MIL-STD-1310E(NAVY)
18 August 1987
SUPERSEDING
MIL-STD-1310D(NAVY)
8 February 1979
(See 6.3)

MILITARY STANDARD

SHIPBOARD BONDING, GROUNDING, AND OTHER TECHNIQUES FOR ELECTROMAGNETIC COMPATIBILITY AND SAFETY

AMSC N/A
AREA EMCS

DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND

Washington, DC 20362-5101

Shipboard Bonding, Grounding, and Other Techniques for Electromagnetic Compatibility and Safety

1. This Military Standard is approved for use by the Naval Sea Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 55Z3, Department of the Navy, Washington, DC 20362-5101 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FOREWORD

The increased use of solid state equipment aboard Naval ships poses a major electromagnetic interference (EMI) problem to ship operation and performance due to the susceptibility of these equipments to the high shipboard electromagnetic environment. Another potential problem to electronic equipment is the detrimental effects of an electromagnetic pulse (EMP). To provide protection to solid state electronics, this revision of MIL-STD-1310 has been expanded to provide additional requirements and details for EMI and EMP protection. Hardware to accomplish this protection has been developed and installation methods have been detailed. The bonding, grounding, and shielding requirements for both EMP protection and EMI reduction are similar since the intent in both cases is to keep electromagnetic radiations (EMP and high frequency (HF) antenna radiations) from coupling to below deck equipment.

The EMP protection requirements specified herein are minimum requirements and are those that can be achieved within the scope of this standard. These requirements do not include methods for EMP hardening of topside equipment or below deck equipment. The hardening for topside equipment, including antennas, and the additional hardening that may be required for below deck equipment shall be specified in equipment acquisition specifications, SHIPALTS, ORDALTS, field changes, or other publications.

This standard does not specify methods for achieving EMI reduction through equipment design, frequency selection, limits on operating power, equipment location, or use of multicouplers or blankers. These requirements may be found in other publications.

CONTENTS

			Page
Paragraph	1.	SCOPE	1
	1.1	Scope	1
	1.2	Application	1
	1.3	Classification	1
	1.4	Bond strap types	1
	1.5	Class B bonding preparation	2
	2.	REFERENCED DOCUMENTS	2
	2.1	Government documents	2
	2.1.1	Specifications and standards	2
	2.1.2	Other Government drawings and publications	3
	2.2	Other publications	4
	2.3	Order of precedence	4
	3.	DEFINITIONS	5
	3.1	Bond, electrical	5
	3.2	Conduit	5
	3.3	Electromagnetic interference (EMI) tests	5
	3.4	Electromagnetic pulse (EMP)	5
	3.5	Enclosure	5
	3.6	Equipment, electrical	5
	3.7	Equipment, electronic	5
	3.8	Ground (ground potential)	5
	3.9	Ground, personnel safety	5
	3.10	Ground plates	5
	3.11	Ground, radio frequency (rf)	6
	3.12	Ground, single point	6
	3.13	Ground system	6
	3.14	Ground, 360 degrees	6
	3.15	Grounding	6
	3.16	Nonlinear junction	6
	3.17	Nontopside areas	6
	3.18	Penetration	6
	3.19	Shield or shielding	6
	3.20	Space, electrical	7
	3.21	Space, electronic	7
	3.22	Tack weld	7
	3.23	Terminal protection device (TPD)	7
	3.24	Topside areas	7
	3.25	Trunk, wireway	7
	4.	GENERAL REQUIREMENTS	7
	4.1	Ground potential designation	7
	4.2	Ground system installation	7
	4.2.1	Metallic hull ships	7
	4.2.2	Nonmetallic hull ships	7
	4.3	EMI and IMI reduction	7

CONTENTS - Continued

			Page
Paragraph	4.3.1	EMI reduction, basic criteria	8
	4.3.1.1	EMI reduction, general requirements	8
	4.3.1.1.1	Equipment	8
	4.3.1.1.2	Cables	8
	4.3.1.1.3	Portable spaces	8
	4.3.1.1.4	Broadband EMI reduction	8
	4.3.1.1.5	Rf grounding	9
	4.3.1.1.6	Maintenance EMI	9
	4.3.2	IMI reduction, basic criteria	9
	4.3.2.1	IMI reduction, general requirements	9
	5.	DETAILED REQUIREMENTS	10
	5.1	Cable ground systems	10
	5.1.1	Nonmetallic hull ships	10
	5.1.1.1	Ground plates	10
	5.1.1.2	Ground cables	10
	5.1.1.2.1	Ground plate interconnecting cable	10
	5.1.1.2.2	Electronic transmitter ground cable	10
	5.1.1.2.3	Antenna tuners ground cable	10
	5.1.1.2.4	Main ground cable	10
	5.1.1.2.5	Branch ground cables	11
	5.1.1.2.6	Ground cable installation	11
	5.1.1.2.7	Lightning protection	11
	5.1.1.3	Equipment requiring grounding	11
	5.1.1.3.1	Grounding to shielded room	11
	5.1.1.3.2	Connections	12
	5.1.1.4	Ground loops	12
	5.2	Personnel safety	12
	5.2.1	Fixed equipment grounding	12
	5.2.2	Workbench grounding	12
	5.2.3	Honeycomb bulkhead grounding	12
	5.2.4	Welding equipment grounding	13
	5.2.5	Rf radiation or burn hazards	13
	5.3	EMI and IMI reduction	13
	5.3.1	EMI reduction	13
	5.3.1.1	Equipment	13
	5.3.1.2	Cables	13
	5.3.1.3	Waveguides, pipes, tubing and exhaust stacks	13
	5.3.1.4	Submarines	14
	5.3.2	IMI reduction	14
	5.3.2.1	Yardarm foot and hand safety ropes	14
	5.3.2.2	Rigging	15
	5.3.2.3	Lifelines and liferails	15
	5.3.2.4	Life and safety nets	15
	5.3.2.5	Portable flagstaffs, jackstaffs, and stanchions	15
	5.3.2.6	Awnings	15
	5.3.2.7	Ladders	15

CONTENTS - Continued

			Page
Paragraph	5.3.2.8	Portable liferails	15
	5.3.2.9	Armored cables	15
	5.3.2.10	Expansion joints	15
	5.3.2.11	Tilting antenna platforms	15
	5.3.2.12	Portable items	16
	5.3.2.13	Masts	16
	5.3.3	EMI/IMI tests	16
	5.4	EMP protection	16
	5.4.1	Cables	16
	5.4.2	Wireway trunks	17
	5.4.3	Waveguides, pipes, and metal tubing	17
	5.5	Bond straps, fabrication and installation	17
	5.5.1	Bond strap fabrication	17
	5.5.1.1	Type I	17
	5.5.1.2	Type II	17
	5.5.1.3	Type III	18
	5.5.1.4	Type IV	18
	5.5.2	Bond strap installation hardware	18
	5.5.3	Bond strap contact surface preparation	18
	5.5.4	Bond strap installation	18
	5.5.4.1	Type I	18
	5.5.4.2	Type II	18
	5.5.4.3	Type III	19
	5.5.4.4	Type IV	19
	5.6	Corrosion protection	19
	5.6.1	Selection of materials	19
	5.6.2	Weathersealing	19
	5.7	Antiseize compounds, use of	20
	5.8	Materials and workmanship inspections	20
	5.8.1	In-progress inspection	20
	5.8.2	Final inspection	21
	6.	NOTES	21
	6.1	Intended use	21
	6.2	Subject term (key word) listing	21
	6.3	Changes from previous issue	21

FIGURES

		Page
Figure 1.	Type I and type II bond strap fabrication details	22
2.	Type III and type IV bond strap fabrication details	23
3.	Ground system, nonmetallic hull ships	24
4.	Grounding of equipments and enclosures	26
5.	Antenna tuners and couplers grounding	27
6.	Cable shield grounding	28
7.	Cable shielding methods	29
8.	Mast cables located within wireway trunk	30
9.	Filter installation, sound-powered telephone boxes	32
10.	Waveguide grounding	33
11.	Conduit grounding, submarines	34
12.	Standing rigging, bonding	35
13.	Metallic life and safety nets, bonding	36
14.	Metallic flagstaff or jackstaff, bonding	37
15.	Metallic inclined-tread ladders, bonding	38
16.	Expansion joints, bonding	39
17.	Tilting antenna mounts, bonding	40
18.	Metallic masts, bonding	41
19.	Cable shielding methods, interior	42
20.	Methods of attaching nonwelded bond straps	43

1. SCOPE

1.1 Scope. This standard provides methods for shipboard bonding, grounding, shielding, and the use of nonmetallic materials for the purpose of electromagnetic interference (EMI) reduction, intermodulation interference (IMI) reduction, protection of personnel from electrical shock, and protection of electronic equipment from an electromagnetic pulse (EMP). In addition, methods for the installation of shipboard ground systems are also provided.

1.2 Application. The requirements specified herein are applicable to all ships, including submarines and nonmetallic hull ships and shall be applied during ship construction, overhaul, alteration, and repair. Certain requirements may be applied by ship's force or other personnel, as needed. Where conflicts exist between the requirements of this standard and other publications, specifications, standards, or drawings, the Supervisor or NAVSEA shall be notified of the conflicts. When this standard is invoked on a ship, all requirements specified herein are not automatically invoked, only those that pertain to that particular ship. Due to cost impact, the EMP protection requirements specified herein are not to be implemented routinely as part of this standard, but only when specifically authorized.

1.3 Classification. The electrical bonding methods specified herein shall be classified in accordance with the following:

Class A - A bond that is established by joining two metallic surfaces through the process of welding or brazing.

Class B - A bond of one ohm (direct current (dc) resistance) or less that is established between an equipment housing, case or cabinet and ground potential, as a result of the installation of that equipment or as a result of the preparation of the mounting surface (see 1.5).

Class C - A bond that is established by bridging two metallic surfaces with a metallic bond strap.

1.4 Bond strap types. The bond straps specified herein shall be identified by usage in accordance with the following:

Type I - Type I bond straps are for use in shipboard topside areas for bonding IMI source items or equipments where class A bonding cannot be accomplished. See figure 1 for fabrication details.

Type II - Type II bond straps are for use in shipboard topside areas for bonding IMI source items or equipments where a permanently installed type I bond strap cannot be used. Use of type II straps shall be kept to an absolute minimum. See figure 1 for fabrication details.

Type III - Type III bond straps are for use in shipboard topside areas or below deck areas for bonding EMI source items, such as antenna tuners or couplers, equipments, enclosures, and cabinets. See figure 2 for fabrication details.

Type IV - Type IV bond straps are for use in shipboard nontopside areas for bonding equipment utilizing sound isolated mounts and for the bonding of electromagnetic shielding conduit aboard submarines. See figure 2 for fabrication details.

1.5 Class B bonding preparation. On below decks (weather protected) installed equipments where a 0.1 ohm dc resistance was not inherent in the equipment installation, the equipment shall be removed and a bright metal contact area be provided both on the equipment mounting surface and on the mounting foundation. This bright metal contact area shall be provided around at least one mounting bolt and shall be at least equal in size to two mounting bolt diameters. A metallized conductive gasket shall be cut and fitted to the bright metal area. The equipment shall be reinstalled and retested for a 0.1 ohm or less dc resistance. On above deck (weather exposed) equipment where a 0.1 ohm dc resistance was not inherent in the equipment installation, then a class C bond shall be installed between the equipment and ground potential.

2. *REFERENCED DOCUMENTS*

2.1 Government documents.

2.1.1 Specifications and standards. Unless otherwise specified, the following specifications and standards of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the solicitation form a part of this standard to the extent specified herein.

SPECIFICATIONS

FEDERAL

FF-N-836	- Nut: Square, Hexagon, Cap, Slotted, Castle, Knurled, Welding and Single Ball Seat.
FF-W-84	- Washer, Lock (Spring).
FF-W-92	- Washer, Flat (Plain).
QQ-B-575	- Braid, Wire, (Copper, Tin-Coated, or Silver Coated, Tubular, or Flat).
QQ-C-576	- Copper Flat Products with Slit, Slit and Edge - Rolled, Sheared, Sawed, or Machined Edges, (Plate, Bar, Sheet, and Strip).
WW-C-440	- Clamps, Hose, (Low-Pressure).

MILITARY

MIL-I-631	- Insulation, Electrical, Synthetic-Resin Composition, Nonrigid.
MIL-C-915	- Cable and Cord, Electrical, for Shipboard Use, General Specification for.
MIL-C-915/21	- Cable, Electrical, 125 Volts, Type TRXF.

MILITARY (Continued)

MIL-S-1222	- Studs, Bolts, Hex Cap Screws, and Nuts.
MIL-C-5541	- Chemical Conversion Coatings on Aluminum and Aluminum Alloys.
MIL-C-11015	- Capacitors, Fixed, Ceramic Dielectric (General Purpose), General Specifications For.
MIL-T-22361	- Thread Compound; Antiseize, Zinc Dust-Petrolatum.
MIL-I-23053/15	- Insulation Sleeving, Electrical, Heat Shrinkable Polyolefin, Heavy-Wall, Coated, Flexible, Outer Wall Crosslinked.
MIL-S-24149	- Studs, Arc Welding, and Arc Shields (Ferrules), General Specification for.
MIL-S-24235	- Stuffing Tubes, Metal, and Packing Assemblies for Electric Cables, General Specification for.
MIL-J-24445	- Joint, Bimetallic Bonded, Aluminum to Steel.
MIL-C-24643	- Cable and Cord, Electrical, Low Smoke, for Shipboard Use, General Specification for.
MIL-C-24643/4	- Cord, Electrical, 600 Volts, Type LSMCOS.
MIL-C-24643/5	- Cable, Electrical, 600 Volts, Type LSMDU.
MIL-C-24643/25	- Cable, Electrical, Type LSPI.
MIL-C-24643/27	- Cable, Electrical, 600 Volts, Type LS2AU (Including Variations LS2A and Type LS2AUS).
MIL-C-24643/30	- Cable, Electrical, Type LS1SWU (Including Variation LSISWA).
MIL-C-28840	- Connectors, Electrical, Circular Threaded, High Density, High Shock Shipboard, Class D General Specification for.
MIL-G-47197	- Gasket, Shielding, Electronic Oriented Wires Embedded in Silicone Rubber, Pressure Seal.
MIL-S-81733	- Sealing and Coating Compound, Corrosion Inhibitive.

STANDARDS

MILITARY

MIL-STD-889	- Dissimilar Metals.
DOD-STD-1399	- Interface Standard for Shipboard Systems.
MIL-STD-1605	- Procedures for Conducting a Shipboard Electromagnetic Interference (EMI) Survey (Surface Ships).
MS35425	- Nut, Plain, Wing, UNC-2B.

2.1.2 Other Government drawings and publications. The following other Government drawings and publications form a part of this standard to the extent specified herein.

DRAWINGS

NAVAL SHIP SYSTEMS COMMAND (NAVSHIPS)

804-4477903	- Staff, Jackstaff and Ensign GRP.
804-4563125	- Climber Safety Rail Notched Tube Type Arrangement and Details.

NAVAL SEA SYSTEMS COMMAND (NAVSEA)

803-5000903 - Liferail System (GRP).
803-5000938 - Lifeline and Awning Stanchions (GRP).
803-5184097 - Safety Nets, Deck Edge GRP or AL FR.
803-5184099 - Inclined Ladder for Exterior Locations, Glass Reinforced Plastic (GRP).
804-5184155 - Liferails, Lifelines and Awning Stanchions (AL & STL) Details and L/M.
804-5959308 - Lifeline System, Kevlar, Assembly and Testing.

BUREAU OF NAVAL WEAPONS (BUWEPS)

63A114J1 - Electronic Workbench Assembly Type "NEB-2".

PUBLICATIONS

NAVSEA

0967-LP-000-0110 - Electronics Installation and Maintenance Book.
S9086-CH-STM-010 - Naval Ships Technical Manual, Welding and Allied Process.
0967-LP-624-6010 - Electromagnetic Radiation Hazards (U) (Hazards to Personnel, Fuel, and Other Flammable Material) (U), Volume I.
S9407-AB-HBK-010 - Handbook of Shipboard Electromagnetic Shielding Practices.

(Copies of specifications, standards, drawings and publications required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Other publications. The following document forms a part of this standard to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted shall be those listed in the issue of the DoDISS specified in the solicitation. The issues of documents which have not been adopted shall be those in effect on the date of the cited DoDISS.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

B 633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel. (DoD adopted)

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

(Nongovernment standards are generally available for reference from libraries. They are also distributed among nongovernment standards bodies and using Federal agencies.)

2.3 Order of precedence. In the event of a conflict between the text of this standard and the references cited herein, the text of this standard shall take precedence.

3. DEFINITIONS

3.1 Bond, electrical. An electrical current path between two metallic surfaces which is established by one of the following methods: welding or brazing (class A bond); inherent or prepared contact surface (class B bond); or the addition of bond straps (class C bond).

3.2 Conduit. Conduit is a metal enclosure, normally of circular construction, used for the purpose of providing electromagnetic shielding to a cable or cables routed within the conduit. Conduit may be rigid or flexible.

3.3 Electromagnetic interference (EMI) tests. EMI tests are tests that will determine whether an EMI condition exists or does not exist. EMI tests are normally conducted in accordance with MIL-STD-1605 after ship construction, ship overhaul, major ship repair, as part of a pre-overhaul inspection, or as a result of reported EMI.

3.4 Electromagnetic pulse (EMP). EMP is a short duration, high intensity pulse resulting from the detonation of a nuclear device in the exoatmosphere. Field intensity levels on the earth's surface under the cone of the burst can reach a magnitude of 50,000 volts per meter.

3.5 Enclosure. An enclosure is a metallic housing such as a cabinet, case, or the like, which provides physical protection and support to equipment, parts, or subassemblies. Enclosures may also provide shielding and contain cooling for equipment installed therein.

3.6 Equipment, electrical. Electrical equipment is any equipment whose primary function is to generate, convert, distribute, control, or utilize electrical power. Examples are generators, motors, power switchboards, power tools, lighting fixtures, and electrical appliances.

3.7 Equipment, electronic. Electronic equipment is any equipment whose primary function is to generate, transmit, convey, receive, store, process, or otherwise use electronic signals. Examples are transmitters, receivers, amplifiers, computers, underwater detection equipment, fire control equipment, and associated test equipment.

3.8 Ground (ground potential). Ground potential is a point, plane, or surface utilized by electrical or electronic equipment or systems as a common reference point for establishment of zero potential.

3.9 Ground, personnel safety. A ground for personnel safety is a contact of 0.1 ohm (dc resistance) or less between an equipment housing and ground potential. This contact can be established either by equipment installation methods (class B bond), by the installation of a bond strap (class C bond), or by the installation of a ground wire.

3.10 Ground plates. Ground plates are 1/8-inch thick copper plate material with dimensions of approximately 2 feet by 4 feet which are installed on each side of the keel of a nonmetallic hull ship to provide an "earth"

ground connection via contact with seawater. Grounding of metallic equipment on the ship is achieved through the installation of a cable ground system installed between the ground plates and the metallic equipment.

3.11 Ground, radio frequency (rf). Unless otherwise specified, an rf ground is the ground established in a class A, B, or C bond.

3.12 Ground, single point. A single point ground is a centralized or common grounding location for one or more ground connections. This definition does not imply a sharp or point ground connection by the use of hardware tapered to a point.

3.13 Ground system. A ground system is the sum total of all conductors utilized between items or equipment and a common ground potential point.

3.14 Ground, 360 degrees. A 360-degree ground is a continuous metal-to-metal connection, existing or provided, between a cylindrical metal item which terminates at or penetrates a metal surface that is at ground potential. This definition implies continuous metal contact between the cylindrical metal item and the interfacing metal surface. An example would be a deck or bulkhead which is at ground potential and a pipe which passes through a hole in the deck or bulkhead and the pipe is continuously welded to the deck or bulkhead in such a manner that the gap between the pipe and the deck or bulkhead is completely closed by the welding. Grounding adapters are specified herein to accomplish this 360 degree grounding at decks, bulkheads, or stuffing tubes for pipes, and overall cable shields.

3.15 Grounding. Grounding is the process of establishing the required low impedance or low resistance path between an item or equipment and ground potential by the methods specified herein. The term grounded means such a path exists.

3.16 Nonlinear junction. A nonlinear junction is a contact or junction area between two metallic surfaces which will exhibit nonlinear voltage-current transfer characteristics when subjected to a rf voltage. This non-linearity is usually caused by corrosion or other semiconducting materials in the contact area which will not permit a low impedance metal-to-metal contact between the two metallic surfaces.

3.17 Nontopside areas. Nontopside areas are all inner or inside areas of a ship not exposed to weather, including the interior of metallic enclosed masts.

3.18 Penetration. A penetration is the immediate location and actual opening area where an item, such as a cable, pipe, waveguide, or such, passes through another surface, such as a deck, bulkhead, or metal structure by means of a stuffing tube, transit block, or other weather sealing method.

3.19 Shield or shielding. A shield or shielding is a metal barrier of solid, screen, or braid construction used to protect electronic components, wires, or cabling from electromagnetic energy or used to reduce the emission of electromagnetic energy from components, wires, or cabling.

3.20 Space, electrical. An electrical space is a space used primarily to contain installed units of electrical equipment. Examples are 60 or 400 hertz (Hz) motor generator spaces and power distribution switchboard spaces.

3.21 Space, electronic. An electronic space is a space used primarily to contain installed units of electronic equipment. Examples are radar spaces, sonar spaces, electronic countermeasures (ECM) spaces, communication centers, transmitter spaces, crypto spaces, and missile control spaces.

3.22 Tack weld. A tack weld is one or more small welds, such as a spot weld, which provides a current path between two metallic items for the purpose of grounding.

3.23 Terminal protection device (TPD). A TPD is an electronic switching device which is installed between a susceptible circuit and ground to protect electronic components from EMP damage. TPDs may also be identified as transient protection devices or surge protection devices.

3.24 Topside areas. Topside areas are all shipboard areas continuously exposed to the weather, such as the main deck and above, sponson decks, catwalks, and those exposed portions of gallery decks. Weather protected areas such as hangar decks, covered decks, foyers, and vestibules are not considered to be topside areas as related to EMC or EMP requirements unless otherwise specified.

3.25 Trunk, wireway. A wireway trunk is a four-sided metal enclosure used for the purpose of enclosing cable runs to provide electromagnetic shielding to the cables routed therein. One or more sides of the trunk may be ship structure.

4. GENERAL REQUIREMENTS

4.1 Ground potential designation. On metallic hull ships, the metal hull shall be designated ground potential. Equipment racks, foundations, structures, cable ground systems, and other large metal items which are welded, brazed, class C bonded, or otherwise attached by a low resistance (one ohm or less) connection to ship hull are considered extensions of the ship hull and are also at ground potential. On nonmetallic hull ships, the ground plates shall be designated ground potential. Ground bus cables attached to these ground plates are considered extensions of the ground plates and are also at ground potential.

4.2 Ground system installation.

4.2.1 Metallic hull ships. When specified, a computer ground system shall be installed for digital computer equipment in accordance with DOD-STD-1399.

4.2.2 Nonmetallic hull ships. A cable ground system shall be installed on nonmetallic hull ships as specified in 5.1.1.

4.3 EMI and IMI reduction.

4.3.1 EMI reduction, basic criteria. Primary sources of electromagnetic interference aboard naval ships are: electrical equipment and associated cables, rf equipment and associated cables, microwave frequency equipment and associated cables, and electrical and mechanical switching devices. From these many active electrical and electronic devices and equipments installed aboard every Naval ship, a shipboard electromagnetic environment is generated. Receiving equipment and equipments containing solid state components installed in the ship must be able to withstand this environment or EMI protection in the form of shielding, grounding, or filtering must be provided. In some cases, active equipment and associated cable radiations can be controlled through shielding, isolation, filtering, frequency control, or power control.

4.3.1.1 EMI reduction, general requirements. To operate in the electromagnetic environment of 4.3.1, the following general requirements apply to the equipment specified:

4.3.1.1.1 Equipment. Electrical and electronic equipment shall be grounded as specified herein.

4.3.1.1.2 Cables. Cables shall be routed within the ship's structure or other metal enclosures, such as masts, to shield the cables against electromagnetic radiations from ship transmitting antennas. Cables routed in ship topside areas shall be shielded as specified in 5.3. Armored (braid) cables shall not be routed in topside areas due to the generation of IMI and broadband EMI (arcing). Sonar system cables and other low frequency system cables, such as power cables and other cables carrying signal information below 300 kilohertz (kHz), shall be installed in accordance with the cable spacing and shielding requirements of NAVSEA S9407-AB-HBK-010. Radar modulator pulse cables and associated power supply cables shall not be routed in cable runs with other cables unless at least an 18-inch cable separation or at least 60 decibels (dB) of shielding is provided. Cables not terminating in transmitter and receiver spaces shall not be routed through these spaces unless cable shielding is provided. All cables interconnecting electrical sensors or transducers to machinery control consoles (MCC) or other similar systems shall be shielded. Cable shields shall be grounded as required by applicable drawings and as specified herein.

4.3.1.1.3 Portable spaces. Portable spaces such as huts, vans, trailers, and shelters that contain electrical and electronic equipment and are located in weather deck areas shall be grounded by type II bond straps. Portable spaces equipped with antennas and requiring rf grounding shall be grounded by type III bond straps. The length of the type III bond straps for this application may be increased beyond the specified 12-inch limit as long as a 5-to-1 length-to-width ratio is maintained. Ground terminals shall be provided for installation of bond straps. Connections and hardware shall be weather sealed as specified in 5.6. Portable spaces mounted to ship deck by bolts are satisfactorily grounded (class B bonded). Tiedown cables shall be nonmetallic or metallic cables, if installed, shall be broken with insulators every 5 feet.

4.3.1.1.4 Broadband EMI reduction. Broadband EMI, usually caused by arcing, is normally generated in ship topside structures or rigging by close

or intermittent contact between metal items which are in proximity to high frequency (HF) transmitting antennas or located within the main beam of radar antennas. Examples of such items are handrails, hooks, links, cables, chains, cable armor, and loosely mounted vertical ladders. EMI reduction shall be achieved by use of bonding, grounding, shielding, insulating, or by use of nonmetallic materials.

4.3.1.1.5 Rf grounding. Unless otherwise specified, electrical and electronic equipment and associated items not purposely insulated from the mounting surface shall be rf grounded by class B or class C bonding methods. Equipment installed on nonconducting resilient mounts shall be grounded through the use of bond straps, as specified herein.

4.3.1.1.6 Maintenance EMI. Several sources of EMI aboard ships are caused by corrosion and lack of proper maintenance. Examples are: improperly installed cable connectors, corrosion in connectors caused by lack of proper weather sealing, other areas of corrosion associated with communication antennas, tuners, couplers, and improperly installed antenna feed lines. Corrections shall be applied after inspection and EMI testing, and should result in cleaning, preserving, repairing, or item replacement, as required.

4.3.2 IMI reduction, basic criteria. To be detrimental to ship's communication receivers, nonlinear junctions must have two or more rf signals of sufficient voltage level impressed across the junction to generate intermodulation signals. In order to capture this threshold voltage level from ship's transmitting antennas, a nonlinear junction must be in the current path of a long metal item that has sufficient length to react as an antenna at HF frequencies. This long metal item could be a metal lifeline or halyard over six feet in length with the nonlinear junction being a chain-link type of end fitting. This long metal item then reradiates the newly created intermodulation signals after signal rectification has taken place in the nonlinear junction. Basic IMI reduction techniques include bonding (providing a current path around the nonlinear junction by the installation of bond straps) and by the use of nonmetallic materials. IMI is only applicable to topside areas on metallic hull surface ships and usually results from HF transmitter radiations.

4.3.2.1 IMI reduction, general requirements. On surface ships, the ship topside areas shall be, as nearly as possible, a single conducting surface free of all pinned, snap-linked, chain-linked, or other metallic discontinuities where nonlinear junctions may develop. Metal-to-metal joints, where movability or removability is not a requirement, shall be class A bonded. The joining of dissimilar metals by bolting or riveting shall be minimized in topside areas. Where movability or removability is not a requirement, aluminum to steel shall be joined by a welding process using bimetallic bonded joints conforming to MIL-J-24445. Armored cables shall be routed within the ship or other metal structures to avoid exposure to radiations from ship's HF transmitting antennas. Armored cable runs normally located on masts and other similar metallic structures shall be relocated on the inside of these structures or enclosed in wireway trunks, as specified herein. During ship construction and ship repair, where electrical or electronic cables are installed or replaced in topside areas, these cables shall be an unarmored type. Loose metallic items, such as pipes, cables, and portable rigging shall not be stowed, stacked, or lashed

down in ship's topside areas. Flexible metal conduit installed in topside areas shall have an outer insulating jacket. Woven metal protective screens shall be replaced with expanded metal type screens and welded to the screen frame or replaced with nonmetallic equivalents. Except for anchor holding, metal chain shall not be installed in topside areas.

5. DETAILED REQUIREMENTS

5.1 Cable ground systems.

5.1.1 Nonmetallic hull ships. A ground system shall be installed in nonmetallic hull ships as specified in 5.1.1.1 through 5.1.1.3.1 and as shown on figure 3. Equipment and metallic items connected to this ground system shall be as specified in 5.1.1.3.

5.1.1.1 Ground plates. A ground plate shall be installed on each side of the keel, to provide an earth ground connection via contact with seawater. These ground plates shall be located as directly under the mast as possible. A through-bolt shall be brazed to each plate to provide a connection point for the cable ground system.

5.1.1.2 Ground cables. The cables used in the ground cable installation shall be in accordance with MIL-C-24643 and shall be type LSSSGU for sizes 1 and 1/0 AWG cables and type LSSHOF-23 for size 7 AWG cables.

5.1.1.2.1 Ground plate interconnecting cable. A size 1/0 AWG cable shall be installed between the two ground plates as shown on figure 3. A lug shall be installed on each end of the cable for connection to each through-bolt.

5.1.1.2.2 Electronic transmitter ground cable. A size 1/0 AWG cable shall be connected to the ground plate's interconnecting cable or through-bolt and shall run as directly as possible to the radio transmitter spaces. Each radio transmitter cabinet or enclosure shall be connected to this ground cable by a size 1 AWG cable. Suitable lugs or connectors shall be used on each end of this cable.

5.1.1.2.3 Antenna tuners ground cable. Antenna tuners and couplers shall be grounded by a 1/0 AWG ground cable, run as directly as possible between each tuner or coupler and the ground plates. In lieu of separate cable runs to the ground plates, each tuner or coupler ground cable may be connected to the main ground cable, to the electronic transmitter ground cable or to the shielded room in order to provide a short direct path to the ground plates. Metal masts may be used as this ground cable as long as the tuners/couplers are firmly grounded to the mast. The lower part of the mast or structure shall then be attached to the ground plates using 1/0 AWG cable. To prevent ground loops, rf transmission lines shall be routed with the tuner/coupler ground cables.

5.1.1.2.4 Main ground cable. A size 1 AWG cable shall be used as the main ground cable for grounding all other equipment and items. This cable shall be connected to the electronic transmitter ground cable or to either

ground plate through-bolt and shall run throughout the ship as required to connect to equipment and metal items.

5.1.1.2.5 Branch ground cables. Branch ground cables shall be size 7 AWG and shall be used to connect equipment and metallic items (see 5.1.1.3) to the main ground cable.

5.1.1.2.6 Ground cable installation. Ground cables shall be installed using the minimum lengths of cable consistent with meeting other requirements specified herein. Cables shall be installed in locations that provide minimum exposure to possible physical damage and shall provide access for inspection, repair, or replacement. Cables shall be installed and supported by fasteners, staples or clips. Where cable installation requires penetration of watertight decks or bulkheads, copper through-bolts shall be used.

5.1.1.2.7 Lightning protection. The cable ground system shall also provide the necessary lightning protection.

5.1.1.3 Equipment requiring grounding. The following equipment and items shall be connected to the ground system:

(a) Equipment utilizing electrical power
(b) Fuel and water tanks
(c) Metallic standing rigging
(d) Metallic cranes, hoisting gear, and king posts
(e) On minesweepers; deck chocks, deck wearing plates, deck padeyes, stern roller chocks, and any other metallic structures used for towing of or in contact with magnetic minesweeping cables
(f) Portable metallic liferail stanchions, liferails, and ladderways
(g) All metallic pipes and piping
(h) Shielded rooms
(i) Engines, steering vanes, bow thruster, bow thruster controls, rudder stock, struts, main shaft (engine or reduction gear mount), main shaft fairing (if not grounded internally) sonar trunks, underwater log, all sea chests and all other large, metallic, underwater appendages
(j) Exceptions - The following items are not required to be grounded:

(1) Berths
(2) Bitts (if not used with minesweeping operations)
(3) Chocks, except as required for minesweepers
(4) Small metal objects, such as metal parts of air ports, hand tools (if not electrically operated), and other objects of comparable size
(5) Ventilators

5.1.1.3.1 Grounding to shielded room. All items and equipments located within six inches of the shielded area and requiring grounding shall be grounded to the shielded area using direct attachment bolts or a section of no. 7 AWG cable less than 12 inches in length.

5.1.1.3.2 Connections. Equipment and items required to be grounded shall have ground connections for terminating the ground cables. Each electrical or electronic equipment shall be individually connected to a branch ground (or main ground) cable so that disconnecting one equipment ground will not cause loss of a ground connection to other equipment. Connections within the ground cable system shall provide the same low resistance as the ground cables. Prior to assembly, threaded and crimp connectors shall be coated with an antiseize compound conforming to MIL-T-22361. All connections shall be protected from corrosion by an application of sealing compound of MIL-S-81733.

5.1.1.4 Ground loops. Installation methods shall minimize ground loops in the ground system. Unless otherwise specified on equipment installation drawings, all shielded cables entering a connection box shall have the cable shields banded together as close to the box entry point as possible using metal banding material and a 0.1 mfd capacitor installed between the band and the metal box. This type grounding shall only be accomplished on one end of each cable shield. The other end shall be grounded 360 degrees at the box entry.

5.2 Personnel safety.

5.2.1 Fixed equipment grounding. The outermost metallic surface of all equipment connected to electrical power of 30 volts or more shall be grounded. Electrical and electronic equipment installed on nonconductive shock or sound isolated mounts shall be grounded by a bond strap as shown on figure 4. Electrical and electronic equipment hard mounted or installed on conductive (metal or metallized) shock mounts shall be class B bonded. Electronic equipment and subassemblies hard mounted in environmental cabinets or enclosures shall also be class B bonded. Slide-mounted or roller-mounted equipment shall be grounded by a conductor within the equipment cable harness. Where manufacturers or installers have not provided this ground conductor, a flexible ground conductor shall be installed between the drawer frame or chassis and the enclosure frame (ground potential). The ground conductor size shall be equal to or greater than the size of one of the conductors supplying alternating current (ac) power to the drawer equipment. Electrical equipment, such as metal connection boxes, switch boxes, and breaker panels shall also be class B bonded. Equipment electrical power connectors or terminals which have a terminal designated for grounding shall have that terminal grounded if required on Installation Control Drawings (ICD's), or other approved drawings.

5.2.2 Workbench grounding. Electronic workbenches shall be grounded in accordance with Drawing 63A114J1.

5.2.3 Honeycomb bulkhead grounding. Electrical equipment mounted on nonmetallic or nonmetallic covered bulkheads shall be grounded by one of the following methods:

(a) Where metal sheeting or metal cores of nonmetallic bulkheads are grounded at installation channels or brackets (class B or class C bonded), electrical equipment installed thereon are considered properly grounded as long as a 0.1 ohm (dc resistance) is not exceeded between each equipment and the metal sheeting or core.

(b) Where metal sheeting or metal cores of nonmetallic bulkheads are insulated from contact with ground potential at installation channels or brackets, electrical equipment installed thereon shall be grounded by a ground conductor routed internal to or external to the power supply cable. The ground conductor shall be at least equal in size to one of the conductors supplying power to the equipment. The ground conductor shall be connected to ground potential at the power connection box or other convenient ground potential point and to the equipment case, chassis or frame.

5.2.4 Welding equipment grounding. Welding equipment shall be grounded in accordance with NAVSEA S9086-CH-STM-010.

5.2.5 Rf radiation or burn hazards. Posting of rf radiation hazard warning signs, rf burn hazard warning signs, the marking of safe distance limits, and other guidance for personnel safety from rf radiation shall be in accordance with NAVSEA 0967-LP-624-6010.

5.3 EMI and IMI reduction.

5.3.1 EMI reduction. The EMI reduction requirements specified by 5.3.1.1 through 5.3.1.4 are applicable to metallic hull surface ships only.

5.3.1.1 Equipment. Antenna tuners, couplers, converters, matching networks, and receiver termination boxes shall be grounded by the methods as shown on figure 5. All other electrical and electronic equipment, grounded as required for personnel safety (see 5.2), are considered properly grounded for EMI reduction.

5.3.1.2 Cables. All cables routed in topside areas shall be shielded. Coaxial cables and other cables with an overall shield are considered properly shielded. The overall shield shall be properly terminated at each end-equipment and shall be grounded at weather penetrations using the methods of figure 6. All other cables which exceed one meter of exposed length in topside areas shall be routed within either rigid conduit (pipe), flexible conduit, or wireway trunks. Flexible conduit shall be as specified on figure 7. Flexible conduit shall terminate into 360 degree grounding configurations as shown on figure 7. Wireway trunks shall be as shown on figure 8. Wireway trunks may contain both shielded and unshielded cables. Where a shielded cable exits the wireway trunk, the overall cable shield shall be grounded at this point using the methods of figure 6. Where an unshielded cable exits the wireway trunk, add-on shielding, such as rigid or flexible conduit, shall be added to that part of the weather-exposed cable. Proper grounding of both ends of the conduit shall be as specified on figure 7. When the EMP requirements of 5.4.1 are applied concurrently with the preceding EMI requirements, the EMP requirements for cable shielding shall take precedence. Portable cables, such as sound-powered telephone cables, shall have rf filters installed in each telephone connection box. Filter type and installation methods shall be as shown on figure 9.

5.3.1.3 Waveguides, pipes, tubing and exhaust stacks. Waveguides, pipes, metal tubing and exhaust stacks routed in topside areas and penetrating a

weather deck or bulkhead shall be grounded at this point using the methods of figure 10 for waveguide grounding and the methods of figure 6 (cable shield grounding) for the grounding of pipes and tubing. Pipes welded at penetration points are properly grounded. Diesel and turbine exhaust stacks shall be grounded at the weather penetration point using four type I bond straps spaced at 90 degree intervals for turbine exhausts and two straps spaced at 180 degree intervals for diesel stacks.

5.3.1.4 Submarines. Submarine cable separation and shielding shall be in accordance with NAVSEA S9407-AB-HBK-010. Shield grounding shall be in accordance with applicable drawings and the following:

Rigid and flexible electromagnetic shielding conduit 10 feet or longer (without insulating jacket) shall be grounded at a point not farther than 5 feet from each end. Conduit less than 10 feet shall be grounded at one point anywhere along the run. Class B bonding is acceptable. Where class B bonding is not inherent in the installation of the conduit, bond straps shall be installed as shown on figure 11. This requirement is in addition to any grounding that may be achieved through conduit termination to equipment and shall be made to a point of ground potential other than the terminating equipment case or cabinet. Electromagnetic shielding conduit with insulating jacket shall be grounded at locations as specified on installation drawings using the method as shown on figure 11.

5.3.2 IMI reduction. The IMI reduction requirements as specified in 5.3.2.1 through 5.3.2.13 apply to metallic items located in topside areas on metallic hull surface ships. These requirements shall be applied only under the following conditions:

(a) Except as noted below, ships with six or more HF transmitters installed shall have all requirements applied.
(b) On ships with less than six HF transmitters installed, the IMI reduction requirements shall be applied only as needed to reduce sources of IMI to acceptable levels as determined by MIL-STD-1605 tests.
(c) Exceptions: Portable items, such as canopies, awnings, stanchions, and rigging which are rigged only when in port, and telescoping stanchions and lifelines are exempt from these IMI reduction requirements. In addition, rigging (see 5.3.2.2), life and safety nets (see 5.3.2.4), portable flagstaffs, jackstaffs and stanchions (see 5.3.2.5), and ladders (see 5.3.2.7) shall be bonded only if IMI tests indicate the need.

Adherence to these requirements will reduce hull generated intermodulation (rusty bolt) type of interference caused by nonlinear junctions in topside areas. The requirements are listed in descending order based on the interference severity of each item.

5.3.2.1 Yardarm foot and hand safety ropes. Metallic walking ropes or hand safety ropes shall not be used on yardarms. Nonmetallic rails or all-welded rails shall be installed. Materials and techniques shall be in accordance with standard methods.

5.3.2.2 Rigging. Rigging such as halyard downhauls, full dress rigging, awning lines, lines associated with lifeboats, and other similar lines shall be nonmetallic. Metallic standing rigging shall be bonded to ground potential as shown on figure 12.

5.3.2.3 Lifelines and liferails. All-welded steel or aluminum liferails shall be installed at all deck edge areas where clear deck edge or personnel access is not required. Metal liferails shall be in accordance with Drawing 804-5184155. Where clear deck edge is required, Kevlar lifelines in accordance with Drawing 804-5959308 shall be installed. Access openings less than 6 feet shall be protected with nonmetallic rope. Materials and installation methods shall be in accordance with standard methods.

5.3.2.4 Life and safety nets. Life and safety nets and net frames shall either be fabricated from nonmetallic material in accordance with Drawing 803-5184097 (except in heat or blast areas), or metallic nets and hinged net frames shall be bonded as shown on figure 13.

5.3.2.5 Portable flagstaffs, jackstaffs, and stanchions. Portable staffs and stanchions shall either be constructed of nonmetallic material in accordance with Drawing 804-4477903 (except in heat or blast areas), or metallic staffs and stanchions shall be bonded as shown on figure 14. This requirement does not apply to heavy weather lifeline stanchions subject to green seas.

5.3.2.6 Awnings. Awning metallic rigging shall be disassembled and stowed when the ship is underway or awning stanchions, braces, and spreaders shall be nonmetallic in accordance with Drawing 803-5000938.

5.3.2.7 Ladders. Metallic inclined-tread ladders shall be grounded as shown on figure 15 or shall be replaced with nonmetallic ladders fabricated in accordance with Drawing 803-5184099. Metallic vertical ladders are considered satisfactorily grounded when installation bolts are tightened securely. Climber safety rails are considered satisfactorily grounded when installed by welded brackets in accordance with Drawing 804-4563125. Climber safety rails installed by brackets clamped to ladder rungs shall utilize a type II bond strap at these points with the welded end of the bond strap attached to ship structure and the detachable end bolted to the safety rail.

5.3.2.8 Portable liferails. Except in heat or blast areas, portable liferails shall be constructed of nonmetallic material in accordance with Drawing 803-5000903.

5.3.2.9 Armored cables. In new construction, armored cables shall not be installed in topside areas. On existing ships, armored cables located on masts shall be relocated internally to the mast or enclosed in a wireway trunk as shown on figure 8.

5.3.2.10 Expansion joints. Expansion joints shall be bonded as shown on figure 16.

5.3.2.11 Tilting antenna platforms. Tilting antenna platforms shall be bonded as shown on figure 17.

5.3.2.12 Portable items. Large or long portable metal items or equipment, such as fog nozzles, davits, and personnel stretchers stowed within 50 feet from any part of an HF transmitting antenna, shall be insulated from contact with ship structure by insulating the hangars, clips, brackets, and other areas of contact with ship structure. Insulating material shall be weather resistant heat-shrinkable tape or tubing, rubber matting, plastics, epoxy, fiberglass, or other similar materials.

5.3.2.13 Masts. Masts, mast braces, king posts, and other similar structures bolted in place shall be grounded by type I bond straps spaced equally around each structure (see figure 18).

5.3.3 EMI/IMI tests. The EMI and IMI tests of MIL-STD-1605 shall be performed, as required, to determine the effectiveness of the shielding and grounding installed and to determine if additional measures are needed.

5.4 EMP protection. To safeguard electrical and electronic equipment located internally to a ship, the following EMP protective measures shall be applied to the following items or equipment which are exposed to the EMP environment. The EMP environment shall be defined as all topside areas (see 3.24) and the areas specified in 5.4.1. The requirements specified in 5.4.1 through 5.4.3 apply only to metallic hull surface ships on which EMP protection has been specifically authorized. These requirements are not to be implemented routinely as part of this standard, but only when EMP protection is specifically invoked as part of contract requirements. When EMP protection requirements are applied concurrently with EMI reduction requirements (see 5.3.1) the EMP protection requirements shall take precedence and govern where conflicts may occur.

5.4.1 Cables. Except as noted below, all cables routed in topside areas shall be EMP shielded by the addition of shielding conduit or wireway trunks using the methods detailed on figures 7 and 8. To provide the necessary EMP shielding, rigid conduit (pipe) or approved flexible conduit shall be installed over single cable runs. Multicable runs shall use rigid or flexible conduit or wireway trunk. It is preferable to run cables within the structure of the ship or within enclosed masts in order to minimize the addition of shielding conduit or wireway trunks.

Exceptions:

(a) Cables with a solid overall shield, such as the RG-333 type cables, do not require additional shielding; however, the overall conductor (solid shield) shall be grounded at the weatherdeck or weather bulkhead penetration point using the methods of figure 6.
(b) Electrical or electronic portable plug-in cables are not required to be conduit shielded.
(c) Double shielded coaxial cables and double shielded multiconductor cables routed less than 8 feet in topside (EMP exposed) areas do not require additional shielding.

Cables routed internally to the ship shall not be routed within 12 inches of weather doorways, hatchways, and windows, unless the cables are routed within shielding conduit or wireway trunks. Cables that terminate at these openings,

such as windshield wiper cables, window deicing cables, and door alarm cables, shall also be shielded as above. Helicopter hangar doors shall not have cables routed within 10 feet of these openings unless they are routed in conduit or wireway trunk. Conduit and wireway trunk installation for internally routed cables near openings shall be in accordance with figure 19. In new work, cables not terminating within hangar bays and well deck areas shall not be routed through these areas. Cables terminating within these areas shall be routed such that minimum length of cable is exposed within the area. Within these constraints, cable penetrations of these areas shall also be kept to a minimum. All penetrations shall be made through connection boxes, switch boxes, breaker boxes or power panels to allow for the installation of terminal protection devices (TPDs).

5.4.2 Wireway trunks. Methods for installation of wireway trunks in topside areas shall be as detailed on figure 8. On aluminum trunks, access covers shall provide electrical grounding with the trunk edges or lap surface. These surfaces shall be free of paint and shall be treated with a class 3 conductive chemical coating in accordance with MIL-C-5541. Steel trunks and covers shall be painted, as required, including the trunk to cover mating areas. Captive bolts shall be used to attach access covers to trunks. The bolts shall be installed on both sides of the trunk cover, even if hinges are employed. The maximum spacing between adjacent bolts on aluminum trunks shall not exceed 12 inches in order to ensure proper electrical grounding of the cover to the trunk. The maximum gap between the vertical ends of adjacent access covers on all trunks shall not exceed 0.25 inch and shall be limited to one side of the trunk. The remaining three sides shall be of continuous metal using welded or bolted lap or butt joints. Cable breakout of wireway trunks shall be as detailed on figure 8.

5.4.3 Waveguides, pipes, and metal tubing. Waveguides, pipes, and metal tubing grounded for EMI (see 5.3.1.3) are properly grounded for EMP.

5.5 Bond straps, fabrication and installation. Bond straps shall be as specified in 5.5.1.1 through 5.5.1.4 and as shown on figures 1 and 2. Bond straps shall be as short as practical.

5.5.1 Bond strap fabrication.

5.5.1.1 Type I. Type I bond straps shall be fabricated from welding cable as shown on figure 1. Lugs shall be installed on each end of the welding cable to facilitate bond strap installation. The type of lug, aluminum or steel, shall be selected to match the mating surface; aluminum lugs for attachment to aluminum surfaces and steel lugs for attachment to steel surfaces. The bond strap length shall be selected on the basis of the particular bonding requirement, always using the shortest length possible. Type I bond straps may be fabricated in standard lengths of 6, 9, and 12 inches and placed in local stock.

5.5.1.2 Type II. Type II bond straps shall be fabricated the same as type I, except that one lug shall be punched or drilled for installation on a threaded stud or bolt (see figure 1).

5.5.1.3 Type III. Type III bond straps shall be fabricated as detailed on figure 2. Holes shall be punched or drilled in each end of the bond strap for strap installation. Type III bond straps may be fabricated in standard lengths of 3, 6, 9, and 12 inches and placed in local stock.

5.5.1.4 Type IV. Type IV bond straps shall be fabricated as detailed on figure 2. Type IV bond straps may be fabricated in standard lengths of 6, 9, and 12 inches and placed in local stock.

5.5.2 Bond strap installation hardware. Bond strap installation hardware, such as nuts, bolts, washers, and studs, shall be 5/16-inch or 3/8-inch, as appropriate. For topside areas, mounting hardware shall be corrosion-resistant steel except where aluminum studs are required. For nontopside areas, mounting hardware (except studs) shall be plated steel. Studs located in nontopside areas shall be aluminum or plated steel, as appropriate. Bond strap installation hardware shall conform to the requirements as specified on figure 20.

5.5.3 Bond strap contact surface preparation. Surface preparation for installation of welded or brazed bond straps (such as type I or type II) and welded studs shall be accomplished by cleaning to bare metal those areas where bond strap lugs shall be welded or brazed. Surface preparation for the installation of bond straps fastened by bolts or studs shall be accomplished by cleaning to bare metal those areas where bond straps shall connect. Cleaned areas and all threaded hardware shall be coated with an antiseize compound conforming to MIL-T-22361 prior to the installation of bolted bond straps. The preceding cleaning requirements do not imply the cleaning away of plating on items such as chassis and bond strap mounting hardware.

5.5.4 Bond strap installation. Bond straps shall be installed in locations which shall permit rapid inspection or replacement and shall be installed in such a manner that vibration, expansion, contraction, or relative movement, incident to normal service, shall not break or loosen the bond strap connection. Bond strap installations shall not interfere with the tightness characteristics of cabinets or enclosures, shall not weaken any structure or item to which a bond strap is attached, and shall not restrict the movement of any hinged or movable item. Existing bolts, studs, or threaded holes shall be used for bond strap installation where possible. Type IV bond straps shall not be installed in weather-exposed locations.

5.5.4.1 Type I. Type I bond straps shall be installed as follows:

(a) Weld or braze the lugs to ground potential and to the item to be bonded. Lug tongues may be bent, if necessary, to provide the most practical bond strap installation.
(b) Clean the welded areas of welding slag.
(c) Coat the lugs and the welded areas as specified in 5.6.

5.5.4.2 Type II. Type II bond straps shall be installed as follows:

(a) Weld or braze one end of the strap to ground potential or to the item to be bonded, as appropriate.

(b) Weld or braze a threaded stud to ground potential or to the item to be bonded, as appropriate, or use existing bolts or holes, if possible.
(c) Attach the bolted end of the bond strap by use of the appropriate method and hardware as shown on figure 20.
(d) Clean the welded area of welding slag.
(e) Coat the lugs and the welded area as specified in 5.6.

5.5.4.3 Type III. Type III bond straps shall be installed as follows:

(a) Secure strap to item and ground potential by use of appropriate securing method as shown on figure 20.
(b) Coat bolted connection as specified in 5.6.

5.5.4.4 Type IV. Type IV bond straps shall be installed as follows:

(a) Secure strap across equipment using existing hardware, where possible (see figure 4). Where existing hardware is not convenient for bond strap installation, drill, or drill and tap mounting holes, or install studs for installation of bond strap. For submarine application, type IV bond straps shall be installed in accordance with the installation details provided on figure 11.

5.6 Corrosion protection.

5.6.1 Selection of materials. All materials used in installations specified by this standard shall be selected and installed to provide maximum protection against corrosion. Selection of fittings shall be in accordance with the following:

(a) Fittings selected to replace stuffing tube gland nuts shall be aluminum for aluminum stuffing tubes and CRES 316 for steel stuffing tubes.
(b) Fittings selected to terminate conduit to electrical or electronic connectors shall be of the same type metal as the connector, aluminum or CRES.
(c) Fittings selected to terminate conduit to electrical boxes or equipment shall be CRES 316 for steel or brass boxes and aluminum for aluminum boxes.

In addition to the preceding requirements, MIL-STD-889 shall be used as guidance for the joining of metals in a marine environment.

5.6.2 Weathersealing. Cable shield grounding areas, conduit terminating fittings and bond straps shall be weathersealed in accordance with the following:

(a) Antiseize compound of MIL-T-22361 shall be applied to all threads and other nonwelded connections where grounding is required.

(b) All fittings which terminate shielding conduit shall be weathersealed with heat shrinkable tubing of MIL-I-23053/15.
(c) Cable shield grounding areas shall be weathersealed with an application of polysulfide sealant of MIL-S-81733, type I. Where fittings are installed in connection boxes, a fillet of polysulfide sealant shall also be applied around the fitting at the connection box.
(d) The ends (lugs) of type I and II bond straps which are welded in place shall be weather sealed by priming and painting the lugs and the areas affected by welding. Although cable jackets of type I and type II bond straps do not require painting, painting the jackets will not affect bond strap performance. The ends of type II and III bond straps which are installed on threaded studs or bolts shall be weathersealed by coating the lugs and associated hardware with an application of MIL-S-81733 sealing compound. Where bond strap installation has affected painted surfaces, affected areas shall be restored to the original paint finish. Bond straps installed in nontopside areas do not require painting. Painted areas affected by bond strap installation shall be restored to the original paint finish.

5.7 Antiseize compounds, use of. The antiseize compound specified for use by this standard is procured in accordance with MIL-T-22361 and is for use between two metal surfaces to preserve grounding conductivity. This compound is added for the purpose of maintaining the quality of grounding by preventing oxidation or corrosion in the ground path area. This compound is electrically conductive but may not show a low dc resistance when test prods of an ohmmeter are immersed in the compound. This compound shall be used only in areas where metal-to-metal contact through the compound can be assured such as with threaded fittings and metal surfaces held together under pressure by the use of bolts. Any flat surface area where the compound is applied shall be edge sealed with MIL-S-81733 sealing compound to prevent the antiseize from melting and running under high temperatures.

5.8 Materials and workmanship inspections.

5.8.1 In-progress inspection. An in-progress inspection shall be conducted during the installation of bond straps and nonmetallic materials specified by this standard. This inspection shall consist of spot checking installation procedures, methods, and materials to determine compliance with the applicable requirements specified herein. The inspection shall also ensure that:

(a) All materials are installed in accordance with requirements for personnel safety.
(b) Quality materials, methods, and workmanship are used.
(c) Each installation will satisfy the intent and purpose of the requirement.
(d) Bond straps will not restrict the movement of any hinged or pinned item and installation methods will not place any bond strap in a binding or restrictive position that shall lead to early breakage of the strap.

(e) Bond straps, nonmetallic materials and metal fittings located in topside areas are fabricated, installed, and treated to prevent deterioration through corrosion, oxidation, or weathering.

5.8.2 Final inspection. After the completion of all required installations, a final inspection shall be made. This inspection shall determine that all requirements, specified for the particular ship involved, have been accomplished and that the requirements specified in 5.8.1 have been met.

6. NOTES

6.1 Intended use. This standard specifies requirements for EMI reduction, EMP protection, personnel safety grounding, and the installation of cable ground systems for shipboard applications.

6.2 Subject term (key word) listing.

Bonding
Electrical
Electromagnetic
Electronic
Grounding
Interference
Pulse
Safety

6.3 Changes from previous issue. Asterisks or vertical lines are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

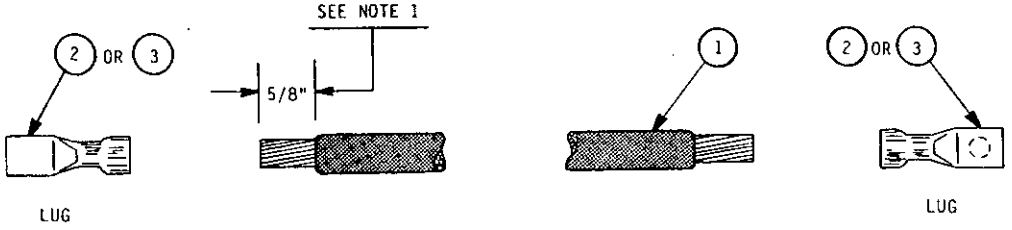
Review activities:
Navy - AS, OS, EC

Preparing activity:
Navy - SH
(Project EMCS-N107)

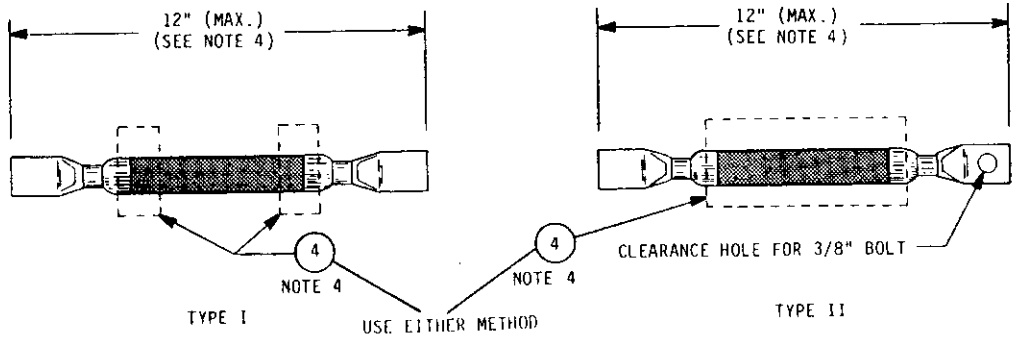
LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	CABLE, WELDING, TRXF-84	MIL-C-915/21	1,2,3,4
2	LUG, ALUMINUM		1,2,3
3	LUG, CRES 316		1,2,3
4	TUBING, HEAT-SHRINKABLE	MIL-I-23053/15	3

NOTES:

1. CABLE JACKET SHALL BE REMOVED AS NECESSARY TO ALLOW THE EXPOSED COPPER CONDUCTORS AND THE JACKETED PORTION OF THE CABLE TO PENETRATE TO THE FULL DEPTH OF THEIR RESPECTIVE CHAMBERS IN THE LUG. ENSURE THE CONDUCTORS ARE BRIGHT COPPER.
2. LUG MATERIAL, STEEL OR ALUMINUM, SHALL BE SELECTED TO MATCH THE CORRESPONDING MATING SURFACE MATERIAL. LUG INSTALLATION SHALL ENSURE WATER TIGHTNESS AND CRIMPING METHODS SHALL ENSURE A LUG PULL OFF EXCEEDING 600 POUNDS.
3. EACH BOND STRAP SHALL BE INSPECTED AFTER COMPLETION BY SLIGHTLY BENDING THE BOND STRAP AT EACH TERMINAL LUG AND LOOKING FOR A GAP BETWEEN THE CABLE JACKET AND THE LUG SHROUD. WHERE WEATHERSEALING IS NOT APPARENT, HEAT-SHRINKABLE TUBING SHALL BE ADDED AS SHOWN. TUBING SHALL BE SHRUNK ONLY AFTER BOND STRAP HAS BEEN WELDED IN PLACE SINCE HEAT FROM WELDING WOULD LOOSEN THE TUBING WEATHERSEAL.
4. IN CERTAIN CASES, SUCH AS ON LIFE NETS, BOND STRAPS MAY BE REQUIRED TO BE SLIGHTLY LONGER TO PREVENT BREAKING THE BOND STRAP WHEN THE NETS ARE RAISED OR LOWERED. BOND STRAPS INSTALLED ON CLIMBER SAFETY RAILS MAY ALSO REQUIRE A SLIGHT INCREASE IN LENGTH.



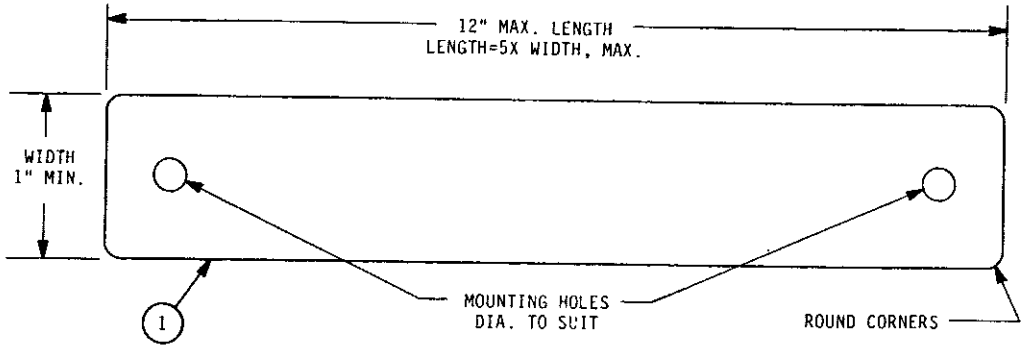
CABLE PREPARED FOR LUG ATTACHMENT



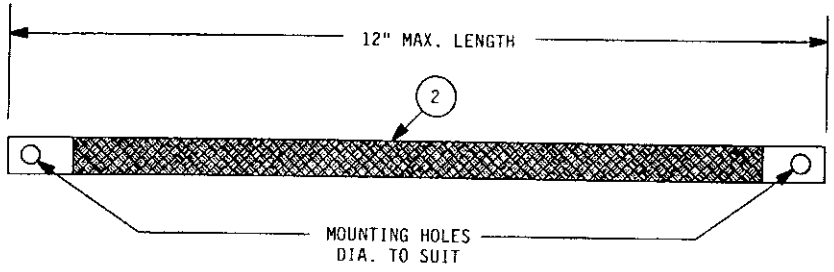
COMPLETED BOND STRAP

SH 13202362

FIGURE 1. Type I and type II bond strap fabrication details.



TYPE III BOND STRAP



TYPE IV BOND STRAP

LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	FLAT COPPER	QQ-C-576	1
2	FLAT COPPER BRAID	QQ-B-575	2,3

NOTES:

1. TYPE III BOND STRAPS SHALL BE FABRICATED FROM FLAT COPPER NOT LESS THAN 0.020 INCH THICK OF QQ-C-576, SHALL NOT EXCEED A LENGTH-TO-WIDTH RATIO OF FIVE-TO-ONE, AND SHALL BE ZINC PLATED PER ASTM-B-633. MOUNTING HOLES SHALL BE PROVIDED IN EACH END OF TYPE III BOND STRAPS.

2. TYPE IV BOND STRAPS SHALL BE FABRICATED FROM FLAT COPPER BRAID, 1.0 INCH MINIMUM WIDTH, IN ACCORDANCE WITH QQ-B-575. END TERMINALS SHALL BE CUT FROM FLAT COPPER OF QQ-C-576 AND SHALL BE 1.0 INCH WIDE BY 2.0 INCHES LONG. END TERMINALS SHALL BE HOT TIN DIPPED, THEN SOLDER COATED ON ONE SIDE. EACH TERMINAL SHALL BE BENT 180 DEGREES TO FIT OVER BRAID USING 1/16 INCH METAL PLATE AS A BENDING TEMPLATE. ENSURE SOLDER COATING IS ON INSIDE. BRAID MATERIAL SHALL BE FLUX COATED 1.0 INCH ON EACH END. END TERMINALS SHALL BE HEATED AND COMPRESSED ONTO THE BRAID USING ADDITIONAL SOLDER AS REQUIRED. THE REQUIRED HOLES SHALL BE PUNCHED IN EACH END.

3. WHERE A TYPE IV BOND STRAP IS USED ONLY FOR PERSONNEL SAFETY GROUNDING, THE LENGTH OF THE STRAP SHALL BE AS REQUIRED.

SH 13202363

FIGURE 2. Type III and type IV bond strap fabrication details.

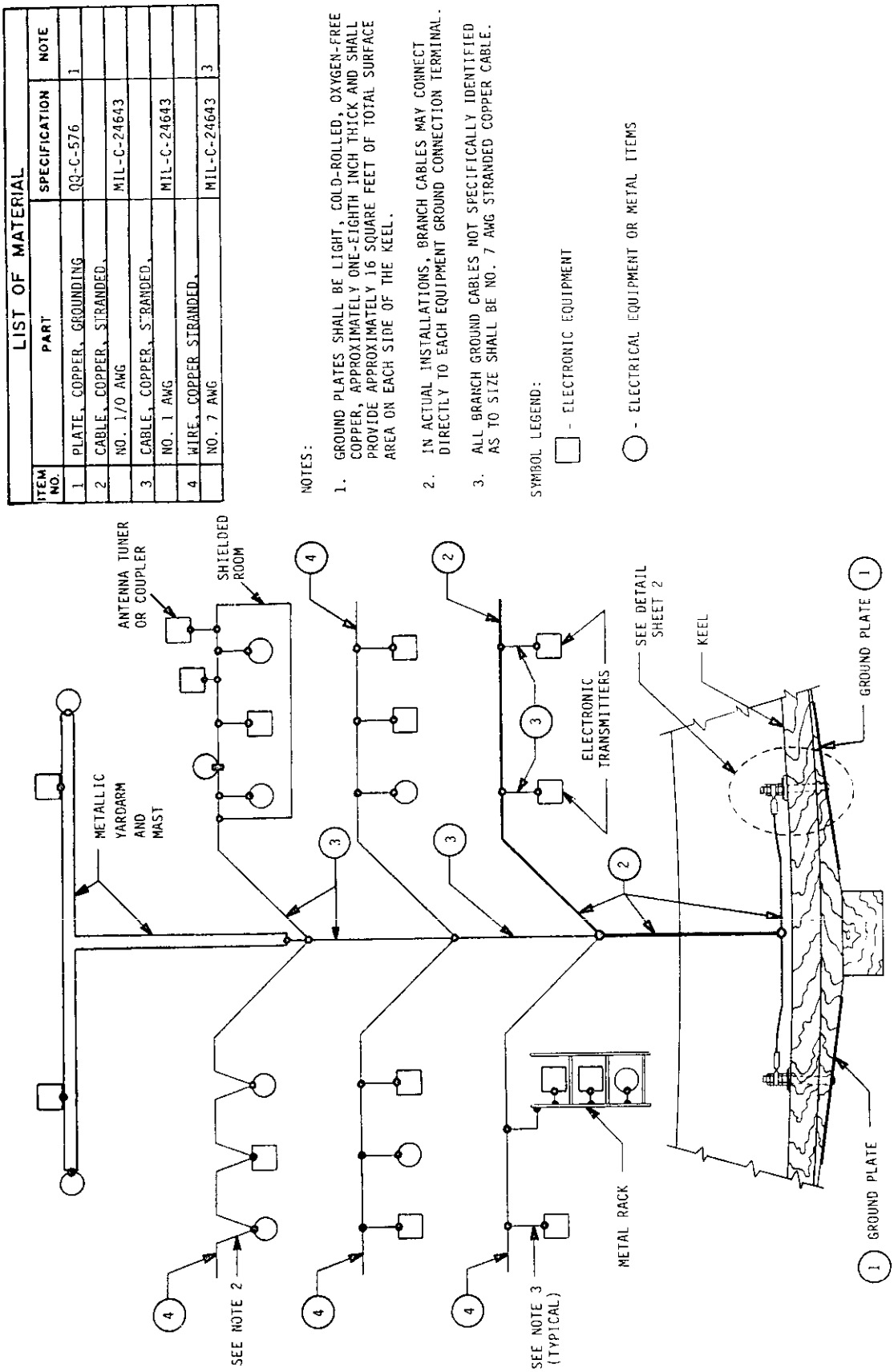
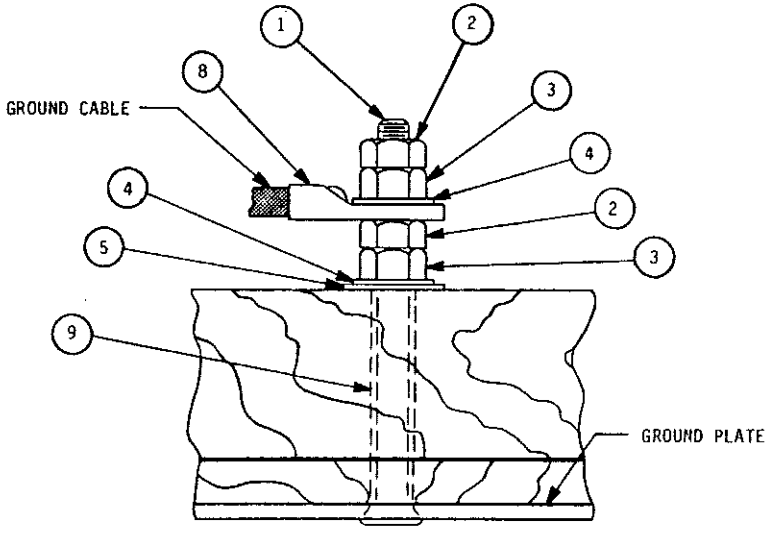
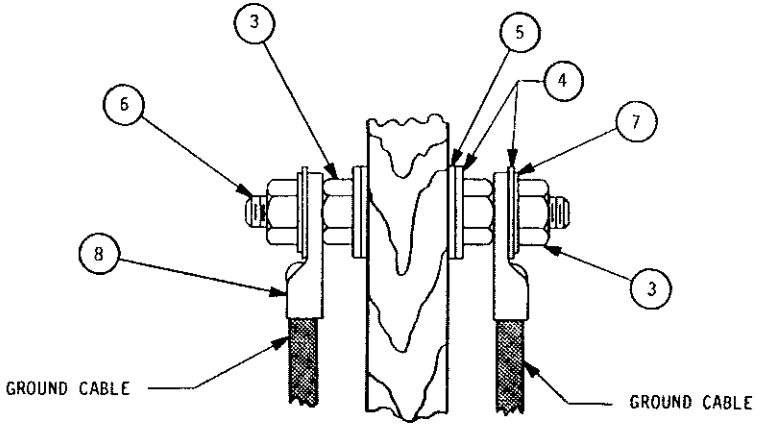


FIGURE 3. Ground system, nonmetallic hull ships (sheet 1 of 2).

SH 13202364



GROUND PLATE BOLT DETAILS (NOTES 1,2, AND 3)



METHOD OF PASSING GROUND BUS THROUGH
WATERTIGHT BULKHEADS OR DECKS (NOTES 2 AND 3)

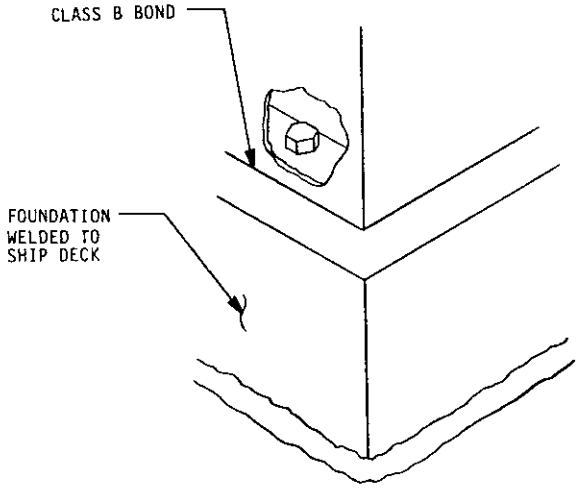
SH 13202364-1

LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	BOLT, COPPER		1,2
2	NUT, JAM, COPPER		
3	NUT, HEX, COPPER		
4	WASHER, COPPER		
5	WASHER, RUBBER		
6	STUD, COPPER		
7	WASHER, LOCK COPPER		
8	TERMINAL, LUG, COPPER		
9	SLEEVE, NONMETALLIC		3

NOTES:

1. HEAD OF THE GROUNDING PLATE THROUGH-BOLT SHALL BE BRAZED TO THE COPPER GROUNDING PLATE.
2. SIZE OF THE GROUNDING PLATE THROUGH-BOLT AND THROUGH-STUD SHALL AT LEAST EQUAL THE SIZE OF THE ASSOCIATED CABLE.
3. PROTECTION SHALL BE PROVIDED FOR THE STUD AGAINST THE CORROSIVE EFFECTS OF DAMP WOOD. THIS PROTECTION SHALL BE BY A NONMETALLIC SLEEVE.

FIGURE 3. Ground system, nonmetallic hull ships (sheet 2 of 2).

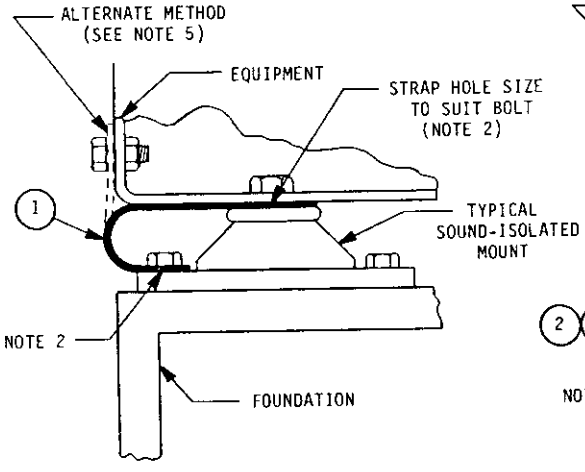


HARD-MOUNTED INSTALLATION (BOLTED)

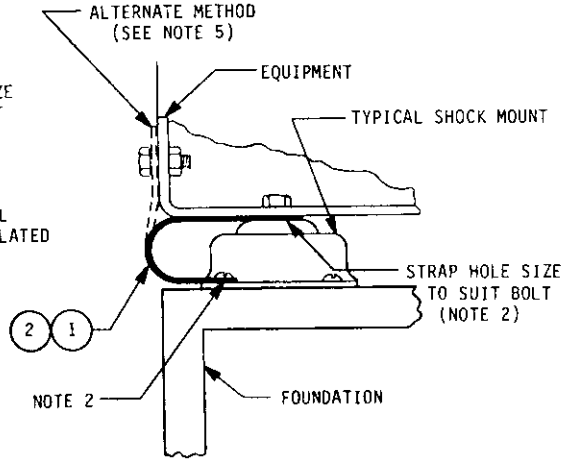
LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	BOND STRAP, TYPE IV		1
2	BOND STRAP, TYPE III		3

NOTES:

1. BOND STRAPS FURNISHED WITH ELECTRONIC EQUIPMENT BY MANUFACTURERS MAY BE USED FOR BONDING RESILIENT MOUNTED EQUIPMENTS IF EQUAL TO, OR SIMILAR TO, THE TYPE IV BOND STRAP AS SPECIFIED HEREIN. WHEN A BOND STRAP IS NOT FURNISHED WITH AN EQUIPMENT, A TYPE IV BOND STRAP SHALL BE INSTALLED. BOND STRAP INSTALLATION SHALL NOT DEFEAT PURPOSE OF RESILIENT MOUNT.
2. WHERE POSSIBLE, USE EXISTING BOLTS, STUDS, OR HOLES FOR ATTACHING BOND STRAP.
3. AS AN ALTERNATIVE, A TYPE III BOND STRAP MAY BE INSTALLED ON SHOCK-MOUNTED EQUIPMENT.
4. EACH BOND STRAP INSTALLED SHALL ACCOMODATE THE FULL DEFLECTION OF EACH RESILIENT MOUNT.
5. IF SHIMMING OF REMAINING MOUNTS IS REQUIRED DUE TO THE INSTALLATION OF THE BOND STRAP, THE ALTERNATIVE GROUNDING METHOD MAY BE USED.



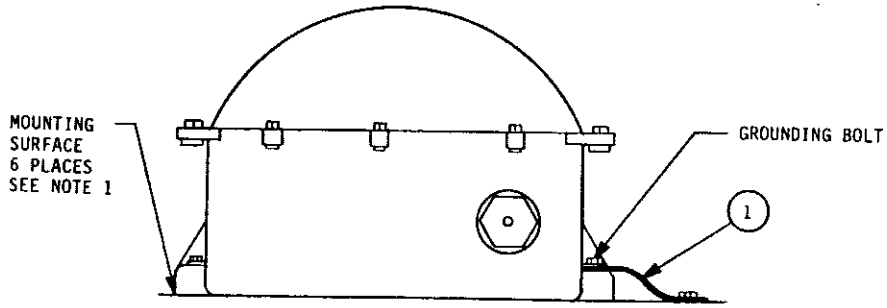
SOUND-ISOLATED INSTALLATION



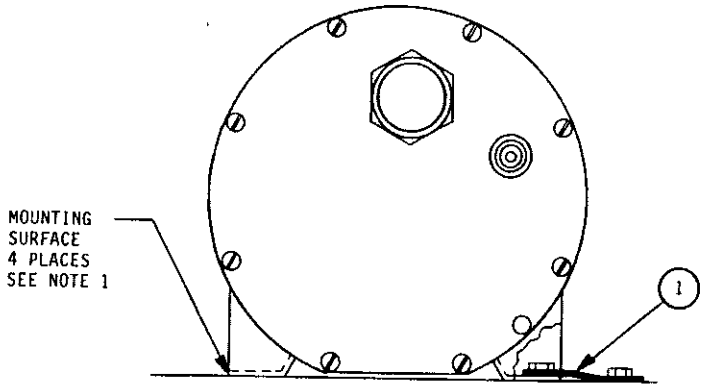
SHOCK-MOUNTED INSTALLATION

SH 13202365

FIGURE 4. Grounding of equipments and enclosures.



AN/URA-38



CU-937/UR

LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	BOND STRAP, TYPE III		1
2	COMPOUND, ANTISEIZE	MIL-T-22361	1
3	COMPOUND, SEALING	MIL-S-81733	1

NOTES:

1. ANTENNA TUNERS AND COUPLERS SHALL BE GROUNDED BY THE FOLLOWING METHODS AS SHOWN:

   AN/URA-38, CU-937/UR

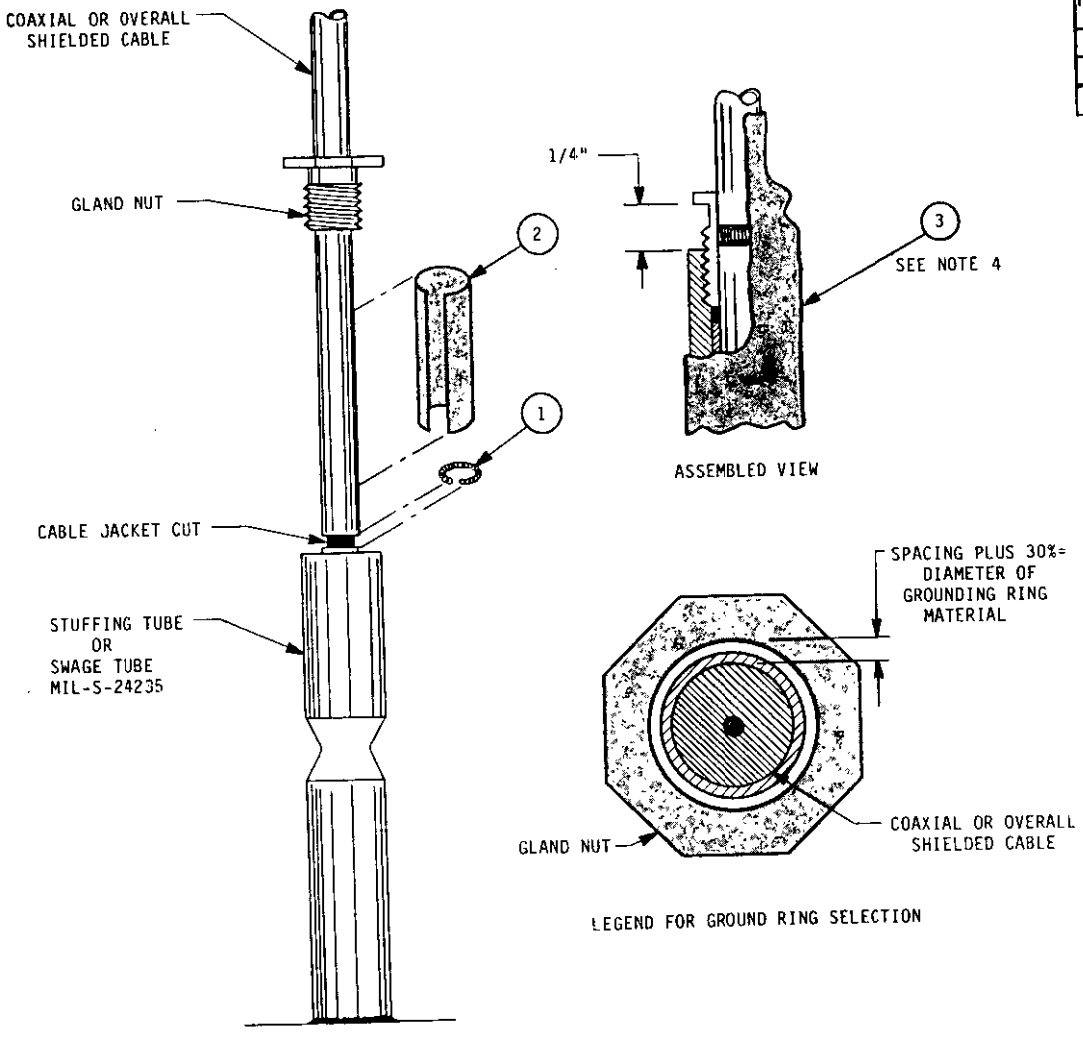
   THE MOUNTING SURFACES BETWEEN EACH TUNER/COUPLER AND GROUND POTENTIAL SHALL BE CLEAN AND FREE OF CORROSION. A HEAVY COAT OF ANTISEIZE COMPOUND OF MIL-T-22361 SHALL BE APPLIED TO THE CLEANED AREAS AND THE TUNER/COUPLER SHALL BE FIRMLY BOLTED IN PLACE. ALL AREAS WHERE ANTISEIZE IS APPLIED SHALL BE EDGE-SEALED USING MIL-S-81733 SEALING COMPOUND.

   IN ADDITION TO THE ABOVE, A TYPE III BOND STRAP SHALL BE INSTALLED ON EACH TUNER/COUPLER. BOND STRAP CONNECTION TO GROUND POTENTIAL SHALL BE BY STUD, STUD PAD, OR BOLT AS SHOWN. THE CONTACT SURFACE BETWEEN THE BOND STRAP AND GROUND POTENTIAL SHALL AT LEAST EQUAL THE WIDTH OF THE BOND STRAP. CONTACT SURFACE AREAS FOR BOND STRAPS SHALL BE THOROUGHLY CLEANED AND COATED WITH ANTISEIZE COMPOUND PRIOR TO BOND STRAP INSTALLATION. ALL HARDWARE AND BOND STRAPS SHALL BE WEATHERSEALED AFTER INSTALLATION USING MIL-S-81733 COMPOUND.

2. THESE ILLUSTRATIONS SHOW TYPICAL TUNER/COUPLER GROUNDING METHODS. OTHER TUNERS/COUPLERS, NOT SHOWN HEREIN, SHALL BE GROUNDED USING SIMILAR METHODS.

SH 13202366

FIGURE 5. Antenna tuners and couplers grounding.



LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	GROUNDING RING		4, 5, 7
2	COMPRESSION SLEEVE - SHIM STOCK		7
3	TUBING, HEAT SHRINKABLE	MIL-I-23053/15	4

NOTES:

1. THIS METHOD OF CABLE SHIELD GROUNDING APPLIES TO NEW CABLE INSTALLATIONS AND TO EXISTING INSTALLATIONS WHERE THE CABLE CANNOT BE REMOVED.

2. UNSCREW PACKING GLAND NUT FROM THE STUFFING TUBE AND MOVE IT SEVERAL INCHES UP THE CABLE AND TAPE. WITH A POCKET KNIFE OR SIMILAR TOOL, MAKE TWO CIRCULAR CUTS IN THE CABLE JACKET, ONE APPROXIMATELY FLUSH WITH THE TOP OF THE STUFFING TUBE OR SWAGE TUBE AND ANOTHER APPROXIMATELY ONE-FOURTH INCH HIGHER. REMOVE THE CUT SECTION OF THE CABLE JACKET.

3. SELECT PROPER DIAMETER GROUNDING RING MATERIAL IN ACCORDANCE WITH THE LEGEND. CUT LENGTH OF GROUNDING RING TO FIT THE AREA WHERE JACKET WAS REMOVED. COAT THE GROUNDING RING WITH ANTISEIZE COMPOUND OF MIL-T-22361. APPLY A COATING OF ANTISEIZE COMPOUND TO THE EXPOSED CABLE SHIELD AND TO THE THREADS OF THE GLAND NUT. ENSURE INSIDE OF GLAND NUT IS CLEAN. CLEANING WITH FINE SANDPAPER MAY BE REQUIRED.

4. PLACE GROUNDING RING AROUND CABLE IN AREA WHERE JACKET WAS REMOVED. PLACE COMPRESSION SLEEVE AROUND CABLE JACKET AND GROUNDING RING. HOLDING COMPRESSION SLEEVE TIGHTLY AROUND CABLE AND GROUNDING RING, SLIDE GLAND NUT DOWN OVER SLEEVE AND THREAD INTO STUFFING TUBE. AFTER THREADS HAVE ENGAGED, REMOVE THE COMPRESSION SLEEVE AND COMPLETE TIGHTENING OF THE GLAND NUT AS REQUIRED FOR PACKING. WHEN COMPLETED, THE GROUNDING RING SHOULD BE LOCATED APPROXIMATELY AS SHOWN. ADDITIONAL PACKING OR GLAND WASHERS MAY BE REQUIRED. WEATHERSEAL AS SPECIFIED FOR CORROSION PROTECTION.

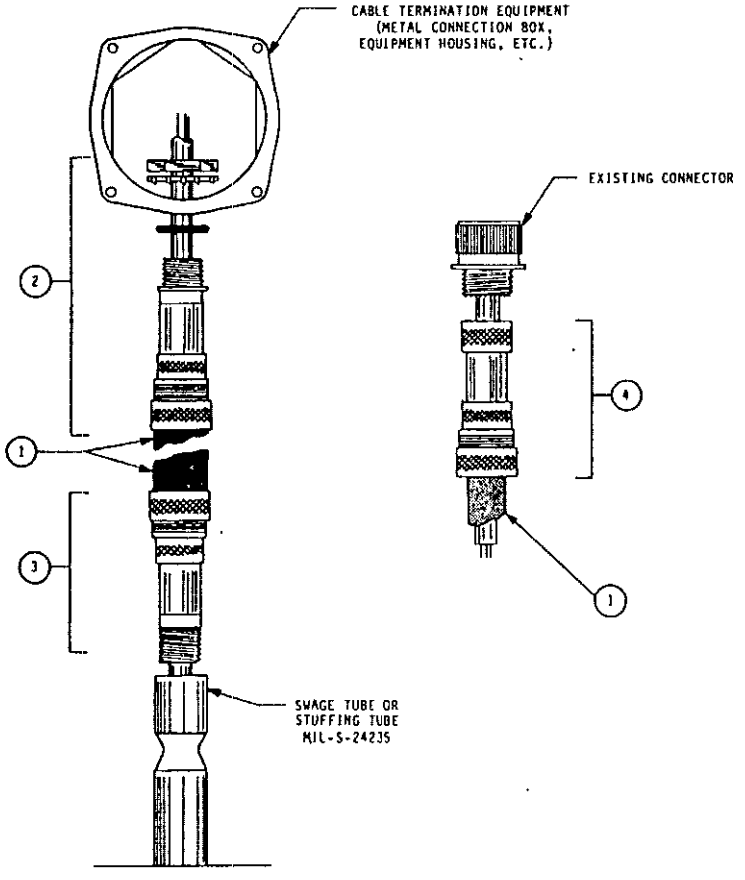
5. THE COMPRESSION SLEEVE IS USED ONLY TO COMPRESS THE GROUNDING RING WHILE REINSTALLING THE GLAND NUT. IT CAN BE CUT FROM APPROXIMATELY 0.005" MATERIAL.

6. THE METHOD SHOWN HERE FOR CABLE SHIELD GROUNDING SHALL BE USED FOR METAL PIPES AND TUBING WHICH ARE ROUTED THROUGH STUFFING TUBES.

7. GROUNDING RING SHALL BE ROUND CROSS SECTION, NEOPRENE SPONGE, FLEXIBLE WIRE MESH.

SH 13202367

FIGURE 6. Cable shield grounding.



LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	CONDUIT, SHIELDING, TYPE E	MIL-C-28840/4	4,5
2	FITTING, CONDUIT-TO-BOX	MIL-C-28840/5	
		25/27	4,5
3	FITTING,		
	CONDUIT-TO-STUFFING TUBE	MIL-C-28840/5	
		25/27	3,4,5
4	FITTING, CONDUIT-TO-CONNECTOR	MIL-C-28840/5	
		25/27	4,5

NOTES:

1. THIS METHOD OF CABLE SHIELDING APPLIES TO NEW CABLE INSTALLATIONS AND TO EXISTING CABLE INSTALLATIONS WHERE THE CABLE CAN BE REMOVED FROM THE TERMINATING EQUIPMENT AND HANGERS AND ROUTED THROUGH THE CONDUIT.

2. FOR NEW CABLE INSTALLATIONS -
PRIOR TO PULLING CABLE THROUGH STUFFING TUBE, REMOVE PACKING GLAND NUT FROM THE TUBE AND DISCARD.

FOR RETROFIT INSTALLATIONS -
REMOVE CABLE FROM TERMINATING EQUIPMENT (LIGHT, CONNECTION BOX, SPEAKER, CONNECTOR, ETC.) AND REMOVE CABLE FROM HANGERS DOWN TO STUFFING TUBE. UNSCREW PACKING GLAND NUT FROM STUFFING TUBE, REMOVE NUT FROM CABLE AND DISCARD.

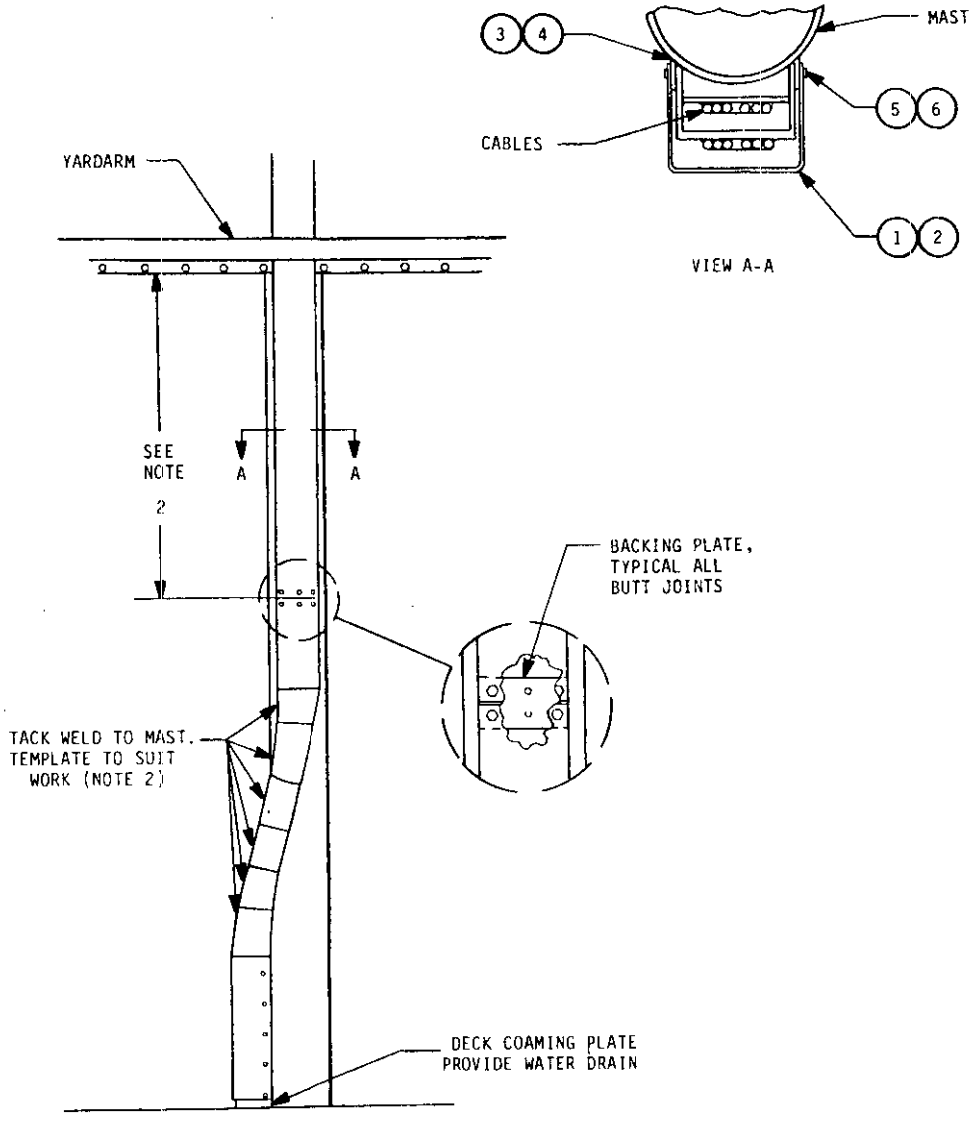
3. FOR BOTH NEW AND RETROFIT INSTALLATIONS -
SELECT CONDUIT-TO-STUFFING TUBE END FITTING TO MATCH CONDUIT SIZE AND TUBE SIZE. ROUTE CABLE THROUGH FITTING. PACK STUFFING TUBE (NEW INSTALLATIONS). COAT LOWER THREADS OF FITTING WITH ANTISEIZE COMPOUND OF MIL-T-22361. SCREW FITTING INTO STUFFING TUBE AND TIGHTEN AS REQUIRED FOR PACKING.

4. MEASURE AND CUT PROPER LENGTH OF CONDUIT TO COVER THE ENTIRE LENGTH OF CABLE FROM STUFFING TUBE TO END TERMINATION. ENSURE CONDUIT IS CUT SQUARE. FEED CABLE THROUGH CONDUIT. COAT UPPER THREADS OF CONDUIT-TO-STUFFING TUBE FITTING WITH ANTISEIZE COMPOUND AND TERMINATE CONDUIT INTO FITTING. INSTALL CONDUIT IN CABLE HANGERS AND TERMINATE OTHER END OF CONDUIT INTO END FITTING AT TERMINATING EQUIPMENT. ENSURE ALL METAL CONNECTING PARTS ARE COATED WITH ANTISEIZE COMPOUND PRIOR TO ASSEMBLY. CONNECT OR RECONNECT CABLE CONDUCTORS TO PROPER TERMINALS.

5. CONDUIT END FITTINGS SHALL BE IN ACCORDANCE WITH MIL-C-28840/5/25/27 EXCEPT END FITTINGS SHALL PROVIDE FOR TERMINATING THE CONDUIT TO THE EQUIPMENTS AS SHOWN. COUPLING CONNECTORS SHALL BE IN ACCORDANCE WITH MIL-C-28840/30. AFTER INSTALLATION, ALL FITTINGS SHALL BE WEATHERSEALED AS SPECIFIED IN CORROSION PROTECTION.

SH 13202368

FIGURE 7. Cable shielding methods.



SH 13202369

LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	SHEET METAL, 1/16" GALV STEEL		1
2	SHEET METAL, 1/8" ALUM PLATE		1
3	FLAT BAR, 2"x1/4", STEEL		1
4	FLAT BAR, 2"x1/4", ALUM		1
5	BOLT, CRES	MIL-S-1222	1
6	LOCKWASHER, CRES		1

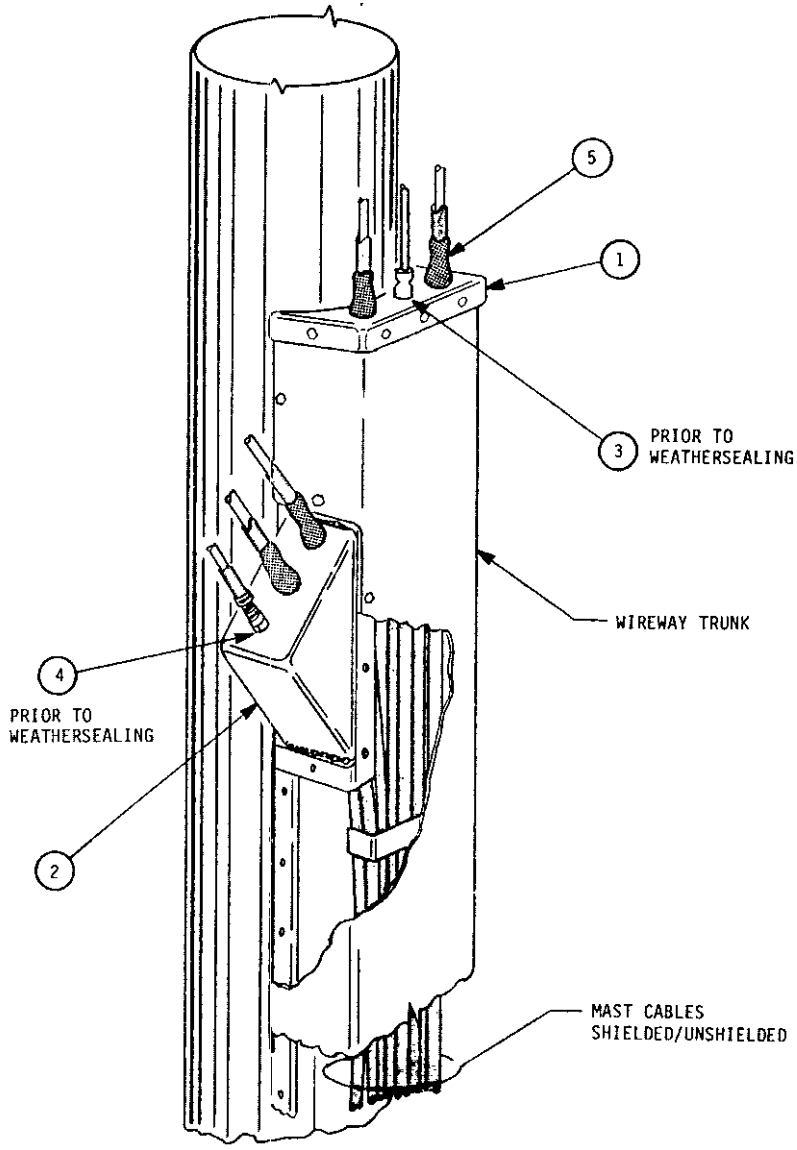
NOTES:

1. FLAT BAR AND WIREWAY TRUNKS SHALL BE ALUMINUM FOR ALUMINUM MASTS AND GALVANIZED STEEL FOR STEEL MASTS. DRILL AND TAP FLAT BAR AS REQUIRED. BAR SHALL BE TACK WELDED TO MAST FOR PROPER SUPPORT OF TRUNK. TRUNKS SHALL BE BOLTED TO FLAT BAR USING BOLT HOLE SPACING AS NECESSARY FOR TRUNK SUPPORT.

2. STRAIGHT TRUNK SECTIONS SHALL BE FABRICATED IN LENGTHS OF 8 FEET OR AS APPROPRIATE. CURVED PORTIONS OF THE TRUNK RUN MAY BE FABRICATED IN SHORT, STRAIGHT SECTIONS AS REQUIRED TO FACILITATE INSTALLATION OVER CURVED SECTIONS OF CABLE RUNS. THESE SHORT SECTIONS CAN BE TACK WELDED DIRECTLY TO THE MAST. CABLES SHOULD BE REARRANGED, IF PRACTICABLE, AT PLACES WHERE BENDING OCCURS TO FACILITATE TRUNK INSTALLATION.

3. SECTIONS OF TRUNK (INSIDE AND OUTSIDE) SHALL BE PRIMED AND PAINTED. THE CONTACT SURFACE BETWEEN THE TRUNK AND FLAT BAR ON STEEL TRUNKS SHALL ALSO BE PAINTED. THE CONTACT SURFACE ON ALUMINUM TRUNKS SHALL NOT BE PAINTED AND SHALL BE TREATED WITH A CLASS 3 CONDUCTIVE COATING OF MIL-C-5541.

FIGURE 8. Mast cables located within wireway trunk (sheet 1 of 2).



SH 13202369-1

LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	END CAP		1
2	BOX, BREAKOUT		1
3	ADAPTER, GROUNDING		4
4	FITTING, CONDUIT		4
5	TUBING, HEAT SHRINKABLE	MIL-I-23053/15	4

NOTES:

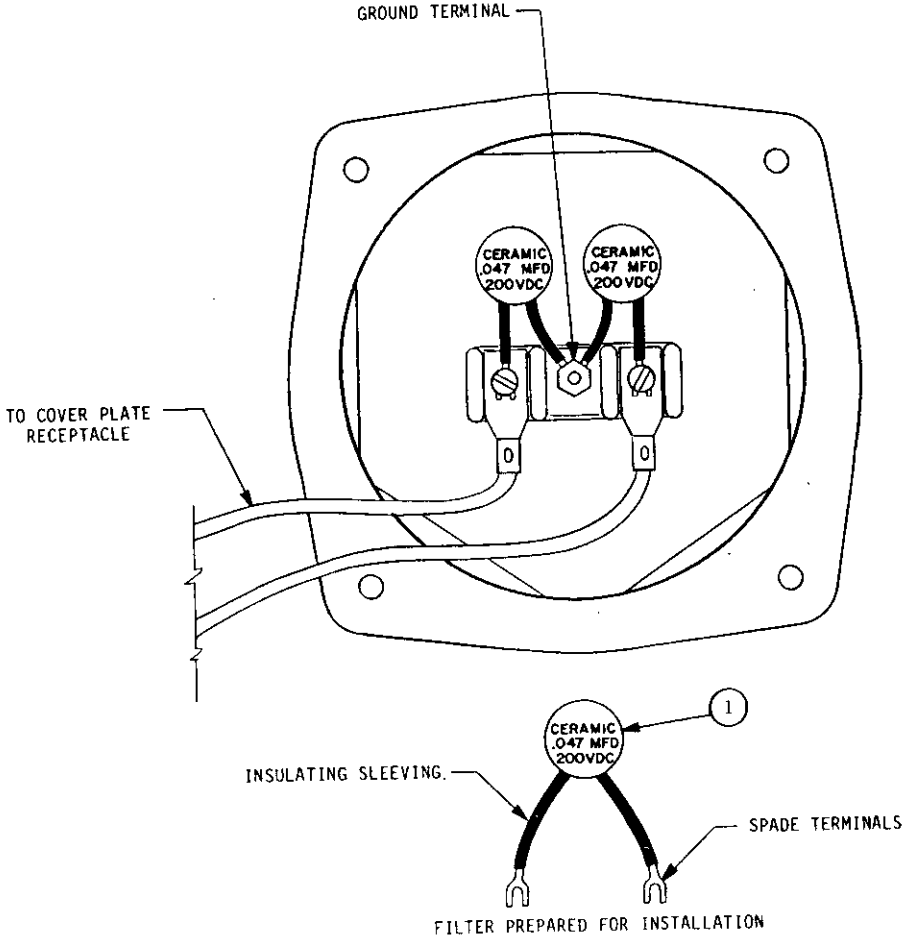
1. FABRICATE END CAP AND BREAKOUT BOXES, AS REQUIRED, TO ACCOMODATE THE NUMBER OF AND TYPE OF CABLES THAT EXIT THE WIREWAY TRUNK. HOLES SHALL BE SIZED TO FIT THE REQUIRED STUFFING TUBES AND CONDUIT TERMINATION FITTINGS.
2. AFTER CABLE TYPES AND GROUNDING AND SHIELDING REQUIREMENTS HAVE BEEN PREDETERMINED, INSTALL THE CABLES THROUGH THE END CAPS, BREAKOUT BOXES, STUFFING TUBES AND THE CONDUIT FITTINGS.
3. MEASURE AND CUT THE REQUIRED LENGTHS OF SHIELDING CONDUIT TO SHIELD ALL REQUIRED CABLES.
4. INSTALL CABLE SHIELD GROUNDING MATERIALS AND FLEXIBLE SHIELDING CONDUIT AS SPECIFIED HEREIN. WEATHERSEAL ALL FITTINGS AS SPECIFIED FOR CORROSION PROTECTION.

FIGURE 8. Mast cables located within wireway trunk (sheet 2 of 2).

LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	CAPACITOR, P/N CK05BX473K	MIL-C-11015	1

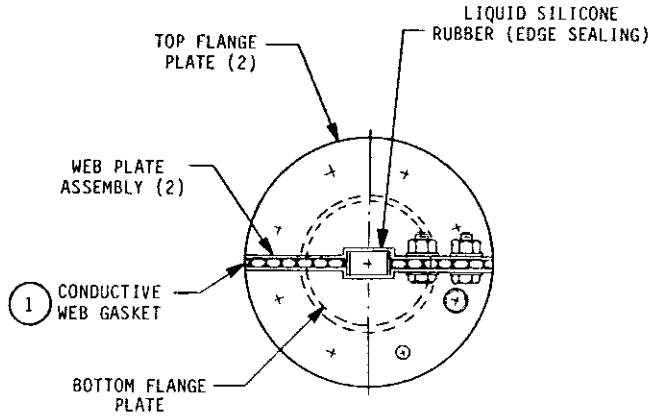
NOTES:

1. INSTALL FILTER CAPACITORS IN ACCORDANCE WITH FIGURE. ENSURE LEADS ARE AS SHORT AS POSSIBLE.
2. THESE FILTER CAPACITORS ARE INSTALLED FOR THE PURPOSE OF FILTERING RF RADIATIONS FROM SHIPBOARD ANTENNAS WHICH ARE COUPLED ONTO PORTABLE TELEPHONE HEAD SETS. THESE FILTERS ARE NOT SUITABLE FOR EMP PROTECTION.

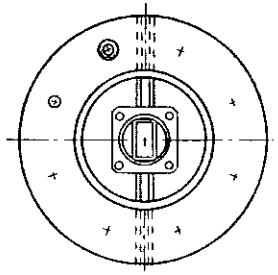


SH 13202370

FIGURE 9. Filter installation, sound-powered telephone boxes.



VIEW A-A

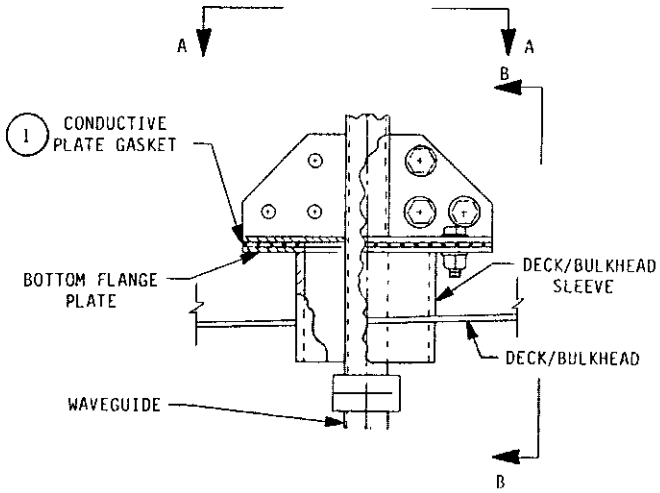


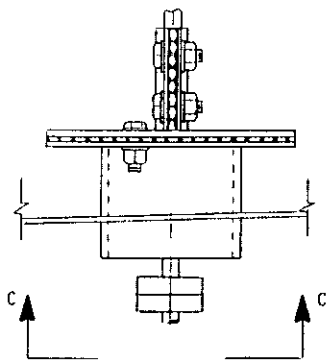
VIEW C-C

LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	GASKET MATERIAL, CONDUCTIVE	MIL-G-47197	1

NOTES:

1. THE MOUNTING SURFACES FOR THE GASKET SHALL BE CLEANED TO BRIGHT METAL AND COATED WITH ANTISEIZE COMPOUND OF MIL-T-22361 PRIOR TO INSTALLING GASKET.
2. SPLIT SLEEVE INSTALLATION SHOWN IS AS DETAILED IN EIMB SERIES, NAVSEA 0967-000-0110. WEATHERSEAL AS SPECIFIED THEREIN.

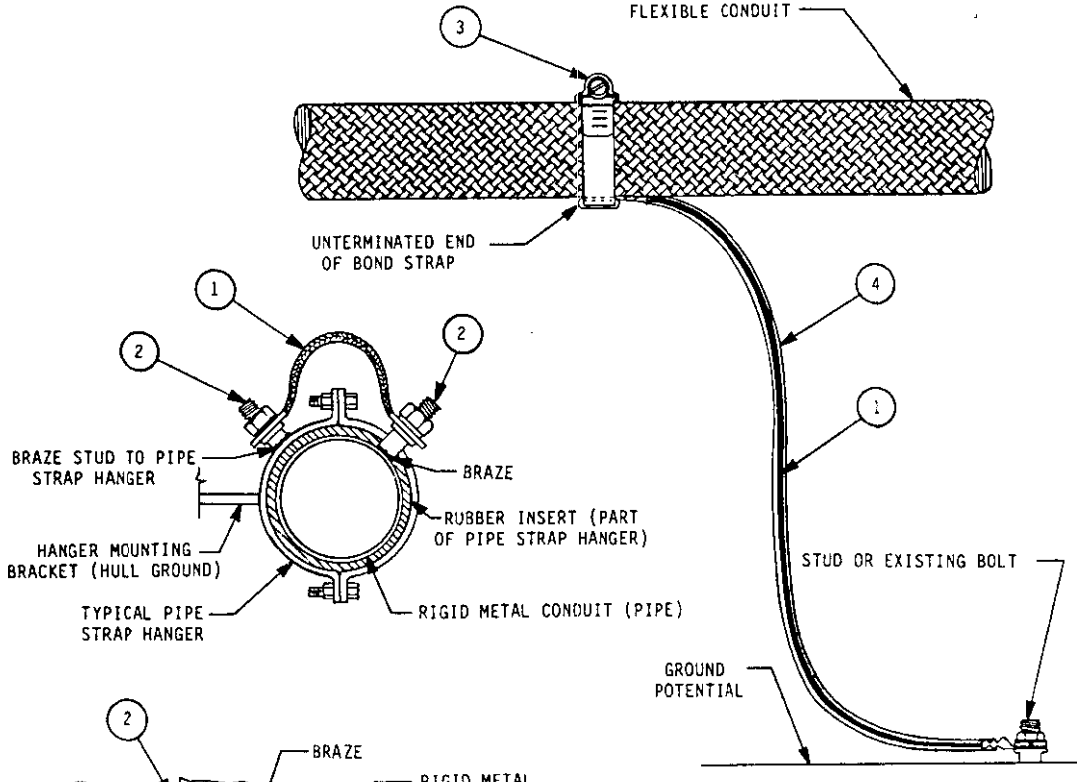


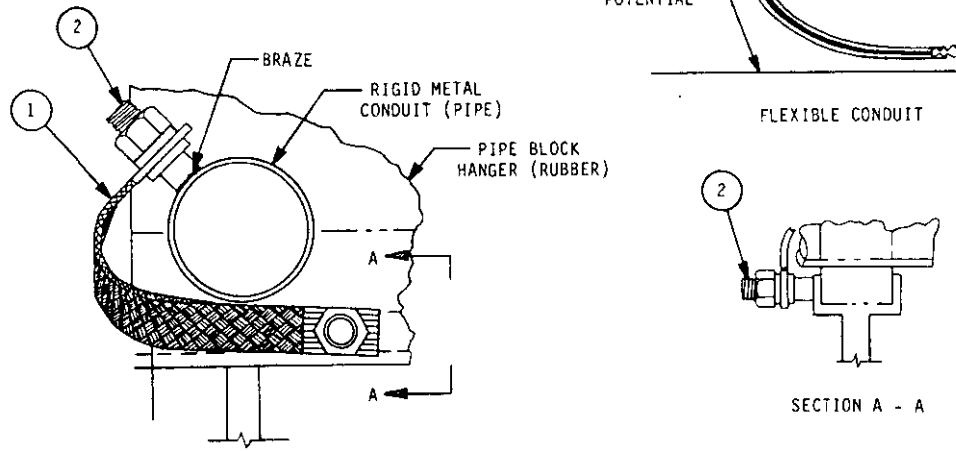


VIEW B-B

SH 13202371

FIGURE 10. Waveguide grounding.





LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	BOND STRAP, TYPE IV		1, 2
2	STUD, COLLAR	MIL-S-24149	
3	CLAMP, HOSE	WW-C-440	
4	TUBING, PVC	MIL-I-631	4

NOTES:

1. FOR RIGID CONDUIT, A TYPE IV BOND STRAP SHALL BE INSTALLED IN THE LOCATION AND BY THE METHOD SHOWN. BONDING INTERVALS SHALL BE AS SPECIFIED (SEE 5.3.1.4).
2. FOR FLEXIBLE CONDUIT, BOND STRAP SHALL BE TYPE IV EXCEPT ONE END SHALL NOT HAVE PROVISIONS FOR STUD OR BOLT MOUNTING. AREA WHERE BOND STRAP IS HELD AGAINST CONDUIT SHALL BE CLEAN AND FREE OF ANY NONCONDUCTIVE MATERIALS.
3. ALL BOND STRAP CONTACT AREAS SHALL BE PROTECTED AGAINST CORROSION AS SPECIFIED HEREIN.
4. BOND STRAPS MAY BE ENCASED IN CLEAR PVC TUBING.

SH 13202373

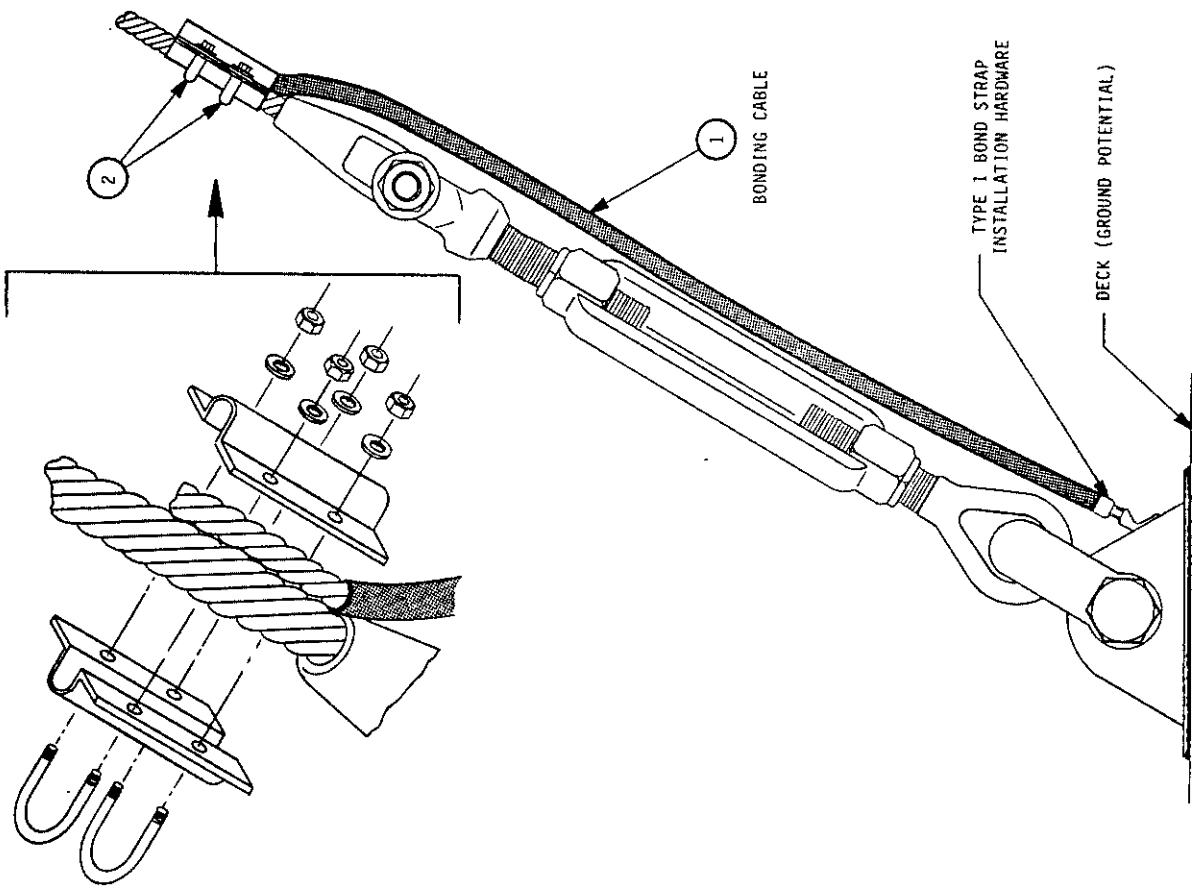
FIGURE 11. Conduit grounding, submarines.

LIST OF MATERIAL

ITEM NO.	PART	SPECIFICATION	NOTE
1	CABLE, WELDING, TYPE TRXF 84	MIL-C-915/21	1
2	U-BOLT ASSEMBLY		1

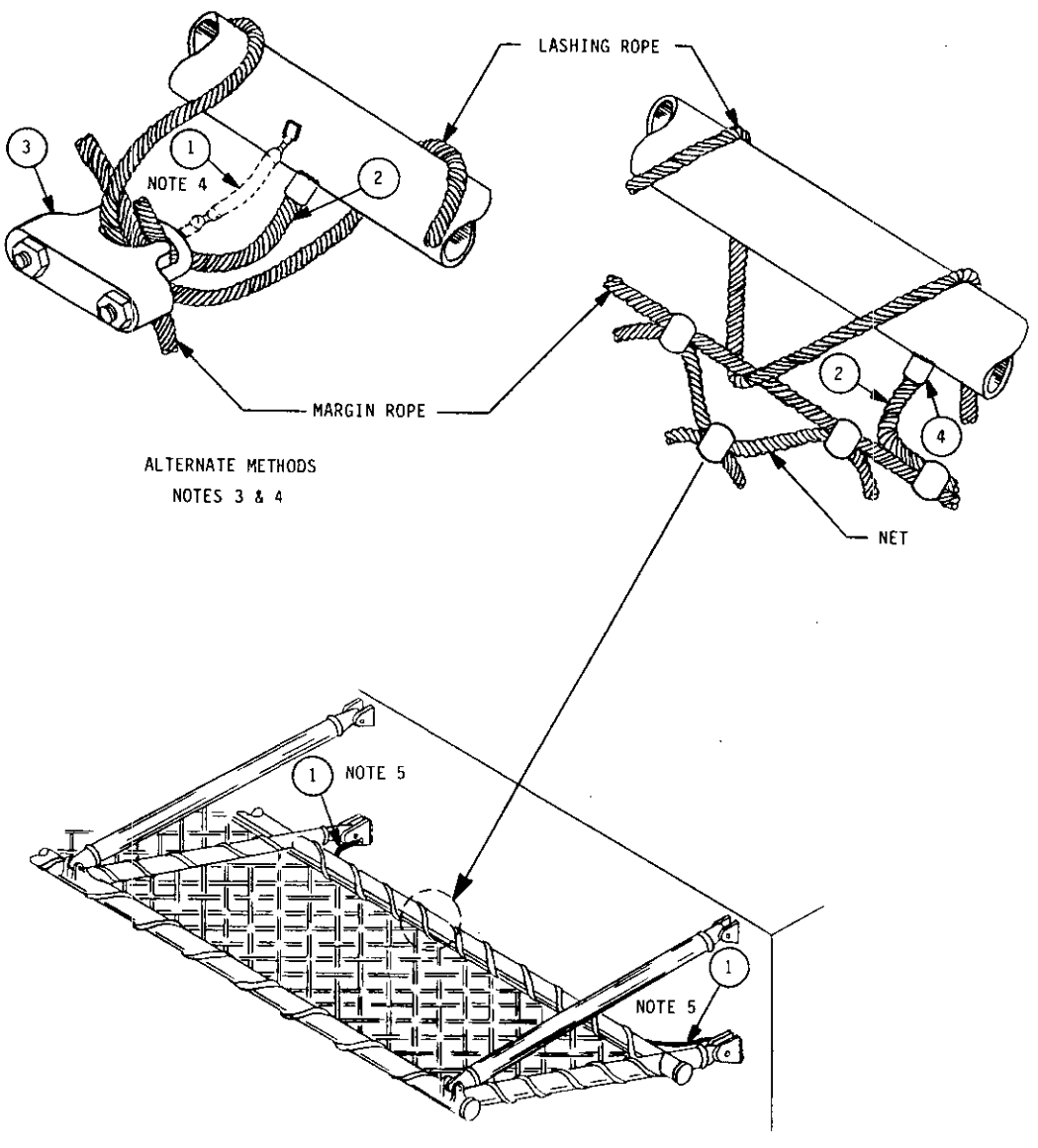
NOTES:

1. BONDING CABLE SHALL BE MEASURED AND CUT TO PROPER LENGTH. ONE END SHALL BE EQUIPPED WITH A LUG TERMINAL INSTALLED THE SAME AS A TYPE I BOND STRAP. THE UPPER END SHALL BE ATTACHED TO THE WIRE-ROPE STAY BY CLEANING BOTH CABLES AT POINT OF CONTACT AND APPLYING MIL-T-22361 ANTISEIZE COMPOUND THEN CLAMPING THE CABLES BY THE METHOD SHOWN. OVERALL WEATHERSEALING SHALL BE PROVIDED USING MIL-S-81733 POLYSULFIDE SEALING COMPOUND.



SH 13202374

FIGURE 12. Standing rigging, bonding.



SH 13202375

LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	BOND STRAP, TYPE I		1
2	BONDING CABLE, CRES		2,3
3	U-BOLT, CRES		3,4
4	SWAGE SLEEVE		2

NOTES:

1. A TYPE I BOND STRAP SHALL BE INSTALLED ACROSS EACH NET FRAME HINGE. THE TYPE I BOND STRAP MAY BE INCREASED IN LENGTH, IF NEEDED, TO ALLOW NETS TO RAISE AND LOWER.
2. SWAGE SLEEVE (OR SIMILAR DEVICE) SHALL BE CRIMPED TO BONDING CABLE AND WELDED TO NEW FRAME.
3. AS AN ALTERNATE METHOD, A CRES U-BOLT MAY BE INSTALLED AROUND THE MARGIN ROPE, LASHING ROPE, AND BONDING CABLE.
4. AS A SECOND ALTERNATE, THE LUG OF A TYPE I BOND STRAP MAY BE WELDED TO A U-BOLT AND INSTALLED AS SHOWN.
5. WHERE NETS ARE REQUIRED TO BE REMOVED PERIODICALLY FOR MAINTENANCE, A TYPE II BOND STRAP MAY BE INSTALLED.

FIGURE 13. Metallic life and safety nets, bonding.

LIST OF MATERIAL

ITEM NO.	PART	SPECIFICATION	NOTE
1	BOND STRAP, TYPE II		1

NOTES:

1. PROPER WEATHERSEALING OF BOND STRAP STUD TERMINALS SHALL BE PROVIDED AS SPECIFIED HEREIN.

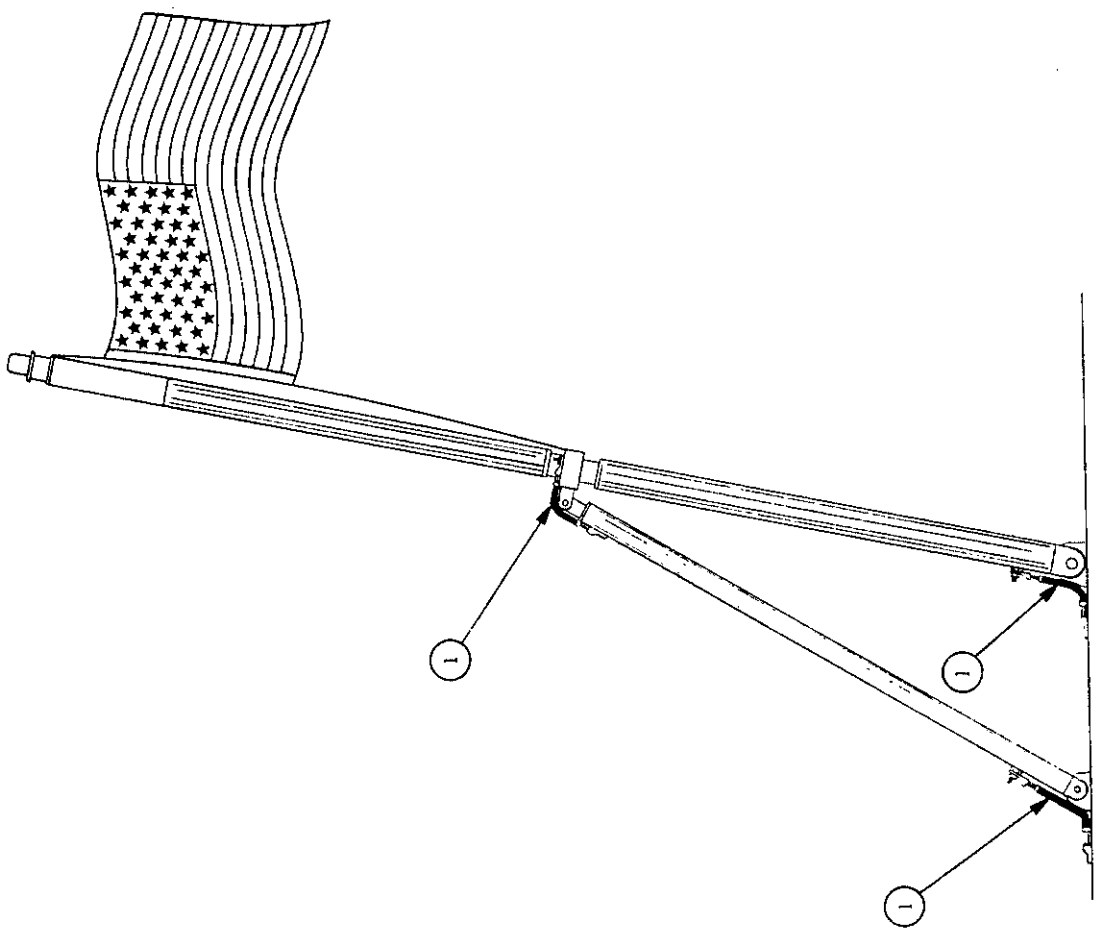
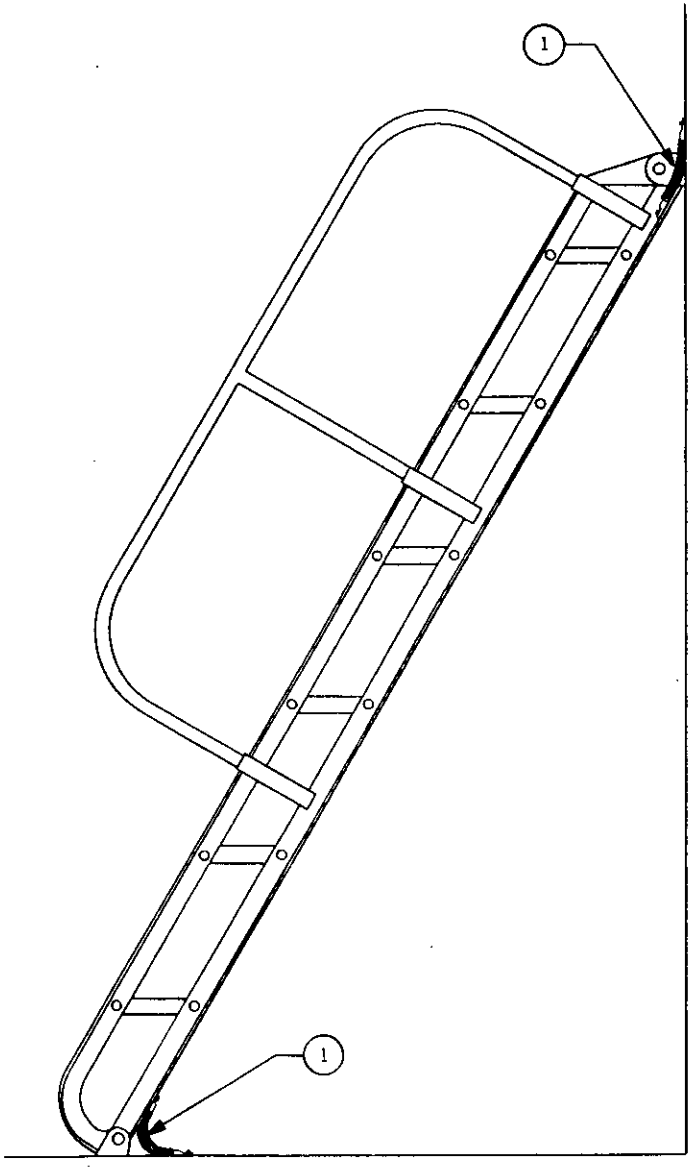


FIGURE 14. Metallic flagstaff or jackstaff, bonding.

SH 13202376



SH 13202377

LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	BOND STRAP, TYPE I OR II		1

NOTES:

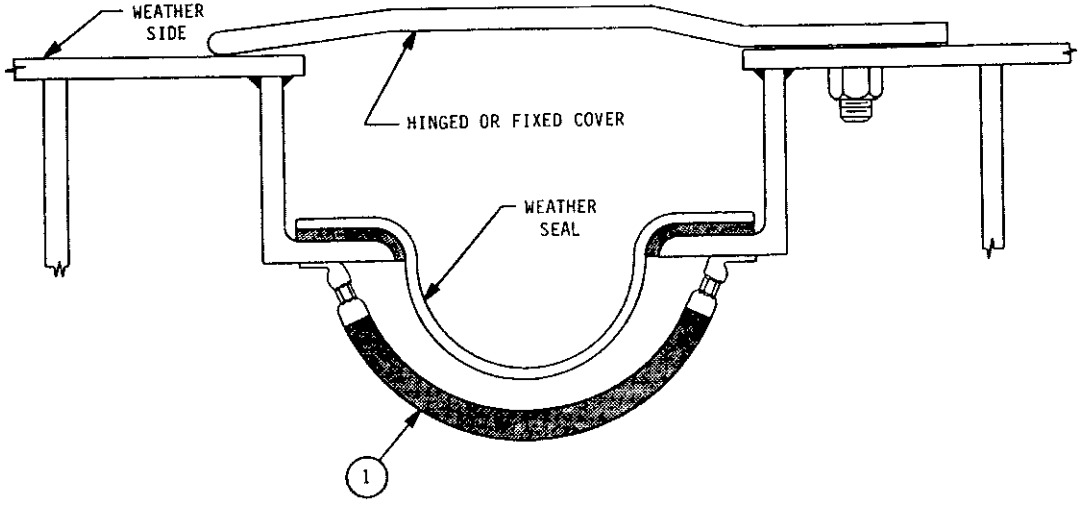
1. INCLINED-TREAD LADDERS SHALL BE BONDED TO GROUND POTENTIAL BY THE INSTALLATION OF A BOND STRAP ACROSS ONE TOP AND ONE BOTTOM PINNED MOUNT. TYPE I BOND STRAPS ARE PREFERRED. WHERE THE LADDER MUST BE PERIODICALLY REMOVED, TYPE II BOND STRAPS SHALL BE INSTALLED. TYPE II BOND STRAPS SHALL BE WELDED TO SHIP HULL OR STRUCTURE AND BOLTED TO THE LADDER. PROPER WEATHERSEALING OF THE BOND STRAP STUD TERMINAL SHALL BE PROVIDED AS SPECIFIED HEREIN.

FIGURE 15. Metallic inclined-tread ladders, bonding.

LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	BOND STRAP, TYPE I		1,2

NOTES:

1. BOND STRAPS SHALL BE INSTALLED ACROSS EXPANSION JOINTS AT INTERVALS OF APPROXIMATELY 5 FEET AND LOCATED ON THE SIDE OF THE JOINT NOT EXPOSED TO THE WEATHER.
2. THE LENGTH OF THE BOND STRAP SHALL BE SUFFICIENT TO PERMIT MAXIMUM EXCURSION OF THE EXPANSION JOINT.



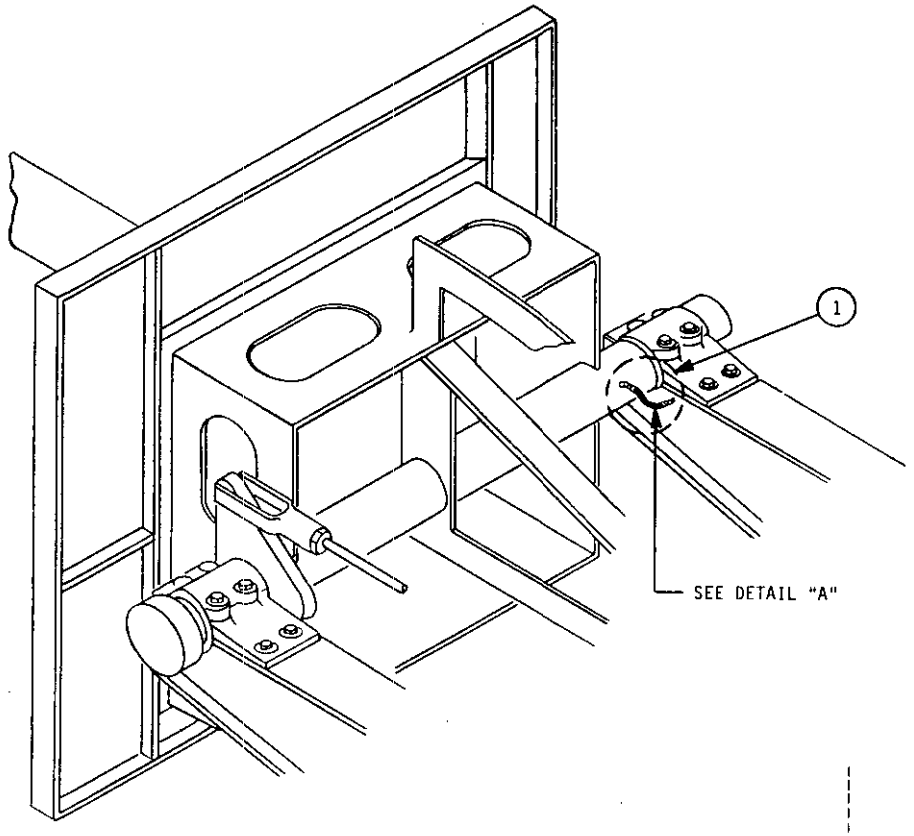
SH 13202379

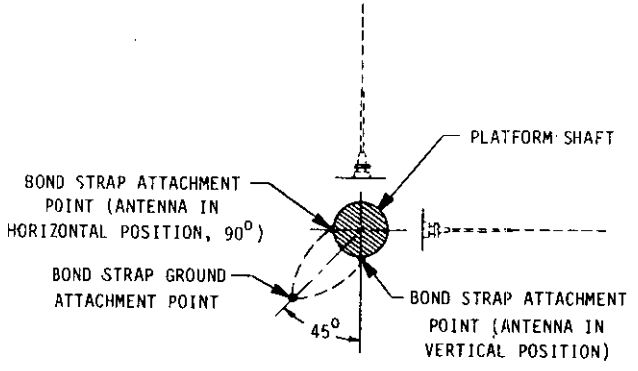
FIGURE 16. Expansion joints, bonding.

LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	BOND STRAP, TYPE I		1

NOTES:

1. A TYPE I BOND STRAP SHALL BE INSTALLED ACROSS EACH BEARING JOINT. BOND STRAP LENGTH AND METHOD OF INSTALLATION SHALL ALLOW FOR MAXIMUM TRAVEL OF ANTENNA TILTING MECHANISM.





DETAIL "A"

SH 13202380

FIGURE 17. Tilting antenna mounts, bonding.

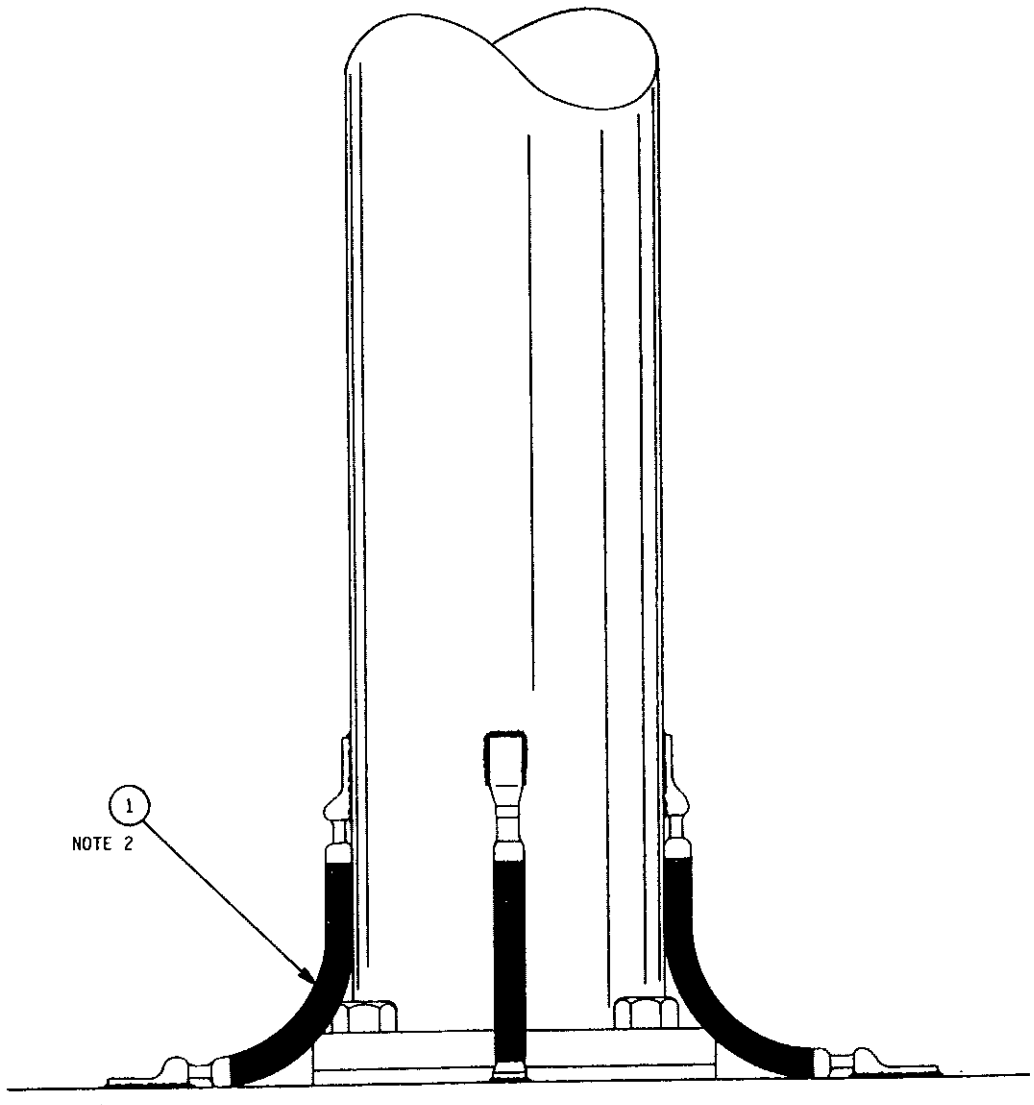
LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	BOND STRAP, TYPE I		1,2

NOTES:

1. BOND STRAPS SHALL ONLY BE INSTALLED ON MASTS WHICH ARE BOLTED IN PLACE.
2. BOND STRAPS SHALL BE INSTALLED IN ACCORDANCE WITH THE FOLLOWING:

MAST DIAMETER	NO. OF BOND STRAPS
20 INCHES OR LARGER	4
19 INCHES TO 8 INCHES	2
LESS THAN 8 INCHES	1

BOND STRAPS SHALL BE EQUALLY SPACED AROUND MAST.



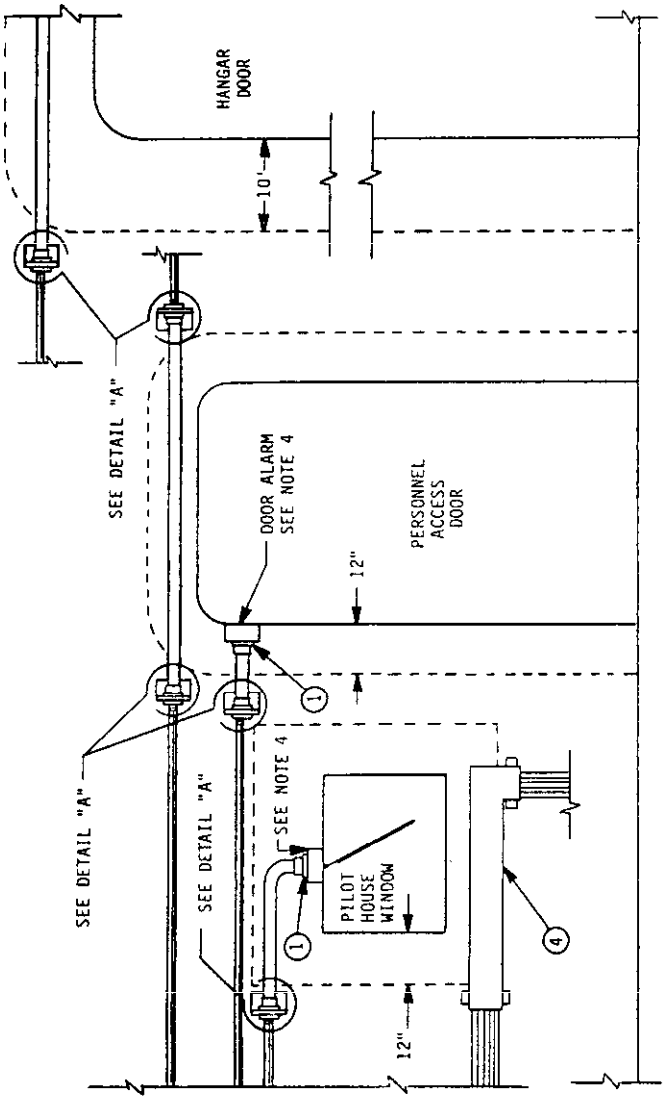
SH 13202381

FIGURE 18. Metallic masts, bonding.

LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	FITTINGS, CONDUIT TERMINATION		2
2	BRACKET, CONDUIT TERMINATION		3
3	CONDUIT		2,4
4	TRUNK, WIREWAY		2,4

NOTES:

1. CABLES TERMINATING IN OR ROUTED THROUGH THE AREAS SPECIFIED SHALL BE ROUTED WITHIN PIPE, FLEXIBLE CONDUIT OR WIREWAY TRUNK.
2. CONDUIT AND TERMINATION FITTINGS SHALL BE AS SPECIFIED HEREIN. RIGID CONDUIT (PIPE) SHALL BE STANDARD SHIPYARD GRADE. WIREWAY TRUNKS SHALL BE SHEET ALUMINUM AND SHALL BE THE MINIMUM THICKNESS REQUIRED FOR BENDING AND PHYSICAL SUPPORT.
3. CONDUIT TERMINATION BRACKET SHALL BE FABRICATED LOCALLY AND SHALL PROVIDE GROUNDING FOR EACH CONDUIT END. BRACKETS MAY BE BOLTED OR WELDED IN PLACE.
4. DOOR ALARMS BOXES, WINDSHIELD WIPER BOXES AND OTHER CABLE TERMINATION BOXES AND EQUIPMENT SHALL PROVIDE FOR THE TERMINATION OF CONDUIT.



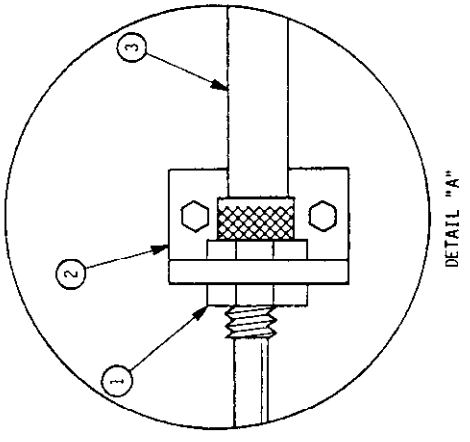
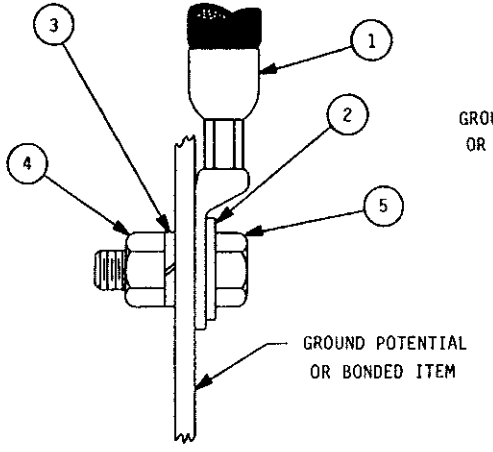
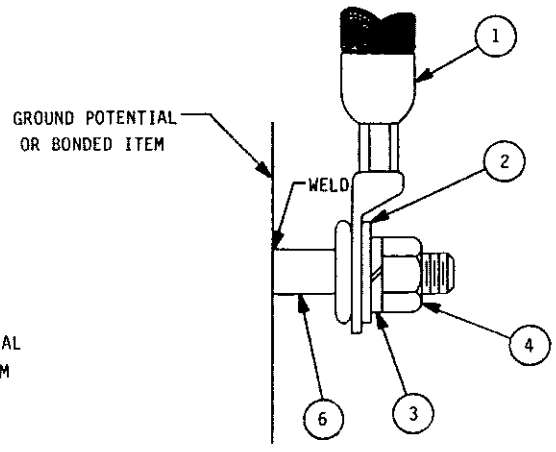


FIGURE 19. Cable shielding methods, interior.

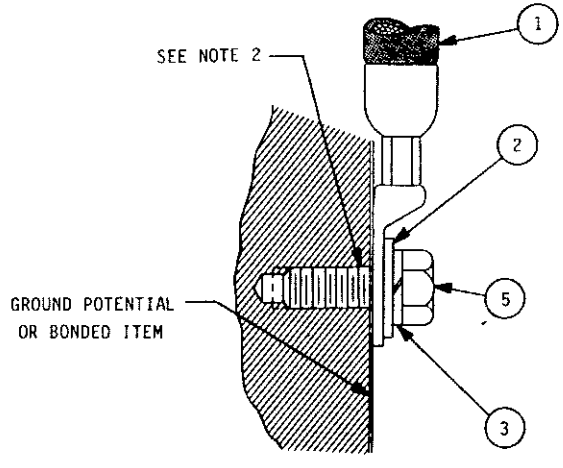
SH 13202372



METHOD 1
BOLT & NUT



METHOD 2
STUD & NUT



METHOD 3
EXISTING BOLT, STUD
OR THREADED HOLE

LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	BOND STRAP, TYPE II, III OR IV		1,2
2	WASHER, FLAT	FF-W-92	5
3	LOCKWASHER, SPLIT	FF-W-84	5
4	NUT	MS35425,and	
		FF-N-836	5
5	BOLT	MIL-S-1222	5
6	STUD, SHOULDER OR COLLAR	MIL-S-24149	3

NOTES:

1. EXISTING BOLTS, STUDS, OR THREADED HOLES MAY BE USED FOR BOND STRAP INSTALLATION.

2. THE INSTALLATION PROCEDURES FOR BOLTED BOND STRAPS SHALL PROVIDE FOR A CLEAN METAL-TO-METAL CONTACT BETWEEN THE BOND STRAP AND THE MATING SURFACE.

3. STUDS USED FOR BOND STRAP ATTACHMENT SHALL BE A COLLAR TYPE. TO PERMIT WELDING, STUDS SHALL CORRESPOND TO THE MATING SURFACE, ALUMINUM STUDS FOR ATTACHMENT TO ALUMINUM SURFACES AND STEEL STUDS FOR ATTACHMENT TO STEEL SURFACES. STUDS USED FOR TYPE II BOND STRAP INSTALLATIONS SHALL CONFORM TO THE FOLLOWING REQUIREMENTS OF MIL-S-24149:

STUD SIZE	- 3/8"-15
STEEL STUDS	-TYPE V, CLASS 4, CRES
ALUMINUM STUDS	-TYPE IV, CLASS 3

4. THREADED HARDWARE SHALL BE PREPARED AND SEALED IN ACCORDANCE WITH THE REQUIREMENTS SPECIFIED HEREIN.

5. FOR SHIPBOARD EXTERIOR APPLICATIONS, ITEMS 2, 3, 4, AND 5 SHALL BE CORROSION RESISTANT STEEL.

SH 13202382

FIGURE 20. Methods of attaching nonwelded bond straps.

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1. DOCUMENT NUMBER	2. DOCUMENT TITLE
MIL-STD-1310E(NAVY)	SHIPBOARD BONDING, GROUNDING, AND OTHER TECHNIQUES FOR

3a. NAME OF SUBMITTING ORGANIZATION	4. TYPE OF ORGANIZATION *(Mark one)*
ELECTROMAGNETIC COMPATIBILITY AND SAFETY	☐ VENDOR ☐ USER ☐ MANUFACTURER ☐ OTHER *(Specify)*:
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b. Recommended Wording:

c. Reason/Rationale for Recommendation:

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