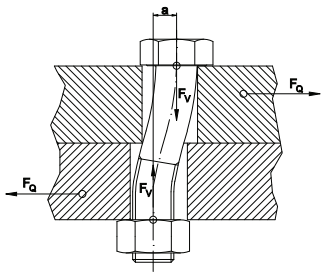
Assembly of screwed fastenings

General information and tightening methods

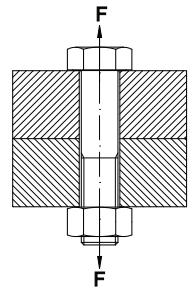
General information
Functional quality and fatigue limit of fasteners are mainly determined with the following factors:

- Mechanical properties (tensile strength, yield strength, elongation)
- Operating conditions (static/dynamic...)
- Service conditions (temperature, corrosion)
- Dimensioning (diameter, length)
- Locking against loosening and unscrewing if necessary
- Assembly (tightening method, preload/clamp load, tightening torque...)

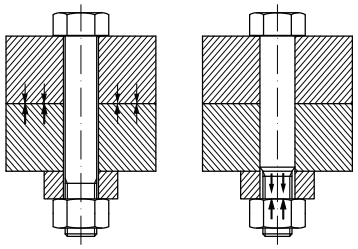
While taking into account all requirements, the task of constructive planning is to determine the suitable fasteners, to define them with the standardised descriptions and to provide the necessary assembly instructions.
The VDI guideline 2230 is available as the recognised standard reference for the "systematic evaluation of highly stressed fasteners".
Fasteners should be evaluated and assembled in such a way that transverse loads (F_Q) perpendicular to the centre of the screw do not have any effect because of the sufficiently intact clamp load under operating conditions. Here, loss of clamp load due to intrusions of parts into materials also needs to be taken into account. If the transverse loads are larger than the clamp load, this will lead to the screwed fastening loosening, and ultimately, to its failure.

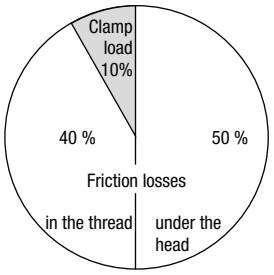


Transverse load F_Q



Preload F_V, Clamp load F_S


Clamp load F_{KL}



Reaction ratio of tightening torque in clamp load

Tightening method
Essential for the quality and fatigue limit of a fastening is the precise setting/adherence to the assembly preload. Thus alongside the size of the screw, the property class and the friction ratios, the tightening/assembly method is of vital importance during assembly. Numerous tests and theory observations have shown that 80-90% of the tightening torque is required to overcome the friction under the head and in the thread. Only a small part is actually put into generating preload.

Differentiations are made between the following methods:

Manual tightening
In general, tightening by feel with manual tools should not be done. Even with experienced workers, the spread is very large. Empirical values show that screws/bolts up to M12 are usually tightened beyond the yield strength, while screws over M14 are usually not tightened enough.

Torque-controlled tightening Tightening with a torque wrench still shows quite a large spread in the preload due to the friction coefficient differences.

Impact-controlled tightening
When assembling with impact screwdrivers, the motor power of the screwdriver in the impact mechanism is converted into tangential angular momentum. This preloaded the screw step-by-step. The advantage of using the impact screwdriver is that the worker absorbs hardly any reaction torque. The disadvantage is to be found in the numerous factors of influence on the screw preloading:

- Elasticity and friction coefficients of the screwed fastening
- Elasticity of the attached tool and the extensions
- Impact strengths and frequency duration or entire impact count

Elongation-controlled tightening
The preload can be calculated from the change in length of the screw, which, for example, can be determined using an ultrasound method during assembly. This method currently offers the highest level of accuracy. However, it is quite complex and expensive.

Angle controlled-tightening
With this method the screw is first preloaded by rotation torque then turned further by a mathematically calculated rotation angle until the ductile deformation starts. The method requires complex trials and is thus quite expensive. Furthermore, it can only be used for screwed fastenings with a long enough stretching length. The mostly ductile deformation of the screw makes it impossible to reuse.

Yield-controlled tightening
This method requires a screwing system consisting of a screwdriver, a control unit and a computer and uses the technical data for controlling, i.e. that upon reaching the yield strength of the screw, the tightening rotational torque no longer increases. The mostly ductile deformation of the screw makes it impossible to reuse.

Hydraulic tightening
Hydraulic preloading is done via the overlong end of the screw. The preloading device supports itself around the nut. The nut can be tightened in a form-fitting way or with a small amount of torque. The centre point of the hydraulic tightening is with large screws up to M200 in system construction. For example, all screws of a flange can be tightened simultaneously which brings about a uniform distribution of load.