As featured in the January '05 issue of Fastener & Fixing Europe Magazine

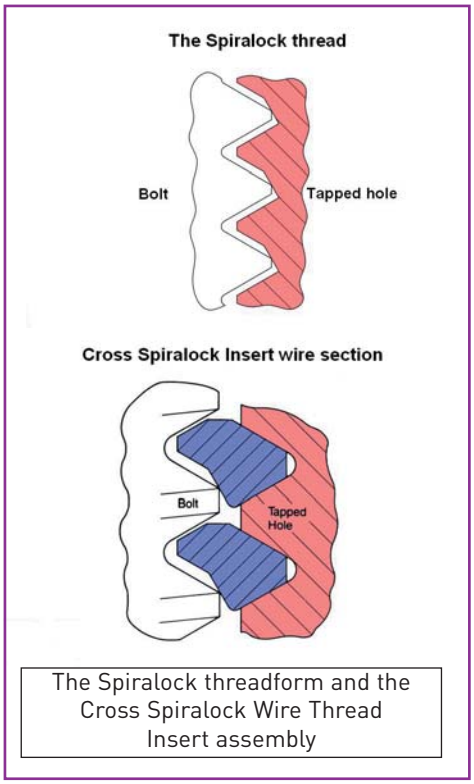
"It works better than we thought it would"

Testing the Cross Spiralock Wire Thread Insert

When Cross Manufacturing developed a wire thread insert based on the Spiralock® thread form they were confident they had a very good product. When a renowned helicopter manufacturer adopted it to reliably lock the bolting for their main rotor head it became apparent they had something very special indeed. Here Cross tell the story of two years exhaustive testing to find the limits of the product.

The Spiralock Corporation developed their unique preload locking internal thread form in the late 1970s. Now extensively proven, it generates exceptional resistance to transverse vibration, the primary cause of thread loosening. Cross's Ralph Flower, during a visit to the USA, witnessed the effectiveness of the thread form and introduced it to the UK company.

The unique geometry is made from very accurately rolled and coiled stainless steel wire, producing the wire thread insert. The images below clearly show the 30° ramp that transforms axial bolt tension into a radial force. This reorganisation of forces is responsible for the many benefits that the Cross Spiralock Wire Thread Insert can engender in applications undergoing severe transverse vibrations.



The Spiralock threadform and the Cross Spiralock Wire Thread Insert assembly

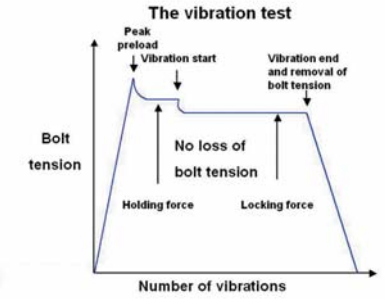
Early applications ranged from London Underground light alloy gearboxes to the attachment of rotor blades to the main rotor head mast (titanium) of a helicopter. The latter, highly critical, application began to indicate that the insert performed significantly beyond expectations: in fact 'it works better than we thought it would'.

Vibration testing

To explore the transverse vibration resistance of the insert, a Junkers Vibration rig was installed. The torque / preload relationship was tested on sizes ranging from M3 to M10 and through the unified forms up to 7/16". The project developed into a comparative investigation and many other anti-vibration systems were tested including standard and Spiralock® threads, prevailing torque and thin wall inserts, spring and various locking washers, and various threadlocking compounds. For each size, a critical amplitude was selected at which only the most vibration resistant systems would survive.

The Cross Spiralock Wire Thread Insert has been installed and tested in aluminium, magnesium, titanium alloys and steel.

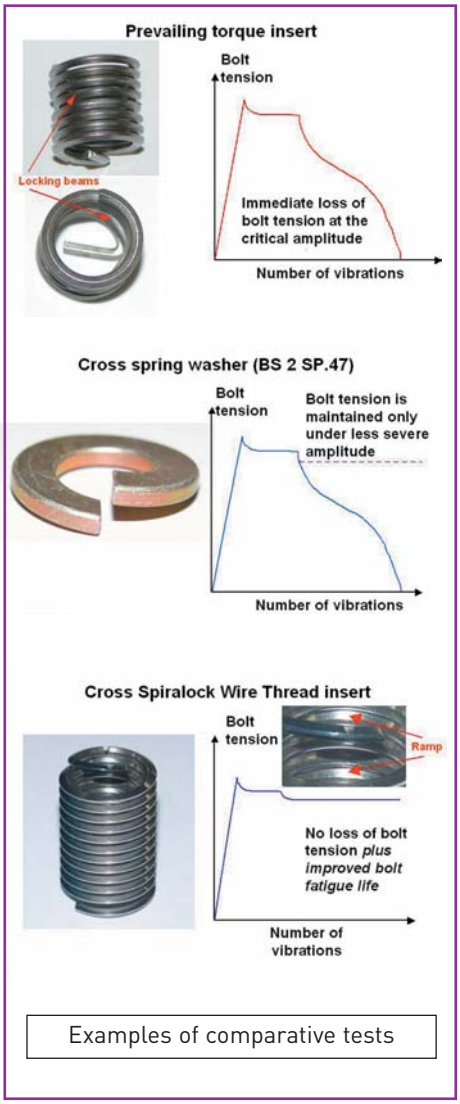
The standard CMC vibration test uses a frequency of 13.6 Hz and has a duration of 8 minutes, applying in excess of 6 500 cycles. At this frequency and at the respective critical amplitude, typical preload / time plots are created.



Typical successful test profile

The profile of a typical preload / time plot shows the peak preload resulting from the applied torque. A period of relaxation produces a plateau (the holding force). When the transverse vibration is applied, another plateau forms (the locking force). If the fastener does not loosen, this plateau continues until the vibration is stopped and the bolt is manually loosened.

Tests in which the fastener either loosens or fails by fatigue reveal the absence of the locking force plateau. Loosening at the critical amplitude produces immediate loss of bolt tension; the fastener head is observed to rotate. The onset of fatigue produces a similar profile in which the locking force plateau is absent. The head of the fastener does not rotate; bolt tension is lost due to the propagation of the fatigue crack.

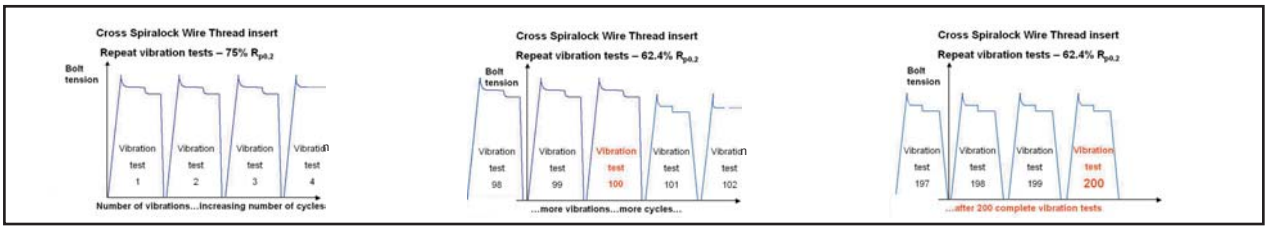


Examples of comparative tests

Re-use and long duration transverse vibration testing

Re-use tests

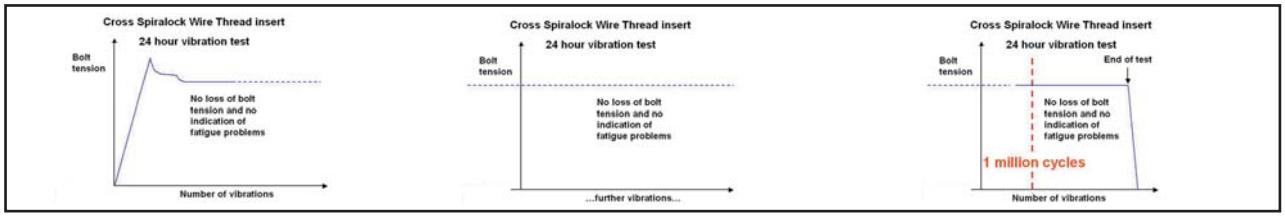
Tests investigating the re-use of a single Cross Spiralock Wire Thread Insert were carried out. An assembly was torqued to a target bolt tension; the system was allowed to relax; vibration testing was applied and the bolt tension was removed. This cycle was repeated 100 times at a preload of 75% Rp0.2 and a further 100 times at 62.4% Rp0.2



No loss of bolt tension was observed during the vibration testing at both of the preload settings ie 75 Rp0.2 and at the lower bound of the 75% Rp0.2 (62.4% Rp0.2).

Long duration testing

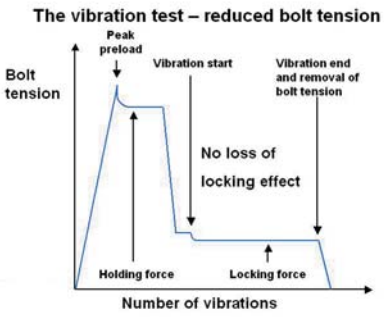
Tests investigating a single Cross Spiralock Wire Thread Insert assembly were carried out. The test included torquing a bolt assembly to a target bolt tension, allowing the system to relax, followed by transverse vibration testing for 24 hours.



No loss of bolt tension or indication of the onset of fatigue was observed during the 24-hour transverse vibration test

Reduced bolt tension tests

The bolt was torqued to the target torque and the system was allowed to 'relax'.
The bolt was then partially off-torqued until the bolt tension was grossly reduced (eg 25% of the 0.2% proof stress), the system was further relaxed and the vibration was commenced.
The bolt remained locked (latched) from the initial application of torque and was only unlocked when the preload was removed.



Factors that might affect the locking effect of the Cross Spiralock Wire Thread Inserts

Base materials - the base or parent material into which the insert is installed has no effect on the required torque or the locking effect.

Length of insert / length of engagement - has no effect on the required torque or the locking effect, but is very important from the aspect of 'pull-out' from low shear strength materials.

Bolt finish - various bolt finishes and plating types have been investigated. The bolt finish contributes to the 'torque resistance' of the system but not the locking effect e.g. the minimum locking force of a bolt installation is inversely proportional to the 'torque resistance'.

Lubricants - more than 40 lubricant systems have been investigated. Light machine oil on the thread has provided the best consistency of results.

Long term transverse vibration - in excess of 1 million cycles have been continuously applied to a single bolt / insert installation with no loss of bolt tension or indication of the onset of bolt fatigue.

Undoing and doing-up - a single insert installation has been tested in excess of 200 torquing, vibration testing and 'undoing' cycles with no loss of bolt tension or test failure.

Straight-line relationships - a number of important relationships has been revealed by the analysis of the various test results enabling CMC to predict accurately the required torque for any specific bolt type and size.

Bolt tension reduction - If a bolt is torqued to the CMC recommended torque value, and then partially off-torqued ('undone') so that the bolt tension drops from the initial design requirement, the system remains locked (latched). Application of the critical transverse vibration will not loosen the bolt. Unlocking only occurs when the bolt tension is removed.

Conclusions

Test results have shown that few locking devices work efficiently when subjected to severe transverse vibrations (e.g. standard and prevailing torque inserts). Those systems that do prevent bolt loosening usually incur the risk of bolt fatigue (eg Schnorr Safety Washers, Nord-Lock, thinwall inserts, Loctite compounds 268 and 270).

Only the Cross Spiralock Wire Thread Insert and the Spiralock threadform (in steel) appear to retain both properties of resistance to bolt loosening and improvement of bolt fatigue life under the severe test conditions.