

DESCRIPTION

Mechanically Locking, High Vibration Resistant Fasteners

- Reversible & reusable with hex socket
- Survived 10x aerospace vibration requirement
- Permanent lock, even with loss of preload
- Accurate preload determination
- Current research: scaling to No.4 - No.10

Self-Aligning Nut Plate

- Engages an off-axis bolt
- Self-aligns during tightening
- Fixed position panel bolt retaining ring
- Reduces FOD (foreign object debris)
- Current research: *mechanically locking*, self-aligning nut plate



RELEVANCE

Mechanically Locking, High Vibration Resistant Fasteners

- Replacement of safety wire in missiles (hypersonic and conventional), satellites, space structures, and aircraft/spacecraft
 - Reduce manufacturing labor time and cost
 - Withstand extreme vibration
 - Withstand extreme temperatures
 - Remain locked even with significant cyclical temperature changes
 - Greater reliability for critical applications

Self-Aligning Nut Plate

- Robotic on-orbit servicing, assembly, and maintenance, and for access panels
 - Engage off-axis bolt to accommodate misalignment
 - Self-aligns structure during bolt tightening
 - First *mechanically locking*, (*not friction dependent*) self-aligning nut plate, which can be magnetically unlocked for maintenance
 - In-space assembly alleviates launch vehicle constraints

ACCOMPLISHMENTS

- US Air Force 20.3 SBIR Phase I for development of No.4 – No.10 fasteners for the elimination of safety wire in missiles and spacecraft
- US Air Force 21.1 SBIR Phase I for development of *mechanically locking*, self-aligning nut plate for in-space assembly and maintenance, and aircraft/spacecraft access panel attachment
- US Army CCDC Ground Vehicle Systems Center purchase of fasteners for ballistics testing for armor attachment on Abrams tank
- Bell Helicopter intention to use Enduralock fasteners on V-280
- Superior Energy: Technology applied to 17,000psi gas fittings
- Proctor & Gamble ordered fasteners for paper manufacturing machines
- Attained 3 new National Aerospace Standards with sponsorship from Bell Helicopter and Boeing
- Project completed for Indian Space Research Organization (ISRO) for attachment of the base ring to the capsule for manned flight
- Indian Defense Research & Development Organization (DRDO) ordered fasteners for ground-based missile launchers
- NASA iTech Cycle I winner 2019
- AFWERX (Air Force/Space Force) Final Selection for 2020 Space Challenge

PATH FORWARD

Mechanically Locking, High Vibration Resistant Fasteners

Enduralock's current research is focused on the development of No.4 – No.10 sizes of our mechanically locking, high vibration resistant fasteners. In a Phase II SBIR, Enduralock will refine the design for improved manufacturability and cost reduction. This will be done through finite element analysis using Dassault's Simulia Abaqus, and further prototyping will be done. Mechanical testing will include vibration, tensile, shear, fatigue, and tension-torque, and results will be compared to safety wire. An analysis will be performed comparing the time and cost of using safety wire in a mock missile assembly versus the use of Enduralock fasteners. Flight testing will advance the technology to a TRL9 to allow current missile, satellite, and spacecraft manufacturers to utilize the technology.

Self-Aligning Nut Plate

Enduralock is developing the first *mechanically locking*, self-aligning nut plate, that can be magnetically unlocked. Through an Air Force Phase I SBIR, a prototype was developed. In a Phase II SBIR, this will be refined through finite element analysis of the magnetic fields of the nut plate and the tool. Thermal analysis will precede qualification testing and potential flight testing. With the increased focus on a modular architecture in Space, it will be of benefit for in-space robotic assembly, maintenance of space structures, and aircraft/spacecraft.