# Why Nuts and Bolts can Self-Loosen

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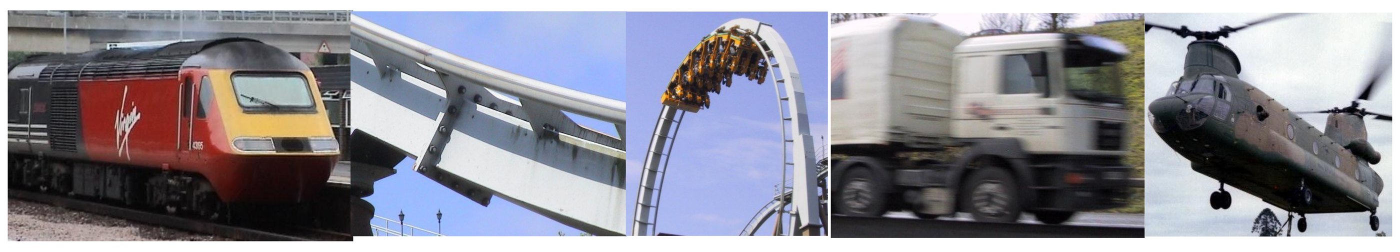

## 1. Introduction

Practically every engineering product with any degree of complexity uses threaded fasteners. A key advantage of threaded fasteners over the majority of other joining methods is that they can be dis-assembled and re-used. However, this can be a source of problems in that they can self-loosen. Such self-loosening has been a problem since the start of the industrial revolution and for the last 150 years inventors have been devising ways in which it can be prevented.

Accidents directly due to fasteners coming loose occur across several industries some of which have catastrophic consequences.

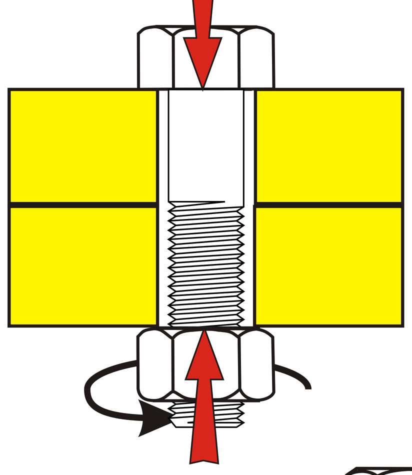

*Figure 1*
*In most applications, bolts are used in clearance holes and rely, for their structural integrity, on the preload induced by tightening the fastener. If the fastener self-loosens, the preload will be reduced or eliminated which can lead directly to structural failure.*

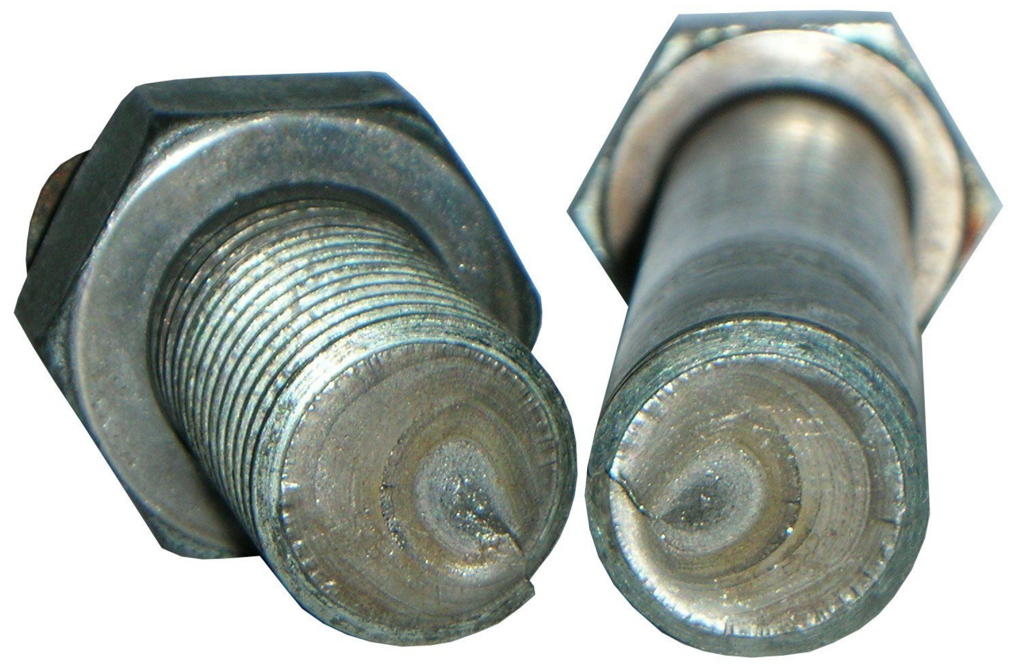

*Figure 2 - Fatigue failures of bolts is often as a consequence of self loosening.*

## 2. Previous Research

The most influential research published on the subject to-date was by Gerhard Junker in 1969 in which he reports on a theory he developed as to why fasteners self-loosen under vibratory loading. Junker found that transverse dynamic loads generate a far more severe condition for self-loosening than dynamic axial loads.

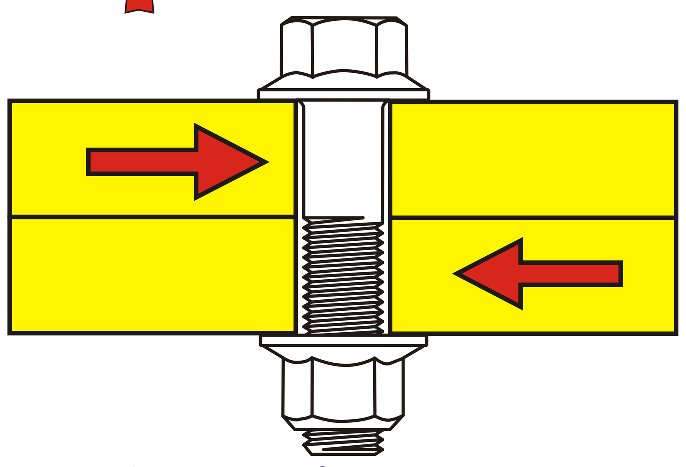

*Figure 3 - Junker found that transverse joint movement was the cause of self-loosening of threaded fasteners.*

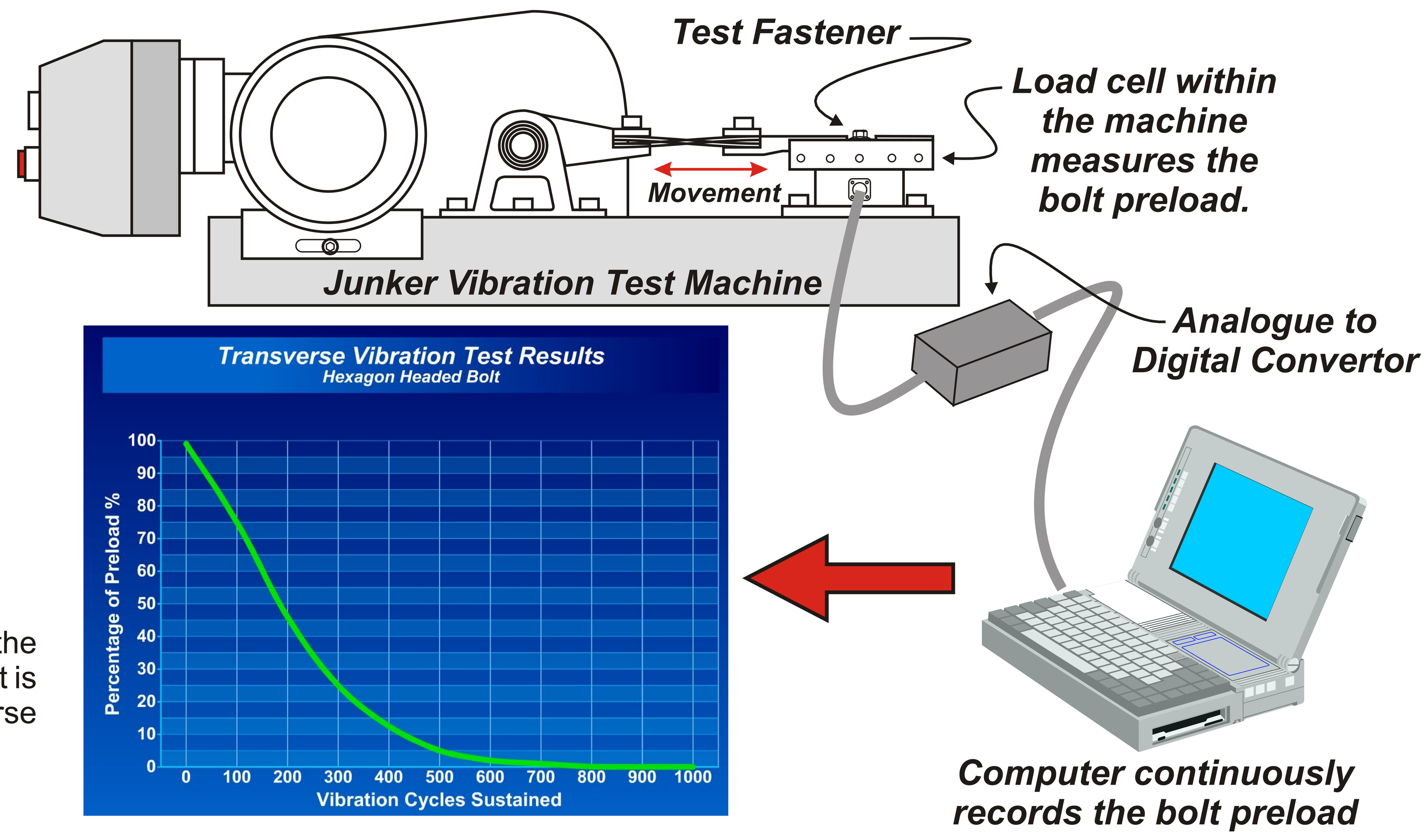


*Figure 4 - So called preload decay charts are used to indicate the resistance of a particular type of fastener to self-loosening. Such charts plot the bolt preload against the number of test cycles.*

## 3. Why do fasteners self-loosen?

Preloaded fasteners self-loosen when relative movement occurs between the mating threads and the fastener bearing surface. Such relative movement will occur when the transverse force acting on the joint is larger than the frictional resisting force generated by the bolt's preload. Under repeated transverse movements this mechanism can completely loosen fasteners.

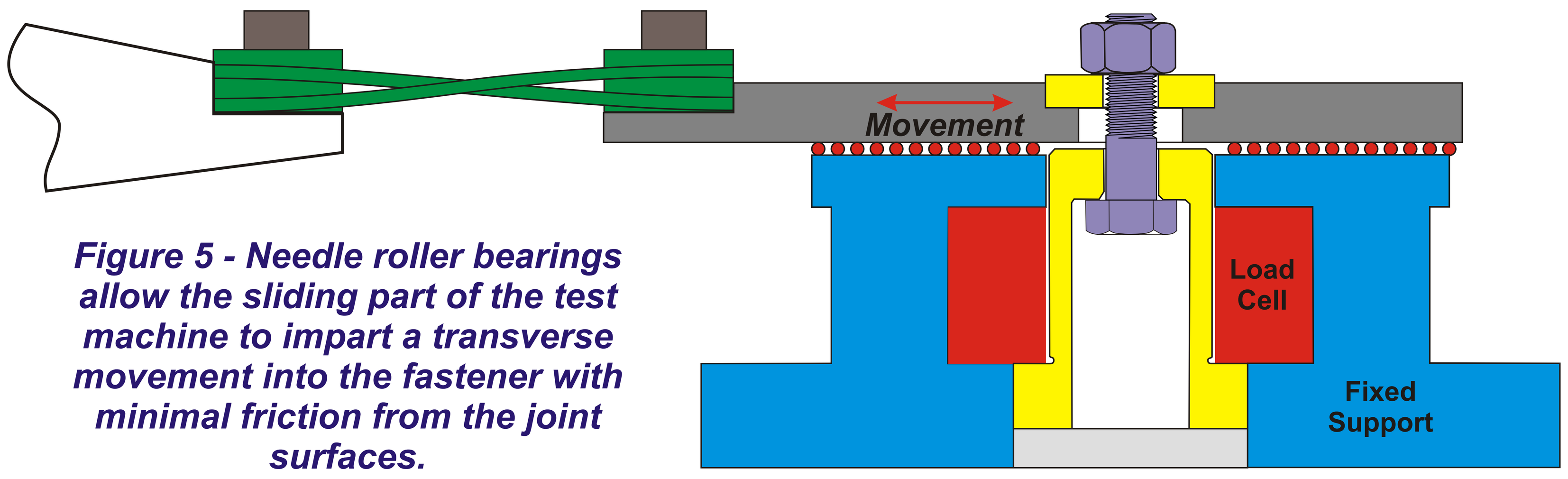


*Figure 5 - Needle roller bearings allow the sliding part of the test machine to impart a transverse movement into the fastener with minimal friction from the joint surfaces.*

## 4. Self-loosening Test for Fasteners

Junker developed a test machine to investigate the effect of transverse movement on preloaded threaded fasteners. The test machine allows a cyclic transverse displacement to be imparted into a bolted joint. A load cell within the joint allows continuous monitoring of the bolt load as transverse motion is applied to the bolted joint. This is the standard type of test machine used to investigate the self-loosening process. An overview of the test arrangement is shown in figure 4 with a section of the machine in figure 5.

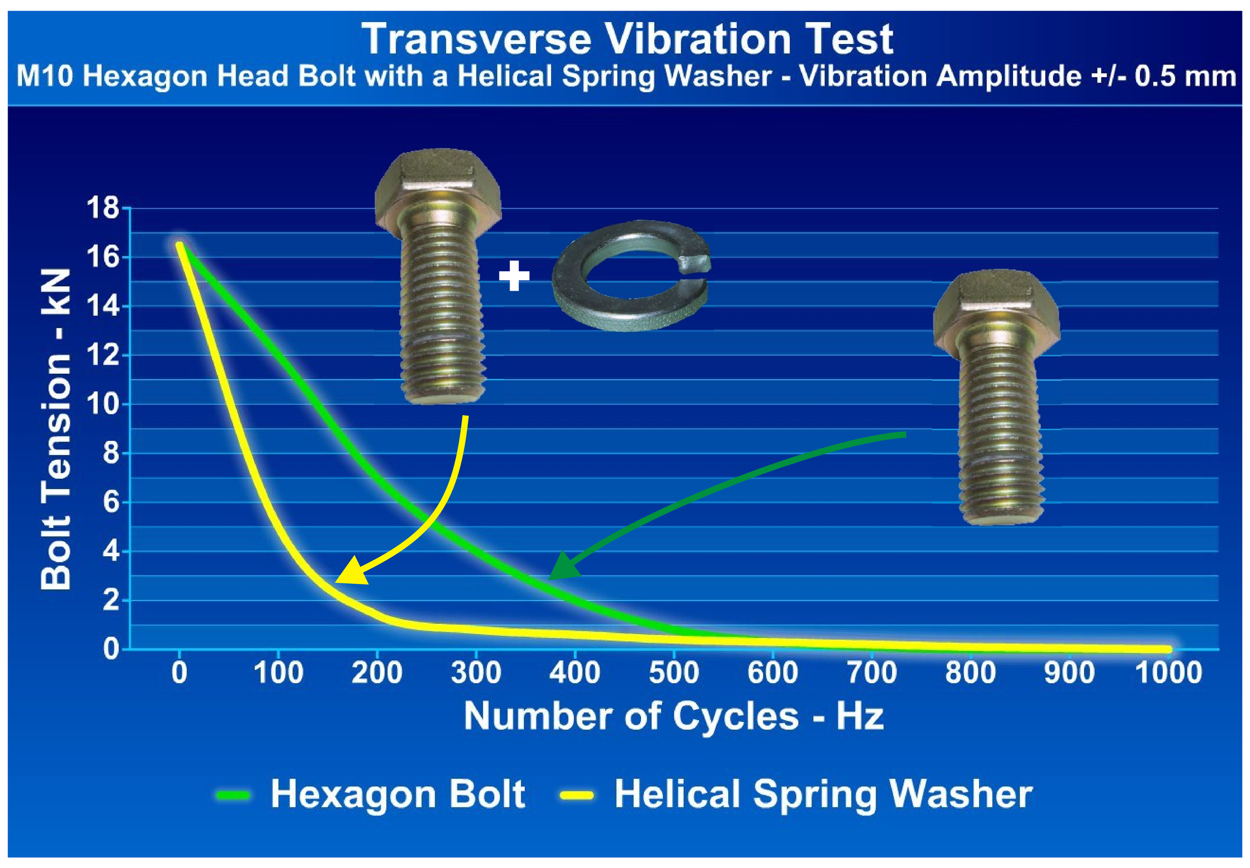


*Figure 6 - Some so called locking devices have been shown to be completely ineffective in preventing loosening. For example placing a helical spring washer under a bolt head can result in it loosening faster than by just using a bolt alone.*

## 5. Prevailing Torque Nuts

Nuts having a prevailing torque are frequently used to prevent complete loosening of a bolted assembly. There are a large number of different types of prevailing torque nuts. As the prevailing torque increases it is known that the resistance to self loosening increases but so does the torsional stress induced by the frictional drag on the threads.

A Junker test machine was modified to allow axial forces to be applied simultaneously to the joint as well as a shear loading. The test arrangement is shown in figure 9.

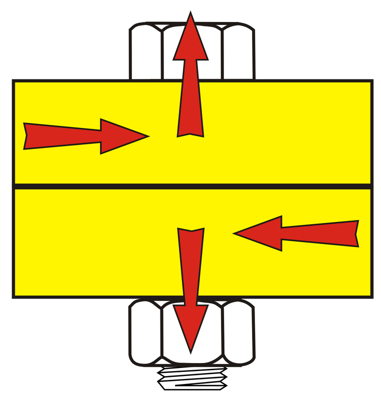

*Figure 7*
*Many joints are loaded simultaneously both axially and in shear.*

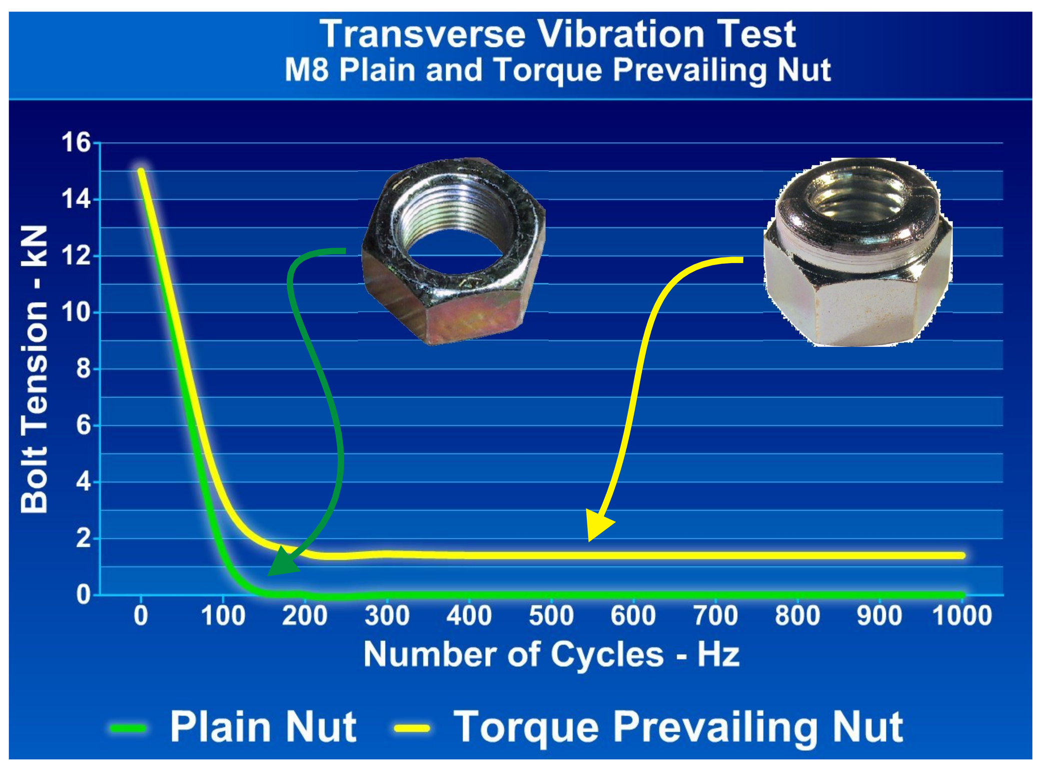


*Figure 8 - Since prevailing torque nuts can really only be regarded as bolt retention devices rather than 'lock nuts'.*

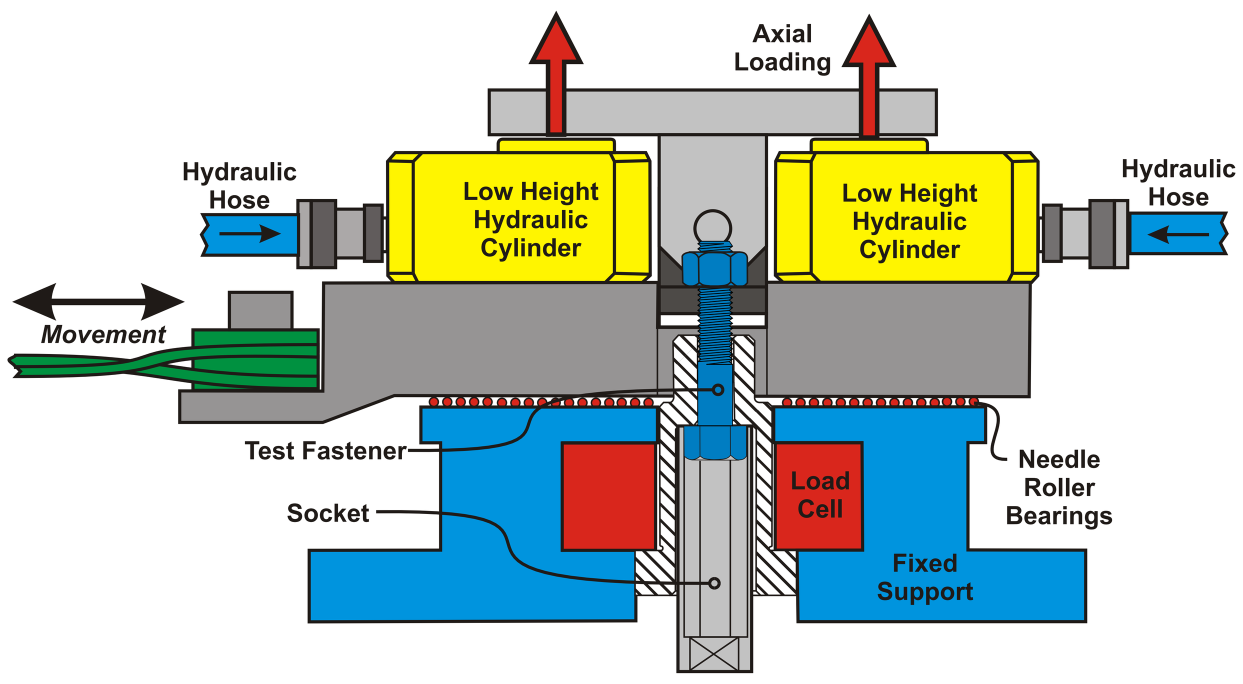


*Figure 9 - A Junker test machine was modified to allow axial loading to be applied to the joint as well as transverse movement. Under suitable test conditions, prevailing torque nuts can continue to self-loosen leading to their possible detachment from bolts.*

## 6. Relaxation

Self-loosening is when the fastener rotates under the action of external loading. Non-rotational loosening is when no relative movement occurs between the internal and external threads but a preload loss occurs. When preload loss occurs without fastener movement, the term relaxation is used.

Embedding is a form of relaxation and is due to local plastic deformation that occurs under the nut face, in the joint faces and in the threads as a result of plastic flattening of the surface roughness. This occurs even when the loading is below the yield point of the bolt or the limiting surface pressure of the joint material and is the result of the real area of contact between surfaces being less than the apparent area.

In practice, the loosening of nuts and bolts is often a combination of relaxation leading to a preload reduction allowing joint movement to occur. Once joint movement is initiated, the fastener/joint usually fails either due to self-loosening or fatigue.

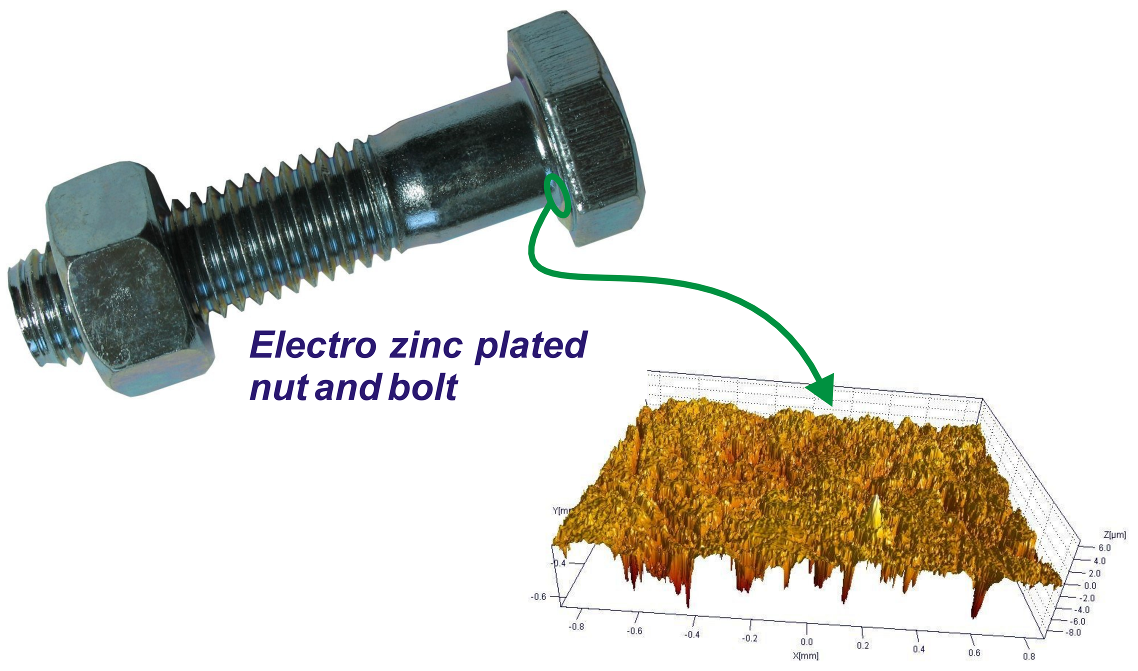


*Figure 10 - The contours of even apparently smooth surfaces are anything but smooth when magnified. This leads to high localised stresses when loads are applied to a bolted joint. This leads to a partial collapse of the contact surfaces and a reduction in the bolt preload. The surface collapse occurs both during tightening and afterwards once joint loads are applied.*

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