INCH-POUND

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SUPERSEDING
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30 DECEMBER 1992

DEPARTMENT OF DEFENSE

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

AMSC N/A **AREA EMCS**

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 (NAVSEA), 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 electrical and electronic equipment aboard naval ships introduces electromagnetic interference (EMI) problems to ship operation and performance. As systems are added, they all contribute and become susceptible to an intense electromagnetic environment (EME). Considering the corrosive salt water environment in which ships must operate and the interaction of a ship's electrically conductive metallic superstructure, topside hardware, antenna systems, etc., the potential for interoperability problems is significantly increased. Potential EMI and personnel safety problems related to electronic equipment operating in these environments are magnified because of: (a) the need to establish and maintain a low impedance (Z), common reference ground for all electrical/electronic equipment, and (b) the detrimental effects of: (1) natural and manmade, (2) spurious and intentional, (3) off-ship and own-ship, electromagnetic (EM) energy.

4. To provide for shipboard EM compatibility (EMC) and safe operation, this revision of MIL-STD-1310 has been expanded to provide additional requirements and guidance for EMI prevention and safe operation in the following EM environmental effects (E^3) areas of concern.

- The ship's common ground plane
- Hull-generated EMI control
- Hull-penetration EMI
- Cable and case penetration/radiation EMI
- Superstructure blockage/reflections, EM signature reduction
- Equipment-generated EMI prevention
- Electrical safety ground

5. This document does not specify EMI reduction through frequency selection, limits on operating power, or use of blankers, and specifies or recommends only limited requirements related to equipment design, location and multicoupler use. Grounding for personnel safety continues to be a major part of this military standard, particularly in regard to commercial-off-the-shelf (COTS) equipment and non-developmental items (NDI). A separate appendix is included herein with procedures to identify whether COTS/NDI equipment meets appropriate safety requirements herein before use, and to provide direction to bring them into conformance when necessary. This document does identify the E^3 inspection and test procedures that can be used as measures of effectiveness of the EM control and personnel safety measures when installed/implemented.

6. Recent Department of Defense (DoD) acquisition policy changes encourage contractor innovation, introduction of advancing technology, and determination of the appropriate methods and materials to be used for all DoD acquisitions. This document implements this policy by use of the permissive "should" in many areas where the mandatory "shall" previously was used. Many effective shipboard EMI control measures and materials have been identified by the government and subsequently specified as requirements for ship construction and availabilities. Mandating compliance works to the possible exclusion of equally effective industry-developed solutions. To avoid that possibility, when appropriate, this document defines EMC and safety requirements; presents yesterday's (proven effective) solution(s) which have met them, but allows the contractor an option to innovate a new solution by use of the permissive "should." Because the appropriate performance demonstration inspections and tests have been identified herein, whichever method/material is used, its effectiveness in meeting the requirement can be determined.

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1. SCOPE

1.1 Scope. This document specifies the performance requirements for shipboard bonding, grounding and shielding; identifies requirements for EMI control in the areas of hull-generated and equipment-generated EMI, hull and cable penetration EMI, and superstructure blockage/reflections; specifies requirements for protection of personnel from electrical shock, and identifies the applicable requirements for measuring the effectiveness of EMI control and safety measures implemented when requirements herein are invoked.

1.2 Application. The requirements specified herein apply to metal and non-metallic hull ships and are applicable during ship construction and ship overhaul, alteration or repair availabilities. Requirements herein may be invoked upon contractor and government (military and civilian) personnel.

1.3 Tailoring. The requirements herein may be subject to deletion tailoring, such that only those items that pertain to a specific ship are specified in the solicitation or contract. Due to cost impact:

a. The shielding provisions for electromagnetic pulse (EMP) protection herein are to be implemented only when specified, and

b. Replacement of bond straps with later approved versions is not recommended or required, unless inspection or testing indicates a need for such action.

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	-	Washers, Flat (Plain).

MILITARY

MIL-A-907	-	Antiseize Thread Compound, High Temperature.
MIL-S-1222	-	Studs, Bolts, Hex Cap Screws, Socket Head Cap Screws, and Nuts.
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-S-24235	-	Stuffing Tubes, Metal, and Packing Assemblies for Electric Cables, General Specification for.
MIL-C-24643	-	Cable and Cords, Electrical, Low Smoke, for Shipboard Use, General Specification for.
MIL-DTL-24749	-	Grounding Straps and Bosses, Electro-magnetic (Inch-Pound), General Specification for.

SPECIFICATIONS (Continued)

MILITARY (Continued)

MIL-C-24758	-	Conduit, Flexible, Weatherproof, and Associated Fittings General Specification for.
MIL-S-45180	-	Sealing Compound, Gasket, Hydrocarbon Fluid and Water Resistant.

STANDARDS

MILITARY

DOD-STD-1399-406	-	Interface Standard for Shipboard Systems Section 406 Digital Computer Grounding (Metric).
MIL-STD-882	-	System Safety Program Requirements

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 03K23, 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.)

DRAWINGS (Continued)

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

0910-LP-003-9770	-	Navy Installation and Maintenance Book (NIMB), CD-ROM volume
S9086-CH-STM-010	-	Naval Ships Technical Manual • Chapter 300, Electric Plant/General • Chapter 074, Welding and Allied Processes.

(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)
A 312	-	Standard Specification for Austenitic Stainless Steel Pipe
A 580	-	Standard Specification for Austenitic Stainless Steel
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. Where conflicts exist between the requirements of this document and other publications, specifications, standards, or drawings, NAVSEA should be notified.

3. DEFINITIONS

3.1 Acronyms used in this standard. The acronyms used in this standard are defined as follows:

AGC	-	Automatic gain control
ASTM	-	American Society for Testing and Materials
AVC	-	Automatic volume control
BBN	-	Broadband noise
CID	-	Commercial item description
COTS	-	Commercial-off-the-shelf
CRES	-	Corrosion-resistant steel
DC	-	Direct current
DoD	-	Department of Defense
DoDISS	-	Department of Defense Index of Specifications and Standards
E^3	-	Electromagnetic environmental effects
EM	-	Electromagnetic
EMC	-	Electromagnetic compatibility
EME	-	Electromagnetic environment
EMI	-	Electromagnetic interference
EMP	-	Electromagnetic pulse
HF	-	High frequency
ICD	-	Installation control drawing
IEMC	-	Industrial electromagnetic compatibility
IMI	-	Intermodulation interference
IOIC	-	Integrated Operational Intelligence Center
LF	-	Low frequency
MF	-	Medium frequency
MHz	-	Megahertz
NAEC	-	Naval Air Engineering Center
NAVSEA	-	Naval Sea Systems Command
NDI	-	Non-developmental item
NFPA	-	National Fire Protection Association
NSTM	-	Naval Ships Technical Manual
NTDS	-	Naval Tactical Data System
PCI	-	Pulse current injection
RAM	-	Radar absorbent material
RF	-	Radio frequency
SCI	-	Signal current injection
SDO	-	Standards development organization
SE	-	Shielding effectiveness
SSS	-	System Safety Society
TDB	-	Test Documentation Booklet
TPD	-	Terminal protection device
TSTP	-	Total Ship Test Program
TSTRs	-	Total Ship Test Requirements
UHF	-	Ultrahigh frequency
UL	-	Underwriters Laboratories
VDE	-	Verbad Deutscher Elektrotechniker (German Institute of Electrical Engineers)
VHF	-	Very high frequency
Z	-	Impedance

3.2 Bond-Bonding (electrical). An electrical bond is a conductive (electrical current) path between two metallic surfaces established by welding, bolting/clamping, or addition of a bond strap. Bonding is the act of creating the bond.

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

Class A - Metallic surfaces bonded by welding or brazing.

Class B - Metallic surfaces bonded by bolting or clamping.

Class C - Metallic surfaces bonded by bridging them with a metallic (conductive) bond strap.

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

Type I - CRES 316 1/4-inch wire rope with lugs of CRES 316L SCHED 80S pipe. (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.

3.5 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.

3.6 Broadband noise (BBN). EM interference that has the spectral energy distributed over a wide frequency in relation to the frequency bandwidth of the equipment receiving the interference. Broadband noise interference is broadly tunable and will exist over all or a portion of the tuning range of an affected receiver.

3.7 Commercial-off-the-shelf (COTS). COTS equipment is any item that can be purchased through commercial retail or wholesale distributors as is, for example; equipment that is available as a catalog item.

3.8 Computer ground system. A separate hardwired ground system installed in accordance with DoD-STD-1399-406 to isolate the power supplies of shipboard digital systems such as the Navy Tactical Data System (NTDS) and Integrated Operational Intelligence Center (IOIC) from EMI and power line transients generated in other electrically-powered systems on board (see Electrical surge suppressor).

3.9 Conduit. Conduit is a metal enclosure, normally of circular construction, used as EM 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.

3.10 Electrical surge suppressor, marine type. A power line conditioning device to protect vulnerable electronic equipment from common mode and normal mode voltage and current transients generated in other electrically-powered on board systems sharing electrical power lines (as opposed to a separate power line/ground system per 3.8 above).

3.11 Electromagnetic compatibility (EMC). The ability of electronic/electrical equipment, subsystem and systems to operate in their intended operational environments without suffering or causing unacceptable degradation because of EM radiation or response.

3.12 Electromagnetic environmental effects (EME). The resulting product of the power and time distribution, in various frequency ranges, of the radiated or conducted EM emission levels that may be encountered by a military force, system or platform when performing its assigned mission in its intended operational environment.

3.13 Electromagnetic interference (EMI). EMI is EM energy which interferes with the detection and analysis of a desired signal, or which causes an equipment malfunction.

3.14 Electromagnetic pulse (EMP). A short duration, high intensity pulse resulting from the detonation of a nuclear device in the exosphere.

3.15 Ground (ground potential). A point, plane, or surface designated as the zero potential (nominally) common reference point for electrical or electronic equipment.

3.16 Ground loop. More than one path to ground for an equipment or system such that designated ground is not maintained at a common (zero voltage) potential; normally caused by multipoint grounding. Lack of a common reference point (ground) results in common mode (interference) currents in the ground loop.

3.17 Ground, personnel safety. Bonding of electrical and electronic equipment cabinets, cases, housings and exposed metal (conductive) components to ground potential by any class bond described herein, or by the installation of a ground wire to establish a contact resistance of 0.1 ohm or less.

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

3.19 Ground, 360 degrees (peripheral). A continuous metal-to-metal bond, existing or provided, around the outer perimeter of a metallic item or cable shield terminating at or penetrating through a metal surface that is at ground potential.

3.20 Grounding. The process of bonding a metallic item to ground potential.

3.21 Intermodulation interference (IMI). The production in a nonlinear element of frequencies equal to the sums and differences of integral multiples of two or more frequency sources which cause EMI in another equipment or system. The nonlinear element may be internal or external to electronic systems.

3.22 Maintenance-related EMI. A designation assigned to EMI problems that can have severe, medium or mild mission area impact, but have been proven to result from improper installation or inadequate maintenance. Proper installation and continuing maintenance will prevent maintenance-related EMI from affecting operations.

3.23 Mobile-transportable electrical equipment. Mobile-transportable electrical equipment is any equipment that: (a) can be moved from place-to-place for use, (b) (normally) remains stationary while in use, and (c) is powered by a plug-in power cord versus being hard-wired to the electrical supply.

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

3.25 Non-developmental item (NDI). NDI equipment is any item not requiring development. NDI can be COTS, ruggedized, or militarized. NDI may include any of the items specified in a through d:

a. An item of supply that is available in the commercial marketplace.

b. A previously developed item of supply that is in use by a department or agency of the United States Government, a state or local government, or a foreign government with which the United States has a mutual defense cooperation agreement.

c. An item described in a or b above that requires only minor modification to conform to the procuring agency's requirements.

d. An item currently being produced that does not conform to requirements specified in a through c above solely because the item is not yet in use, or not yet available in the commercial marketplace.

3.26 Non-topside areas. Areas inside the hull or superstructure of a ship, a deck mounted shelter, or an enclosure not exposed to weather.

3.27 Portable equipment. Portable equipment is any equipment easily moved from place-to-place for use and (normally) capable of being hand-held while in operation.

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

3.29 Shielded area. Area not directly exposed to EM energy. 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.

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

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

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

4. GENERAL REQUIREMENTS

4.1 Performance requirements. The following shipboard EMI control bonding, grounding, and other techniques for EMC and safety shall be installed or implemented and maintained as necessary for optimized electrical and electronic system performance and safe operation.

4.1.1 Grounding; ship's ground potential. On both metallic and nonmetallic hull ships, ground potential shall be established and maintained in accordance with 5.1.1 as required for electrical and electronic equipment operation, EMC, and electrical safety grounding.

4.1.1.1 Common reference ground plane. Any metallic item, such as; sheet metal, flat stock, stranded or solid conductor cable, etc., that is class A bonded (welded or brazed) to ground potential in accordance with 5.1.2 shall be designated as an element of the ship's ground plane.

4.1.1.2 Class B and class C bonding and grounding for EMC. Electrical and electronic equipment shall be class B or class C bonded to the ground plane. Minimum direct current (DC) resistance and RF impedance (Z) shall be established across all class B and class C bonding and grounding junctions.

4.1.1.2.1 Metal-to-metal contact at bonded junction(s). Metal-to-metal contact at all class B and class C bond mating surfaces shall be established as required to attain and maintain minimum DC resistance and RF impedance, as follows:

a. DC resistance. The DC resistance across bonding and grounding junctions shall not exceed 0.1 ohm for electrical safety.

b. RF Impedance. The RF impedance across bonding and grounding junction(s) shall not exceed 25 ohms at 30 megahertz (MHz) (see 6.4).

4.1.1.2.2 Preservation of bolted mating surfaces. All metallic mating surfaces that are bolted together to form a class B or class C bond shall be sealed and preserved to prevent contamination and deterioration from environmental factors, such as; seawater, salt air, stack gas, etc., and to maintain bond effectiveness between scheduled maintenance availabilities.

a. Installing activities option. Unless the procedure to be used is specified in an installation control drawing (ICD) or other directive, surface preparation and preservation procedures used to meet 4.1.1.2.1a and 4.1.1.2.1b (above) shall be at the option of the installing activity.

b. Advancing technology. Introduction of advancing technology and innovation in the areas of shipboard system installation, corrosion control procedures and preservation materials is encouraged.

c. Appendix A. Appendix A provides guidelines and suggested procedures which may be used for surface preparation, installation and preservation.

4.1.1.2.3 Bond strap installation. Bond straps shall be installed using methods that permit inspection and removal and reinstallation or replacement when required. They shall be installed such that: vibration, expansion, contraction, or relative movement incident to normal service shall not break or loosen the bond strap connection.

a. Topside installation. Type I and II bond straps only shall be installed topside.

b. Below decks installation. Type III and IV bond straps shall be installed in below decks locations.

c. Structural integrity and motion. Installations of bond straps shall not affect the integrity of equipment cases, cabinets or enclosures. They shall not:

(1) Weaken any structure or item to which a bond strap is attached, or
(2) Restrict the movement of any hinged or movable item.

d. Mounting studs, bolts and holes. When available and in good condition, existing studs, bolts, or threaded holes shall be used for Type II, III and IV bond strap installation.

4.1.2 Hull-generated EMI. To prevent harmful EMI caused by nonlinear or intermittent metal-to-metal contact junctions in the topside EME, the ship's topside areas shall be, as nearly as possible, a single conducting surface free of all pinned, snap-linked, chain-linked, or other metallic discontinuities that might act as source(s) of IMI and BBN. Hull-generated EMI control measures shall be implemented in accordance with the general control requirements listed below and the detailed requirements specified in 5.2.

a. Metal-to-metal contact junctions in the topside EME should be avoided by use of nonmetallic substitutes when available.

b. Metal-to-metal contact junctions, where movability or removability is not a requirement, should be class A bonded.

c. Metal-to-metal contact junctions, where movability or removability is a requirement, should be class B or class C bonded to provide a low impedance current path around the junction.

d. The joining of dissimilar metals by bolting or riveting should be avoided in topside areas.

e. Except for anchor and anchor holding, metal chain shall not be installed in topside areas.

f. Loose metallic items, such as pipes, cables, and portable rigging should not be stowed, stacked, or lashed down in topside areas.

4.1.3 Hull and cable penetration EMI. Harmful EM radiations intruding past shielding boundaries established by the hull, shielded compartments, and cable shields shall be prevented in accordance with 5.3

4.1.3.1 Cable shielding. EM shielding for cables that must be routed in ship topside areas exposed to EM energy shall be provided by routing them within: (a) the metallic mast, (b) the skin of the ship, or (c) a metal enclosure such as a wireway trunk or conduit until within the skin of the ship.

4.1.3.2 Hull penetrations. Cables, conduit, waveguide and pipes penetrating the hull (or shielded compartments) shall be treated to prevent topside EME energy intrusion (hull penetration EMI) through the skin of the ship into below decks spaces and equipment.

4.1.4 Superstructure blockage and reflections. Mast/superstructure construction practices and materials shall be implemented in general compliance with 5.4 as required to prevent harmful reflections, false target generation and degraded system performance resulting from antenna-structure coupling.

4.1.5 Equipment-generated EMI prevention.

4.1.5.1 Equipment-generated IMI. Low frequency (LF), medium frequency (MF), high frequency (HF), very high frequency (VHF), and ultrahigh frequency (UHF) receiving equipment should be connected to associated antennas via protective devices in general conformance with 5.5 to preclude equipment-generated IMI.

4.1.5.2 BBN suppression; portable electrical tools. Arc suppression filters shall be provided across the commutator/brushes of all electric motor-driven tools.

4.1.6 Electrical safety; personnel shock hazard prevention. Electrical and electronic equipment operated from an external electrical power source of 30 volts or more shall be grounded to provide electrical shock hazard protection integral to the equipment (see 5.6 and Appendix B).

4.2 Performance demonstration. Effective shipboard bonding, grounding and other techniques for EMC and safety shall be demonstrated in accordance with the testing requirements of the NAVSEA Total Ship Test Program (TSTP) and the inspections and tests specified in the construction Test Documentation Booklet (TDB) or the availability Total Ship Test Requirements (TSTRs) list.

4.2.1 Ground plane and hull-generated EMI control. Effectiveness of the ship's ground plane and effective IMI and BBN control shall be demonstrated in accordance with visual inspections and system readiness, IMI/BBN recognition and discovery tests when specified in the TDB/TSTRs list.

4.2.2 Hull-penetration EMI. Effective hull-penetration EMI control shall be demonstrated in accordance with Pulse Current Injection (PCI) or Signal Current Injection (SCI) test(s) when specified in the TDB/TSTRs list.

4.2.3 Cable and case penetration/radiation EMI. Effective cable/case penetration and radiation EMI control shall be demonstrated in accordance with system visual inspections, EMI recognition and discovery test(s) when specified in the TDB/TSTRs list.

4.2.4 Superstructure blockage/reflections, EM signature reduction. Effective superstructure blockage/reflections control and EM signature reduction shall be demonstrated in accordance with a topside visual inspection and system readiness and discovery testing when specified in the TDB/TSTRs list.

4.2.5 Equipment-generated IMI prevention. Effectiveness of the narrowband filters, tuning circuitry and multicouplers for prevention of equipment-generated IMI shall be demonstrated in the course of the IMI recognition and source location test(s) when specified in the TDB/TSTRs list.

4.2.6 Electrical safety ground. Effective electrical safety grounding shall be demonstrated in accordance with visual inspection(s), continuity, and other electrical safety test(s) when specified in the TDB/TSTRs list.

5. DETAILED REQUIREMENTS

5.1 Ground potential and ship's ground plane(s).

5.1.1 Ground potential.

5.1.1.1 Ground potential for metallic hull ships. On metallic hull ships, the metal hull, when in contact with the water, shall establish and be designated as ground potential.

5.1.1.2 Ground potential for nonmetallic hull ships. On nonmetallic hull ships, ground plate(s), installed to provide an earth ground connection via contact with sea water, shall be installed to establish ground potential.

5.1.1.2.1 Ground plate location. On nonmetallic hull ships, the ground plate(s) shall be installed at the lowest point of the structural hull, as close as possible to the vertical of the mast.

5.1.1.2.2 Connection of the cable ground system. A throughbolt shall be brazed to each ground plate to provide a connection point for installation of the cable grounding system ground plane (see Appendix C).

5.1.2 Ground plane(s). For both metallic and nonmetallic hull ships, all class A bonded (welded or brazed) extensions to ship's ground potential, topside and below decks, shall be designated as the ship's ground plane.

5.1.2.1 Elements of the ground plane. The following should be class A bonded to ground potential to form elements of the ground plane.

5.1.2.1.1 Superstructure, equipment foundations and racks. Metallic superstructure, equipment foundations and racks (not shock mounted), and mounting studs or brackets to which equipment is bolted for installation should be class A bonded to ground potential.

5.1.2.1.2 Cable grounding system's branches. Cable grounding system's branches and branch extensions connected to or terminating at the ground plate(s) of a nonmetallic hull ship's ground plane (see 5.1.1.2.2 above) should be class A bonded to ground potential.

5.1.2.1.3 Shielded room(s). Shielded room(s) on nonmetallic hull ship's should be class A bonded to the ground plate(s) via the cable ground system, as necessary, to maintain the shielding boundaries at ground potential.

5.1.2.1.4 Computer ground system. Installation of a separate computer ground system in accordance with DoD-STD-1399-406 should be specified for hard-wired shipboard digital computer equipment to isolate the power supplies of major digital systems such as the Navy Tactical Data System (NTDS) and Integrated Operational Intelligence Center (IOIC) from other electrically-powered systems on board.

5.1.2.2 Grounded items. Equipment and hardware that is class B or class C bonded to the ship's ground plane (see 5.1.3) shall be designated as grounded, but not as an element of the ground plane for grounding other items.

a. Stacked (cascaded) grounding. Items that are class B or class C bonded to the ground plane (i.e.; grounded) shall not be used as a tie point to ground potential (i.e.; the ground plane) for subsequent items.

b. Bond strap and grounding wire routing. All bond straps and grounding wires bonded to the ground plane shall be directly routed and as short as practical.

5.1.2.2.1 Equipment cabinets and hardware items. Electrical and electronic equipment cases, cabinets or enclosures that may require routine removal for repair and replacement during the ship's life cycle should be class B or class C bonded to ground.

5.1.2.2.2 Shock-mounted. Shock-mounted equipment and equipment racks, and equipment mounted therein, should be class B or class C bonded to ground.

5.1.2.2.3 Large/long hardware items. Unless insulated to prevent metal-to-metal contact in accordance with 5.2.3 (below), topside metallic hardware items with any physical dimension greater than approximately 3 meters or 10 feet should be class B or class C bonded to ground.

5.1.3 Class B and class C bonding and grounding.

5.1.3.1 Class B and C bond installation. All class B and C bonding is dependent on establishing and maintaining low resistance, low RF impedance, metal-to-metal contact junction(s) between the items to be bonded by bolting or clamping as required for safe system operations and EMC.

a. Unless otherwise specified, the method by which the metal-to-metal contact surfaces are prepared and whether the junction is bolted or clamped is at the option of the installing activity.

b. Appendix A provides various methods and materials that can be used to prepare the metal-to-metal contact surfaces for bonding, and to seal and preserve the junctions to retard subsequent contamination and corrosion.

c. Class B and C bond installations shall meet all specified safety and E^3 inspection and test requirements.

5.1.3.2 Hardware for class B and C bonding. All hardware (e.g.; straps, bosses, bolts, nuts, and washers) used for new or replacement shipboard class C bonding shall conform to MIL-DTL-24749 requirements. Unless otherwise specified in an installation control drawing (ICD), hardware for equipment and metallic items requiring class B bonding also shall conform to that specified in MIL-DTL-24749.

5.1.3.3 Class C bond straps. Class C bond strap requirements shall be documented in an EM Control Topside Arrangement drawing as specified in the applicable drawing development or revision procedure.

a. Excess or unnecessary bond straps shall not be installed.

b. Unless removal and reinstallation is required in the course of production, still functional bond straps fabricated from TRXF-84 copper (welding cable) wire, copper-nickel (CuNi) alloy straps, and other previously approved materials shall not be removed or replaced.

c. When removal and reinstallation is required in the course of production, bond straps fabricated from previously approved materials shall be replaced with hardware conforming to MIL-DTL-24749.

d. Equipment cases, cabinets and enclosures shall not be damaged or altered for bond strap installation. Holes shall not be drilled into and boss(es) shall not be welded to, an equipment case, cabinet or enclosure.

(1) Factory-installed grounding studs, bolts, or threaded holes shall be used as the bond strap tie-point to the equipment (when available).

(2) When a factory-installed tie point is not available, the bond strap end-lug shall be bolted to the equipment at pre-drilled holes in the mounting surface(s).

5.1.3.3.1 Type I bond strap. Type I bond straps shall be used in shipboard topside areas when appropriate to bonding metal-to-metal junctions identified as hull-generated EMI sources.

5.1.3.3.2 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.

5.1.3.3.3 Type III bond strap. Type III bond straps shall be used in shipboard non-topside areas for bonding equipments, enclosures, and cabinets.

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

5.2 Hull-generated EMI prevention. Hull-generated EMI, caused by topside nonlinear or intermittent metal-to-metal contact junctions as a result of EM energy induced as nearby antennas are radiated, shall be prevented through:

a. Nonmetallic material

b. Topside stowage practices

c. Insulation material

d. Bonding and grounding

5.2.1 Nonmetallic topside material. A nonmetallic substitute should be used to eliminate (at least one of) the metal item(s) that make up topside metal-to-metal contact junction(s).

a. Implementation of advancing technology. To eliminate metal-to-metal contact junctions in the shipboard topside EME, incorporation of state-of-the-art composite and nonmetallic materials, implementation of advancing technology, related fabrication practices and installation procedures is encouraged.

b. Performance requirements. New materials and advancing technology introduced in ships shall meet all contract performance specifications.

c. Nonmetallic substitutes and fabrication practices. Nonmetallic items and fabrication practices to be considered include but are not limited to the following:

(1) Fiberglass or composite stowage lockers and racks, portable-removable stanchions, flagstaffs and jackstaffs.

(2) Hybrid ladder assemblies, i.e.; fiberglass or composite siderails - metal treads and handrail(s).

(3) Fiberglass or composite (double-insulated) equipment cabinets and motor casings.

(4) Aramid fiber (KEVLAR®) rope lifelines, mast stays, standing rigging and safety nets.

5.2.2 Topside stowage. Stowage brackets, lockers, bins, or other stowage protected from the topside EME, shall be provided for portable and removable hardware used topside, such as: awning stanchions, flag and jackstaffs, accommodation ladders; wire rope slings, gripes, and stays, and tie-down chains/chocks when not in use. Deck stowage for metallic material not required for use topside should be avoided.

5.2.2.1 Portable and removable metallic deck hardware. Portable and removable metallic deck hardware items should be stowed when not in use on; sponson decks, inside covered companionways, below decks, or in stowage lockers and other protected areas isolated from HF transmitter antennas.

5.2.2.2 Other metallic material. Metallic items carried for stock, turn-in, or repair and not requiring immediate access, such as; angle iron, I-beams, pipes, sheet metal, barrels, argon-oxygen-nitrogen gas bottles, expended ordnance shell casings, etc., shall not be stowed topside near EM antennas.

5.2.3 Insulate topside metal-to-metal contact junctions. Unless isolating the item from ground will result in its becoming an RF burn hazard, insulating material shall be installed on the contact surfaces of built-in stowage brackets for metallic hardware items located in the topside EME whenever:

a. A suitable nonmetallic substitute is not available,

b. The items, such as; booms, dismountable highline stanchions and their stowage cradles, cannot be relocated from the topside EME, and

c. Insulation is preferable to, or the item is not suited to bonding.

5.2.4 Bond topside metal-to-metal contact junctions. Whenever metallic hardware in the topside EME is identified as a hull-generated EMI source, and the EMI is not resolved in accordance with 5.2.1, 5.2.2 or 5.2.3 (above), the metal-to-metal contact junction shall be class A, B, or C bonded in accordance with 5.1.2 and 5.1.3 as required to eliminate IMI/BBN.

a. Class A bonding recommended. Stationary metallic hardware items commonly installed topside, such as; liferails, stanchions, swab racks, etc., should be class A bonded.

b. Class B or C bonding recommended. Portable and removable hardware items commonly installed topside, such as; equipment cabinets, enclosures, and cases, dismountable lifeline and heavy weather stanchions, flagstaffs and jackstaffs, etc., should be class B or C bonded.

c. Bonding not recommended. Bonding is not a suitable alternative for hull-generated EMI control when bonding of the IMI/BBN source junction(s) will prevent or impede physical or mechanical operation or functional use of the item(s).

(1) Emergency equipment. Emergency equipment shall not be bonded when unbolting or removal of a bond strap will delay access or prevent use.

(2) Moving hardware. Moving hardware items shall not be bonded when doing so will prevent operation over the item's full range of travel or rotation.

(3) Quick-release fittings. When installation of a bond strap will delay operation of quick-release fittings, such as those used with; lifeline assemblies, jettissonable fuel and ordnance storage racks and lockers, pelican hooks, etc., the item shall not be bonded.

5.3 Cable and hull penetration EMI control.

5.3.1 Topside cable installations. All electrical and electronic system cables routed outside the skin of the ship, where subject to illumination by high power EM energy, shall be EM shielded (or otherwise treated) to prevent coupling of own-ship's EM transmissions via the cable's conductors and shields. This EM shielding (or other treatment) is intended to minimize the inter-system transfer of electromagnetic energy, particularly to below deck items.

5.3.1.1 Shielded cable. Coaxial cables and other cables with inherent overall shielding shall be grounded at the:

a. Cable end terminations. Shielded cables shall be fabricated using the appropriate coaxial connector(s) or connector EMI backshells to bond the cable shield 360 degrees at each end.

b. Hull penetration point. Shielded cables should be 360-degree bonded at the point of entry into the hull, superstructure, deck, bulkhead, shielded compartment or wireway trunk (see 5.3.2).

5.3.1.2 Unshielded cable. Unshielded cables which exceed 3 feet of exposed length in topside areas shall be EM shielded or filtered as required to prevent cable penetration EMI.

a. Installed cable. Unshielded fixed-installed cables which exceed 3 feet of exposed length in topside areas should have the entire exposed length routed within a wireway trunk, rigid (pipe) or flexible conduit.

b. Portable cable. Unshielded portable cables exposed in topside areas and exceeding 3 feet in length, such as those for sound-powered phone and remote handsets or headsets, should have an EM filter installed when required (see figure 1).

5.3.1.3 Wireway trunks. Wireway trunks should be constructed and installed as shown on figure 2.

a. Wireway trunks may contain both shielded and unshielded cables.

b. Where an unshielded cable exits the wireway trunk, add-on shielding such as rigid or flexible conduit should be added to the weather-exposed cable.

5.3.2 Hull penetration EMI.

5.3.2.1 Bonding metallic hull-penetrators. The outer perimeter of all cable shields and metallic conduit, waveguide and pipes penetrating the hull (or shielded compartments) shall be bonded to hull ground and provide a 360-degree peripheral bond at the penetration point as shown on figure 3 to prevent inter-system and below decks coupling of own-ship's EM transmissions.

5.3.2.1.1 Rigid conduit. The ends of rigid conduit should be circumferentially welded to the ground plane.

5.3.2.1.2 Flexible metal conduit. Flexible metal conduit installed in topside areas should be in accordance with MIL-C-24758. Flexible conduit shall terminate into a 360-degree ground as shown on figures 4a or 4b.

5.3.2.1.3 Waveguides, pipes, tubing, and exhaust stacks. Waveguides, pipes, metal tubing, and exhaust stacks routed in topside areas and penetrating a weather deck or bulkhead should be grounded at the penetration point as shown on figure 5 for waveguide grounding, and figure 3 for the grounding of pipes and metal tubing.

a. Pipes. Pipes welded or threaded at penetration points are properly grounded.

b. Turbine exhaust stacks. Turbine exhaust stacks should be grounded at the weather penetration point using four, Type I bond straps spaced at 90 degree intervals.

c. Diesel exhaust stacks. Diesel exhaust stacks should be grounded at the weather penetration point using two, Type I bond straps spaced at 180 degree intervals.

5.3.2.2 Shielding effectiveness (SE). Unless otherwise specified, grounded hull penetrations shall provide 60 dB SE.

5.3.2.3 Signal cables penetrating the hull. Terminal protection devices (TPDs) and aperture protection devices (APDs) should be used as required to prevent hull-penetration EMI through active signal cables (e.g.; receiver and transmitter input/output ports).

5.3.3 Below decks cable installations. To prevent cable-coupled EMI, all below decks cables should be separated, shielded and routed in general conformance with NAVSEA S9407-AB-HBK-010.

5.4 Superstructure blockage and reflections. Superstructure EM blockage and reflections shall be controlled for minimal affect on system operations. The following design and production practices should be implemented to minimize blockage and reflections and to reduce the EM signature of the ship.

5.4.1 Topside configuration drawings. Superstructure, antennas and topside-mounted equipment shall be located in accordance with the specified Topside Antenna Arrangement and Configuration drawings.

5.4.2 Flat and reflective surfaces. Flat surfaces and corner reflectors subject to illumination by main-beam transmit signals from directional antennas should be avoided in developing ICDs and fabricating topside structure.

a. Round stock and pipe. To diffuse and scatter reflections, round stock and pipe should be used as a general rule in the design and fabrication of mast stanchions, supports and equipment foundations that will be illuminated by the main beam of a directional transmit antenna.

b. Tilted/angled installation. Antenna mounting base(s) or foundation(s) should be fabricated to offset, angle or tilt the antenna as necessary to minimize coupling between nearby antennas; to isolate antennas from nearby metallic structure; and to enhance antenna radiation and reception patterns.

c. Radar-absorbent material (RAM). RAM should be installed where necessary to control harmful EM reflections and to reduce the EM signature of the ship when specified.

5.5 Equipment-generated IMI prevention. Narrowband filters, preselectors, multicouplers, etc., as required to protect the receiver front end stage(s) should be installed or inserted between the associated antenna(s) and shipboard LF, MF, HF, VHF, and UHF communications, intelligence, weather facsimile, navigation, and ship's entertainment receiving equipment.

5.5.1 Wideband receiver front-end stages. Protective devices that limit the passband of frequencies and signal power level to wideband receiver front-end stage(s) should be installed to prevent equipment-generated IMI.

a. When intercepted by own-ship's receive antenna(s) directly patched to wideband receiver front-end stages, own-ship's high-powered in-band and adjacent-band transmissions overdrive them and cause equipment-generated IMI.

b. Resultant equipment-generated IMI is radiated back through the unprotected receive antenna(s).

5.5.2 RF tuned receiver front-end stages. No additional protection should be required for LF, MF, HF, VHF, or UHF receivers with an RF-tuned front-end stage. The greater selectivity of an RF-tuned front-end stage prevents equipment-generated IMI inherently. In addition, built-in automatic gain/volume control (AGC/AVC) circuitry often associated with these receivers may protect them against front-end overload from own-ships transmissions at tuned frequency.

5.5.3 LF-MF receiver(s), but no in-band transmitter(s). No additional protection should be required for LF and MF receivers if:

a. The ship has no onboard LF and MF transmit capability, and

b. The selectivity of the LF/MF receiver's front-end stages prevents entry of out-of-band HF and higher signals.

5.5.4 Active wideband receiver coupler systems. Active amplifier wideband receive antenna coupler systems, intended to improve received signal-to-noise ratio, shall not be installed on ships. These systems cause equipment-generated IMI in a high power HF transmit EME.

5.6 Electrical safety; personnel shock hazard prevention. All shipboard equipment operating from an external electrical power source of 30 volts or more, including COTS or NDI, shall provide personnel shock hazard protection in accordance with the following and Appendix B.

Note that, unless otherwise documented in an equipment's technical specifications, electrical safety grounding as required by this section for personnel shock hazard protection does not ensure EMC.

a. Use of a marine type electrical power line surge suppressor may be required to protect electrical/electronic equipment circuitry from conducted EMI on the power line (see Appendix B).

b. Built-in arc-suppression circuitry may be required to prevent radiated and conducted EMI generated by electrical/electronic equipment affecting other on board systems.

5.6.1 Portable and mobile-transportable electrically-powered equipment. Shock hazard protection for portable and mobile-transportable electrically-powered equipment to be used aboard ship shall be provided through:

a. Built-in grounding through a 3 conductor power cord and 3-pronged plug for electrical equipment with a conductive case or exposed conductive elements.

b. Use of a non-conducting enclosure/case. Electrical equipment with a double insulated or non-conductive case needs no safety ground.

5.6.1.1 Electrical equipment with a conductive case. Portable or mobile-transportable electrical equipment with a conductive case or exposed conductive elements shall require a 3 conductor power cable and 3-pronged plug. The third conductor shall be attached to the ground prong of the plug and the equipment frame or chassis. For acceptance, an insulation resistance test shall determine:

a. 1 megohm (minimum) resistance between the conductive case and each active power conductor prong.

b. 0.1 ohm (maximum) resistance between the conductive case and the power cord ground prong.

5.6.1.2 Electrical equipment with a non-conductive case. Portable or mobile-transportable electrical equipment with a non-conductive case requires no electrical safety ground. Unless a grounding wire is required for EMI control, a two conductor power cord and two-pronged plug is acceptable.

5.6.2 Fixed-installed, electrically-powered equipment. Shock hazard protection for fixed-installed, electrically-powered equipment to be used aboard ship shall be provided through:

a. A hard-wired power cord.

b. The mounting hardware to provide class B or C bonding to ground.

c. Use of a non-conducting enclosure/case.

d. A combination of a through c above.

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.

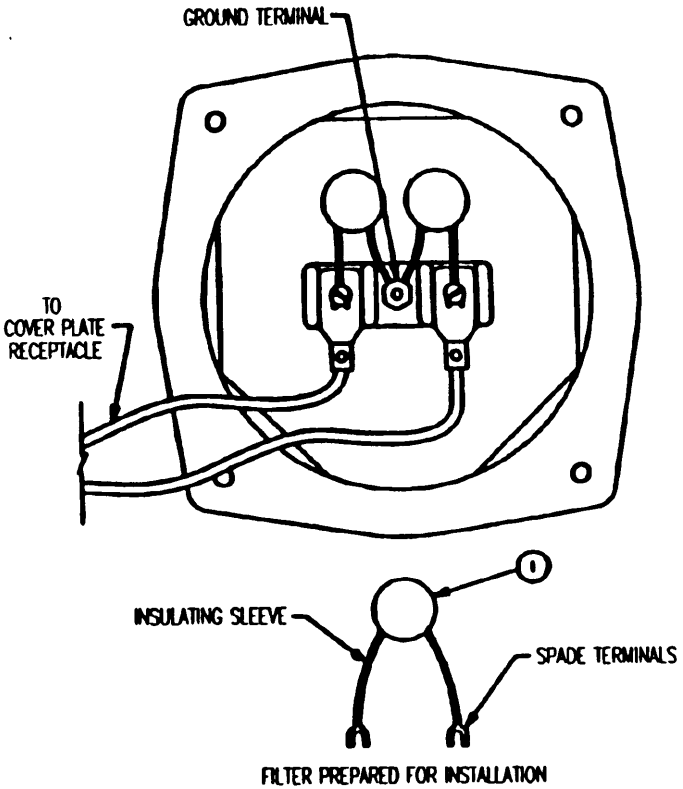
Bond, classification
Bond, electrical straps
Bond strap
Broadband noise (BBN)
Cable ground system
Electromagnetic interference (EMI)
Electromagnetic pulse (EMP)
Ground, peripheral (360 degrees)
Ground plates
Ground, radio frequency (RF)
Intermodulation interference (IMI)
Junction, nonlinear
Penetration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

6.4 RF impedance measurement. There is no need to perform routine RF impedance measurements on every bond for acceptance; routine measurement to demonstrate the RF impedance of any individual bond during the acceptance process should never be necessary. However, in the event any system's performance is erratic during operational or acceptance testing and problem indications are symptomatic of poor electrical grounding, this measurement specification is included to help pinpoint or eliminate grounding as the cause.

6.5 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-N159)

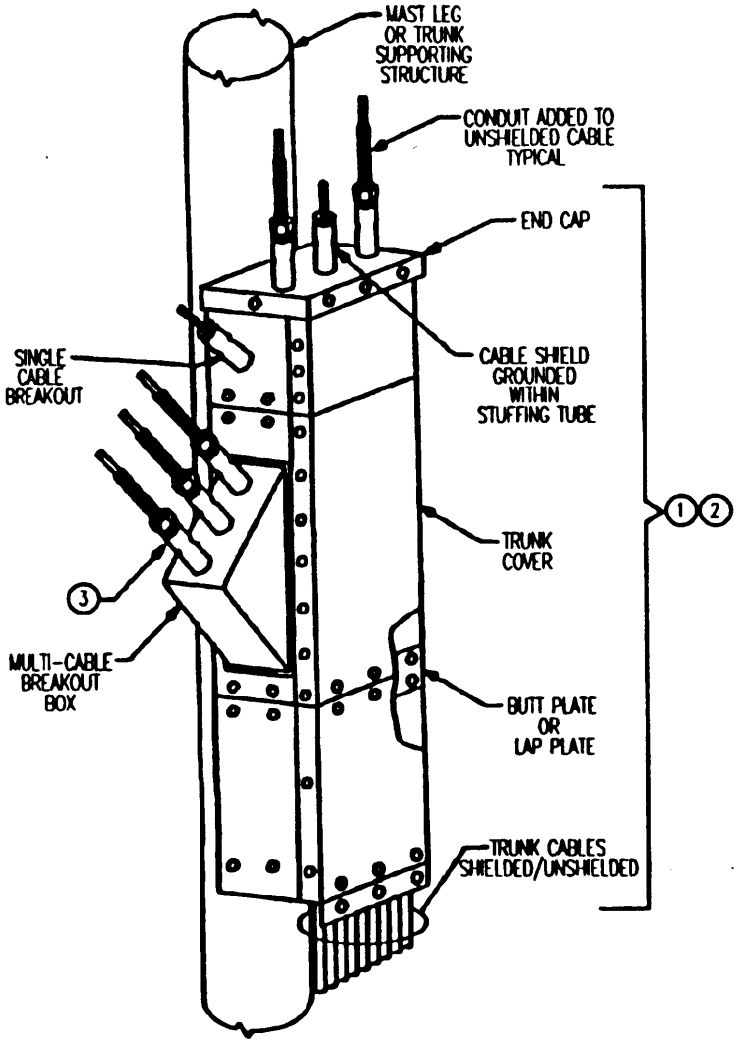


LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	CAPACITOR, P/N CRK05BX470K, 200V	MIL-C-39014/1	1, 2

NOTES:

1. FILTER CAPACITORS AS SHOWN IN THIS FIGURE ARE APPLICABLE ONLY TO SOUND-POWERED PHONES. FOR OTHER APPLICATIONS WHERE UNSHIELDED PORTABLE CABLE MAY REQUIRE EM FILTERING, SUCH AS FOR RADIO-TELEPHONE HEADSETS/HANDSETS, FILTER CAPACITOR(S) OF DIFFERENT VALUE MAY BE REQUIRED.
2. THESE FILTER CAPACITORS ARE INSTALLED FOR THE PURPOSE OF FILTERING RF RADIATIONS FROM SHIPBOARD ANTENNAS WHICH ARE COUPLED BELOW DECKS VIA THE UNSHIELDED (VOICE AUDIO SIGNAL) WIRES OF PORTABLE TELEPHONE HEADSETS WHEN USING A TOPSIDE-MOUNTED SOUND-POWERED PHONE JACK.
3. ENSURE FILTER CAPACITORS LEADS ARE AS SHORT AS POSSIBLE.

FIGURE 1. EMI filter capacitor installation in sound powered telephone boxes.

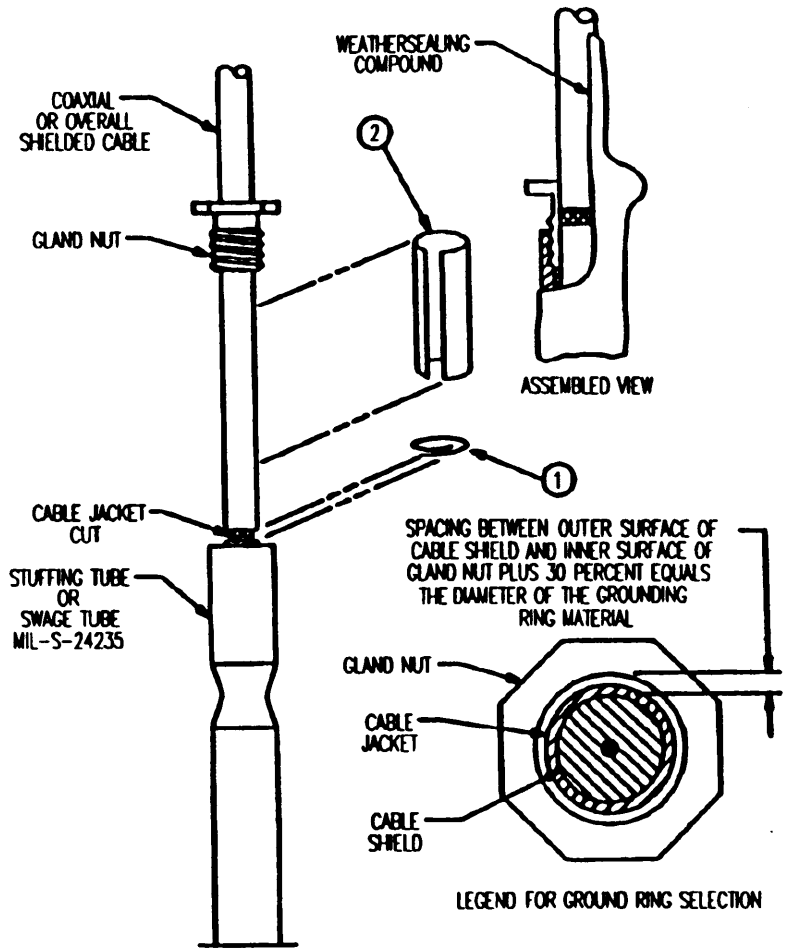


LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	SHEET METAL, STEEL	MIL-S-22698	1
2	SHEET METAL, ALUMINUM	5086H116	1
3	SWAGE TUBE	MIL-S-24235	4

NOTES:

1. BASIC TRUNK DESIGN SHOULD BE IN ACCORDANCE WITH 5.3.1.3 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 SHOULD 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 SHOULD BE PRIMED AND PAINTED.

FIGURE 2. Wireway trunk.

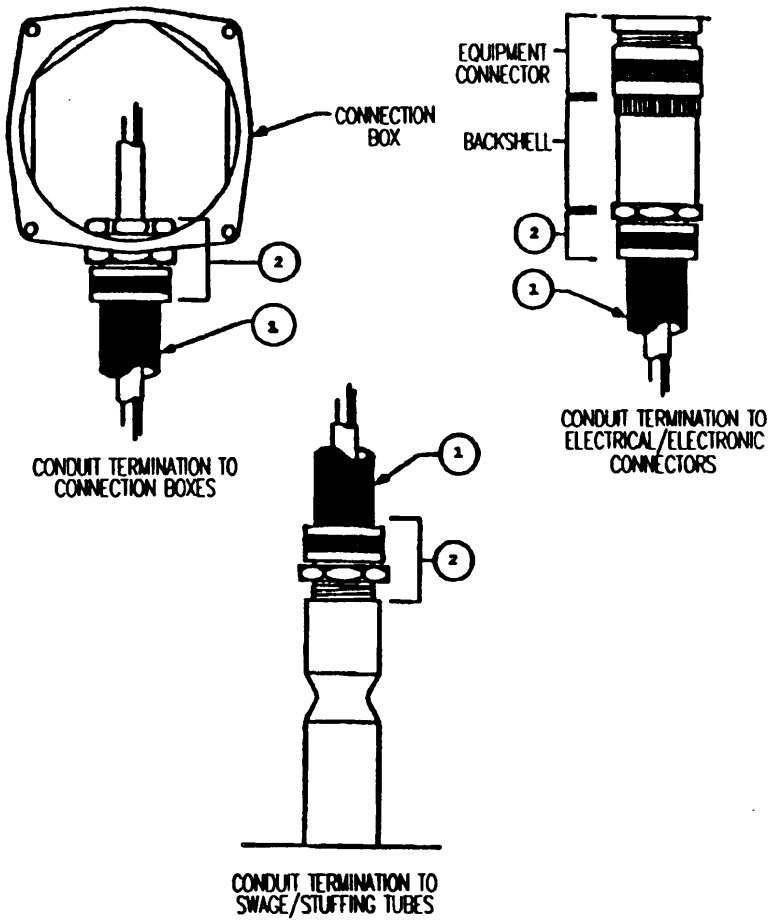


LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	GROUNDING RING	COMM	3, 5, 6, 7
2	COMP SLEEVE, SHIM STOCK	COMM	6, 7

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 IS ALSO APPLICABLE FOR USE 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 SHOULD BE ROUND CROSS SECTION, NEOPRENE-SPONGE, FLEXIBLE-WIRE-MESH STRIP.
4. UNSCREW THE PACKING GLAND NUT FROM THE STUFFING TUBE AND MOVE IT SEVERAL INCHES UP THE CABLE AND TAPE IT IN PLACE. ENSURE THE INSIDE OF THE 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 THE JACKET WAS REMOVED. COAT THE GROUNDING RING, EXPOSED CABLE SHIELD AND THREADS OF THE GLAND NUT WITH MIL-T-22361 ANTISEIZE COMPOUND.
6. PLACE THE GROUNDING RING AROUND CABLE IN CONTACT WITH THE EXPOSED SHIELD. PLACE THE COMPRESSION SLEEVE AROUND THE CABLE JACKET AND GROUNDING RING. HOLDING THE COMPRESSION RING TIGHTLY AROUND THE CABLE AND GROUNDING RING, SLIDE THE GLAND NUT DOWN OVER THE COMPRESSION SLEEVE AND THREAD IT INTO THE STUFFING TUBE. AFTER THE THREADS HAVE ENGAGED, REMOVE THE COMPRESSION SLEEVE. WEATHERPROOF AS REQUIRED 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 3. Cable shield, metal pipe, metal tubing, and rigid conduit grounding.

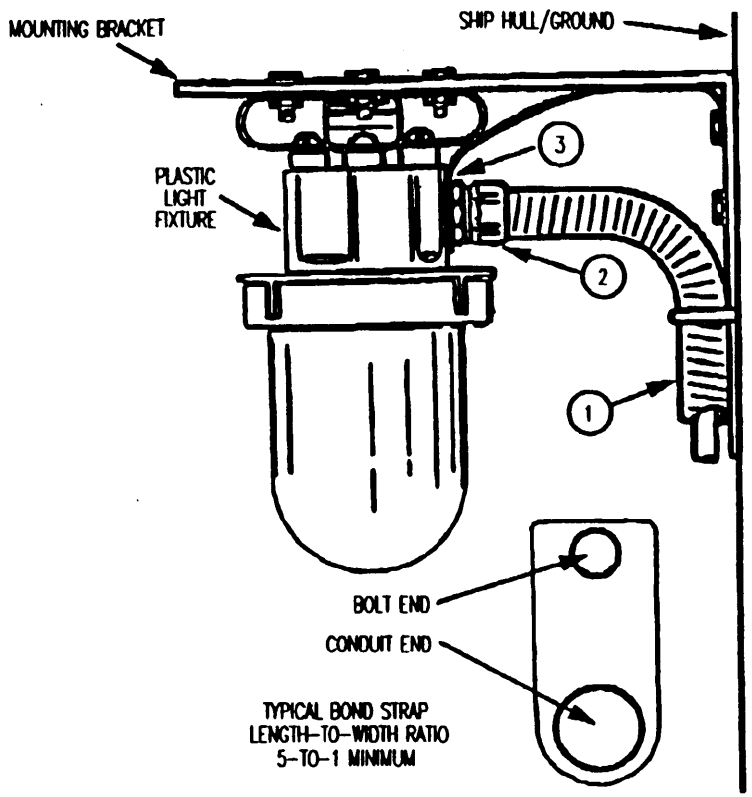


LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	CONDUIT, FLEXIBLE	MIL-C-24758	2, 3, 4
2	FITTING, CONDUIT	MIL-C-24758	4, 5

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. INSTALLATION OF CONDUIT AND FITTINGS IN ACCORDANCE WITH THIS FIGURE WILL PREVENT CABLE-PENETRATION EMI.
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, SHOULD BE USED, WHERE NEEDED, TO REDUCE STRAIN ON CONNECTORS AND CONDUIT. SELECT CONDUIT FITTINGS TO MATCH CONDUIT SIZE AND TERMINATING EQUIPMENT.
5. CONDUIT FITTINGS SHOULD BE SELECTED TO AVOID DISSIMILAR METALS. ANTISEIZE COMPOUND SHOULD BE USED AT ALL METAL-TO-METAL JUNCTIONS AND ALL TOPSIDE JUNCTIONS SHALL BE WEATHERPROOFED.

FIGURE 4a. Cable shielding method, flexible conduit.

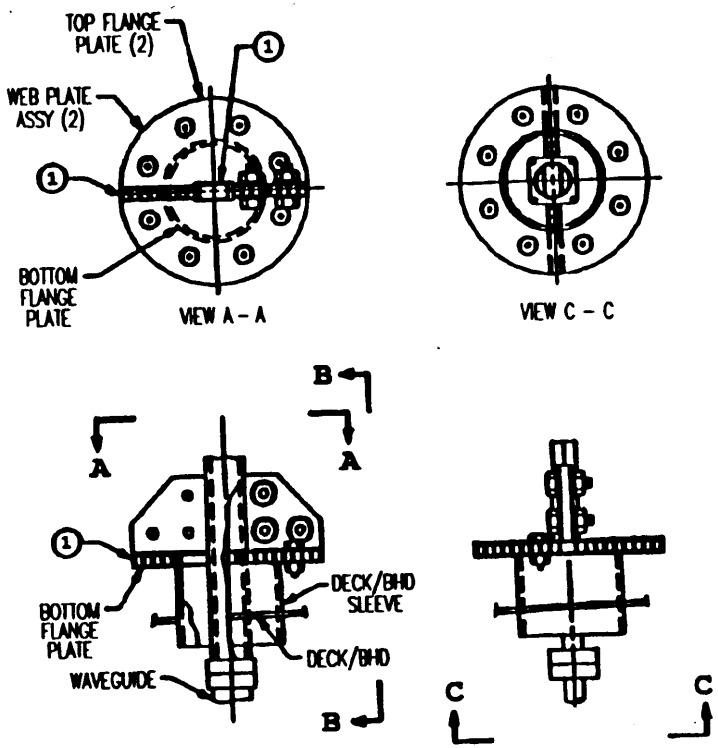


LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	CONDUIT, FLEXIBLE	MIL-C-24758	
2	FITTING, CONDUIT	MIL-C-24758	1
3	BOND STRAP, TYPE II	MIL-S-24749	1, 2

NOTES:

1. THIS METHOD SHOULD BE USED TO GROUND CONDUIT TERMINATING AT NONMETALLIC FIXTURES.
2. CONDUIT FITTING SHOULD MAKE PERIPHERAL CONTACT WITH A TYPE II BOND STRAP.
3. THE BOND STRAP MAY BE CONNECTED TO THE HULL SIDE OF THE MOUNTING BRACKET AS LONG AS THE SURFACE IS PROPERLY PREPARED TO ASSURE A MINIMUM RESISTANCE/IMPEDANCE BOND.

FIGURE 4b. Cable shielding method, flexible conduit - Continued.



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

NOTES:

1. THE CONDUCTIVE ELEMENT OF THE GASKET SHOULD BE CRES OR COPPER-NICKEL WIRE FIBERS PROVIDING CONDUCTIVITY ACROSS THE THICKNESS DIMENSION. THE STABILIZING AND SEALING ELEMENT OF THE GASKET SHOULD BE EITHER CONDUCTIVE OR FABRICATED SUCH THAT IT DOES NOT PREVENT ELECTRICAL CONTACT BETWEEN MATING SURFACES. IT MUST SEAL AND PRESERVE THE JUNCTION TO PREVENT CORROSION.
2. THE MOUNTING SURFACES IN CONTACT WITH THE GASKET SHOULD BE CLEANED TO BRIGHT METAL AND COATED WITH CONDUCTIVE PAINT, MIL-T-22361 ANTISEIZE COMPOUND OR OTHER SURFACE PRESERVATIVE PRIOR TO INSTALLATION OF THE GASKET.
3. SPLIT-SLEEVE INSTALLATION SHOWN IS AS DETAILED IN THE NAVY INSTALLATION AND MAINTENANCE BOOK (NIMB) CD-ROM EDITION NSN 0910-LP-003-9770 OR EIMB SERIES, NAVSEA 0967-LP-000-0110.

FIGURE 5. Waveguides grounding.

APPENDIX A

TOPSIDE CLASS B AND CLASS C BOND INSTALLATION

A.1 Scope. All shipboard class B and class C bonding involves either bolting equipment or bolting a bond strap in place to attain a minimum resistance (0.1 ohm), low RF impedance (less than 25 ohms at 30 MHz) electrical bond. This appendix provides suggested methods for surface preparation, material selection, installation techniques, and sealing and preservation applicable to this objective. Compliance with this Appendix is optional, but the requirement to ensure EMC and safety through effective and sustainable bonding and grounding (where applicable) is mandatory. The information contained herein is provided as effective solutions to troublesome bonding, grounding, and corrosion control problems identified as a result of extensive military ship maintenance experience. Unless alternative solutions are available as a result of advancing technology or improved materials, implementation of the procedures herein is invited.

A.2 Applicable documents.

NAVSEA DRAWING STD-407-5287561 - Industrial Electromagnetic Compatibility (IEMC) Work Process Instructions

A.3 Definitions. This section is not applicable to this Appendix.

A.4 General Requirements. Class B bonding, and almost invariably class C bonding, involves establishing and maintaining an electrically conductive, minimum resistance/impedance path between metallic surfaces by bolting them together.

a. For this Appendix, the only distinction of significance between class B and C bonding is that class C always involves a bond strap - where in almost every case both ends/lugs of the bond strap are to be bolted.

b. Unless disturbed, a shipboard class B or class C bond should survive between scheduled availabilities or five years.

c. In the military-ship (with its highly corrosive and intense EME environment) maintaining an effective bond over an extended time period can prove more troublesome than establishing it. To meet these requirements, especially in the ship's topside environment, these are the major factors to be considered:

(1) Maximum metal-to-metal contact.

(2) Minimize dissimilar metals.

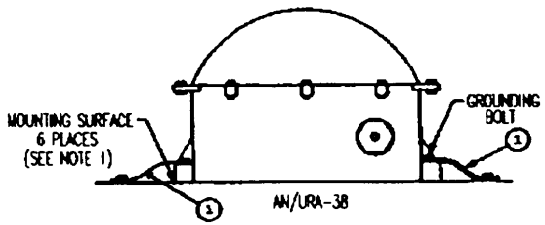
(3) Evacuate contaminants.

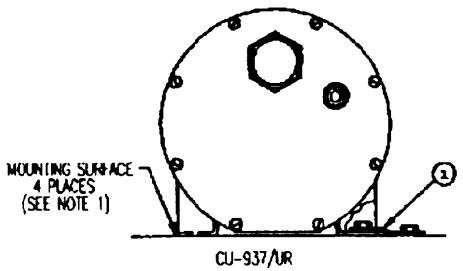
(4) Seal and preserve the junction.

A.5 Detailed requirements. For equipment and bond straps to be installed by bolting, metal-to-metal contact between the mounting and mating surfaces resulting in a DC resistance of 0.1 ohm or less and an RF impedance of 25 ohms or less at 30 MHz must be attained and sustained. The method used to meet these requirements is at the option of the installing activity.

a. Surface preparation and bond junction preservation is the determinant of the bond's DC resistance RF impedance and determines how long the bond will survive in the marine environment.

b. NAVSEA DRAWING STD-407-4287561 describes three methods and the materials that have proven effective when used for mounting antenna couplers (see figure A-1). Each one of these methods is adaptable to effectively bond any bolted junction, such as when installing a bond strap (see figure A-2), the difference being the degree of surface preparation, and sealing and preservation required to form the junction. These three methods are described herein, in the most effective and suggested order, for possible implementation. However, implemen-



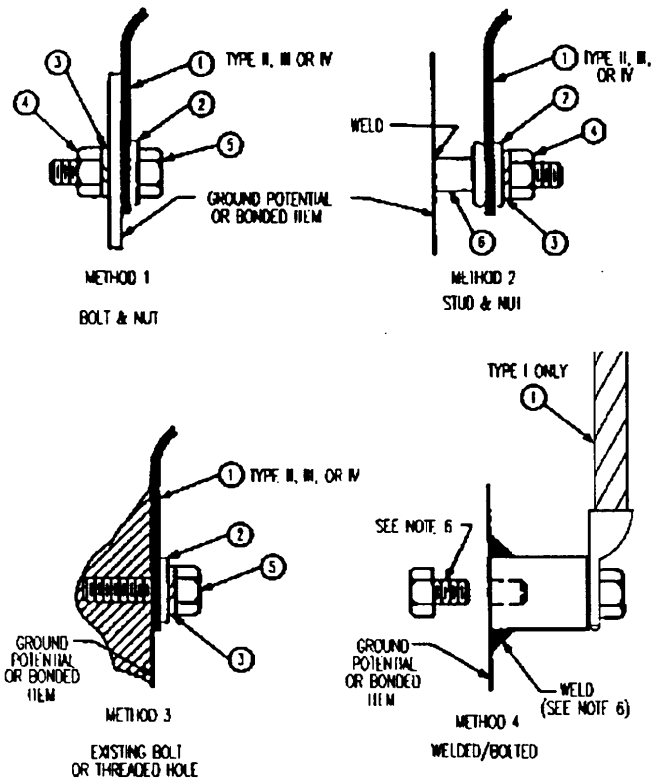


LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	BOND STRAP, TYPE II	MIL-DTL-24749	1

NOTES:

1. HF ANTENNA TUNER/COUPLERS SHALL BE GROUNDED AS REQUIRED FOR TUNING AND OPERATION. THE MOUNTING SURFACES BETWEEN THE TUNER/COUPLER AND GROUND POTENTIAL SHOULD BE CLEAN AND FREE OF CORROSION. A HEAVY COAT OF ANTISEIZE COMPOUND, MIL-T-22361, SHOULD BE APPLIED TO THE CLEANED AREAS AND THE TUNER/COUPLER SHOULD BE FIRMLY BOLTED IN PLACE. EXCESS ANTISEIZE SHOULD BE REMOVED AFTER BOLTING. ALL AREAS WHERE ANTISEIZE IS APPLIED SHOULD BE EDGE-SEALED USING MIL-S-45180 TYPE II SEALING COMPOUND. IN ADDITION TO THE ABOVE CLASS B BOND, ONE OR MORE TYPE II BOND STRAPS MAY BE REQUIRED ON EACH TUNER/COUPLER TO ATTAIN AN EFFECTIVE DC AND RF BOND. BOND STRAP CONNECTION TO GROUND POTENTIAL SHOULD BE BY STUD, STUD PAD, OR BOLT. THE CONTACT SURFACE BETWEEN THE BOND STRAP AND GROUND POTENTIAL SHOULD BE AT LEAST EQUAL THE WIDTH OF THE BOND STRAP. CONTACT SURFACE AREAS FOR BOND STRAPS SHOULD 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 SHOULD BE GROUNDED USING SIMILAR METHODS.

FIGURE A-1. Antenna tuner and coupler grounding.



LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	BOND STRAP	MIL-DTL-24749	1, 2, 4
2	WASHER, FLAT	FF-W-92	5
3	WASHER, SPLIT	FF-W-84	5
4	NUT	MS 35425 AND FF-N-836	5
5	BOLT	MIL-S-1222	5
6	STUD, SHOULDER OR COLLAR	MIL-S-24149	3

NOTES:

1. EXISTING BOLTS, STUDS OR THREADED HOLES MAY BE USED FOR BOND STRAP INSTALLATION.
2. THE INSTALLATION PROCEDURE FOR BOLTED STRAPS PROVIDES FOR CLEAN BRIGHT METAL CONTACT BETWEEN THE BOND STRAP AND THE MATING SURFACE.
3. STUDS USED FOR BOND STRAP ATTACHMENT SHALL BE A COLLAR TYPE. TO PERMIT WELDING, 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 WEATHERPROOFED.
5. FOR SHIPBOARD EXTERIOR APPLICATIONS, ITEMS 2, 3, 4 AND 5 SHALL BE OF CORROSION RESISTANT STEEL (CRES 316L).
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 THE BOLT SUPPLIED WITH THE BOSS. THE BOLT SHALL NOT CONTACT THE BOTTOM OF THE BOSS THREADED SOCKET.

FIGURE A-2. Methods of attaching bond straps.

tation of state-of-the-art material and technology in the area of shipboard corrosion control is invited and encouraged.

A.5.1 Bonding by direct metal-to-metal contact. When metallic items are directly bolted together, maximum metal-to-metal contact area ensures minimum DC resistance and RF impedance, and allows hull and ground currents to flow over maximum contact area.

A.5.1.1 Paint, preservative, corrosion and contaminant removal. Clear (e.g.; sand, file, grind, brush, scrape, etc.) down to smooth, bright metal both the equipment mounting feet or bond strap end lug and the mounting contact surface(s) to which it/they will be mated.

a. Use care not to gouge deep pits or grooves in the mating surfaces.

b. Clear the contact surface(s) on the mounting area (ground plane) approximately 1/4-inch larger than the mounting feet (or bond strap end lug, such that complete bare-metal contact will be achieved when they are mated.

A.5.1.2 Clean surface(s). Before proceeding, wipe down all surfaces to be mated with MIL-C-81302 non-residue type cleaning solvent to ensure they are clean and free of paint chips, metal filings and other residue.

A.5.1.3 Enhance conductivity, expel contaminants, retard corrosion. Apply a thin film of MIL-T-22361 antiseize compound to the cleaned areas of the mating surfaces and to the threads of all hardware (bolts and nuts) to be used.

NOTE: Various conductive compounds and paints may be found to serve the same or similar purpose as MIL-T-22361 in this application. Some materials used, including conductive faying material (see A.5.2), might eliminate the need for sealant in accordance with A.5.1.4 and A.5.1.5. Nothing in this MIL-STD should be interpreted as preventing implementation of advancing technology or use of state-of-the-art materials for EMI and corrosion control, enhanced system operation and maintainability and personnel safety.

A.5.1.4 Bolt to the mating surface. Apply MIL-S-45180 sealing compound to the edges of all hardware such that water and contaminants cannot intrude past the nut-bolt-washer into the mounting hole(s), fasten and tighten all hardware as required.

A.5.1.5 Seal and preserve the junction. When firmly fastened in place, using clean, dry rags, wipe excess antiseize compound that may have been forced from between the mating surfaces as the junction was compressed.

a. Lay a bead of MIL-S-45180 sealing compound around the perimeter of the mating surfaces and mounting hardware, using an orangewood stick (or similar aid) to apply compound to hard-to-reach areas.

b. Use finger or orangewood stick to contour and mold sealing compound to the edges of the material around the mating surfaces.

c. Paint/repaint scraped and brushed areas.

A.5.2 Bonding with conductive faying material. When similar or dissimilar metallic items are bolted together, a conductive faying material between the metal contact surfaces can enhance electrical bond formation, reduce the effects of galvanic corrosion and eliminate the need for external bond straps.

a. Potential advantages of conductive faying material are promising. No single type of conductive faying material has proven applicable for all installations and not all possible conductive faying materials, such as bimetallic strips, have been investigated. Little advantage over a properly sealed and watertight direct contact junction is gained by using a conductive faying material if the wider gap resulting from this material between the contact surfaces is not effectively sealed to prevent intrusion of contaminants. However, some

products available provide electrical contact and seal the junctions as a one-step process. Properly applied in appropriate installations, such material can significantly reduce the number of class C bond straps required. Any mounting procedure that eliminates the need for an external bond strap is encouraged.

b. Ongoing tests with conductive faying mesh material with a jell-like sealant indicate that junction corrosion can be inhibited while an effective electrical bond is maintained. However, other products may not seal the perimeter of the mating surfaces. Sealing (as in A.5.1.5 above) is a separate step required to prevent corrosion intrusion, material slippage or preservative leakage from the junction. In addition, other conductive faying materials perform satisfactorily only when compressed (typically, to 15 pounds per square inch). This material is not suitable for use with rectangular waveguide at the point(s) of hull-penetration. Rectangular waveguide (typically) is limited to 5 pounds per square inch sidewall compression.

c. Continued development of these and similar materials appears to provide a method of eliminating the excessive number of bond straps currently installed on ships and reducing maintenance manhours resulting from rust and corrosion in the marine environment.

A.5.2.1 Surface preparation. When a bimetallic conductive faying material is used, surface preparation is identical to A.5.1.1 through A.5.1.3 (above). An additional step of cutting the bimetallic faying material and fitting it between the contact surfaces of the junction is required as they are bolted together.

A.5.2.2 Pre-fit faying material. Cut the faying material to size and cut out the appropriate sized bolt hole.

A.5.2.3 Bolt to the mating surface. With the faying material in place between the contact surfaces, fasten and tighten all hardware as required. Apply MIL-S-45180 or similar non-acidic sealing compound to all edges where contaminants can intrude into the junction.

A.5.2.4 Seal and preserve the junction. When firmly fastened in place, seal and preserve the junction in accordance with the procedure of A.5.1.5 (above). (Unless the junction is sealed and preserved in accordance with this step, the bonded junction is subject to contamination and early failure.)

A.5.3 Bonding with non-conductive (insulating) faying material. When metallic items are bolted together with a non-conductive faying material between the metal contact surfaces, a conductive (class B) bond is formed only where the metallic mounting hardware (i.e., bolts, nuts, and washers) are in contact around the bolt holes. (In many cases, when this method is used, to attain a low resistance - impedance bond, additional class C bonding is required.)

A.5.3.1 Surface preparation. When an insulating faying material is used, both mounting surfaces separated by the material should be painted or otherwise preserved to prevent hidden corrosion. For a distance of approximately 3/4-inch surrounding the bolt hole(s), clear and clean the surfaces [which will be in contact with bolt head(s), nut(s) and washer(s)] to smooth, bright metal.

A.5.3.2 Pre-fit faying material. Cut the faying material to size and cut out the appropriately sized bolt hole(s).

A.5.3.3 Bolt to the mating surface. With the faying material in place and MIL-T-22361 antiseize applied to the threads and contact surfaces of the hardware, fasten and tighten it as required.

A.5.3.4 Seal and preserve the junction. When firmly fastened in place, seal and preserve the exposed area(s) that were cleaned to bright metal and the junction(s) of bolt head(s), nut(s), and washer(s) with MIL-S-45180 sealing compound.

APPENDIX B

ELECTRICAL SAFETY AND PROTECTION FOR COTS AND NDI EQUIPMENT

B.1 PURPOSE. To ensure that all electrically-powered COTS/NDI equipment procured for shipboard use is: (1) in compliance with electrical shock hazard protection requirements when procured outside normal procurement channels, and (2) power line surge protected when applicable as mobile-transportable equipment is operated on ship's power.

a. Scope. Compliance with the electrical shock hazard protection requirements of 4.1.6 and 5.6 will be certified upon acceptance when MIL-STD-1310 is invoked in the procurement specifications for COTS/NDI equipment procured by government contract and issued from stock. However, portable and mobile-transportable electrical COTS/NDI equipment not conforming to MIL-STD-1310 electrical safety requirements might be procured for shipboard use on the open market. In this case, the COTS/NDI may not have been tested to MIL-STD-1310 requirements; the end-user must determine if they have been met.

b. Implementation. This appendix allows end-user determination whether electrically-powered COTS/NDI equipment is suitable for shipboard use, and provides guidelines for modification of the equipment or ship's power, as necessary, to bring them into compliance with the established shipboard electrical shock hazard and power line surge protection requirements.

c. Application. These data in MIL-STD-1310 specifically address portable and mobile-transportable COTS/NDI equipment, such as; tools, test equipment, desktop and laptop computers and peripherals, etc., on board for official use. It may also be applicable to personal equipage when used aboard ship. Authorization for use of personal electrical/electronic equipment on board is discussed in detail in Naval Ships Technical Manual (NSTM) Chapter 300.

B.2 GROUND SYSTEM CABLES. COTS/NDI electrical and electronic equipment procured for shipboard use may not have been tested to determine whether it meets the electrical safety requirements of MIL-STD-1310. As a result of ongoing DoD acquisition initiatives, future COTS/NDI electrical equipment procurements should meet MIL-STD-882 or (when issued) commercial equivalent System Safety Society (SSS) Standard 882 requirements. With respect to COTS/NDI electrical and electronic equipment procured for shipboard use, the results of any testing performed by national or international standards development organization (SDO), such as; the Underwriters Laboratories (UL) in the United States and Canada, the Verbad Deutscher Elektrotechniker (VDE) of Germany, etc., should be included with the technical data supplied.

B.3 ELECTRICAL SHOCK HAZARD PROTECTION REQUIREMENTS. Requirements for electrical shock hazard protection for portable and mobile-transportable electrical equipment are dependent on whether the equipment case is non-conductive or conductive.

B.3.1 Double insulated and non-conducting equipment. Double insulated and non-conducting equipment is exempted in accordance with B.4.1.2 (below) need not be grounded.

a. A 2-conductor power cord and 2-pronged plug is acceptable.

b. If initially provided with a 3-conductor power cord and 3-pronged plug for grounding, this type cord and plug shall be retained for the life of the device.

B.3.1.1 Double insulated equipment. Double insulated (UL listed) electrical equipment having the words "double insulated" or "double insulation" stamped on its enclosure/case shall require no grounding.

B.3.1.2 Non-conducting equipment. Electrical equipment with a non-conducting enclosure/case that is not stamped "double insulated" may be exempted from the requirement for a grounding conductor, provided that the equipment:

a. Case and handle is made of non-conducting material, and

b. Meets both of the following requirements:

(1) Passes an initial inspection for rugged, safe construction, and

(2) Has a minimum of 1 megohm DC resistance from any phase conductor to any exposed metal part (such as chuck housing, mounting screws, ear plug jacks, or antennas) or metal chassis.

B.3.2 Equipment with a conductive case or exposed conductive elements. Electrical equipment with a conductive case shall be grounded via a 3-conductor power cord and 3-pronged plug.

B.3.2.1 Installation requirements; 3-pronged plug. Electrical equipment with a conductive case or exposed conductive elements that are supplied with a 3-conductor power cord and 3-pronged plug shall not require additional grounding for electrical safety. Portable electrical equipment that has a 3-pronged plug shall not require additional grounding for EMI control.

B.3.2.2 Installation requirements; 2-pronged plug. Electrical equipment with a conductive case or exposed conductive elements that are supplied with a 2-conductor power cord and 2-pronged plug shall have the power cord and plug replaced with a 3- conductor cable of appropriate capacity and 3-pronged plug.

a. The third conductor shall be attached to the ground prong of the plug and the equipment chassis where the following conditions can be met:

(1) Where it is determined that a ground conductor can be conveniently connected to exposed metal parts on the equipment chassis.

(2) The modification does not compromise the equipment operation.

(3) The modification does not compromise the enclosure integrity.

b. Before use, an insulation resistance test shall determine:

(1) 1 megohm (minimum) resistance between the conductive case and each active power conductor prong.

(2) 0.1 ohm (maximum) resistance between the conductive case and the power cord ground prong.

B.4 POWER LINE SURGE PROTECTION FOR MOBILE ELECTRICAL EQUIPMENT. Any single-phase 115-volt mobile-transportable equipment which is permanently located and is energized more than 50 percent of the time (such as copiers, personal computers and peripherals and soda machines) shall not be connected to the ship's existing isolated receptacle circuits to prevent electrical overload resulting in a fire hazard.

B.4.1 Separate single-phase circuit. Each piece of equipment of this type should be connected to a separate single-phase circuit through an isolation transformer supplied by the lighting distribution system, using a multi-outlet power line strip (surge suppressor) in accordance with NSTM Chapter 300 when appropriate.

a. Where a multi-outlet power line strip is required, only one is allowed on one isolated receptacle circuit and the total equipment load must not exceed 13 amperes.

b. Since most commercial personnel computers and peripherals and similar equipment generally do not disconnect both power lines when the power switch is

in the "off" position, each of these mobile equipments should be unplugged from the power receptacle when switched off.

B.4.2 Power line strip surge suppressor for marine use. A marine type surge suppressor has a metal case, a double-pole switch/circuit breaker, multiple plug-in receptacles, and dual thermal fuses to prevent overheating in accordance with commercial item description (CID) A-A-50622. When all computer and peripheral equipments at a single work station are energized by power supplied through the "on/off" switch of a electrical surge suppressor, it will not be necessary to unplug each equipment from the power line receptacles or unplug the power line strip from the isolated receptacle circuit.

APPENDIX C

NONMETALLIC HULL SHIPS

CABLE GROUND SYSTEM FABRICATION

C.1 PURPOSE. The cable ground system shall provide the common reference (earth potential) ground plane for nonmetallic hull ships.

C.1.1 Primary common ground reference; systems and shielded spaces. Separate branches of the multi-tree ground plane shall be directly connected from the ground plate (see figure C-1) to: (1) all shielded spaces; (2) the metallic mast; (3) the ship service and ship service emergency switchboards, and (4) the ship service and ship service emergency generator sets.

C.1.2 Common ground reference outside shielded spaces. Separate branches of the cable ground plane shall provide the common ground reference required for operation of electrical and electronic equipment located outside shielded spaces and for bonding of metallic items located in the topside EME when required for hull-generated EMI control.

C.1.3 Common ground reference inside shielded spaces. Separate branches of the cable ground plane may be required to directly connect equipment utilizing electrical power inside shielded spaces in the event the short circuit current capacity of the enclosure, and the primary branch, trunks, and ground plate connection points thereto would be exceeded.

C.1.4 Electrical safety ground for shock hazard protection. Separate branches of the cable ground plane may be required to provide a dedicated connection for electrical and electronic equipment to the ground plate for personnel protection.

C.2 GROUND SYSTEM CABLES. The cables used in the ground cable installation should be in accordance with MIL-C-24643, and should have a minimum conductor size as specified herein.

C.2.1 Ground cable installation. Ground cables should be of minimum lengths consistent with other requirements specified herein. Cables should be installed in locations that provide minimum exposure to physical damage, and should provide access for inspection, repair, or replacement. Cables installed on nonmetallic hull structures should be supported by fasteners. Ground lugs installed on cables should be copper and should be connected by brazing. Lugs should not be crimped to the extent that conductor diameter is affected.

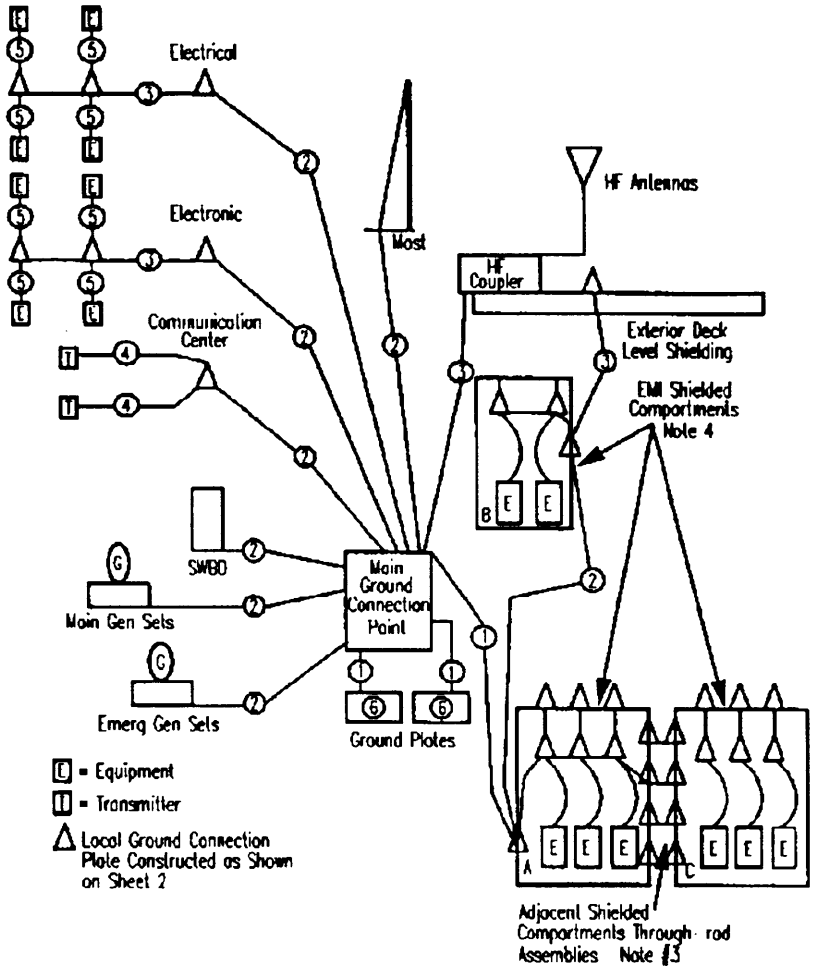
C.2.2 Ground plate interconnecting cable. A number 650 million circular mils (MCM) cable should be installed from each ground plate to the main ground connection point.

C.2.3 Main ground cable. Number 0000 AWG cables should be used as main ground cables for grounding all electrical and electronic equipment and metallic items. These cables should be connected to the main ground connection point and should run throughout the ship as shown on figure C-1.

C.2.4 Branch ground cables. Branch ground cables should be number 10 AWG and should be used to connect equipment requiring grounding (see C.1.3) to main ground cables.

a. Branch ground cables should be attached to the main ground cable by brazing or by connectors.

b. 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.

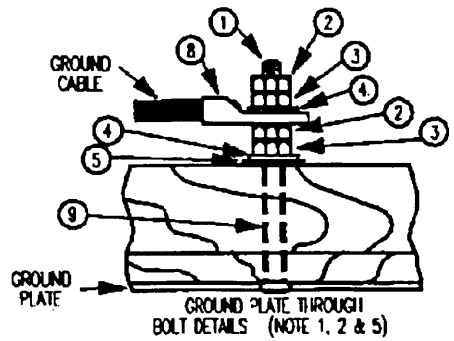


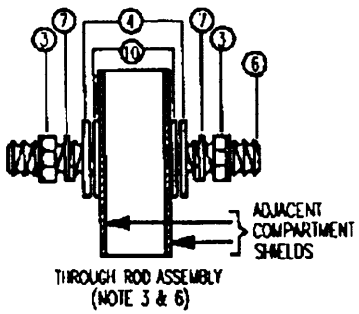
LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	WIRE, COPPER NO. 650 MCM	MIL-C-24643	1
2	WIRE, COPPER NO. 0000 AWG	MIL-C-24643	1
3	WIRE, COPPER NO. 1/0 AWG	MIL-C-24643	1
4	WIRE, COPPER NO. 1 AWG	MIL-C-24643	1
5	WIRE, COPPER NO. 10 AWG	MIL-C-24643	1
6	PLATE, COPPER, 1/8"	ASTM B 152	2

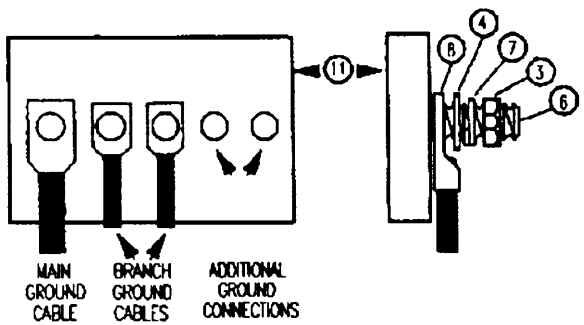
NOTES:

1. ALL CONDUCTOR SIZES ARE MINIMUM REQUIREMENTS ONLY.
2. GROUND PLATES SHOULD BE LIGHT, COLD-ROLLED, OXYGEN-FREE COPPER, APPROXIMATELY 1/8" THICK AND SHOULD 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 SHOULD BE DIRECTLY CONNECTED VIA THE 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 C-1a. 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. THE HEAD OF THE GROUND PLATE THROUGH-BOLT SHOULD BE BRAZED TO THE GROUND PLATE.
2. THE GROUND PLATE THROUGH-BOLT SHOULD AT LEAST EQUAL IN SIZE TO THE DIAMETER OF THE ASSOCIATED CABLE.
3. THE SHIELD THROUGH-ROD SHOULD BE 3/8 INCH DIAMETER (MINIMUM).
4. THE STUD OF LOCAL GROUND CONNECTION PLATES SHOULD BE 3/8 INCH DIAMETER (MINIMUM) AND BRAZED TO THE ASTM B 152 PLATE.
5. PROTECTION AGAINST SEEPAGE SHALL BE PROVIDED. USE MARINE CAULK OR POTTING MATERIAL COMPATIBLE WITH THE HULL MATERIAL AND NON CORROSIVE TO THE THROUGH-BOLT.
6. THE SHIELD INTERFACE MATERIAL, E.G., WASHER OR CONDUCTIVE GASKET, SHALL BE SELECTED TO PROVIDE ELECTRICAL CONTINUITY FROM THE SHIELD TO THE THREADED ROD VIA A COPPER WASHER AND HEX NUT TO MINIMIZE DISSIMILAR METALS.

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

(1) Ground conductor should connect to the generator or distribution panel and to metal housings of each component within the electrical supply system.

(2) The generator or distribution panel should then be connected to the ground plates.

c. Ground loops should be avoided where multiple ground conductors or cable shields terminate to equipment housings.

d. The power cable method of grounding should follow the safety grounding requirements of the NFPA National Electrical Code Handbook.

e. Class B bonding to metallic decks, bulkheads, or masts may be used in lieu of a branch ground wire.

C.2.5 Electronic transmitter ground cable. A number 0000 AWG cable should be connected to the main ground connection point and should run as directly as possible to the radio transmitter space(s).

a. Each radio transmitter cabinet or enclosure should be connected to this ground cable by a number 1 AWG cable.

b. Copper lugs or connectors, corresponding to cable size, should be used on each end of this cable.

C.2.6 Antenna tuners and couplers, ground cable. Each HF antenna coupler should 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.

a. Each HF coupler ground cable may be connected to the electronic transmitter ground cable, in lieu of the main ground connection point.

b. Other couplers and tuners located on metal masts or structures connected to the ground system should be class B bonded to the mast or structure.

c. Where couplers and tuners are mounted on nonmetallic masts or structures, a number 10 AWG ground system cable should be provided.

d. To minimize effect of ground loops, RF transmission lines should be routed with the tuner/coupler ground cables.

C.2.7 Lightning protection. A separate 0000 AWG cable connected to the main ground connection point should be installed for lightning protection. This cable should be routed in as straight a line as possible and should be continuous and unspliced from the highest conductive surface to the main ground connection point.

C.2.8 Metal mast. Where a metal mast is used, it should be connected to the ground plates using a size 0000 AWG cable. Equipment on the mast that requires grounding should be grounded to the mast (see C.3).

C.3 EQUIPMENT/ITEMS GROUNDING REQUIREMENTS.

C.3.1 Equipment/items that should be grounded. The following equipment and items should be connected to the ground system:

a. Equipment utilizing electrical power and any associated cabinets and interconnection 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 metallic underwater appendages.

C.3.2 Items that should not require grounding. The following items should not require grounding:

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.

C.4 GROUNDING TO SHIELDED AREA. Items and equipments specified in C.3.1 (above) located within 6 inches of a shielded area should 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.

C.5 CONNECTIONS. Equipment and items required to be grounded should have ground connections for terminating the ground cables. Each electrical or electronic equipment should 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 should provide the same low resistance as the ground cables. Prior to assembly, threaded and crimp connectors should be coated with an antiseize compound in accordance with MIL-A-907. Connections should be protected from corrosion by an application of MIL-S-45180, Type II sealing compound.

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7.
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I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER	2. DOCUMENT DATE (YYMMDD)
	MIL-STD-1310G(NAVY)	28 JUNE 1996

3. DOCUMENT TITLE
STANDARD PRACTICE FOR SHIPBOARD BONDING, GROUNDING, AND OTHER TECHNIQUES ...

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)	
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c. ADDRESS (Include Zip Code) 2531 JEFFERSON DAVIS HWY. ARLINGTON, VA 22242-5160	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	