

FC43®: A New Structural Panel Fastener

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ABSTRACT

Structural panel fasteners have been used in the aerospace industry for longer than the previous half century. This paper presents the new FC43® Panel Fastener with a novel retaining feature which enables the use of a full shank stud. The retaining feature can be used with a variety of thread configurations and is independent of nut style or head configuration, providing an unprecedented modularity for this type of fastening system. With a stud design that is free of slots or axial recesses, the FC43® provides higher mechanical performance than existing equivalent panel fasteners. Mechanical characteristics and performance comparisons with the most commonly used panel fasteners in the aerospace industry are also presented.

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PANEL FASTENERS DEFINITIONS AND CHARACTERISTICS

Panel fasteners are a family of fastening systems characterized by three main features. First, they are usually semi-permanently attached to their respective panels. They are also designed to be used in high load applications where the panels they are used to attach are an integral part of the structure. And thirdly, panel fasteners are intended for high reusability. They are extensively used on exterior load carrying panels of both military and commercial aircraft.

Structural Panel Fasteners Typical Components

Structural panel fastener systems usually have four major components: a stud, a retainer, a basket and a receptacle. Through the years, those components have assumed different forms and configurations, but retained their basic characteristic or functionalities.

Stud

The stud is the component of the panel fastener system that acts like a bolt. If it is externally threaded, it is called a stud-bolt; if it is internally threaded it is called a stud-nut, as shown in [Figure 1](#). Most panel fasteners have a wrenching recess in the stud head.



Figure 1. Types of panel fastener studs: internally threaded (left) and externally threaded (right)

Receptacle

This component of the system acts like a nut. It is commonly captivated by the basket. If it is internally threaded, it is simply called a nut. [Figure 2](#) illustrates an externally threaded receptacle and an internally threaded receptacle, or nut.

Retainer

This component of the system retains or captivates the stud to the panel. It is usually composed of a retaining ring that can be floating or held by a grommet or enclosure [7]. [Figure 3](#) shows examples of retainers. Traditional retainers sit in grooves or axial slots on the stud body, providing axial

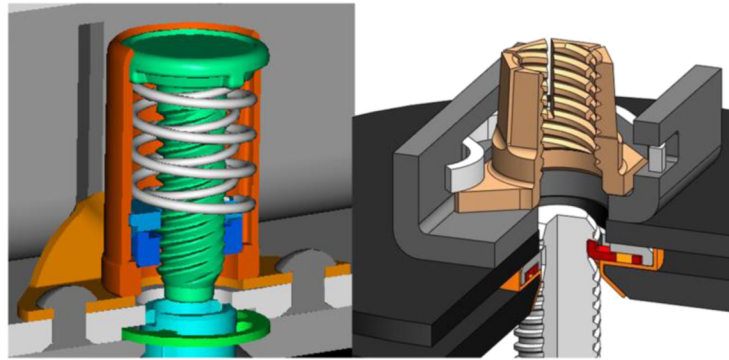


Figure 2. Types of panel fastener receptacles: externally threaded (left) and internally threaded (right)

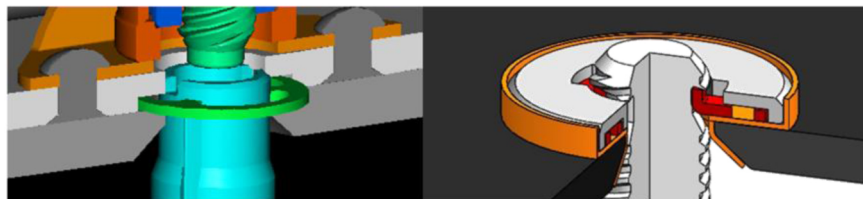


Figure 3. Examples of retainers: floating retaining ring (left) and captivated retaining ring (right)

freedom while preventing the stud from completely detaching from the panel.

Basket

This component holds the receptacle and is connected or captivated to the structure or airframe. It can assume different forms and configurations. Figure 4 illustrates some examples of baskets. The most common type is the metallic basket, usually made of stainless materials, but there are also baskets made out of composite and other non-metallic materials. Baskets can be attached to the structure by rivets or by adhesive bonding. Some baskets have a clip mechanism that permits retainer replacement without removing the basket from the structure.

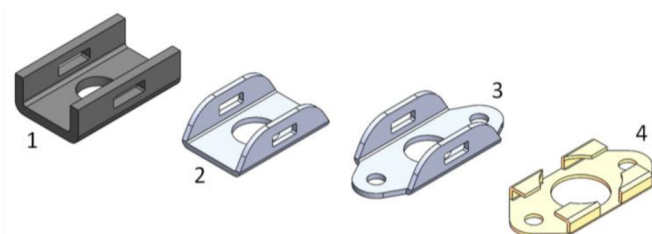


Figure 4. Examples of baskets: bonded composite (1), bonded metallic (2), riveted metallic (3), riveted metallic with fold-over tabs (4)

Following is a summary of the most relevant panel fasteners developed in this period.

Milson®

Developed in the late 1950's, the Milson® panel fastener is a simple design that utilizes a smooth exterior, interior threaded stud and a mating receptacle that floats in a basket. Locking torque is achieved by a slight elliptical deformation of the lower tubular portion of the fastener, inducing friction when the stud nut engages the male thread of the receptacle. Its characteristic design of a long tubular nose provides excellent hole probing capabilities. The first application of this fastener was the F-111 aircraft, subsequent use included McDonnell-Douglas F-4, F-15 and F-18.

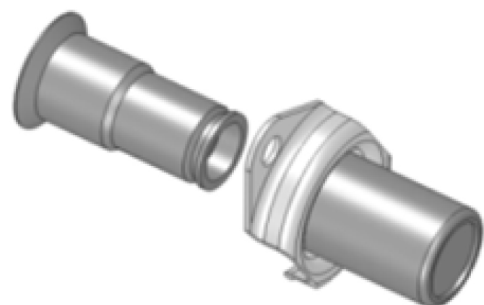


Figure 5. The Milson® Panel Fastener

Historic Evolution

Panel fasteners evolution during the past 50 years is closely related to the development of new aircraft and the challenges they posed to existing fastening technologies.

This fastener is composed of a hollow stud with an internal thread, also called stud nut, a cup like receptacle which contains in its bottom a floating screw, and a sheet metal basket that captivates the receptacle to the structure.

The stud nut is captivated to the panel through a star-shaped spring clip attached to an annular groove in its extremity.

QR®

This multi-piece panel fastener was invented in 1959 [1] to address the need for limited space and reduced weight design. It possesses relatively high shear strength and a small size envelope. One of the first applications for this panel fastener was on the gun bay panel for the A-4 US Navy carrier aircraft, being later adopted in diverse aircraft and missile applications.

The QR® panel fastener has a three piece stud, composed of an external sleeve, a wireform holdout device and a captivated internal screw. The stud sleeve contains two radial wire springs that provide hold-out when the stud is in extended position. The stud sleeve also contains a retaining ring, sitting on a groove in its extremity.



Figure 6. The QR® Panel Fastener

This fastener has a three piece receptacle, composed of a deep flanged cup that acts like a nutplate, a floating nut, and an internal captivated sleeve.

Live Lock™

This fastener was developed in 1962 for applications that required low installation and removal torque [2]. Its uniqueness was that it applied a different approach to achieve vibration resistance than the usual torque friction that was common at the time. Employing a spring-loaded ratchet mechanism, vibration resistance was obtained by transferring rotary unloosening forces to axial forces that were resisted by the springs. The resultant lower installation and removal torques helped in reducing operator fatigue when operating large quantities of fasteners with manual tools. Employing multi-lead threads provided significant operation cycle time reduction in comparison with single lead panel fasteners. One of the first applications for this fastener was the Polaris missile system. In 1968 it was selected for the F-14 program and subsequently adopted in numerous military and commercial aircraft, such as the B-1 and 737.

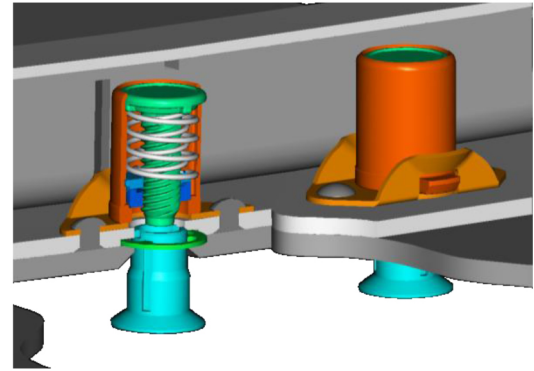


Figure 7. The Live Lock™ Panel Fastener

The Live Lock™, in one of its versions, has an axially-slotted stud nut that contains a sliding retaining ring. In the extremity of the stud nut there are anti-rotation recesses that mate with a ratcheting mechanism contained in the receptacle.

The receptacle is composed of a deep floating cup that holds in its bottom a captive screw. Inside the cup, around the screw there is a spring-loaded ratcheting mechanism that slides longitudinally.

Mark IV™

Developed in the early 1970's [4], this fastener addressed most of the complaints and application problems that occurred with prior fasteners. The design became simpler by reducing the number of components, and focusing on maximizing performance under the most severe conditions. Common field problems related to enclosed receptacles being contaminated by debris such as dirt, grease, crystallized salt, form-in-place gasket material, and many other contaminants. The effect of these contaminants would deteriorate fastener performance and cause a high degree of additional maintenance. As a result these concerns were addressed by using a receptacle with self-cleaning capabilities. The stud bolt design, paired with a Flat Beam™ nut, provided high reusability and superb vibration resistance [3].

One of the first applications for this fastener was the A-10 aircraft, when the vibration resistance was confirmed by withstanding the massive dynamic loads generated by firing of the famous 30mm Gatling gun. Versions of this fastener were later incorporated on the B-1 bomber, F-14, F-16, F-117, F-22, F-35, cruise missiles, and several civil aircraft.

This panel fastener has an axially slotted, externally threaded stud, which possesses a radial wire spring mounted in an internal recess located in its extremity [5][6]. This spring provides positive hold-out when the stud is fully extended. A retaining ring slides axially on the stud slots, and sits in a "flared-in-place" grommet attached to the panel [7].

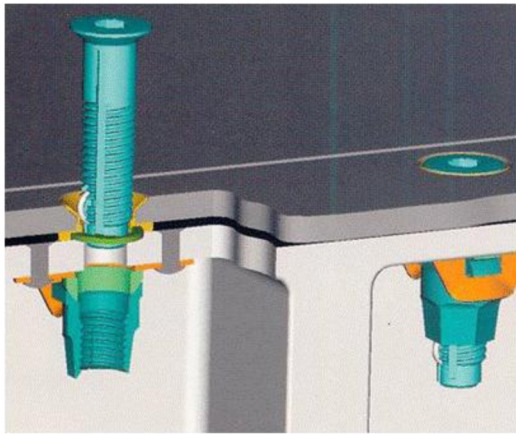


Figure 8. The Mark IV™ Panel Fastener

The receptacle of the Mark-IV™ is composed of a floating Flat Beam™ nut captivated on a sheet metal basket.

THE FC43® PANEL FASTENER

Developed in 2011, this panel fastener was designed to provide maximum strength by using a full shank stud, without internal recesses or longitudinal slots. Its retaining mechanism provides positive hold-out in all positions, providing full protrusion for hole-probing or full retraction for clearance and ease of alignment. The modular design permits different stud configurations to be paired with various nut configurations, such as a Flat Beam™ nut for high reusability, or a sheet metal low-cycle nut for low weight and low cost.

As shown in Figure 9, in a general configuration, the FC43® panel fastener is composed of an externally threaded stud, an annular retainer, a nut receptacle, and a basket.

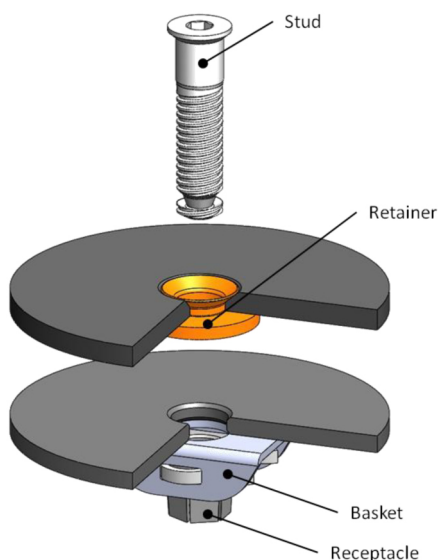


Figure 9. FC43® Panel Fastener general configuration

In order to provide captivation and hold-out capability, most panel fastener designs have employed features like stud axial slots and holes. Although those features perform their function properly, they reduce the fastener tensile and shear strength. The FC43® was developed to address this issue, designed around a retaining and hold-out mechanism concept that enables the use of externally threaded, full shank studs, without axial slots or holes, and therefore capable of performing panel fastener functions without penalizing strength.

Retaining Mechanism

The FC43® retaining mechanism is designed to provide strong captivation and improved hold-out characteristics without the need for stud features that reduce strength. This is accomplished by using a compact, self-contained, dual-purpose retaining spring shown in Figure 10.

The retaining spring features arms that connect the central working elements to a surrounding support ring. This configuration enables the spring to accommodate large deflections, providing high radial loads at the end of stroke, while still maintaining a small diameter work envelope.

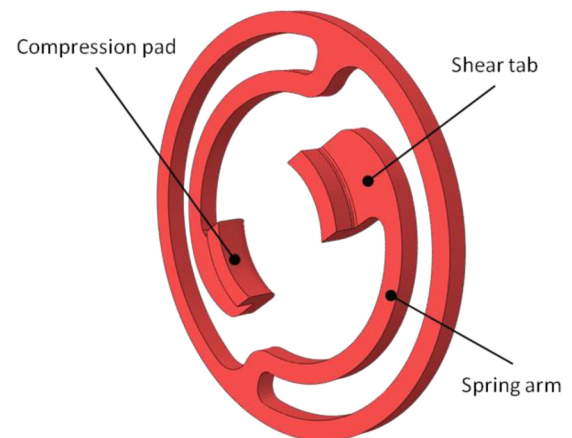


Figure 10. FC43® Retaining Spring

The shear tabs for each fastener size are dimensioned to withstand high loads, and in consequence provide high pull-out capability to the studs. The FC43® pull-out loads exceed the ones obtained by panel fasteners of similar size.

The compression pads were designed to ride over the thread crests and the stud outside diameter, enabling axial freedom to the stud, while providing a firm grip and positive hold-out, independently of the stud axial position, as illustrated in Figure 12. The pad is also configured to effectively engage an annular groove on the stud tip, providing superb captivating properties.