INCH-POUND

MIL-STD-1310F(NAVY)
30 December 1992
SUPERSEDING
MIL-STD-1310E(NAVY)
18 August 1987
(See 6.4)

MILITARY STANDARD

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

AMSC N/A
AREA EMCS
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FOREWORD

1. This military standard is approved for use by the 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, ATTN: SEA 55Z3, 2531 National Center Building 3, Washington, DC 20362-5160 by using the Standardization Document Improvement Proposal Form (DD 1426) appearing at the end of this document or by letter.

3. 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 dense 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.

4. The EMP protection requirements specified herein are minimum requirements and are those that can be achieved within the scope of this document. These requirements do not include methods for EMP hardening of topside equipment or below deck equipment.

5. This document 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. Grounding for personnel safety continues to be a major part of this military standard.

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FIGURES

1. SCOPE

1.1 Scope. This document provides methods for shipboard bonding, grounding, shielding, and the use of nonmetallic materials for 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, requirements for the installation of shipboard ground systems are provided.

1.2 Application. The requirements specified herein apply to all ships, including submarines and nonmetallic hull ships, and are to be applied during ship construction, overhaul, alteration, or repair. Certain requirements may be applied by ship's company or other personnel, as needed. Where conflicts exist between the requirements of this document and other publications, specifications, standards, or drawings, NAVSEA should be notified of the conflicts. When this document 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 document, but only when specifically authorized.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards and handbooks form a part of this document to the extent specified therein. Unless otherwise specified, the issues of these documents are those listed in the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

FEDERAL

FF-N-836	-	Nut: Square, Hexagon, Cap, Slotted, Castle, Knurled, Welding and Single Ball Seat.
FF-W-84	-	Washers, Lock (Spring).
FF-W-92	-	Washer, Flat (Plain).
QQ-B-575	-	Braid, Wire, (Copper, Tin-Coated, or Silver Coated, Tubular, or Flat).
QQ-P-35	-	Passivation Treatments for Corrosion-Resistant Steel.
WW-C-440	-	Clamps, Hose, (Low-Pressure).

MILITARY

MIL-I-631	-	Insulation, Electrical, Synthetic-Resin Composition, Nonrigid.
MIL-A-907	-	Antiseize Thread Compound, High Temperature.
MIL-C-915/21	-	Wire, Electrical, 125 Volts for Welding Electrode Circuit Use Only, Type TRXF.
MIL-S-1222	-	Studs, Bolts, Hex Cap Screws, Socket Head Cap Screws and Nuts.

MILITARY (Continued)

MIL-C-5541	-	Chemical Conversion Coatings on Aluminum and Aluminum Alloys.
MIL-T-22361	-	Thread Compound; Antiseize, Zinc Dust- Petrolatum.
MIL-S-22698	-	Steel Plate, Shapes and Bars, Weldable Ordinary Strength and Higher Strength: Structural.
MIL-I-23053	-	Insulation Sleeving, Electrical, Heat Shrinkable, General Specification for.
MIL-I-23053/15	-	Insulation Sleeving, Electrical, Heat Shrinkable Polyolefin, Heavy-Wall, Coated, Flexible, Outer Wall Crosslinked.
MIL-R-24050	-	Rope, Fibrous, Double-Braided (Nylon).
MIL-S-24149	-	Studs, 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-S-24749	-	Straps, Electrical Grounding (Metric), General Specification for.
MIL-C-24758	-	Conduit, Flexible, Weatherproof, and Associated Fittings General Specification for.
MIL-R-30500	-	Rope, Polyester.
MIL-C-39014/1	-	Capacitors, Fixed, Ceramic Dielectric (General Purpose) Established Reliability, Style CKR05, NATO Type Designation NCC61.
MIL-S-45180	-	Sealing Compound, Gasket, Hydrocarbon Fluid and Water Resistant.

STANDARDS

MILITARY

MIL-STD-889	-	Dissimilar Metals.
DOD-STD-1399-406	-	Interface Standard for Shipboard Systems Section 406 Digital Computer Grounding (Metric).
MIL-STD-1605	-	Procedures for Conducting a Shipboard Electromagnetic Interference (EMI) Survey (Surface Ships).

MILITARY (Continued)

MIL-STD-1686	-	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices) (Metric)
DOD-STD-2003-2	-	Electric Plant Installation Standard Methods for Surface Ships and Submarines (Equipment).

HANDBOOKS

MILITARY

MIL-HDBK-263	-	Electrostatic Discharge Control Handbook for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices) (Metric)

NAVAL SEA SYSTEMS COMMAND (NAVSEA)

S9407-AB-HBK-010	-	Handbook of Shipboard Electromagnetic Shielding Practices.

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, Bldg. 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.1.2 Other Government documents, drawings, and publications. The following other Government documents, drawings and publications form a part of this document to the extent specified herein. Unless otherwise specified, the applicable issues are those cited in the solicitation.

DRAWINGS

NAVAL SHIP SYSTEMS COMMAND (NAVSHIPS)

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

(Copies of above drawings are available from Commander, Portsmouth Naval Shipyard, Naval Engineering Drawing Support Activity, Code 202.2, Portsmouth, NH 03804-5000.)

NAVAL SEA SYSTEMS COMMAND (NAVSEA)

407-5287561	-	Industrial Electromagnetic Compatibility (IEMC) Work Process Instructions.
407-5291780	-	Standard Electromagnetic Interference (EMI) Survey Procedures.

(Copies of above drawings are available from Commander, Naval Sea Systems Command, SEA 06K23, Washington, DC 20362-5160.)

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.

(Copies of above drawings are available from Commander, Portsmouth Naval Shipyard, Naval Engineering Drawing Support Activity, Code 202.2, Portsmouth, NH 03804-5000.)

NAVAL AIR ENGINEERING CENTER (NAEC)

28638-6SE00063	-	Avionic Workbench, Deck Support and Ground Installation Drawing.

(Copies of above drawing are available from Ground Support Equipment Department, Naval Air Engineering Center, Philadelphia, PA 19112.)

PUBLICATIONS

NAVSEA

0967-LP-000-0110	-	Electronics Installation and Maintenance Book.
S9086-CH-STM-010	-	Naval Ships Technical Manual, Welding and Allied Processes.
OP 3565	-	Electromagnetic Radiation Hazards (U) (Hazards to Personnel, Fuel, and Other Flammable Material) (U), Volume I.

(Copies of above publications are available from the Standardization Documents Order Desk, Bldg. 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

A 666	-	Standard Specification for Austenitic Stainless Steel, Sheet, Strip, Plate, and Flat Bar. (DOD adopted)

B 152 - Standard Specification for Copper Sheet, Strip, Plate, and Rolled Bar. (DOD adopted)

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

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

National Electrical Code Handbook

(Application for copies should be addressed to the National Fire Protection Association, One Batterymarch Park, P. O. box 9101, Quincy, MA 02269-9101.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 Bond. An electrical current path between two metallic surfaces established by welding (class A bond), bolting or clamping (class B bond), or the addition of a bond strap (class C bond). The direct current (dc) resistance across bonded surfaces (not using the bolt, clamp or bond strap as one of the surfaces) must be 0.1 ohms or less.

3.2 Bond classification. The electrical bonding methods specified herein are classified as follows:

Class A - A bond established by joining two metallic surfaces by welding or brazing.

Class B - A bond established by bolting or clamping two metallic surfaces together. The dc resistance across the surfaces (not using the bolt or clamp as one of the surfaces) must be 0.1 ohm or less.

Class C - A bond established by bridging two metallic surfaces with a metallic bond strap. The dc resistance across the bonded surfaces (not using the bond strap as one of the surfaces) must be 0.1 ohm or less.

3.3 Bond strap. A device used to establish a class C bond. Bond straps are classified, according to construction, into five types:

Type I - Corrosion-resisting copper/nickel alloy assembly. (Note: Separately acquired mounting bosses are required to install type I bond straps.)

Type II	-	Flat CRES 316 with mounting holes in each end.
Type III	-	Flat copper with mounting holes in each end.
Type IV	-	Flat copper braid with mounting holes in each end.
Type V	-	TRXF-84 cable with mounting lugs and hardware selected to suit individual installation requirements.

3.4 Bright metal. The cleaning of any paint, grease, rust, corrosion or other foreign material from a metal surface thereby exposing the basic metal in a clean or bright condition.

3.5 Broadband noise (BBN). A form of electromagnetic interference (EMI) that covers a wide portion of the frequency spectrum of a receiving equipment as compared to a single received signal. BBN can reduce the signal-to-noise ratio of a receiver by affecting the automatic gain control; thus causing an apparent loss of received signals.

3.6 Conduit. Conduit is a metal enclosure, normally of circular construction, used as electromagnetic shielding for a cable or cables routed within the conduit. Conduit may be rigid or flexible. Flexible conduit used to satisfy requirements of this document shall be in accordance with MIL-C-24758.

3.7 Electromagnetic compatibility (EMC). The condition which prevails when all electronic/electrical equipment groups are collectively performing their individually designed functions in a common electromagnetic environment without causing or suffering unacceptable degradation due to electromagnetic interference to or from other equipment or systems in the same environment.

3.8 Electromagnetic interference (EMI). Electrical or electronic voltages or currents which cause an equipment to operate at less than its maximum design capability. EMI may result from intentional and proper operation of equipment, or it may be unintentionally generated. For shipboard application, EMI is categorized as mild, medium or severe depending upon the reaction of the victim equipment (see MIL-STD-1605 and NAVSEA 407-5291780).

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

3.10 EMP hardening. The employment of any device, design or manufacturing technique which circumvents or mitigates the effects of an electromagnetic pulse.

3.11 Enclosure. Any housing such as a cabinet or case which provides physical protection and support to equipment, parts, or subassemblies. Enclosures may also provide shielding and contain cooling for equipment installed therein.

3.12 Equipment, electrical. 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.

3.13 Equipment, electronic. 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.

3.14 Ground (ground potential). A point, plane, or surface used as a common reference point by electrical or electronic equipment or systems and as an arbitrary reference of zero potential.

3.15 Ground loop. More than one ground path between an equipment or system and a common ground connection or ground point; normally caused by multipoint grounding.

3.16 Ground multipoint. Use of more than one ground conductor or path between a circuit, or an equipment, and a common ground point.

3.17 Ground, personnel safety. The establishment of a contact resistance of 0.1 ohm or less between an equipment housing and ground potential. This contact can be established by any class bond described herein, or by the installation of a ground wire.

3.18 Ground plates. One-eighth inch thick copper plates with dimensions of approximately 2 feet by 4 feet which are installed at the lowest points on each side of the structural hull of a nonmetallic hull ship. Ground plates provide an "earth" ground connection via contact with seawater.

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

3.20 Ground system. The aggregate of all conductors used to provide a common ground reference point.

3.21 Ground system, multi-tree. A ground system consisting of multiple main ground trunks, with associated branches, which connect to a main ground connection point.

3.22 Ground, 360 degrees (peripheral). A continuous metal-to-metal connection, existing or provided, between the outer surface of a metal item or cable shield which terminates at or penetrates into a metal surface that is at ground potential. An example is the ground established between a deck (which is at ground potential) and a pipe which passes through a hole in that deck in which the pipe is continuously welded to the deck in such a manner that the gap between the pipe and the deck is completely closed by welding. Grounding methods are specified herein to accomplish this 360 degree ground at decks, bulkheads, or stuffing tubes for pipes, waveguides, and the outer shield or conductor of cables.

3.23 Grounding. The process of establishing an electrical current path of 0.1 ohm or less dc resistance between an item or equipment and ground by the methods specified herein. The term "grounded" means such a path exists.

3.24 Hard mounted. Mounting of equipment by bolts or welding. Hard mounted equipment is considered nonportable equipment.

3.25 Intermodulation interference (IMI). An electromagnetic (EM) disturbance resulting from the generation of frequencies equal to the sum or difference of integral multiples of two or more frequency sources when mixed in a nonlinear junction. The interference can be equipment generated or result from energy mixing in corroded junctions of ship's structure or rigging, and to a lesser extent, in ferrous metal parts in the RF path.

3.26 Nonlinear junction. A contact area between two metallic surfaces which exhibits nonlinear voltage-current transfer characteristics when subjected to an RF voltage. This non-linearity is usually caused by corrosion or other semi-conducting materials in the contact area.

3.27 Nontopside areas. Areas inside the hull or superstructure of a ship, a deck mounted shelter, or enclosure not exposed to weather. When the hull, superstructure, shelter or enclosure is metallic the area is also a shielded area. The interior of metallic masts is also considered a nontopside shielded area.

3.28 Penetration. The immediate location and actual opening area where an item, such as a cable, pipe or waveguide passes through another surface, such as a deck, bulkhead, or metal structure. Passage is usually by means of a stuffing tube, transit block, or other weatherproofing method.

3.29 Shield. A metal barrier of solid, screen, or braid construction used to protect electronic components, wires, or cables from electromagnetic energy; or used to reduce the emission of electromagnetic energy from components, wires, or cabling.

3.30 Shielded area. Area not directly exposed to electromagnetic energy from ship EM emitters or EMP. This includes areas inside the hull and superstructure of metallic hull ships; areas inside metallic shelters, a metallic enclosure or a metallic mast; and areas in screen rooms on nonmetallic hull ships.

3.31 Space, electrical. 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.

3.32 Space, electronic. 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.

3.33 Tack weld. One or more small welds bridging two metallic items which are bolted together.

3.34 Terminal protection device (TPD). A quick reaction 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.

3.35 Topside areas. All shipboard areas continuously exposed to the weather, such as the main deck and above, sponson decks, catwalks, well decks, and those exposed portions of gallery decks. Unless otherwise specified, 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.

3.36 Trunk, wireway. A metal enclosure that provides electromagnetic shielding to the cables routed therein. One or more sides of the trunk may be ship's structure.

4. GENERAL REQUIREMENTS

4.1 Ground potential designation.

4.1.1 Metallic hull ships. On metallic hull ships, the metal hull shall be designated ground potential. Equipment racks, foundations, structures, and large metal items which are welded and cable ground systems brazed to the hull are extensions of the hull and are also designated ground potential. Items that are class B or class C bonded to ground shall not be used as a ground for subsequent items.

4.1.2 Nonmetallic hull ships. On nonmetallic hull ships, the ground plates shall be designated ground potential. Main ground cables (and their associated branch ground 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-1399-406.

4.2.2 Nonmetallic hull ships. A cable ground system shall be installed on nonmetallic hull ships as specified in 5.1.

4.3 EMI and IMI reduction.

4.3.1 EMI reduction, basic criteria. Primary sources of electromagnetic radiation 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. These many active electrical and electronic devices and equipments board every Naval ship create a shipboard electromagnetic environment. If receiving equipment and other equipment containing solid state components are unable to operate at its design capacity within this environment, EMI protection in the form of shielding, grounding, or filtering must be provided. In some cases, electromagnetic radiation from active equipment and associated cables can be controlled through shielding, isolation, filtering, frequency control, or power control.

4.3.1.1 EMI reduction, general requirements. To minimize EMI and promote electromagnetic compatibility the following general requirements apply.

4.3.1.1.1 Equipment. Electrical and electronic equipment shall be grounded as specified in 5.3.1.1 for metallic hull ships or 5.1.7 for nonmetallic hull ships. Unless otherwise specified, electrical ground wire and power return conductors are not acceptable for EMI reduction.

4.3.1.1.2 Cables. Cables shall be routed within the metallic 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 5.3.1.2.

4.3.1.1.3 Broadband noise EMI reduction. Broadband noise 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 the proximity of 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 for these items shall be as specified in 5.3.3 for IMI reduction.

4.3.1.1.4 Maintenance related EMI. Maintenance related EMI is electromagnetic interference resulting from improper preventive or corrective maintenance. Examples of maintenance which has resulted in EMI include: improperly installed cable connectors (not terminating grounds); improper weatherproofing causing corrosion of connectors; use of ferrous components associated with communication antennas, tuners and couplers; improperly installed antenna feed lines; improper transmitter modulation distortion alignment; and improper checkout of newly installed magnetron. Maintenance procedures must be scrupulously followed to preclude introduction of EMI. See applicable Planned Maintenance System (PMS) Maintenance Index Pages (MIPs) and Maintenance Requirement Cards (MRCs) for general maintenance and EMI related inspection maintenance procedures; or see industrial work process instructions NAVSEA 407-5287561, for installation of representative topside equipment.

4.3.2 IMI reduction, basic criteria. Intermodulation signals can be generated in equipment or hull related nonlinear junctions when two or more RF signals of sufficient voltage are simultaneously impressed across a nonlinear junction. To produce interference, a nonlinear junction must be in the current path of a 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 6 feet in length with the nonlinear junction being a chain-link type of end-fitting. This item then reradiates the newly created intermodulation signals after signal rectification has taken place in the nonlinear junction. To cause interference, the intermodulation signals must be coupled or reradiated to a victim receiver. IMI can be kept to acceptable levels by filtering, bonding and isolation.

4.3.2.1 Hull generated IMI reduction, general requirements. 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 can develop. Metal-to-metal joints, where movability or removability is not a requirement, shall be class A bonded. Aluminum to steel shall be joined by welding using bimetallic bonded joints in accordance with MIL-J-24445. The joining of dissimilar metals by bolting or riveting shall be minimized in topside areas. Armored cables shall be routed within metallic ship's hull, superstructure, deck houses or other metal structures to avoid exposure to radiations from ship's HF transmitting antennas. Existing armored cable runs located on masts and other similar metallic structures shall be relocated to the inside of these structures or shall be enclosed in wireway trunks as specified in 5.3.3.2 and 5.4.1. 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 topside areas. Flexible metal conduit installed in topside areas shall be in accordance with MIL-C-24758. 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. Basic IMI reduction techniques for hull generated IMI include class C bonding (providing a current

path around the nonlinear junction by installation of bond straps) and the use of nonmetallic materials. Hull generated IMI reduction requirements shall be as specified in 5.3.3.

4.3.2.2 Equipment generated IMI reduction, general requirements. To preclude equipment generated IMI all LF, MF, HF, VHF, and UHF receiving equipment shall be connected to associated antennas via narrow band filters. This includes weather facsimile receivers, ship's entertainment receivers and navigation receivers.

4.4 EMP protection, basic criteria. An EMP will couple to metal objects such as antennas, pipes, waveguides, cables and metal structures. Cables connected directly to equipments couple the high currents and voltages into equipment components causing degradation or damage. Metal items such as pipes and waveguides can couple an EMP into a ship where cross coupling to cables or equipment may occur. Solid state components are particularly vulnerable to the effects of EMP. Shielding, grounding, terminal protection devices (TPDs), aperture protection devices (APDs) and isolation shall be used to mitigate the effects of EMP.

4.4.1 EMP protection, general requirements. To preclude introduction of EMP energy into interior spaces of metallic hull ships pipes, waveguides, and overall cable shields shall be peripherally grounded at hull, deck, and bulkhead penetrations. Unshielded cables shall have shielding added and shall be grounded to topside terminations. Coaxial cables shall have terminal protection devices installed. Apertures such as view ports, windows, port holes, and vents shall have aperture protection devices installed. Cables routed internal to the ship close to doors and hatches shall be shielded. Detailed EMP protection shall be as specified in 5.4.

4.5 Class B bond achievement. For equipments installed below deck (nontopside) where a 0.1 ohm or less dc resistance from the equipment to ground potential is not inherent in the equipment installation, the equipment shall be removed and contact areas shall be cleaned to bright metal. Bright metal area shall be not less than twice the mounting bolt diameter. Antiseize compound in accordance with MIL-T-22361 shall be applied to the bright metal areas. The equipment shall be reinstalled and retested for a dc resistance of 0.1 ohm or less. For equipment installed in topside areas where a dc resistance of 0.1 ohm or less is not inherent in the equipment installation, a bond strap (class C bond) shall be installed between the equipment and ground.

5. DETAILED REQUIREMENTS

5.1 Cable ground systems, nonmetallic hull ships. A multi-tree cable ground system, as specified in 5.1.1 through 5.1.7 and as shown on figure 1 shall be installed in new construction ships. The ground system shall be connected to a main ground connection point. The cable ground system shall be installed:

a. To connect electrical equipment and metallic items located outside shielded spaces.
b. To indirectly connect equipment utilizing electrical power inside shielded spaces provided the short circuit current capacity of the enclosure, branch, trunks, and main ground connection points are not exceeded.
c. To connect, as required, electronic equipment that is connected to a ground system for personnel protection, to the main ground connection

point via a dedicated tree.

In addition to the multi-tree system, the shielding of shielded spaces, the metallic mast, the ship service and ship service emergency switchboards, the ship service and ship service emergency generator sets shall be directly connected to the main ground connection point.

5.1.1 Ground plates. Ground plates shall be installed at the lowest point of the structural hull, as close as possible to the vertical of the mast to provide an earth ground connection via contact with sea water. A throughbolt shall be brazed to each plate to provide a connection point for the ground plate interconnecting cable.

5.1.2 Ground system cables. The cables used in the ground cable installation shall be in accordance with MIL-C-24643, and shall have a minimum conductor size as specified herein.

5.1.2.1 Ground cable installation. Ground cables shall be of minimum lengths consistent with other requirements specified herein. Cables shall be installed in locations that provide minimum exposure to physical damage, and shall provide access for inspection, repair, or replacement. Cables installed on nonmetallic hull structures shall be supported by fasteners. Ground lugs installed on cables shall be copper and shall be connected by brazing. Lugs shall not be crimped to the extent that conductor diameter is affected.

5.1.2.2 Ground plate interconnecting cable. A number 650 million circular mils (MCM) cable shall be installed from each ground plate to the main ground connection point.

5.1.2.3 Main ground cable. Number 0000 AWG cables shall be used as main ground cables for grounding all electrical and electronic equipment and metallic items. These cables shall be connected to the main ground connection point and shall run throughout the ship as required (see figure 1).

5.1.2.4 Branch ground cables. Branch ground cables shall be number 10 AWG and shall be used to connect equipment requiring grounding (see 5.1.3) to main ground cables. Branch ground cables shall be attached to the main ground cable by brazing or by connectors. A separate ground conductor in a power supply cable may be used in lieu of a separate ground wire connecting electrical or electronic equipment to associated connection boxes and switch boxes. This ground conductor shall connect to the generator or distribution panel and to metal housings of each component within the electrical supply system. The generator or distribution panel shall then be connected to the ground plates. Ground loops shall be avoided where multiple ground conductors or cable shields terminate to equipment housings. The power cable method of grounding shall follow the safety grounding requirements of the NFPA National Electrical Code Handbook. Class B bonding to metallic decks, bulkheads, or masts directly connected to the main ground connection point may be used in lieu of a branch ground wire.

5.1.2.5 Electronic transmitter ground cable. A number 0000 AWG cable shall be connected to the main ground connection point and shall run as directly as possible to the radio transmitter space(s). Each radio transmitter cabinet or enclosure shall be connected to this ground cable by a number 1 AWG cable. Copper lugs or connectors, corresponding to cable size, shall be used on each end of this cable.

5.1.2.6 Antenna tuners and couplers, ground cable. Each HF antenna coupler shall normally be grounded by a dedicated number 1/0 AWG ground cable, run as directly as possible between each coupler and the main ground connection point. Each HF coupler ground cable may be connected to the electronic transmitter ground cable, in lieu of the main ground connection point. Other couplers and tuners located on metal masts or structures connected to the ground system shall be class B bonded to the mast or structure. Where couplers and tuners are mounted on nonmetallic masts or structures, a number 10 AWG ground system cable shall be provided. To minimize effect of ground loops, RF transmission lines shall be routed with the tuner/coupler ground cables.

5.1.2.7 Lightning protection. A separate 0000 AWG cable connected to the main ground connection point shall be installed for lightning protection. This cable shall be routed in as straight a line as possible and shall be continuous and unspliced from the highest conductive surface to the main ground connection point.

5.1.2.8 Metal mast. Where a metal mast is used, it shall be connected to the ground plates using a size 0000 AWG cable. Equipment on the mast that requires grounding shall be grounded to the mast (see 5.1.3).

5.1.3 Equipment/items grounding requirements.

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

a. Equipment utilizing electrical power and associated boxes.
b. Fuel tanks, water tanks, and associated piping.
c. Metallic standing rigging.
d. Metallic cranes, hoisting gear, king posts, and masts.
e. Any metallic structure used for towing of, or in contact with, magnetic minesweeping cables, such as deck chocks, deck wearing plates, deck padeyes, and stern collar chocks.
f. Portable metallic liferails and ladderways.
g. Shielded rooms.
h. Engines, steering vanes, bow thruster controls, rudder stock, struts, main shaft (engine or reduction gear mount), main shaft fairing (if not grounded internally) sonar trunks, and underwater appendages.

5.1.3.2 Items not requiring grounding. The following items are not required to be grounded:

a. Berths and desks.
b. Bitts and chocks (if not used with minesweeping operations).
c. Small metal objects, such as metal parts of air ports, hand tools (if not electrically operated), and other objects of comparable size.
d. Ventilators and ducting.

5.1.4 Grounding to shielded area. Items and equipments specified in 5.1.3.1 located within 6 inches of a shielded area shall be grounded to the shielded area or to any ground cable from the shielded area connection point. Class B bonding to the shielded area may be used in lieu of a cable ground connection.

5.1.5 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 in accordance with MIL-A-907. Connections shall be protected from corrosion by an application of MIL-S-45180, type II sealing compound.

5.1.6 Cable shield grounding. Cable shield grounding requirements shall be in accordance with individual ship specifications and detailed design drawings. Individual equipment installation control drawings (ICDs) will be developed dependent upon individual ship specifications.

5.1.7 EMI reduction. Unless otherwise specified, electrical and electronic equipment grounded as specified in 5.1.1 through 5.1.6 are properly grounded for EMI reduction purposes.

5.1.8 Ground loops. Installation methods shall minimize ground loops in the ground system.

5.2 Personnel safety.

5.2.1 Hard mounted (nonportable) 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 2. Electrical and electronic equipment hard mounted on metal or metallized shock mounts shall be considered to be class B bonded if the dc resistance from the equipment to ground potential is 0.1 ohm or less. Electronic equipment and subassemblies hard mounted in metallic enclosures shall meet class B bonding requirements. 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 ground bus (ground potential). Electrical and electronic equipment installed on nonconductive surfaces, such as desk tops, shall also be grounded by a ground conductor. The ground conductor size shall be not less than the size of the largest conductor supplying alternating current (ac) power to the equipment. Electrical equipment, such as metal connection boxes, switch boxes, and breaker panels shall also be class B bonded. Equipment electrical power connectors or terminal blocks which have a terminal designated for grounding shall have that terminal grounded if required on installation control drawings (ICDs), or other approved drawings.

5.2.2 Workbench grounding. Electronic workbenches shall be grounded in accordance with NAEC 28638-6SE00063. Requirements and guidance for the protection of electrical and electronic equipment from electrostatic discharge (ESD) damage are contained in MIL-STD-1686 and MIL-HDBK-263.

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 ground potential.

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 separate ground conductor or a ground conductor routed within the power supply cable. The ground conductor size shall be not less than the largest conductor 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 OP 3565 or applicable NAVSEA EM Control Topside Arrangement Drawing.

5.2.6 Submarine grounding. Floating and/or sound isolated platforms shall be grounded by the following methods:

a. Each power consuming or power switching equipment shall be grounded to its mounting surface in accordance with DOD-STD-2003-2, section 406. Power generating sound isolated equipment, such as rotating generators, shall be grounded to its mounting surface by two ground straps as specified below for floating platforms. These ground straps shall be installed on opposite sides of the generators.

b. Sound isolated floating platforms, decks and bedplates shall be grounded to the submarine hull by using two type IV ground straps using lug terminals on each end. These ground straps shall be located on the opposite sides of the platform and shall be installed on studs welded to the platform and hull. Ground straps shall be located away from traffic areas and shall have sufficient slack to allow for platform movement without causing a sound short.

NOTE: These are minimum grounding requirements for sound isolated decks, platforms, and bedplates. Ground straps that have been installed by other requirements shall not be removed.

5.3 EMI and IMI reduction.

5.3.1 EMI reduction. The EMI reduction requirements specified in 5.3.1.1 through 5.3.1.5 are applicable to metallic hull surface ships only.

5.3.1.1 Equipment. HF antenna tuner/couplers shall be grounded as shown on figure 3. Matching network boxes for transmitting antennas shall be tack welded to the ship's structure near the coaxial cable entrance and the antenna entrance insulator(s) when the box material and ship's structure are compatible. Bimetallic material shall be used for grounding a matching network box to a dissimilar metal structure. Receive antenna termination boxes shall be class A or B bonded, or class C bonded using a type II bond strap. All other electrical and electronic equipment, bonded as required for

personnel safety [except when an individual wire or conductor of the equipment cable provides the electrical power safety ground(see 5.1)] and in accordance with applicable ICD, or other authoritative documentation provided by the equipment manager or in-service engineering agent (ISEA), are considered properly grounded for EMI reduction.

5.3.1.2 Cables. All cables routed in topside areas shall be electromagnetically shielded. Coaxial cables and other cables with inherent overall shielding are considered properly shielded provided the overall shield is grounded at end-equipment using coaxial connectors or EMI connector backshells, and is also grounded at penetration to the hull, superstructure, deck, bulkhead or wireway trunk as shown on figure 4. Unshielded cables which exceed 3 feet of exposed length in topside areas shall have the entire exposed length routed within rigid conduit (pipe), flexible conduit, or wireway trunks. The ends of rigid conduit shall be circumferentially welded or grounded as shown on figure 4. Flexible conduit shall terminate into a 360 degree ground as shown on figure 5. Wireway trunks shall be constructed and installed as shown on figure 6. Wireway trunks may contain both inherently shielded and unshielded cables. Where an unshielded cable exits the wireway trunk, add-on shielding, such as rigid or flexible conduit, shall be added to the weather-exposed cable. Both ends of the conduit shall be grounded as shown on figure 5. Armored (braid) cables shall not be routed in topside areas due to the generation of IMI and broadband noise. Radar modulator pulse cables and associated power supply cables routed in cable runs with other cables shall have not less than 18 inches of cable separation or electromagnetic shielding of not less than 60 decibels (dB). Unshielded cables not terminating in transmitter and receiver spaces shall not be routed through these spaces. All cables interconnecting electrical sensors or transducers to machinery control consoles (MCCs) or other similar systems shall be shielded. Cable shields shall be grounded 360 degrees using standard EMI backshells. In new construction, sonar system cables and cables associated with systems or equipments operating at 300 kilohertz (kHz) and below shall be installed in accordance with cable spacing and shielding requirements of NAVSEA S9407-AB-HBK-010. When the EMP requirements of 5.4.1 are invoked, the EMP requirements for cable shielding shall take precedence over 5.3.1.2.

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 the penetration point as shown on figure 7 for waveguide grounding and figure 4 for the grounding of pipes and metal tubing. Pipes welded or threaded at penetration points are properly grounded. Turbine exhaust stacks shall be grounded at the weather penetration point using four type I bond straps spaced at 90 degree intervals. Diesel exhaust stacks shall be grounded at the weather penetration point using two type I bond straps spaced at 180 degree intervals.

5.3.1.4 Topside sound powered telephone headset plug-in connection boxes. Sound powered telephone headset plug-in connection boxes which have been identified as EMI coupling paths shall have EMI filter capacitors installed in each box as shown on figure 8.

5.3.1.5 Portable spaces. Portable spaces such as huts, vans, trailers, and shelters that contain electrical or electronic equipment and are located in weatherdeck areas shall be grounded by type I or II bond straps. Ground terminals shall be provided for installation of bond straps. Connections and hardware shall be weatherproofed as specified in 5.6.2. Portable spaces bolted to a ship deck are considered to be properly grounded (class B bonded).

Metallic tiedown cables shall be interrupted with insulators every 5 feet or nonmetallic restraining straps shall be used.

5.3.2 EMI reduction (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 9. 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 shown on figure 9.

5.3.3 IMI reduction (surface ships). The detailed hull generated IMI reduction requirements of 5.3.3.1 through 5.3.3.14 shall be applied under the following conditions:

a. Paragraphs 5.3.3.1 through 5.3.3.4 apply to all ships.
b. Paragraphs 5.3.3.1 through 5.3.3.6 apply to all metallic hull ships.
c. Paragraphs 5.3.3.1 through 5.3.3.14 apply to all metallic hull ships with six or more HF transmitters.
d. Bonding requirements of paragraphs 5.3.3.7 through 5.3.3.9 shall not be routinely applied unless MIL-STD-1605 or NAVSEA 407-5291780 testing confirms the requirement to bond.
e. Portable items such as canopies, awnings, stanchions, and rigging which are only rigged in port are exempt from bonding requirements.

Adherence to these requirements will reduce IMI caused by nonlinear junctions in topside areas. These requirements do not address IMI that may be generated within equipment or systems.

5.3.3.1 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 NAVSEA 803-5000938.

5.3.3.2 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 internal to the mast or enclosed in a wireway trunk as shown on figure 6, or armor shall be removed using the procedure in NAVSEA 407-5287561.

5.3.3.3 Tilting antenna platforms. Tilting antenna platforms shall be bonded as shown on figure 10.

5.3.3.4 Climber safety rails. Climber safety rails installed by brackets clamped to metallic ladder rungs shall utilize a type I bond strap at each clamp with the strap attached to ship structure and to the safety rail. Climber safety rails attached to welded brackets and installed in accordance with NAVSHIPS 804-4563125 are considered satisfactorily grounded and require no bond straps.

5.3.3.5 Expansion joints. Expansion joints shall be bonded as shown on figure 11 using type I bond straps at intervals not greater than 5 feet. Bond strap length should be sufficient to allow maximum excursion of the expansion joint.

5.3.3.6 Metallic 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 12).

5.3.3.7 Portable flagstaffs, jackstaffs, and stanchions. Portable flagstaffs, jackstaffs, and stanchions of similar height shall be constructed of nonmetallic material in accordance with NAVSHIPS 804-4477903 or shall be bonded as shown on figure 13 if metallic. This requirement does not apply to heavy weather lifeline stanchions, nor does it apply to standard height portable lifeline stanchions.

5.3.3.8 Life and safety nets. Life and safety nets and net frames shall either be fabricated from nonmetallic material in accordance with NAVSEA 803-5184097, or metallic nets and hinged net frames shall be bonded as shown on figure 14.

5.3.3.9 Ladders. Metallic inclined-tread ladders over 6 feet in length shall be grounded as shown on figure 15 or shall be replaced with nonmetallic ladders fabricated in accordance with NAVSEA 803-5184099. Metallic vertical ladders are considered satisfactorily grounded when installation bolts are tightened securely.

5.3.3.10 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 16. This requirement does not apply to rigging which is used only when in port.

5.3.3.11 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 NAVSEA 804-5184155. Where clear deck edge is required, Kevlar lifelines in accordance with NAVSEA 804-5959308 shall be installed. Access openings less than 6 feet shall be protected with 5/8-inch MIL-R-30500 or MIL-R-24050 nonmetallic rope.

5.3.3.12 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. Fabrication and installation techniques shall be in accordance with NAVSEA 803-5000903 or 804-5184155.

5.3.3.13 Portable liferails. Portable liferails shall be constructed of nonmetallic material in accordance with NAVSEA 803-5000903.

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

5.4 EMP protection. 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 invoked the EMP protection requirements shall take precedence over the EMI reduction requirements specified herein.

5.4.1 Cables. Except as noted below, all cables routed in topside areas shall be electromagnetically shielded and grounded as shown on figures 4 and 5. The shield of coaxial cable or overall shielded cable and shielding conduit terminating a topside equipment shall be peripherally grounded using coaxial connectors, EMI backshells, or conduit termination fittings. Additionally, the shield and conduit shall be grounded at the penetration of the hull, superstructure, deck bulkhead, or wireway trunk. Rigid conduit (pipe), or flexible conduit in accordance with MIL-C-24758, shall be installed over single cable runs. Multi-cable 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. Unshielded cables routed internal 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. Conduit and wireway trunk installation for internally routed cables near openings shall be as shown on figure 17. Cables that terminate at these openings, such as windshield wiper cables, window de-icing cables, and door alarm cables, shall be shielded and terminated as above. Cables shall not be routed within 10 feet of helicopter hangar doors unless they are shielded or routed in conduit or wireway trunk.

Exceptions:

a. Overall shielded cables routed less than 18 inches in topside areas do not require additional shielding. However, the overall shield of these cables shall be grounded at the weather penetration point as shown on figure 4.
b. Cables with a solid overall shield, such as the RG-333, do not require additional shielding. However, the overall shield shall be grounded at the weather penetration point as shown on figure 4.
c. Except for that part of the cable which may exceed 52 feet in topside areas, coaxial cables connecting HF transmitters to HF antennas do not require additional shielding. However, cable shield shall be grounded at the weather penetration point as shown on figure 4. Additional shielding is required for that part of the cable over 52 feet. This additional shielding shall be added to the coaxial cable at the weather penetration end or at the topside termination end. This additional shielding shall be rigid or flexible conduit or sheet metal trunk. The coaxial cable shield shall be grounded 360 degrees at the entrance to this additional shielding.
d. Double shielded cables (coaxial or multi-conductor) routed less than 8 feet in topside areas do not require additional shielding. However, cable shield shall be grounded at the weather penetration point as shown on figure 4. Additional shielding is required for double shielded cables routed over 8 feet in topside areas. This additional shielding shall be added to the cable at the weather penetration end or at the topside termination end. This additional shielding shall be rigid or flexible conduit or a sheet metal trunk.

The cable shield shall be grounded 360 degrees at the entrance to this additional shielding.

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 so 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.

5.4.2 Wireway trunks. Wireway trunks shall be fabricated from sheet metal and bent to provide a three sided trunk as shown on figure 6. The thickness of the sheet metal shall be sufficient to provide physical support and allow bending. The width and depth of the trunk shall be determined by the number of trunk routed cables. Each trunk section and cover shall have minimum cracks, seams, and lap joints. The trunk outer edges shall be bent inward at least 1 inch to reinforce each trunk side. Cable hangers sufficient to accommodate the required number of cables shall be installed within the trunk. The trunk shall be mounted on the mast, mast leg or other supporting structure by brackets. Trunk covers shall be metal, with the vertical edge bent to overlap the cover-to-trunk joint and to reinforce the cover. Covers shall be bolted to the trunk along the vertical edges with bolts spaced not more than 12 inches apart. Captive nuts shall be installed within the trunk to receive the trunk cover bolts. Trunk cover sections shall be joined across the front with butt plates or lap plates. Bolt spacing across horizontal joints shall not exceed 4 inches. Lap plates shall attach to the covers so as to lay the entire trunk open for cable access when covers are removed. The bottom of the trunk and the bottom trunk cover shall attach to a coaming plate welded to the ship deck. Weep holes or drain tubes shall be provided. The upper end of the wireway trunk shall have an end cap with provisions for cable exit. Cable break-out of the trunk shall be by stuffing tubes. Cables that exit the trunk shall be shielded and grounded as specified in 5.4.1. Lap areas of aluminum trunks shall be treated with a class 3 conductive coating in accordance with MIL-C-5541.

5.4.3 Waveguides, pipes, metal tubing, and exhaust stacks. Waveguides, pipes, metal tubing, and exhaust stacks grounded as specified in 5.3.1.3 are properly grounded for EMP requirements.

5.5 Bond straps, fabrication and installation. Bond straps shall only be installed when specifically required for safety, equipment operation, or EMI/IMI reduction. The types and locations of bond straps required for EMI/IMI reduction are identified in EM Control Topside Arrangements Drawings specified in NAVSEA 407-5291780. Bond straps shall be installed as specified in 5.5.2 through 5.5.3.3.2. NAVSEA 407-5287561 provides comprehensive work process instructions for bond strap installation.

5.5.1 Bond straps fabrication. Bond strap types I through IV shall be fabricated in accordance with MIL-S-24749 and as shown on figures 18, 19, and 20. Type V bond straps are constructed as shown on figures 14 and 16. Type I bond straps will not normally be produced by public or private shipyards.

5.5.2 Bond strap types and uses. The following bond strap types shall be used as specified. Current replacements for previously used bond straps are shown on figure 21.

5.5.2.1 Type 1 bond strap. Type I bond straps shall be used in shipboard topside areas to bond EMI and IMI source items and to provide safety grounds for equipments where class A bonding cannot be accomplished.

5.5.2.2 Type II bond strap. Type II bond straps shall be used in shipboard topside areas for bonding EMI source items such as antenna tuners or couplers, equipments, enclosures, and cabinets.

5.5.2.3 Type III bond strap. Type III bond straps shall be used in shipboard nontopside areas for bonding equipments, enclosures, and cabinets.

5.5.2.4 Type IV bond strap. Type IV bond straps shall be used in shipboard nontopside areas for bonding equipment utilizing sound isolated mounts or shock mounts (nonmetallic mounts).

5.5.2.5 Type V bond strap. Type V bond straps shall be used topside as specified in 5.3.3.8 and 5.3.3.10.

5.5.3 Bond strap installation. Bond straps shall be installed so as to permit rapid inspection or replacement. They 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. Installations of bond straps shall not affect the integrity 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, in good condition, shall be used for type II, III, IV, and V bond strap installation where possible. Type III and IV bond straps shall not be installed in weather exposed locations.

5.5.3.1 Bond strap installation hardware. Installation hardware for type I bond straps shall be acquired with component parts. Installation hardware for types II, III, IV, and V bond straps shall be 5/16-inch or 3/8-inch, as appropriate. Topside area mounting hardware shall be corrosion-resistant steel except where bond straps are connected to aluminum studs. Where aluminum studs are required or installed, mounting hardware shall be aluminum. For nontopside areas, mounting hardware 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 shown on figure 22.

5.5.3.2 Bond strap mounting surface preparation. Areas where type I bond strap bosses and other type bond strap ends are to be mounted shall be cleaned to bright metal. The bright metal area shall be at least 1.5 times the size of the boss base or bond strap end. Bosses shall also be cleaned to bright metal. Bosses to be welded in place shall be welded while mounting area is in bright metal condition. Where bosses are to be bolted to equipment and ground, and for installation of type II, III, IV, and V bond straps, bright metal areas and all threaded hardware shall be coated with an antiseize compound in accordance with MIL-T-22361 prior to installing the components. After installation, excess antiseize compound shall be removed and weatherproofing shall be accomplished as specified in 5.6.2.

5.5.3.3 Bond strap installation procedures. Following bond strap mounting surface preparation as specified in 5.5.3.2, complete installation of bond straps as follows:

5.5.3.3.1 Type I bond straps.

a. Weld or bolt the bosses to ground potential and to the item to be bonded. If bolted, torque bolts to 22.5 +/- 2.5 foot-pounds (ft-lb); do not over-torque.
b. Clean the welded areas of welding slag; clean top of bosses to bright metal.
c. Apply antiseize to all threaded surfaces and mating surfaces as specified in 5.5.3.2.
d. Bolt bond strap to bosses. Torque bolts as in a. above.
e. Clean and weatherproof bond strap installation as specified in 5.6.2.

5.5.3.3.2 Type II, III, IV, and V bond straps.

a. Clean contact areas of bond straps to bright metal and apply antiseize as specified in 5.5.3.2.
b. Secure strap to item and ground potential as shown on figure 22. Torque bolts as specified in 5.5.3.3.1.a.
c. For all type II and III, and those type IV and V bond straps which may be exposed to heavy condensation or salt water, weatherproof bond strap as specified in 5.6.2.

5.6 Corrosion protection.

5.6.1 Selection of materials. All materials specified by this standard shall be selected to provide maximum protection against corrosion. Bond strap bosses shall be selected to match surfaces to which they are to be mounted: Copper-nickel/steel for mounting to steel and brass; and copper-nickel/aluminum for aluminum. Conduit and fittings shall be acquired in accordance with MIL-C-24758 and 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 Weatherproofing. In topside areas, cable shield grounding surfaces, conduit terminating fittings , bond straps, and nonmetallic hull ground system mechanical (crimped and threaded) fasteners shall be weather-proofed within 4 hours of installation in accordance with the following:

a. Fittings which terminate shielding conduit, and all cable shield grounding surfaces, shall be weatherproofed with an application of MIL-S-45180, type II sealing compound. Where sealing compound is applied to cable or conduit jackets, the jacket shall be abraded with fine sandpaper prior to application of sealing compound. Where fittings are installed in connection boxes, a fillet of the sealing compound shall also be applied around the connection box/fitting interface surface.

b. Type I bond straps shall be weatherproofed by priming and painting the entire bond strap assembly after installation. Other bond straps installed in topside locations shall be weatherproofed by coating the bond strap mounting hardware with an application of MIL-S-45180, type II sealing compound after installation. Bond straps installed in nontopside areas do not normally require weatherproofing. All painted areas affected by bond strap installation shall be restored, including base coat/primer, to the original paint finish. As an alternate to MIL-S-45180, type II sealing compound, heat shrinkable tubing in accordance with MIL-I-23053 and MIL-I-23053/15 may be used for weatherproofing.

5.6.3 Antiseize compounds, use of. The antiseize compound specified by this standard shall be acquired in accordance with MIL-T-22361 or MIL-A-907. MIL-T-22361 shall be used between two metal surfaces to preserve grounding conductivity. This compound is added to prevent oxidation or corrosion in a ground path area. Although a low dc resistance may not be present when test probes of an ohmmeter are immersed in the compound, it is electrically conductive under pressure. This compound shall be used only where metal-to-metal contact through the compound can be ensured, such as threaded fittings and metal surfaces bolted or clamped together. For topside applications, the immediate area where the compound is applied shall be edge sealed with MIL-S-45180, type II sealing compound to prevent displacement of the antiseize.

5.7 Materials and workmanship inspections.

5.7.1 In-progress inspection. During all installations in-progress inspections shall be conducted to verify and evaluate installation procedures, methods, and materials to determine compliance with applicable requirements. The inspection shall ensure that:

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

5.7.2 Final inspection. Upon 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 met and, that the requirements specified in 5.7.1 have been met.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. This standard specifies EMI/IMI reduction techniques, EMP protection measures, personnel safety grounding requirements and methods for installing shipboard cable ground systems.

6.2 Issue of DODISS. When this standard is used in acquisition the issue of the DODISS to be applied must be cited in the solicitation (see 2.1.1 and 2.2).

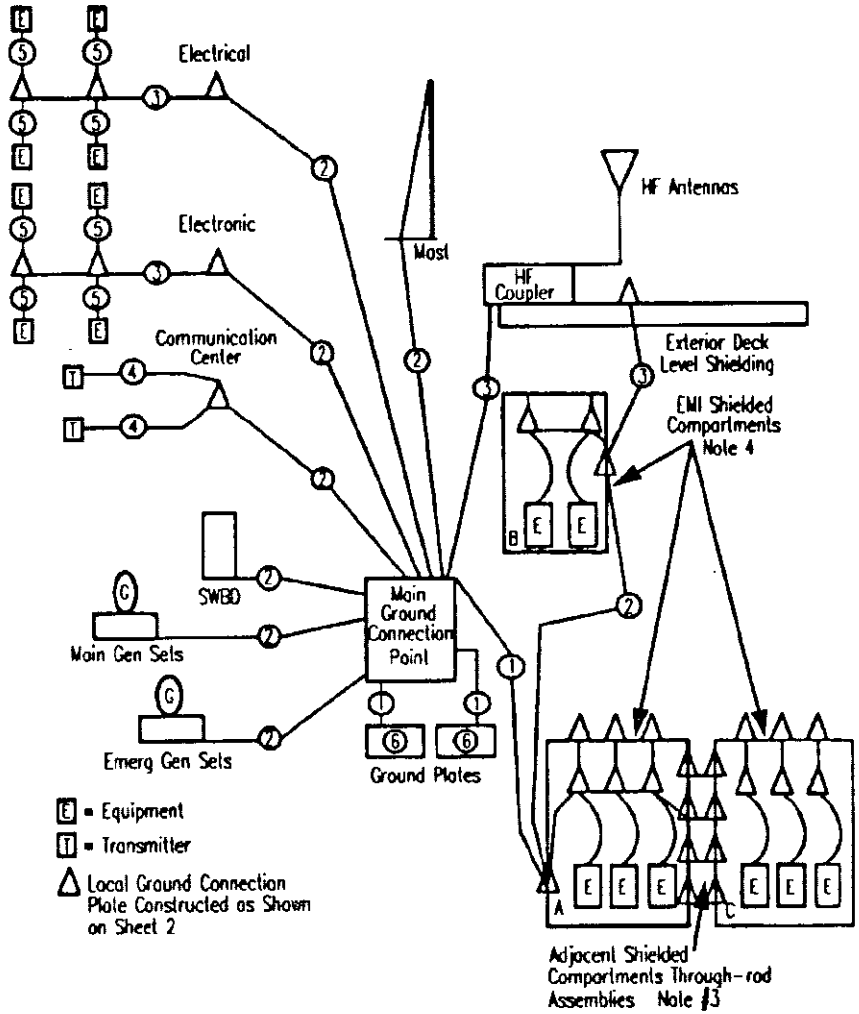
6.3 Subject term (key word) listing.

Bond, classification
Bond, electrical straps
Bond, strap
Broadband noise
Cable ground system
Corrosion protection
Electromagnetic interference (EMI) reduction
Electromagnetic pulse (EMP) hardening
EMP protection
Ground, peripheral (360 degrees)
Ground plates
Ground, radio frequency (RF)
Intermodulation interference (IMI) reduction
Junction, nonlinear
Penetration
Personnel safety
RF grounding
Shield
Shielding, electromagnetic
Waveguide grounding
Weatherproofing
Wireway trunks

6.4 Changes from previous issue. Marginal notations 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-N135)

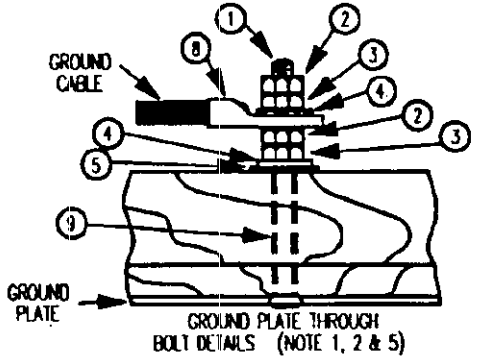


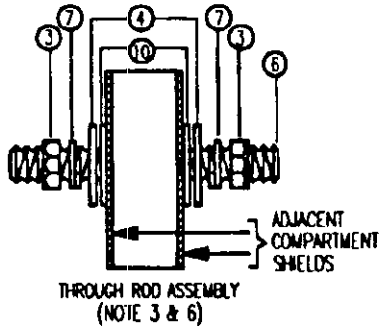
LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	WIRE, COPPER NO. 650 MCM	MIL-C-24643	1
2	WIRE, COPPER NO. 0000 AWG	MIL-C-24643	1
3	WIRE, COPPER NO. 1/0 AWG	MIL-C-24643	1
4	WIRE, COPPER NO. 1 AWG	MIL-C-24643	1
5	WIRE, COPPER NO. 10 AWG	MIL-C-24643	1
6	PLATE, COPPER, 1/8"	ASTM B 152	2

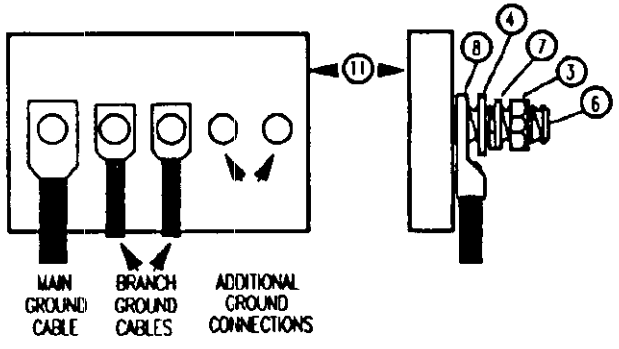
NOTES:

1. ALL CONDUCTOR SIZES ARE MINIMUM REQUIREMENTS ONLY.
2. GROUND PLATES SHALL BE LIGHT, COLD-ROLLED, OXYGEN-FREE COPPER, APPROXIMATELY 1/8" THICK AND SHALL PROVIDE APPROXIMATELY 16 SQ. FEET OF TOTAL SURFACE AREA DIVIDED INTO TWO EQUAL PARTS AT THE LOWEST POINT ON THE STRUCTURAL HULL, AS CLOSE AS POSSIBLE TO THE VERTICAL OF THE MAST.
3. SHIELDING OF ADJACENT SHIELDED COMPARTMENTS SHALL BE DIRECTLY CONNECTED VIA THROUGH ROD ASSEMBLY. SEE SHEET 2.
4. EMI SHIELDED COMPARTMENTS A&B REPRESENT THE NORMAL EQUIPMENT GROUNDING CONFIGURATION (I.E., COMBINATION OF CABLES AND LOCAL GROUND CONNECTION PLATES FROM A TERMINAL EQUIPMENT TO THE MAIN GROUND CONNECTION POINT). EMI SHIELDED COMPARTMENT C REPRESENTS AN EQUIPMENT GROUNDING OPTION (I.E., A COMBINATION OF CABLES, LOCAL GROUND PLATES AND COMPARTMENT SHIELDING MATERIAL) FROM THE TERMINAL EQUIPMENT TO THE MAIN GROUND CONNECTION POINT. THIS OPTION CAN ONLY BE UTILIZED IF THE SHIELDING MATERIAL AND LOCAL GROUND PLATES CAN BE SHOWN TO CONTINUOUSLY HANDLE THE FULL SHORT CIRCUIT CURRENT OF THE EQUIPMENT.

FIGURE 1. Nonmetallic hull ship multi-tree ground system.





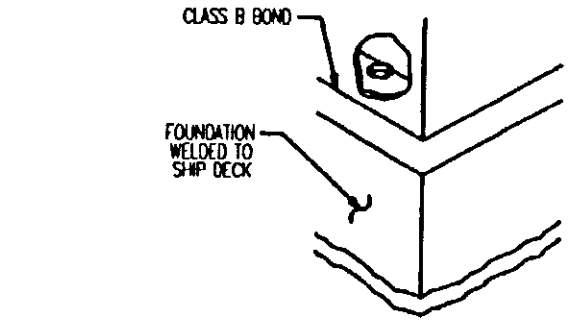


LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	BOLT, COPPER		1, 2
2	NUT, JAM, COPPER		
3	NUT, HEX, COPPER		
4	WASHER, COPPER		
5	WASHER, RUBBER		
6	ROD, COPPER, THREADED		3, 4
7	WASHER, LOCK, COPPER		
8	TERMINAL, LUG, COPPER		
9	CAULK, POTTING MATERIAL		5
10	MATERIAL, SHIELD INTERFACE		6
11	PLATE, COPPER	ASTM B 152	4

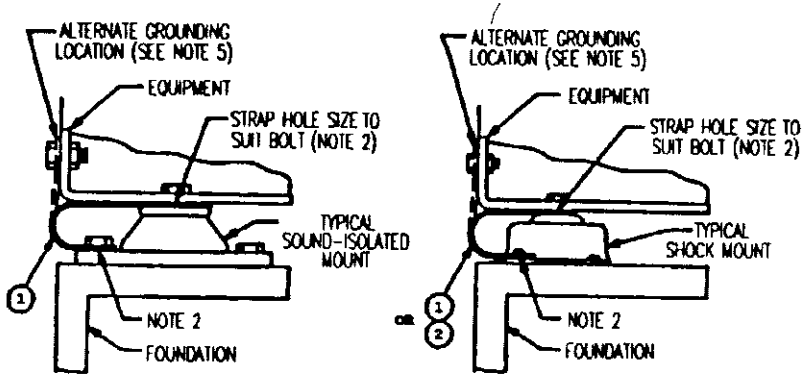
NOTES:

1. HEAD OF THE GROUND PLATE THROUGH BOLT SHALL BE BRAZED TO THE COPPER GROUND PLATE.
2. SIZE OF THE GROUND PLATE THROUGH BOLT SHALL AT LEAST EQUAL THE SIZE OF THE ASSOCIATED CABLE.
3. SHIELD THROUGH ROD SHALL BE 3/8 INCH DIAMETER.
4. STUD OF LOCAL GROUND CONNECTION PLATES SHALL BE MINIMUM 3/8 INCH DIAMETER AND SHALL BE BRAZED TO ASTM B 152 PLATE.
5. PROTECTION AGAINST SEEPAGE SHALL BE PROVIDED BY A MARINE CAULK OR POTTING MATERIAL COMPATIBLE WITH THE HULL MATERIAL AND NON CORROSIVE TO THROUGH BOLT.
6. SHIELD INTERFACE MATERIAL, E.G., WASHER OR CONDUCTIVE GASKET, SHALL BE SELECTED TO PROVIDE ELECTRICAL CONTINUITY FROM THE SHIELD TO THE THREADED ROD VIA COPPER WASHER AND HEX NUT.

FIGURE 1. Nonmetallic hull ship multi-tree ground system - Continued.



HARD-MOUNTED INSTALLATION (BOLTED)

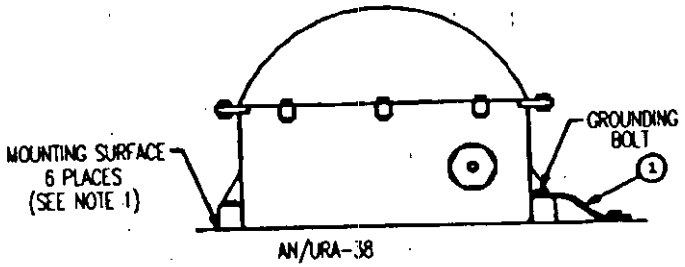


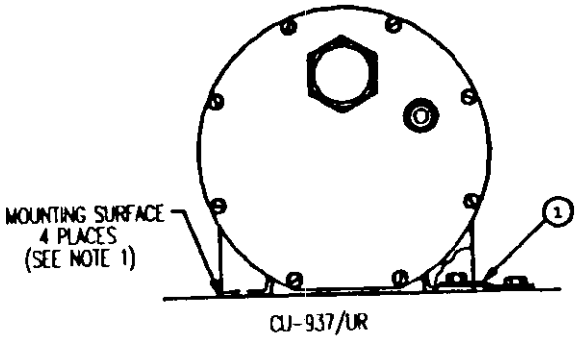
LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	BOND STRAP, TYPE IV	MIL-S-24749	1, 2, 3, 4
2	BOND STRAP, TYPE III	MIL-S-24749	2, 3, 4

NOTES:

1. RESILIENT MOUNTED EQUIPMENT SHALL BE BONDED AS SHOWN. BOND STRAPS FURNISHED WITH ELECTRONIC EQUIPMENT MAY BE USED FOR BONDING RESILIENT MOUNTED EQUIPMENT IF EQUAL TO BOND STRAPS REQUIRED.
2. WHERE POSSIBLE, USE EXISTING BOLTS, STUDS, OR HOLES FOR ATTACHING BOND STRAPS.
3. EACH BOND STRAP INSTALLED SHALL ACCOMMODATE THE FULL DEFLECTION OF EACH RESILIENT MOUNT. BOND STRAP INSTALLATION SHALL NOT DEFEAT THE PURPOSE OF THE RESILIENT MOUNT.
4. A TYPE IV BOND STRAP MAY BE INSTALLED ON SHOCK-MOUNTED EQUIPMENT AS AN ALTERNATE FOR TYPE III BOND STRAPS.
5. THE ALTERNATE GROUNDING LOCATION MAY BE USED IF SHIMMING OF UNBONDED MOUNTS WOULD BE REQUIRED AS A RESULT OF BONDING ONE MOUNT.

FIGURE 2. Grounding of hard mounted equipment and enclosures.





LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	BOND STRAP, TYPE II	MIL-S-24749	1

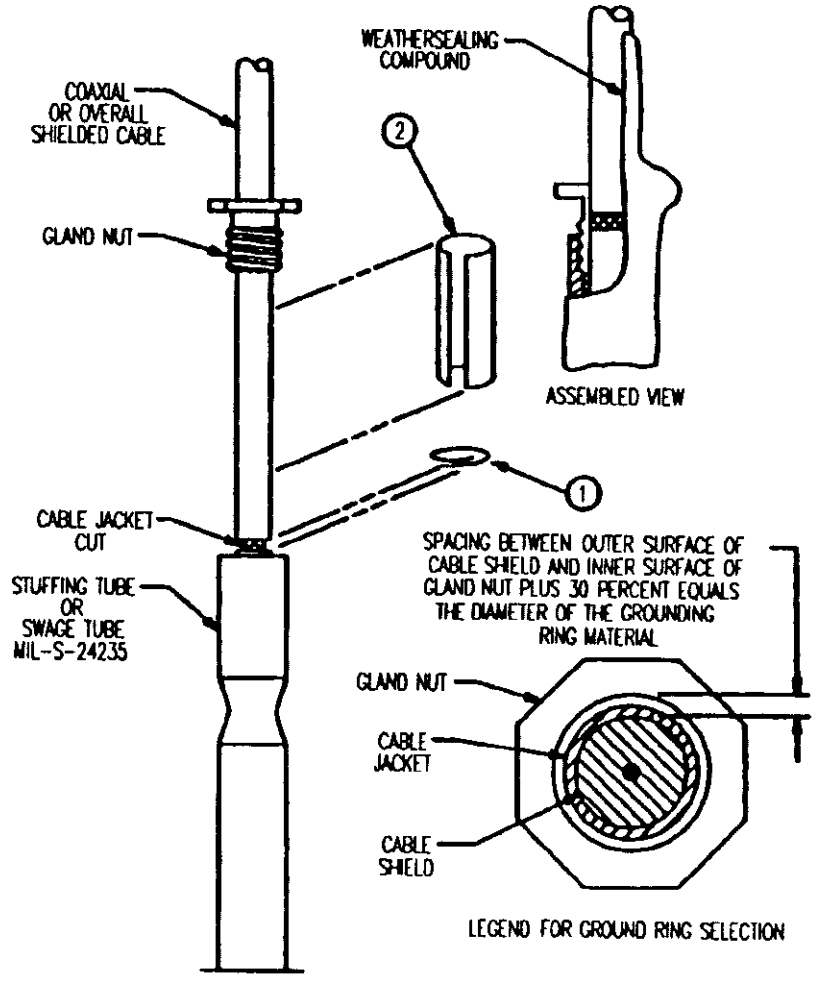
NOTES:

1. HF ANTENNA TUNER/COUPLERS SHALL BE GROUNDED AS SHOWN IN THIS FIGURE AND AS DESCRIBED BELOW.

   THE MOUNTING SURFACES BETWEEN THE TUNER/COUPLER AND GROUND POTENTIAL SHALL BE CLEAN AND FREE OF CORROSION. A HEAVY COAT OF ANTISEIZE COMPOUND, MIL-T-22361, SHALL BE APPLIED TO THE CLEANED AREAS AND THE TUNER/COUPLER SHALL BE FIRMLY BOLTED IN PLACE. EXCESS ANTISEIZE SHALL BE REMOVED AFTER BOLTING. ALL AREAS WHERE ANTI-SEIZE IS APPLIED SHALL BE EDGE-SEALED USING MIL-S-45180 TYPE II SEALING COMPOUND. IN ADDITION TO THE ABOVE CLASS B BOND, A TYPE II BOND STRAP SHALL BE INSTALLED ON EACH TUNER/COUPLER. BOND STRAP CONNECTION TO GROUND POTENTIAL SHALL BE BY STUD, STUD PAD, OR BOLT. 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 CLEANED TO BRIGHT METAL AND COATED WITH ANTISEIZE COMPOUND PRIOR TO BOND STRAP INSTALLATION. ALL HARDWARE AND BOND STRAPS SHALL BE WEATHERPROOFED AFTER INSTALLATION USING MIL-S-45180 TYPE II GASKET COMPOUND.

2. THESE ILLUSTRATIONS SHOW GROUNDING METHODS FOR SPECIFIC HF TUNER/COUPLERS. OTHER TUNERS AND COUPLERS THAT REQUIRE GROUNDING IN ACCORDANCE WITH INSTALLATION CONTROL DRAWINGS SHALL BE GROUNDED USING SIMILAR METHODS.

FIGURE 3. Antenna tuner and coupler grounding.

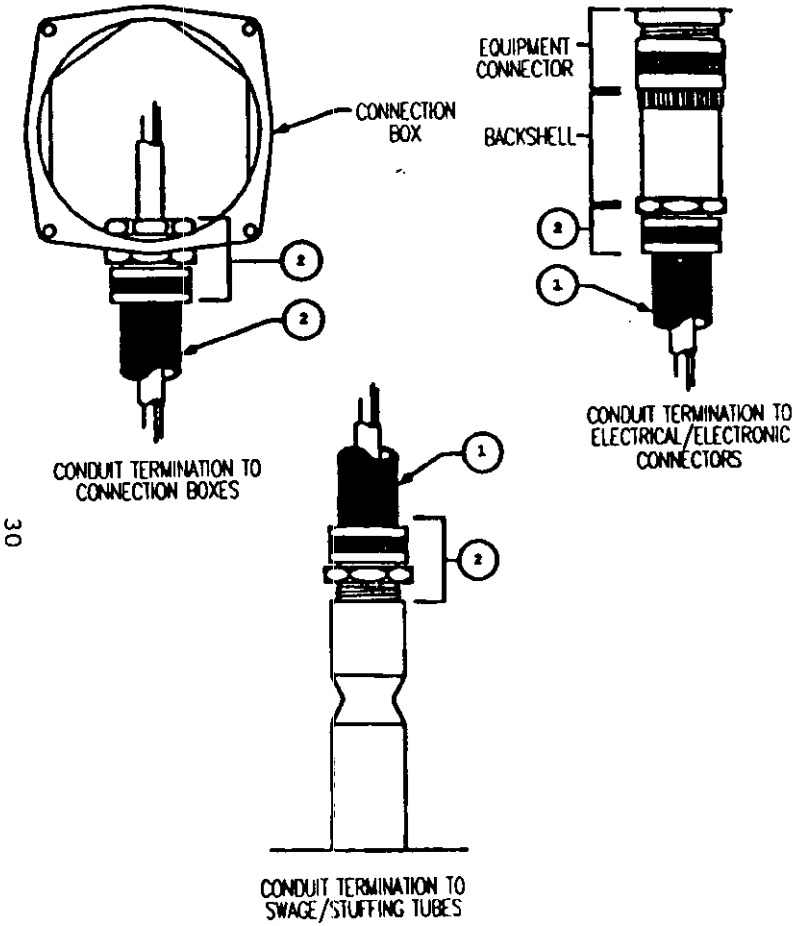


LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	GROUNDING RING	COMM	3, 5, 6, 7
2	COMP SLEEVE, SHIM STOCK	COMM	6, 7

NOTES:

1. THIS METHOD OF CABLE SHIELD GROUNDING APPLIES TO EXISTING CABLE INSTALLATIONS, WHERE GROUNDING IS REQUIRED AND CABLE REPLACEMENT IS NOT OTHERWISE AUTHORIZED.
2. THE METHOD SHOWN HERE FOR CABLE SHIELD GROUNDING SHALL ALSO BE USED FOR METAL PIPES AND TUBING WHICH ARE ROUTED THROUGH STUFFING TUBES, AND FOR RIGID CONDUIT TERMINATING AT STUFFING OR SWAGE TUBES.
3. THE GROUNDING RING SHALL BE ROUND CROSS SECTION NEOPRENE-SPONGE FLEXIBLE-WIRE-MESH STRIP.
4. UNSCREW PACKING GLAND NUT FROM THE STUFFING TUBE AND MOVE IT SEVERAL INCHES UP THE CABLE AND TAPE IN PLACE. ENSURE INSIDE OF GLAND NUT IS CLEAN. CLEANING WITH FINE SANDPAPER MAY BE REQUIRED. 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.
5. 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, EXPOSED CABLE SHIELD AND THREADS OF THE GLAND NUT WITH MIL-T-22361 ANTISEIZE COMPOUND.
6. PLACE GROUNDING RING AROUND CABLE IN CONTACT WITH EXPOSED SHIELD. PLACE COMPRESSION SLEEVE AROUND CABLE JACKET AND GROUNDING RING. HOLDING COMPRESSION RING TIGHTLY AROUND CABLE AND GROUNDING RING, SLIDE GLAND NUT DOWN OVER COMPRESSION SLEEVE AND THREAD INTO STUFFING TUBE. AFTER THREADS HAVE ENGAGED REMOVE THE COMPRESSION SLEEVE. WEATHERPROOF AS SPECIFIED FOR CORROSION PROTECTION.
7. THE COMPRESSION SLEEVE IS USED ONLY TO COMPRESS THE GROUNDING RING WHILE REINSTALLING THE GLAND NUT. IT CAN BE CUT FROM 0.005" SHIM STOCK.

FIGURE 4. Cable shield, metal pipe, metal tubing, and rigid conduit grounding.

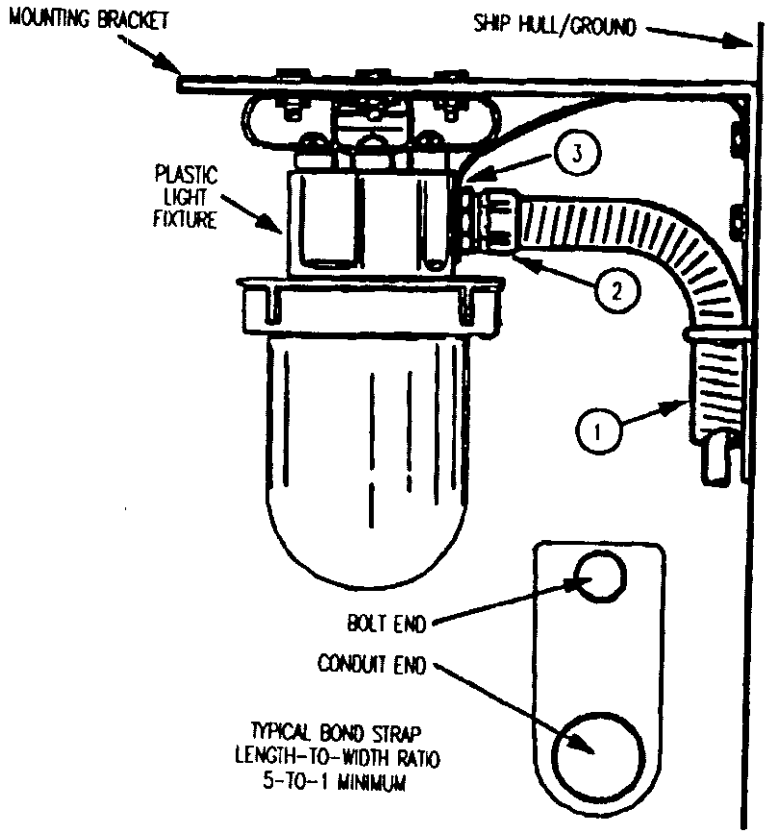


LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	CONDUIT, FLEXIBLE	MIL-C-24758	2, 3, 4
2	FITTING, CONDUIT	MIL-C-24758	4, 5

NOTES:

1. THIS METHOD OF CABLE SHIELDING APPLIES TO NEW CABLE INSTALLATIONS AND TO EXISTING CABLE INSTALLATIONS WHERE THE CABLES CAN BE REMOVED FROM THE TERMINATING EQUIPMENT AND HANGERS, AND ROUTED THROUGH THE CONDUIT. INSTALL CONDUIT AND FITTINGS IN ACCORDANCE WITH THIS FIGURE.
2. SELECT CONDUIT SIZE TO ACCOMMODATE CABLE OVERALL DIAMETER.
3. THE MINIMUM BEND RADIUS OF CONDUIT SHALL NOT BE EXCEEDED.
4. ELBOW FITTINGS, 45 OR 90 DEGREE, SHALL BE USED, WHERE NEEDED, TO REDUCE STRAIN ON CONNECTORS AND CONDUIT. SELECT CONDUIT FITTINGS TO MATCH CONDUIT SIZE AND TERMINATING EQUIPMENT.
5. CONDUIT FITTINGS SHALL BE SELECTED USING THE METALS SPECIFIED IN 5.6.1. APPLICATION OF ANTISEIZE COMPOUND AND WEATHERPROOFING SHALL BE IN ACCORDANCE WITH 5.6.2.

FIGURE 5. Cable shielding method, flexible conduit.

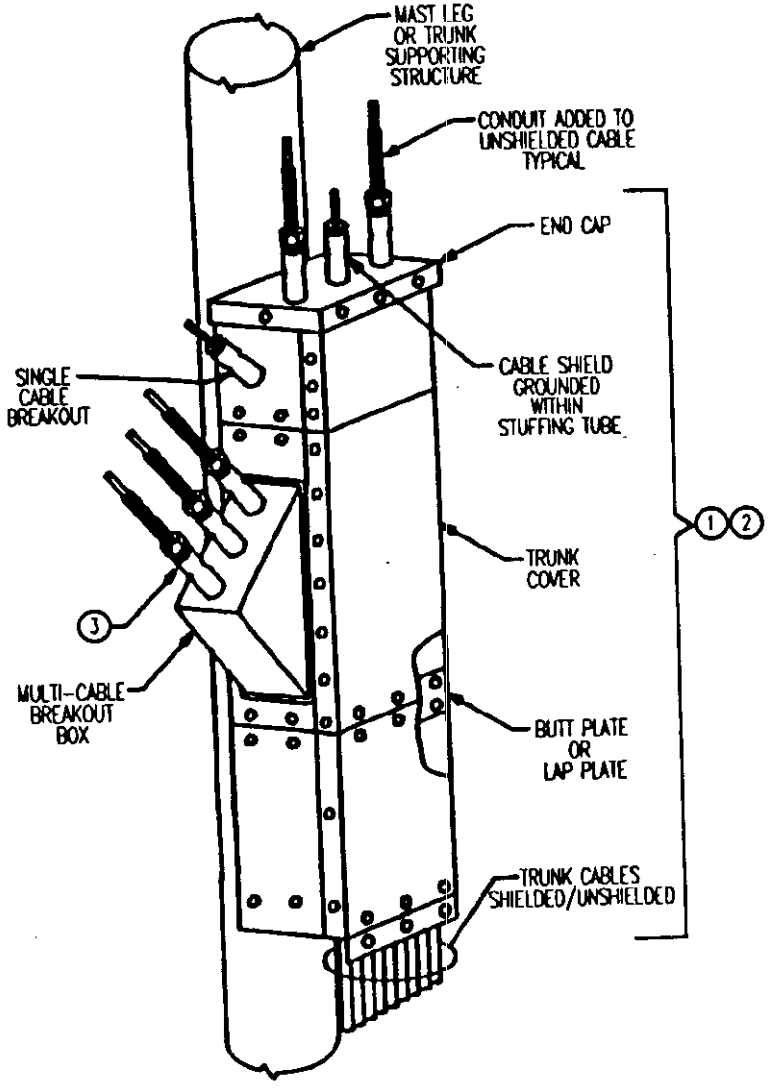


LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	CONDUIT, FLEXIBLE	MIL-C-24758	
2	FITTING, CONDUIT	MIL-C-24758	1
3	BOND STRAP, TYPE II	MIL-S-24749	1, 2

NOTES:

1. THIS METHOD SHALL BE USED TO GROUND CONDUIT TERMINATING AT NONMETALLIC FIXTURES.
2. CONDUIT FITTING SHALL MAKE PERIPHERAL CONTACT WITH TYPE II BOND STRAP.
3. BOND STRAP MAY BE CONNECTED TO HULL SIDE OF MOUNTING BRACKET PROVIDED SURFACE IS PREPARED AS SPECIFIED IN 5.5.3.2.

FIGURE 5. Cable shielding method, flexible conduit - Continued.

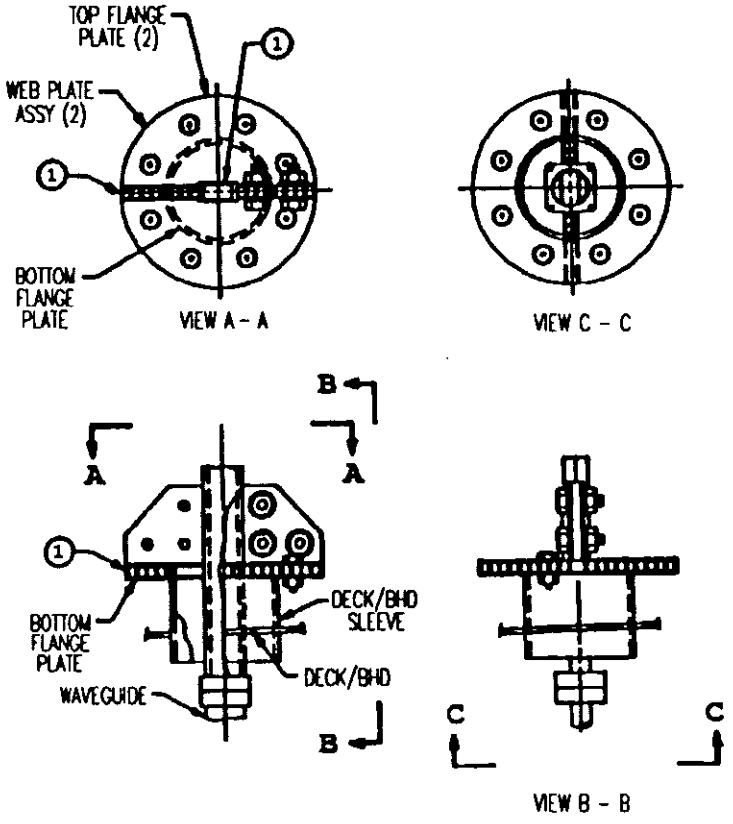


LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	SHEET METAL, STEEL	MIL-S-22698	1
2	SHEET METAL, ALUMINUM	5086H116	1
3	SWAGE TUBE	MIL-S-24235	4

NOTES:

1. BASIC TRUNK DESIGN SHALL BE IN ACCORDANCE WITH 5.4.2 AFTER CABLE TYPES, AND GROUNDING AND SHIELDING REQUIREMENTS HAVE BEEN DETERMINED.
2. FABRICATE END CAP AND BREAKOUT BOXES, AS REQUIRED, TO ACCOMMODATE THE NUMBER AND TYPE OF CABLES THAT EXIT THE WIREWAY TRUNK. HOLES SHALL BE SIZED TO FIT THE REQUIRED STUFFING TUBES AND CONDUIT TERMINATION FITTINGS.
3. INSTALL CABLES FROM BELOW DECK EQUIPMENT TO TOPSIDE EQUIPMENT LOCATION THROUGH END CAPS, BREAKOUT BOXES, STUFFING TUBES AND HOLES FOR CONDUIT FITTINGS.
4. CONDUIT TERMINATION FITTINGS OR BULKHEAD FEED THRU FITTINGS MAY BE USED FOR CABLE EXIT IN LIEU OF STANDARD SWAGE TUBES.
5. MEASURE AND CUT SHIELDING CONDUIT TO LENGTHS REQUIRED.
6. INSTALL CABLE SHIELD GROUNDING MATERIALS AND FLEXIBLE SHIELDING CONDUIT AS SPECIFIED HEREIN. WEATHERPROOF ALL FITTINGS AS SPECIFIED FOR CORROSION PROTECTION.
7. ALL FITTINGS ARE DEPICTED PRIOR TO WEATHERPROOFING.
8. AFTER COVERS ARE INSTALLED, WIREWAY TRUNK SHALL BE PRIMED AND PAINTED.

FIGURE 6. Wireway trunk.

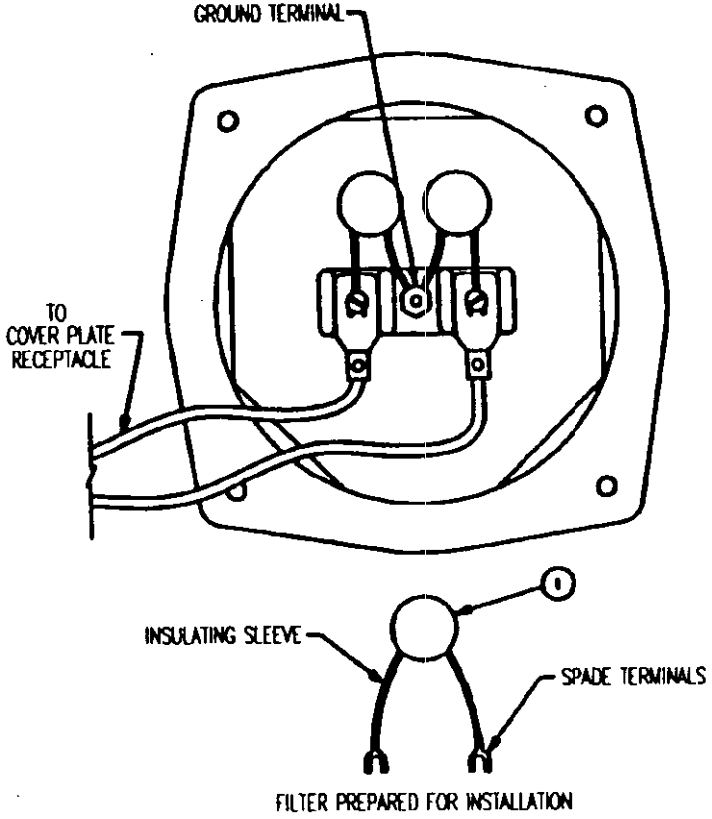


LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	GASKET MATERIAL, CONDUCTIVE	COMMERCIAL	1, 2

NOTES:

1. CONDUCTIVE GASKET SHALL BE 1/8" SILICON RUBBER MATERIAL WITH CRES OR COPPER-NICKEL WIRE FIBERS PROVIDING CONDUCTIVITY ACROSS THE THICKNESS DIMENSION.
2. THE MOUNTING SURFACES FOR THE GASKET SHALL BE CLEANED TO BRIGHT METAL AND COATED WITH ANTI-SEIZE COMPOUND OF MIL-T-22361 PRIOR TO INSTALLATION OF GASKET.
3. SPLIT SLEEVE INSTALLATION SHOWN IS AS DETAILED IN EIMB SERIES, NAVSEA 0967-LP-000-0110.

FIGURE 7. Waveguides grounding.



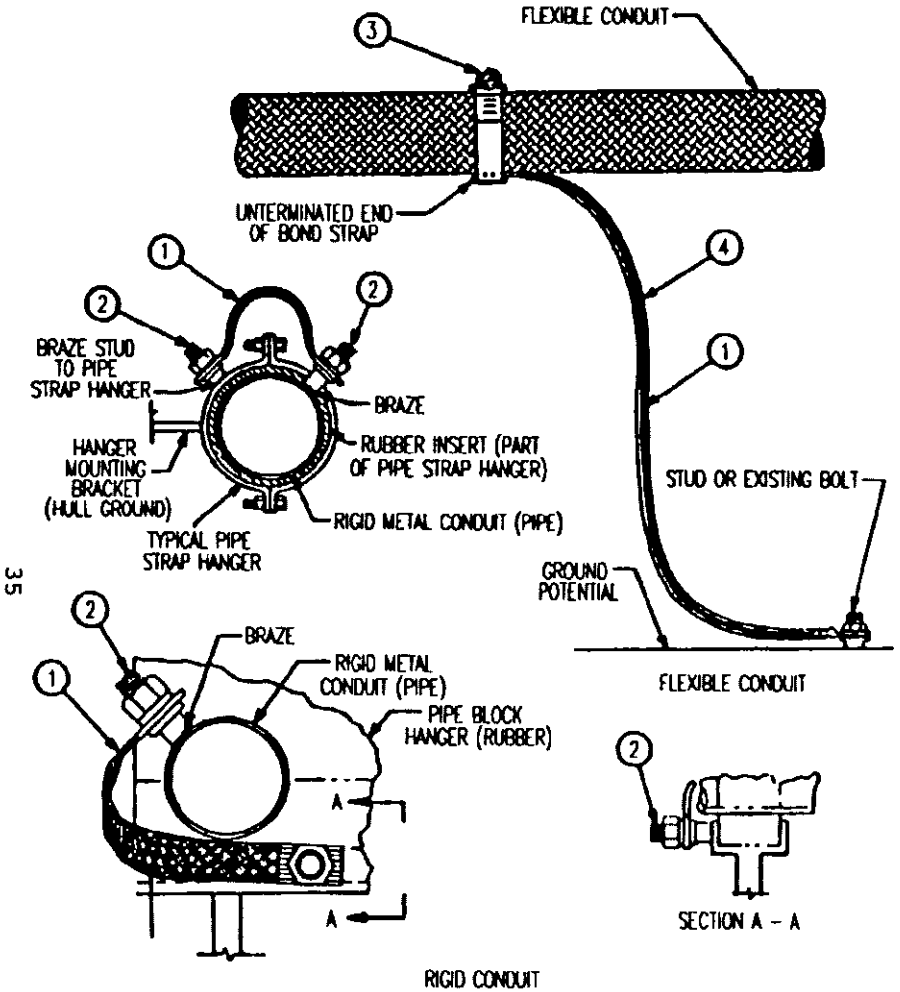
LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	CAPACITOR, P/N CRK05BX470K, 200V	MIL-C-39014/1	1, 2

NOTES:

1. INSTALL FILTER CAPACITORS AS SHOWN IN THIS FIGURE ONLY AS SPECIFIED IN 5.3.1.4. 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 HEADSETS.

FIGURE 8. EMI filter capacitor installation in sound powered telephone boxes.

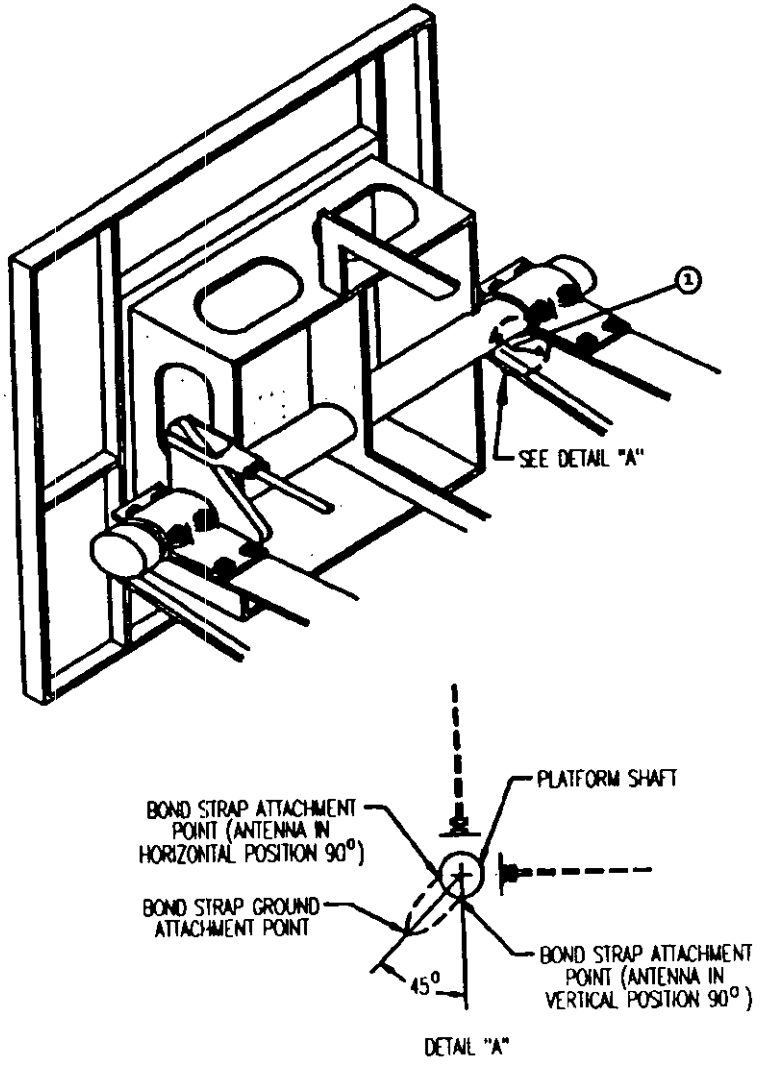


LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	BOND STRAP, TYPE IV		1, 2
2	STUD, COLLAR	MIL-S-24149	
3	CLAMP, HOSE	WW-C-440	
4	TUBING, PVC	MIL-I-631	4

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 IN 5.3.2.
2. FOR FLEXIBLE CONDUIT, BOND STRAP SHALL BE TYPE IV, EXCEPT ONE END SHALL NOT HAVE END TERMINAL ATTACHED. AREA WHERE BOND STRAP CONTACTS CONDUIT SHALL BE CLEANED TO BRIGHT METAL.
3. ALL BOND STRAP CONTACT AREAS SHALL BE PREPARED AS SPECIFIED IN 5.5.3.2 AND SHALL BE WEATHERPROOFED AS SPECIFIED IN 5.6.2.b.
4. BOND STRAPS MAY BE ENCASED IN CLEAR PVC TUBING.

FIGURE 9. Conduit grounding, submarines.

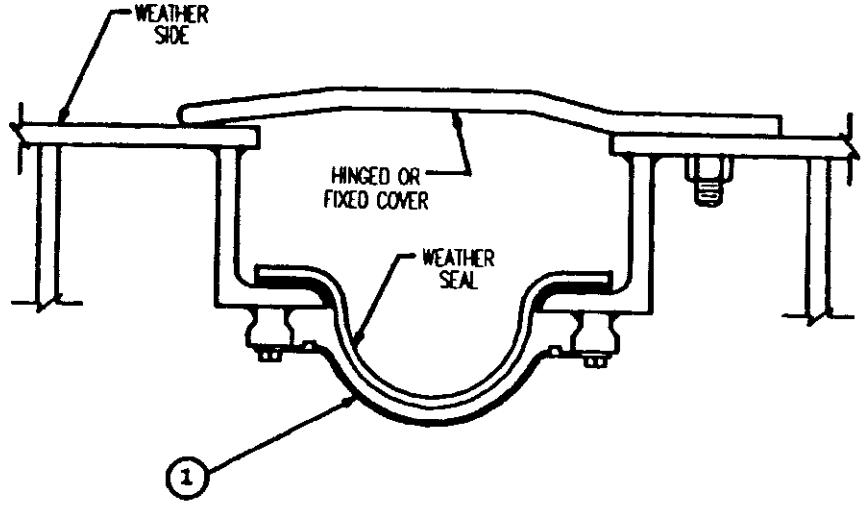


LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	BOND STRAP, TYPE I	MIL-S-24749	1

NOTES:

1. A TYPE I BOND STRAP SHALL BE INSTALLED ACROSS EACH BEARING JOINT. BOND STRAP INSTALLATION SHALL BE AS SPECIFIED IN 5.5.3.

FIGURE 10. Antenna tilt platform bonding.

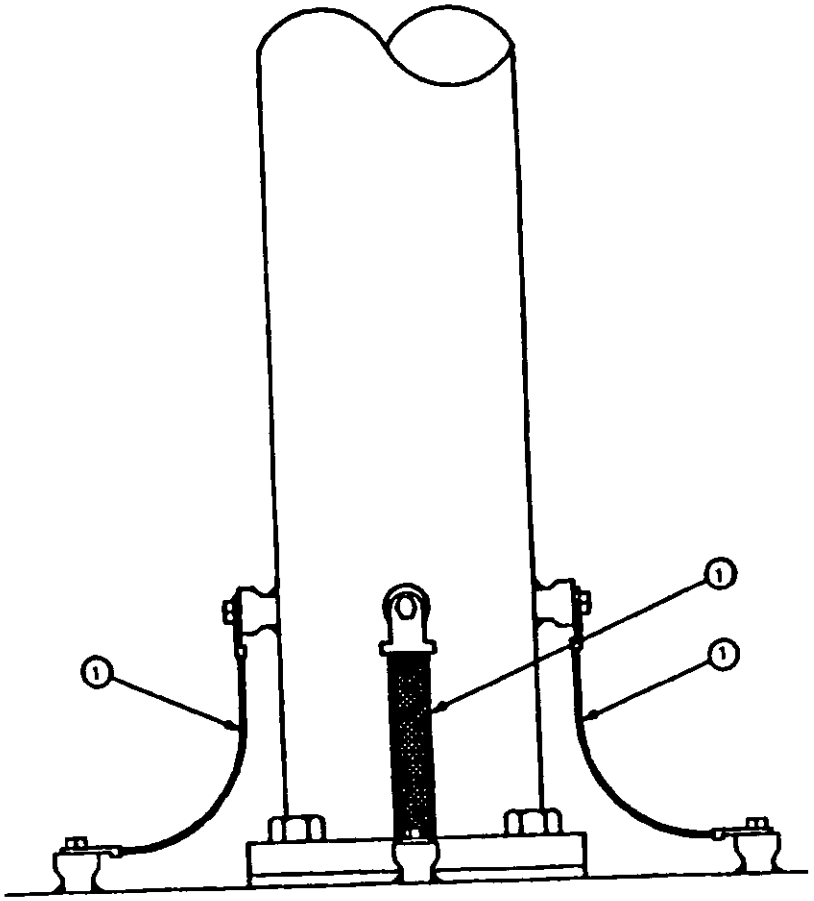


LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	BOND STRAP, TYPE I	MIL-S-24749	1,2

NOTES:

1. BOND STRAPS SHALL BE INSTALLED ACROSS EXPANSION JOINTS AT INTERVALS OF APPROXIMATELY 5 FEET AND SHALL BE LOCATED ON THE SIDE OF THE JOINT NOT EXPOSED TO THE WEATHER.
2. THE INSTALLATION OF EACH BOND STRAP SHALL BE AS SPECIFIED IN 5.5.3.

FIGURE 11. Expansion joint bonding.



LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	BOND STRAP, TYPE I	MIL-S-24749	1, 2, 3

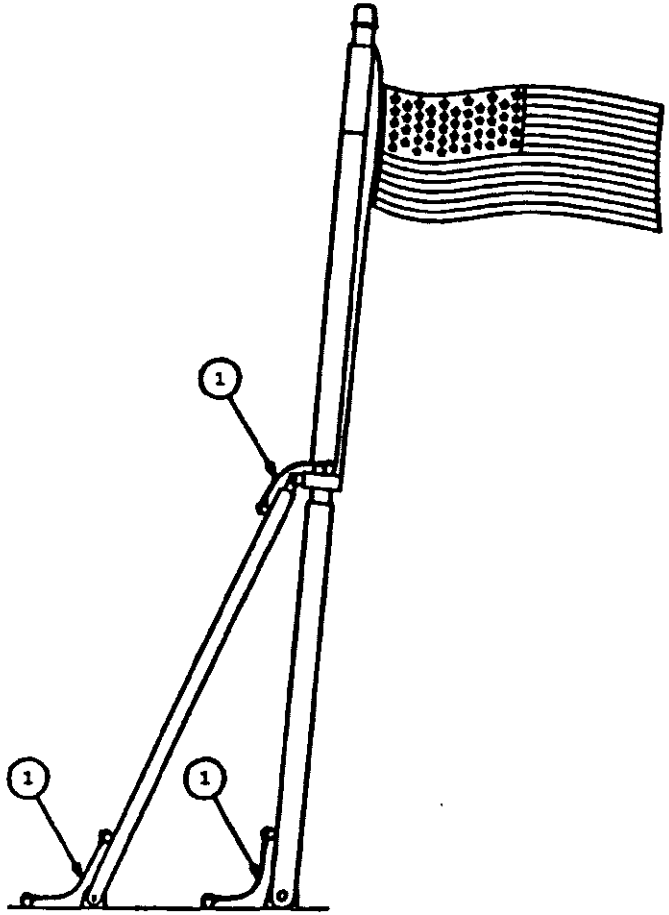
NOTES:

1. BOND STRAPS SHALL ONLY BE INSTALLED ON MASTS WHICH ARE BOLTED IN PLACE.
2. THE NUMBER OF BOND STRAPS INSTALLED SHALL BE 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

3. BOND STRAPS SHALL BE EQUALLY SPACED AROUND MAST.

FIGURE 12. Metallic mast bonding.

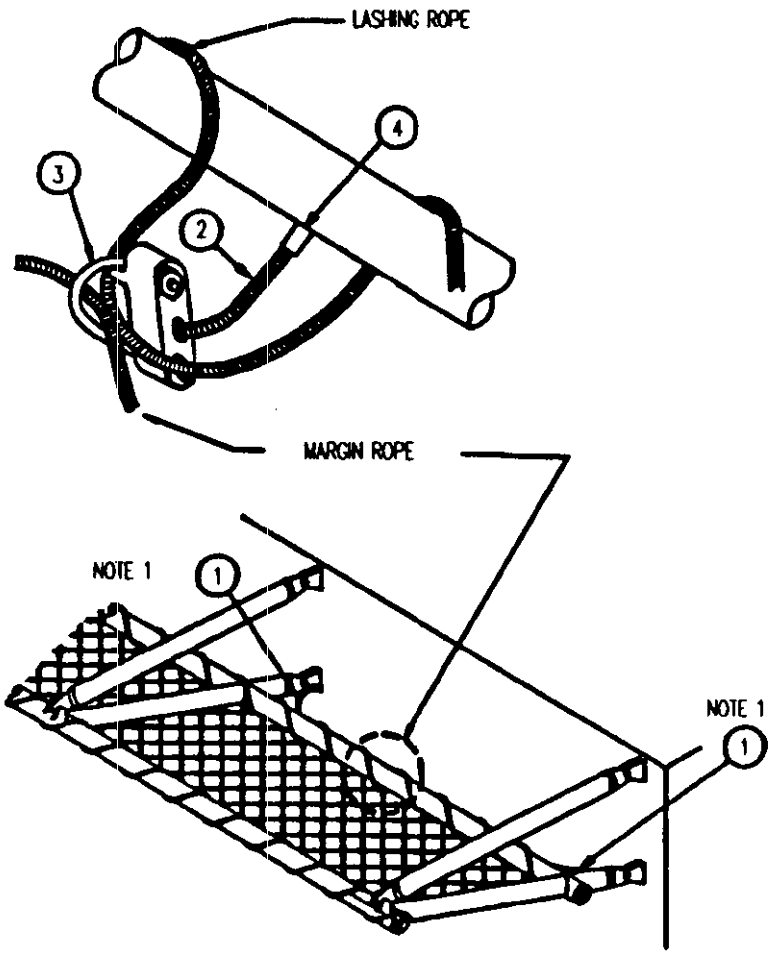


LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	BOND STRAP, TYPE I	MIL-S-24749	1

NOTES:

1. BOND ONLY AS SPECIFIED IN 5.3.3 AND 5.3.3.7.
2. WEATHERPROOFING OF BOND STRAPS SHALL BE PROVIDED AS SPECIFIED IN 5.6.2.

FIGURE 13. Metallic flagstaff and jackstaff bonding.

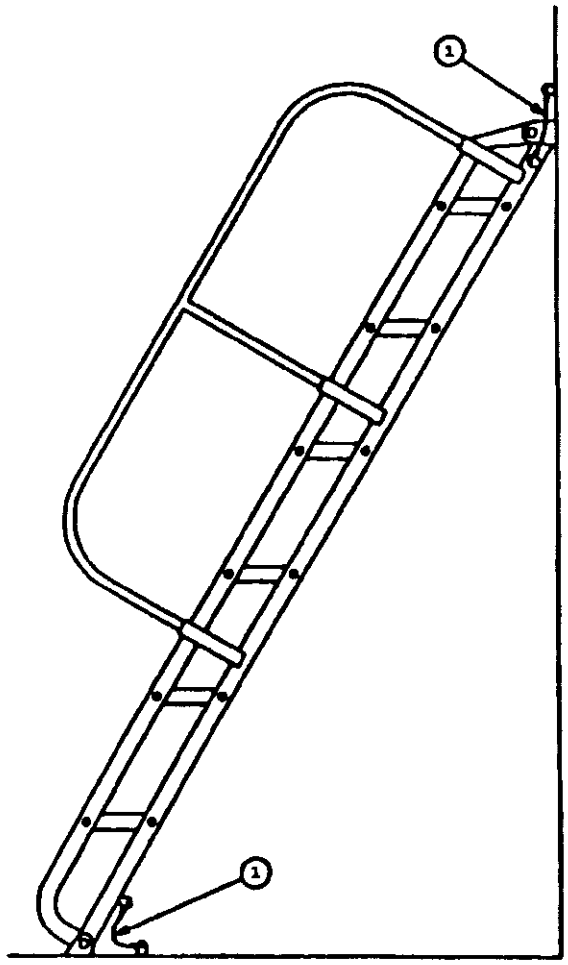


LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	BOND STRAP, TYPE I	MIL-S-24749	1, 2
2	CABLE, WELDING TYPE TRXF-84		1, 2, 3
3	CLAMP, WIRE, ROPE, SADDLED		3
4	LUG, ALUMINUM		2
5	LUG, CRES		2

NOTES:

1. BONDING OF NET FRAMES AND NETS SHALL ONLY BE ACCOMPLISHED AS SPECIFIED IN 5.3.3.d.
2. A TYPE I BOND STRAP SHALL BE INSTALLED ACROSS EACH NET FRAME HINGE. LENGTH OF BOND STRAP WILL BE CHOSEN TO ALLOW NETS TO RAISE AND LOWER WITHOUT INTERFERENCE. INSTALLATION SHALL BE AS SPECIFIED IN 5.5.3.
3. NETS SHALL BE BONDED TO NET FRAME USING A LENGTH OF TRXF-84 CABLE WITH LUG CRIMPED ON EACH END AND A WIRE ROPE CLAMP WELDED TO ONE LUG. THE RESULTING ASSEMBLY CAN BE CLAMPED TO THE MARGIN ROPE AND NET MATERIAL AND WELDED TO THE FRAME. A CRES LUG SHALL BE ATTACHED TO THE END TO BE WELDED TO THE CLAMP. THE LUG TO BE WELDED TO THE FRAME WILL BE ALUMINUM FOR ALUMINUM FRAME OR CRES FOR STEEL FRAME.

FIGURE 14. Metallic life and safety net bonding.

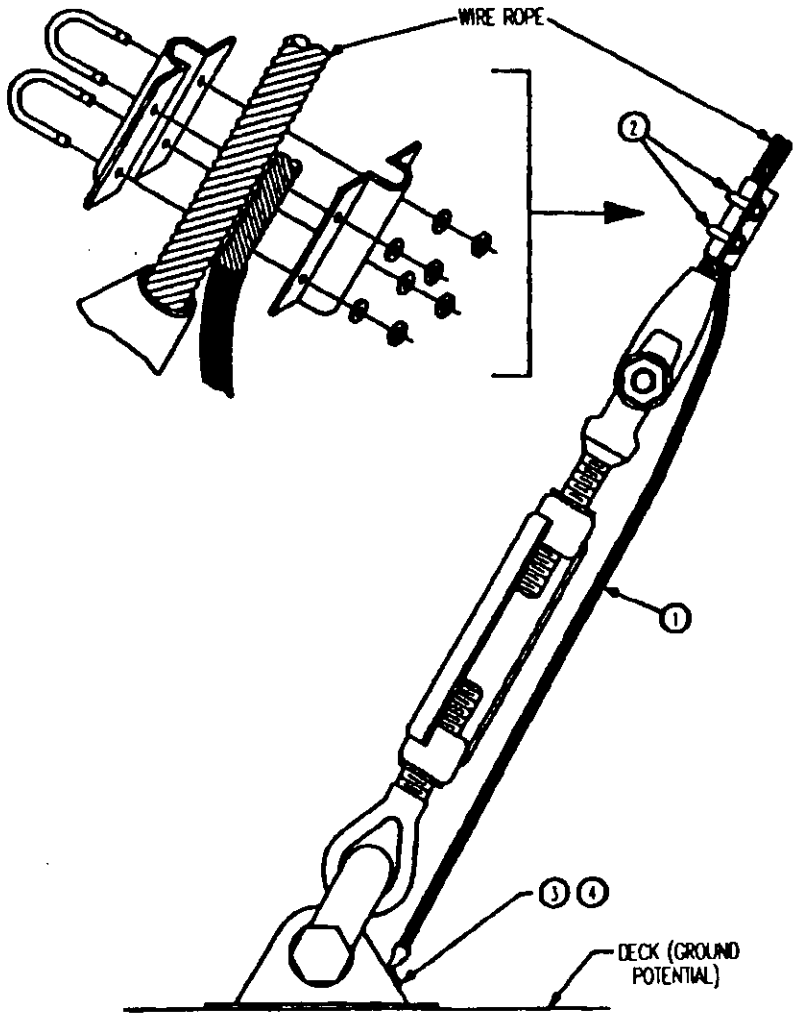


LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	BOND STRAP, TYPE I	MIL-S-24749	1

NOTES:

1. INCLINED-TREAD LADDERS SHALL BE BONDED TO GROUND POTENTIAL BY THE INSTALLATION OF A BOND STRAP ACROSS ONE TOP AND ONE BOTTOM MOUNT. WEATHER-PROOFING OF THE BOND STRAPS SHALL BE AS SPECIFIED IN 5.6.2.

FIGURE 15. Metallic inclined-tread ladder bonding.



LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	CABLE, WELDING, TYPE TRXF 84	MIL-C-915/21	1
2	U-BOLT ASSEMBLY	MADE LOCALLY	1
3	LUG, ALUMINUM		2
4	LUG, CRES		2

NOTES:

1. WELDING CABLE SHALL BE MEASURED AND CUT TO ALLOW MINIMUM 20% MOVEMENT OF TURNBUCKLE. A LUG SHALL BE ATTACHED TO ONE END OF THE CABLE AND THE OTHER END SHALL BE ATTACHED TO THE WIRE ROPE STAY AS FOLLOWS:

   A) STRIP 2 INCHES OF INSULATION FROM THE END OF THE TRXF-84 CABLE

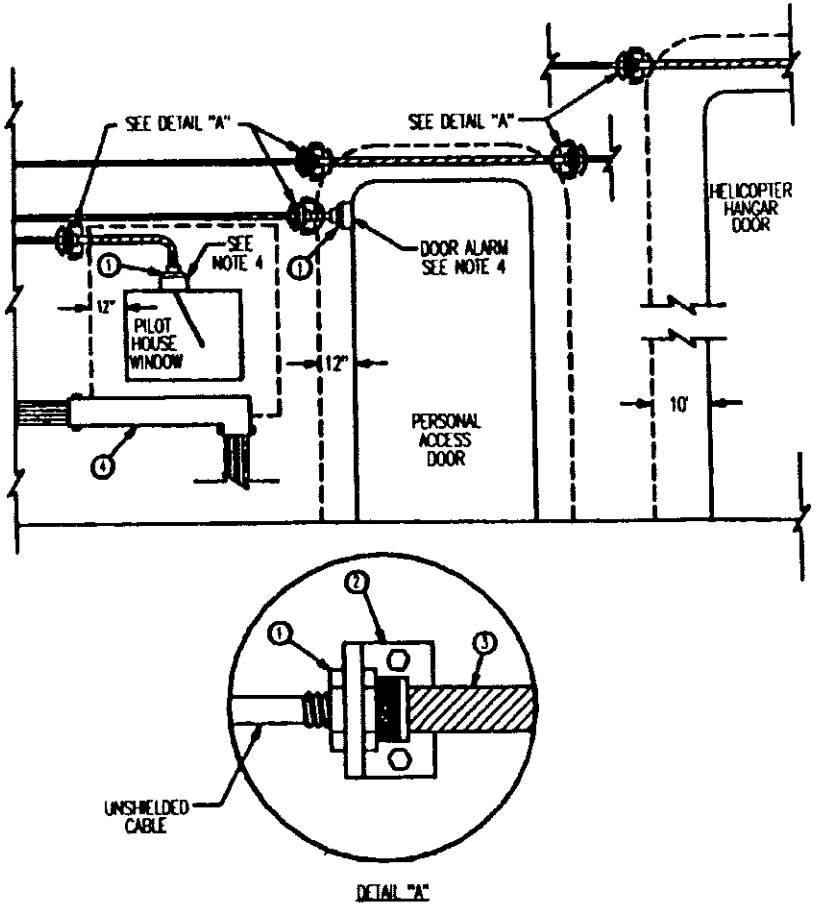
   B) CLEAN WIRE ROPE AT POINT OF CONTACT WITH BONDING CABLE AND APPLY MIL-T-22361 ANTI-SEIZE COMPOUND AT THESE LOCATIONS.

   C) CLAMP WELDING CABLE TO WIRE ROPE AND VERIFY PROPER INSTALLATION SPECIFIED IN 5.5.3.

   D) WEATHERPROOF AS SPECIFIED IN 5.6.2.

2. LUG SHALL BE SELECTED TO MATCH MATERIAL TO WHICH IT WILL BE WELDED. LUG SHALL BE ATTACHED TO EMPLOY ITS INHERENT WEATHERPROOFING CHARACTERISTIC. WEATHERPROOF U-BOLT ASSEMBLY AND WELDED LUG AS SPECIFIED IN 5.6.2.

FIGURE 16. Standing rigging bonding.



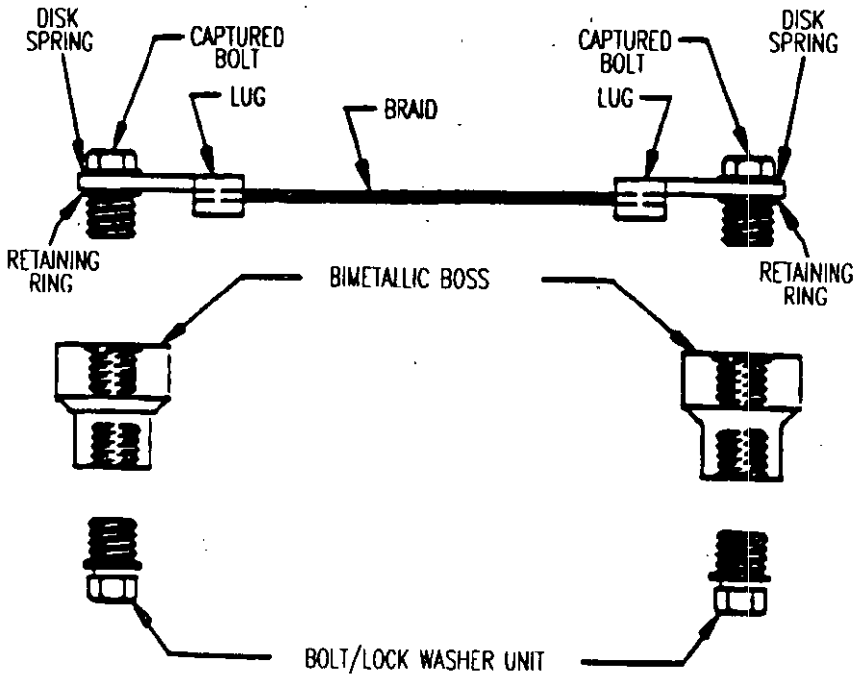
LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	FITTINGS, CONDUIT TERMINATION	MIL-C-24758	2
2	BRACKET, CONDUIT TERMINATION	PARA. 5.6.1	3
3	CONDUIT	MIL-C-24758	2, 4
4	TRUNK, WIREWAY	PARA. 5.4.2	2, 4

NOTES:

1. CABLES TERMINATING IN OR ROUTED THROUGH AREAS SPECIFIED IN 5.4.1 SHALL BE OVERALL SHIELDED OR SHALL BE ROUTED WITHIN PIPE, FLEXIBLE CONDUIT OR WIREWAY TRUNK.
2. CONDUIT AND TERMINATION FITTINGS SHALL BE AS SPECIFIED HEREIN. WIREWAY TRUNKS SHALL BE SHEET ALUMINUM AND SHALL BE THE MINIMUM THICKNESS REQUIRED FOR BENDING AND PHYSICAL SUPPORT.
3. CONDUIT TERMINATION BRACKETS SHALL BE FABRICATED LOCALLY AND SHALL PROVIDE GROUNDING FOR EACH CONDUIT END. BRACKETS SHALL BE CLASS A OR B BONDED TO GROUND.
4. DOOR ALARM BOXES, WINDSHIELD WIPER BOXES AND OTHER CABLE TERMINATION BOXES AND EQUIPMENT SHALL BE BONDED TO GROUND TO PROVIDE FOR THE TERMINATION OF CONDUIT. WIREWAY TRUNK SHALL ALSO BE BONDED TO GROUND.

FIGURE 17. Cable shielding methods, interior.

TOP VIEW

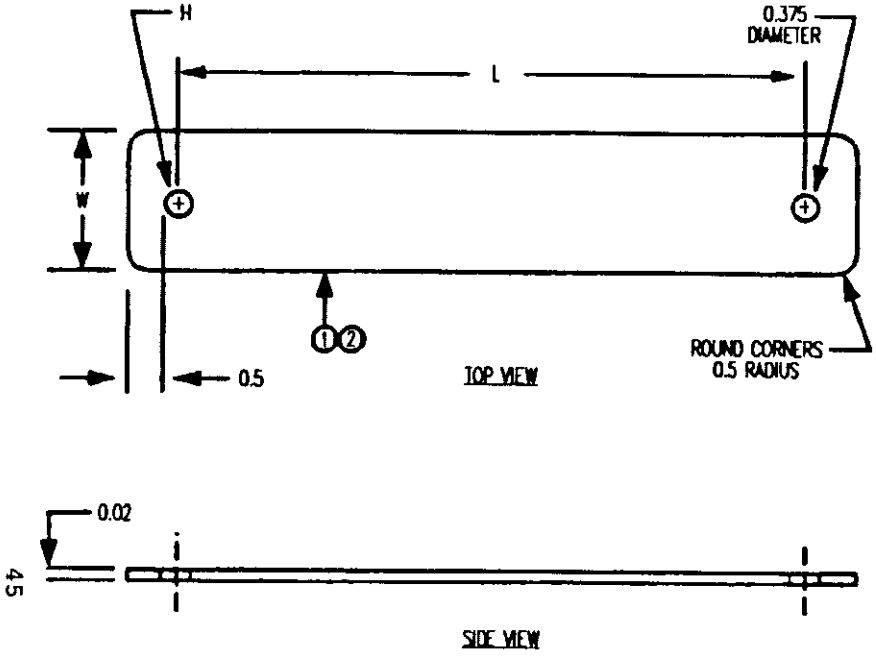


LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	BOND STRAP	MIL-S-24749	1
2	BOSS, ALUMINUM/COPPER NICKEL	MIL-S-24749	1, 2
3	BOSS, STEEL/COPPER	MIL-S-24749	1, 2

NOTES:

1. BOND STRAP AND BIMETALLIC BOSSES ARE NOT USUALLY FABRICATED AT SHIPYARDS.
2. SELECT BOSSES THAT CORRESPOND TO MATERIAL TO WHICH THEY WILL BE ATTACHED; ALUMINUM/COPPER NICKEL FOR INSTALLATION ON ALUMINUM SURFACES AND STEEL/COPPER NICKEL FOR INSTALLATION ON BRASS OR STEEL.

Figure 18. Type I bond strap assembly.



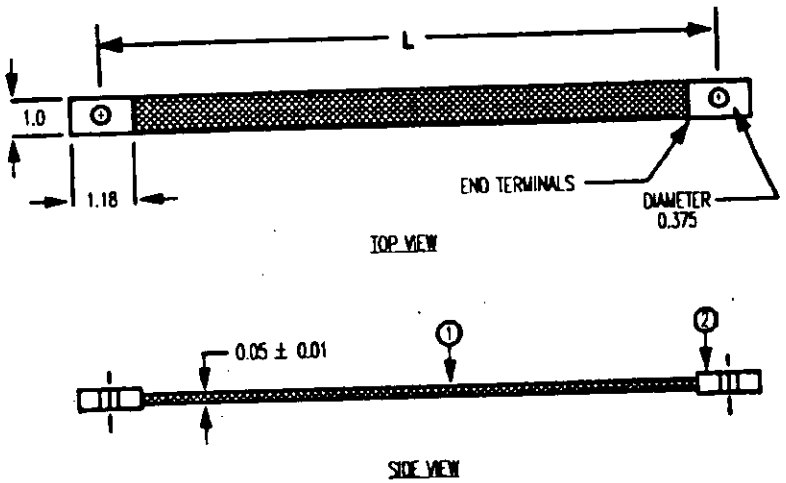
LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	FLAT CRES STOCK	QQ-P-35	1, 2 3
2	FLAT COPPER STOCK	ASTM B 152	1, 2 3

NOTES:

1. TYPE II BOND STRAP MATERIAL SHALL BE FLAT CORROSION RESISTANT STEEL (CRES) 316 AS SPECIFIED IN ASTM A 666, ANNEALED AND PASSIVATED IN ACCORDANCE WITH QQ-P-35.
2. TYPE III BOND STRAP MATERIAL SHALL BE FLAT COPPER IN ACCORDANCE WITH ASTM B 152.
3. LENGTH (L), WIDTH (W) AND HOLE DIAMETER (H) MAY BE SPECIFIED IN NON-STANDARD SIZES PROVIDED (L) IS NO MORE THAN FIVE TIMES (W) AND END TO END RESISTANCE DOES NOT EXCEED 0.1 ohm DC RESISTANCE.
4. ALL DIMENSIONS ARE IN INCHES.

STANDARD SIZES			
STANDARD SIZE CODE	L (LENGTH)	W (WIDTH)	H (HOLE DIAMETER)
A	3.0	1.0	0.375
B	6.0	1.5	0.375
C	9.0	2.0	0.375
D	12.0	2.5	0.375

FIGURE 19. Type II and III bond strap fabrication details.



LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	BRAID, WIRE, FLAT	QQ-B-575	1, 5
2	FLAT COPPER STOCK	ASTM B 152	2, 3 4, 5 6

NOTES:

1. TYPE IV BOND STRAP BRAID MATERIAL SHALL BE FLAT COPPER BRAID IN ACCORDANCE WITH QQ-B-575.
2. TYPE IV BOND STRAP END TERMINALS SHALL BE IN ACCORDANCE WITH ASTM B 152.
3. END TERMINALS SHALL BE 18.18 INCHES LONG BY 2.0 INCHES WIDE BEFORE BENDING.
4. END TERMINALS SHALL BE HOT TINNED DIPPED AND SHALL HAVE A COATING OF SOLDER ON ONE SIDE. EACH TERMINAL SHALL BE BENT 180 DEGREES WIDTHWISE, TO FIT THE BRAID, USING A .0625 INCH METAL PLATE AS A BEND TEMPLATE. THE SOLDER COATED SIDE SHALL BE ON THE INSIDE OF THE BEND.
5. BRAID MATERIAL SHALL BE FLUX COATED 1.0 INCHES ON EACH END. END TERMINALS SHALL BE HEATED AND COMPRESSED ONTO THE BRAID ENSURING GOOD SOLDER FLOW.
6. HOLES SHALL BE PUNCHED IN EACH END AFTER END TERMINAL INSTALLATION.
7. LENGTH (L) MAY BE SPECIFIED IN NON-STANDARD SIZES.
8. ALL DIMENSIONS ARE IN INCHES.

STANDARD SIZES			
STANDARD SIZE CODE	L (LENGTH)	W (WIDTH)	H (HOLE DIAMETER)
A	6.0	1.0	0.375
B	12.0	1.0	0.375
C	18.0	1.0	0.375

FIGURE 20. Type IV bond strap fabrication details.

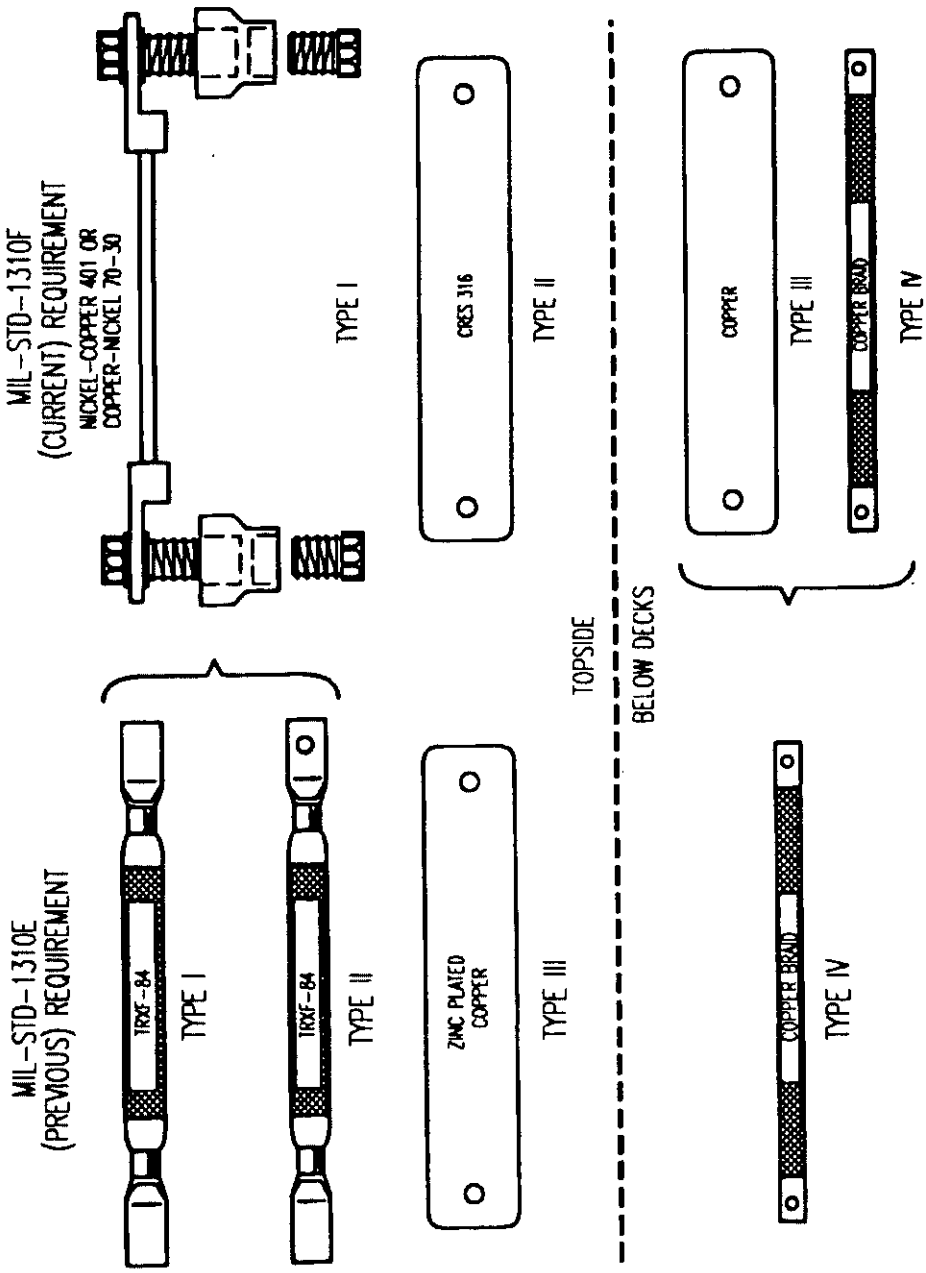
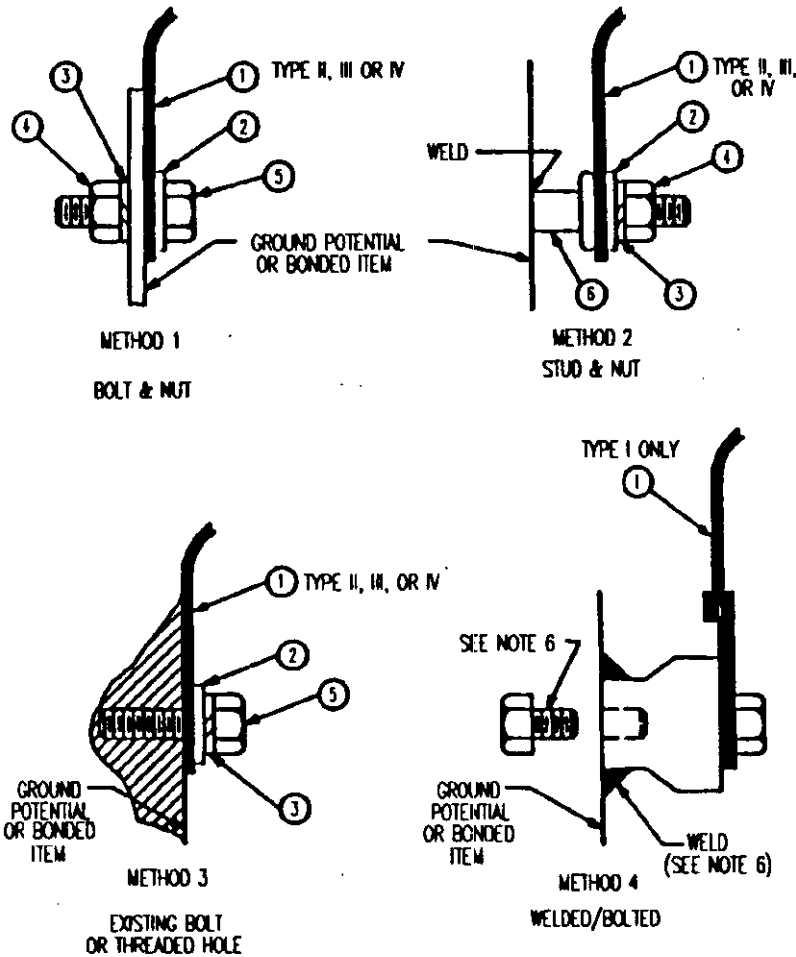


FIGURE 21. Bond strap replacement guide.



LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	BOND STRAP	MIL-S-24749	1, 2, 4
2	WASHER, FLAT	FF-W-92	5
3	WASHER, SPLIT	FF-W-84	5
4	NUT	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 STRAPS SHALL PROVIDE FOR A CLEAN METAL-TO-METAL CONTACT BETWEEN THE BOND STRAP AND THE MATING SURFACE AS SPECIFIED IN 5.5.3.2.
3. STUDS USED FOR BOND STRAP ATTACHMENT SHALL BE A COLLAR TYPE. TO PERMIT WELDING, STUD MATERIAL SHALL CORRESPOND TO THE MATING SURFACE MATERIAL; ALUMINUM STUDS FOR ATTACHMENT TO ALUMINUM SURFACES AND STEEL STUDS FOR ATTACHMENT TO STEEL SURFACES.
4. BOLTED BOND STRAP CONNECTIONS SHALL BE PREPARED AND WEATHERPROOFED AS SPECIFIED IN 5.5.3.3 AND 5.6.2.
5. INSTALLATION HARDWARE MATERIAL SHALL BE AS SPECIFIED IN 5.5.3.1.
6. THE BOSS OF TYPE I BOND STRAPS MAY BE BOLTED IN PLACE ON EQUIPMENT WHERE WELDING CANNOT BE ACCOMPLISHED. BOLT LENGTH IS CRITICAL. USE BOLT SUPPLIED WITH BOSS. BOLT SHALL NOT CONTACT BOTTOM OF BOSS THREADED SOCKET.

FIGURE 22. Methods of attaching bond straps.

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I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER	2. DOCUMENT DATE (YYMMDD)
	MIL-STD-1310F(NAVY)	1992 December 30

3. DOCUMENT TITLE SHIPBOARD BONDING, GROUNDING, AND OTHER TECHNIQUES FOR ELECTROMAGNETIC COMPATIBILITY AND SAFETY

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)*

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME (Last, First, Middle Initial)	b. ORGANIZATION	
c. ADDRESS (Include Zip Code)	d. TELEPHONE (Include Area Code) (1) Commercial (2) AUTOVON (If applicable)	7. DATE SUBMITTED (YYMMDD)

8. PREPARING ACTIVITY

a. NAME	b. TELEPHONE (Include Area Code)	
TECHNICAL ENGINEER: Mr. Ron Bradley, SEA 06K231	(1) Commercial (703) 602-2549	(2) AUTOVON 332-2549
c. ADDRESS (Include Zip Code) Commander, Naval Sea Systems Command ATTN: SEA 05Q42, 2531 National Ctr., Bldg 3 Washington, DC 20362-5160	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466 Telephone (703) 756-2340 AUTOVON 289-2340	