

TECH SHEET

PEM® - REF / PEM® RT™ THREAD FORM

SUBJECT: Technical review of PEM® RT™ vibration resistant thread technology

Loosening of threaded fasteners due to vibration has been a problem from the first use of threaded fasteners. However, the cause of vibration loosening was not well understood until relatively recently.

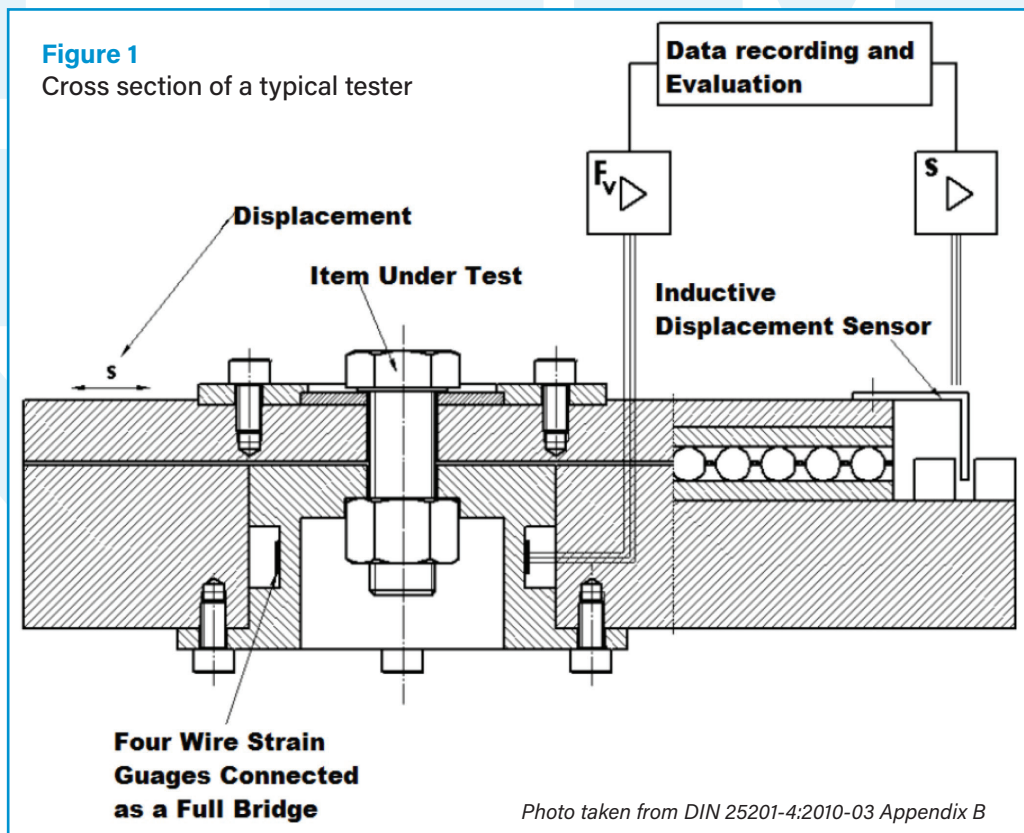
In 1969, Gerhard Junker published SAE paper No. 690055 titled "New Criteria for Self-loosening of Fasteners under Vibration." Junker put forth the theory that fasteners "self-loosen" when there is simultaneous relative motion between the mating threads and the loaded face of the bolt or nut that is loosening. To understand how this simultaneous relative motion causes self-loosening, two other concepts must be understood.

First, we must understand the limits of frictional forces. If frictional forces are overcome causing relative motion in one direction, there is no additional frictional force available to oppose motion in a different direction. For example, if a cardboard carton containing 20 pounds of PEM® brand self-clinching fasteners is being pushed across a level concrete warehouse floor to the north, it is theoretically possible to push the carton to the west with zero additional force. In the same manner, a cork can be removed from a bottle with minimal axial force while it is being rotated with a corkscrew. A similar but slightly different illustration is a car being driven around a curve at a speed so high that the tires are about to break loose. If the driver were to hit the brakes, the car would immediately go into a skid because the available friction force was nearly consumed by steering, leaving very little for braking.

Second, we must understand the distribution of the tightening torque applied to a threaded fastener. Typically, only 10 to 15 % of the applied torque is used to induce clamp load. This can be easily demonstrated by comparing the tightening torque to the loosening torque. The loosening torque will typically be 70 to 80 % of the tightening torque. If we assume a given fastener was tightened to 100 units of torque and loosened using 76 units of torque we know that 12 % of the tightening torque was used to induce load. We know this by understanding that friction always opposes motion and by understanding that the tightening torque is a function of clamp load and the thread helix angle. Clamp load in combination with the thread helix would cause rotation in the loosening direction if there were no friction present. Therefore, in this example, during tightening there were 88 units of friction and 12 units of tightening for a total torque of a 100 units. During loosening there were still 88 units of friction but the 12 units of tightening changed direction for total loosening torque of 88 minus 12 or 76 units. It is also important to note that studies have shown that the frictional torque is nearly equally divided between the threads and the loaded face of the turned member (screw or nut). If these two torques were exactly the same in the above example the thread frictional

torque would be 38 units and the bearing face frictional torque would be 38 units. Note that both of these frictional torques are over three times the loosening torque generated by the clamp load. This means that either one alone will prevent self-loosening and is why there must be simultaneous movement at both friction interfaces for self-loosening to happen.

With these basics in mind, we can now understand that if Junker could cause simultaneous motion at both friction interfaces, he could cause self-loosening. To do this he developed a machine that causes one of two plates clamped together by a test fastener to move relative to the other in a transverse direction. For short grip lengths and large enough transverse displacement there will be transverse movement between the mating thread flanks and between the loaded face of the test fastener and the non-rotating plate. Junker added a load cell to monitor the clamp load during testing and added needle bearings between the two plates to reduce the force needed to cause transverse motion. Today, in industry, transverse vibration testers of this type are typically referred to as Junkers machines. There are now two consensus standards covering this type of testing; ISO 16130 and DIN25201-4.



We can now understand why PennEngineering[®] fasteners with the PEM[®] RT™ threads resist vibration loosening. The PEM RT internal thread form has a modified angle on the loaded flank. Instead of the standard flank angle, which is 60 degrees from the long axis of the fastener, the angle at the initial point of contact with the mating screw is 30 degrees. The 30 degree angle resists transverse motion between the mating threads. This means the frictional torque in the thread remains in place turning vibration and prevents self-loosening. Self-loosening will not occur, even if the vibration causes relative motion at the loaded face. This is true because as previously described, both frictional torques are significantly greater (typically about three times) than the self-loosening torque.

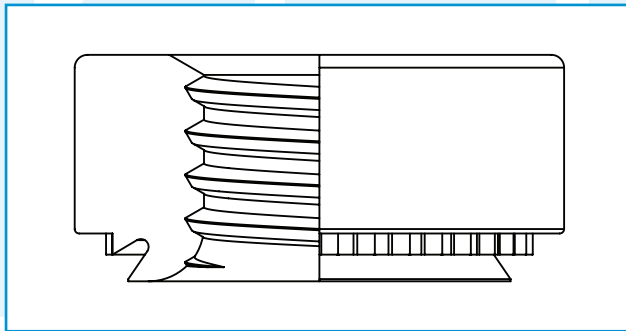


Figure 2
Thread pitch that is >0.7mm will have the "Compound Angle" profile.

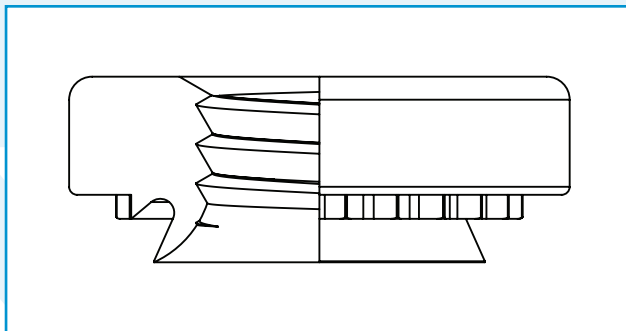


Figure 3
For ≤ 0.7 mm pitch, the thread profile will be the "Saw Tooth".

The PEM RT internal thread form also has the advantage of being free spinning when mated with screws sized below the maximum of class 2A/6g until clamp load is developed. When unified RT internal threads are mated with class 3A (or metric tolerance position h) screws or plated class 2A (metric 6g) screws exceeding the maximum size of class 2A (metric 6g), there may be a slight prevailing torque.

The PEM RT internal thread form is directional meaning that the vibration loosening benefit is only realized when the screw is inserted in the correct direction. Since self-clinching nuts are by design also directional, they are ideal for use of this special thread form to create a vibration loosening resistant fastener. This assumes the screw is entered from the shank end and the induced clamp load pulls the head of the clinch nut against the panel.

Common Questions about the RT Thread Form:

▪ What is the Effect on Torque-Tension?

Because the initial contact between a PEM RT internal thread and the mating screw is at the screw major diameter, the "K" value or nut factor might be higher than with standard screw threads. Testing of various thread sizes of the PEM RT internal thread in standard S™ clinch nuts with ZI (zinc and clear trivalent) mated with socket head cap screws with black oxide finish have shown that the average K value is 0.30. This is higher than the typical value of 0.18 to 0.20 for zinc plated steel hardware.

▪ What Happens if Clamp Load is Lost?

The RT thread is free spinning until clamp load is induced, but consequently it also returns to being free spinning when all clamp load is lost. For routine disassembly for maintenance, this is a good feature. However, some designers are concerned about complete self-loosening and loss of the loose fastener with resulting catastrophic failure. It is sometimes believed that a prevailing torque-locking feature is a better choice. PennEngineering has produced several different styles of self-clinching nuts with prevailing torque locking features for many years and they are appropriate in many applications. However, testing shows that most prevailing torque locknuts do not retain preload when subjected to transverse vibration. Therefore, the RT thread form could be the better solution in certain applications, particularly when the joint is subject to transverse loading and the usefulness of the device depends on some level of clamp load being maintained. One common example of a joint that loses its usefulness with preload loss is a casketed pressure joint. Below some level of preload, the internal pressure will open the joint and cause leakage.