

CAPABILITY PAPER

Enduralock® Vibration Resistant Fasteners

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Bottom Line Up Front (BLUF):

Fasteners are often overlooked as commodity items, but their reliability and attributes are essential not only to the warfighter but essential also in the reduction in the time and cost of maintenance for the Command. Enduralock® offers numerous fastener designs, all intended for use in high vibration harsh environments. All Enduralock® fasteners are mechanically locking, highly vibration-resistant permanent fasteners, but for maintenance they are fully reversible and reusable with a standard hex socket. They remain locked even with total loss of preload (clamping force). In vibration testing, Enduralock® fasteners withstood 10x the aerospace requirement. Enduralock®'s self-aligning nut plate will engage an off-axis bolt and then self-align during tightening. It also provides for a fixed position panel bolt retaining ring, which reduces the chance of FOD (foreign object debris). Enduralock® fasteners and nut plate provide for a dramatic reduction in the time and cost of installation and maintenance.

Technology Category: Various

Technology Readiness Level: 9

Fastener Technology

The **Radial Lock Fastener** is a mechanically locking, high vibration-resistant permanent fastener, that for maintenance is reversible and reusable. There are 2 machined flats on the bolt down to the root of the thread and similar flats on the hole of the washer. This constrains the washer in rotation. There are circumferential teeth along the inner rim of the washer. A lock member spring has arms that snap onto the nut with teeth at their base. When the components mesh, the nut can no longer rotate, as the lock member mechanically couples it to the washer, which is constrained in rotation by the machined flats. The nut is permanently locked, but when a standard hex socket is applied, the arms flex inward and disengage the teeth, which unlocks the fastener.

The **Radial Lock Bolt** incorporates the Radial Lock fastener's locking technology in the head of the bolt. The bolt flats are eliminated, and axial or radial tabs are added to the washer to constrain the rotation of the washer. The technology provides for the permanent attachment of a panel to a substrate, yet it allows for easy removal of the panel for maintenance with a standard hex socket.



The **Silver Lock Fastener** and the **Silver Lock Bolt** employ stamping, forging, and metal injection molding processes to reduce the cost of the fasteners. Other than the orientation of the teeth on the washer and the lock member spring, they function identically to the Radial Lock fastener and Radial Lock bolt.

The **Tidal Lock Fastener** and the **Tidal Lock Bolt** are manufactured through stamping, forging and metal injection molding processes. The preassembled 2-piece washer has radially inward facing teeth at the end of arms. The nut contains a serrated gear component (preassembled), and there are machined flats on the bolt down to the root of the thread and on the hole of the washer. When the components mesh, the nut is locked, but when a standard socket applies axial force on the washer, the arms are deflected, and the teeth are disengaged. The nut is free-running until the socket is removed, at which point it permanently locks. The Tidal Lock bolt incorporates the locking mechanism into the head of the bolt.



Innovation Capabilities

A primary benefit of the technology is that it saves time and money in installation and maintenance. Enduralock fasteners can eliminate the need for safety wire. A mechanic at Bell Helicopter, for example, can safety wire 10 fasteners per hour (\$150 hourly labor rate). In the same amount of time, *over 300 Enduralock fasteners* can be applied. No specialized tools are required, as only a standard 6-point socket is utilized. As the fastener permanently locks (through teeth engagement), fewer maintenance checks are required to ensure that the fastener remains tightly engaged. The fastener does not rely on friction or thread deformation for its locking feature, so it can be removed and reapplied numerous times. The teeth of the fastener are not engaged during installation or removal, so there is minimal wear of the teeth over time. As the nut is free-running with socket engagement, an accurate preload (clamping force) can be applied. This is essential when clamping composites. All components of the fastener are manufactured out of metal, so they are also ideal in high temperature applications. The mechanical lock is unaffected by large temperature changes.

Innovation Test Outcomes

The requirement for a self-locking nut in aerospace (NASM 1312-7) is to withstand 30,000 cycles of vibration. These fasteners survived 300,000 cycles. Following vibration testing, the fatigued parts underwent tensile testing, where they proved to be Type I bolts and Class II nuts. They have been tested for reuse up to 250 times. Variance in preload bolt to bolt is approximately 5.7%, which is comparable to fasteners that permanently deform the thread.

Applications

Applications include armor attachment, tread components, ground vehicle suspension, elimination of safety wire in gun turrets, and use throughout rotorcraft.

Specifications and Availability

The Radial Lock and Silver Lock fasteners are available in sizes of ¼” to 1” and larger. The Tidal Lock fasteners are available from ¼” to ½”. All of the fasteners can be manufactured out of most metals. Orders are custom, and lead time is typically 6-8 weeks. Protective caps that thread onto the washers and protect the locking mechanism are also available for all of the fasteners.



Nut Plate Technology

Enduralock’s **Self-Aligning Nut Plate** is the only nut plate to incorporate an axially spring-loaded nut element. This allows for axial and radial flotation of the nut element. It will engage a bolt that is off-axis (up to 15 degrees), and it then self-aligns during tightening of the bolt. It also allows for a fixed position panel bolt retaining ring, which greatly reduces the chance of breakage and FOD (foreign object debris).

Innovation Capabilities

The primary benefit of the technology is that it saves time and cost in maintenance. Other nut plates may provide for radial flotation of the nut element, but they do not provide for axial flotation, so off-axis bolts will not engage. Access panels can have many bolts attached to the rim of the panel. During reapplication, other nut plates require that all bolts be lined up to the axis of each nut plate before the first one can be tightened. For large panels, this lengthens the time required for maintenance. Enduralock®’s nut plate will engage off-axis bolts and then self-align during tightening, so there is a dramatic reduction in the time required for reapplication of the panel.

Innovation Test Outcomes

In independent testing per NASM25027 Rev. 1, the nut plates satisfied the locking torque, breakaway torque, and removal torque for 25 cycles (only 15 cycles are required per the protocol). Axial tensile testing surpassed the requirements of NASM1312-8 Rev. 2.

Applications

Nut plates are used for the attachment of access panels in aircraft and drones. There are, for example, 3500-4500 nut plates in a helicopter. They are also utilized in the dashboard of ground vehicles.

Specifications and Availability

The nut element is A286, and the other components are CRES 300 series. Nut plates are available to accommodate 3/16” to ½” bolts. Orders are custom, and lead time is typically 6-8 weeks.

Past Performance of Technology and Company

- Enduralock has a US Air Force contract to develop *No.4 – No.10* high vibration resistant, mechanically locking fasteners for the elimination of safety wire in spacecraft and missiles (conventional and hypersonic).

- Enduralock has a US Air Force contract to develop the first *mechanically locking*, self-aligning nut plate.
- CCDC Ground Vehicle Systems Center (GVSC) purchased fasteners in Q2 2020 for ballistics testing for armor attachment. Current armor is attached with normal bolts that are torqued to a high degree to try to prevent loosening over time due to vibration. Studies show that with a blast force, the bolts shear at the head. GVSC did a study that showed that bolts applied with 40% recommended preload survived the blast. With this preload, however, they would vibrate loose over time. Enduralock bolts remain locked with reduced preload. Due to Covid-19, testing is planned for 2021.
- Bell Helicopter has expressed intent to use Enduralock fasteners as a replacement for castle nuts on the V-280.
- Enduralock attained 5 new National Aerospace Standards for its Radial Lock fastener (NAS9936 and NAS9937), Silver Lock fastener (NAS9940 and NAS9942), and Self-Aligning Nut Plate (NAS9938) with sponsorship of Boeing and Bell Helicopter. Both have expressed significant interest in use of the technologies on future platforms.
- Enduralock won the NASA iTech Cycle I 2019 competition.
- Enduralock was a final selectee in the AFWERX (Air Force/Space Force) 2020 Space Challenge.
- Enduralock completed a project Q4 2020 for ISRO (Indian Space Research Organization) using its nut plate technology to attach the capsule to the base ring for manned flight.
- Indian Defense Research & Development Organization ordered Silver Lock fasteners for ground-based missile launchers.
- Enduralock applied the Radial Lock bolt technology to 17,000psi gas fittings for offshore well completions for Superior Energy.
- BROMMA has purchased Silver Lock and Tidal Lock fasteners for use in crane spreaders.
- Procter & Gamble has ordered Silver Lock fasteners for their paper manufacturing machines.

Single POC for All Communication:



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