Lockheed Martin Aeronautical Systems
Fort Worth
FSCM 81755

FPS-3024 G
Date: 19 February 2002
Superseding: FPS-3024 F

ELECTRICAL BONDING REQUIREMENTS FOR F-16 AIR COMBAT FIGHTER

Contract Number F33657-88-C-0037

DISTRIBUTION STATEMENT D: Distribution authorized to the DoD and United States DoD contractors only; Critical Technology; 28 August 2003. Other requests shall be referred to the appropriate F16 technical office.

WARNING - This document contains technical data whose export is restricted by the Arms Export Control Act (Title 22, U.S.C., Sec 2751, et seq.) or the Export Administration Act of 1979, as amended, Title 50, U.S.C., App 2401 et seq. Violations of these export laws are subject to severe criminal penalties. Disseminate in accordance with provisions of DoD Directive 5230.25.

Lockheed Martin Aeronautical Systems
Fort Worth
FSCM 81755

FPS-3024 G
Date: 19 February 2002
Superseding: FPS-3024 F

ELECTRICAL BONDING REQUIREMENTS FOR F-16 AIR COMBAT FIGHTER

Concurrence:

R. A. Niemiec
F-16 Electromagnetic
Effects Engineering

Approved By:

J. T. Amin
F-16 Materials and
Processes Engineering

CHANGE INDEX

The following changes have been made since the F revision:

Paragraph	Change	Reason for Change
1.4	Added a paragraph to show that FPS-3024 does not contain specific requirements for processing of inherently bonded assemblies.	Change made at the request of Design Engineering and Electromagnetic Effects.
3.2.1.1 and 3.2.1.3	Add a note to allow chemical cleaning (deoxidizing) of electrical bond areas.	LM Aero Fort Worth has used chemical cleaning for many years. This change acknowledges the process.
Table following 3.6.1	Table completely replaced.	Change made at the request of Design Engineering and Electromagnetic Effects.
3.6.2.5	Paragraph added to define which areas are to be prepared for electrical bonding if one of two mating surfaces has previously been prepared for bonding.	There are many drawings requiring electrical bond and only one of the details is prepared. This addition to FPS-3024 will eliminate guesswork about what area should be prepared on the mating surface.
Table I	Change the maximum resistance for “Dummy” LRU installation to 0.0025 Ohms.	Trays, racks and rails should be prepared to comply with functional equipment bonding requirements at aircraft delivery.
6.4 and 6.4.1	Added a definition for inherent electrical bond.	Change made at the request of Design Engineering and Electromagnetic Effects.
Figure 6	Add reference to brackets	Some legacy drawings bond the clamp directly to a bracket without a jumper. In this case the bracket functions as a jumper. This editorial change acknowledges this design and improves readability of the figure.
Figure 8	Inactivate Figure 8C, Modify title of 8D	Change made at the request of Design Engineering and Electromagnetic Effects. Per Electromagnetic Effects, there are no connectors with circular mount areas.
Figure 29	Inactivate Figure 29, replace with Figures 7, 10, 11, or 23	Change made at the request of Design Engineering and Electromagnetic Effects.

TABLE OF CONTENTS

Paragraph **Page**

1 SCOPE 1
1.1 Purpose 1
1.2 Application 1
1.3 Changes in Scope Between E and F Revision 1
1.4 Parts Inherently Bonded 1

2 APPLICABLE DOCUMENTS 1
2.1 Federal Documents 1
2.2 Military Documents 1
2.2 LM - Aero Documents 2

3 GENERAL REQUIREMENTS 2
3.1 Production Aids / Materials 2
3.1.1 General Cleaner 2
3.1.2 Cleaning Cloth 2
3.1.3 Materials Used to Prepare Metallic Bonding Surfaces 3
3.1.4 Resistance Measurements 3
3.1.5 Production Aids 3
3.2 Preparation for Bonding 3
3.2.1 Aluminum Bond Surfaces 3
3.2.2 Graphite Bond Surfaces 4
3.2.3 Titanium Bond Surfaces 4
3.2.4 Steel Bond Surfaces 4
3.2.5 Plated Surfaces 4
3.2.6 Bond Surfaces Prepared in Advance 4
3.2.7 Limitation for Fatigue and Fracture Critical Parts 4
3.2.8 Exception for GFE and CFE 4
3.3 Assembly 5
3.4 Verification of Bond 5
3.4.1 Verification Methods 5
3.4.2 Verification Special Cases 5
3.4.3 Re-Verification of Bonds 6
3.5 Touch-Up and Sealing 6
3.5.1 Touch-up 6
3.5.2 Sealing 6
3.6 Engineering Drawings Call-outs and Interpretation 6
3.6.1 Drawing Call-Out 6
3.6.2 Drawing Interpretation 7

4 QUALITY ASSURANCE PROVISIONS 8

5 PREPARATION FOR DELIVERY 8

6 NOTES 8
6.1 Marginal Indicia 8
6.2 Distribution List 8
6.3 Engineering Reference 8
6.4 Definition 8

7 ACKNOWLEDGMENT 9

8 NONCONFORMANCE 9

9 ENVIRONMENTAL HEALTH AND SAFETY 9

TABLE OF FIGURES

Figure **Page**

Figure 1: Bolted Connection - Jumper to Aluminum Structure....11
Figure 2: Bolted Connection – Jumper to Plated Steel, Cres, or Titanium....12
Figure 3: Bolted Connection – Jumper to Plated Steel, Cres, or Titanium - Where Temperature Exceeds 300 Degrees F....13
Figure 4: Bolted Connection – M83454/( ) Blind Plate Stud Terminals....14
Figure 5: Riveted Connection – Jumper to Aluminum....15
Figure 6: Clamp Connection – Jumper to Tube....16
Figure 7: Preparation of Bonding Connection in Bolted Structural Joints....17
Figure 8: Methods of Bonding Connectors to Attaching Part....18
Figure 9: Electrical Bonding of Details that are Electrically Isolated by Adhesives....22
Figure 10: Method of Bonding through Bolted Connections....23
Figure 11: Method of Bonding between Structural Parts in an Assembly....24
Figure 12: Electrical Bonding of Equipment Installed on Aircraft Structure with Mounting Feet....25
Figure 13: Method of Bonding between Attaching Flange of Electronic Package and Rack....26
Figure 14: Typical Method of Bonding Electrical Packages through Dagger Pins....27
Figure 15: Method of Bonding Electrical Packages to Rack through Front Attachments....28
Figure 16: Method of Bonding Edge Lighted Panels....29
Figure 17: Installation of Bonding Strips on Shock Mounts....30
Figure 18: Method of Bonding Electronic Equipment to Mount through Front Attachments....31
Figure 19: Method of RF Bonding Access Doors and Panels....32
Figure 20: Method of Bonding Static Discharger Assembly to Exterior of Aircraft....33
Figure 21: Jumper Assembly, Electric, Bonding and Current Return....34
Figure 22: Method of Bonding through Bolted Connection Requiring Sealant....35
Figure 23: Method of Bonding between Structural Parts of an Assembly Requiring Sealant....36
Figure 24: Electrical Bonding of Junction Block Assemblies to Attaching Part....37
Figure 25: Methods of Verifying the Bonding of Assemblies or Units....39
Figure 26: Method of Bonding Circuit Breakers to Circuit Breaker Panel....40
Figure 27: Method of Bonding Antenna....41
Figure 28: Method of Bonding through Fasteners....42
Figure 29: Preparation of Bonding Connection in Riveted Joints....43
Figure 30: Electrical Bonding of Components on Panels, Matrices, etc. to Attaching Part....44
Figure 31: Bond Verification of CFE LRU and Rack....45
Figure 32: Bond Verification of GFE LRU and CFE Rack....46
Figure 33: Bond Verification of Rack Mounted on Door....47
Figure 34: Bond Verification of Bonding Jumper....48

ELECTRICAL BONDING REQUIREMENTS FOR F-16 AIR COMBAT FIGHTER

1 SCOPE

1.1 PURPOSE

This specification establishes the procedures for electrical bonding and grounding of F-16 aircraft. This process replaces the Electromagnetic Environmental Effects related requirements contained in all versions of Mil-Std-464, Mil-E-6051, Mil-B-5087, and Mil Std-1818, and tiered specifications referenced therein.

1.2 APPLICATION

This specification is applicable, where specified on engineering drawings, for assembly and quality control of electrically bonded aircraft components.

The engineering drawing will define the electrical bonding configuration one of the following ways:

A. The shape and location for electrical bonding requirements are defined on the engineering drawing.

B. The shapes of the electrical bonding areas are defined using the figures herein.

1.3 CHANGES IN SCOPE BETWEEN E AND F REVISION

Information relating to the design of assemblies has been removed from this specification. That information may now be found 16PR15564.

1.4 PARTS INHERENTLY BONDED

FPS-3024 does not address inherently bonded parts.

2 APPLICABLE DOCUMENTS

The publications listed below shall apply only as required within this document. The contract or purchase order may list added requirements. Unless a particular issue is listed, use only issues listed in 16PR711. Usage of any other issues requires written approval from Lockheed Martin Aeronautical Systems – Fort Worth (LM – Aero) before use. This specification shall govern if conflicts are found with any publication listed below.

2.1 FEDERAL DOCUMENTS

Documents are available from DODSSP, Subscriptions Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

A-A-58054	Abrasive Mats, Non-Woven, Non-Metallic

2.2 MILITARY DOCUMENTS

Available from DODSSP, Subscriptions Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

Mil-B-5087	Bonding, Electrical, and Lightening Protection, for Aerospace Systems
Mil-C-5541	Chemical Conversion Coatings on Aluminum and Aluminum Alloys
Mil-C-81706	Chemical Conversion Materials for Coating Aluminum and Aluminum Alloys
Mil-C-83413	Connectors and Assemblies, Electrical, Aircraft Grounding: Type IV Jumper Cable Assembly, Lead, Electrical
MS25083	Jumper Assembly, Electric, Bonding and Current Return

2.2 LM - AERO DOCUMENTS

Available from LM - Aero Service Library, P. O. Box 748, MZ 1519, Fort Worth, TX 76101.

16PR070	Finishing Codes for F-16 Air Combat Aircraft
16PR711	F-16 Materials Procurement and Processing Specifications Applicable Issues
16PR15563	F-16 Air Combat Fighter Electrical Bonding Requirements Specification
16PR15564	F-16 Air Combat Fighter Electrical Bonding Design Requirements
FMS-2004	Cleaning Solvent
FPS-1003	Sealing Specification – Pressurized and Non-Fuel Areas
FPS-1004	Sealing Specification, Integral Fuel Tanks
FPS-3001	Contractor Finish Specification for F-16 Air Combat Fighter
FPS-3035	Process and Quality Control of Adhesively Bonded Integral Fuel Tanks
P5396	Cloth, Cleaning, Woven
P6174	Cleaner, Solvent, Non-Aromatic
P6228	Cleaner, Solvent, Mil-C-38736 Alternate
P6230	Cleaner, Solvent, ASTM D 740

3 GENERAL REQUIREMENTS

3.1 PRODUCTION AIDS / MATERIALS

3.1.1 GENERAL CLEANER

Wipe solvents that are approved for use as "General Cleaner" include A-A-59281, P6228, P6230, P6174 and FMS-2004. FMS-2004 shall be used at LM Aero where General Cleaner is specified. Maximum cleaning efficiency when using a general cleaner is obtained as follows:

A. Wipe substrate with clean cloths (reference paragraph 3.1.2) moistened with cleaner.

B. Immediately wipe surface dry using clean, dry cloths (reference paragraph 3.1.2).

3.1.2 CLEANING CLOTH

Cloths used in cleaning and wiping operations shall conform to P5396.

3.1.3 MATERIALS USED TO PREPARE METALLIC BONDING SURFACES

Materials used for preparation of metallic bonding surfaces shall be chosen from those listed in FQPL-3024 or the following list of products:

(a) 240 – 400 grit aluminum oxide abrasive cloth

(b) 240 – 400 grit abrasive disk with power tool

(c) Fine or Very Fine abrasive pad (reference A-A-58054)

(d) Fine or Very Fine abrasive pad (reference A-A-58054) with power tool

(e) Unitized wheels, cut and polish 7A medium or

Unitized wheels, general purpose, 5A fine

(f) Fiberglass brushes.

Power tools shall not be used on fatigue and fracture critical parts. Abrasive material shall be reused only on the same type of material (i.e. aluminum) on which it was originally used.

3.1.4 RESISTANCE MEASUREMENTS

Equipment used for resistance measurements shall be chosen from those listed in FQPL-3024.

3.1.5 PRODUCTION AIDS

Plastic "colored lead" pencils, from a locally approved source, may be used to mark locations for electrical bond preparation. Pencils containing graphite "leads" shall not be used.

3.2 PREPARATION FOR BONDING

Preparation for bonding is expected to occur immediately prior to assembly. In some cases, the bond surface will be prepared in advance. It is permissible to rely on the existing bond preparation provided the bond area is cleaned per paragraph 3.2.6 and meets the requirements of paragraph 3.4. Preparing the bond surface immediately prior to assembly will optimize the condition of the surface and increase the chances of acceptable bond verification.

3.2.1 ALUMINUM BOND SURFACES

3.2.1.1 Parts Not Anodized at Time of Bond Preparation

When a part contains areas that will be anodized, and other areas that will be electrically bonded, process as follows. Abrade bond area with #180 grit or finer abrasive such as aluminum oxide or emery cloth. Within 4 hours, chemical film treat (immersion or brush) per Mil-C-5541 using materials conforming to Mil-C-81706 Class 3. Materials meeting the requirements of Mil-C-81706 Class 1A may be used provided the bond meets the requirements of paragraph 3.4. After chem film treatment, apply a suitable maskant to the bond area. Anodize the part in accordance with the engineering drawing, and associated finish codes. Remove the maskant and clean the bond surface with clean P5396 cloth moistened with General Cleaner (reference paragraph 3.1.1).

Note: Chemical deoxidation may be used as an alternate to abrasion when approved in writing.

3.2.1.2 Anodized Surfaces

When a part requiring electrical bonding has been anodized in the bond area, proceed as follows. Remove the anodic coating from the area to be bonded using an approved material, reference paragraph 3.1.3. Clean the bond surface with clean P5396 cloth moistened with General Cleaner (reference paragraph 3.1.1). Chemical film treat per Mil-C-5541 using materials conforming to Mil-C-81706 Class 3. Materials meeting the requirements of Mil-C-81706 Class 1A may be used provided the bond meets the requirements of paragraph 3.4. The chem film treatment shall be applied within 4 hours of removal of anodize.

3.2.1.3 Parts Not Requiring Anodize

Parts whose final finish does not require anodize (reference FPS-3001 and the engineering drawing) shall be prepared as follows. Abrade bond with #180 grit or finer abrasive such as aluminum oxide or emery cloth. Clean the bond surface with clean P5396 cloth moistened with General Cleaner (reference paragraph 3.1.1). Chemical film treat per Mil-C-5541 using materials conforming to Mil-C-81706 Class 3. Materials meeting the requirements of Mil-C-81706 Class 1A may be used provided the bond meets the requirements of paragraph 3.4.

Note: Chemical deoxidation may be used as an alternate to abrasion when approved in writing.

3.2.2 GRAPHITE BOND SURFACES

The fastener hole shall be free of all coatings allowing fiber end contact with the fastener.

3.2.3 TITANIUM BOND SURFACES

Abrade the bond area using an approved material, reference paragraph 3.1.3. Remove all paint and or primer, if present.

3.2.4 STEEL BOND SURFACES

Abrade the bond area using an approved material, reference paragraph 3.1.3. Remove all paint and or primer, if present.

3.2.5 PLATED SURFACES

Platings shall not be removed. Polish the bond area using one of the materials approved in FQPL-3024. Clean the bond surface with clean P5396 cloth moistened with General Cleaner (reference paragraph 3.1.1).

3.2.6 BOND SURFACES PREPARED IN ADVANCE

Where bond surfaces are prepared in advance of assembly, masking residue, fingerprints and other surface contaminates shall be removed immediately prior to bonding. Clean the bond surface with clean P5396 cloth moistened with General Cleaner (reference 3.1.1).

3.2.7 LIMITATION FOR FATIGUE AND FRACTURE CRITICAL PARTS

Fatigue and fracture critical parts shall be chem-filmed using a brush process (reference FPS-3001 and 16PR070 Element 178) or by immersion process (reference FPS-3001 and 16PR070 Element 176). No metal removal, beyond the initial oxide layer, is permitted.

3.2.8 EXCEPTION FOR GFE AND CFE

For Government Furnished Equipment (GFE) and Company Furnished Equipment (CFE), clean the bond surface with clean P5396 cloth moistened with General Cleaner (reference paragraph 3.1.1). Paint or other insulating finishes shall not be removed without contractual approval.

3.3 ASSEMBLY

Assemble the parts in accordance with the engineering drawing.

3.4 VERIFICATION OF BOND

Verify electrical bonds immediately following assembly of the bond using equipment listed on FQPL-3024. Minor removal of surface finish to allow verification of the bond is allowed. The finish shall be restored per paragraph 3.5.

3.4.1 VERIFICATION METHODS

Verification of electrically bonded parts and equipment may be made by either of the following methods.

3.4.1.1 Indirect Measurement of Bond

Place the probes of the milliohm meter between the newly bonded part and the nearest convenient airframe structure (i.e. a known ground point). The measured resistance shall meet the requirements of Table 1.

3.4.1.2 Individual Method of Measurement

Measure each individual mating joint in a series of bonds from the newly bonded part to airframe structure. The milliohm meter probes shall be placed as close as practical to the bond. Each individual bond joint shall meet the requirements of Table 1.

3.4.2 VERIFICATION SPECIAL CASES

The following requirements are to be used in conjunction with paragraph 3.4.1.

3.4.2.1 Verification of Equipment Rack Bonding

For equipment rack bonding, verify the resistance between the dagger pin boss, LRU clamps, tray surface or other bonding interface provision and the structure immediately adjacent to the rack. Reference Figure 33.

3.4.2.2 Verification of LRU Bonding

For Line Replaceable Units (LRU), verify the resistance between the LRU and its mounting rack. Bonding checks on LRUs shall be performed with all external power and signal connections disconnected. Reference Figures 31 and 32.

3.4.2.3 Verification of Items on a Door or Hinged Panel

For items installed on a door or hinged panel, verify the bond between the item and the door structure. Reference Figure 34.

3.4.2.4 Verification of Bond Jumpers

For bond jumpers, verify the bond between the jumper wire terminal and the structure to which the terminal is attached. Verify both ends of the bond jumper.

3.4.2.5 Verification of Wiring Harnesses

Verify ground wire-to-structure connections by a continuity test (FACT tester) after installation of the wiring harness. Ground connections made after mating or after the FACT tester station shall be verified individually.

3.4.2.6 Verification of Bonds with Allowed Resistance Greater than 0.5 Ohms

For electrical connection type measurements where the limits of Table 1 are greater than 0.5 ohms, a Volt-Ohm meter may be used (reference FQPL-3024). The ground wire termination resistance shall be zero (meter should indicate no resistance) on the times 1 (X1) resistance scale of the V-O-M.

3.4.2.7 Verification of Hydraulic Lines

Bonding measurements of hydraulic lines shall not be required as they are inherently bonded.

3.4.3 RE-VERIFICATION OF BONDS

3.4.3.1 Re-Verification When the Bond Has Not Been Disturbed

Once a bond procedure is completed with an acceptable bond resistance measurement, there is no need to re-verify the bond unless the bond is disturbed.

3.4.3.2 Re-Verification When the Bond Has Been Disturbed

When equipment requiring electrical bonding is removed, and either reinstalled or replaced, verify the electrical bond as a part of the reinstallation. The requirements for re-verification are identical to the initial verification.

3.5 TOUCH-UP AND SEALING

3.5.1 TOUCH-UP

Touch-up finish in the areas where anodize, prime or paint was either omitted or removed to accomplish electrical bonding. Touch-up any areas where finish was removed to verify electrical bonding. Take care that the touch up material does not wick in between the components that are bonded. The areas shall be touched-up per the applicable portion of the finish code specified by the engineering drawing, FPS-3001, and 16PR070. Touch-up may be delayed until after final bond verification. In the case of equipment that is expected to be removed and reinstalled, touch-up may be delayed until the final installation has been verified. For electrical bonds made at a subcontractor's facilities, the touch-up shall be completed prior to shipment to LM – Aero.

3.5.2 SEALING

If sealing is specified on the engineering drawing, apply the sealant specified by the drawing in accordance with FPS-1003, FPS-1004, or FPS-3035. The sealant shall be applied following bond verification and touch-up.

3.6 ENGINEERING DRAWINGS CALL-OUTS AND INTERPRETATION

3.6.1 DRAWING CALL-OUT

The engineering drawing shall specify electrical bonding requirements. Figures 1 thru 30 of this specification may be used to define the size and shape of the prepared areas. Sample drawing notes are shown below.

Design Condition	Sample Note
For detail part drawings:	
For parts with the electrical bond area defined by reference to a figure of FPS-3024	Prepare surface for electrical bond per FPS-3024, Figure ____.
For parts with the electrical bond area dimensioned or defined as an entire surface	Prepare surface for electrical bond per FPS-3024.
For assembly and installation drawings:	
For assembly and installation drawings with the electrical bond area defined at the detail part level for at least one of the mating parts. The part without surface preparation will be prepared at assembly / installation to match the bonding surface of the mating part.	Electrical bond per FPS-3024.
For assembly and installation drawings with no electrical bonding area defined at the detail part level. Both mating surfaces will be prepared at assembly / installation per the figure.	Electrical bond per FPS-3024, Figure ___.
For assembly and installation drawings with an electrical bond area defined at the assembly or installation level by dimensioning.	Prepare surface for electrical bond per FPS-3024.
For assembly and installation drawings with an electrical bond area defined at the assembly or installation level by referring to a figure in FPS-3024.	Prepare surface for electrical bond per FPS-3024, Figure ____.
For assembly and installation drawings involving a surface other than aluminum, specify the bond resistance on the face of the drawing.	Electrical bond per FPS-3024, maximum resistance _____ ohms.

3.6.2 DRAWING INTERPRETATION

3.6.2.1 Omit Paint and Prime

Where “Omit Paint and Prime” is specified and the drawing also specifies FPS-3024, the words “omit paint and prime” shall be interpreted to mean omit anodize, paint and prime in the specified area.

3.6.2.2 Immersion Chem Film

Where the note says, “Prepare surface per Figure ____ Method I,” the part shall be immersion chem filmed per FPS-3001 Element 176.

3.6.2.3 Brush Chem Film

Where the note says, “Prepare surface per Figure _____ Method II,” the part shall be brush chem filmed per FPS-3001 Element 178.

3.6.2.4 Bond Verification

There have been changes to the standard engineering drawing notes over the course of the F-16 program. Some drawings have a separate note to verify electrical bond. All electrical bonds are to be verified at the time of assembly, whether or not the engineering drawing contains a note stating, “Verify Electrical Bond per FPS-3024.”

Note: In rare cases, an installation drawing may specify to verify a particular bond that was accomplished at a lower level. Verify the bond when two parts are first joined. The second verification will be noted on a drawing that specifies, "Verify electrical bond" but does not specify "Electrical bond per FPS-3024." Perform the second verification when the engineering drawing specifies.

3.6.2.5 Bond Area

If an assembly or installation drawing requires electrical bonding per FPS-3024 without reference to a figure number, and one of the details defines an area to be prepared, then the matching areas on the mating part shall be prepared for bonding. The dimensions of the prepared area on the mating part shall be equal to the dimensions of the defined area, minimum; and no larger than the defined area plus .125 inches, maximum.

4 QUALITY ASSURANCE PROVISIONS

Verification of electrical bonds is an inherent part of making the bond. Quality assurance provisions are, therefore included within Paragraph 3.

5 PREPARATION FOR DELIVERY

Packaging and delivery of parts shall be as specified in the contract or purchase order.

6 NOTES

6.1 MARGINAL INDICIA

This specification was completely revised since the last revision. Marginal indicia are not included since every paragraph was modified in some way.

6.2 DISTRIBUTION LIST

Contact LM-Aero for additions, deletions, and corrections to distribution lists.

6.3 ENGINEERING REFERENCE

Requirements in this specification are intended to ensure proper electrical bond between mating parts. The figures provide guidelines for preparing mating surfaces for electrical bonding. These figures are examples and may or may not be exact duplicates of the actual design.

6.4 DEFINITION

The following definition is taken from MIL-B-5087A and edited slightly. The definition is included here for information only.

6.4.1 Inherent Electrical Bond -

Bonding requirements are considered as being met inherently by permanent metal-to-metal joints made by welding, brazing, sweating, or swaging, or by semi-permanent metal-to-metal joints of machined metal

surfaces held together by lock-threaded devices, tie rods, or structural wires under heavy tension, pinned fittings driven tight and not subjected to wear, and clamped fittings normally permanent and immovable after installation.

7 ACKNOWLEDGMENT

A supplier shall reference this specification number, its revision letter, amendment, and any applicable program supplement in all quotations and when acknowledging purchase orders.

8 NONCONFORMANCE

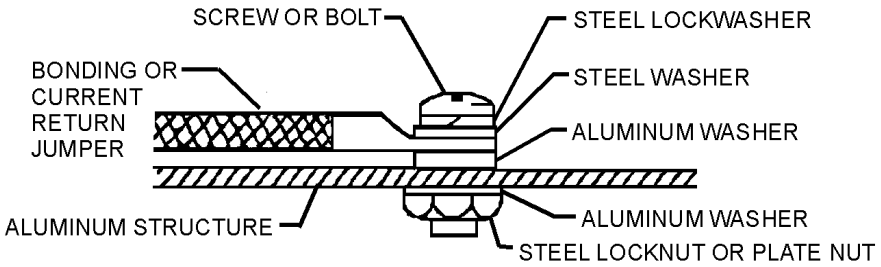
Product not conforming to this specification or the purchase order is unacceptable.

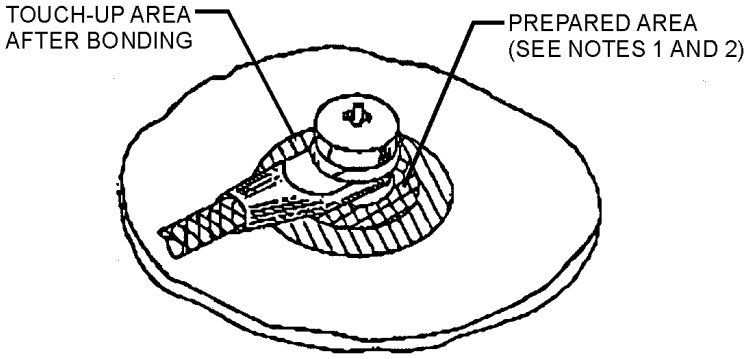
9 ENVIRONMENTAL HEALTH AND SAFETY

Chemicals or materials must meet the VOC/HAP content limits as maintained by LM – Aero Environmental Resources Management. Details for handling chemicals or materials may be found in Material Safety Data Sheets (MSDS) and Safe Practice Instructions (SPIs). Contact Occupational Health and Safety, Department 003-3 for MSDSs and SPIs. Subcontractors or vendors are responsible for compliance with all applicable regulations for their facilities. Contact Occupational Health and Safety for questions about handling information and protective gear needs.

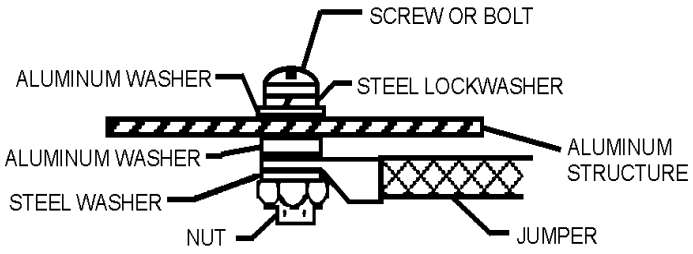
Application	Maximum Resistance
General Bond Requirement	0.0025 Ohm
Antenna Installations	0.0025 Ohm
RF Potentials	0.0025 Ohm
Shock Hazard	0.0025 Ohm
Circuit Breakers – bonded to their mounting panels	0.50 Ohms
Static Charge	0.50 Ohm
Static Dischargers	0.20 Ohm
Current Returns	0.0025 Ohm
Hydraulic Lines	1.0 Ohms
Fuel Lines	1.0 Ohms
Air Ducts	1.0 Ohm
“Dummy” LRU installed in lieu of functional equipment	0.0025 Ohm
Wiring harness connector contact to structure (including the resistance of the ground wire)	0.005 Ohm plus the wire resistance
Assemblies and Installations listed 16PR15563	Refer to 16PR15563

Table 1 – Resistance Requirements



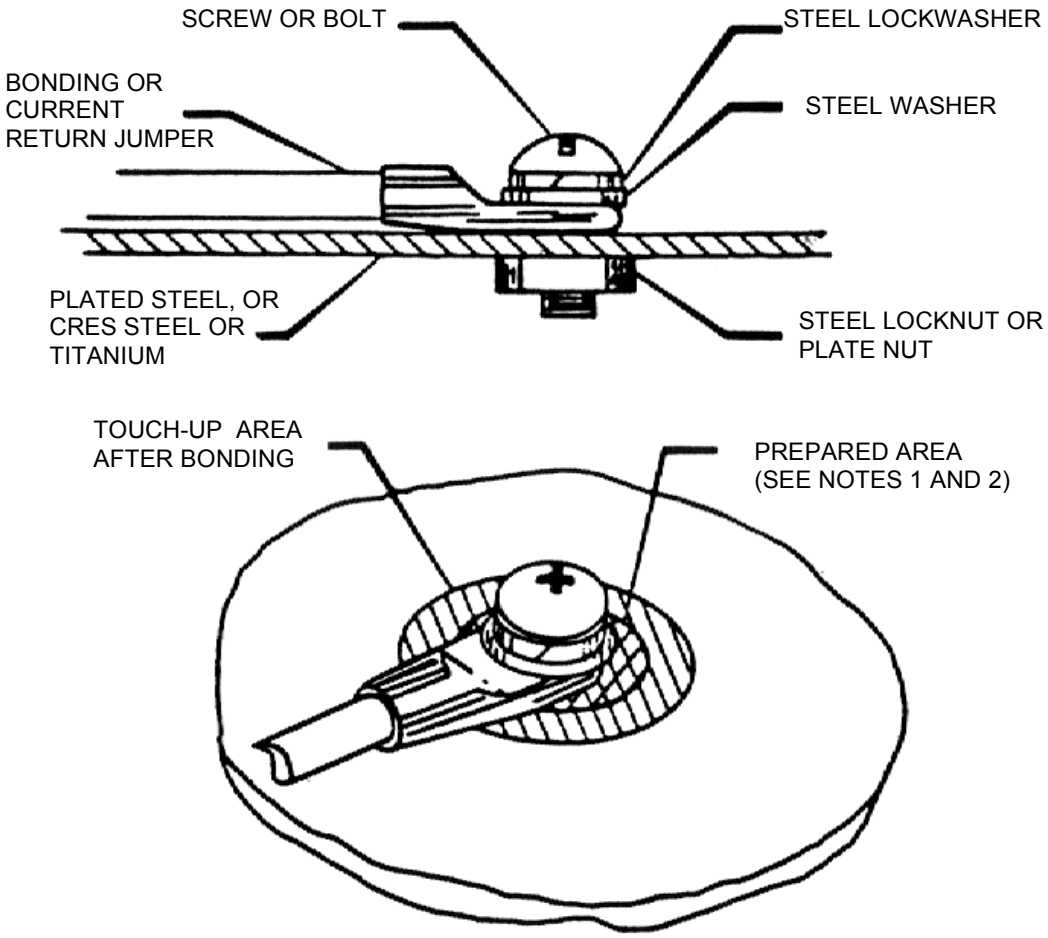


ALTERNATIVE HARDWARE ARRANGEMENT



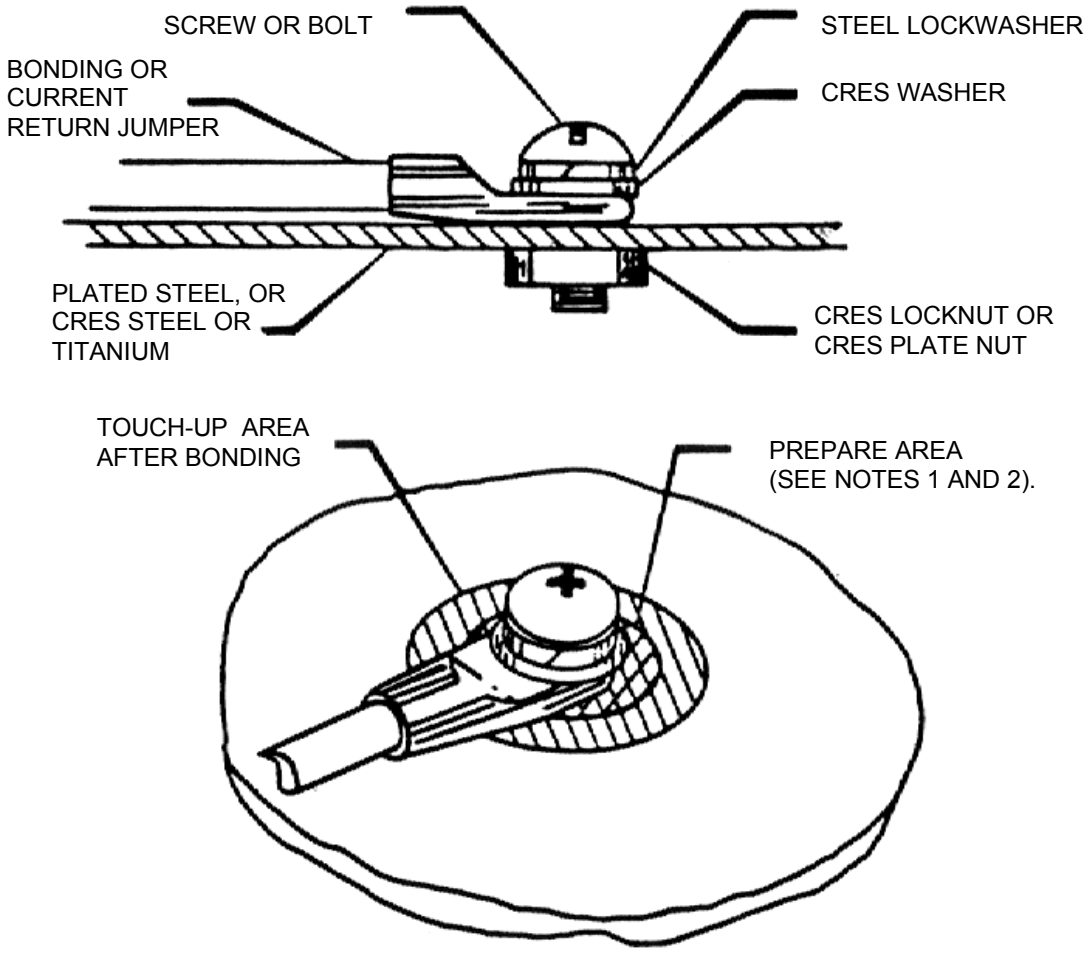
Notes:
1. Clean and prepare surface per paragraph 3.2.
2. Diameter of the prepared area shall be equal to the diameter of the washer plus .030 inches, minimum; to 1-1/2 times the diameter of the washer, maximum.
3. Touch-up the areas where finish was removed or omitted per paragraph 3.5.

Figure 1: Bolted Connection - Jumper to Aluminum Structure



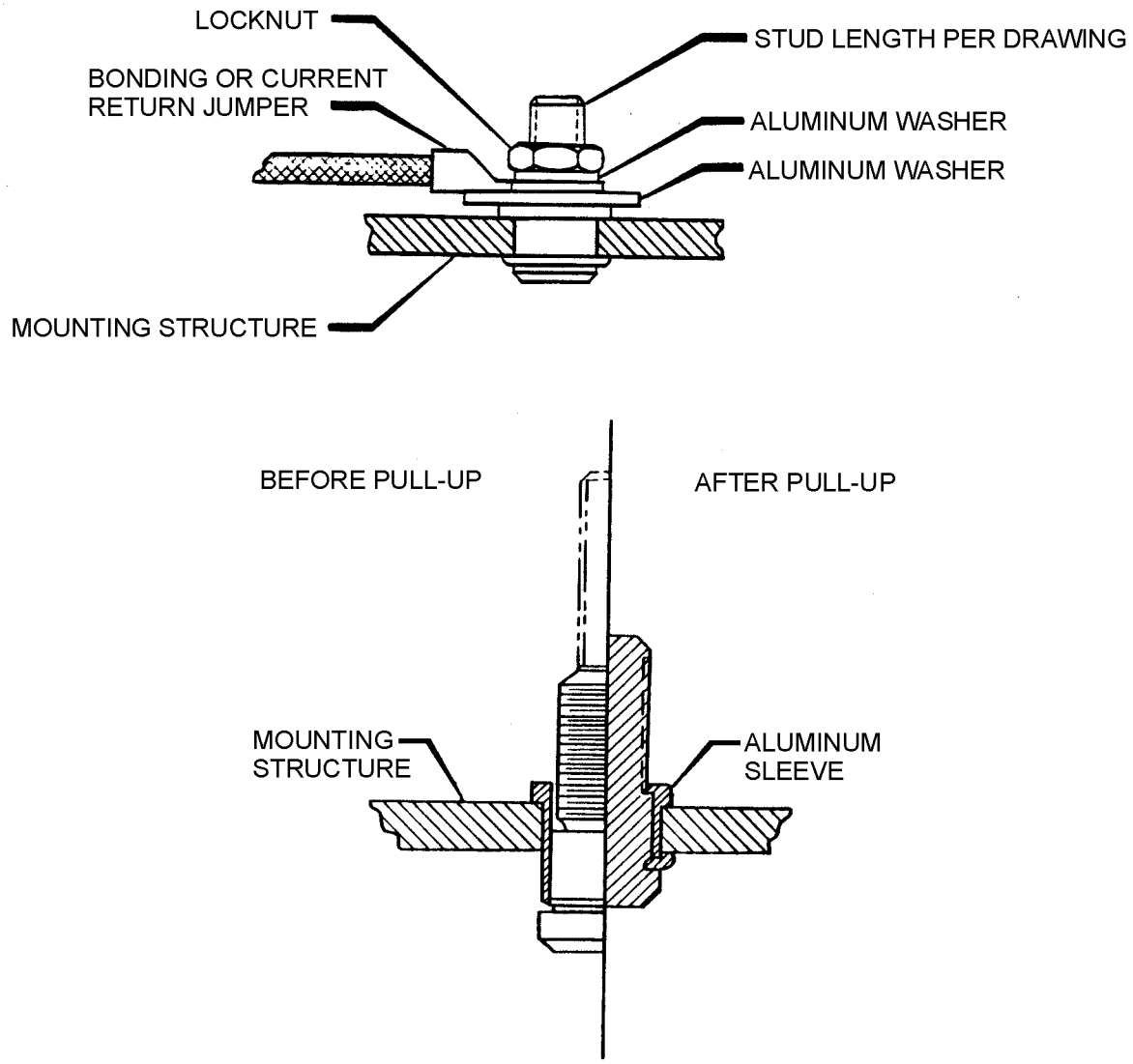
Notes:
1. Clean and prepare surface per paragraph 3.2.
2. Diameter of the prepared area shall be equal to the diameter of the washer plus .030 inches, minimum; to 1 ½ times the diameter of the washer, maximum.
3. Touch-up the areas, where finish was removed or omitted, per paragraph 3.5.

Figure 2: Bolted Connection – Jumper to Plated Steel, Cres, or Titanium



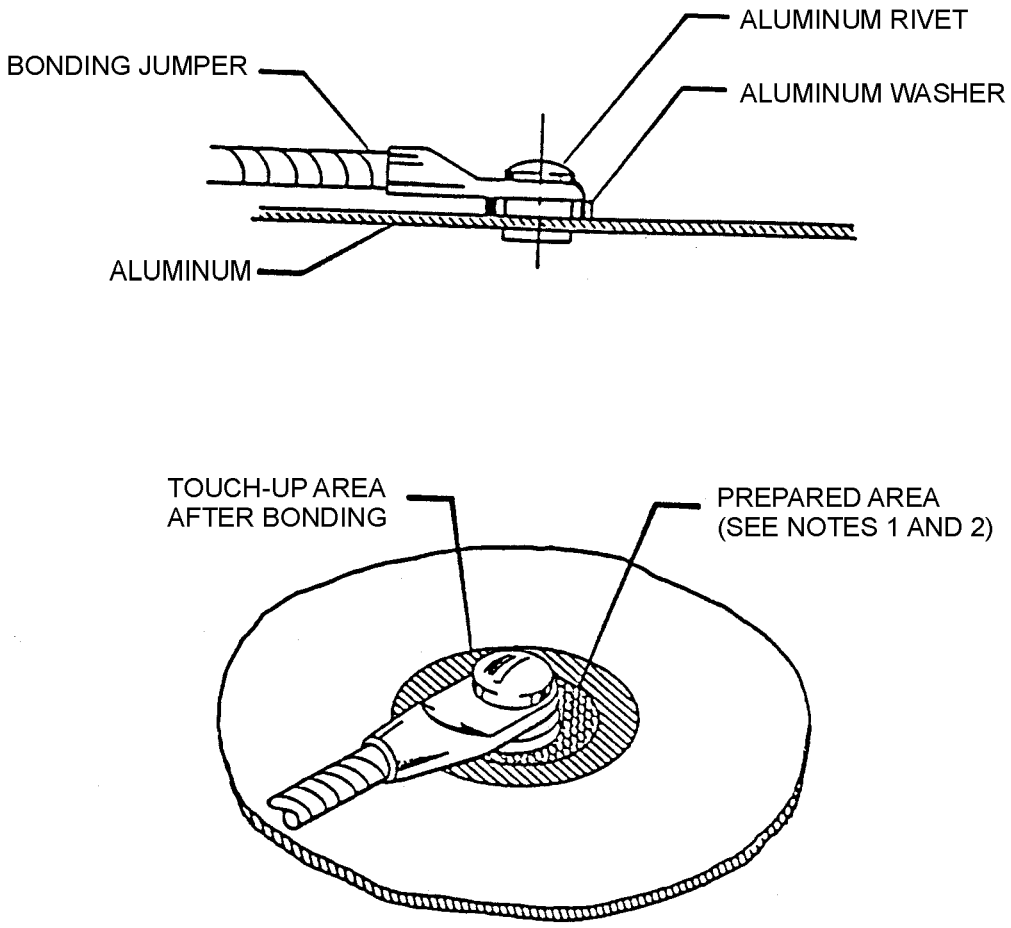
Notes:
1. Clean and prepare surface per paragraph 3.2.
2. Diameter of the prepared area shall be equal to the diameter of the washer plus .030 inches, minimum; to 1 ½ times the diameter of the washer, maximum.
3. Touch-up the areas, where finish was removed or omitted, per paragraph 3.5.

Figure 3: Bolted Connection – Jumper to Plated Steel, Cres, or Titanium - Where Temperature Exceeds 300 Degrees F



Notes:
1. Clean and prepare surface per paragraph 3.2.
2. Diameter of the prepared area shall be equal to the diameter of the sleeve plus .030 inches, minimum; to 1-1/2 times the diameter of the sleeve, maximum.
3. Touch-up the areas where finish was removed or omitted per paragraph 3.5.

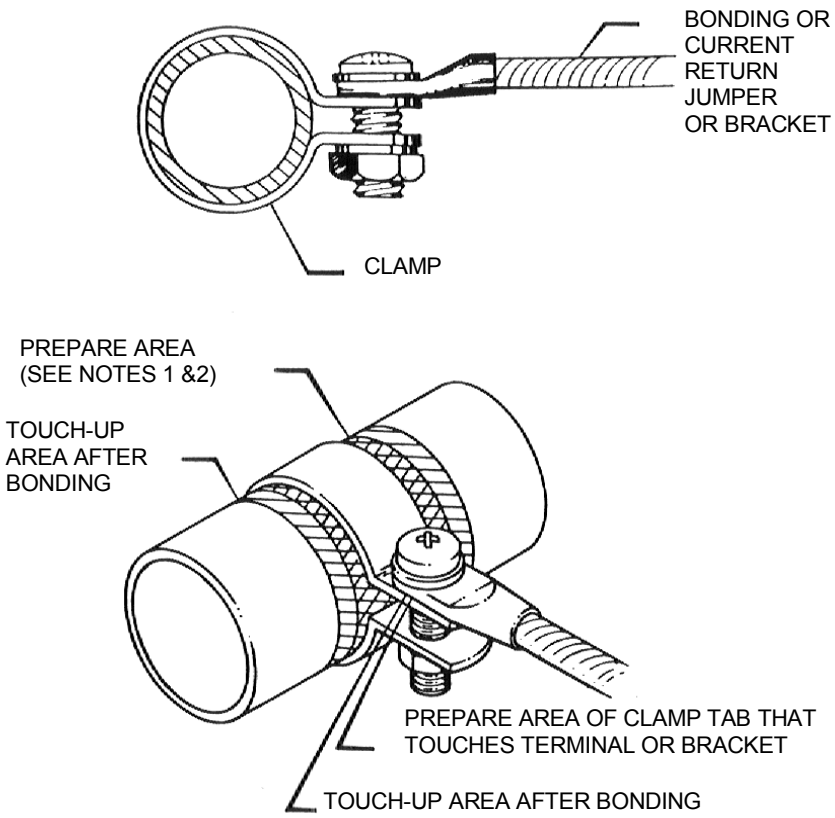
Figure 4: Bolted Connection – M83454/( ) Blind Plate Stud Terminals



INACTIVE FOR NEW DESIGN AFTER APRIL 1989

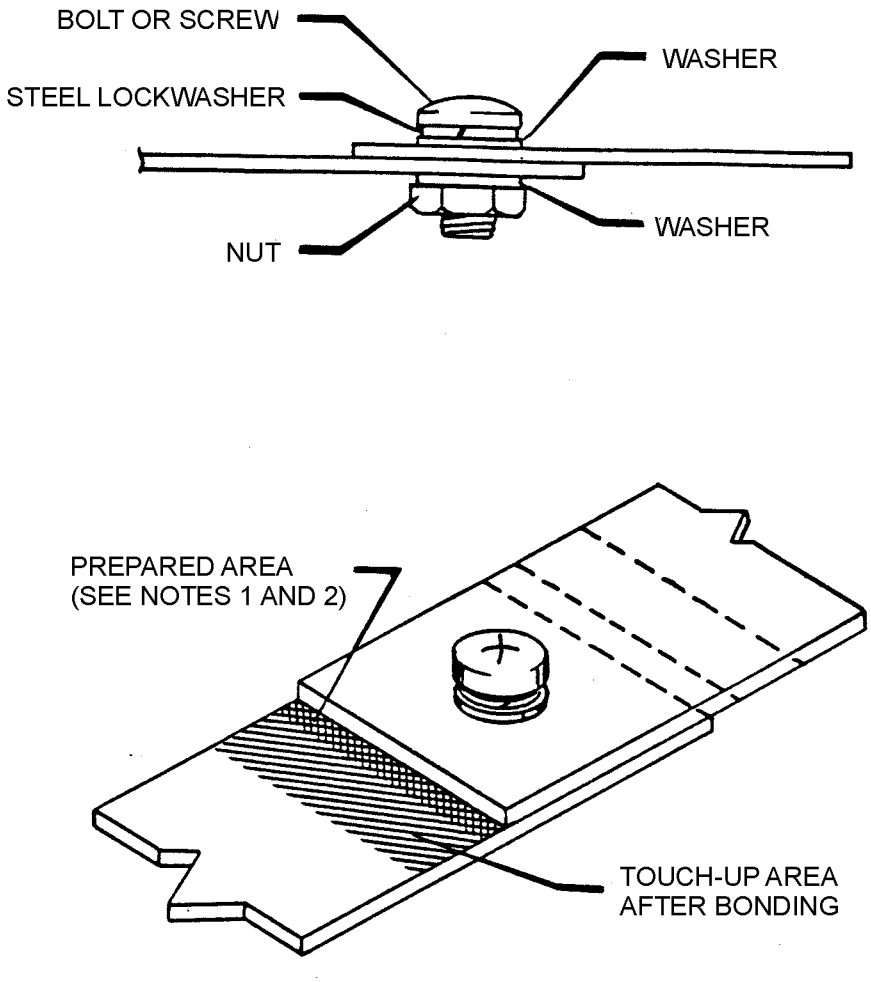
Notes:
1. Clean and prepare surface per paragraph 3.2.
2. Diameter of the prepared area shall be equal to the diameter of the washer plus .030 inches, minimum; to 1 ½ times the diameter of the washer, maximum.
3. Touch-up the areas, where finish was removed or omitted, per paragraph 3.5.
4. Do not use existing rivet for attachment.

Figure 5: Riveted Connection – Jumper to Aluminum



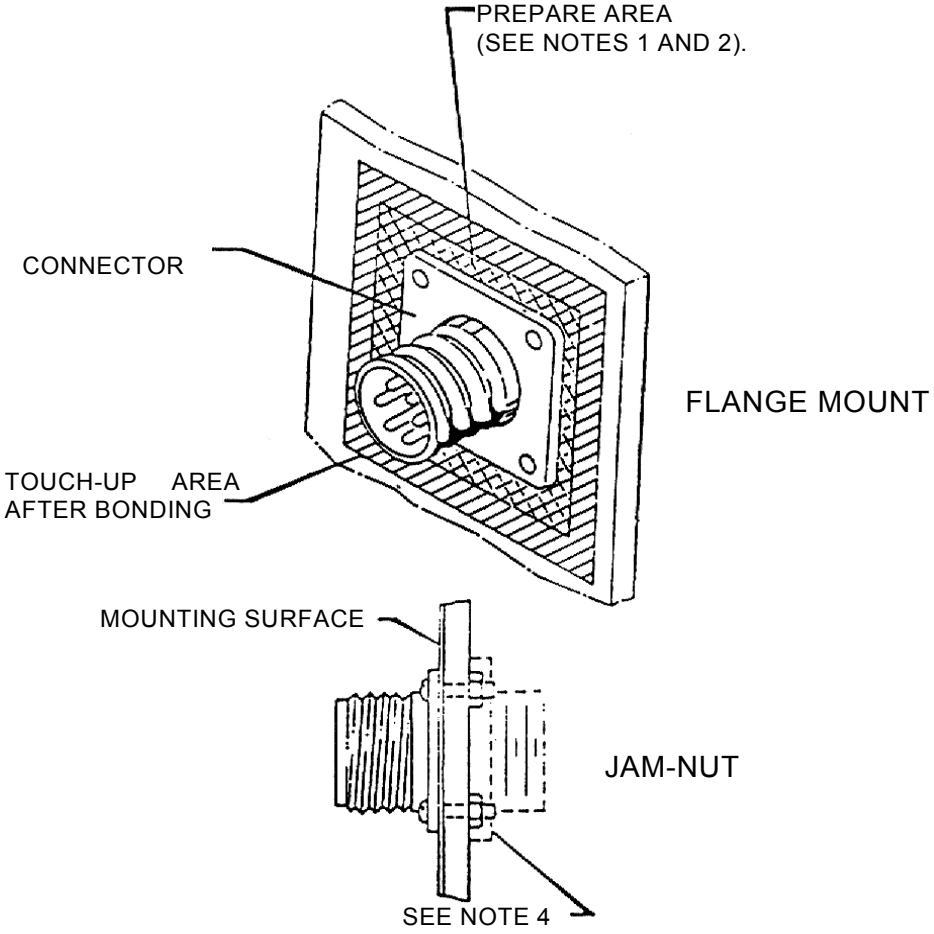
Notes:
1. Clean and prepare surface per paragraph 3.2.
2. Dimensions of the prepared area shall be equal to the dimensions of the attaching hardware plus .030 inches, minimum; to 1 ½ times the dimension of the hardware, maximum.
3. Touch-up the areas, where finish was removed or omitted, per paragraph 3.5.

Figure 6: Clamp Connection – Jumper to Tube



Notes:
1. Clean and prepare surface per paragraph 3.2.
2. Dimensions of the prepared area shall be equal to the dimensions of the attaching hardware plus .030 inches, minimum; to 1-1/4 times the dimension of the attaching hardware, maximum.
3. Touch-up the areas, where finish was removed or omitted, per paragraph 3.5.

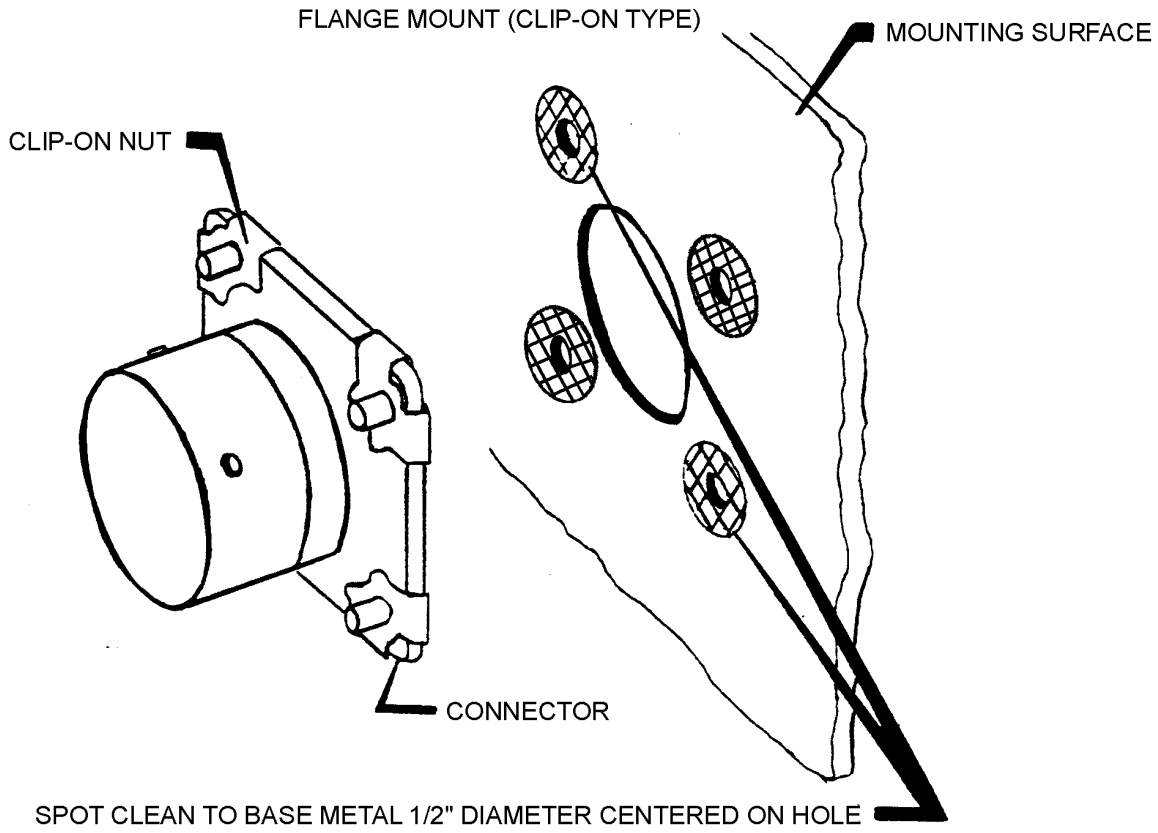
Figure 7: Preparation of Bonding Connection in Bolted Structural Joints



Notes:
1. Clean and prepare surface per paragraph 3.2.
2. Dimensions of the cleaned area shall be equal to the dimensions of the attaching hardware plus .030 inches, minimum; to 1 1/4 times the dimension of the hardware, maximum.
3. Touch-up the areas, where finish was removed or omitted, per paragraph 3.5.
4. This method of bonding is applicable for flange or jam-nut mounted connectors.

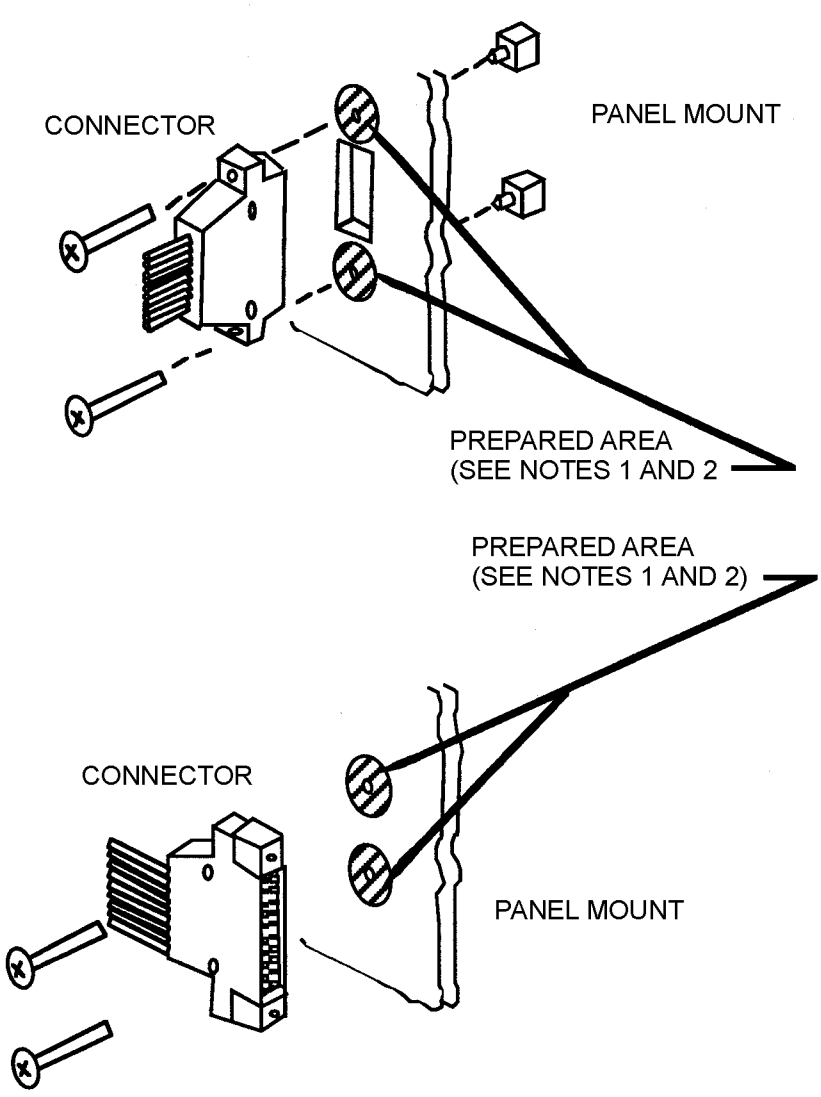
Figure 8A: Flange Mounted Connectors

Figure 8: Methods of Bonding Connectors to Attaching Part



Notes:
1. Clean and prepare surface per paragraph 3.2.
2. Dimensions of the cleaned area shall be as shown in the figure above.
3. Touch-up the areas, where finish was removed or omitted, per paragraph 3.5.
4. The connector bonding method noted above shall be used only with connectors mounted with clip-on nuts. Connectors mounted with hardware that position the connector flange flush with the mounting surface shall be mounted to a surface prepared for bonding as noted in figure 8A.

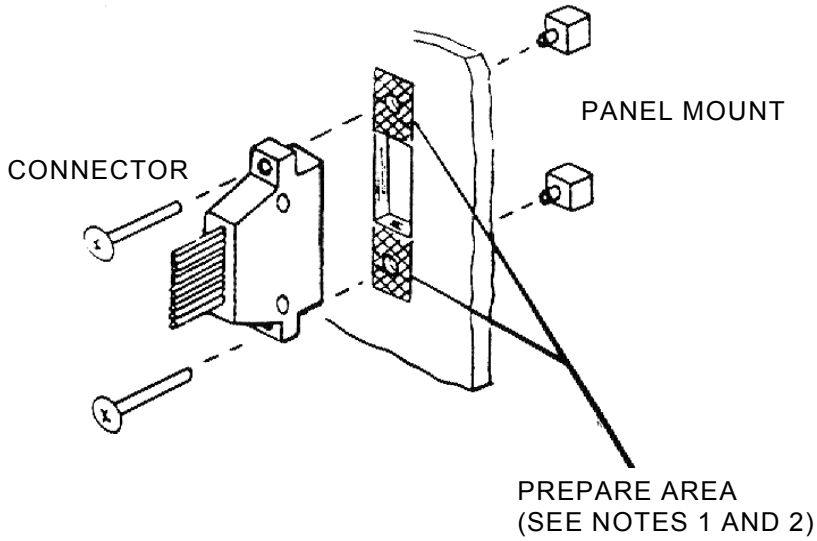
Figure 8B: Methods of Bonding Connectors to Attaching Part – Clip-On Type Nut

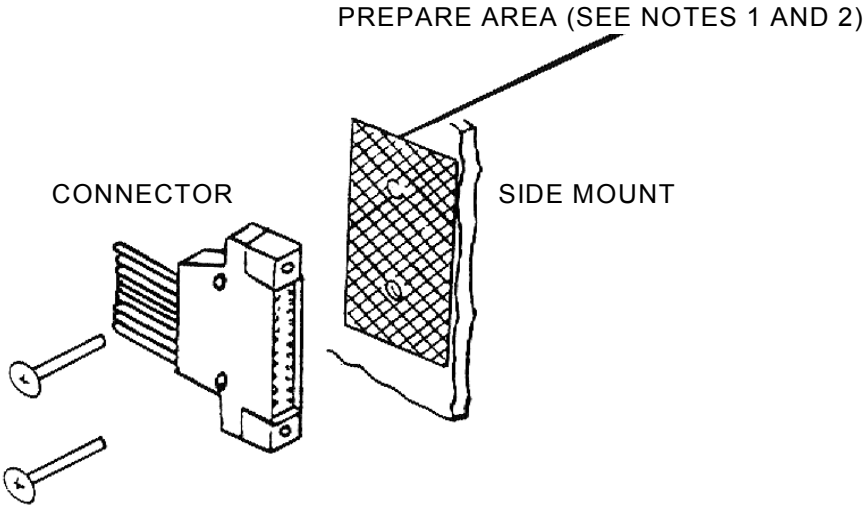


This figure is inactive for new design after January 2002

Notes:
1. Clean and prepare surface per paragraph 3.2.
2. Dimensions of the prepared area shall be larger than the dimensions of the attaching hardware by .030 inches, minimum; to .125 inches, maximum.
3. Touch-up the areas where finish was removed or omitted per paragraph 3.5.
4. Match the shape of the prepared area to the shape of the mating surface of the connector. For square areas, refer to Figure 8D.

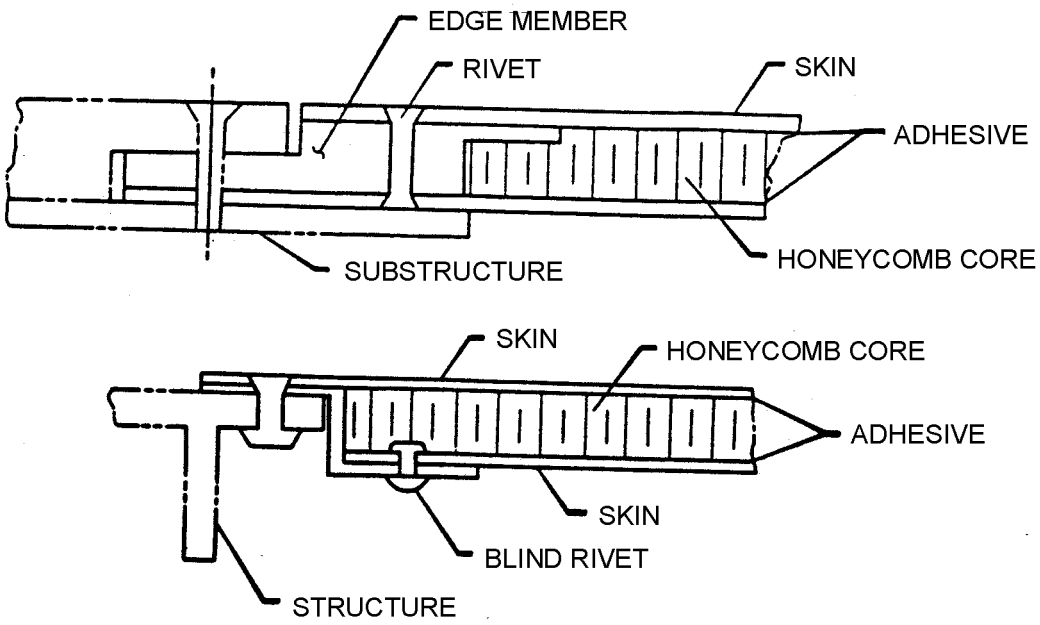
Figure 8C: Methods of Bonding Connectors to Attaching Part – Panel Mount Circular Area





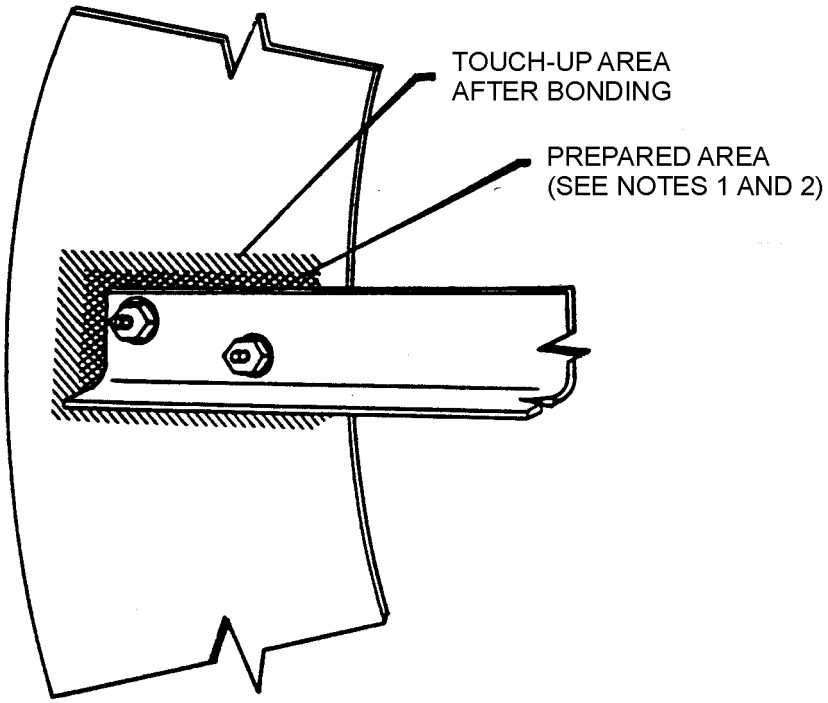
Notes:
1. Clean and prepare surface per paragraph 3.2.
2. Dimensions of the prepared area shall be equal to the dimensions of the attaching hardware plus .030 inches, minimum; to .125 inches, maximum.
3. Touch-up the areas, where finish was removed or omitted, per paragraph 3.5.
4. Match the shape of the prepared area to the shape of the mating surface of the connector.

Figure 8D: Methods of Bonding Connectors to Attaching Part – Wafer Connector



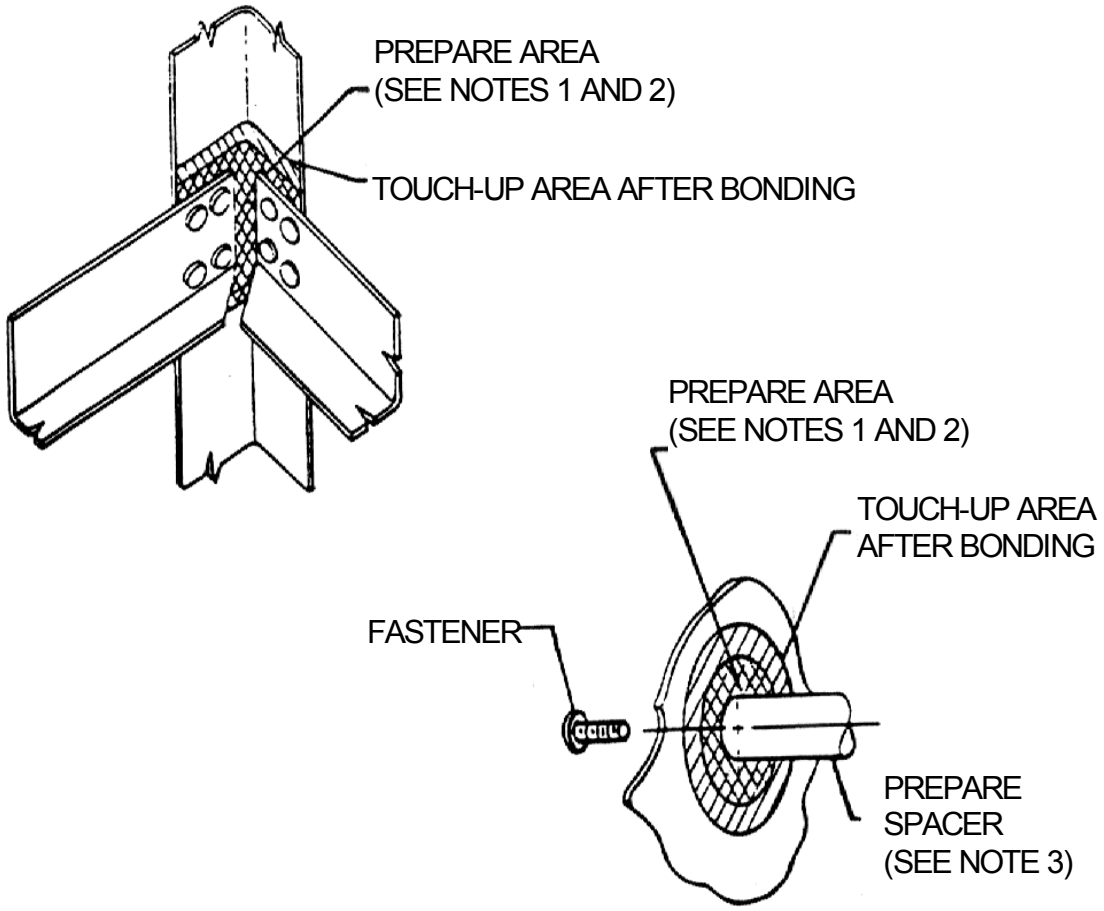
Notes:
1. After adhesive bond is cured, drill rivet holes and install rivets.
2. Apply sealant over rivets if specified by the engineering drawing. Reference paragraph 3.5.2.

Figure 9: Electrical Bonding of Details that are Electrically Isolated by Adhesives



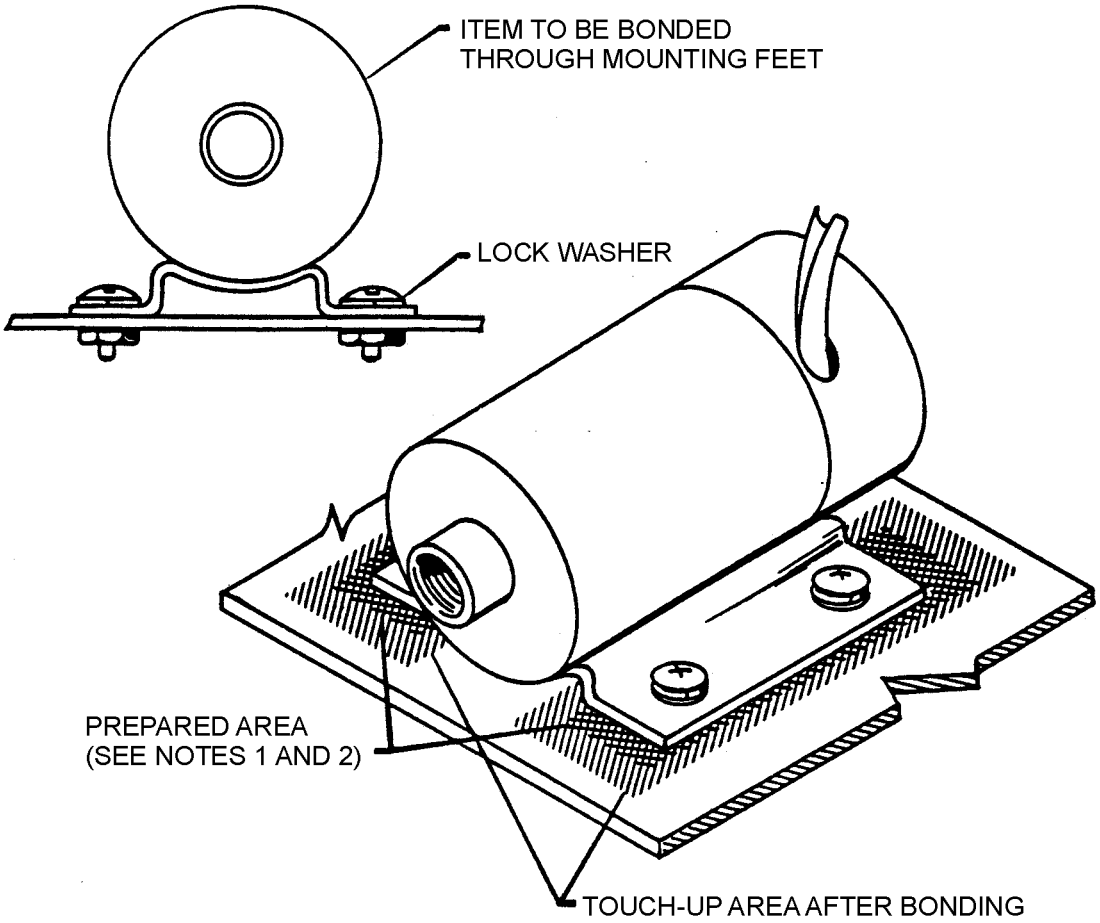
Notes:
1. Clean and prepare surface per paragraph 3.2.
2. Dimensions of the prepared area shall be equal to the dimensions of the attaching hardware plus .030 inches, minimum; to 1-1/4 times the dimension of the attaching hardware, maximum.
3. Touch-up the areas, where finish was removed or omitted, per paragraph 3.5.

Figure 10: Method of Bonding through Bolted Connections



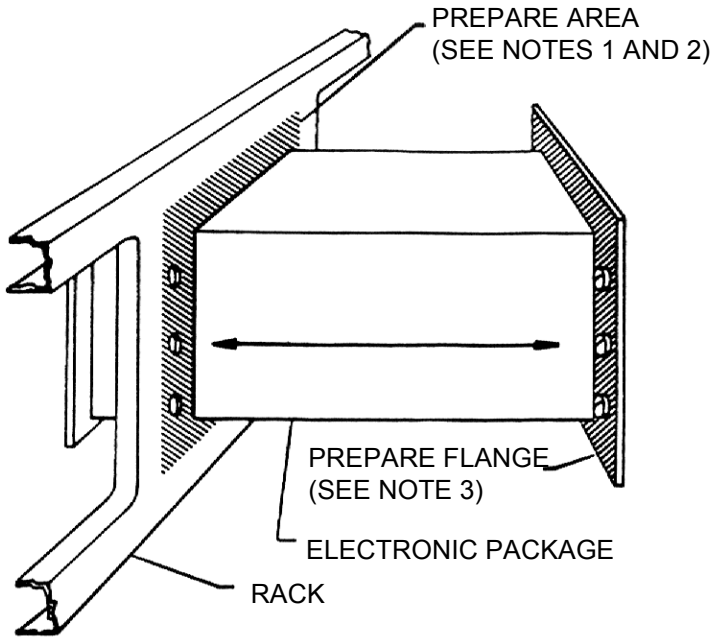
Notes:
1. Clean and prepare surface per paragraph 3.2.
2. Dimension of the prepared area shall be larger than the attaching hardware by .030 inch, minimum; to .125 inch, maximum.
3. Clean and prepare the entire mating surface of the spacer per paragraph 3.2.
4. Touch-up the areas, where finish was removed or omitted, per paragraph 3.5.

Figure 11: Method of Bonding between Structural Parts in an Assembly



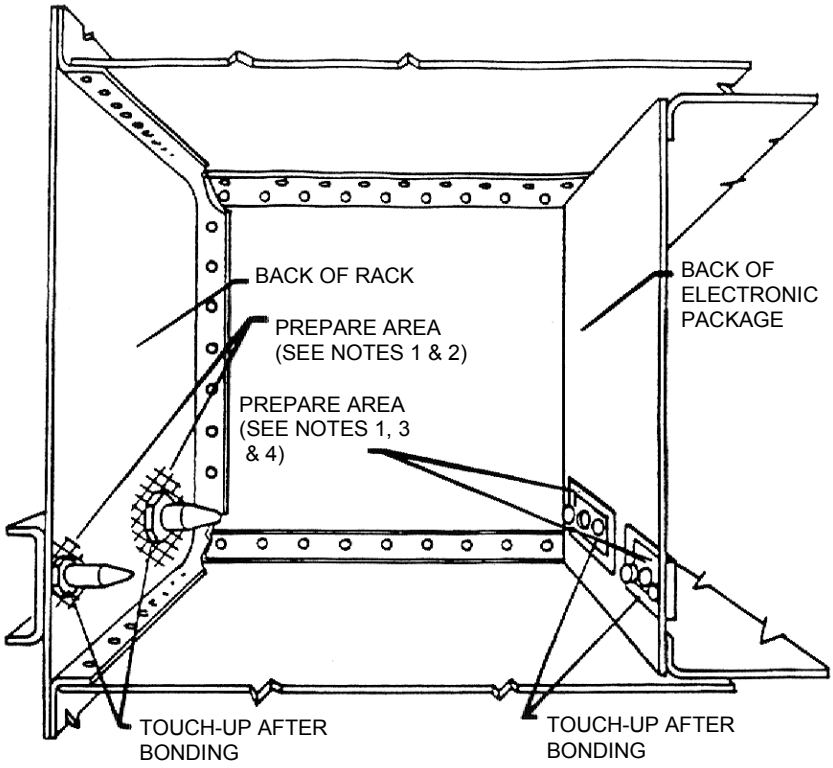
Notes:
1. Clean and prepare surface per paragraph 3.2.
2. On items that have the bolts spaced more than 2 inches apart, prepare the area 1 inch on each side of the attach bolts or screws. On items with closer fastener spacing, prepare the entire mating surface.
3. Touch-up the areas where finish was removed or omitted, per paragraph 3.5.

Figure 12: Electrical Bonding of Equipment Installed on Aircraft Structure with Mounting Feet



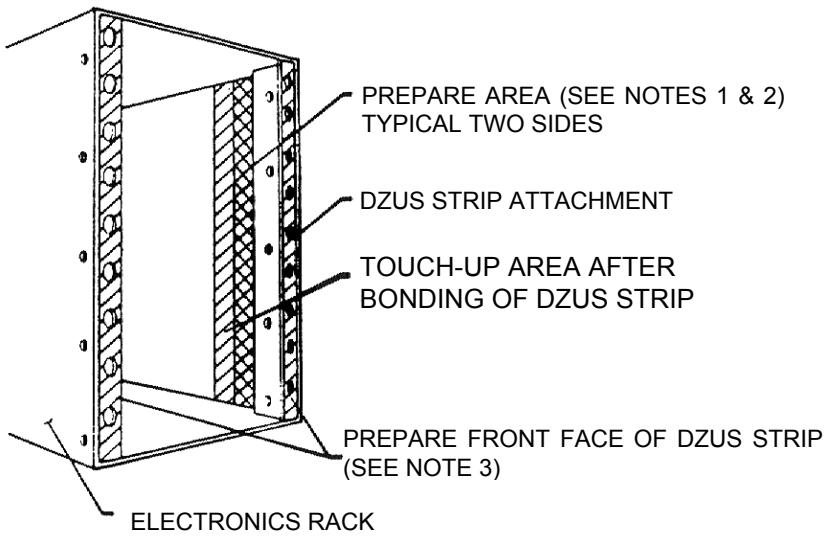
Notes:
1. Clean and prepare surface per paragraph 3.2.
2. Dimensions of the prepared area shall be larger than the dimension of the attaching flange by .030 inch, minimum; .125 inch, maximum.
3. Clean and prepare the entire mating surface of the flange per paragraph 3.2.
4. Touch-up the areas, where finish was removed or omitted, per paragraph 3.5.

Figure 13: Method of Bonding between Attaching Flange of Electronic Package and Rack



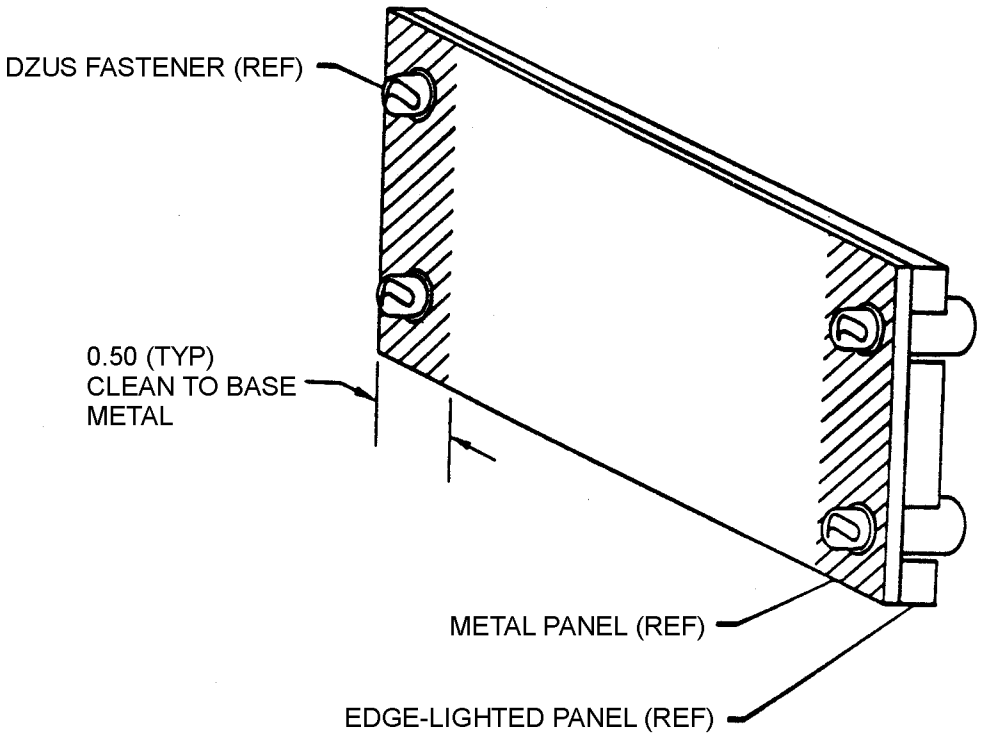
Notes:
1. Clean and prepare surface per paragraph 3.2.
2. For the dagger pins, the diameter of the prepared area shall be equal to the diameter of the area of contact plus .030 inch, minimum; to 1 1/4 times the diameter of the area of contact, maximum.
3. Dimension of the prepared area on the back of the electronic package shall be larger than the strike plate by .030 inch, minimum; .125 inch, maximum.
4. Clean and prepare the entire mating surface of the strike plate per paragraph 3.2.
5. Touch-up the areas, where finish was removed or omitted, per paragraph 3.5.

Figure 14: Typical Method of Bonding Electrical Packages through Dagger Pins



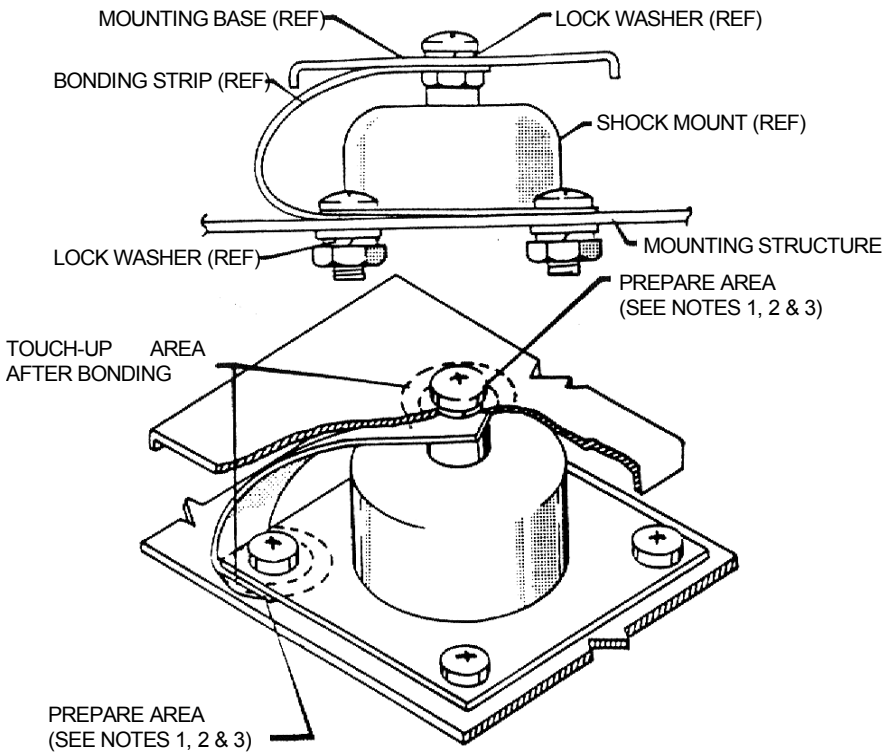
Notes:
1. Clean and prepare surface per paragraph 3.2.
2. The width of the prepared area shall be equal to the width of the DZUS strip plus .030 inches, minimum; to 1 ½ times the width of the DZUS strip, maximum. The length of the prepared area shall be larger than the DZUS strip by .030 inch, minimum; .125 inch maximum.
3. Clean and prepare the entire front face of the DZUS Strip per paragraph 3.2.
4. Touch-up the areas, where finish was removed or omitted, per paragraph 3.5.

Figure 15: Method of Bonding Electrical Packages to Rack through Front Attachments



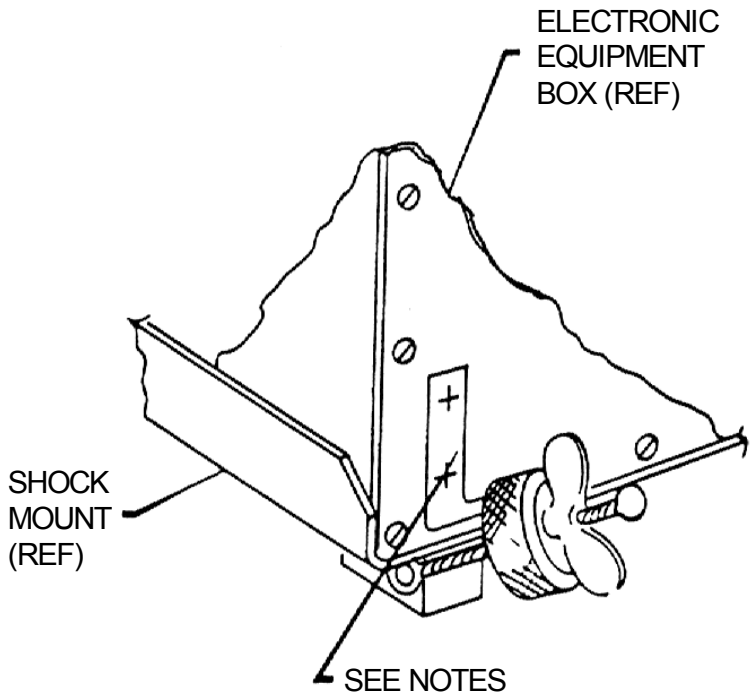
Notes:
1. Clean and prepare surface per paragraph 3.2.
2. Dimension of the prepared area shall be as defined in the figure above.
3. Touch-up the areas where finish was removed or omitted, per paragraph 3.5.

Figure 16: Method of Bonding Edge Lighted Panels



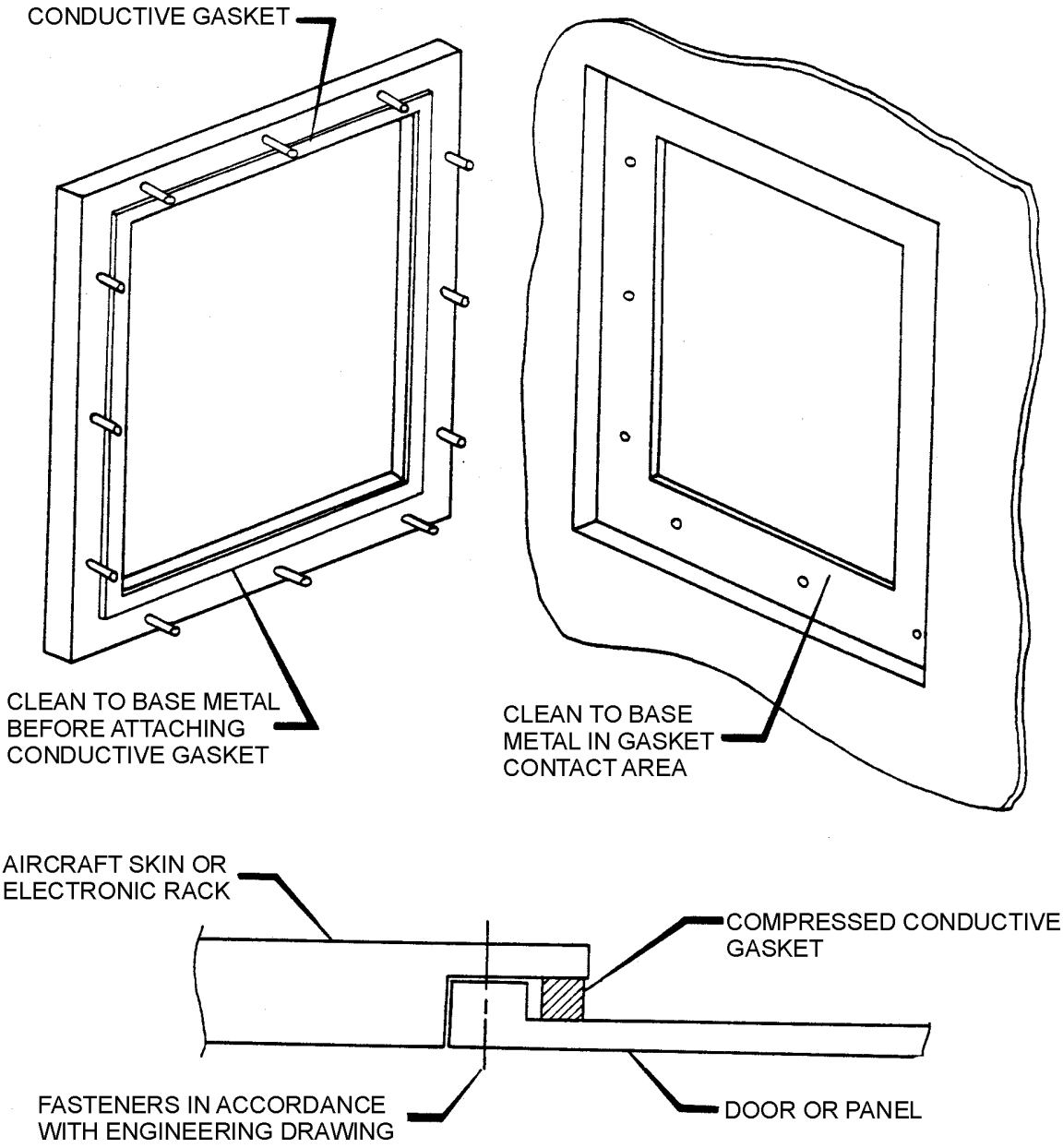
Notes:
1. Clean and prepare surface per paragraph 3.2.
2. Diameter of the prepared area on the mounting structure and mounting base shall be equal to the width of the bonding strip plus .030 inches, minimum; to 1 ½ times the diameter of the bonding strip, maximum.
3. Clean and prepare the bonding strip per paragraph 3.2. Diameter of the cleaned area shall be equal to the width of the bonding strip.
4. Install bonding strip under shock mount pad so that the strip does not alter shock mount function.
5. Touch-up the areas, where finish was removed or omitted, per paragraph 3.5.
6. All riveted elements of the shock mount shall bond. If elements of the mount do not bond, mount shall be disassembled, bonded per Figure 11 and reassembled.

Figure 17: Installation of Bonding Strips on Shock Mounts



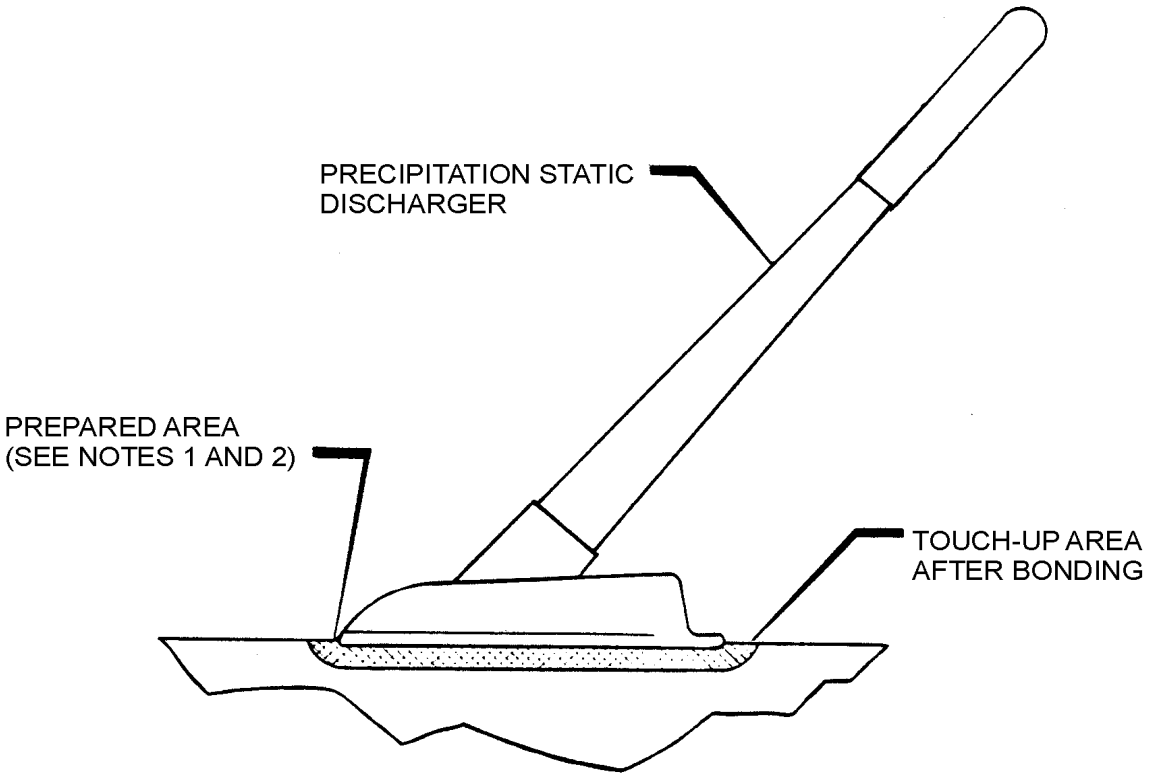
Notes:
1. Clean and prepare surface per paragraph 3.2.
2. Dimension of the prepared area on the electronic equipment box shall be larger than the attaching hardware by .030 inch, minimum; to 1 ½ times the dimension of the attaching hardware, maximum.
3. Clean and prepare the entire mating surface of the attaching hardware per paragraph 3.2.
4. Touch-up the areas, where finish was removed or omitted, per paragraph 3.5.

Figure 18: Method of Bonding Electronic Equipment to Mount through Front Attachments



Notes:
1. Clean and prepare surface per paragraph 3.2.
2. Dimensions of prepared area shall be larger than the gasket by .030 inches, minimum; to .125 inches, maximum.
3. Touch-up the areas where finish was removed or omitted, per paragraph 3.5.

Figure 19: Method of RF Bonding Access Doors and Panels

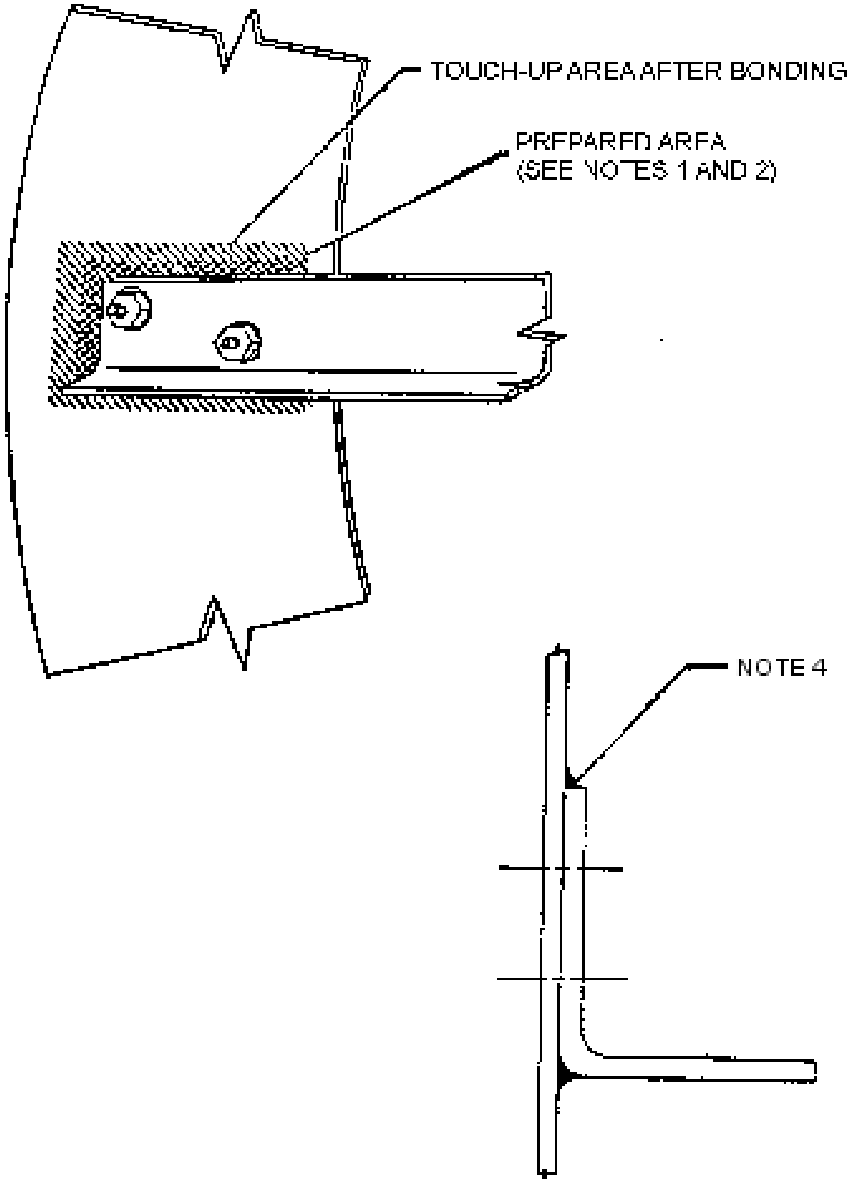


Notes:
1. Clean and prepare surface per paragraph 3.2.
2. Dimension of the prepared area on the structure shall be equal to the dimensions of the mounting base plus .030 inches, minimum; to 1-1/4 times the dimension of the mounting base, maximum.
3. Clean and prepare the entire mating surface of the mounting base per paragraph 3.2.
4. Touch-up the areas where finish was removed or omitted, per paragraph 3.5.
5. Install in accordance with manufacturer's procedure.

Figure 20: Method of Bonding Static Discharger Assembly to Exterior of Aircraft

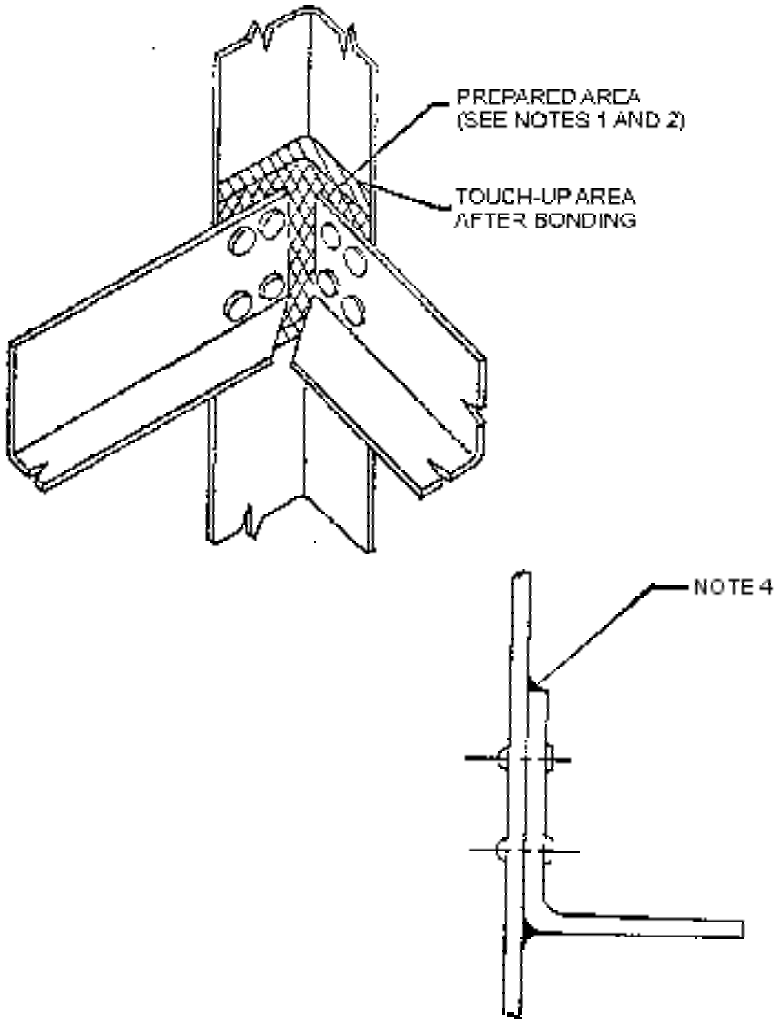
Figures 21A and 21B provided copies of MS25083 and Mil-C-83413/8 respectively. MS25083 has been cancelled and replaced with Mil-C-83413/8. Refer to the latest revision of Mil-C-83413/8 carried in the Department of Defense Index of Specifications and Standards (DoDISS).

Figure 21: Jumper Assembly, Electric, Bonding and Current Return



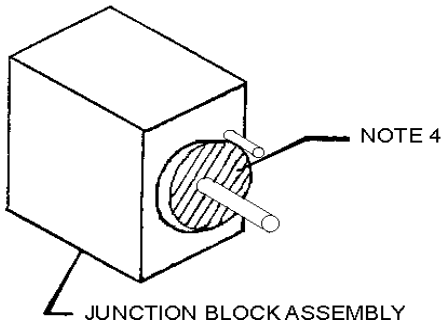
Notes:
1. Clean and prepare surface per paragraph 3.2.
2. Dimension of the prepared area shall be larger than the attaching hardware by .030 inches, minimum; to .125 inches, maximum.
3. Touch-up the areas where finish was removed or omitted per paragraph 3.5.
4. Apply sealant to perimeter of bond area per paragraph 3.5.2.

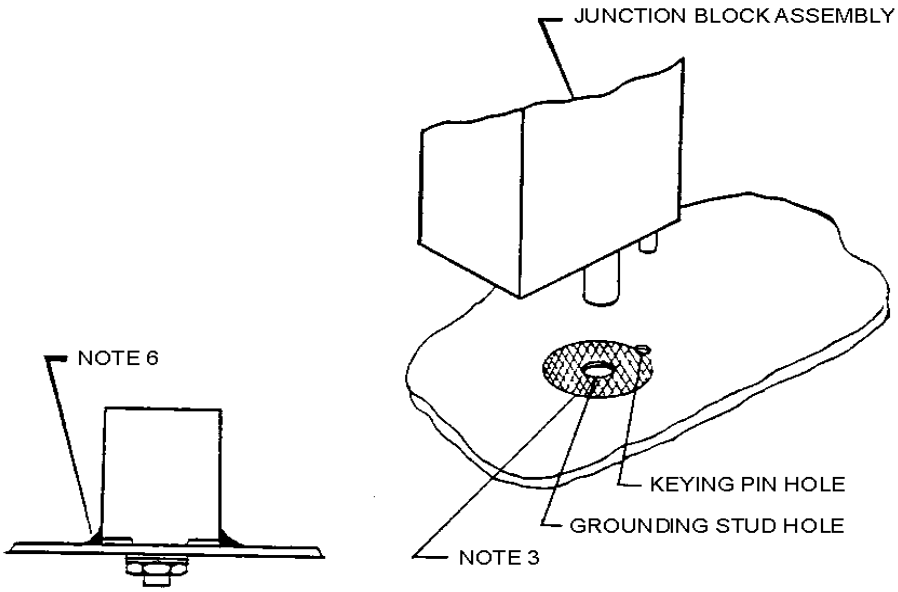
Figure 22: Method of Bonding through Bolted Connection Requiring Sealant



Notes:
1. Clean and prepare surface per paragraph 3.2.
2. Dimension of the prepared area shall be larger than the attaching hardware by .030 inches minimum; to .125 inches, maximum.
3. Touch-up the areas where finish was removed or omitted per paragraph 3.5.
4. Apply sealant to perimeter of bond area per paragraph 3.5.2.

Figure 23: Method of Bonding between Structural Parts of an Assembly Requiring Sealant

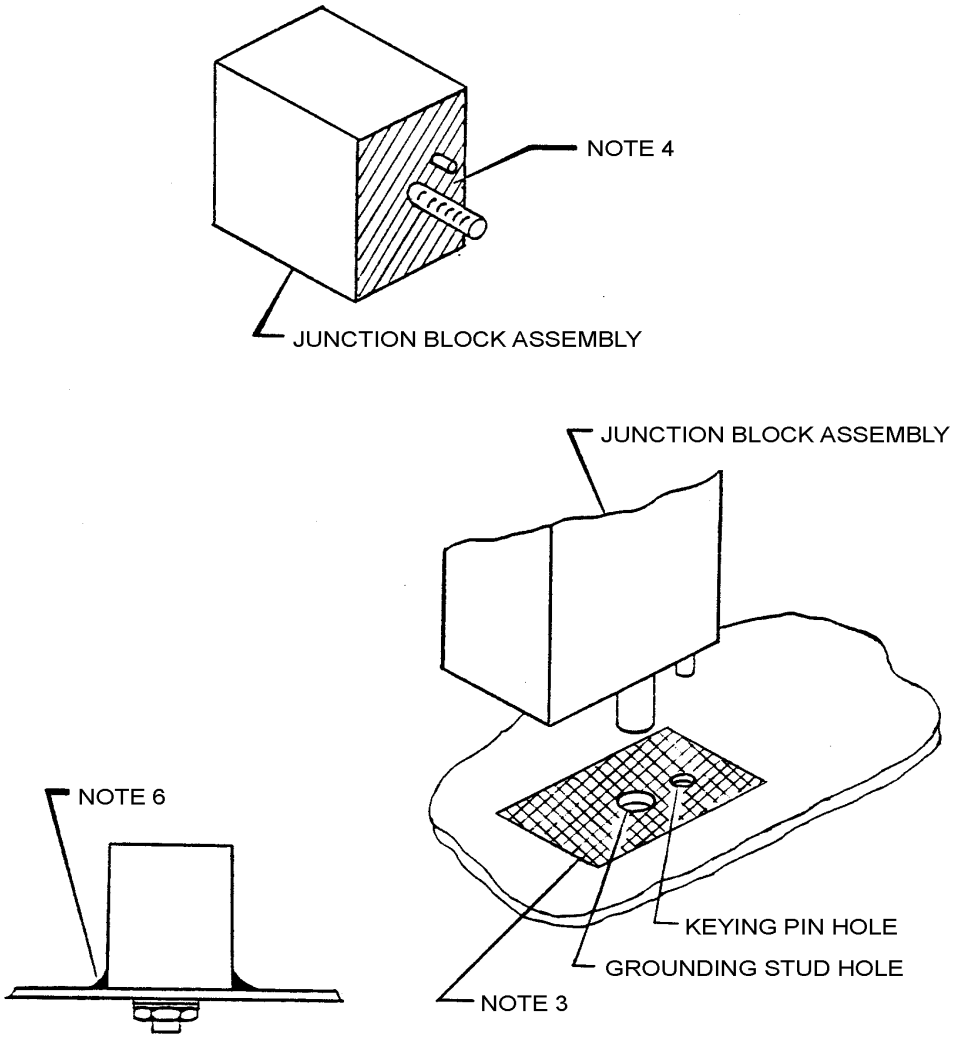




Notes:
1. Match the shape of the prepared area to the shape of the mating surface of the junction block. For junction blocks with a square contact area, see Figure 24B.
2. Clean and prepare surface per paragraph 3.2.
3. Diameter of the prepared area shall be larger than the attaching hardware by .030 inches, minimum; to .125 inches, maximum.
4. Clean and prepare the entire mating surface of the junction block assembly per paragraph 3.2.
5. Touch-up the areas where finish was removed or omitted per paragraph 3.5.
6. After installation and bond verification, apply sealant if specified on installation drawing. Reference paragraph 3.5.2.

Figure 24A: Round Contact Area

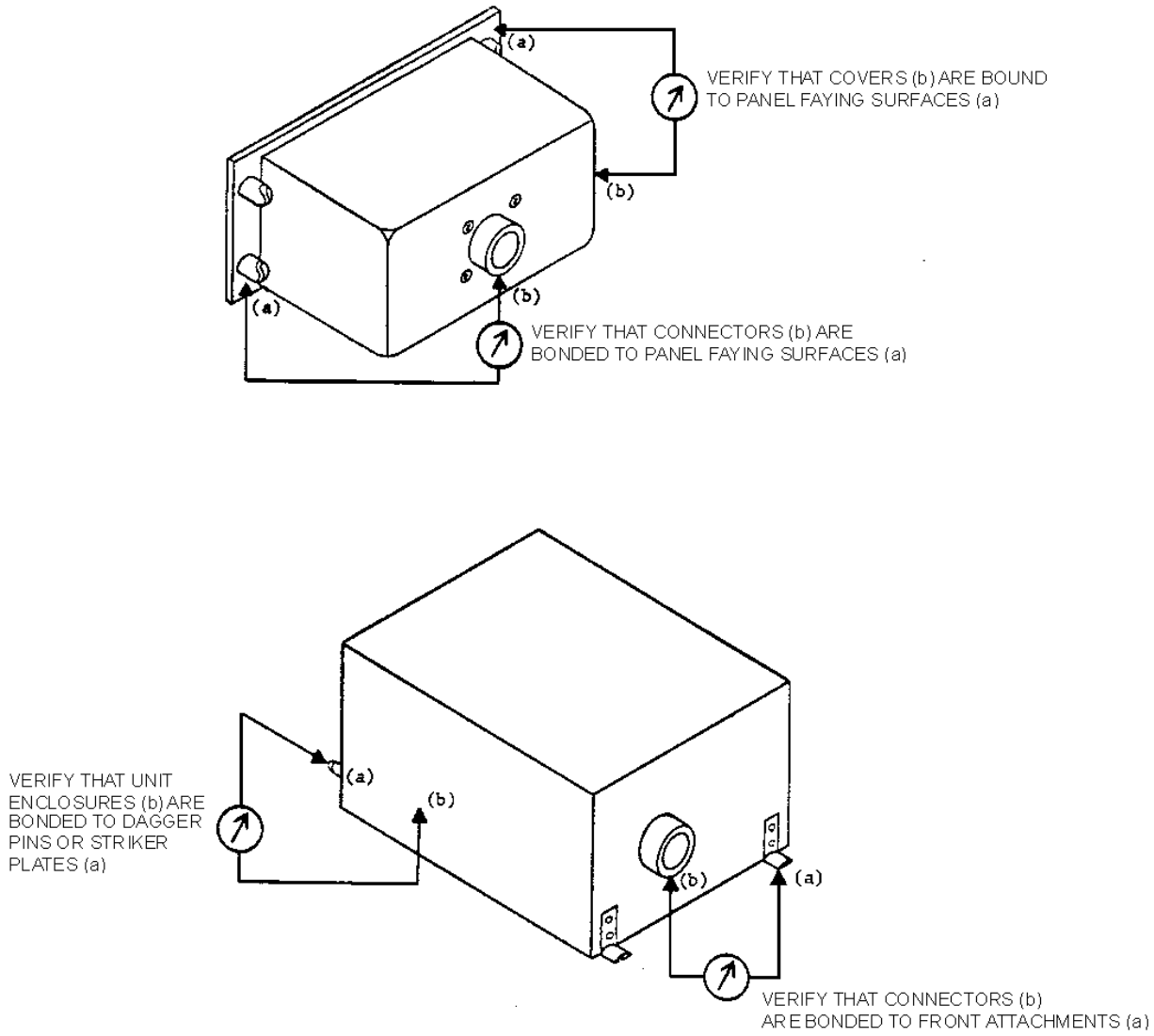
Figure 24: Electrical Bonding of Junction Block Assemblies to Attaching Part



Notes:
1. Match the shape of the prepared area to the shape of the mating surface of the junction block. For a round contact area see Figure 24A.
2. Clean and prepare surface per paragraph 3.2.
3. Dimension of the prepared area shall be larger than the attaching hardware by .030 inches, minimum; to .125 inches, maximum.
4. Clean and prepare the entire mating surface of the junction block assembly per paragraph 3.2.
5. Touch-up the areas where finish was removed or omitted per paragraph 3.5.
6. After installation and bond verification, apply sealant if specified on installation drawing. Reference paragraph 3.5.2.

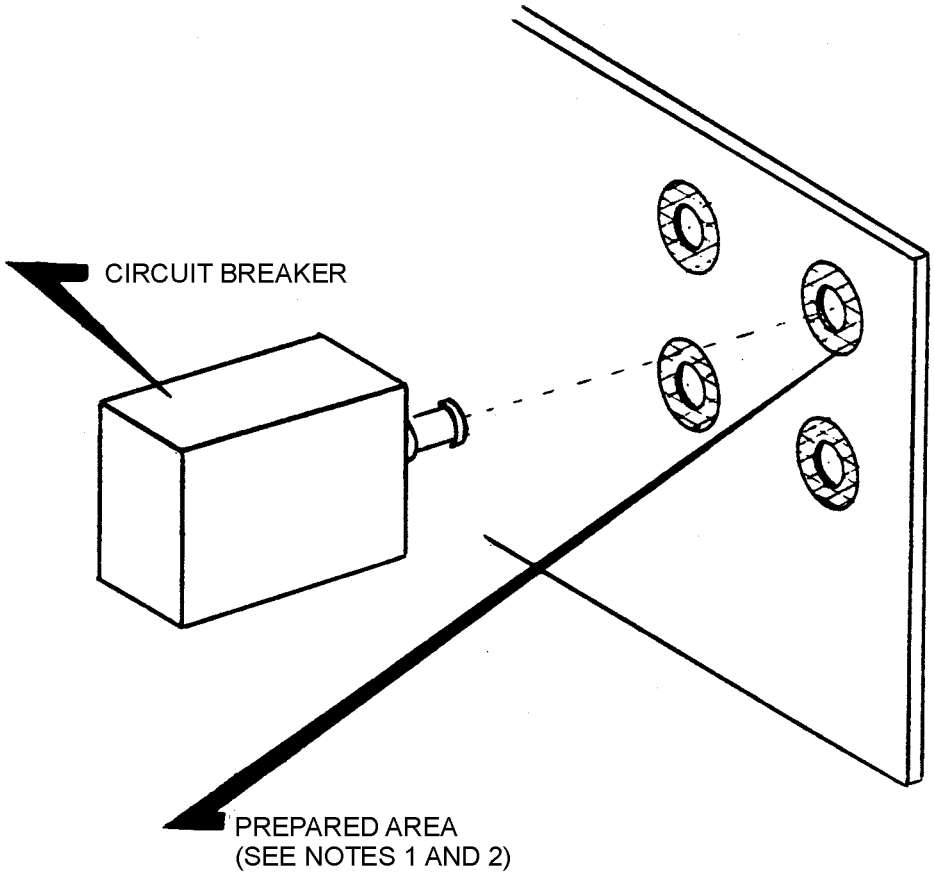
Figure 24B: Square Contact Area

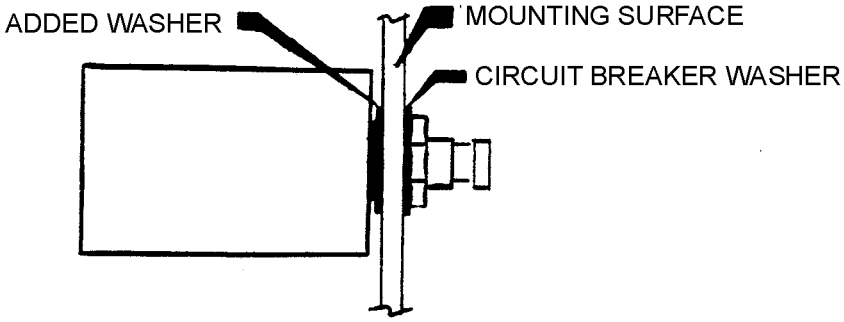
Figure 24: Electrical Bonding of Junction Block Assemblies to Attaching Part



Notes:
1. Bonding effectiveness of a competed assembly or unit shall be verified by resistance measurements per paragraph 3.5.
2. Measurements shall be made between the installation-bonding surface (a) and the enclosure or extremities (b) of the assembly or unit.
3. The illustrations shown above are general, and verification points (a) and (b) must be determined for each assembly or unit.

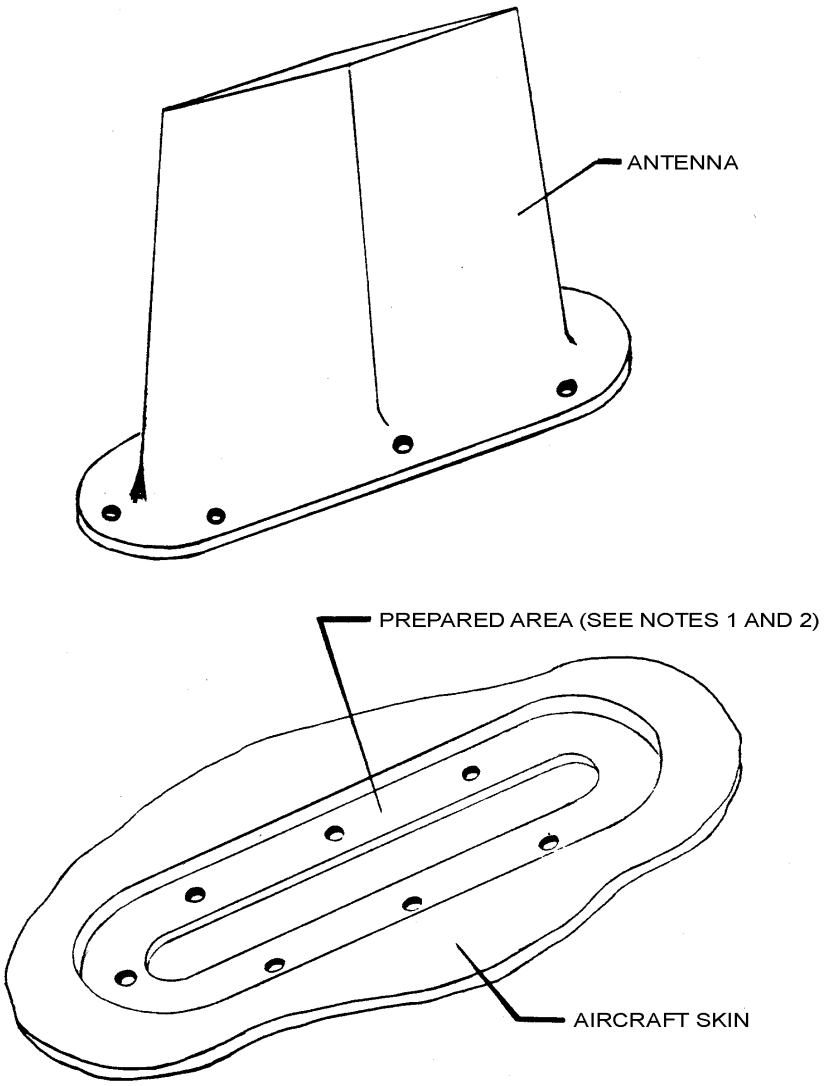
Figure 25: Methods of Verifying the Bonding of Assemblies or Units





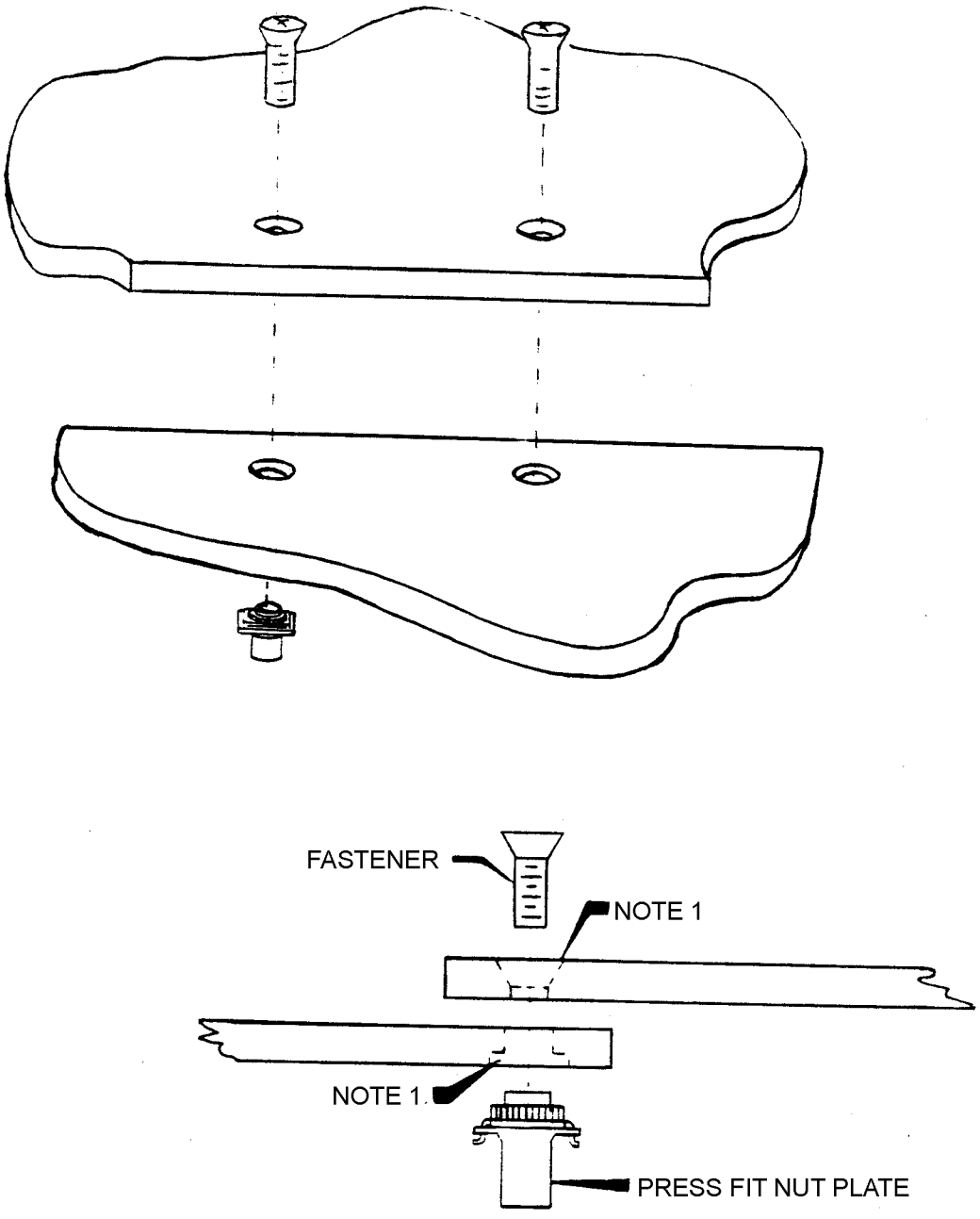
Notes:
1. Clean and prepare surface per paragraph 3.2.
2. Diameter of the prepared area shall be equal to the diameter of the washer plus .030 inches, minimum; to 1-1/2 times the diameter of the washer, maximum.
3. Touch-up the areas where finish was removed or omitted per paragraph 3.5.

Figure 26: Method of Bonding Circuit Breakers to Circuit Breaker Panel



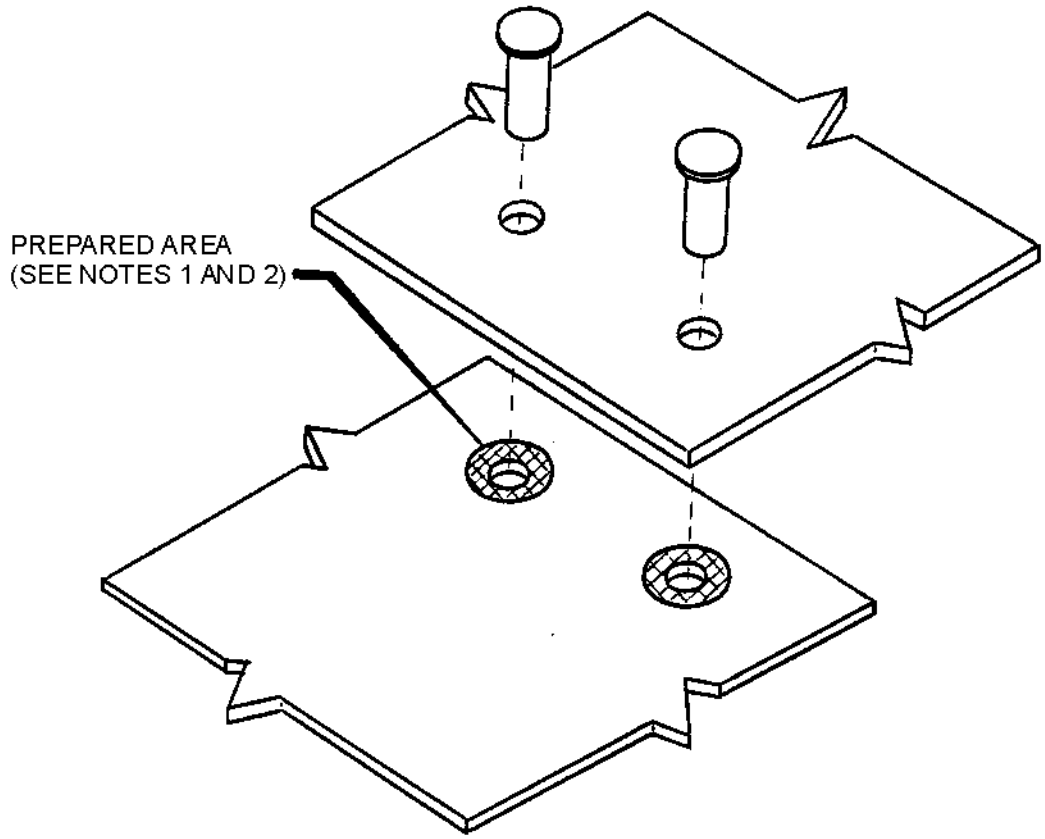
Notes:
1. Clean and prepare surface per paragraph 3.2.
2. If antenna is recessed into the aircraft skin, clean and prepare entire recess area per paragraph 3.2.
3. If the antenna is not recessed into the aircraft skin, the dimensions of the prepared area on the aircraft skin shall be equal to the dimensions of the antenna base plus .030 inches, minimum; to 1-1/4 times the dimension of the mounting base, maximum.
4. Clean and prepare the entire mating surface of the antenna per paragraph 3.2.
5. Touch-up the non-recessed areas where finish was removed or omitted per paragraph 3.5.
6. After installation and bond verification, apply sealant if specified on installation drawing. Reference paragraph 3.5.2.

Figure 27: Method of Bonding Antenna



Notes:
1. Mounting hole shall be clean and free of any surface coating.
2. After installation and bond verification, apply sealant if specified by installation drawing.

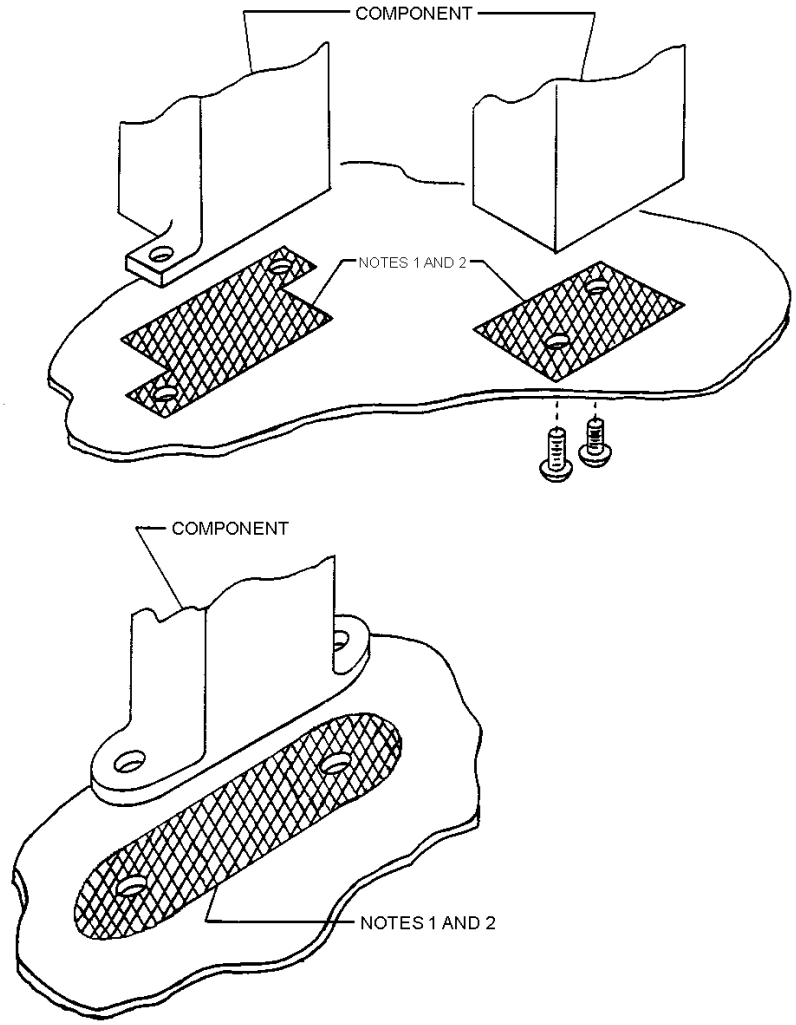
Figure 28: Method of Bonding through Fasteners



This figure inactive for new design after January 2002

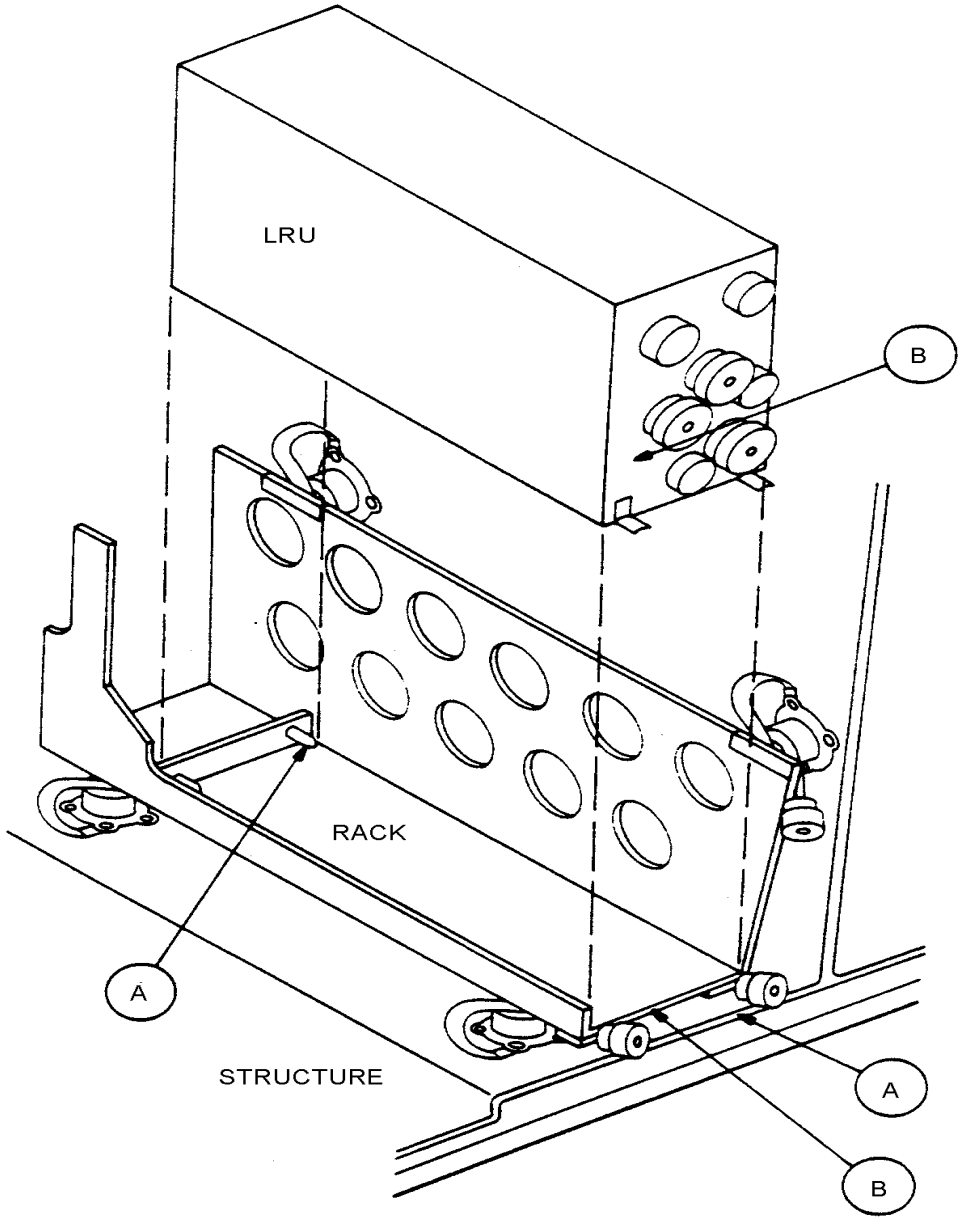
Notes:
1. Clean and prepare surface per paragraph 3.2.
2. Prepare surfaces on both mating parts. Diameter of prepared area shall be equal to three times the diameter of the rivet hole.
3. Alternate preparation method - Surface may be prepared per Figures 7, 10, 11, or 23.

Figure 29: Preparation of Bonding Connection in Riveted Joints



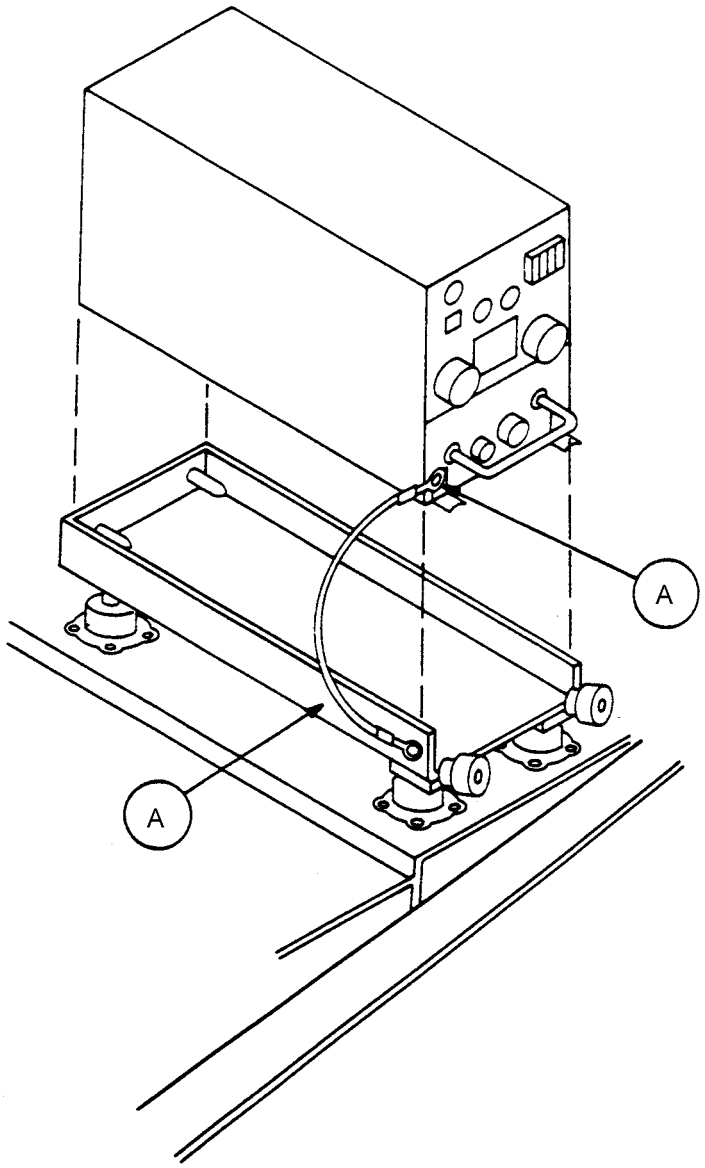
Notes:
1. Clean and prepare surface per paragraph 3.2.
2. Dimensions of the prepared area shall be larger than the attaching hardware by .030 inches minimum; to .125 inches, maximum.
3. Clean and prepare the entire mating surface of the component per paragraph 3.2.
4. Touch-up the areas, where finish was removed or omitted, per paragraph 3.5.
5. After installation and bond verification, apply sealant if specified on installation drawing. Reference paragraph 3.5.2.

Figure 30: Electrical Bonding of Components on Panels, Matrices, etc. to Attaching Part



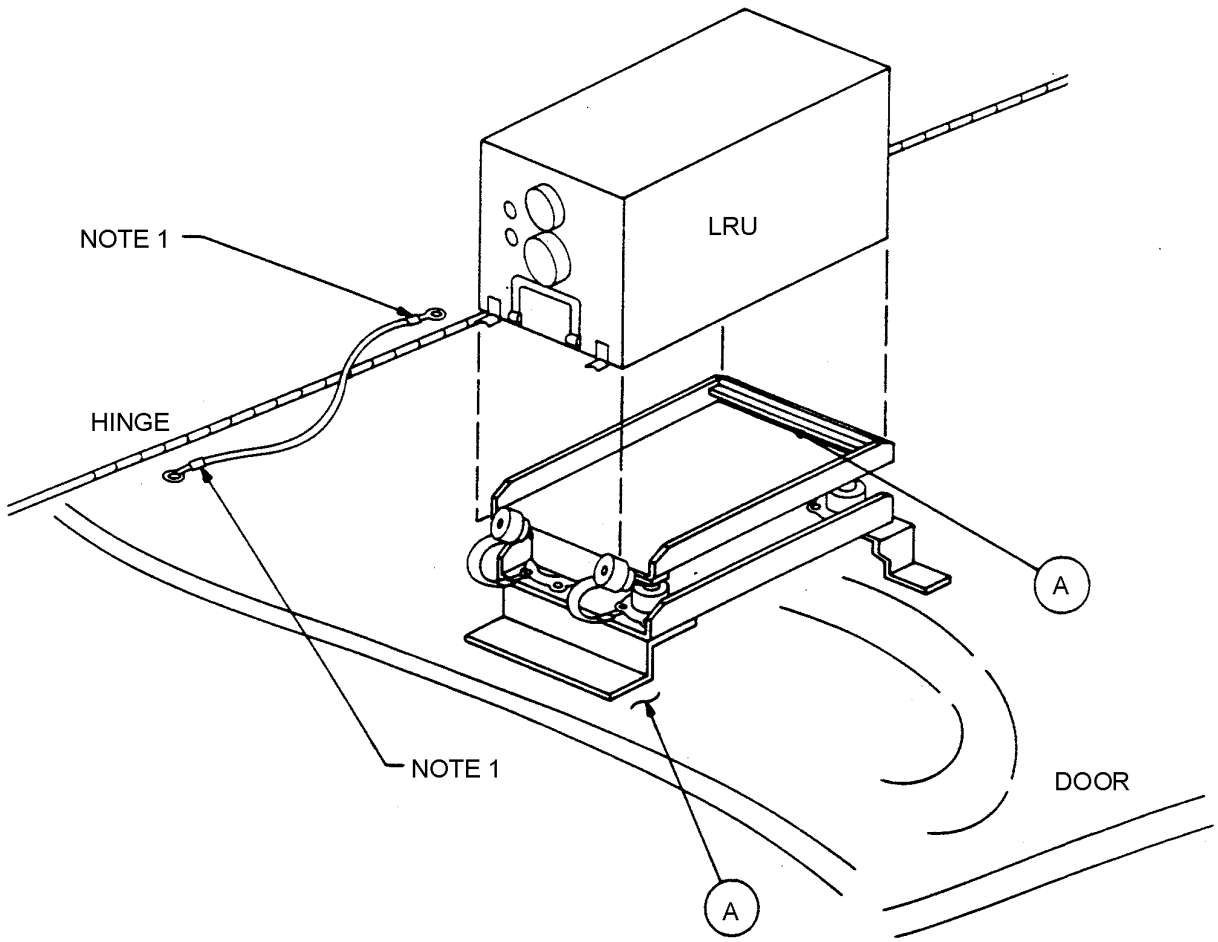
Notes:
1. Rack bond verification – Measure A to A
2. LRU bond verification – Measure B to B

Figure 31: Bond Verification of CFE LRU and Rack



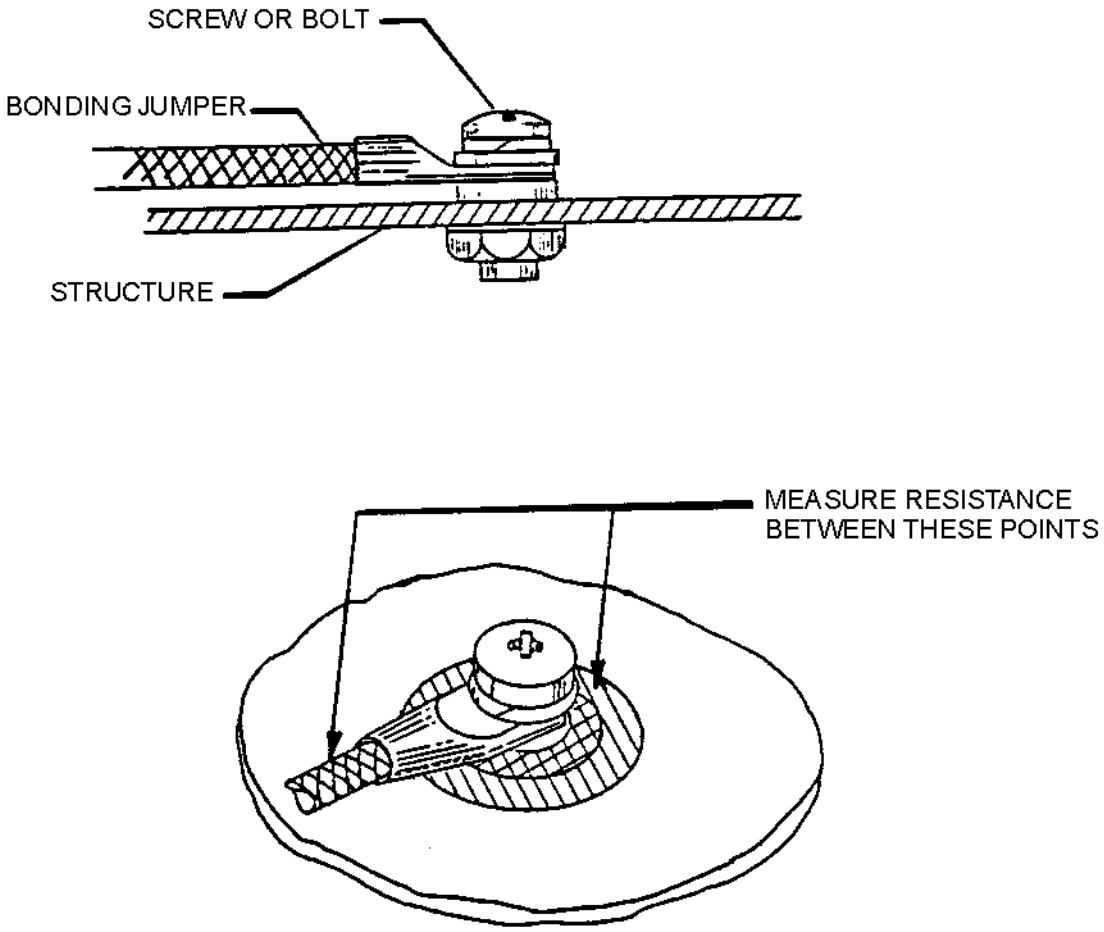
Notes:
1. GFE LRU bond verification – Measure A to A to verify bond interface.

Figure 32: Bond Verification of GFE LRU and CFE Rack



Notes:
1. Bond jumper verification—see paragraph 3.4.
2. Rack bond verification—measure A to A.

Figure 33: Bond Verification of Rack Mounted on Door



Notes:
1. Measure in accordance with paragraph 3.4.

Figure 34: Bond Verification of Bonding Jumper

AMENDMENT TO
FPS-3024 G,

ELECTRICAL BONDING REQUIREMENTS FOR F-16 AIR COMBAT FIGHTER

Contract Number: F33657-88-C-0037

Releasability of this material under the Freedom of Information Act is subject to the restrictions on release in DoD Regulation 5400.7-R and DoD Directive 5230.25.

Copyright© 2004 Lockheed Martin Corporation

This amendment forms a part of and shall be attached to Lockheed Martin Aeronautical Systems Specification, FPS-3024, Electrical Bonding Requirements for F-16 Air Combat Fighter. This amendment is effective immediately upon issue.

Paragraph

3.5.1 Change: Change paragraph 3.5.1 to read as follows:

3.5.1 TOUCH-UP

Touch-up finish in the areas where anodize, prime or paint was either omitted or removed to accomplish electrical bonding. Touch-up any areas where finish was removed to verify electrical bonding. The areas shall be touched-up per the applicable portion of the finish code specified by the engineering drawing, FPS-3001, and 16PR070. Touch-up may be delayed until after final bond verification. In the case of equipment that is expected to be removed and reinstalled, touch-up may be delayed until the final installation has been verified. Touch-up of electrical bond witness areas surrounding electrically bonded components on aluminum surfaces is not required, provided the area has been treated with chemical film conversion coating, and the witness area is minimized. However, complete finish touch-up is the preferred configuration. For electrical bonds made at a subcontractor's facilities, the touch-up shall be completed prior to shipment to LM Aero.

Reason: This change is made per program management direction resulting from a production issue resolution meeting held 25 June 2004. Management representatives from Program Office, Engineering, and Quality Assurance were in attendance.

Figures Change: Make the following changes to the figures of FPS-3024:

Figure Number	Change from	Change to
Figures 1, 2, 3, 5, 6, 7, 8A, 10, 12, 22, 23	Touch-up area after bonding.	Touch-up area after bonding. (see note 3.)
	Prepared area (see notes 1 and 2)	Prepare area (see notes 1, 2 and 3.)
Figures 8C (2 places), 8D (2 places), 26	Prepared area (see notes 1 and 2)	Prepare area (see notes 1, 2 and 3.)
Figures 11(2 places), 20	Touch-up area after bonding.	Touch-up area after bonding. (see note 4.)
	Prepared area (see notes 1 and 2)	Prepare area (see notes 1, 2 and 4.)
Figure 13	Prepared area (see notes 1 and 2)	Prepare area (see notes 1, 2 and 4.)

Figure Number	Change from	Change to
Figure 14 (2 places)	Touch-up area after bonding.	Touch-up area after bonding. (see note 5.)
	Prepared area (see notes 1 and 2)	Prepare area (see notes 1, 2 and 5.)
Figure 15	Prepare area (see notes 1 and 2)	Prepare area (see notes 1, 2 and 4.)
	Touch-up area after bonding of DZUS strip.	Touch-up area after bonding of DZUS strip (see note 4.)
	Prepare front face of DZUS strip. (see note 3.)	Prepare front face of DZUS strip. (see note 3 and 4.)
Figure 17	Prepare area (see notes 1, 2 & 3.)	Prepare area (see notes 1, 2, 3 and 5.)
	Touch-up area after bonding.	Touch-up area after bonding. (see note 5.)
Figure 19	Clean to base metal before attaching conductive gasket.	Clean to base metal before attaching conductive gasket. (see notes 1,2 and 3)
	Clean to base metal in gasket contact area.	Clean to base metal in gasket contact area. (see notes 1, 2 and 3)
Figure 24B	Note 3	See notes 3 and 5.
Figure 30 (2 places)	Notes 1 and 2	See notes 1, 2 and 4.

Reason: To clarify engineering intent to touch-up finish in areas prepared for electrical bond. (reference REA MK99018.) This change is made per program management direction resulting from a production issue resolution meeting held 25 June 2004. Management representatives from Program Office, Engineering, and Quality Assurance were in attendance.

Prepared and Approved by:

JT Amin
Manager, F-16 Materials
and Processes Engineering