Simple Test Technique to Determine Type of Fastener Loosening

Bolted joints have been around since the dawn of the industrial revolution. They are still widely used to join components in modern products and that is not surprising since they are cost effective while being relatively easy to assemble and disassemble. Bolted joints are extremely reliable through the life of the product, as long as the bolt remains tight. Unfortunately, bolts often loosen when placed in service, and they can become a source of reliability problems. Bolt loosening can be due to relaxation, self-loosening, or a combination of both.[2]

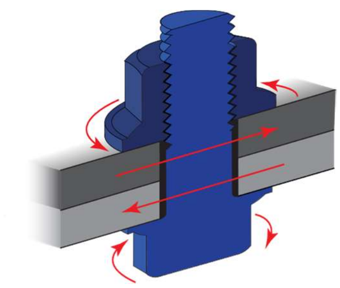

Image 1: *Self-Loosening of Bolt & Nut*

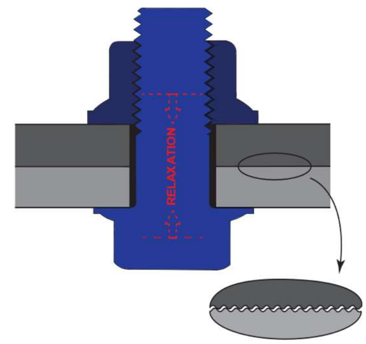

Image 2: *Magnified View Showing Asperities in Contact*

Self-loosening is the process where the external and internal threads rotate counterclockwise relative to each other due to external loading. [2][3] This type of loosening usually is triggered by repeated slipping of the joint due to reversing shear loads as shown in Image 1. In extreme cases, it is possible for the bolt to self-loosen completely, and for the bolt to fall out altogether.

Relaxation is the process where the external and internal threads do not rotate and yet the bolt still loosens.[2] This type of loosening is usually caused by the plastic flattening, or embedment of the load bearing surfaces as shown in Image 2. The surfaces of the joint interface and fastener threads appear to be smooth. Yet under a microscope, it becomes apparent that the surfaces consist of asperities. When the mating surfaces are brought together to create the joint, the asperities make contact and plastically deform.[1][2] While some of the relaxation occurs during the tightening process, the majority of relaxation occurs during the initial high load cycles. Since most bolted joints are not repeatedly retightened after the initial assembly, the relaxation which happens in service results in loosening.

Product Testing

Products are commonly tested under simulated or actual service conditions and loose bolts are frequently discovered after the test. When loose bolts are discovered, it is important for the engineer to understand the type of loosening which occurred. This information can be used to guide the engineer to make design changes and/or choose the thread locking method (i.e. wedge lock washer, chemical thread locker, etc.) that will prevent the joint from loosening when it is placed in service.

Use of Torque Stripes to Detect Type of Loosening

Many companies require assemblers to mark the head of the bolt or the nut with a paint stripe, otherwise known as a torque stripe or witness mark, to attest that the bolt was tightened to the proper torque value. This technique is a valuable quality assurance step, but what is not widely known is that torque stripes can also be used to detect the type of bolt loosening which occurred during a test if the paint stripe is extended to include the joint as shown in Image 3.

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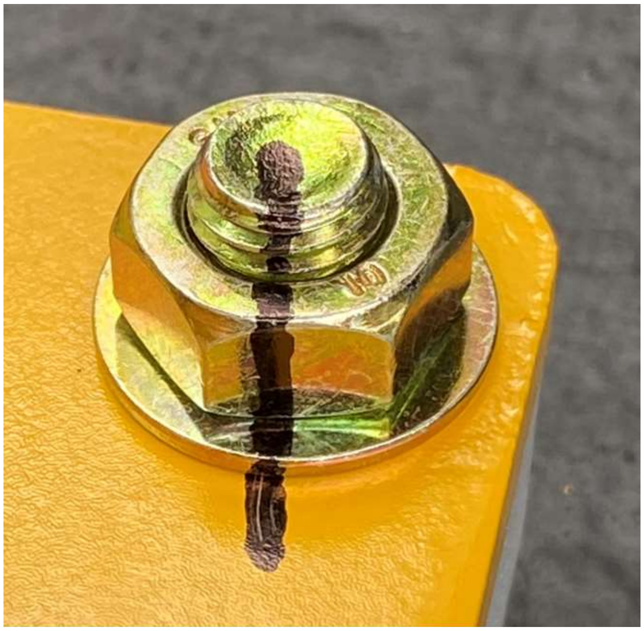
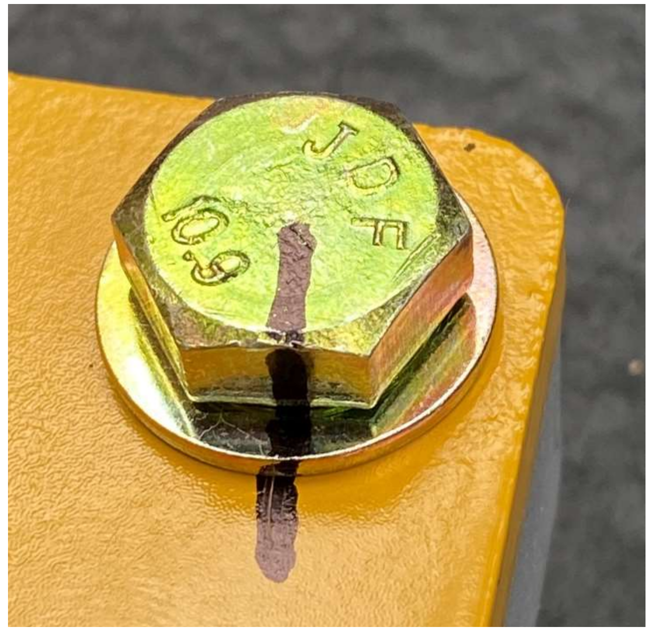


Torque Stripe Applied to Bolt & Nut



Torque Stripe Applied to Bolt Head (Bolt in Assembled in Tapped Hole)

Image 3: *Torque Stripes to Detect Type of Loosening*

Detecting Self-Loosening
Self-loosening can easily be detected after the test by looking for evidence that there was relative counterclockwise movement between the internal and external threads as shown in Figure 4.

Detecting Relaxation
A qualitative measurement of relaxation in the bolted joint can also be made using torque stripes if the bolt is retightened to the original torque value after the test. If the torque stripe shows relative clockwise movement between the internal and external threads after re-tightening, it is likely relaxation occurred during the test as shown in Figure 4.

Following is a simple test procedure which can be used to identify self-loosening and/or relaxation in a bolted joint.

1. Prior to assembling, lubricant the threads and the rotating, load bearing surfaces of the nut or bolt.
2. Assemble and tighten the nut or bolt to the recommended torque value using a calibrated torque wrench.
3. Using a paint marker, apply the torque stripe to each nut/bolt. The stripe should extend from the nut/bolt head, over the washer and to the joint as shown in Image 3.
4. Complete the desired test(s) in simulated or actual service conditions.
5. Observe and record the angle of relative counterclockwise movement between the internal and external threads.
6. Loosen the nut/bolt approximately 30° and retorque the nut/bolts to the same torque value used in Step 2 using a calibrated torque wrench.

7. Observe and record the angle of relative clockwise movement between the internal and external threads.
8. The type of loosening which occurred during the test can be determined using Figure 5.

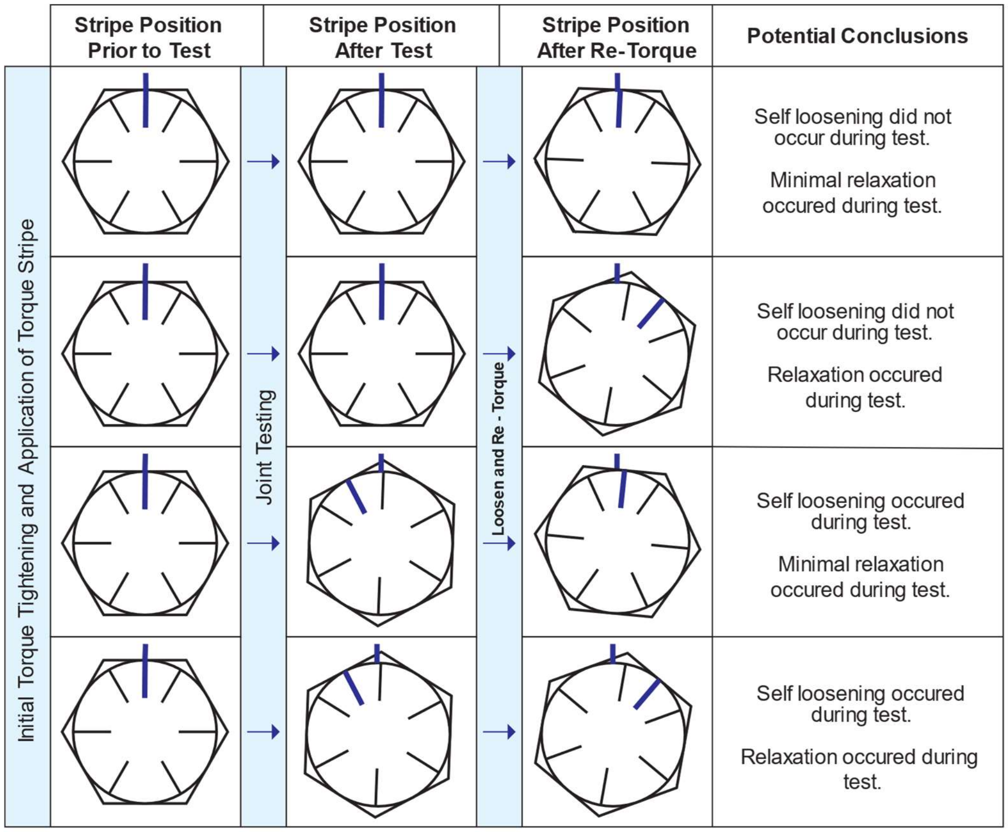


***Figure 4** – Using Torque Stripes to Detect Type of Loosening*

Note: To improve the accuracy of the technique a calibrated torque wrench should be used to tighten the bolt or nut.

Understanding whether a bolt loosened due to self-loosening, relaxation or a combination of both is critical for making the right design changes or choosing the best thread locking method. Fortunately, a simple torque stripe can used to detect the type of bolt loosening that occurred.

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Jon Ness has over 30 years of engineering and design experience related to the development of mobile equipment, with technical expertise in the design and validation of dynamically loaded bolted joints. He has served as a consultant in the investigation of multiple field failures of bolted joints and led fastener testing activities. He has participated in numerous research projects related to preload relaxation in bolted joint, several of which are on-going. He has taught numerous classes related to Failure Modes and Effects Analysis and Bolted Joint Design. He is a licensed P.E. in the state of MN, a current member of UL2703 Standards Technical Panel and an FTI - Certified Fastener Specialist. www.matrixengrg.com

Special thanks to Tim Francis, and Karen Selof at RFA Engineering for their help creating in this article.

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