SAE INTERNATIONAL

AEROSPACE RECOMMENDED PRACTICE

ARP6881™	REV. A
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Guidelines for the Use and Installation of Bonded Cable Harness Supports

RATIONALE

Revision A incorporates an update of Figure 1 and 5.6 along with its subparagraphs.

1. SCOPE

This SAE Aerospace Recommended Practice (ARP) provides recommended use and installation procedures for bonded cable harness supports.

1.1 Purpose

The purpose of this ARP is to provide guidance for acceptable use of bonded cable harness supports.

1.2 General

The manufacturing and overhaul of an aircraft requires the use of studs and standoffs to secure a cable via harness supports. Rivets and through-bolts are the recommended technique and have traditionally been the method for securing this type of hardware. When this is not an option, such as on composite structure or where a penetrating hole compromises the structural integrity of the airframe structure, an alternative method is to secure the wire support hardware via structural adhesives or sealants. There can be significant advantages to the use of adhesive bonded fasteners on metal airframe structures, including: eliminating the stress concentration associated with the required hole(s), eliminating the rivet, which is a potential source of corrosion (dissimilar metals), or reducing the potential for scrapping expensive airframe structure when holes are mis-drilled. There are also potential labor savings associated with the speed at which mechanics can install adhesive bonded fasteners compared to riveting. For pressure vessels, eliminating holes has obvious benefits, and in the case of fuel tanks (for example, wet wing applications), eliminating the rivets eliminates the possibility of fuel leaks associated with leaking rivets. Adhesive bonded fasteners also allow for aerodynamic flushness on the opposite side of the fastener and, on thin airframe structures, may prevent knife edge conditions where countersunk rivets are required for aerodynamic flushness.

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Although there are significant benefits to the use of adhesive bonded studs, standoffs, and cable tie mounts for wiring applications, there is also a legitimate concern about the strength of the adhesive bonded fastener. The adhesive bonding is process dependent and requires good adhesive selection, mixing, and application, as well as good surface preparation of the bonding surfaces. For that reason, training mechanics in proper adhesive bonding techniques is a key to successful use of adhesive bonded fasteners in aerospace applications. In most cases, with proper adhesive selection and surface preparation, the strength of adhesive bonded cable tie mounts can exceed the strength of the nylon zip ties that are used to attach the wiring to the adhesive bonded cable tie mount. For adhesive bonded cable tie mounts, the strength is such that adhesive failures are extremely rare; typically, if nylon zip ties are replaced by stainless-steel wire ties, then the failure mode is usually a mechanical failure of the adhesive bonded cable tie mount. For adhesive bonded studs or standoffs used to attach p-clamps, the strength capabilities of these adhesive bonded studs and standoffs are even greater than for adhesive bonded cable tie mounts; however, overloading may be more likely, since the length of the stud or standoff may allow for a significant moment-arm making peel failures (or cleavage failures) more likely. In any case, the most likely cause for well-installed adhesive bonded fasteners is overloading or abuse (bumping, kicking, or stepping on the adhesive bonded fastener or pulling on, hanging from, or stepping on the wiring attached by adhesive bonded fasteners).

Another concern is the substrate material bonding surface for the fastener. In many aerospace applications, airframe structure is painted or primed or has some other surface treatment, such as a chemical conversion coating (Alodine© or anodize). The most effective bond will occur with freshly abraded and properly cleaned bare substrates. If the paint is removed, then after the adhesive bonded fastener has been installed and the adhesive has cured, a touch-up of any unpainted surfaces is required. For other surface treatments, it would be prudent to test and evaluate the adhesive selected on the substrate to determine the optimum surface preparation. For well-adhered paints, scuff the glossy surface, followed by a solvent cleaning to remove any abrasive residue. Caution is advised when bonding to a treated surface since some adhesives do not adhere well to conversion coatings (Alodine©). Although many adhesives have excellent strength properties on anodized surfaces, it is not uncommon to have a sealed anodize, which will likely result in inferior adhesive attachment strength.

One final concern is environmental exposure of adhesives or sealants to aerospace fluids (aviation fuels, hydraulic fluids, de-icing fluids, corrosion-protective coatings, etc.) or stresses, such as extreme temperatures and changes, vibration, and high G-loads. Adhesive bonding has a long history in aerospace applications, and it is critical that adhesives specifically qualified for aerospace applications be used and the appropriate adhesive be selected for the intended application. Selected adhesives need to have documented temperature ranges matching expected application temperature ranges and resistance to typical aerospace fluids. Applying a sealant over the adhesive fillet and/or painting the entire adhesive bonded part is an effective method of providing additional protection to the adhesive attaching the adhesive bonded fastener.

Successful implementation requires:

a. Selecting the proper adhesive. Selection should be based on static and dynamic load requirements, operating temperature, and fluid vulnerability.

b. Verification of the bonded support substrate, material type, and thickness.

c. Selecting the proper bonded support. Consideration should be focused on application geometry, support material requirements, and bonded surface area based on static and dynamic load requirements.

d. Proper surface preparation of the substrate to ensure long-term durability.

e. Locating the fastener support correctly to minimize mechanical stresses.

f. Tooling to ensure positive pressure throughout adhesive cure and adhesive bond line control.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AS50881 Wiring Aerospace Vehicle

2.1.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D1002 Standard Test Method for Apparent Shear Strength of Single-Lap-Joint Adhesively Bonded Metal Specimens by Tension Loading (Metal-to-Metal)

ASTM D1876 Standard Test Method for Peel Resistance of Adhesives (T-Peel Test)

2.1.3 FAA Publications

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov.

AC 25.1701-1 Certification of Electrical Wiring Interconnection Systems on Transport Category Airplanes

2.2 Definitions

CONTAMINANT: An impurity or foreign substance present in a material or environment that affects one or more properties of the material, particularly the adhesive.

CURE: A chemical reaction that irreversibly changes the properties of a thermosetting resin.

CURING AGENT: A catalytic or reactive agent that, when added to a resin, causes polymerization. Also called hardener.

CURING TIME: Length of time necessary for a part to be subjected to heat or pressure (or both) to fully cure a resin.

DEGRADATION: A deleterious change in the chemical structure, physical properties, or appearance of a plastic adhesive or any other material.

ELASTICITY: A material property where the material recovers its original size and shape after removal of a force, causing deformation.

FATIGUE: Failure or degradation of mechanical properties as a result of cyclic loading of stress.

GALVANIC CORROSION: Corrosion associated with the current of a galvanic cell made up of dissimilar anodes.

HANDLING STRENGTH: The low-level strength initially obtained by an adhesive that allows the specimen to be handled, moved, or unclamped without causing disruption of the curing process.

IMPACT STRENGTH: The ability of a material to withstand shock loading.

LAP JOINT: A joint made by placing one adherent partly over another and bonding the overlapped portions.

MEK: Methylethylketone, a solvent used for cleaning purposes.

MOLD RELEASE AGENT: A lubricant, liquid, or powder used to prevent sticking of molded articles in the cavity.

PEEL STRENGTH: Adhesive bond strength obtained in the peeling mode selected.

POT LIFE: Length of time at some specified temperature that a catalyzed thermosetting resin system retains a viscosity low enough to be used in processing.

SEALANT: A material applied to a joint, in a paste or liquid form, that hardens or cures in place, forming an environmental seal against gas or liquid entry.

SERVICE CONDITION: Heat, cold, flexing, shock, impact, vibration, and other stresses that an adhesive or composite will be subjected to in service.

SHEAR: A force or load that tends to produce a sliding failure on a material along a plane that is parallel to the direction of the force.

SHEAR STRENGTH: The strength of a material or component against the type of yield or structural failure where the material or component fails in shear.

SHELF LIFE: Length of time a material, substance, product, or reagent can be stored under specified environmental conditions and continue to meet all applicable specifications.

SINGLE LAP SHEAR: In adhesive testing, a specimen made by bonding the overlapped edges of two sheets or strips of material. In adhesive testing, a single lap shear specimen is usually loaded in tension.

STRUCTURAL ADHESIVE: Adhesive used for transferring required loads between adherents exposed to service temperatures typical for structure involved.

SURFACE ACTIVATION: Chemical process of making a surface more receptive to bonding to a coating or an encapsulating material.

SURFACE PREPARATION: Physical and/or chemical preparation of an adherent to make it suitable for adhesive bonding.

T-PEEL STRENGTH: The average load per unit width required to produce progressive separation of two bonded, flexible adherents under conditions designated in ASTM D1876. Reported in pounds per linear inch (pli) or Newton/meter (N·m).

3. REQUIREMENTS

3.1 Preparation Cautions

3.1.1 Safety

Follow all site safety requirements for working with solvents, adhesives, and power tools. Solvents and uncured adhesives are flammable; follow all procedures for handling chemicals.

3.1.2 Environmental

Adhesive material and bonding surface temperatures must be between 50 and 90 °F, and the bonding surface must be dry and at least 5 °F above dew point.

3.1.3 Atmosphere

The bonding surfaces must be clean when bonding occurs. If dust, airborne particulates, spills, etc., contaminate the bonding substrates after surface preparation, the surface must be reprocessed prior to bonding. If clean surfaces cannot be maintained, postpone bonding until conditions are suitable.

3.2 Adhesive Recommendations

Electrical harnesses are generally loaded in modified sheer. High T-Peel strength (force to separate the bond, see 2.2) of the wire support bond is critical for long-term durability. Two additional key factors that must be known prior to adhesive selection are bonding structure thickness and environmental exposure. Both need to be verified prior to adhesive selection.

Typical adhesive data is given in Table 1. The property information in Table 1 is provided only as information and should not be used for actual design since actually selected adhesives may have significantly different performance characteristics.

Table 1 - Typical wire support adhesive properties data (provided by Click Bond, Inc.)

Adhesive	Working Time (minutes)	Room Temp		Strength		Service Temp		Shelf Life	Storage
		Handling Strength	Full Strength	Shear ASTM D1002 psi(1) (MPa)	T-Peel ASTM D1876 pli(2) (N·m)	Min	Max	Room Temp 72 °F (22 °C)	Refrigeration 35-50 °F (1.6-10 °C)
Modified Acrylics	5	30 minutes	24 hours	4400 (30.33)	21 (3.67)	-67 °F (-55 °C)	250 °F (121 °C)	6 months	1 year
Polysulfides	30	12 hours	14 days	218 (1.50)	45.7 (8.00)	-65 °F (-54 °C)	250 °F (121 °C)	9 months	9 months
Moderate Service Temperature Epoxies	60	24 hours	5-7 days	4500 (31.02)	60 (10.51)	-67 °F (-55 °C)	200 °F (93 °C)	6 months	1 year
High Service Temperature Epoxies	90	24 hours	3-5 days	4200 (28.96)	5 (0.87)	-67 °F (-55 °C)	350 °F (176 °C)	1 year	1 year

(1) psi = pounds per square inch
(2) pli = pounds of force per linear inch

3.2.1 Adhesive Recommendations Based on Substrate Thickness

See Figure 1.

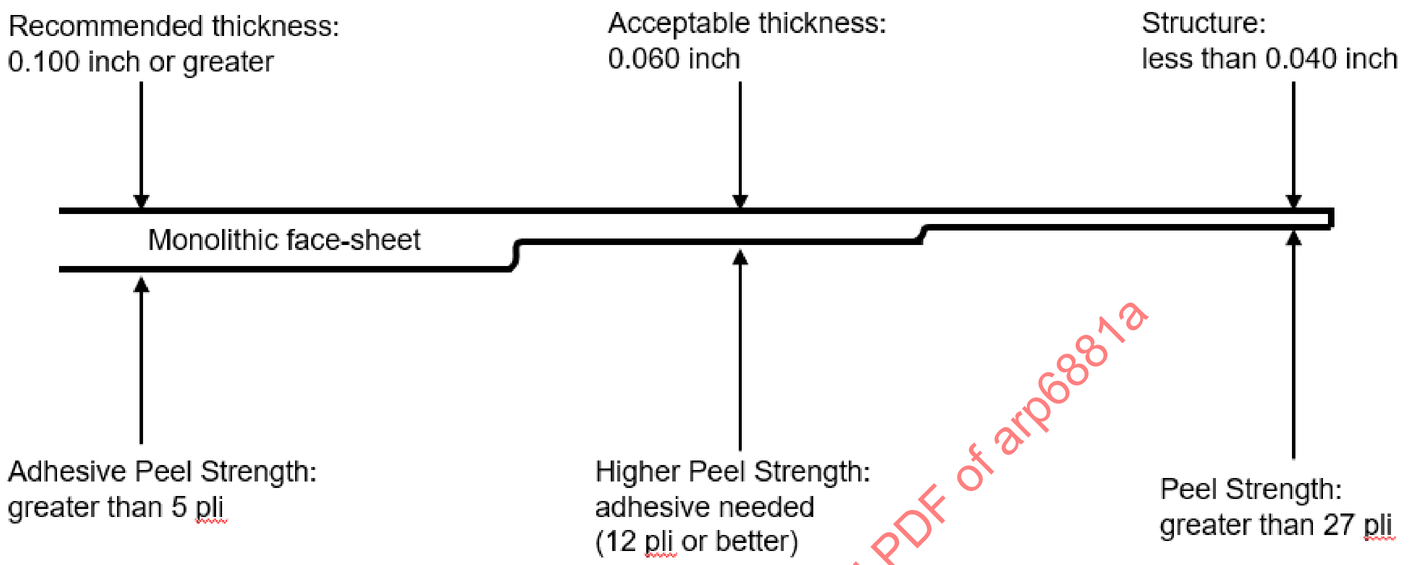


Figure 1 - Suggested adhesives based on substrate thicknesses (provided by Click Bond, Inc.)

3.3 Substrate Surface Preparation Recommendations

3.3.1 All surfaces to be bonded should be initially clean and free of oil, dirt, and other foreign materials. Surface preparation is accomplished by solvent wiping the surface followed by wiping with a clean, dry cloth.

3.3.2 Abrade the substrate with the proper media to ensure high energy surface. Bonding should occur within 8 hours of accomplished surface preparation for composite, aluminum, and stainless-steel substrates and within 2 hours for titanium. See Tables 2 and 3.

3.3.3 Remove abrading dust from all bonding surfaces by wiping with a solvent wipe. Immediately after solvent wiping, wipe with a clean, dry cloth (see Figure 2).

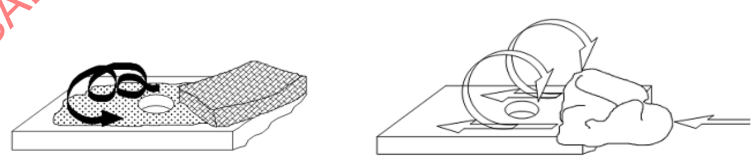


Figure 2 - Preparation of the bonding surface (provided by Click Bond, Inc.)

3.3.4 The most effective bond will occur with freshly abraded and properly cleaned bare substrates. Bonding to painted surfaces relies on adhesion between the fastener support and paint and can give significantly lower bond strength than fastener support to bare (unpainted) surfaces. As an example, tension testing yielded 510 pounds on a painted surface versus 1370 pounds on bare steel.

3.4 Recommended Abrasive Media and Solvents for Bare Substrates

See Table 2.

Table 2 - Recommended abrasive media for bare substrates

Substrate	Abrasive Material	Solvent
Aluminum	120-180 grit Aluminum Oxide	Acetone/MEK
Titanium	120 grit Aluminum Oxide	Acetone/MEK
Carbon Composite/Glass	120-180 grit Aluminum Oxide	Acetone/MEK

3.5 Recommended Abrasive Media and Solvents for Painted Substrates

See Table 3.

Table 3 - Recommended abrasive media for painted substrates

Substrate	Abrasive Material	Solvent
Aluminum-Primed	120-180 grit Aluminum Oxide	Acetone/MEK
Titanium-Primed	120-180 grit Aluminum Oxide	Acetone/MEK
Carbon Composite/Glass-Primed	120-180 grit Aluminum Oxide	Acetone/MEK
Aluminum-Primed/Top Coat	120-180 grit Aluminum Oxide	Acetone/MEK
Titanium-Primed/Top Coat	120-180 grit Aluminum Oxide	Acetone/MEK
Stainless Steel-Primed/Top Coat	120-180 grit Aluminum Oxide	Acetone/MEK

3.6 Dispensing of the Adhesive and Fastener Installation

Pre-metered cartridges and static mixing tips should be used to ensure proper mixing of adhesive components. These systems ensure correct ratios of catalyst and resin, resulting in a complete chemical reaction that will ensure full adhesive cure. Adhesive out time while during use needs to be continuously monitored for optimal joint strength (see Figure 3).

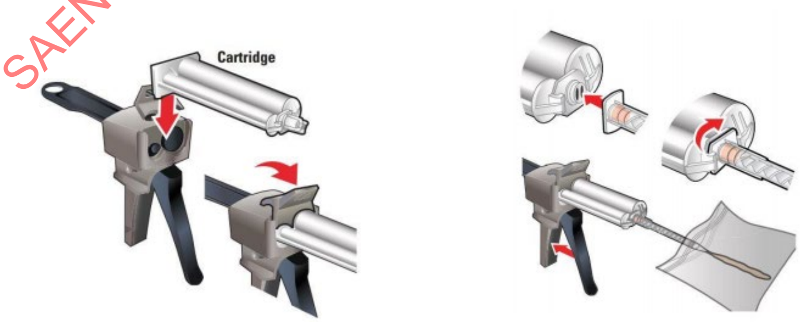


Figure 3 - Typical adhesive application tool (provided by Click Bond, Inc.)

3.6.1 The mixed adhesive should be applied as a built-up spot to the center of the stud, standoff, or cable tie mount baseplate bonding area. The applied quantity of adhesive should be just sufficient to provide the squeeze out of a small excess of adhesive completely around the circumference of the baseplate. See Table 4 for approximate adhesive spot diameters for each baseplate size. The installation process is described below and in Figure 4.

Table 4 - Baseplate size versus adhesive spot diameter (provided by Click Bond, Inc.)

Baseplate Size (inches)	Adhesive Spot Diameter (inch)
0.62	0.38
1.25	0.62

3.6.2 Remove the protective sheet from the baseplate and clean with solvent. Remove the protective sheets from foam tape pads and discard. Apply the mixed adhesive to the fastener baseplate.

3.6.3 Locate the fixture on the substrate using a template or by aligning the fixture's index marks with the fastener location centerlines. Press down on the fixture's outer body to adhere the foam tape to the surface.

3.6.4 Press down on the inner body of the fixture to actuate. Do not press on the protruding fastener. The over center action of the fixture applies positive pressure to the adhesive bond line during the cure process and holds the disposable fixture, which holds the fastener in place while the adhesive cures. Follow the adhesive cure time provided by the manufacturer.

3.6.5 After the adhesive has cured, remove the fixture by grasping with pliers and pulling it off of the substrate. Discard the fixture.

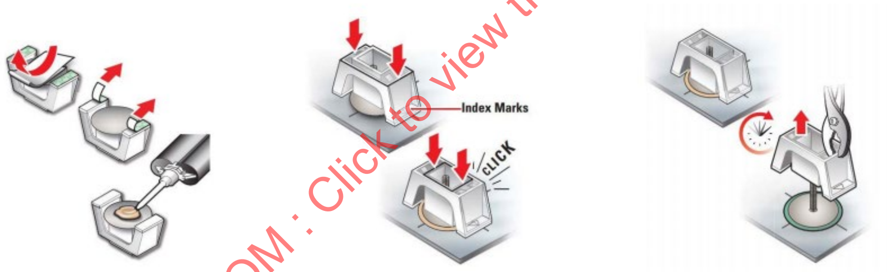


Figure 4 - Fastener installation process (provided by Click Bond, Inc.)

3.7 Bonded Fastener Removal Options

3.7.1 Room-Temperature Removal

The following removal method is not recommended for composite or fiberglass substrates.

3.7.1.1 Remove Fastener

Use a nonmetallic drift and a mallet. Position the drift as high as possible on the edge of the fastener, as shown in Figure 5. Strike the drift with a mallet to knock off the fastener.

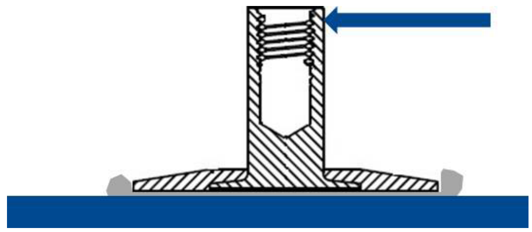


Figure 5 - Process for removing a fastener
(provided by Click Bond, Inc.)

NOTE: Care must be taken during this operation to prevent damage to the surrounding structure.

3.7.1.2 Clean Up Adhesive

Scrape excess adhesive with the nonmetallic scraper. To reinstall a fastener, repeat the above surface preparation and installation procedures.

3.7.2 High-Temperature Removal Method

3.7.2.1 Secure Thermocouple

Secure at least one thermocouple near the fastener using pressure-sensitive, high-temperature tape (also known as “flash tape”) to remove the fastener, as shown in Figure 6.

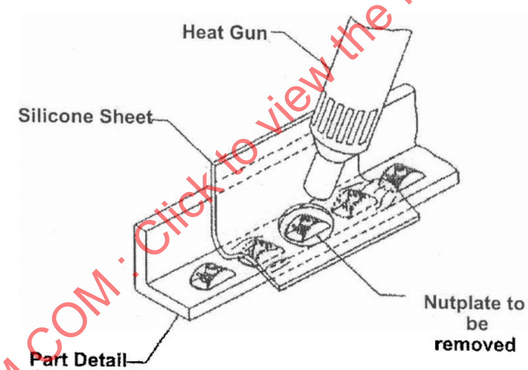


Figure 6 - Fastener removal using heat gun
(provided by Click Bond, Inc.)

3.7.2.2 Apply Heat

Using a hot air gun, heat the bond line to 120 °C ± 6 °C (250 °F ± 10 °F) for 45 seconds.

Hold the hot air gun so that the airstream impinges upon the fastener as near to a right angle to the plane of the substrate as possible. Position the tip of the hot air gun approximately 25 mm from the baseplate of the fastener. Keep the airstream centered on the fastener.

3.7.2.3 Remove Fastener

Remove the fastener immediately after applying heat. Use a nonmetallic scraper/wedge, and, with a mallet, drive the scraper/wedge against the adhesive and underneath the fastener.

3.7.2.4 Clean Up Adhesive

If necessary, repeat the heat application and scrape excess adhesive using a nonmetallic scraper. To reinstall a fastener, repeat the above surface preparation and installation procedures.

3.8 Harness Supports

Bonded cable tie harness supports are always strongest in tension, compression, and shear but need additional consideration when loaded in Peel (modified shear). The correct adhesive and baseplate diameter must be considered based on the expected static and dynamic loads.

3.8.1 Representative design loads are given below using a specific type of adhesive and 1/8 inch or greater bare aluminum substrate (see Tables 5, 6, and 7 and Figures 7, 8, and 9). For each unique application, ultimate loads will vary based on the selected substrate, its thickness, and the adhesive type. Design loads need to be measured using actual materials and manufacturing processes for the intended application.

Table 5 - Typical studs/standoffs

Test Type		Avg Force	Design Load 40%
Tension	Stud/Standoffs Fastener Base Diameter 1.25 inches (A-286 CRES Material)	1250 pounds	500 pounds
Shear		1875 pounds	750 pounds
Modified Shear (Peel)		164 lb-in	66 lb-in

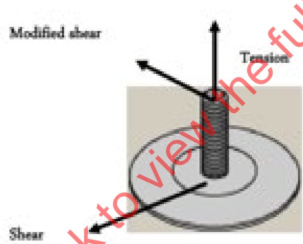


Figure 7 - Typical studs/standoffs example (provided by Click Bond, Inc.)

Table 6 - Typical right angle supports

Test Type		Avg Force	Design Load 40%
Tension	Right Angle Nutplate Fastener Base Diameter 1.25 inches (Glass/Epoxy 250 °F Cure)	100 pounds	40 pounds
Shear		100 pounds	40 pounds
Modified Shear (Peel)		74 lb-in	29 lb-in

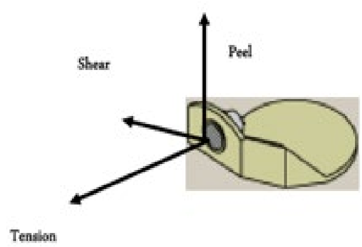


Figure 8 - Typical right angle supports example (provided by Click Bond, Inc.)

Table 7 - Typical nutplate standoffs

Test Type		Avg Force	Design Load 40%
Tension	Standoff Nutplate (Glass/Epoxy 250 °F Cure)	100 pounds	40 pounds
Shear		100 pounds	40 pounds
Modified Shear (Peel)		50 lb-in	20 lb-in

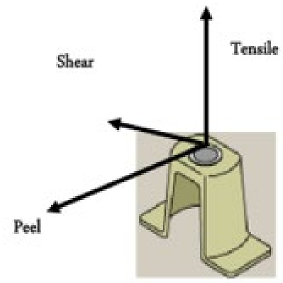


Figure 9 - Typical nutplate standoffs example (provided by Click Bond, Inc.)

3.9 Test Method

An example of joint verification/nondestructive testing of the bonded harness support via torque or tension is given in Figures 10 and 11.

3.9.1 General Test Steps

General steps to accomplish the test are below.

a. Ensure the bond is fully cured prior to loading by following the adhesive cure time provided by the manufacturer.

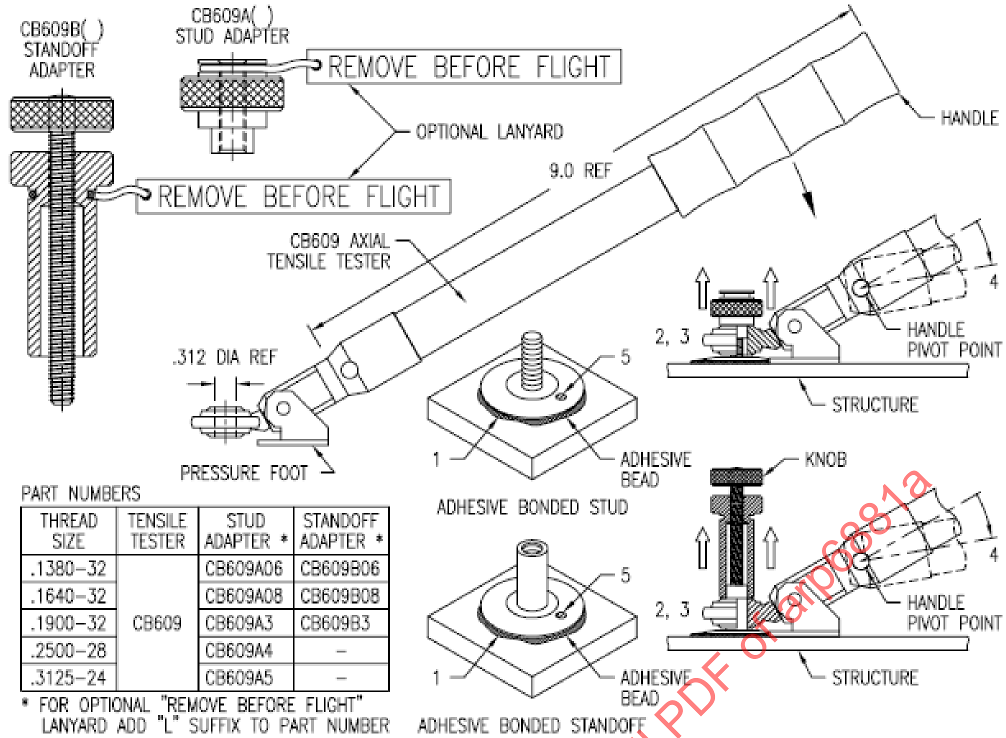
b. Ensure adhesive bead is visible around entire outer edge of the baseplate. Press on adhesive with finger to determine if adhesive is properly cured. Adhesive should not feel soft or sticky; that would indicate an incomplete cure.

c. Place the test tool onto the adhesively bonded support.

d. Install the stud tool adapter onto the stud and tighten against the tool. Slide the standoff adapter onto the standoff and turn the knob to engage the first few standoff threads.

e. Apply force on the tool handle until it breaks over at the handle pivot point. A properly installed fastener will remain bonded to the structure.

f. Remove the tool and apply a paint dot onto the fastener baseplate to show it has been tested.



THREAD SIZE	TENSILE TESTER	STUD ADAPTER *	STANDOFF ADAPTER *
.1380–32	CB609	CB609A06	CB609B06
.1640–32		CB609A08	CB609B08
.1900–32		CB609A3	CB609B3
.2500–28		CB609A4	–
.3125–24		CB609A5	–

* FOR OPTIONAL "REMOVE BEFORE FLIGHT" LANYARD ADD "L" SUFFIX TO PART NUMBER

Figure 10 - Test method: stud or standoff (provided by Click Bond, Inc.)

NOTE: Part numbers are provided only as a reference; equivalent components are acceptable.