Key considerations for fastening solar structures

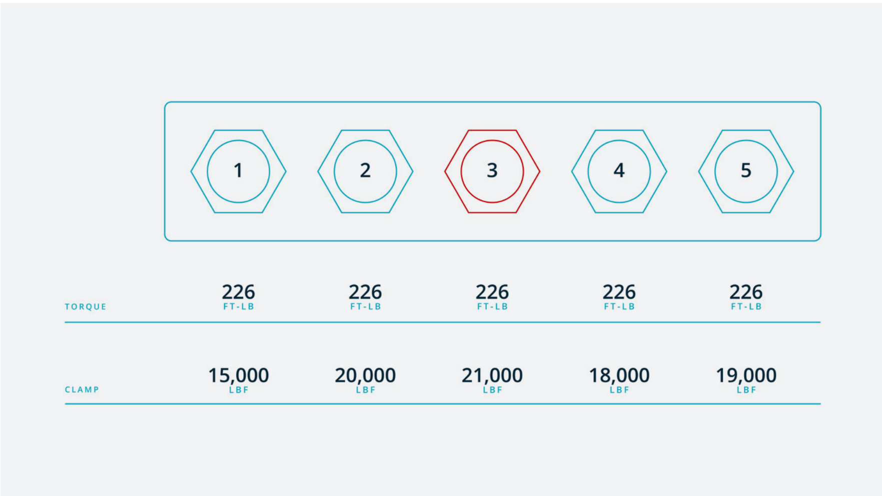
Solar racking and tracking systems contain thousands of fasteners throughout the various types of structures. Small and seemingly simple, the criticality of fasteners in the strength and structural integrity of photovoltaic systems is often overlooked.

Fastening methods in solar joining

Torque has long been the standard by which tightness of a joint is measured. Conventional thinking has been that the tighter the joint, the more secure it is. It then follows that the more torque that is applied to a standard nut and bolt assembly, the tighter and more durable the joint becomes.

In practice, however, using torque to fasten joints is no guarantee of joint tightness. Torque is not a measure of tightness but a measure of friction.

A better indicator of joint security is clamp. This is defined as the load on a joint brought about by the drawing together of the fastener components. This is a difficult value to measure when using torque installation, as any number of variables can affect the level of torque needed to appropriately tighten a nut onto its corresponding bolt.

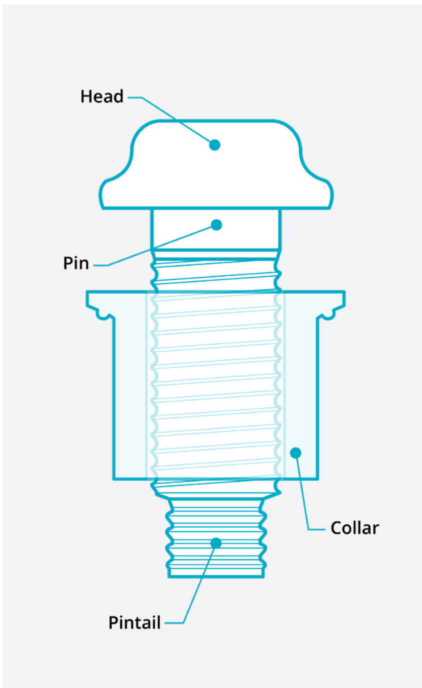


These variables, such as lubrication, diameter and thread pitch variance, atmospheric conditions, contaminants, tool calibration, and even thread wear, can result in clamp scatter of 30% or more. Clamp scatter of this magnitude is a challenge for joint designers because it can mean that the joint is not fastened as tightly as it could be.

Though a number of solutions exist to try and mitigate the clamp scatter experienced with conventional bolts and nuts, the only true method of controlling clamp is via direct tension installation.

Direct tension fasteners consist of two pieces which differ slightly from conventional fasteners. These two pieces are a pin, a version of a bolt, and a collar, a version of nut. The major difference between the fasteners is in the installation method.

During installation, a tool pulls on the pin to stretch it and take out the gap between the sheets of metal being fastened. The tool then deforms the collar around the threads or grooves of the pin to lock it in place.



The reason direct tension delivers a more consistent clamp than torque reliant fasteners (±2%) is that the metal in the pin is elastic. It stretches, in a similar way to an elastic band. When the collar locks into the pin grooves, it holds it in this slightly stretched position and when the tool releases, the pin tries to relax, thus exerting pressure on the joint that keeps it tight.

The elasticity of any bolt or pin is a measurable quantity. Direct tension installation takes advantage of the elastic range of the pin to deliver a consistent, repeatable clamp that results in reliable, tight joints upon installation.

Considerations for joint loading

Not only is clamp the true measurement of joint quality, it is a critical component of long term durability. Bolts with low or inconsistent clamp can experience the same service load as the joint. With a loose bolt, the cyclical loading is put on the bolt, which will subject it to fatigue.

Cyclic loading is a common challenge in traditionally high vibration joints such as Class 8 trucks or rail cars, but it is equally common in solar applications. Solar racking and tracking systems experience similar loads in windy conditions or when components move.

Joint failure usually occurs when there is high frequency loading, and often only several cycles are required to slowly propagate a crack across the cross section of a bolt. The nut and bolt will either loosen or fail when the diminished cross sectional area of the bolt is low enough to where it can no longer support the load.

In the same way, inconsistent clamp creates problems in joint integrity over time. The bolt or bolts that have more clamp will carry more of the service load while the bolts with less clamp actually contribute little or nothing to the strength of the joint as compared to those exhibiting proper clamp.

For example, in an application where only three out of six bolts exhibit proper clamp, the three properly clamped fasteners carry the majority of the load of the joint. Because those three bolts are doing the work of six, they are highly prone to failure.

Joints that are designed with direct tension fasteners see far less clamp scatter; ±2% versus 30% or more in conventional bolts and nuts, making them less prone to failure.

Vibration effects in solar installations

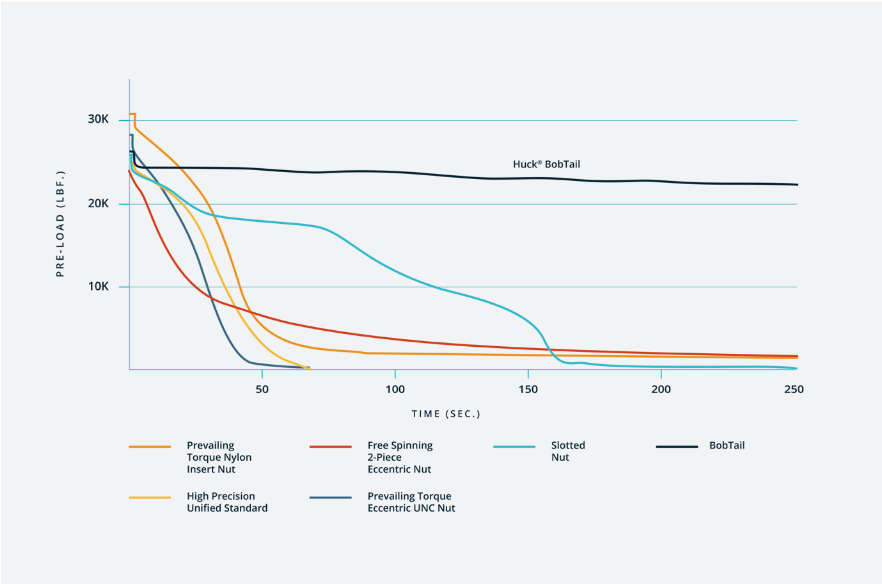
It is easy to overlook the effect of vibration loosening on joint integrity in solar applications. Solar racking appears to be a stable platform, particularly when compared to joint design in other industries such as commercial transportation or aerospace. But racking and photovoltaic panels experience vibration forces from wind, panel tracking, and seismic activity.

A properly clamped joint will offer more resistance to vibration loosening but is still subject to loosen over time. Fasteners that offer higher levels of loosening resistance will reduce maintenance costs and improve the longevity of the system itself.

Fastener loosening is a known challenge in joint design. Solutions such as torque indicating fasteners were created to delay or reduce the incidence of loosening. The challenge is that these fasteners typically rely on torque to install in the first place, therefore delivering varying levels of joint tightness.

Other, simpler solutions accept vibration loosening as a matter of course. Many torque installed fasteners require torque striping after installation, creating a simple visual marker to show when a nut has vibrated loose. This requires regular preventive maintenance that relies on human factors for problem identification and replacement.

In a properly tightened fastener, a major cause of vibration loosening is transverse vibration. Conventional bolts and nuts exhibit



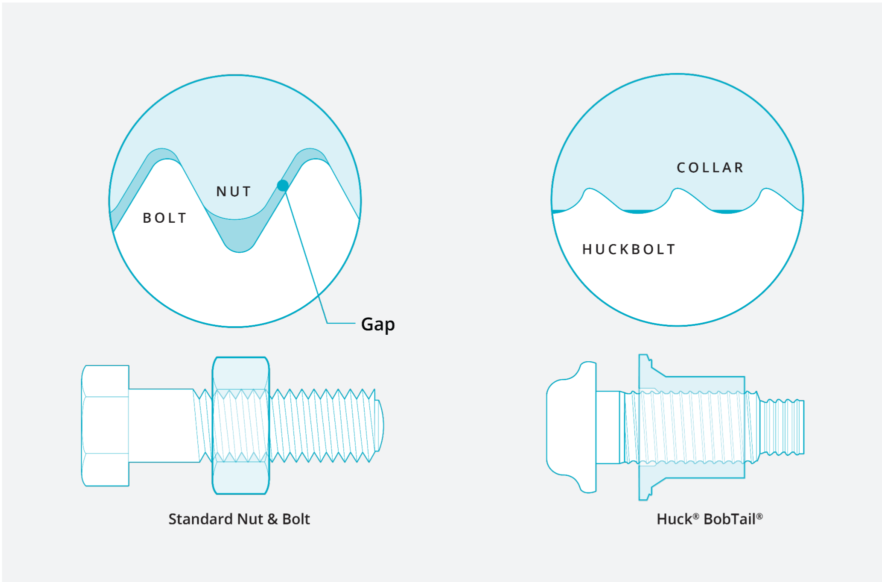
a gap between the crest of the bolt thread and the nut. When the vibration force acts perpendicular to the bolt, the nut can shift side to side and eventually 'back off'.

Because the gap between bolt and nut is an identified challenge for joint longevity, there are some torque type fasteners with vibration resistant nuts that have various methods of filling this gap between bolt and nut.

Alternatively, fasteners that install using direct tension are extremely vibration resistant. The installation tool deforms the collar into the threads of the pin during installation, a process called swaging. Swaging eliminates the gap between the pin and the collar and forms a permanent mechanical lock between pin and collar.

Reliability of installation

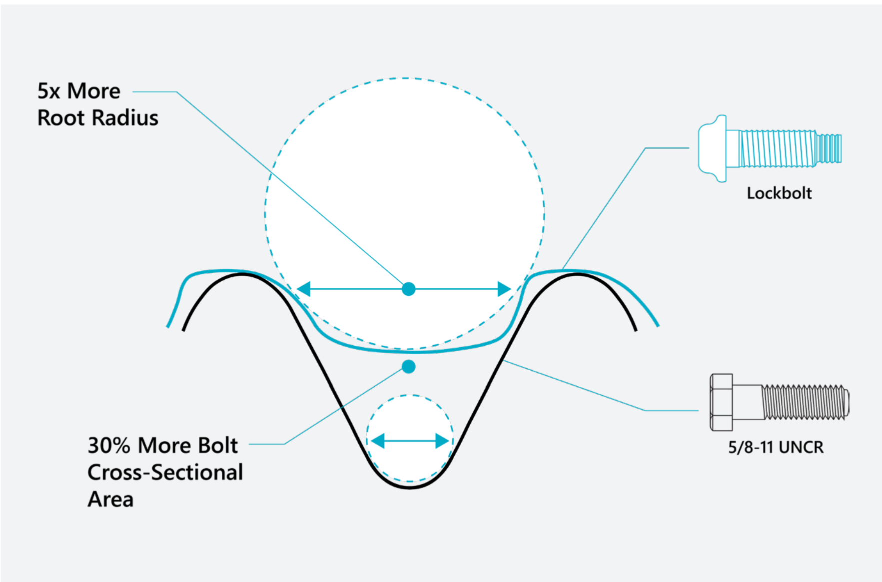
Direct tension fasteners are nothing new. They were invented in the 1940s to solve



challenges with installation speed and consistency. The fasteners and tools have evolved significantly in the intervening decades, but that speed and consistency is still an important factor to consider when designing a joint.

Solar racking and tracking systems are installed all over the world, sometimes in relatively inaccessible locations. While designers are tasked with considering the integrity and longevity of their joint, the achievability of that joint in the field should also play a part in the design.

Torque installation relies heavily on the conscientiousness of the operator and the calibration of the tool for proper installation. Alternatively, direct tension installation is easy, requires very little operator training, and is increasingly performed with next generation battery tools that are both ergonomic and environmentally friendly.



With the global reach of solar installations, installer up time cannot be discounted. Nor can the repeatable consistency of direct tension installations. The final installed cost of the fastener should be considered when selecting the right fastener solution for an application.

Though a seemingly minor part of the final product, fasteners play a key role in the design of solar racking and photovoltaic panels. When making selections, joint designers should consider the full installed cost for their application. Joint tightness, longevity, and maintenance cost over the life of the product should be factored into the design. Ease and repeatability of installation is another crucial factor that designers should also consider when making fastener selections. Direct tension fasteners demonstrate a number of distinct advantages in each of these criteria and should be used seriously in joint design for solar applications.

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