Enduralock® High Vibration Resistant Fasteners

***White Paper* – Comparison of permanently locking fastening solutions**

Introduction:

The reliability of assemblies that are subject to high vibration conditions is an on-going issue in the aerospace industry. While there are various joining solutions available, including the use of conventional fasteners, welding, adhesives etc., the failure of these assemblies continues to be a high priority issue. In critical high vibration applications, failure of these joining technologies is not an option.

Conventional fasteners with self-locking nuts and bolts, are not reliable when used to assemble components of systems exposed to very high vibration. This could result in loss of preload and eventually in failure of the assembly and the system.

Innovation in recent years has led to the development of various permanently locked fastener solutions, each with their own advantages and disadvantages. While the decision to choose a suitable technology is subject to the application under consideration, there are critical factors that assist in this decision, which are as follows:

Installation Time:

The time invested in the installation of fasteners has a significant impact on the cost of production and maintenance. To increase productivity and efficiency, the mechanical technology must be easy to apply during installation and easy to remove for maintenance. The time saved during installation and removal, due to the ease of fastener application, helps cut down the expense of the assembly and maintenance of the system in the after-market, thus lowering the overall lifecycle cost of the assembly.

Installation Tool:

The required tooling needed for installation of the fastener is an important criterion for selection of the appropriate fastener technology for a given application. Fasteners that require standard tooling for installation are always

preferred over technologies that require specialty tooling. Use of custom designed tools increases the overall cost of installation. It also causes issues with field maintenance due to lack of access to the special tooling and the need for hands-on training for technicians.

Preload Loss:

Applied preload creates an equal compressive force on the joint components, forming a bolted assembly. A small loss in preload, specifically in systems exposed to high vibration, results in a failure of the bolted joint. Hence, it is imperative that for systems undergoing high vibration, a permanently locking fastener technology be used for the system assembly. Permanently locking fasteners retain almost all the preload necessary to keep the system functioning, even when some preload is lost. With conventional fasteners, this would result in a failure.

Re-Usability:

Conventional fastener bolts can technically be reused after disassembly, since the preload applied would extend the bolt within the elastic range, such that no plastic deformation occurs. However, under service conditions the bolt can be deformed into its plastic region, offering no re-usability of the fastener. Some of the current fastening technologies are uniquely designed such that the bolt and nut do not yield plastically under service, thus allowing re-usability. Re-use of fasteners is very economical in the long-run, considering the money saved during the entire life cycle of the assembled system.

High Temperature Resistance:

The fastener components and the assembly components tend to expand when exposed to high temperature environments. With materials of different coefficients of thermal expansion, the components expand to different extents, resulting in fastener preload loss and eventually the failure of the assembly. Hence, high temperature resistant fastener technologies are designed to address this issue. In fact, the design of these technologies must be more robust when the assembly is installed in a system exposed to both high temperature and vibration environments.

In this white paper, various permanently locking fastening solutions available in the market are presented and compared in terms of the above-mentioned specifications.

- **Huck Bolt**

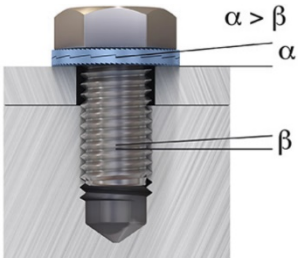
Huck bolts are permanently locking solutions that require custom designed electric tooling for installation. The assembly consists of a bolt and collar, which undergoes permanent deformation during installation. Disassembly requires cutting tools to break down the bolt, thus preventing reuse of the assembly. Huck bolts have a 5% variance in preload applied. One of the disadvantages of

the Huck bolt is that once installed, the fastener cannot be tightened again. Hence, it is very critical to know the precise preload required for the assembly and apply the same during installation. Inability to retighten the bolt becomes very disadvantageous when Huck Bolt joints are exposed to high temperature. Due to the mismatch of the thermal expansion of the collar versus the bolt, the applied preload is lost, and since the fastener cannot be tensioned again after it cools, a new Huck Bolt must be installed. Therefore, this solution is not very feasible for high temperature application. Also, because of the nature of the design, Huck Bolts also lack standards and design criteria.

- **Safety Wired Fasteners**

This technology uses safety wire as positive locking devices. The safety wire is passed through the predrilled hole in the bolt head and twisted around the bolt head and to itself on one end. The other end of the wire is similarly anchored to another bolt that serves as an anchor point, such that required retentive force is exerted between the bolts. Safety wires assure that the assembly of the fastener components subjected to vibration remains intact by maintaining the tension between the bolts. The technique does not, however, prevent the loss of preload, which is imperative in critical systems. Application of the safety wires do not require any special tooling, but the time consumed in installation of the safety wire is one of the biggest disadvantage of the technology. Formal training is also required to familiarize the technicians of the need and the methods for maximizing the retentive force of the safety wire. Since the bolted joint is secured due to the friction between the threads of bolt and nut, the safety wired fasteners do not offer reusability and are not temperature resistant. This type of technology also increases over-all weight of the assembly and introduces higher possibility of FOD.

- **Nord-Lock**



Nord-Lock's wedge locking technology consists of a pair of lock washers with cams on one side and radial teeth on the other. The cams are designed such that the thread angle is less than the cam angle. During assembly, the applied preload causes the teeth to grip the mating surface by creating serrations. The difference in the cam angle and the thread angle creates a wedge effect, forming a locking mechanism. Thus, the bolted joints are essentially secured with tension instead of friction. The technology does not require any special tool for installation and the installation time is not significant. The disadvantage of Nord-Lock washers is that the material of the assembled components should be softer than the washer material, since for the locking mechanism to function effectively, the teeth in the washer must create serrations on the surface of the bolted components. The locking mechanism also requires a high clamping load to function as designed. If the assembled components collapse, the wedge effect and the preload is lost, and the locking mechanism fails.

- **Enduralock® Radial Lock Fastener**

The locking mechanism consists of a lock washer with teeth along the inner circumference and a lock member with three teeth that are designed in radially opposite positions. The lock nuts are designed with slots to accommodate the lock member. The flats on the bolt and the washer hole are such that the relative rotation between these components are constrained. When assembled, the teeth on the washer and the lock member engage, which causes the assembly to be permanently locked. For disassembly, a standard six-point socket engages the lock nut, which deflects the lock member tabs and results in disengagement of the teeth. The lock nut then becomes free running. With a standard six-point socket used for installation, the time required for installation is minimal and the installation procedure is the same as with a standard nut-bolt fastener. The locking mechanism primarily depends on the mating teeth. Therefore, the threads of the bolt and nut are not deformed, which allows the entire assembly to be reused.

Table: Comparison of four permanently locking fasteners

	Huck Bolt®	Safety Wired	Nordlock®	Enduralock® Radial Lock Fastener
Less Installation Time	Yes	No	Yes	**Yes (5% VARIANCE)**
Standard Installation/Removal Tool	No	Yes	Yes	**Yes**
Preload Retained	Yes	No	Yes	**Yes (5.7% VARIANCE)**
High Temperature Resistant	No	No	Yes	**Yes**
Re-usability	No	No	Yes	**Yes**
Compatible with All Mating Material	Yes	Yes	No	**Yes**
Permanently Locked Under Collapsed Structure	Yes	No	No	**Yes**