



AEROSPACE INFORMATION REPORT

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(R) Guide for the Design of Threaded Screw or Stud Type Electrical Equipment Terminations

RATIONALE

AIR38B has been reaffirmed to comply with the SAE five-year review policy.

INTRODUCTION

The standardization and use of electrical wire lug terminals are generally well covered in various government and commercial specifications and practices. Design of the terminations on electrical equipment, to which lug terminals are attached, however, is less well covered. This guide, therefore, sets forth design recommendations for equipment terminations that will provide satisfactory connections to lug terminals.

TABLE OF CONTENTS

1.	SCOPE.....	3
2.	REFERENCES.....	3
2.1	Aerospace References	3
2.2	Other Useful References	5
3.	GENERAL.....	6
3.1	Lug Terminal Selection	6
4.	SCREW AND STUD SIZE SELECTION.....	7
4.1	Threads	7
4.2	Size	7
4.3	Length	7
4.4	Strength.....	7
5.	TERMINAL CONTACT AREA DESIGN.....	7
5.1	Equipment Leads	7
5.2	Contact Supporting Materials.....	8
5.3	Contact Materials and Finish	8
5.4	Aluminum Considerations	8
6.	INSULATOR DESIGN.....	9
6.1	Materials.....	9
6.2	Terminal Spacing and Barriers	9
6.3	Covers.....	10
7.	FASTENER HARDWARE	10

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7.1	Screws	10
7.2	Nuts	10
7.3	Washers	10
8.	HARDWARE ARRANGEMENTS.....	11
8.1	Copper-to-Copper Terminations	11
8.2	Aluminum-to-Aluminum Terminations.....	11
8.3	Copper-to-Aluminum Terminations.....	11
9.	SPECIAL TOOLS.....	11
10.	NOTES.....	11
TABLE 1	RECOMMENDED SCREW SIZES AND STRENGTH OF SCREW OR STUD TERMINATIONS	12
TABLE 2	MINIMUM RECOMMENDED TERMINATION SCREW OR STUD SIZES FOR CURRENT AND CONDUCTORS.....	13
TABLE 3	GROUPING OF DISSIMILAR METALS FOR ELECTROLYTIC CORROSION PROTECTION	14
TABLE 4	MINIMUM SPACING FOR VARIOUS VOLTAGES AND ALTITUDES.....	15
TABLE 5	ELECTRICAL CLEARANCE AND CREEP DISTANCES FOR ELECTRONIC EQUIPMENT	16
FIGURE 1	SCREW	17
FIGURE 2	STUD	17
FIGURE 3	CURRENT CARRYING STUD.....	17
FIGURE 4	SCREW	18
FIGURE 5	STUD (NO EQUIPMENT LEAD).....	18
FIGURE 6	SCREW	19
FIGURE 7	SCREW	19

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1. SCOPE

To establish design recommendations that will provide a basis for safe and reliable connections to threaded screw- or stud-type electrical equipment terminations. These recommendations are directed primarily, but not solely, to the aerospace and ground support equipment industries.

Since individual design criteria may alter the details as outlined, it is therefore important that this Aerospace Information Report (AIR) not be considered mandatory, but be used only as a design guide.

2. REFERENCES

The following publications for a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of the 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 Aerospace References

2.1.1 SAE International Publications

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

ARP506	High Temperature Insulated Terminal Lugs
AIR1263	Tin Plated Solderless Terminal Lugs and Splices on Nickel Coated High Temperature Wire
AS50881	Wiring, Aerospace Vehicle
AS70991	Terminals: Lug and Splice, Crimp Style, Aluminum, For Aluminum Aircraft Wire
AS7928	Terminals, Lug: Splices, Conductor: Crimp Style, Copper, General Specification For
AS7928/1	Terminals, Lug and Splices, Conductor, Crimp Style, Copper Terminal, Lug, Crimp Style, Copper, Insulated, Ring Tongue, For Thin Wall Wire, Type II Class 1 for 105 °C Total Conductor Temperature
AS7928/2	Terminals, Lug and Splices, Conductor, Crimp Style, Copper, Insulated, Rectangular Tongue, for Thin Wall Wire, Type II Class 1 for 105 °C Total Conductor Temperature
AS7928/4	Terminals, Lug and Splices, Conductor, Crimp Style, Copper Terminal, Lug, Insulated, Ring Tongue, Bell-Mouthed, Type II Class 1 (for 150 °C Total Conductor Temperature)
AS7928/5	Terminals, Lug and Splices, Conductor, Crimp Style, Splice, Electric (Permanent, Type II, Class 1) for 105 °C Total Conductor Temperature
AS7928/6	Terminals, Lug and Splices, Conductor, Crimp Style, Splice, Electric (Permanent, Type II, Class 1) for 150 °C Total Conductor Temperature
AS7928/7	Terminal Lug and Splices, Conductor, Crimp Style, Copper, Terminal Lug, Crimp Style, Copper Uninsulated, Ring Tongue, Type I Class 1 for 175 °C Total Conductor Temperature
AS7928/8	Terminals, Lug and Splices, Conductor, Crimp Style, Copper Terminal, Crimp Style, Copper, Insulated, Ring Tongue, for Thin Wall Wire, Tin Whisker Resistant, Type II Class 1 for 105 °C Total Conductor Temperature
AS7928/9	Terminals, Lug and Splices, Conductor, Crimp Style, Copper, Insulated, Rectangular Tongue, Tin Whisker Resistant for Thin Wall Wire, Type II Class 1 for 105 °C Total Conductor Temperature

AS7928/10	Terminals, Lug and Splices, Conductor, Crimp Style, Splice, Electric, Tin Whisker (Permanent, Type II, Class 1) for 105 °C Total Conductor Temperature
AS7928/11	Terminal, Lug, Crimp Style, Copper, Uninsulated, Ring Tongue, Tin Whisker Resistant, Type I, Class I, for 175 °C Total Conductor Temperature
AS7928/12	Terminal, Lug, Crimp Style, Copper, Insulated, Ring Tongue, Bell-Mouthed, Tin Whisker, Type II, Class 1, (for 105 °C Total Conductor Temperature)
AS7928/13	Terminals, Lug and Splices, Conductor, Crimp Style, Copper Terminal, Lug, Insulated, Tin Whisker Resistant, Ring Tongue, Bell-Mouthed, Type II, Class 1, (for 150 °C Total Conductor Temperature)
AS17143	Terminal, Lug, Crimp Style, Copper, Insulated, Rectangular Tongue, Type II, Class 1, For 105 °C Total Conductor Temperature
AS20659	Terminal, Lug, Crimp Style, Copper, Uninsulated, Ring Tongue, Type I, Class 1, For 175 °C Total Conductor Temperature
AS21004	Terminal, Lug, Uninsulated, Rectangular Tongue, Crimp Style, Copper, Type I, Class 1, For 175 °C Total Conductor Temperature
AS25036	Terminal, Lug, Crimp Style, Copper Insulated, Ring Tongue, Bell Mouthed, Type II, Class 1 (For 105 °C Total Conductor Temperature)
AS27212	Terminal Board Assembly, Molded-in Stud, Electric
AS50151	Connectors, Electrical, Circular Threaded, AN Type, General Specification For

2.1.2 AIA/NAS Publications

Available from Aerospace Industries Association, 1000 Wilson Boulevard, Suite 1700, Arlington, VA 22209-3928, Tel: 703-358-1000, www.aia-aerospace.org.

NASM6812	Bolts, Aircraft
NASM25027	Self-Locking Nuts
NASM21042	Nut, Self-Locking, 450°F, Reduced Hexagon, Reduced Height, Ring Base, Non-corrosion Resistant Steel
NASM21044	Nut, Self-Locking, Hexagon - Regular Height, 250°F, 125 KSI FTu and 60 KSI FTu
NASM21045	Nut, Self-Locking, Hexagon - Regular Height, 450° F, 125 KSI FTu
NASM25440	Washers, for Use with Aircraft Aluminum Terminals
NASM35275	Screw, Machine-Drilled Fillister Head, Slotted, Corrosion Resisting Steel
NASM35338	Washer, Lock-Spring, Helical, Regular (medium) Series
NASM35649	Nut, Plain - Hexagon, Machine Screw, UNC-2B
NASM35650	Nut, Plain - Hexagon, Machine Screw, UNF-2B

2.1.3 Military Publications

Available from the Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, <http://assist.daps.dla.mil/quicksearch/>.

A-A-59126 General Specification for Insulated Feed-through Terminals and Noninsulated Stud Terminals

MIL-STD-108 Definitions of and Basic Requirements for Enclosures for Electric and Electronic Equipment

MIL-PRF-6106L(5) SUP 1 RELAYS, ELECTROMAGNETIC, GENERAL SPECIFICATION FOR

MIL-HDBK-454 General Guidelines for Electronic Equipment

Guideline 1, Safety (personnel hazard)

Guideline 11, Electrical Insulating Materials

Guideline 12, Fastener Hardware

Guideline 16, Dissimilar Metals

Guideline 69, Internal Wiring Practices

MIL-STD-889 Dissimilar Metals

MIL-HDBK-1277 Splices, Chips, Terminals, Terminal Boards, Binding Posts, Electrical

MIL-STD-1285 Marking of Electrical and Electronic Parts

MIL-STD-7179 Finishes, Coatings, And Sealants, For The Protection Of Aerospace Weapons Systems

MS25435 Terminal-Lug, Crimp Style, Straight Type, for Aluminum Aircraft Wire, Class 1

2.1.4 Federal Publications

Available from the Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, <http://assist.daps.dla.mil/quicksearch/>.

FF-N-836 Nut, Square, Hexagon Cap, Slotted, Castle, Knurled, Welding and Single Ball Seat

FF-S-85 Screw, Cap, Slotted and Hexagon Head

FF-S-92 Screws, Machine, Slotted, Cross - Recessed or Hexagon Head

FED-STD-H28 Federal Standard, Screw Thread Standards for Federal Services

NASA - DHB-S-001 System Safety Handbook

2.2 Other Useful References

TIFI Standard - Fasteners Handbook, industrial Fasteners institute

Aluminum Building Wire Reference Book - The Aluminum Association

Aluminum Building Wire installation Manual - The Aluminum Association

MIL-T-16366 (Ships) - Pressure Grip, Electrical Clamps, Lug Terminals and Conductor Splices

3. GENERAL

Solderless crimp-type lug terminals are now widely used and accepted as a means to satisfactorily terminate electrical conductors. A high degree of reliability has been achieved through standardization of sizes, dimensions, materials, crimping techniques, and performance specifications. The overall connection reliability, however, is equally dependent on the integrity of the interface contact between the lug terminal tongue and its mating surface. This critical connection has often been overlooked when threaded fasteners are used, probably due to the apparent simplicity of attachment.

There are many design factors to consider in achieving the same degree of reliability at the tongue contact as in the crimp contact to the conductor. Both mechanical and electrical requirements are to be taken into account including such factors as selection of screw size, fastening hardware, materials, insulator design, and consideration for both copper and aluminum wire.

WARNING

This document includes cadmium as a plating material. The use of cadmium has been restricted and/or banned for use in many countries due to environmental and health concerns. The user should consult with local officials on applicable health and environmental regulations regarding its use.

3.1 Lug Terminal Selection

Since the equipment termination is an electrical extension of a lug terminal, proper design must include considerations of the style and characteristics of the lug terminals expected to be used. Preferred copper crimp-type lug terminals are those specified in AS7928. Several of the more common straight types are detailed in the following associated SAE standards, although a variety of other tongue configurations are also standardized:

AS7928/4	Insulated Ring Tongue
AS25036	Insulated Ring Tongue
AS17143	Insulated Rectangular Tongue
AS20659	Uninsulated Ring Tongue
AS21004	Uninsulated Rectangular Tongue

These range in wire size from No. 26 AWG through 0000 AWG with stud holes from No. 2 (0.086 in.) through 0.875 in. diameter. The temperature rating of tin-plated copper lug terminals is 105 °C to 150 °C for the insulated type and 175 °C for uninsulated. Specialized terminals such as Tin whisker resistant types are also available.

Preferred aluminum crimp-style terminals are those specified in AS70991 for aluminum aircraft wire. MS25435 details a straight, uninsulated tongue with aluminum wire size from No. 8 AWG through 0000 AWG and stud holes from No. 10 (0.190 in.) through 0.500 in. diameter. Uninsulated aluminum terminals are rated for 105 °C conductor temperature.

Recommended military practice is to use pre-insulated terminals.

Both AS70991 and AS7928 provide excellent references for lug terminal performance requirements which could also be applicable, in part, for the stud contact on equipment terminations.

Reference information for higher temperature wire terminals is found in SAE ARP506, Aerospace Recommended Practice for High Temperature insulated Terminal Lugs. This document establishes design and performance requirements for 200 °C and 260 °C wire terminals on wire sizes from 26 AWG through 10 AWG.

4. SCREW AND STUD SIZE SELECTION

4.1 Threads

Screws and studs should be of the unified standard form and be selected in accordance with AS8879, Screw Threads - UNJ Profile, Inch Controlled Radius Root With Increased Minor Diameter, so that the maximum usage is of a limited number of sizes for aircraft. Refer to FED-STD-H28, Screw Thread Standards for Federal Services and its sister documents (FED-STD-H28/1 through /23). Recommended sizes are listed in Table 1.

4.2 Size

Screw or stud size is initially established from wire size and current requirements of the equipment.

Table 2 lists minimum recommended termination screw sizes for various current loads with both copper and aluminum wire. These are based on bundled cable wire ratings from AS50881.

Selection and Installation of Aircraft Wiring. When determining the largest probable wire size to be used, consider one stud size larger. This will assure adequate termination conductivity when voltage drop or circuit protection considerations require larger wires than on the basis of wire current rating alone.

4.3 Length

Length should be sufficient to accommodate at least two, but not more than four lug terminals, plus a flat washer, a split lock-washer, and a nut while maintaining a minimum of 1 1/2 screw threads showing after the assembly is complete. Lug terminals are usually positioned back-to-back as illustrated in Figure 2. For aircraft installations see AS50881 Terminal Lugs for guidance on how and the number of terminals or bus bars to be used on one screw stud.

4.4 Strength

In addition to meeting the electrical requirements, screws or studs should have sufficient mechanical strength to resist deformation or damage from tension test loads in any direction. The terminal tongue of a straight lug may be bent up to 90 degrees maximum, provided the bend radius is not less than twice the thickness of the lug tongue, and the distance from the tip of the tongue to the beginning of the bend is not less than the diameter across the lug. The size and retaining means should meet the equipment physical test requirements and withstand repeated torque loads from attaching terminated wires. Consideration should be given to tensile, shock, vibration, and thermal cycling loads to meet performance testing and service conditions.

3.4.1 Unless equipment design dictates specific strength criteria, Table 1 lists recommended minimum static tensile and torque test values to insure satisfactory mechanical and electrical performance.

5. TERMINAL CONTACT AREA DESIGN

5.1 Equipment Leads

5.1.1 Contact areas of equipment leads should be flat, clean, burr free, and raised above the surface of the surrounding insulator material. The area should preferably be equal to the mating surface of the tongue of the largest wire terminal expected to be used, but never less than required to permit the current density to exceed 1000 amps per sq in. (155 amps per sq cm.).

5.1.2 It is recommended practice that the lug terminal stud hole be selected to match the stud size for both maximum effective electrical connection and mechanical security. Also, when lug terminals of different tongue sizes are attached to the same stud the largest should be located on the bottom directly against the equipment lead as illustrated in Figure 6.

5.1.3 Current carrying stud should avoided where possible, however when necessary, the contact area should be an integral part of the stud with a shoulder section as illustrated in Figure 3. Separate spacers or washers should not be used between the integral stud shoulder and the lug terminal tongue. This adds another interface in series with the circuit creating additional contact resistance.

5.2 Contact Supporting Materials

The pressure for electrical contact must not be transmitted through or dependent on materials that shrink or relax with time or at elevated temperatures. Soft metal plating or interfaces such as soft solder are to be avoided. No insulating material should be in compression when the screw or nut is tightened over the lug terminal tongue. Insulating plastic materials may be used with retaining studs or captive nuts due to repeated torque or tension loads, but must remain contact pressure free since most are subject to varying degrees of excessive relaxation.

5.3 Contact Materials and Finish

5.3.1 Current carrying members should be made of copper or high-conductivity copper alloy and be plated with silver, tin, nickel, gold, or other suitable finishes to resist corrosion and maintain low and stable contact resistance. Steel is to be avoided but may be used for low current applications and must be cadmium plated, preferably with a chromate treatment. Stainless steel does not generally require plating. Aluminum equipment leads may be used with special design considerations and must be tin plated, at least at the contact interface (see 4.4).

WARNING

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5.3.2 Screws, studs, and nuts are preferably steel or other suitable high-strength materials. Softer screw or stud materials such as copper or aluminum could result in excessive thread wear and should be avoided. Brass nuts should be considered where greater corrosion resistance or where high wear is anticipated. Current carrying studs of heat treated beryllium copper or high tensile phosphor bronze offer improved thread wear resistance, yet provide good conductivity.

5.3.3 Magnesium equipment leads or termination hardware is to be avoided especially in contact with copper due to the high level of galvanic corrosion potential. Due to chemical incompatibility, cadmium plating of termination hardware is not recommended for use in fuel or hydraulic systems.

5.4 Aluminum Considerations

5.4.1 Special consideration must be given to connecting aluminum equipment leads, aluminum lug terminals, or combinations of copper and aluminum materials which must be taken into account to provide reliable terminations. These differences are related to lower conductivity, oxide formation, galvanic corrosion, creep, and thermal expansion.

5.4.2 Since conductivity is lower, larger cross-sectional areas are used in current carrying members. Lug terminal tongues have larger contact surfaces which must be provided for on equipment leads. Aluminum has different properties than copper

5.4.3 Aluminum oxide is always present on bare aluminum and creates a high-contact resistance barrier to current flow. Plating, such as tin, provides intimate contact to the bare aluminum and presents a low-contact resistance to adjacent members.

5.4.4 Aluminum will corrode and is sacrificial relative to copper in the presence of moisture. Tin plating also greatly reduces the galvanic corrosion rate between aluminum and copper since it falls between them in the galvanic series. A moisture seal or protective coating may be applied to aluminum-copper connections to minimize galvanic action. The proper arrangement of dissimilar metals for control of galvanic or electrolytic corrosion should be consider using MIL-STD-889 as guidance.

5.4.5 Aluminum has a high rate of creep or cold flow and will continue to relax when stressed until the stress is equal to its yield strength. This has the effect of significantly reducing the residual contact pressure to the point of possible failure. To compensate for creep; it is common practice to use spring washers under the screw head. The creep problem is compounded with aluminum-copper terminations since aluminum, when heated, expands about 40% more than copper. If the heating is sufficiently high, such that the stresses exceed the elastic limit of the aluminum, then permanent deformation will occur.

With repeated heating and cooling, the contact pressure will progressively become less. Application temperature limitations and the use of spring washers will insure long-life reliable copper-aluminum terminations.

6. INSULATOR DESIGN

6.1 Materials

Insulator design first must comply with the equipment requirements. Material selection, however, should include consideration of many characteristics such as:

Arc resistance (non-carbon tracking)

Dielectric strength

Flame resistance

Mechanical strength

Noxious or toxic fume emission

Impact strength

Heat distortion temperature

Temperature Endurance

Corrosion resistance to metals

Solvent resistance

Moisture absorption

Fungus resistance

In general, a plastic insulation material should combine the more important properties of flame resistance, arc resistance, and low toxicity with good electrical and mechanical properties.

MIL-HDBK-454, Guideline 1 - Safety (Personnel Hazard) and Guideline 11 - Electrical Insulating Materials, provide good references for safety and establishes criteria for the selection and use of a broad range of insulating materials.

6.2 Terminal Spacing and Barriers

6.2.1 Terminal spacing should provide adequate creep distance to meet the voltage requirements of the equipment. Table IV lists minimum spacing for various voltages and altitudes and is based on AS50151 for AN connectors. Another spacing reference is MIL-HDBK-454, Guideline 69, Internal Wiring Practices for electronic equipment from which Table 5 has been taken,

6.2.2 Barriers increase the creepage path and help prevent accidental shorting between lug terminals. In addition to the electrical requirements, the size of the equipment should be taken advantage of to provide as much space as possible to simplify lug terminal installation with tools and minimize electrical hazards.

6.3 Covers

Covers should be designed to provide electrical and mechanical protection for all equipment terminations and accommodate at least two lug terminals. Covers are usually made of a substantial insulating material, although if metal is required for electrical shielding, care must be taken to afford adequate support against shorting if accidentally crushed. Provision for cover removal is necessary so that when used in an otherwise protected location, such as a junction box, it can be removed to eliminate the weight.

7. FASTENER HARDWARE

Fastener hardware should preferably be selected in accordance with MIL-HDBK-454, Guideline 12, which establishes guidance for electronic equipment.

7.1 Screws

Selection of screw and bolt types will vary widely with user preference and equipment requirements, although, head styles should be those with larger diameters. Pan head, binding head, or hexagon head will provide maximum contact area over a washer. Screws may directly be selected from the following specifications:

FF-S-85 Cap Screws

NASM6812- Bolts, Aircraft

7.2 Nuts

Plain nut types are preferred as detailed in NASM35649 - Nut, Plain - Hexagon, Machine Screw, UNC-2B and NASM35650 - Nut, Plain - Hexagon, Machine Screw, UNF-2B and specified in FF-N-836. In applications where vibration is of concern, self-locking nuts may be required to insure the integrity of the connection, however, caution is advised in their use. They should not be used on brass studs nor where frequent removal is anticipated due to greater thread wear neither should they be used on stainless steel studs since there is a tendency to seize. Self-locking nuts are detailed in NASM21042, NASM21044, NASM21045 and specified in NASM25027.

7.3 Washers

Flat washers and spring split lock washers must always be used to insure maximum contact reliability. Flat washers distribute pressure over the lug terminal tongue. Spring split lock washers, in addition to resisting nut loosening, maintain contact pressure when metals relax that are in compression.

This follow-up is especially important for aluminum.

Plain fiat washers may be selected from various materials, although Grade II aeronautical, cadmium-plated steel or tin-plated brass are preferred for use on copper wire terminals and copper equipment leads. Aluminum terminations require a special flat washer as shown in NASM25440, Washers for Use with Aircraft Aluminum Terminals. This is an oversized, cadmium-plated, steel washer to match larger aluminum lug terminal tongues.

Spring split helical lock washers are detailed in NASM35338. Steel lock washers should be cadmium plated. Where greater corrosion protection is required phosphor bronze lock washers may be used. Tooth-type lock washers should not be used.

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8. HARDWARE ARRANGEMENTS

Preferred hardware arrangements for equipment terminations are shown in Figures 1 through 7. These include typical equipment lead configurations with screws and studs on combinations of copper and aluminum materials. The insulators and equipment leads as illustrated, are schematic only, and not intended to represent *any* specific detail design.

In general, flat washers must be used directly over all lug terminal tongues, and spring split lock washers used under all screw heads or nuts. Washers should never be placed in the current path. Care must be exercised in the proper selection of base metals and plating for electrolytic corrosion considerations, especially where aluminum is involved.

8.1 Copper-to-Copper Terminations

Figures 1, 2, and 3 show typical arrangements for copper-to-copper connections with screws and studs. Note that lug terminals are always placed directly against the equipment lead and that only standard size washers need be used.

8.2 Aluminum-to-Aluminum Terminations

Figure 4 shows an aluminum equipment lead connection to an aluminum lug terminal. In this case, the special oversize NASM25440 washer is used over both the aluminum lug terminal tongue and the equipment lead. Split lock washers should never be placed directly on any aluminum surface. Figure 5 shows the situation where there may be no equipment lead involved and the current path is directly through two aluminum lug terminals, such as found on a terminal board or binding post. This illustrates that the NASM25440 washer preferably be used on both sides of the wire terminals for full bearing pressure.

8.3 Copper-to-Aluminum Terminations

Figure 6 shows the arrangement of both copper and aluminum lug terminals to a copper equipment lead. When the aluminum lug terminal tongue is larger than the copper tongue, it should be placed directly on the equipment lead as shown. If the copper lug terminal is larger than the aluminum, then it should be placed on the equipment lead, in which case a NASM25440 washer would be used under the split lock washer.

Figure 7 shows the case where a copper equipment lead is connected to aluminum lug terminals in which the NASM25440 washer is used directly on the aluminum tongue.

9. SPECIAL TOOLS

Selection of hardware and insulator design should be such that no special tools are required and that adequate clearance space is provided for assembly, maintenance, and ready replacement of damaged or worn parts. The design should accommodate standard maintenance tools such as pliers, screwdrivers, socket and spinner wrenches.

10. NOTES

A change bar (I) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

TABLE 1 - RECOMMENDED SCREW SIZES AND
STRENGTH OF SCREW OR STUD TERMINATIONS

SCREW SIZE	MINIMUM STATIC TEST WITHSTAND VALUES			
	Tension		Torque	
	lb	N	lb-in	N-m
No. 2 (0.086) – 56 UNC-2A	4	17.8	4	0.45
No. 4 (0.112) – 40 UNC-2A	7	31.1	6	0.68
No. 6 (0.138) – 32 UNC-2A	30	133	10	1.1
No. 8 (0.164) – 32 UNC-2A or 3A	35	156	20	2.3
No. 10 (0.190) - 32 UNF-2A or 3A	40	178	40	4.5
0.250 - 28 UNF-2A or 3A	50	222	80	9.0
0.312 – 24 UNF-2A or 3A	70	311	160	18.1
0.375 - 24 UNF-2A or 3A	100	445	240	27.1
0.500 – 20 UNF-3A	150	667	400	45.2
0.625 – 18 UNF-3A	200	890	500	56.5

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TABLE 2 - MINIMUM RECOMMENDED TERMINATION SCREW OR STUD SIZES FOR CURRENT AND CONDUCTORS

Based on current carrying capacity of wires in conduit or bundles, AS50881

CURRENT RATING CONTINUOUS DUTY AMPERES	WIRE SIZE – AWG/kcmil		TERMINATION SCREW OR STUD SIZE
	Copper	Aluminum	
	26	-	No. 2 (0.086) - 56 - UNC
2	24	-	No. 4 (0.112) - 40 – UNC
5	22	-	
7.5	20	-	No. 6 (0.138) – 32 UNC
10	18	-	
13	16	-	No. 8 (0.164) – 32 UNC
17	14	-	
23	12	-	No. 10 (0.190) – 32 UNF
33	10	-	
36	-	8	
46	8	-	
50	-	8	
60	6	-	
66	-	4	0.250 - 28 UNF
80	4	-	
82	-	2	
100	2	-	
105	-	1	0.312 – 24 UNF
123	-	0	
125	1	-	
145	-	00	
150	0	-	
175	00	-	
162	-	000	
190	-	0000	
200	000	-	
210	-	2(1)	
225	0000	-	
246	-	2(0)	
250	2(1)	-	
290	-	2(00)	
300	2(0)	-	
324	-	2(000)	
350	2(00)	-	
380	-	2(0000)	
400	2(000)	-	

TABLE 3 - GROUPING OF DISSIMILAR METALS FOR
ELECTROLYTIC CORROSION PROTECTION

Based on MIL-STD-889 - Dissimilar Metals

GROUP I	GROUP II	GROUP III	GROUP IV
Magnesium alloys	Aluminum Aluminum alloys (all)	Zinc Cadmium	Copper and its alloys Nickel and its alloys
Aluminum alloys 5052, 5056, 5356, 6061, and 6063	Zinc Cadmium	Steel Lead	Chromium Stainless Steel (passive)
Tin	Tin Stainless Steel (active) Tin Lead (solder) Titanium	Tin Stainless Steel(active) Nickel and its alloys Tin lead (solder) Titanium	Gold Silver Titanium

Metals listed in the same group are similar and considered compatible when in contact and when protected in accordance with MIL-STD-7179. Metals listed in different groups are considered dissimilar and incompatible with one another. The tendency toward galvanic corrosion is greater between widely separated groups than between adjacent groups. Metals from different groups may be placed in contact where suitable protection against galvanic action is provided. The method of protection required will be largely dependent on design and usage environments. Surface composition of a part should be considered when determining dissimilarity; a cadmium- or tin-plated copper part is considered similar to aluminum.

WARNING

This document includes cadmium as a plating material. The use of cadmium has been restricted and/or banned for use in many countries due to environmental and health concerns. The user should consult with local officials on applicable health and environmental regulations regarding its use.

TABLE 4 - MINIMUM SPACING FOR VARIOUS VOLTAGES AND ALTITUDES

Minimum Distance				Voltage at Sea Level		Voltage at 50 000 ft Altitude (15 240 m)		Voltage at 70 000 ft Altitude (21 336 m)	
Air Space		Creepage Distance		Min. flash-over V_{rms}	Test V_{rms}	Min. Flash-over V_{rms}	Test V_{rms}	Min. Flash-over V_{rms}	Test V_{rms}
in.	mm.	in.	mm.						
*	-	0.046	1.19	800	600	300	225	200	150
*0.031	0.79	0.062	1.59	1400	1000	500	375	375	300
0.046	1.19	0.078	1.98	2000	1500	700	525	500	375
0.062	1.59	0.109	2.78	2500	1800	900	675	600	450
0.078	1.98	0.125	3.18	3000	2250	1050	790	675	500
0.093	2.38	0.156	3.97	3600	2700	1200	900	750	560
0.125	3.18	0.187	4.76	4500	3300	1400	1065	900	675
0.187	4.76	0.250	6.35	6100	4500	1800	1350	1100	825
0.250	6.35	0.312	7.94	7300	5400	2000	1500	1300	975
0.312	7.94	0.375	9.53	8500	6300	2300	1725	1420	1065

*Contacts should be continuously insulated. There should be no open airspace between any parts of the conductors having this mechanical spacing.

The creepage distances apply to dry, clean, smooth surfaces. For installations unprotected from contamination by dust and/or subject to the condensation of moisture by thermal or altitude cycling, it is recommended that the creepage distance be increased. For installations exposed directly to moisture or other conductive contaminants, it is recommended that sealing or other environment-resisting methods be used.