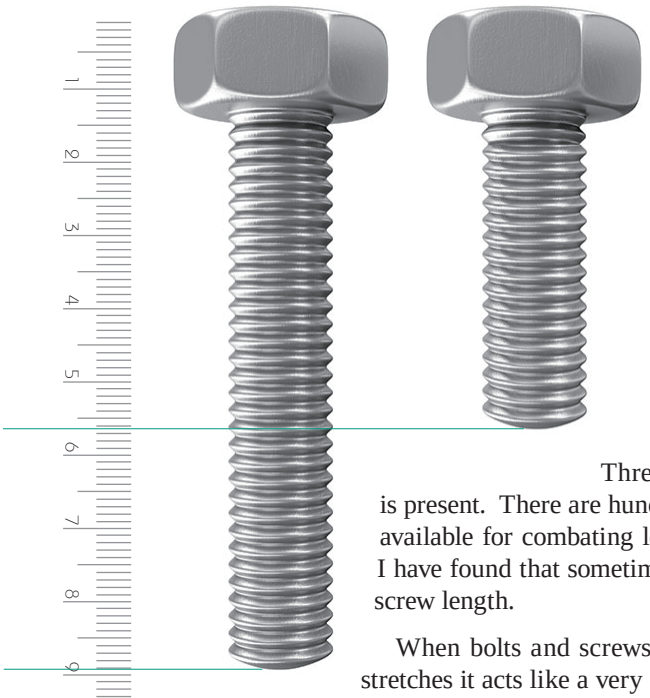
- Host your Middle Schools and High Schools for Manufacturing Day and create relationships with principals and select teachers, just as you would with a prospective customer.
- Include on your website, non-proprietary photos of your shop floor and work-in-progress to illustrate your operation is not a remnant of the early 20th century; training and advancement tracks; and testimonials from current employees.
- Consider a commuter or relocation package/ contract for program graduates from other parts of your region or state.
- Utilize established Tech Schools like El Camino Community College in Compton, CA or Rock Valley Community College in Rockford, IL.
- Support FEF (Fastener Education Foundation) through donations to enable funding of key initiatives. FEF is a 501(c)3 non-profit and supports the development and advancement of many of these training programs.
- Ally and align with other local manufacturers through your local chamber of commerce or manufacturing association.
- Consider finding sources that can lead you to the availability of veteran availability.
- Consider integrating this effort, as a measurable deliverable, into your HR manager' s annual plan.
- Do not decrease your investment in this process should you be successful in your current recruitment efforts.

Recruiting and retaining talent is a challenge we have and will continue to face. Our success depends, ultimately, on the people we employ in an ever changing shop floor and operational environment. Our traditional 20th century sources of skilled and non-skilled labor have turned against us or simply no longer exist. Fastener manufacturers and distributors today need to apply the same concepts of innovation to recruitment and retention as we do to production if we are to grow, let alone survive. Consider the applicability of the suggestions above in your organization. Even though margins are slim and challenged daily, this talent war requires long-term investment and budgeting as does every other aspect of our operations.

About the authors

Michael J. Lynch served Illinois Tool Works Inc. for nearly 30 years as its senior global public policy advocate including representing the company on K-12 education policy in the United States.

Phil Johnson is the President and CEO of ContMid Group LLC, recently acquired by the Agrati Group. Prior to CMG Phil was responsible for several ITW business units such as ITW Shakeproof and CIP (California Industrial Products). Phil is the current Vice-Chairman of the IFI and a current Board member and Past President of FEF (Fastener Education Foundation).



Long Bolts Resist Loosening Better Than Short Bolts

by Larry Borowski

Threaded fastener loosening is a common problem in applications where vibration is present. There are hundreds of bolt and screw types and additives such as lock washers and adhesives available for combating loosening fasteners. During my years of applications engineering experience I have found that sometimes the only thing that needs to be added to stop vibration loosening is bolt or screw length.

When bolts and screws are properly tightened they actually stretch a little. When a bolt or screw stretches it acts like a very stiff coil spring, which continually pulls the mating surfaces of the application toward one another. When the application is subject to vibration, the bolts will not loosen if the coil-spring like tension is adequate.

A scientist named Dr. Hooke derived what is referred to as Hooke's Law when he was developing springs to make clocks run for extended periods of time during the 1600s. Hooke's Law states that the strain (stretch) of a material is directly proportional to the amount of stress (force) exerted on the material until that stress exceeds the elastic limits of the material.

Hooke's Law is the underlying principle of bolting technology. Bolt stress increases as torque is applied. The strain or stretch of the bolt increases proportionally to the increase in stress. Bolt stretching occurs in the area between the bearing surface of the underside of the bolt's head and the bearing surface of the nut or face of the assembly component having the tapped hole into which the bolt is driven.

In steel bolts and screws the stretch is approximately .001 inch for every one inch of length between the bolt and nut bearing surfaces for every 30,000 pounds per square inch (PSI) of stress that is applied. If the distance between the bearing surfaces is one inch and 30,000 PSI is exerted on the bolt, it stretches .001 inches. If the bolt has a distance of 5 inches between the bearing surfaces it stretches .005 inches when 30,000 PSI of stress is exerted on the part.

If both ends of a fastener are accessible, one of the most accurate ways to determine optimum bolt or screw tightness is to carefully measure its length before installing it and then measure again as the part is being tightened. If the distance between the bearing surfaces is known, and the amount of stress that is required is known, the amount of desired stretch can be easily calculated.

Example:

Bolt description:	12-13 X 5 Grade 5 Hex Head Cap Screw
Distance between bearing surfaces:	4.000 inches
Desired stress in PSI:	75% of the yield strength
Grade 5 yield strength	92,000 PSI
75% of yield strength for Grade 5	69,000 PSI
Target stretch for this bolt:	(69,000 PSI / 30,000 PSI) * 4.000 in.=Target 2.3 * 4.000 in.=Target .009 in.=Target

This target stretch length is the same regardless of the bolt's diameter within a given strength grade because the stress rate is related to the PSI strength of the grade of bolt and is not related to the absolute number of pounds of stress exerted on the bolt. The number of pounds of force required to achieve the target stretch on a ¾-10 Grade 5 bolt is considerably greater than the pounds of force exerted on a 3/8-16 Grade 5 bolt, but the PSI (pounds per square inch of the minor diameter of the thread) required to achieve the target stretch is identical for both bolt diameters.

When short bolts or screws are used to join assembly components in an application subject to vibration, it is sometimes very difficult to stop loosening problems. Frequently, adding various types of washers or adhesives will not stop the loosening. What will usually stop the problem is to lengthen the bolt or screw used in the application so it can stretch more, thus enabling it to maintain greater tightness. Review the following chart showing the amount of target stretch for Grade 5 bolts having different distances between the bolt and nut bearing surfaces:

Distance Between Bearing Surfaces	Target Stretch Length
1.000 inches	.0023 inches
2.000 inches	.0046 inches
3.000 inches	.0069 inches
4.000 inches	.0092 inches

If the distance between the bearing surfaces on a Grade 5 bolt is only 1.000 inch, the joint only has to compress or otherwise move .0023 inches before the bolt will lose all its stretch and become loose. If the distance between the bearing surfaces is increased to 4.000 inches, the joint will have to compress or otherwise move .0092 inches before bolt stretch is completely lost and loosening occurs.

If exactly the same torque is applied to two bolts that are identical in every respect except length, the longer bolt is less likely to loosen than is the shorter bolt because the longer bolt will be stretched more. This is the essence of Hooke's Law.

When short bolts or screws persistently loosen they can be lengthened to take advantage of Hooke's Law by modifying the application in one of two ways:

A hardened bushing can be put on the bolt before screwing it into the tapped hole, or the application component having the tapped hole can be counterbored above the tapped hole providing more distance for the bolt to stretch.

Lengthening a bolt or screw is an extremely simple way to stop loosening due to vibration in many applications. Unfortunately, this approach is seldom utilized because most fastener users do not understand the role of Hooke's Law in bolting technology.