.60	2.20	2.95	3.60	5.70	8.10	9.70
M6	2.80	3.70	4.90	6.10	9.80	14.0	17.0
M8		8.90	10.50	15.0	24.0	33.0	40.0
M10		17.0	21.0	29.0	47.0	65.0	79.0
M12		30.0	36.0	51.0	81.0	114.0	136.0
M14		48	58	80	128	181	217
M16		74	88	123	197	277	333
M18		103	121	172	275	386	463
M20		144	170	240	385	541	649
M22		194	230	324	518	728	874
M24		249	295	416	665	935	1120
M27		360	435	600	961	1350	1620
M30		492	590	819	1310	1840	2210
M36		855	1030	1420	2280	3210	3850
M42		1360		2270	3610	5110	6140
M45		1690		2820	4510	6340	7610
M48		2040		3400	5450	7660	9190



Example of screw designation.

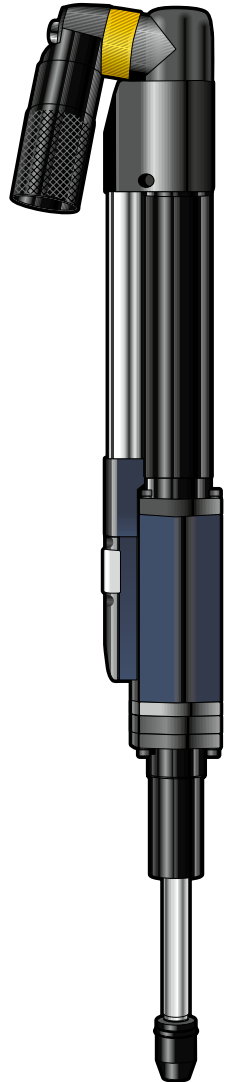
6. JOINT TYPES

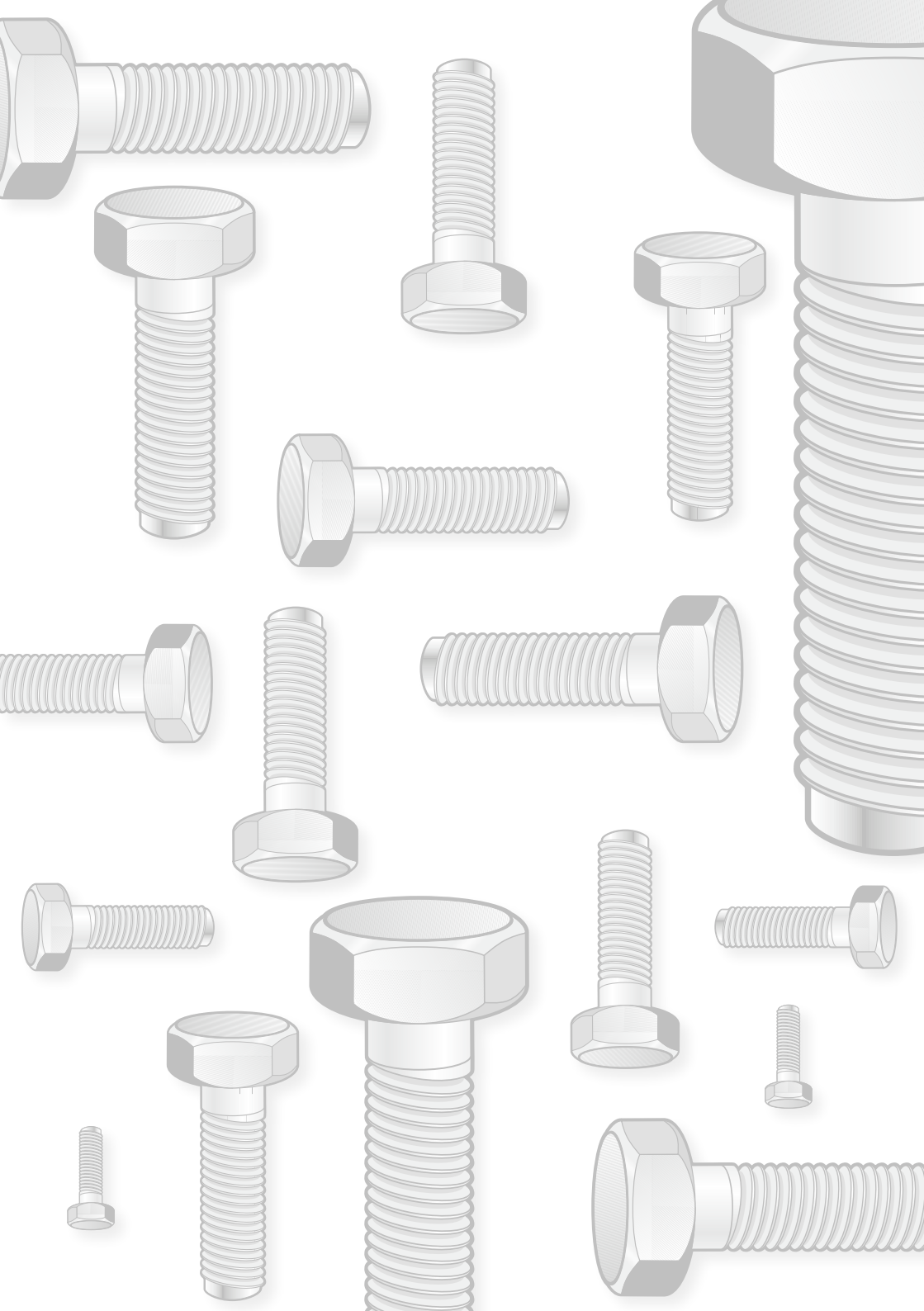
Screw joints vary not only in size but also in type, which changes the characteristics of the joints. From a tightening point of view the most important quality of a joint is the “hardness”. In figures this can be defined as the “torque rate”, which is the tightening angle necessary to achieve the recommended torque of the screw dimension and quality in question measured from the snug level – the point at which the components and the screw head become tight.

The torque rate can vary considerably for the same diameter of screw. A short screw clamping plain metal components reaches the rated torque in only a fraction of a turn of the screw. This type of joint is defined as a “hard joint”. A joint with a long screw that has to compress soft components such as gaskets or spring washers requires a much wider angle, possibly even several turns of the screw or nut to reach the rated torque. This type of joint is described as a soft joint. Obviously the two different types of joints behave differently when it comes to the tightening process.

STAY TUNED FOR NEXT WEEKS CHAPTERS...

- 7. Torque and angle**
- 8. Measurement methods**
- 9. The tightening process**
- 10. Mean shift**
- 11. Standards for measurement**





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