Bolt securing system slashes costs and increases safety in the wind industry

During the past decade it has become extremely important to optimise all aspects of product design. Competition is tougher than ever and steel costs have skyrocketed. For economic reasons each component must be utilised to its maximum capacity.

Bolted joints became the centre of attention after recent findings that they were often used to as little as 30 per cent of their capacity. Moreover, a failed critical bolted joint could lead to expensive warranty claims or maintenance costs. Control of the clamp load in a bolted joint is vital. However, when faced with a problem joint, it is not surprising that the design engineer will not have an answer if asked about the clamp load. Torque calculations must always be based on the existing conditions that often are very vague. Unless all parameters are correct, the calculation will be unreliable. Examples of parameters are:

- Thread condition of the fasteners
- Hardness of contact surface
- Material (steel, aluminium, copper, etc.)
- Extra friction from a locking fastener
- Extra friction from an adhesive
- Lubricant on the thread
- Type of bolt head (flanged, regular or serrated)
- Surface coating of the bolt
- New or reused fastener

Figure 1: NORD-LOCK washers

Major automotive companies test incoming fastener batches on the actual material of any specific bolted joint to obtain the torque/load relationship and its deviation. Their engineers therefore know the clamp loads in the joints. However, smaller and medium sized companies are usually not in possession of sophisticated bolt testing laboratories.

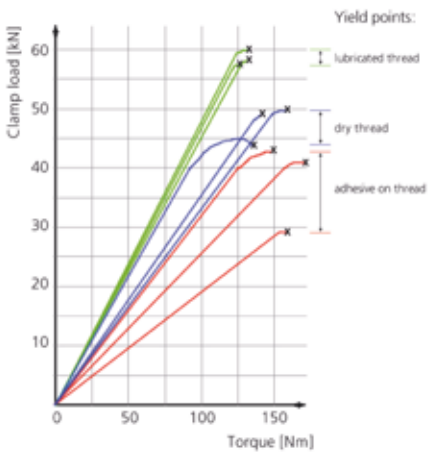
During tightening, bolts are subjected to both tensile and torsional stress. The total stress in a bolt can be calculated using the formula.

$$\text{Total stress} = \sqrt{\sigma_x^2 + 3\tau_{xy}^2}$$

In order to maximise the desired tensile stress (σ_x) it is vital to minimise the torsional stress (τ_{xy}). Tensile stress (clamp load) is achieved when the bolt is axially elongated. Unwanted torsional stress (twisting) in bolts arises during tightening due to thread friction. High thread friction increases torsional stress and causes yielding at lower clamp load levels than normal. A lubricant is necessary to minimise the malign torsional stress. However, many commonly used bolt-locking systems are based on increased thread friction (deformed nuts, adhesives etc). To minimise thread friction and concurrently safely secure the joint has often incorrectly been considered impossible. The use of locking systems that increase thread friction is the single most common reason why the full capacity of bolted joints is not utilised. The adjacent diagram illustrates the problem.

Applying an adhesive significantly increases thread friction during tightening. The red graphs (fig. 2) show tightening of bolts with adhesive on the threads. Due to increased thread friction and torsional stress, only half as much clamp load is obtained before reaching the yield points (marked with x). When tightening the same type of bolts in lubricated condition, which is illustrated by the green graphs, almost twice as much clamp load is obtained. The diagram clearly shows why low and uniform friction during tightening is necessary to ensure that the bolt's full capacity can be used.

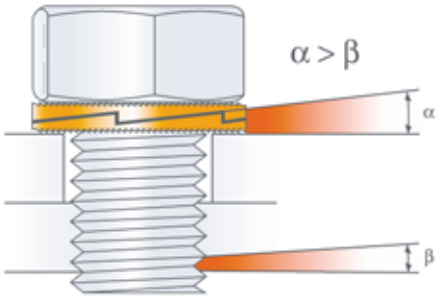
Figure 2: Example of a torque-load diagram for M12 bolts (8.8)



Under static load the achieved clamp load in a joint is maintained. However, bolted joints exposed to dynamic loads or

vibrations are likely to gradually loosen. Even if some of the common bolt locking methods (such as serrated washers, adhesives or deformed nuts) work fairly well when the dynamic loads are lenient, only NORD LOCK Bolt Securing System has proven fully reliable when conditions are extreme. Furthermore, its locking function is not lost by lubrication which means that thread friction and thereby also the torsional stress can be minimised.

Figure 3: Use the NORD-LOCK principle and let geometry work for you



The NORD-LOCK bolt securing system consists of a pair of pre-assembled washers. The washers have a cam angle "α", which is greater than the thread pitch "β". In addition, there are radial teeth on the opposite sides of the washers (figure 3).

The washers are always installed in pairs, cam-face to cam-face. When the bolt or nut is tightened the teeth grip and seat the mating surfaces. The NORD-LOCK washers are locked in place, allowing movement only across the face of the cams. Any loosening attempt of the bolt/nut to rotate loose is blocked by the wedge effect of the cams.

NORD-LOCK AB has developed well equipped in-house laboratories where clients get the opportunity to put joints from their own applications to the test. In simulations of real-life conditions torque-load ratios are measured and Junker vibration tests are performed. In a Junker vibration test (meeting DIN 65151) bolted joints are subjected to transverse movements while a load cell continuously measures the bolt tension.

The Junker test is used to compare different bolted joint configurations and is a first step in selecting the best technical solution to prevent bolt loosening. The Junker test is often considered a worst-case scenario and bolted joints performing well in this test normally function flawlessly in real life conditions. Many commonly used bolt-securing devices show limited locking performance when exposed to vibration, see figure 4.

Bolted joints secured by NORD-LOCK only lose some initial preload due to normal settlements between the contact surfaces. NORD-LOCK's wedge-locking effect is verified by the increase in clamp load during untightening. Settlement between the contact surfaces could continue throughout the lifespan of a bolt, but the wedge locking effect of NORD-LOCK will work continuously to maintain the clamp load during the lifetime of the bolt.

For machineries requiring regular service and maintenance, NORD-LOCK is the optimum solution. Bolted joints secured with NORD-LOCK are easily assembled and disassembled and no special tools are needed. Because the NORD-LOCK bolt securing system uses tension instead of friction to secure bolted joints the locking function is not affected by lubrication. The use of a good lubricant is recommended in order to reduce torsional stress, minimise clamp load deviation and to protect against corrosion. Since the clamp load deviation is very low when tightening lubricated fasteners secured by NORD-LOCK, joints can always be safely locked at the highest possible preload level.

NORD-LOCK washers have been used by various industries for more than 25 years with excellent results. To improve safety within the wind energy sector NORD-LOCK is selected to prevent any self-loosening of bolted joints. NORD-LOCK washers secure critical joints in constructional as well as in mechanical applications, e.g. on the engine, cable shoes, gear units, base, etc. One of the advantages of NORD-LOCK is the reduction of assembly time; with only one locking system you can secure nearly all your different bolt assemblies. Fitters and maintenance staff will gain a lot of time.

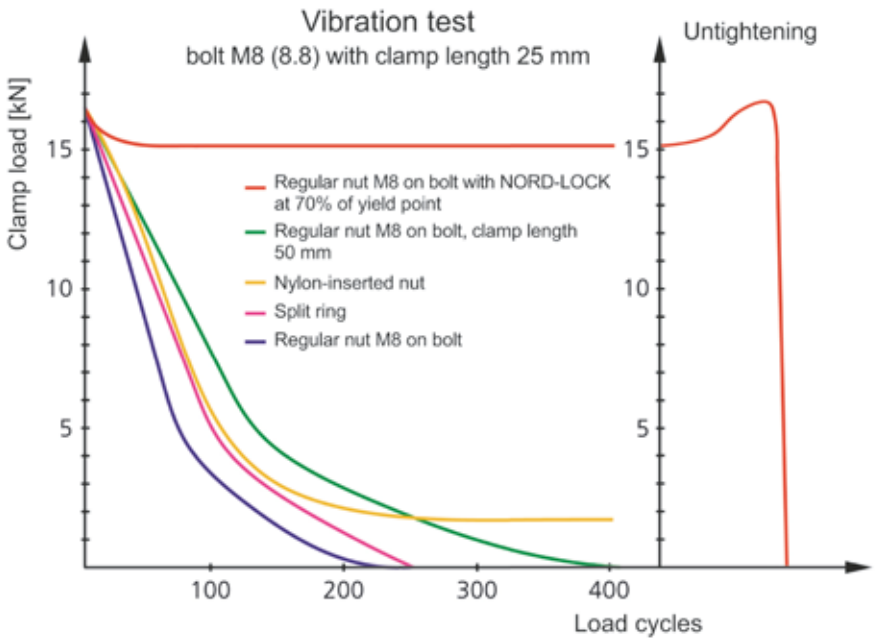
Furthermore, NORD-LOCK washers are used in many types of energy applications. In nuclear power stations, for example, NORD-LOCK will safeguard the effectiveness of the bolted joints in case of seismic activities. The time spent in the radioactive working area will be reduced to a minimum, and as reusing the washers is possible, NORD-LOCK will contribute to minimising contaminated waste.

In hydro-electric power stations the clamp load must be maintained for many years in places where accessibility can be limited. NORD-LOCK washers are also used in several applications in this sector.

NORD-LOCK will help you to slash costs and increase safety.

For further information, contact:
NORD-LOCK International AB, Radmansgatan 10, SE-211 46 Malmo, SWEDEN. Tel: +46 40 100 390, Fax: +46 40 240 851.
info@nord-lock.com, www.nord-lock.com

Figure 4: Junker test diagram for M8



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