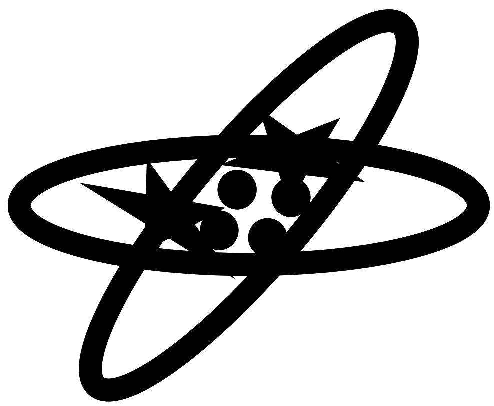
U.S. Department of
Homeland Security

United States
Coast Guard

ET2 UNIT 4: ELECTRONIC INSTALLATION STANDARDS



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ET2 UNIT 4: ELECTRONIC INSTALLATION STANDARDS

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QUESTIONS ABOUT THIS TEXT SHOULD BE
ADDRESSED TO THE SUBJECT MATTER SPECIALIST
FOR THE ET RATING

Record of Changes

Change Number	Date of Change	Date Entered	By Whom Entered

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Appendixes

Acknowledgments and References

Acknowledgments

Material is included in this pamphlet through courtesy of the designated source. The Coast Guard appreciates permission of the source to use this material, which contributes greatly to the effectiveness of this course. No copies or reproductions of the material are authorized without permission of the appropriate source.

The Coast Guard wishes to thank the following individuals for their expertise and support in the development of this document

ETC Chris Meyer

ETCS Aaron Cordell

ETC Kevin Odom

ETC Dave Baker

List of References

This pamphlet contains original material developed at the U. S. Coast Guard Training Center, Petaluma, California, and excerpts from the following technical publications:

- Electronics Manual, COMDTINST M10550.25 (series)
- Navy Electronics Installation and Maintenance Book, Installation Standards, SE000-00-EIM-110
- MIL-STD-1310G Standard Practice for Shipboard Bonding, Grounding, and other Techniques for Electromagnetic Compatibility and Safety
- MIL-STD-188-124B Grounding, Bonding and Shielding for Common Long haul/Tactical Communications Systems, Including ground based Communications- Electronics Facilities and Equipment
- MIL-HDBK-419A Grounding, Bonding, and Shielding for Electronic equipment and facilities

Notice to Students

Purpose

This pamphlet serves as a training aid to provide you with a general knowledge of Electronic Installation Standards tasks required of an ET2.

Important Note

This text has been compiled for TRAINING ONLY. It should NOT be used in place of official directives or publications. The test information is current according to the references listed. You should, however, remember that it is YOUR responsibility to keep up with the latest professional information available for your rating.

Current information is available from the Enlisted Performance Qualifications version (03-2009).

Course Content

This course content is based on the requirements stated in the Enlisted Performance Qualifications version (03-2009).

Record of Changes

From time to time courses, after they are printed, have minor editorial changes made to them by the Subject Matter Specialist that do not require a new course. The student is responsible for any changes made to the course after printing and receipt from the Coast Guard Institute. The Coast Guard Institute will post on their web site a listing of current changes based on the course code and edition that should be downloaded in a **.pdf** format and entered in the current course material. The Coast Guard Institute will send an errata sheet out with each ordered course that list the required changes.

Pamphlet Content

This pamphlet contains six lessons:

- Lesson 1: How to Trace point-to-point connections through multiple compartments
- Lesson 2: How to Maintain fault protection, lightning protection and signal reference systems
- Lesson 3: How to Install cables through multi-cable transits
- Lesson 4: How to Install Heliax cable connectors
- Lesson 5: How to Evaluate Heliax cables
- How to install stuffing tubes

Notice to Students

Learning Objectives

Read the learning objectives before you begin reading the text. The objectives will guide you through the text and help you answer the questions in the self-quiz at the end of each lesson.

Quizzes

Each lesson has a self-quiz and each pamphlet has a pamphlet review quiz. You will find the answers to each quiz on the pages following the quiz. Included are the reference pages for the answers.

These self-quizzes are meant to check your comprehension of the material you covered. If you are having problems understanding a section, go through it again or ask someone for help. The pamphlet review quiz questions are samples of the type of questions you will find on the end-of-course-test (EOCT).

SWE Study Suggestion

Servicewide exam questions for your rate and pay grade are based on the Professional and Military Requirements sections of the Enlisted Personnel Qualifications version (03-2009).

If you use the references from this text and consult the Enlisted Performance Qualifications Manual, you should have good information for review when you prepare for your servicewide exam (SWE).

Lesson 1

HOW TO TRACE POINT-TO-POINT CONNECTIONS THROUGH MULTIPLE COMPARTMENTS

Overview

Introduction

There are many times when being able to troubleshoot and repair the electronic equipment is not enough to fix the electronic system. As an Electronics Technician, you must be able to also trace wires and cables through multiple compartments. This requirement involves the ability to read wiring diagrams, blueprints, and physically tracing wiring and cable connections.

All electronic and electrical wiring and cabling is installed with cable, and connector destination tags. This lesson will provide training on interpreting and translating these tags to enable you to trace point-to-point connections.

Objectives

DEMONSTRATE how to trace point-to-point cable/wire connections through multiple compartments.

- IDENTIFY the proper cable tag specifications
- IDENTIFY the proper connector destination tags

References

The following references were used for this lesson:

- Electronics Manual, COMDTINST M10550.25 (series)
- Unit Drawing/COEDS
- Navy Electronics Installation and Maintenance Book, Installation Standards, SE000-00-EIM-110

Cable Tag Specifications

Introduction

All cables must be properly labeled with cable tags during installation. Cable tags consist of soft aluminum material and are secured to the cable with aluminum strips. Properly installed cable tags allow technicians to:

- Quickly identify an individual cable and its equipment association within a wiring bundle
- Trace point-to point connections for troubleshooting and cable replacement

Placement

Cable identification tags shall be installed:

- On all permanently installed cables
- As close as practicable to each point of termination
- On both sides of decks and bulkheads
- No more than 50 feet apart

The cable tags shall always be positioned so that they can easily be read without disturbing equipment circuitry.

Exceptions

The following are exceptions to the placement rules above:

- Only one tag is required when cables within a space are direct and are traceable, e.g., vertical run between decks
- Only one tag is required within a space where the trace can easily be viewed
- Additional tags are required when cables run through congested areas

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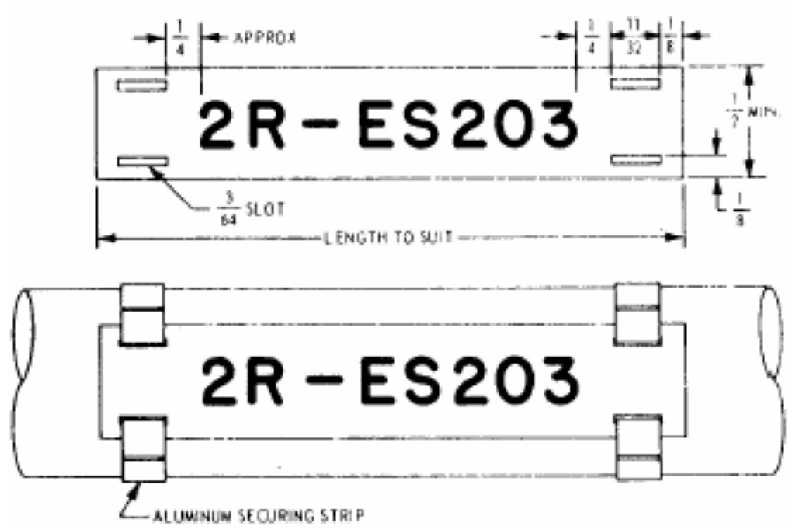
Cable Tag Specifications (Continued)

Identification and Markings

Cable tags consist of a series of letters and numbers separated by a dash. Reading from left to right, the letters and numbers are grouped as follows:

- The first number represents the identical system number
- The second letter is the cable segregation marking
- The center markings indicate the system designation marking
- The third group of numbers indicate the system cable number



Identical System Numbering

2R-ES203

The first number is used in cases where there are two or more identical electronic systems. In the example above, the number 2 represents the second system. When there is only one system, this identical system number is not required.

Continued on next page

Cable Tag Specifications (Continued)

Cable Segregation Marking

2R-ES203

The letter “R” is used to identify all cables used for electronics equipment interconnection service. The second letter (if any) identifies the class of the cable. The example above is a passive cable (having no second letter). The chart below provides the classifications:

Classification	Marking
Active cables	“A”
Susceptible cables	“S”
Passive cables	No marking

System Designation Marking

2R-ES203

The next set of letters “ES” (not underlined), indicates what type of system the cable is used for. The example above represents a surface search radar and because of the identical system number “2” this cable tag is for the second search radar. The chart below provides the most common system designations. For a complete list, refer to Cable Function Markings in NAVSEA 0967-LPP-000-0140.

System	Marking
Radar remote indicators	ER
Surface search radar	ES
Radio receiver circuits	RR
Radio synchronization	RS
Radio transmitter control	RT
Radio teletype	RY
Radio navigation	RN

Cable Tag Specifications (Continued)

System Cable Number

2R-ES203

The last group of numbers (underlined above), indicates the number of a cable in a particular system. In the example above, this tag number would represent cable 203.

Connector Destination Tags

Tag Placement

Electronic equipment/system cables that terminate in a connector shall have a tag placed on the cable next to the connector. The tag shall designate the jack number to which the connector is attached.

In the example above, the first tag indicates that this cable is connected to J602. The second tag (R-RR69) is the normal cable tag.

Antenna Connections

When a cable is connected to an antenna, the antenna number and type shall be indicated on a tag located at the equipment end of the cable.

In the example above, the center tag is showing "ANT" and the number "2-2 AS-899." This tag is located at the equipment end of the cable. The first tag is the connector tag (J301) and the third tag is the normal cable tag (R-RR70).

Conductor Tags

When conductors are connected to a terminal board they should be properly labeled with a conductor tag. Conductor tags can also be referred to as wire markings. These tags are made from flexible vinyl sleeving, either clear or white opaque, and sized to properly fit the wire being marked. Conductor tags shall be marked with the following information:

- The terminal to which the conductor will be connected
- The unit and terminal board to which the conductor is connected on the opposite end
- The terminal to which the connector is attached on the opposite end

Note: A spare conductor shall have the word "Spare" written on the conductor tag.

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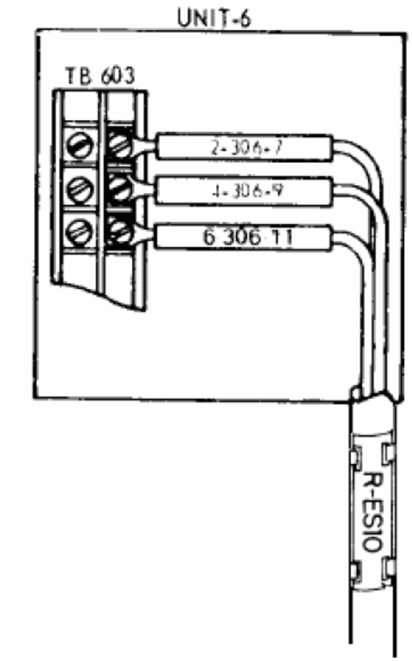
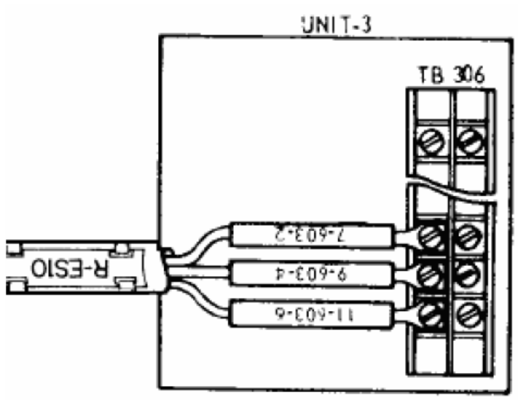
Connector Designation Tags (Continued)

Diagram 1



In the diagram above, the conductor tag labeled 2-306-7 is connected to terminal number 2 of TB 603, unit 6. The second and third numbers (306-7) identify that the wire is connected to unit 3, TB 306, terminal number 7. See Diagram 2.

Diagram 2



In the diagram above, the top wire's conductor tag labeled 7-603-2 is connected to terminal number 7 of TB 306, unit 3. The second and third numbers (603-2) identify that the wire is connected to unit 6, TB 603, terminal number 2.

Trace Point-to-Point Connections

Procedure

Perform the procedure below to trace point-to point connections through multiple compartments:

Step	Action
1.	Check with your supervisor to determine: • The type of electrical or electronic system • The type of wiring/cable within the system that requires tracing • The location of the wire/cable run (get a general idea of the start and end points of the wire/cable run)
2.	Gather any available blueprints or diagrams (these will assist you in determining feed-thru and bulkhead connections).
3.	Determine your starting point.
4.	Read the wire/cable and connector tags.
5.	Follow the wire/cable run by continuing to read and understand the tags from one point to another.

Summary

Interpreting cable and connector tags and knowing the specifications on where they are installed will enable you to trace cables and wires from point-to-point through shipboard and station compartments.

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Review Quiz

Questions

1. Which material are cable tags made out of?
   A. Aluminum
   B. Tin
   C. Steel
   D. Zinc

2. How do you determine which cable to trace?
   A. Identification tags on one side of the space
   B. Identification tags on both sides of the space
   C. Blueprints of all spaces
   D. Unit Standard Operating Procedures (SOP)

3. What does the first letter on the cable tag represent?
   A. Cable designator
   B. Space identifier
   C. Identical system marker
   D. Cable segregation marking

4. What does the letter R as the second character on a cable tag represent?
   A. States that the cable is for electronic equipment
   B. States the space the cable is going to
   C. States the space the cable is coming from
   D. States the equipment the cable is for

5. If the second letter on a cable tag is an A, what does that mean?
   A. Cable is used for electronics
   B. No meaning
   C. Cable is susceptible
   D. Cable is active

6. An ES to begin the second set of characters after the hyphen represents what?
   A. Radio Teletype
   B. Radio Navigation
   C. Surface search radar
   D. IFF equipment

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Review Quiz Answers

Answers

Question	Answer	Reference
1.	A	1-2
2.	B	1-2
3.	C	1-3
4.	A	1-4
5.	D	1-4
6.	C	1-4

Lesson 2

HOW TO MAINTAIN FAULT PROTECTION, LIGHTNING PROTECTION AND SIGNAL REFERENCE SYSTEMS

Overview

Introduction

This lesson introduces you to the facility ground system. The facility ground system forms a direct path of known low impedance between earth and various power, telecommunications and other types of electronic equipment, in order to effectively extend the ground reference throughout the electronics facility. When viewing the proper grounding of electronic equipment, it is important to look at the facility ground system from a total system viewpoint, which includes the various subsystems making up the total facility ground system.

Objectives

Upon completing this lesson, you will:

- Identify the three primary functions of the facility ground system
- List the four subsystems comprising the facility ground system

References

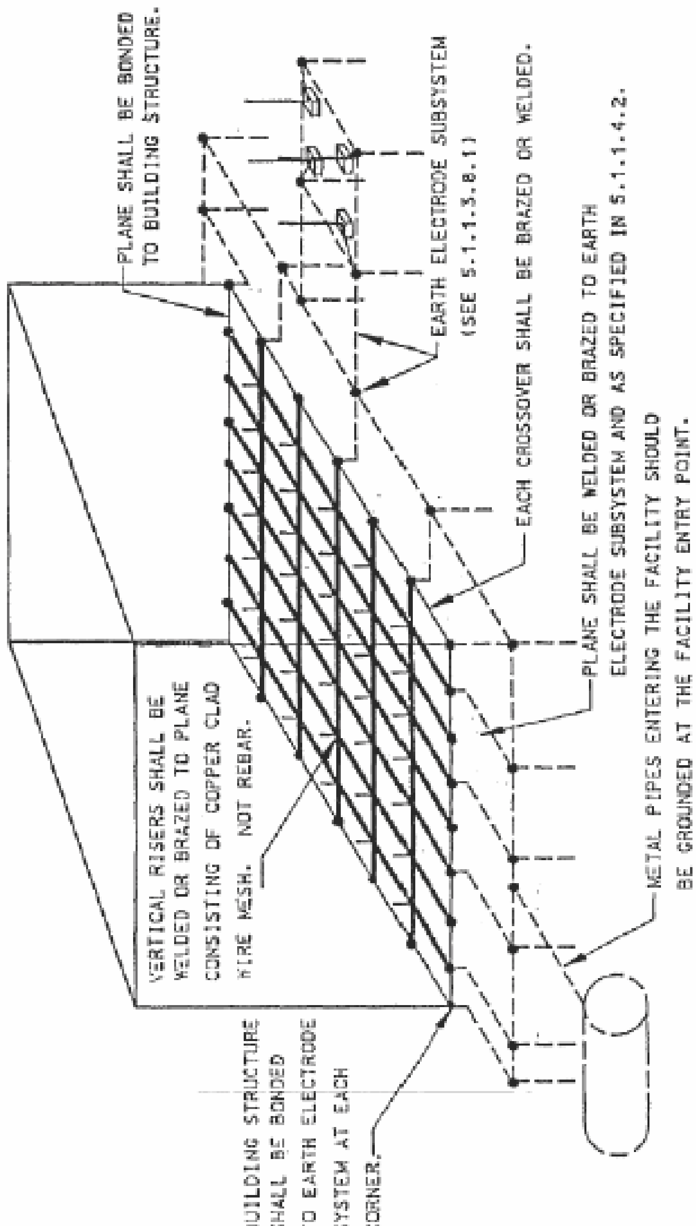
This lesson was written using the following references:

- Electronics Manual, COMDTINST M10550.25 (series)
- Standard Practice for Shipboard Bonding, Grounding, and other techniques for Electro-Magnetic Compatibility and Safety, MIL-STD-1310G
- Grounding, Bonding and Shielding for Common Long haul/Tactical Communications Systems Including Ground Based Communications-Electronics Facilities and Equipment, MIL-STD-188-124B
- Grounding, Bonding, and Shielding for Electronic Equipment & Facilities, MIL-HDBK-419A

Earth Electrode Subsystem

Introduction

The earth electrode subsystem and its relationship to the other subsystems of the facility ground system can be seen in the graphic depiction below:



Earth Electrode Subsystem

Earth Electrode Subsystem Components

The earth electrode subsystem consists of a network of earth electrode rods, plates, mats, or grids and their interconnecting conductors. Ground reference is established by electrodes in the earth at the site or installation. The earth electrode subsystem includes the following components:

- A system of buried, driven rods interconnected with bare wire that normally form a ring around the building
- Metallic pipe systems (e.g., water, gas, fuel, etc.) that have no insulation joints (these must not be used as the sole earth electrode subsystem)
- A ground plane of horizontal buried wires

Note: Extensions from buried electrodes entering buildings often serve as the principal ground point for connections to equipment ground subsystems.

Ground Rods

The most common type of ground rods are those made of copper-clad steel. Copper-clad steel ground rods are used due to the steel core providing strength to withstand the driving force used to drive them into the earth and the copper provides compatibility with copper or copper-clad interconnecting cables and corrosion protection. For most applications, ground rods of 1.90 cm (3/4 inch) diameter, and length of 3.0 meters (10 feet), are used where bedrock is beyond a depth of three meters (10 feet).

Buried Horizontal Conductors

Buried horizontal conductors include:

- Strips of metal, solid wires or stranded cables where bedrock is near the surface of the earth. With low impedance being desirable for minimizing lightning surge voltages and length of the buried horizontal conductors affecting the impedance of the conductors, several wires, strips, or cables arranged in a star pattern, with the facility at the center, is preferable to one long length of conductor
- Grid systems, consisting of copper cables buried in the ground and forming a network of squares, to provide equipotential areas throughout the facility area. These systems usually extend over an entire area with the spacing of the conductors varying according to requirements of the installation and bonded together at each crossover point
- Rectangular or circular plate electrodes in contact with the soil. With a burial depth of five to eight feet, this system is considered very expensive for the value produced and generally not recommended

Earth Electrode Subsystem (Continued)

Metal Framework

The metal framework of buildings may exhibit a resistance to earth of less than 10 ohms, depending upon the size of the building, the type of footing, and the type of subsoil at a particular location. Buildings that rest on steel pilings in particular may exhibit a very low resistance connection to earth. For this low resistance to be used advantageously, it is necessary that all elements of the framework be bonded together.

Metal Pipes

Metal underground pipes have traditionally been used as a source for grounding electrodes. The resistance to earth provided by piping systems is usually quite low because of the extensive contact made with soil. Municipal water systems in particular establish contact with the soil over a wide area. For water pipes to be effective, any possible breaks in the continuity of the pipe must be bridged with bonding jumpers. The NEC requires that water metering equipment and service unions be bypassed with a jumper not less than that required for the grounding connector.

Shipboard Ground Plane

Introduction

The shipboard ground plane is used to provide a ground in both:

- Metallic hull ships
- Non-metallic hull ships

Metal Hull Ships

In metallic hull ships, the metal hull, when in contact with sea water, establishes and is designated as ground potential for all electrical and electronic equipment.

Bond Categories and Methods

As defined in the previous lesson, bonds are the paths between two metallic surfaces and are created using a variety of methods. Bond categories and the methods used in creating bonds include:

Class A bond: Welding of metallic surfaces

Class B bond: Bolting or clamping of metallic surfaces

Class C bond: Bridging using a metallic (conductive) strap

Shipboard Ground Plane Requirements

Following are some of the requirements for the shipboard ground plane. For a complete listing of shipboard ground plane requirements, refer to MIL-STD-1310G (Navy).

- For metallic and non-metallic hull ships, all class A extensions to the ship's ground potential shall be designated as the ship's ground plane
- Items that are class B or class C bonded to the ground plane shall not be used as a tie point to ground potential for subsequent items
- Routing of all bond straps and grounding wires bonded to the ground plane shall be directly routed and kept as short as practical
- DC resistance across bonding and grounding junctions shall not exceed 0.1 ohms for electrical safety
- RF impedance across bonding and grounding junctions shall not exceed 25 ohms at 30 megahertz (MHz)

Inspection Requirements

Introduction

While not the responsibility of the Electronics Technician to inspect the earth electrode subsystem or the shipboard ground plane, the following sections list some (but not all) of the activities involved in performing a visual and electrical inspection of the earth electrode subsystem and shipboard ground plane. Refer to MIL-STD-188-124B and MIL-STD-1310G (Navy) for additional requirements.

Earth Electrode Subsystem Visual Inspect

A visual inspection of the facility's earth electrode subsystem is used to determine if:

- The earth electrode subsystem shown in the facility's engineering drawing complies with MIL-STD-188-124B
- The earth electrode subsystem consists of rods uniformly spaced around the facility, and outside the drip line of the facility
- The grounding rods of the earth electrode subsystem are made of copper clad steel
- The earth electrode subsystem rods are interconnected with No. 1/0AWG, or larger, bare copper cable
- The earth electrode subsystem interconnecting cables are brazed or welded to each ground rod
- The earth electrode subsystem provides a complete loop that fully encloses the facility
- Other structures (e.g., tower, etc.) are located within 6m (20 feet) of main facility and if one earth electrode subsystem encompasses all structures
- The tower has an earth electrode subsystem connected to the earth electrode subsystem of the building
- Other structures located greater than 6m (20 feet), are provided with a separate earth electrode subsystem
- There is more than one earth electrode subsystem, and if so, if they are interconnected with two bare No.1/0 AWG copper cables that use independent routes

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Inspection Procedures (Continued)

Fall of Potential Method

An electrical inspection of the facility's earth electrode subsystem includes, but is not limited to the following activities:

- Measure the resistance to earth every 12 months after the initial 12-month period of installation using the FALL-OF-POTENTIAL METHOD (including a diagram of the test procedure in the test data results)
- Determine if the resistance of the earth electrode subsystem to ground using the FALL-OF-POTENTIAL METHOD is less than 10 ohms
- Determine if the wideband noise with respect to earth ground measures less than 100 mV p-p, with periodic noise burst not exceeding 0.5 V p-p, and occasional bursts up to 1.0 V p-p or greater
- Measure the resistance to earth of all equipment, structures, fences and gates that are required to be bonded to ground and meets requirements of being less than 0.5 ohms

Inspection of Shipboard Ground Plane

Visual inspection procedures for the shipboard ground plane are performed to determine if:

- Metallic superstructure, equipment foundations and racks (not shock mounted), and mounting studs or brackets to which equipment is bolted for installation are class A bonded to ground potential.
- Equipment and hardware that is class B or class C bonded to the ship's ground plane is designated as grounded, but not as an element of the ground plane for grounding other items.
- Electrical and electronic equipment cases, cabinets or enclosures that may require routine removal for repair and replacement during the ship's life cycle are class B or class C bonded to ground.
- Shock-mounted equipment and equipment racks, and equipment mounted within them, are class B or class C bonded to ground.

Fault Protection

Introduction

Under conditions of current overload or excessive voltage, the fault protection subsystem ensures that:

- Personnel are protected from shock hazards
- Equipment is protected from damage or destruction

For fault protection, a low impedance path through the earth electrode subsystem will ensure that adequate fault current can flow in order to trip circuit breakers or open fuses. The fault protection subsystem provides for the grounding of conduits containing signal conductors, all other structural metallic elements and cabinets or racks of equipment.

Fault Protection Subsystem Components

Components of the fault protection subsystem include:

- Fault protection conductors
- Fault protection devices

Conductors

Fault protection conductors are provided throughout the power distribution system in order to allow electrical paths of sufficient current- carrying capacity to operate fuses and circuit breakers. Fault protection conductors include:

- Grounding electrode conductors
- Equipment grounding conductors
- Non-current carrying metal structures

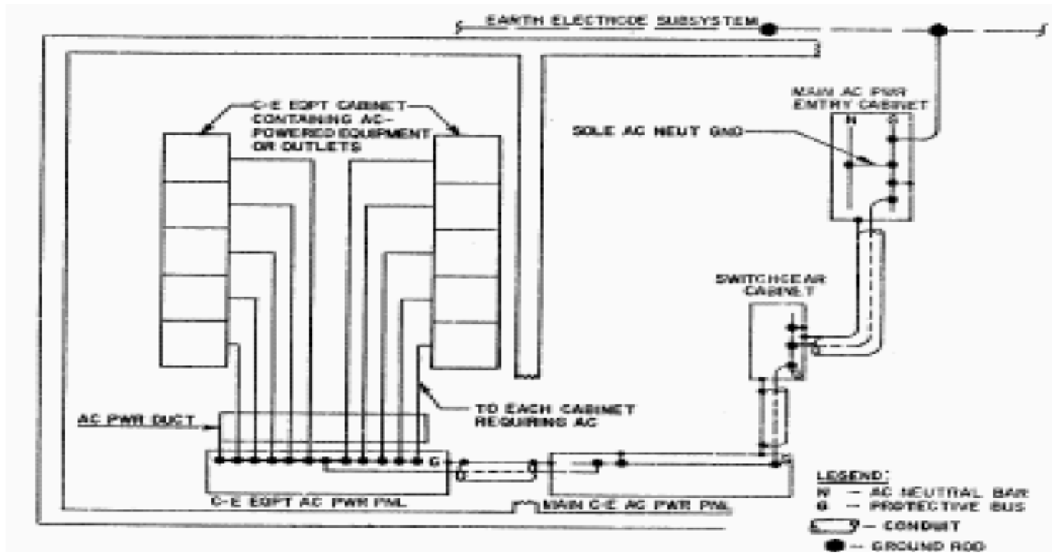
Note: If at all possible, fault protection conductors should be physically separate from signal reference ground conductors except at where they connect to the earth electrode subsystem.

Continued on next page

Fault Protection (Continued)

Interconnecting Fault Protection Conductors

The fault protection subsystem provides a low impedance path to ground by interconnecting all equipment to the facility's earth electrode subsystem using grounding conductors (green wires). Interconnecting all equipment at the earth electrode subsystem creates an equipotential plane that eliminates the difference of potential between individual equipment and from the equipment to ground. See example below:



Note: The AC neutral and phase conductors are not shown for clarity. The "G-Protective Bus" is the equipment-grounding conductor. All grounding conductors that penetrate or cross a designated RF barrier or shield should be bonded to the barrier or shield.

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Fault Protection (Continued)

Grounding Electrode Materials

Protective measures must be taken during installation and maintenance to prevent corrosion from taking place. The material selected should be resistant to any corrosive condition that may exist and may be made of:

- Copper
- Aluminum
- Copper-clad steel

Grounding Electrode Types

Grounding electrode conductors may be:

- Solid
- Stranded
- Insulated
- Covered
- Bare wires

Grounding Conductor Materials

Equipment grounding conductors may be made up of one or more, or a combination, of the following types of materials:

- Copper or other corrosion-resistant material (solid, stranded, insulated, covered, or bare, and in the form of a wire or bus bar of any shape)
- Rigid metal conduit
- Intermediate metal conduit
- Electrical metallic tubing
- Flexible metal conduit
- Armor of AC-type cable
- Copper sheath of mineral-insulated, metal-sheath cable
- Metallic sheath or the combined metallic sheath and grounding conductors of type MC cable
- Cable trays as permitted by the National Electrical Code (NEC)
- Cable bus framework as permitted by the National Electrical Code
- Other electrically continuous metal raceways

Fault Protection Devices

Introduction

Fault protection devices include:

- Fuses
- Circuit breakers
- Ground fault sensors
- Ground fault circuit interrupters (GFCIs)

Fuses

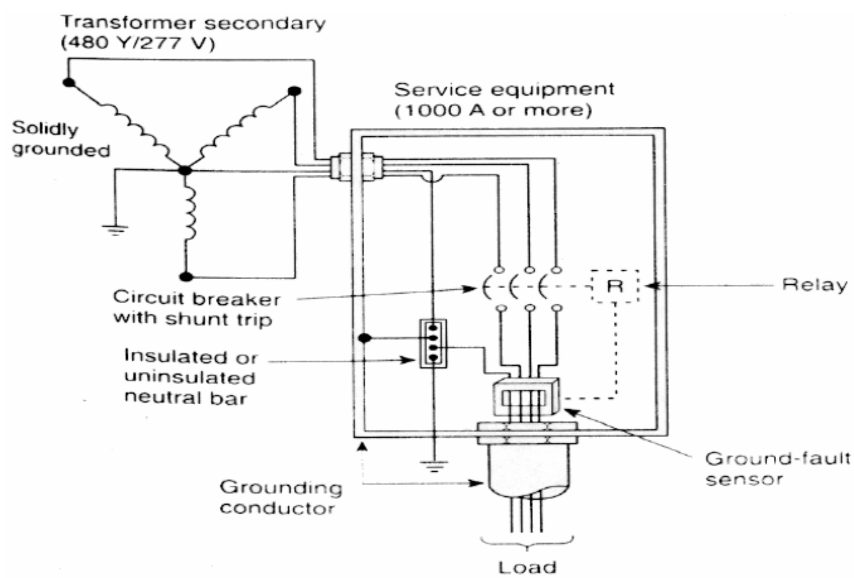
Each ungrounded service conductor (phase lead) should have overload protection provided by an over-current device such as a fuse. The fuse should be in series with each ungrounded service conductor and have a rating or setting no higher than the current carrying capability of the conductor.

Circuit Breakers

Circuit breakers allow for manually making, carrying and breaking currents under normal circuit conditions, making and carrying currents for a specified time, and automatically breaking currents under specified abnormal circuit conditions.

Ground Fault Sensors

Ground fault sensors operate in a manner similar to GFCI but primarily serve to protect equipment from fault conditions. The sensors monitor the current that runs through them and cause circuit breakers to trip whenever a fault condition exists. Below is an example:



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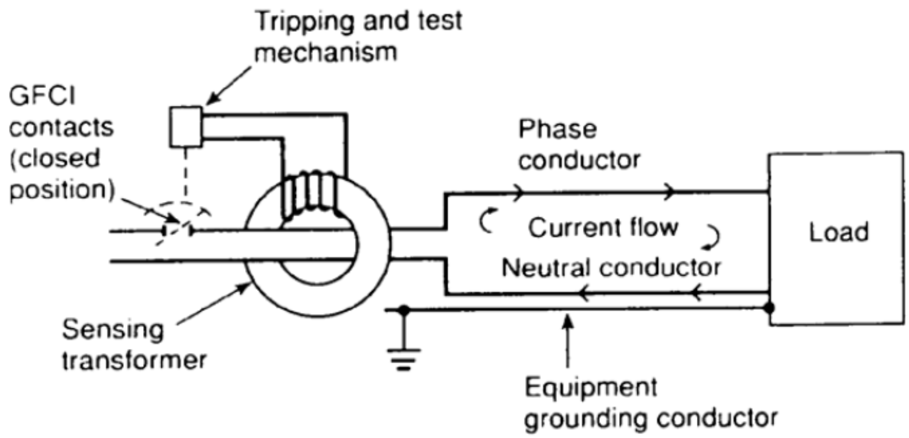
Fault Protection Devices (Continued)

GFCIs

GFCIs (Ground Fault Circuit Interrupters) have a very fast response time, and their sensitivity to detection of fault currents makes these devices extremely valuable for personnel safety. GFCIs monitor the current supplied from the source and the current returning from the load.

Whenever a change in current is detected, the GFCI's trip mechanism will activate and disconnect the equipment from its source of supply. Refer to the diagram below:



MIL-STD-188-124B recommends that GFCIs be installed on 120-volt, single-phase, 15- and 20-ampere receptacles of C-E facilities.

Non-current Carrying Metal Structures

Introduction

Non-current-carrying metal structures include:

- Metal frames or enclosures of apparatus
- Metal sheaths and the armor of armored cables
- Metal conduits and joints in metal conduits

Inspection

Inspecting non-current-carrying metal structures includes inspecting:

- Metal frames or enclosures of apparatus to ensure that they are fixed to, and in metallic contact with the ship's structure, provided that the surfaces in contact are clean and free from rust, scale or paint when installed and are firmly bolted together

Note: Metal frames or enclosures of apparatus shall be connected to the hull, either directly or via the grounding terminal of a receptacle outlet. Do not rely solely on metallic cable sheaths for this purpose.

- Metal sheaths and the armor of cables shall be designed and grounded by means of connectors intended to ensure an effective ground connection and be firmly attached in order to make an effective electrical contact with a grounded metal structure

Metal conduits and joints in metal conduits shall be grounded by either being screwed into a metal enclosure, or by nuts on both sides of the wall of a metal enclosure or by means of clamps or clips of corrosion-resistant metal, making effective contact with the sheath or armor and grounded metal; provided the surfaces are clean and free from rust, scale or paint and that the enclosure is grounded.

Metal conduits, ducts and metal sheaths of cables which are used for ground continuity shall be soundly made and protected where necessary against corrosion.

Fault Protection Inspection Procedures

Introduction

Inspecting the fault protection subsystem involves two types of inspections:

- A visual inspection of the system conductors and devices
- An electrical inspection of system conductors

Inspection Schedule

Inspections of the fault protection subsystem are to be performed:

- During the initial site survey,
- Annually, after the initial site survey, and
- Following any major changes to equipment or systems.

Note: Before beginning the inspections, review the past 12 months for any occurrences of power disturbances, (blackouts, sag, surges, impulses, distortion or noise) and document any findings and subsequent changes made to the fault protection subsystem resulting from the inspection.

Visual Inspections

Visually inspecting system conductors for low-impedance connections and lead reversals between ground and neutral conductors takes up most of the work involved in maintaining the fault protection subsystem.

Inspection Tools

Performing an electrical inspection requires tools and strict adherence to safety procedures. Tools normally used for performing inspections include:

- Safety glasses
- Insulated tools (pliers, screwdrivers, etc.)
- Multimeter
- Clamp-on ammeters
- Ohmmeters capable of measuring resistance as low as 1 milliohms (.001-ohms)

Fault Protection Inspection Job Aids

Introduction

An inspection of the fault protection subsystem is divided into two parts:

- A visual inspection
- An electrical inspection

Refer to the appropriate job aids below to perform each of these inspections.

Visual Inspection Procedure

To complete a visual inspection of the facility's fault protection subsystem, complete the checklist below:

Step	Action	Yes	No	N/A
1.	Obtain copies of MIL-STD-188-124B, NEC documentation and MIL-HDBK-419.			
2.	Is there a separate grounding conductor (green wire) for the power system and is it installed with phase and neutral conductors? *Ref: MIL-STD 188-124B Para. 5.1.1.2.1*			
3.	Are there any white-wire/green-wire reversals?			
4.	Are green wires of the required size? *Ref: NEC handbook, Chap. 2, Table 250-66*			
5.	Are the neutral and green conductors properly interconnected and grounded at the first service? *Ref: MIL-STD 188-124B Para. 5.1.1.2.5*			
6.	Are all major non-current carrying metal objects grounded, to include metal support structures, cable trays and wireways? *Ref: MIL-STD 188-124B, Para. 5.1.1.2.1*			
7.	Are all main metallic structural members electrically continuous and grounded? *Ref: MIL-STD 188-124B, Para. 5.1.1.2.2*			
8.	Are all metallic piping, tubing and supports electrically continuous and grounded? *Ref: MIL-STD 188-124B, Para 5.1.1.2.3*			
9.	Are all electrical supporting structures electrically continuous and grounded? *Ref: MIL-STD-188-124A, Section 5.1.1.2.4*			
10.	After disconnecting power and opening electrical boxes, distribution panels and switch boxes, are any white (neutral) wires grounded?			

Fault Protection Inspection Job Aids (Continued)

Inspection Procedure (Cont'd)

Step	Action	Yes	No	N/A
11.	Are the ground terminals of all AC outlets connected to the facility ground system through the grounding (GREEN) conductor? *Ref: MIL-STD 188-124B, Para 5.1.1.2.5.3*			
12.	Do bonds show any sign of corrosion? *Ref: MIL-STD-188-124B, Para. 5.2.3.1*			
13.	Do all bonds appear to be tight? *Ref: MIL-STD-188-124B, Para. 5.2.3.3 & 5.2.6.5*			
14.	Do bonding clamps conform to AN 735 and AN742? C-clamps or spring type clamps are not permitted. *Ref: MIL-STD-188-124B, Para. 5.2.6.6*			
15.	Are bonded areas visually clean? *Ref: MIL-STD-188-124B, Para. 5.2.8*			
16.	Are bonds exposed to moisture or bonds located in areas not reasonably accessible for maintenance painted with a moisture proof paint or sealed with a silicone or petroleum-based sealant? *Ref: MIL-STD-188-124B, Para. 5.2.3.1*			
17.	Is each subassembly and chassis bonded to the rack, frame, or cabinet IAW the reference? *Ref: MIL-STD-188-124B, Para. 5.2.10*			
18.	Are all cabinets individually grounded by a single, unbroken ground conductor attached to the ground rail of each cabinet and terminated at the facility ground? *Ref: MIL-STD-188-124B, Para. 5.2.10.2* *MIL-HDBK-419A, Volume II, Section 3.2.3*			
19.	Are adjacent cabinets and racks bonded to each other? *Ref: MIL-STD-188-124B, Para. 5.2.10.2* *MIL-HDBK-419A, Volume II, Section 3.2.3*			
20.	Are cable connectors adequately mounted to their panel so that bonding between the mating jack and plug is accomplished completely around the periphery of the flange of the connectors? *Ref: MIL-STD-188-124B, Para. 5.2.11*			

Continued on next page

Fault Protection Inspection Job Aids (Continued)

Inspection Procedure (Cont'd)

Step	Action	Yes	No	N/A
21.	Are shields of coaxial cables fastened according to the reference? *Ref: MIL-STD-188-124B, Para. 5.2.12*			
22.	Are shield pigtails less than 2.5 cm (1 inch) long? *Ref: MIL-STD-188-124B, Para. 5.2.12*			

Electrical Inspection Procedure

Step	Action	Yes	No	N/A
1.	Obtain copies of MIL-STD-188-124B, NEC Handbook and MIL-HDBK-419.			
2.	Is the facility fault protection subsystem and signal reference network free of AC neutral return current? ***Note***: Generally less than 1.0 Amp is acceptable, depending on the situation. *Ref: MIL-STD 188-124B, Para 5.1.1.2.5.*			
3.	Do any bonds have a resistance across the bond in excess of 1 milliohm? ***Note***: Measure the bond resistances according to MIL-HDBK 419, Volume II, Section 2.2.2.3.1 of five to 10 bonds that visually appear tight, well-made, and corrosion- free. ***Note***: Measure the bond resistances of at least 10 bonds that exhibit visual defects such as corrosion or loose connections. *Ref: MIL-STD-188-124B, Para. 5.2.4*			
4.	Are all neutral conductors grounded only at one point? (At the facility first service disconnect point or to the earth electrode system point nearest to the facility common distribution transformer). ***Note***: Generally less than 1.0 Amp is acceptable, depending on the situation. *Ref: MIL-STD 188-124B, Para 5.1.1.2.5*			

Inspecting Lightning Protection Subsystems

Introduction

This lesson provides training on the maintenance and inspection of lightning protection subsystems. The lightning protection subsystem provides a nondestructive path to ground for lightning energy contacting or induced in facility structures. To effectively protect a building, mast, tower, or similar self-supporting objects from lightning damage, an air terminal (lightning rod) of adequate mechanical strength and electrical conductivity to withstand the stroke impingement must be provided. An air terminal will intercept the discharge to keep it from penetrating the nonconductive outer coverings of the structure, and prevent it from passing through devices likely to be damaged or destroyed. A low impedance path from the air terminal to earth must also be provided. These requirements are met by either:

- An integral system of air terminals, roof conductors, and down conductors securely interconnected to provide the shortest practicable path to earth
- A separately mounted shielding system, such as a metal mast or wires (which act as air terminals) and down conductors to the earth electrode subsystem

Fundamentals

To understand lightning, it is best to review the basic theory of lightning—what are its causes, its characteristics, the likelihood of being struck by lightning and its effects.

Causes

Lightning is caused by the static buildup of positive and negative charges within clouds, and between the clouds and ground. This static buildup can charge the cloud to a point (millions of volts) where it will exceed the breakdown dielectric of air. Once this occurs, a lightning strike will occur.

Characteristics

Most lightning flashes (strikes) observed from the ground are actually a series of strokes occurring so fast that they appear to be just one single strike. An average lightning strike consists of about three strikes, with the first strike discharging an average of 18 kA. Subsequent lightning strikes will discharge about half the current of each preceding lightning strike.

Effects of Lightning

Introduction

Any object struck by lightning is subject to damage. The severity of the damage depends upon the effects of the lightning strike. Below are listed each of the five types of effects along with a brief description.

- Thermal
- Mechanical
- Electrical
- Conductor Impedance
- Induced Voltage

Thermal Effects

How much damage an object sustains depends in part on the conductive power of the object. Large metal structures will probably withstand all but the strongest of lightning discharges. Even a telephone wire will be left intact, except at the point of entrance or exit where severe damage is most likely to occur. The damage caused by thermal effects may include the following:

- Small deformation at the tip of a lightning rod or small melted area on the intercepting cable
- Very strong discharges that can melt or burn holes in solid metal plates

Mechanical Effects

A short duration, high-peak current pulse will produce a mechanical effect that may tear or bend metal parts because of the electromagnetic force created by the current surge. This effect makes it necessary to ensure that lightning rods, down conductors, and other elements of the protection system are securely fastened.

Electrical Effects

The voltages developed by fast-rising, high-current lightning strikes are usually high enough to:

- Cause insulation breakdown
- Pose a safety hazard for personnel
- Cause component and device failure

Continued on next page

Effects of Lightning (Continued)

Conductor Impedance Effects

Impedance effects of conductors cause extremely high voltages to develop across conductors due to inductance. Inductance refers to the property of a conductor that opposes a change in current. The high voltage that develops may be high enough to cause a flashover to conducting objects located as close as 14 inches away. For this reason, metal objects within six feet of lightning down conductors should be electrically bonded to the down conductors.

Induced Voltage Effects

The high voltage developed in a down conductor will be induced to nearby electronic circuits when such circuits run parallel to the down conductor. For this reason, cables that terminate in electronic devices should not run parallel to down conductors. This includes power, signal, and control lines. If this situation cannot be avoided, the separation between the down conductors and other cables should be as large as possible.

Lightning Protection Requirements

Introduction

In order to protect facilities and personnel from lightning strikes, certain requirements must be implemented into the facility's design to minimize the damage caused by even a direct lightning hit.

Applicable Codes

The lightning protection code, NFPA No. 780, issued by the National Fire Prevention Association, contains the basic requirements for personnel protection from a lightning strike to a structure.

Code of Federal Regulations (CFR), Title 46 – Shipping, Subchapter J – Part 111: Electric Systems and General Requirements for shipboard applications.

Basic Requirements

To protect any structure, such as a building, vessel, mast, etc., from lightning damage, the following basic requirements must be met:

- An air terminal must be installed to attract the lightning to the terminal and away from the facility and equipment
- Roof and down conductors must be a separate 0000 AWG cable, continuous, un-spliced and installed in as straight a line as possible in order to provide a low-impedance path from the highest conductive surface (air terminal) to the main ground connection point
- Where a metal mast is used, it should be connected to the ground plates using a size 0000 AWG cable. Equipment on the mast requiring grounding should be grounded to the mast
- Nonmetallic masts and topmasts must have a lightning ground conductor using a size 0000 AWG cable
- Dedicated ground rods (for ashore units) and ground plates (for afloat units) must be used to connect the roof/down conductors and lightning ground conductors respectively

Protection Devices

Introduction

Lightning protection devices include:

- Air terminals
- Down conductors
- Ground rods

Air Terminal

An air terminal attracts the lightning and protects other structures from direct lightning hits. The tip of the air terminal should be at least 10 inches above the structure you are protecting. The air terminal should be a conductor of adequate strength, and must possess the conductivity to withstand the high lightning current that will pass through it.

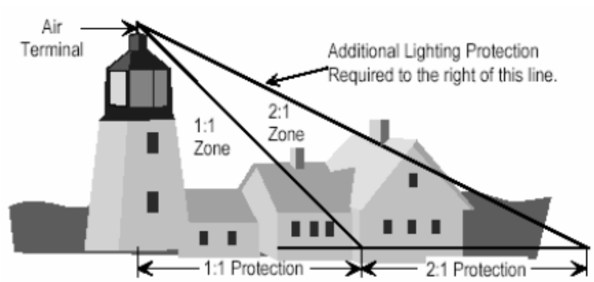
Air Terminal Placement

The air terminal should be placed in an area where lightning will most likely strike. (For example, the highest point of a structure, such as a chimney that extends past the roof in a building.) Refer to the chart below:

If a building has a …	Then air terminal placement should be …
Flat roof	On the corners or edges
Pitched roof	Within two feet of ridged ends
Sloping roof	On the corners and edges where terminals that are: • Less than 24 inches in height are spaced a maximum of 20 ft. apart • Equal to or greater than 24 inches in height are spaced a maximum of 25 ft. apart

Air Terminal Example

A tall structure with lightning protection offers a cone of protection to smaller structures nearby. Any critical structures within a 1:1 cone of protection do not require lightning protection. Any non-critical structures within a 2:1 cone of protection also do not require protection.



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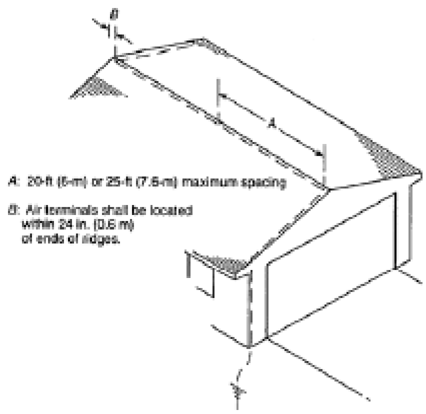
Protection Devices (Continued)

Air Terminal Example (Cont'd)

In the example on the page, the structure closest to the air terminal is critical and is inside of the 1:1 cone of protection. The next nearest structure is non-critical and is within the 2:1 zone, so it requires no additional protection. A portion of structure farthest away from the air terminal is outside of the 2:1 zone and does require additional protection.

Air Terminal Placement on Roofs

The following diagrams illustrate the proper location of air terminals on various types of roofs:



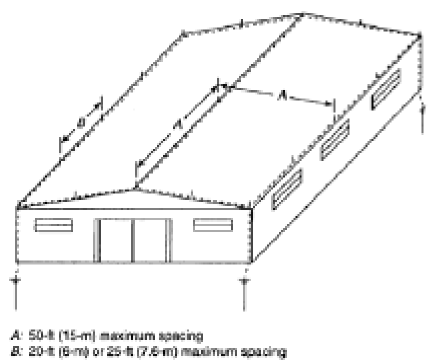
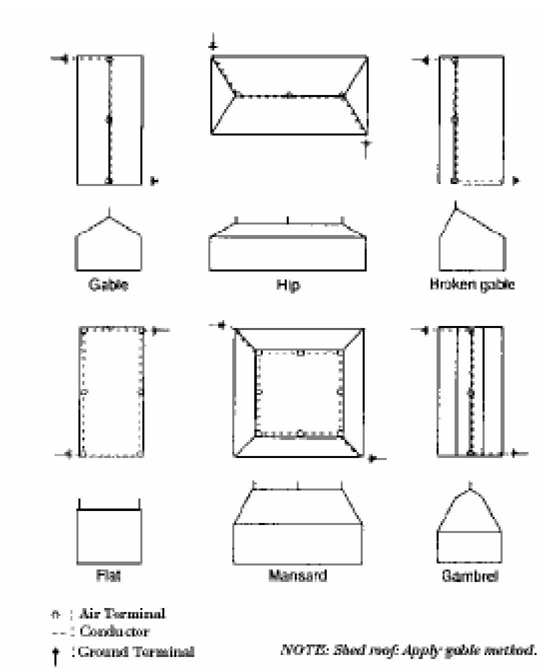


Figure 3-8.1.2(b) Air terminals on gently sloping roof.



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Protection Devices (Continued)

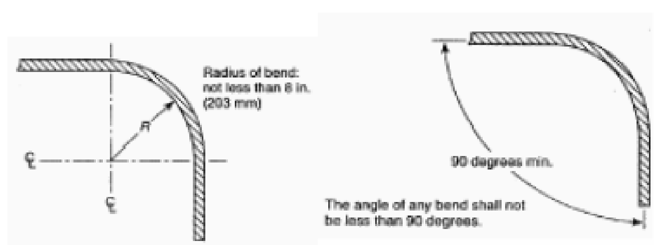
Down Conductors

As the conductor connecting the air terminal or overhead ground wire to the earth electrode subsystem, the down conductor must be:

- Continuous and bonded to the earth electrode subsystem
- Bonded to tower legs at the base in situations where the structural elements of the metal tower are not used as down conductors
- Protected against mechanical damage
- Installed in plastic or non-metallic conduit as it passes through foundations or footings

Down Conductor Requirements

When copper-clad steel is used as a down conductor, the DC resistance shall meet the following specifications:

Conductors up to 75 ft.	The maximum DC resistance shall not be greater than 0.176 ohms per 1000 ft.
Conductors more than 75 ft.	The maximum dc resistance shall not be greater than 0.088 ohms per 1000 ft.
Size	The size of the wire shall not be less than No. 14 AWG. (No. 6 AWG copper wire is recommended).
Conductivity	The conductivity of copper-clad steel shall not be less than 30% of a solid copper conductor with an equivalent cross-sectional area.
Bends	Bending of the down conductor should be gradual; the bend radius should not be less than eight inches. The angle of any bend shall not be less than 90 degrees. 

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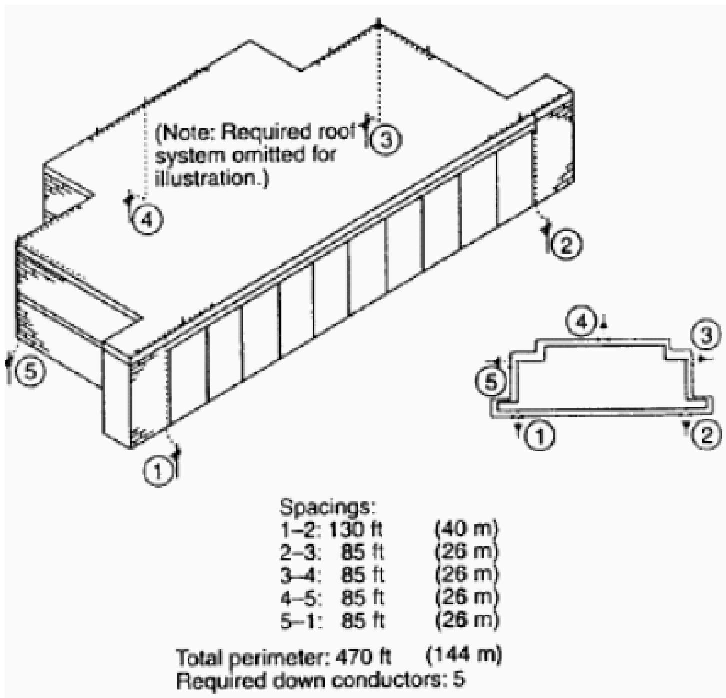
Protection Devices (Continued)

Down Conductor Placement

An air terminal must have at least two paths for discharging the lightning to ground. This is accomplished through the use of roof and down conductors. Roof conductors interconnect all air terminals to the down conductors. At least two down conductors shall be placed on any structure. On structures exceeding 250 ft. in perimeter, an additional down conductor is required for each additional 100 ft. of perimeter. The average distance between down conductors shall not exceed 100 ft.



Ground Rods

Ground rods make up the final element of the lightning protection subsystem:

- Ground rods are constructed of copper-clad steel, solid copper, hot-dipped galvanized steel, or stainless steel
- The ground rod shall be at least eight feet long and ½ inch in diameter
- A ground rod dedicated exclusively for lightning protection shall terminate each down conductor
- All lightning ground rods shall be connected together and to the facility’s earth electrode subsystem

Note: To prevent galvanic corrosion, all ground rods should be constructed of the same materials. This includes the earth electrode subsystem ground rods.

Lightning Protection Inspections

Introduction

A site survey of the lightning protection subsystem is divided into two parts:

- A visual and mechanical inspection
- An electrical inspection

Refer to the appropriate job aid on the following pages to perform each of these inspections.

Inspection Frequency

The lightning protection subsystem should be inspected visually every two months and mechanically every 12 months per NETA guidelines.

Visual and Mechanical Inspections

Visual and mechanical inspections include:

- Verifying that all facility components and antennas are within the cone of protection
- Checking for evidence of burning and/or pitting, as well as melting of air terminals
- Checking for burned fasteners
- Checking for broken or melted down conductors or severely damaged as well as distorted roof conductors, down conductors, and bonding jumpers
- Looking for signs of arcing or flashover indicating a need for bonding jumpers or spark gaps
- Checking for corroded or loose connectors and fasteners
- Verifying that copper-to-aluminum contact does not occur except through Underwriters Laboratories (UL) approved bimetallic connectors
- Verifying that all guards for down conductors are in place and without severe mechanical damage
- Verifying that all guards are bonded to down conductors (at both ends of guard).

Electrical Inspection

Electrical inspection of the lightning subsystem tests a sample of the bonds included in the lightning protection subsystem from the air terminal to the earth electrode subsystem or shipboard ground plane.

Lightning Protection Inspection Job Aids

Procedure

Follow the procedure below to complete an inspection of the facility's lightning protection components. Refer to MIL-HDBK-419A, Sections 2.2.2.2.3 and 2.3.2.2 for additional information on inspection, maintenance, and reporting major discrepancies found during inspections.

Step	Action	Yes	No	N/A
1.	Obtain copies of MIL-STD-188-124B, NEC Handbook and MIL-HDBK-419.			
2.	Is the facility protected against lightning? *Ref: MIL-STD 188-124B, Para 5.1.1.3.2*			
3.	Do large structures with flat or gently slopping roofs have lightning protection as described in MIL-HDBK-419A, Volume II, Section 1.3? *Ref: MIL-STD-188-124A, Para. 5.1.3.8.3*			
4.	Are all antennas inside a 1:1 cone of protection? *Ref: MIL-HDBK-419B, Volume I, Section 3.5.2*			
5.	Are all down conductors, fasteners, and mounting hardware secure and corrosion free? *Ref: MIL-HDBK-419A, Vol. II, Para 1.3.2.3.b.*			
6.	All down conductors of the lightning protection subsystem have bends with a radius less than 20 cm (8 inches) or bends not less than 90°? *Ref: MIL-STD-188-124A, Para. 5.1.1.3.3*			
7.	Are all metal objects within 1.8 meters (6 ft) of the lightning down conductor bonded or grounded to the facility ground? *Ref: MIL-STD 188-124B, Para 5.1.1.3.3*			
8.	Are all bonds between elements of the lightning protection subsystem welded, brazed, or secured by UL-approved clamps? *Ref: MIL-STD 188-124B, Para 5.1.1.3.4*			
9.	Are two tower legs independently grounded to the earth electrode subsystem? *Ref: MIL-STD 188-124B, Para 5.1.1.3.8.1*			
10.	Are the down conductors from the tower bonded to the tower at the base? *Ref: MIL-STD 188-124B, Para 5.1.1.3.8.1*			

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Lightning Protection Inspection Job Aid (Continued)

Procedure (Cont'd)

Step	Action	Yes	No	N/A
11.	Are two bare 1/0 AWG copper cables, using different routes, used to bond the tower earth electrode subsystem to the earth electrode subsystem of the building and structure that have signal, control and power line interface with the tower and are separated by less than 60 meters (200 ft). *Ref: MIL-STD 188-124B, Para 5.1.1.3.8.1*			
12.	Are all lightning down conductors continuous and welded or brazed to the electrode subsystem. *Ref: MIL-STD 188-124B, Para 5.1.1.1.5*			
13.	Are all waveguides and the outer shields of rigid and semi-rigid coaxial cables grounded near the antenna? *Ref: MIL-STD 188-124B, Para 5.1.1.3.8.5.a*			
14.	Are the shields of all coaxial cables entering the building bonded to the facility's entrance plate and in turn to the earth electrode subsystem IAW the guidelines presented in MIL-HDBK-419A, Volume II, Paragraph 1.3.3.4 *Ref: MIL-STD-124B, Para. 5.1.1.3.8.6*			
15.	Are handrails, ladders, stairways, antenna pedestals and objects subject to human contact grounded? *Ref: MIL-STD-188-124A, Para. 5.1.1.3.9*			
16.	Are exposed and underground power lines, not otherwise protected, provided with UL approved lightning arrestors, also known as transient voltage surge suppressors (TVSS)? *Ref: MIL-STD-188-124B, Para. 5.1.1.3.12*			
17.	Are arrestors properly installed? *Ref: National Electrical Code, Article 280 and MIL-HDBK-419A, Vol II, Para 1.3.3.5.12*			
18.	Are all unused wires/pairs of communications cables grounded at each end? *Ref: MIL-HDBK-419A, Vol. II, Para 1.3.3.5.27*			

Lightning Protection Inspection Job Aid (Continued)

Procedure (Cont'd)

Step	Action	Yes	No	N/A
19.	Are all security or perimeter fence grounded IAW MIL-HDBK-419A, Volume II, Section 1.12. *Ref: MIL-STD-188-124B, Para. 5.1.1.3.13*			
20.	Are there signs of arcing or flashover?			
21.	Are there signs of burning, pitting, or melting air terminals?			
22.	Are there signs of burned or melted conductors or fasteners?			
23.	Are guards bonded to the down conductor at both ends?			
24.	Are there signs of broken or damaged roof conductors, down conductors, or bonding jumpers?			

Inspecting Signal Reference Ground Subsystems

Introduction

This lesson provides training on the maintenance and inspection of signal reference ground subsystems. The signal reference ground subsystem establishes a common point to reference all signals for Communications Electronics (C-E) equipment by minimizing voltage differences between equipment units. This common reference point also reduces the current flow between equipments and minimizes or eliminates noise voltages on signal paths or circuits. Within a single unit of equipment, the signal reference ground subsystem may be a bus bar or conductor that serves as a reference for some or all of the signal circuits within the equipment. Between equipments, the signal reference subsystem will be a network consisting of a number of interconnected conductors. Whether serving a collection of circuits within a single equipment unit or serving several equipment units within a facility, the signal reference ground network may use multiple point or equipotential planes but may also utilize a single reference point ground system depending upon equipment's design, facility, and frequencies used.

The signal reference ground subsystem establishes a common reference for C-E equipment by minimizing voltage differences between equipments and reducing the current flow between equipments resulting in minimizing or eliminating noise voltages on signal paths or circuits.

Grounding Configurations

Signal reference subsystem grounding configurations for all of the equipment in a facility falls into one of three grounding configurations:

- Floating ground configuration
- Single-point ground configuration
- Multi-point (or equipotential) ground configuration

Note: Of the three configurations listed above, the multi-point or equipotential ground configuration is preferred for Communications Electronics (C-E) facilities.

Floating Ground Configuration

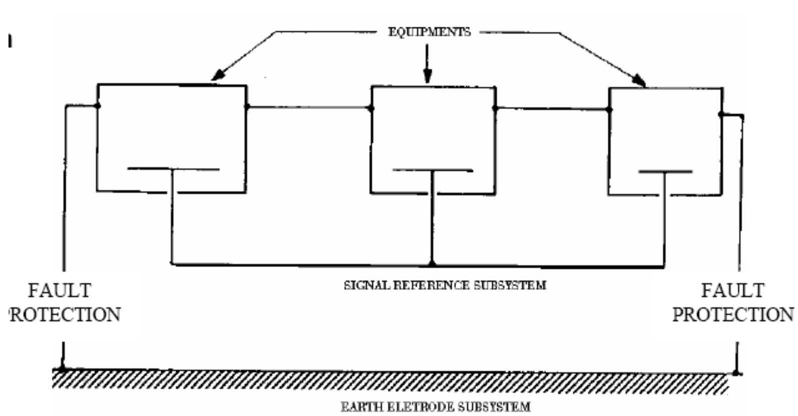
Introduction

In the floating ground configuration, the signal ground is electrically isolated from the building ground and other conductive objects. Advantages and disadvantages of the floating ground configuration are listed below:

Advantages	Disadvantages
• Prevents noise that may be in the facility's ground from being conductively coupled to the signal circuits • Prevents noise currents in equipment cabinets from being coupled to the signal circuits	• Static charge buildup on the isolated signal circuits may present a shock and/or spark hazard • Power faults to the signal system can cause the system to rise to hazardous voltage levels relative to other conductive objects in the facility • There is a danger of flashover between cabinet and signal system in the event of a lightning strike to the facility, which causes insulation breakdown and arcing • Electrical isolation is difficult to maintain in a shore facility, thus it is not generally recommended for C-E facilities

Floating Ground Diagram

A floating ground subsystem is depicted below:



Single Point Ground Configuration

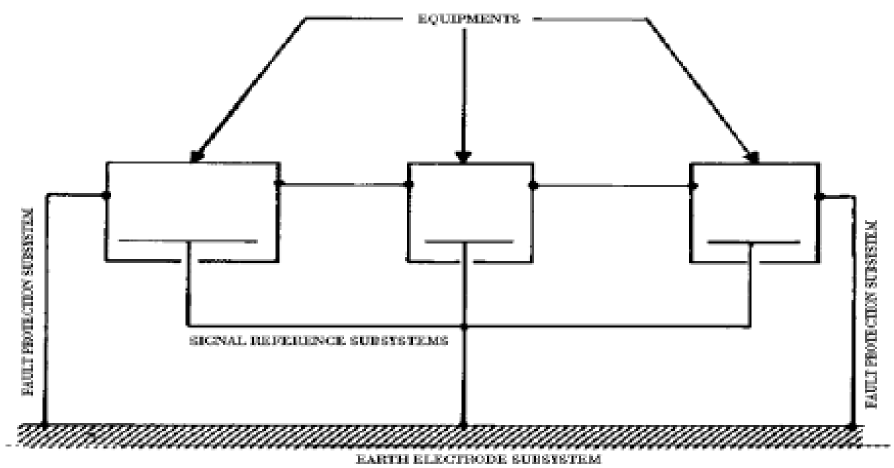
Introduction

The single point ground configuration is recommended for use in low frequency electronic systems (up to approximately 300 kHz). In this configuration, signal circuits are referenced to a single point which is then connected to the facility ground. The advantages and disadvantages of using this type of configuration are listed below:

Advantages	Disadvantages
• Control of conductively coupled interference by minimizing the effects of lower frequency noise currents that may be flowing in the facility ground	• Single-point grounds are extremely poor grounds at RF frequencies because the ground impedance varies with frequency • Grounds used become transmission lines at higher frequencies • Every piece of equipment bonded to a single-point ground system becomes a tuned stub • Long conductors in large installations are required • Single-point grounds are not recommended for use in C-E facilities

Single Point Ground Diagram

A single point ground system is depicted below. All signal circuits are connected to a single point, and that point is then connected to the facility's ground.



Multi-Point Ground Configuration

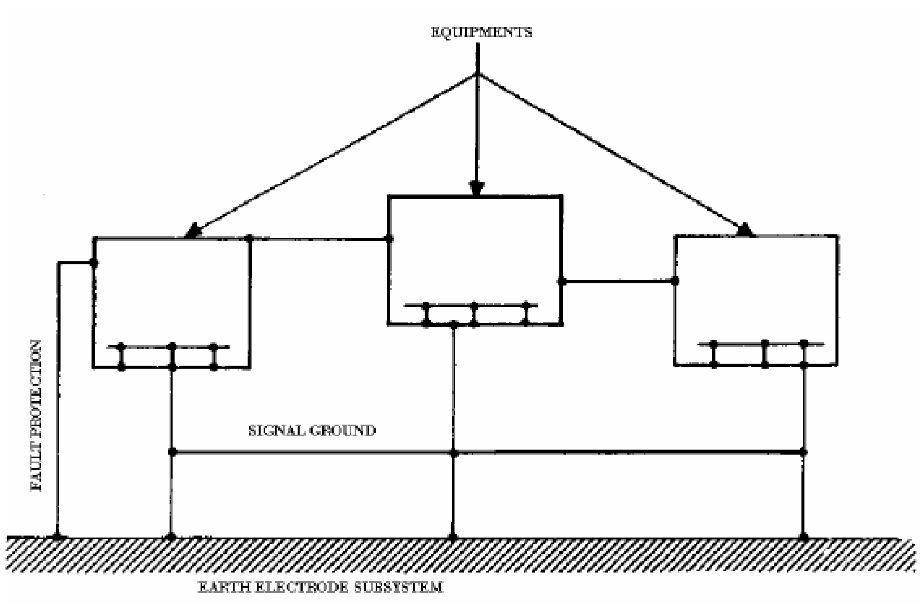
Introduction

The multi-point ground type of configuration is recommended for higher frequencies—30 kHz and above. Multi-point grounds provide many conductive paths from any electronic system or piece of equipment to the earth electrode subsystem. To be effective, this type of configuration requires the use of an equipotential ground plane whenever the conductors exceed 1/8 wavelength at the highest frequency of concern. The advantages and disadvantages of using this type of configuration are listed below:

Advantages	Disadvantages
• Simplification of circuit construction inside complex equipment • Easier interface of equipment employing coaxial cables because the outer conductor of the coaxial cable does not have to float relative to the equipment cabinet or enclosure	• Exhibits transmission line characteristics at RF frequencies • Requires the use of equipotential ground plane • Care must be taken to ensure low-frequency currents are not coupled into the signal circuits, creating interference facilities.

Multi-point Ground Diagram

A multi-point ground subsystem is depicted below:



Equipotential Ground Plane

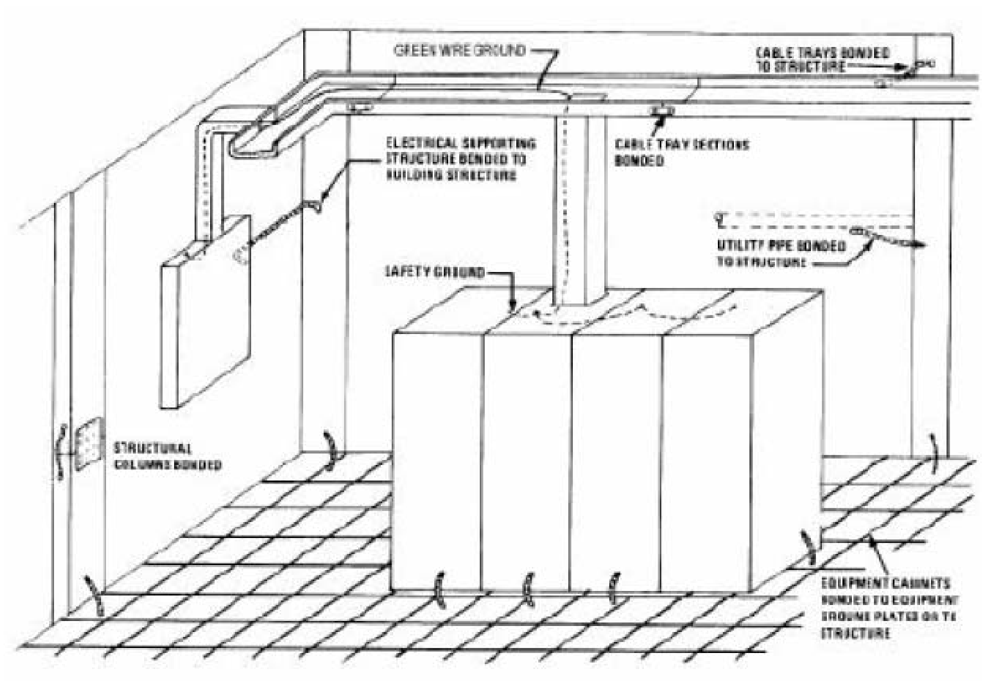
Introduction

The equipotential ground plane consists of a network of multiple conductors connected in the form of a grid or mesh that offers very low impedance to ground at high frequencies. New facilities can be designed with an equipotential plane built into the floor of the equipment to be protected. In the case of an existing facility, the plane can be installed above the equipment to be grounded. The advantages and disadvantages of using this type of configuration are listed below:

Advantages	Disadvantages
• Proper equipment operation • Suppression of noise and static • Reduction of electromagnetic interference (EMI) • Reduction or elimination of noise in cables or conductors by the use of filters or bond straps by “shorting out” the noise field.	• Possible exposure to high potentials when metallic conductors (which are part of the ground plane) are not properly bonded. This high potential is in respect to earth • May increase interference by providing conductive coupling paths or inductive loops.

Equipotential Ground

An equipotential ground plane is depicted below:



Equipotential Ground Plane Types

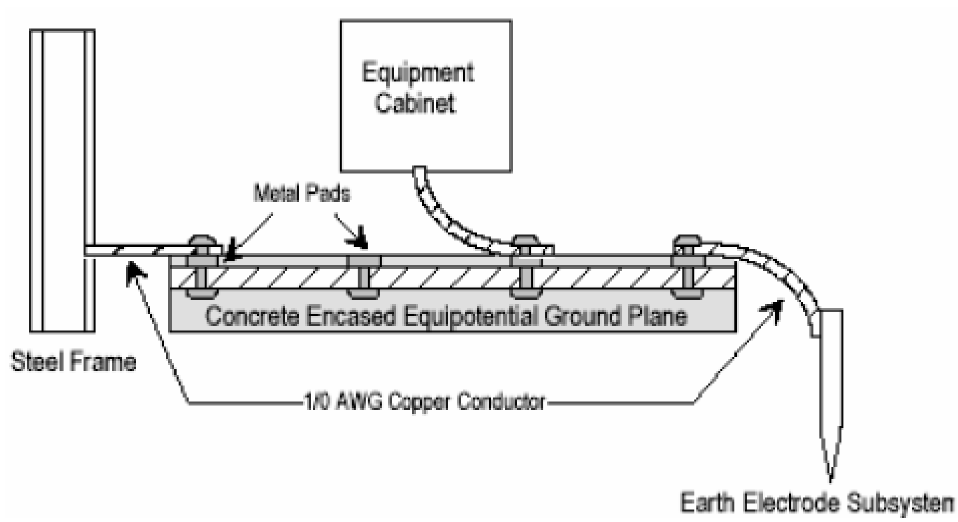
Introduction

Equipotential ground planes may exist in the floors or ceilings of buildings. The equipotential ground plane may be installed either during the construction of a new building or after construction is completed. Building characteristics present several different configurations of installation, with the most common configuration being in the floor or subfloor. Below is a list of the most common types:

- Concrete floor with embedded copper grids
- Raised floors, with metal panels, stringers or pedestals installed (e.g., computer floors)
- Sub-floor of tile or carpet with a metal sheet of aluminum, copper, or phosphor bronze screen laid underneath
- Overhead in the ceiling above the equipment using a grid

Concrete Floor

This type of equipotential ground plane is installed during the construction of a new facility. A typical installation will consist of TWO-inch square metal pads located throughout the building, flush with the surface of the concrete floor. Equipment cabinets are bonded to these pads or to a bus that is bonded to the pad. Refer to the diagram below:



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Equipotential Ground Plane Types (Continued)

Raised Floor

Raised computer floors provide support for equipment cabinets and provide space between the original floor and the computer deck to run air conditioning ducts, cables, etc. The bolted-grid stringer system is the only acceptable type for use as an equipotential plane. This type of computer floor provides:

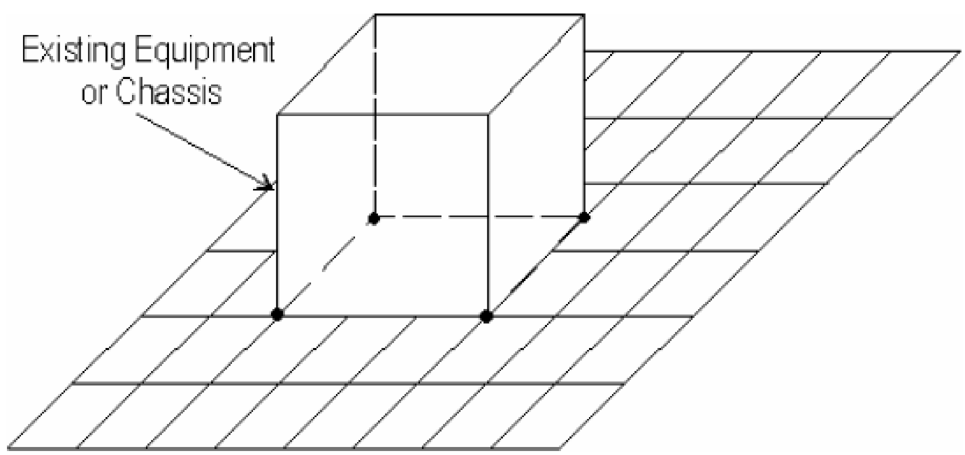
- An electrically continuous sheet at RF frequencies
- A low-impedance path to earth at lower frequencies by connecting the equipment cabinets with bonding straps

Construction of a computer floor equipotential plane consists of:

- Drop-in panels constructed of metal or metal-plated wood (should not be larger than 24” x 24”)
- Stringers that are used for connecting the equipment cabinets
- Pedestals that provide support for metal plates and equipment cabinets

Sub-floor

Sheets of metal or rolls of aluminum, copper, or phosphor bronze under the floor tile or carpet can be installed to provide an equipotential ground plane. The plane should be bonded to the main structural steel members of the building at multiple locations. The steel member should, in turn, be bonded to the earth electrode subsystem. In the case of an existing facility, the conducting plane does not have to be installed underneath the equipment cabinets but should be bonded to the equipment at all four corners.



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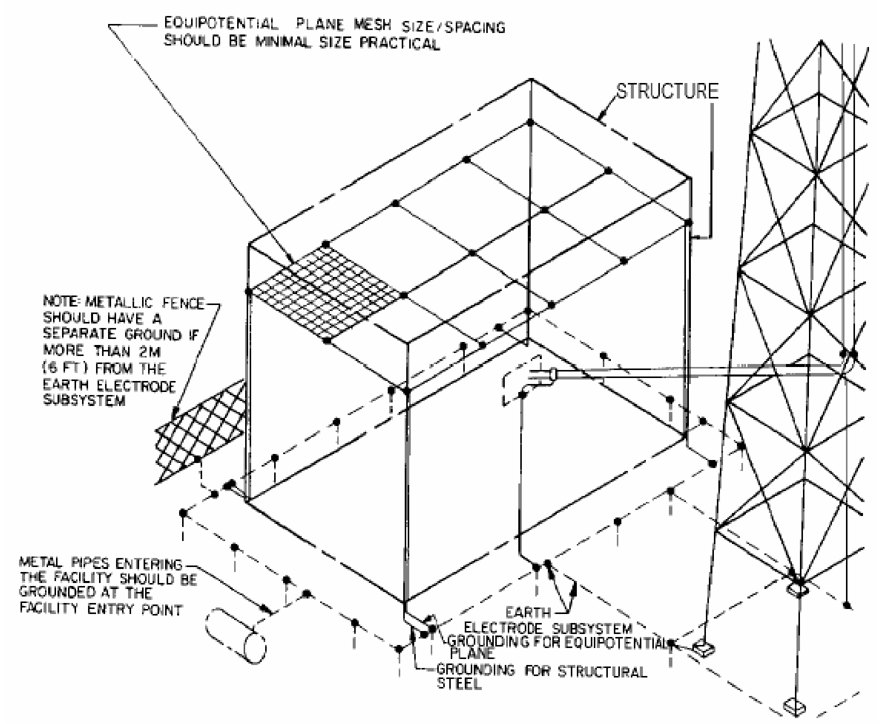
Equipotential Ground Plane Types (Continued)

Overhead

An alternative to installing the equipotential ground plane on the floor is to install an overhead plane, which can be constructed of thin metal sheets or screen above the ceiling. Phosphor bronze screen is light, durable, and easy to work with; therefore, it is the preferred material for this type of installation. When bonding equipment to the plane, use bond straps which are as short as possible; this will provide a low-impedance path at lower frequencies. Ground the plane to the building structure as before.



Inspecting Signal Reference Grounding

Introduction

Inspecting the signal reference ground subsystem for equipment consists of:

- Visually inspecting signal reference ground connections for proper bonding and grounding
- Performing signal reference ground connection resistance checks

Note: Inspections vary by equipment category.

Equipment Categories

Connection methods used to connect the signal reference ground subsystem to electronic equipment varies by the category of equipment being connected. The three categories of equipment are:

- Low frequency equipment (with frequencies from DC to 30 kHz)
- High frequency equipment (with frequencies above 30 kHz)
- Hybrid equipment (with both lower and higher frequencies)

Inspecting Low Frequency Equipment

Performing a Visual Inspection

When performing a visual inspection of low frequency equipment and the signal reference ground subsystem, ensure that:

- Equipment is connected using a single-point ground system via a ground terminal
- The signal reference ground is isolated from the chassis of the equipment
- Balanced lines are used to interconnect low-frequency signals between units of low frequency equipment

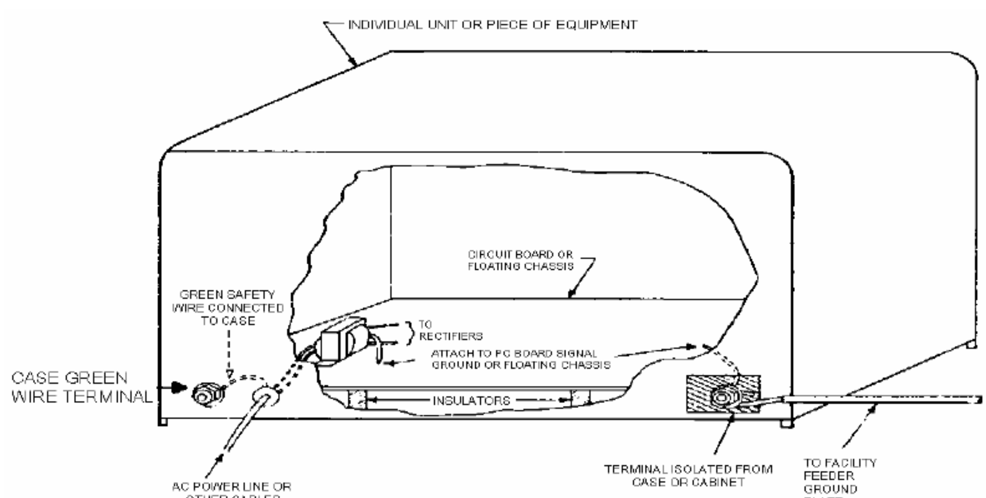
---

When inspecting the ground terminal connection, verify that one of the following methods are used to connect the low frequency equipment to the signal reference ground subsystem:

- Connector pin
- Screw or pin on a terminal strip
- Insulated wire or insulated stud
- Jack
- Feed-through type connection

Note: If using insulated wires, they must be at least 16 AWG. If 16 AWG is used, it must be less than five feet in length. The signal ground terminal should be marked with a permanent yellow label or color-coded.

Ground Terminal Diagram



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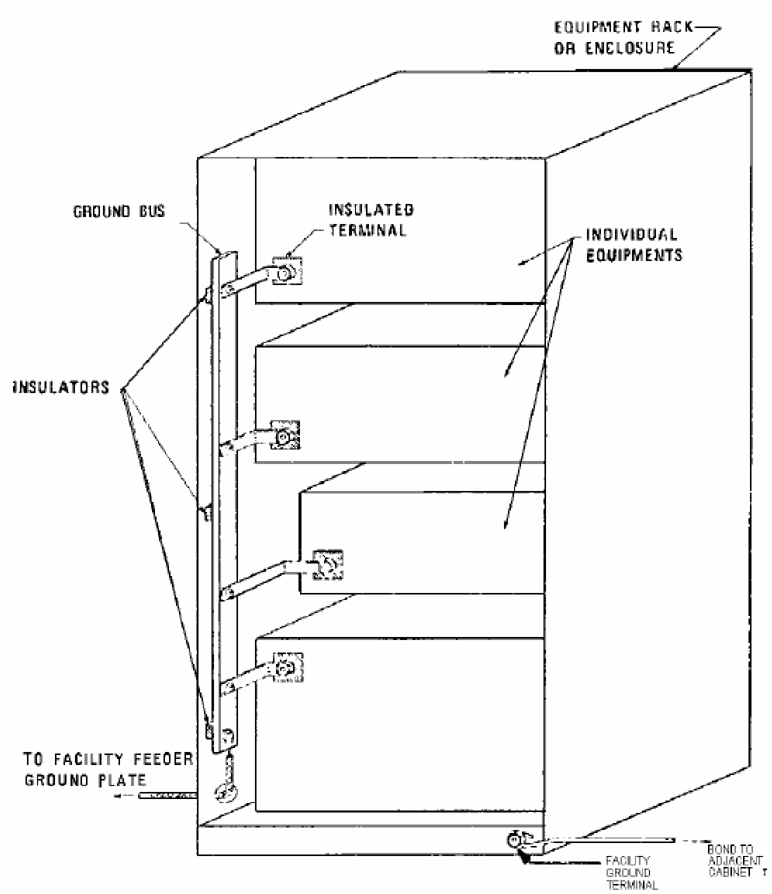
Inspecting Low Frequency Equipment (Continued)

Signal Ref. Ground Isolation

When verifying that the signal reference ground is isolated from the chassis of the low frequency equipment, ensure that ground bus bars and any signal reference ground wires are not in contact with the chassis.

Unless proper installation procedures are followed, the isolated insulation resistance of the equipment will be defeated when the equipment chassis makes contact with the cabinet enclosure. See diagram below:



Note: The bus bar in the diagram above is isolated from the cabinet.

Inspecting High Frequency and Hybrid Equipment

Inspecting High Frequency Equipment

When connecting high frequency equipment to the signal reference ground subsystem, the chassis is normally used as the signal reference ground plane. The chassis is then grounded through the case or cabinet to the equipotential ground plane.

Yellow covered wire or cable of adequate size should be employed for all interconnections of the higher frequency signal reference network.

To interface signals between high-frequency equipment, use unbalanced, constant-impedance, transmission lines such as coaxial cables. The shield of coaxial cables should be grounded at both ends of the cable and at intermediate points along the cable run.

Inspecting Hybrid Equipment

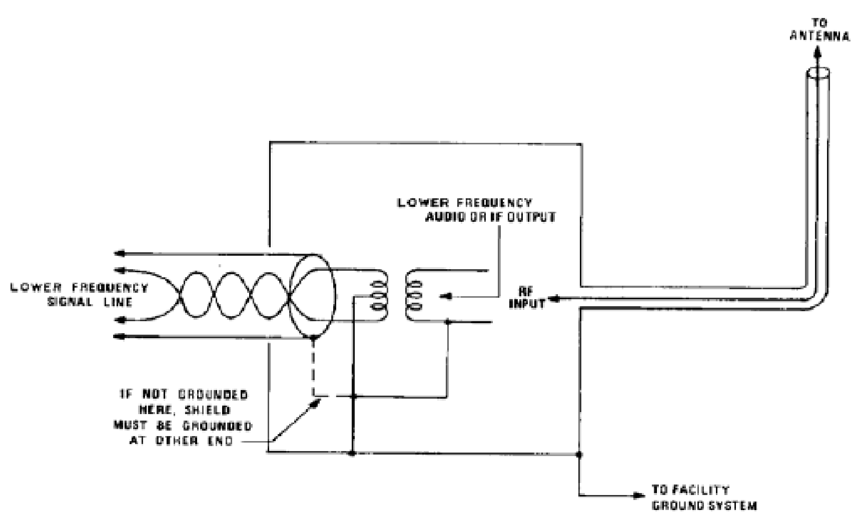
In equipment where both lower and higher frequency circuits must share a common signal ground, the equipment must be grounded using the same criteria as used for inspecting higher frequency equipment.

The important thing to remember is to interface the low- and high frequency signals accordingly. For example, to interface:

Low frequency equipment	Use balanced, twisted-pair lines with the shield grounded at one end only.
High-frequency equipment	Use coaxial cables with the shield grounded at both ends.

Grounding Hybrid Equipment

Refer to the illustration below for grounding hybrid equipment to the signal reference ground:



Inspection Job Aids

Introduction

To complete a visual inspection of the facility's signal reference ground subsystem, the first place to start would be to differentiate between the low frequency, high frequency and hybrid equipment. Once you have identified the various types of equipment, you will complete the checklists included for each type of equipment.

Low Frequency Equipment Procedures

Step	Action	Yes	No	N/A
1.	Obtain copies of MIL-STD-188-124B, NEC documentation and MIL-HDBK-419.			
2.	Is the ground terminal correctly color-coded or identified with a yellow label?			
3.	Are balanced signal lines used between equipment cabinets?			
4.	Are the shields of cables utilized for low frequency such as telephone, audio and digital traffic with data rates less 38.4 KBPS connected to the earth electrode subsystem at only one point? *Ref: MIL-STD-188-124B, Para 5.1.1.4.3*			
5.	Is the routing and layout of wire, are power lines and signal lines kept separate? *Ref: MIL-STD 188-124B, Para 5.3.2.5.2*			
6.	Are signal lines shielded by using shielded cable, conductive conduit or conductive duct? *Ref: MIL-STD-188-124B, Para. 5.3.1* *MIL-HDBK-411B, Volume I, Para. 4.19.1.1*			
7.	Are all signal lines separated from power circuits by a minimum of 15 cm (6 inch)? *Ref: MIL-HDBK-411B, Vol I, Para 4.19.1.2*			
8.	Are all metallic power, control and signal lines fed into a shielded enclosure through filters, feed-thru capacitors, or optic isolators? *Ref: MIL-STD-188-124B, Para 5.3.2.3*			
9.	Are conductive gaskets and finger stock used on doors and covers used on shielded enclosures clean and in good repair? *Ref: MIL-STD-188-124B, Para 5.3.1*			

Continued on next page

Inspection Job Aids (Continued)

Low Frequency Equipment Procedures

Step	Action	Yes	No	N/A
10.	Is it possible to receive FM radio or television inside the shielded enclosure without the use of an antenna that is external to the enclosure? (Shielded Facilities Only) *Ref: MIL-STD-188-124B, Para 5.3.1*			
11.	Is the proper size wire used for the signal ground cable?			

Inspection Job Aids (Continued)

High Frequency Equipment Procedures

Step	Action	Yes	No	N/A
1.	Obtain copies of MIL-STD-188-124B, NEC documentation and MIL-HDBK-419.			
2.	Is the ground terminal correctly color-coded?			
3.	Is the high frequency reference point directly grounded to the chassis and the equipment case?			
4.	Is the high frequency plane directly grounded to the chassis and the equipment case?			
5.	Are the shields of cables utilized for high frequency terminated to a ground at both ends?			
6.	Are the interfacing cables properly matched constant-impedance cables?			
7.	Do the line shield terminations outside of the equipment case have any pigtails?			
8.	Are the interfacing cable connectors properly mounted?			
9.	Are the interfacing cable connectors secure?			
10.	Are the interfacing cable connectors clean?			
11.	Is the signal ground cable size correct?			

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Review Quiz

Questions

1. What is the length and diameter of a typical grounding rod?

   A. 12 feet long by 3/4 in. diameter
   B. 10 feet long by 3/4 in. diameter
   C. 10 feet long by 1/2 in. diameter
   D. 12 feet long by 1/2 in. diameter

2. Which of the following metals should not used in the construction of down conductors?

   A. Aluminum
   B. Copper
   C. Tin
   D. Copper clad steel

3. The metal framework of an earth electrode subsystem should have a resistance of less than ____ ohms?

   A. 10
   B. 25
   C. 20
   D. 15

4. What class of bonding requires the welding of two pieces of metal together?

   A. Class A
   B. Class B
   C. Class C
   D. Class D

5. DC resistance across bonding and grounding junctions shall not exceed _____ ohms?

   A. 5
   B. .5
   C. 1
   D. .1

Continued on next page

Review Quiz (Continued)

Questions (Cont'd)

6. Which of the following documents is not required when inspecting fault protection subsystems?

   A. MIL-STD-188-124B
   B. Civil Engineering manual
   C. NEC documentation
   D. MIL-HDBK-419

7. To protect a structure, such as a building, vessel, mast, etc., from lightning damage, the grounding cable should be _____?

   A. 12 AWG
   B. 0000 AWG
   C. 2 AWG
   D. 10 AWG

8. What is an advantage of using a floating ground subsystem?

   ____

   ____

9. A single point ground configuration is recommended for use in what frequency range?

   ____

   ____

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Review Quiz Answers

Answers

Question	Answer	Reference
1.	B	2-3
2.	C	2-1
3.	A	2-4
4.	A	2-5
5.	D	2-5
6.	B	2-15
7.	B	2-21
8.	Prevents noise that may be in the facility’s ground from being conductively coupled to the signal circuits and prevents noise currents in equipment cabinets from being coupled to the signal circuits	2-31
9.	Up to 300 Khz	2-32

Lesson 3

HOW TO INSTALL CABLE THROUGH MULTI-CABLE TRANSITS

Overview

Introduction

The Electronics Manufacturers Directory website describes multi-cable transits (MCTs) as follows:

“Cable transits are sealing systems which seal and protect cable and pipe transits against fire, smoke, gas, water, etc. A cable transit is used for protecting against the ingress of liquids and electromagnetic disturbances or interference at a wall transit location within a wall. Cable transits are generally modular systems including outer frames (at least one module-based cable seal and a final seal which fills out the frame together with the cable seal) such as two semi-cylindrical bodies that are made of a compressible material and that together fit into the internal cavity of the sleeve.”

Lesson Objectives

Given the proper instruction and materials, **INSTALL** cabling through multi-cable transits IAW the following:

- Nelson Firestop materials
- Roxtec transit materials

References

This lesson was written using the following references:

- Electronics Manual, COMDTINST M10550.25 (series)
- Navy Installation and Maintenance Book, Installation Standards SE000-00-EIM-110
- Manufacturers Guidelines

Cable Transits

Introduction

In this lesson you will learn how to install multi-cable transits by using the documentation provided in the following materials:

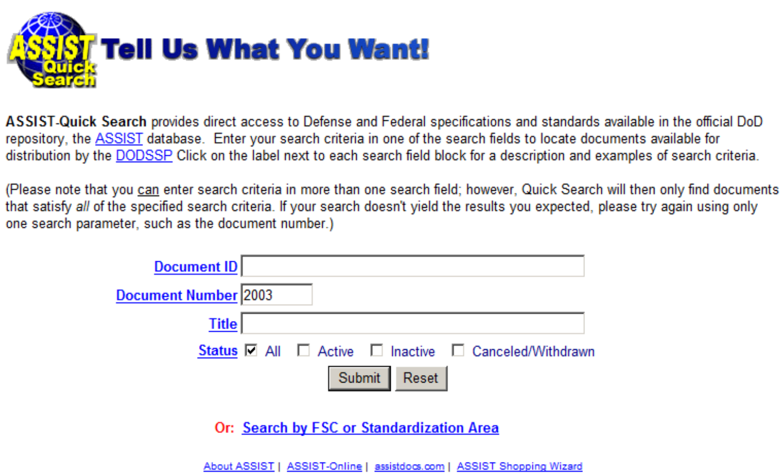
- MIL-STD-2003
- Nelson Firestop
- Roxtec

MIL-STD-2003

You are encouraged to obtain a copy of MIL-STD-2003 (Navy) by Quick Search through the Acquisition Streamlining and Standardization Information System (ASSIST) database at:

http://assist.daps.dla.mil/quicksearch/

At the site, type 2003 in the “Document Number” box and click on “Submit.”



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Cable Transits (Continued)

MIL-STD-2003 (Cont'd)

The following screen will appear:

This Is What We Found!

All ASSIST documents matching your search criteria are listed below. Click on a ***Document ID*** value to view the Basic Profile for a document. In cases where a digital image or warehouse document is available, a icon will be displayed next to the ***Document ID*** link.

You Searched For... **Document Number:** 2003
Status: All

Showing records 1 thru 10 of 10

Click on column headings for a description of column content.

Document ID	Document Status	FSC/ Area	Title
MIL-STD-2003A	Active	SESS	Electric Plant Installation Standard Methods for Surface Ships and Submarines
MIL-STD-2003-1A	Active	SESS	Electric Plant Installation Standard Methods for Surface Ships and Submarines (Cable)
MIL-STD-2003-2A	Active	SESS	Electric Plant Installation Standard Methods for Surface Ships and Submarines (Equipment)
MIL-STD-2003-3A	Active	SESS	Electric Plant Installation Standard Methods for Surface Ships and Submarines (Penetrations)
MIL-STD-2003-4A	Active	SESS	Electric Plant Installation Standard Methods for Surface Ships and Submarines (Cableways)
MIL-STD-2003-5A	Active	SESS	Electric Plant Installation Standard Methods for Surface Ships and Submarines (Connectors)

Click on the appropriate section and the following screen will appear:

Basic Profile

Document ID: **MIL-STD-2003** Scroll down to access document images.
Spec/Std Sheet: **4**

Overview

Title: Electric Plant Installation Standard Methods for Surface Ships and Submarines (Cableways)
Scope: This standard covers standard practices for electric plant installation of cableways on surface ships and submarines.
Status: Active — Document Date: 03-SEP-2009
FSC/Area: SESS — Dist Stmt: See below
Doc Category: Standard Practice

Responsibilities

Lead Standardization Activity: SE — ODDR&E Systems Engineering
Preparing Activity: SH — Naval Sea Systems Command (Ship Systems)
Coordination: Limited
Navy Custodian: SH — Naval Sea Systems Command (Ship Systems)

Changes to military standards or handbooks issued after August 1, 2003 are incorporated in the modified document.

Revision History — Click on column headings for a description of column content.

Media	Document Part Description	Dist Stmt	Document Date	Pages	Size
	Revision A	A	03-SEP-2009	337	4793.9 KB
	Change Notice 1	A	17-DEC-1990	3	149.2 KB
	Base Document	A	24-JUN-1987	129	9274.1 KB

Click on the most recent document revision and begin your research.

Note: There are 5 different sections to this manual. The section you choose will be determined by which part of the cable install you are working on. These are very extensive documents.

Nelson Firestop

Nelson Firestop Products

While MIL-STD-2003 contains general guidelines on MCT/MCP installation, instructions from the equipment manufacturers are usually more specific, relevant, and current. Here, for example, is an MCT diagram, glossary, and installation instructions from Nelson Firestop Products at:

http://www.nelsonfirestop.com/MCT%20Engineering%20Manual.pdf

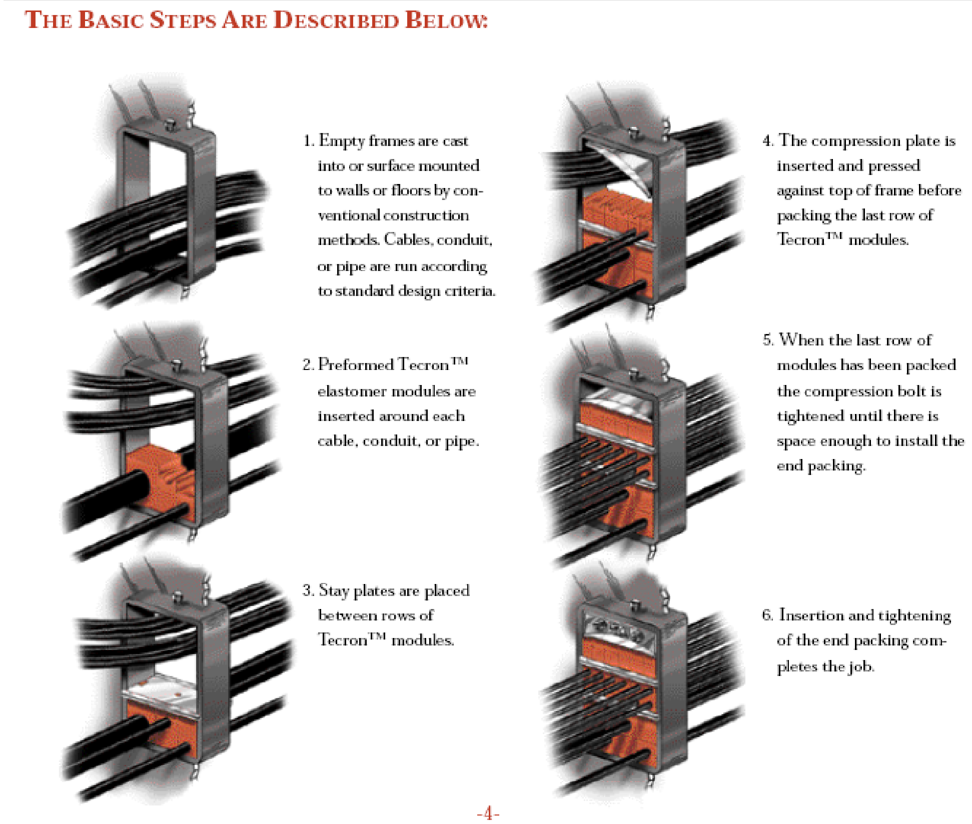
MULTI-CABLE TRANSIT – MCT™

Multi-Cable Transit is based on a simple but effective design. It consists of a rectangular metal frame suitable for floor or wall installation, which is available in single or multiple units. Each frame contains an arrangement of Tecron™ elastomer modules grooved to fit snugly around cables, pipes, or conduits passing through the frame. The intumescent Tecron™ modules expand when exposed to heat, providing a continuous seal even if cable jackets disintegrate. The entire assembly within each frame is locked in position to prevent dislodgement and the spread of fire and the products of combustion.

Continued on next page

Cable Transits (Continued)

Nelson Firestop Products (Cont'd)



Note: Please take the time to familiarize yourself with the technical publication ***before*** you begin your cable install.

Roxtec

Here's some information from another manufacturer, Roxtec, at:

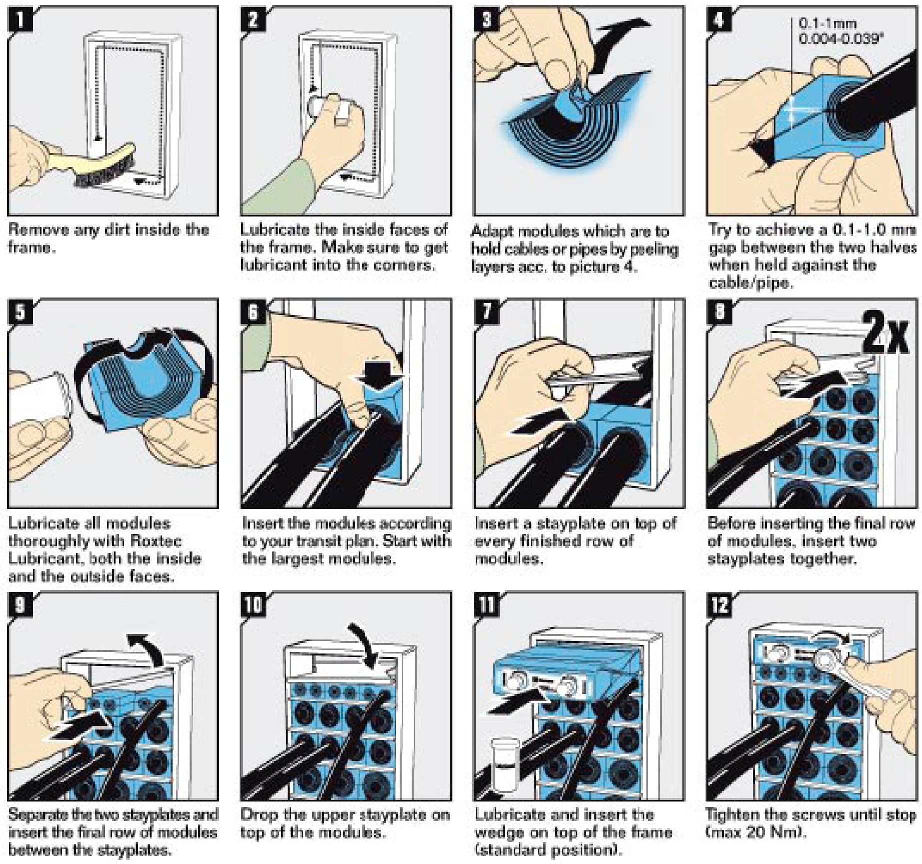
http://www.roxtec.com/the-roxtec-solution/multidiametertm/

Continued on next page

Cable Transits (Continued)

Roxtec (Cont'd)

How it works:



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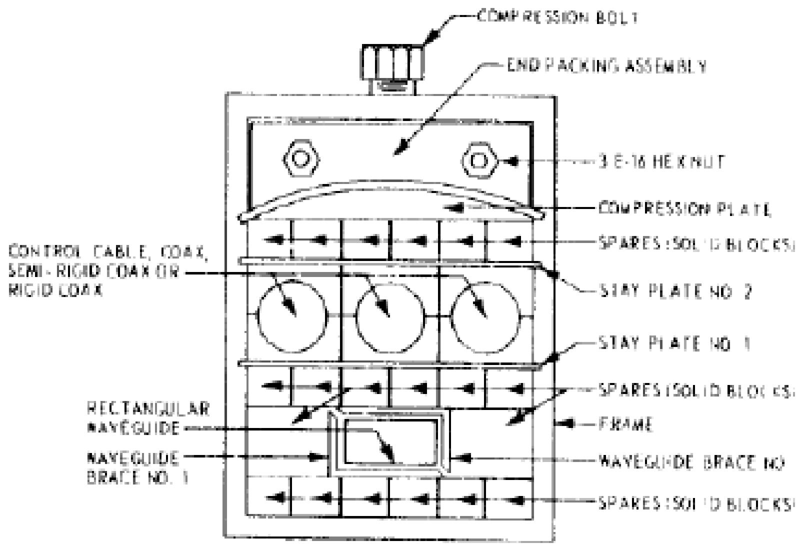
Cable Transits (Continued)

MCT for Waveguide or Coax Cables

According to Section 5-2.5.5 of the Navy Installation and Maintenance Book (NIMB), Installation Standards, “multi-cable transit device can be used for passing waveguide and/or rigid coaxial lines through watertight decks or bulkheads with minor modifications . . . .” The following figure “identifies components of an assembled multi-cable transit device modified to accept rectangular waveguide and rigid coaxial transmission lines”:



Note: Multi-Cable Transit device use on weather decks is not authorized per MIL-STD-2003.

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Review Quiz

Questions

1. In regards to this lesson, what does MCT stand for?

   A. Main Cable Trace
   B. Main Cable Transit
   C. Multi Cable Trace
   D. Multi Cable Transit

2. What are the two main types of MCT's in use by the CG? Choose two answers.

   A. Nelson Firestop
   B. Roxtec
   C. Mil-STD - 3 - 2003
   D. Mil STD - 2 – 3003

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Review Quiz Answers

Answers

Question	Answer	Reference
1.	D	3-1
2.	A & B	3-4 & 3-6

Lesson 4

HOW TO INSTALL HELIAX CABLE CONNECTORS

Overview

Introduction

HELIAX® is the brand name given to a type of high-performance coaxial cable manufactured by the Andrew® Corporation, which also supplies various versions of HELIAX®-compatible cable connectors.

Virtually all of the information and guidance you need to have to install HELIAX® cable connectors is supplied by the printed instructions included with the cable connectors themselves or through the Andrew® Corporation website:

http://www.andrew.com/products/trans line/heliax/default.aspx

You are strongly encouraged to visit the Andrew website and familiarize yourself with the information and materials available to you.

Lesson Objectives

Given the proper installation instructions, **INSTALL** a Heliax cable connector.

References

This lesson was written using the following materials:

- Electronics Manual, COMDTINST 10550.25 (series)
- Navy Electronics Installation and Maintenance Book, Installation Standards SE000-00-EIM-110
- Manufacturers publications

Continued on next page

Types of Heliax Coaxial Cable

Types of Cable

There are two main types of Heliax cables. They are:

- Coaxial (Heliax 2.0)
- Waveguide

Types of Connectors

We will discuss the following types of connectors in this section:

- Ezfit Series
- Heliax Standard
- OnePeice Family
- RingFlare
- Positive Stop

Elliptical Waveguide

Heliax Elliptical Waveguide is the recommended feeder for most microwave antenna systems in the 3.4 to 26.5 GHz frequency range. The corrugated copper walls give Heliax elliptical waveguide excellent crush strength and good flexibility. A rugged black polyethylene jacket provides protection during handling and installation.

Continued on next page

Types of Heliax Coaxial Cable (Continued)

Rectangular Waveguide

Andrew Solutions offers rectangular waveguide for standard and low VSWR applications. Standard waveguide components cover the entire recommended frequency ranges, while low VSWR components are generally only available over narrow frequency ranges.

Wireless Cable Heliax 2.0

Andrew Solutions offers a wide variety of cable types and sizes for any application including the world's only complete family of FXL aluminum and AVA copper, HELIAX 2.0. Andrew Solutions lowest-loss closed cell foam, lowest-loss end-to-end solution, snap-clean foam dielectric, and easy connector attachment ensures consistent quality. Continuous improvements in technology and manufacturing processes are your guarantee of the highest level of performance, quality, and reliability.

Types of Heliax Coaxial Cable (Continued)

RADIAX Radiating Coaxial

RADIAX radiating coaxial cables solve wireless communication problems in confined areas by functioning as a continuous distributed antenna:

- Carefully controlled slots in the outer conductor allow RF signals to be coupled from and into the cable uniformly along the entire length
- Excellent tool where obstructions can cause RF blockage to point-source antennas and where multiple services are required
- RCT series – optimized for specific frequency bands for single or dual-band RF systems
- Coupled mode (RXL) series – for frequency bands from 50 MHz to 2.4 GHz
- Plenum Rated (RXP) series – for use where fire codes require fire retardant cables: meet or exceed requirements of Underwriters' Laboratories, Inc. (UL) and the National Electric Code (NEC)

Braided Cables

Cinta™ Braided Cables. Andrew Solutions Cinta™ Cables cover the entire radio frequency (RF) footprint for applications that connect the world: mobile phones, in-building, E911, unlicensed band, mobile antennas, satellite antennas, terrestrial microwave, Wi-Fi, broadband, medical, military, and air traffic control.

Andrew Solutions Cinta braided cables are constructed with the highest quality copper, aluminum, and polyethylene materials. Andrew Solutions braided cables are compatible with industry standard connectors, tools, and other needed accessories.

Types of Connectors

Heliax 2.0 EZfit

HELIAX® 2.0 solutions make connector installation simple with EZfit® connectors and tools. A technology breakthrough from the industry's leading aluminum and copper engineering teams, EZfit connectors fit both cable AVA and FXL types. The new EZfit Series tools streamline and ensure the installation process for contractors and network operators. The results are faster, more accurate installations and minimized maintenance requirements.

Benefits:

- One connector fits both FXL aluminum and AVA copper cable
- Fewer products to inventory
- Smaller and lighter two-piece connector design helps to minimize user error
- Quick installs on both cable types
- Consistent installation practices
- Weatherproof designs for both cable technologies

Heliax Standard

Andrew Solutions HELIAX standard connectors are designed for fast, accurate installation and to ensure low IMD, low VSWR, and system integrity in the harshest of outdoor environments.

Continued on next page

Types of Connectors (Continued)

OnePiece Family

OnePiece connectors save time and money. System engineers, installers, and purchasing personnel all benefit from the advanced design of OnePiece connectors. The captivated, preset inner contact pin and patented clamping mechanism provide lower IM and attenuation and exceptional mechanical reliability. One-step installation is faster, easier, and more precise. OnePiece connectors are priced lower than most standard connectors.

RingFlare

Fast-fitting RingFlare connectors are available in a variety of interface types for a large selection of HELIAX® LDF series cables. The RingFlare connector is a simple, two-piece threaded connector with a captivated one-piece inner contact pin, factory set to the correct depth. RingFlare connectors are completely weatherproof and field proven. With fewer components and attachment procedures, the RingFlare also offers fast installation. 7-16 DIN male, 7-16 DIN female, N-male, and N-female connectors are available for most HELIAX LDF style cables.

Continued on next page

Types of Connectors (Continued)

Positive Stop

Secure, foolproof, no-special-tools required connection every time.

Easy connector attachment issues and ensures excellent RF transmission line performance with Positive Stop connectors from Andrews Solutions. Revolutionary Positive Stop connectors for HELIAX® corrugated coaxial cables require no special tools or torque wrenches, eliminating both guesswork and time consuming measurements.

Using standard wrenches and in less than one rotation, Positive Stop connectors give the installer a clear visual and mechanical verification of a correct fit, sealing out water and sealing in excellent electrical performance. The connectors' easy verification eliminates the need to control torque levels and provides consistent attachment integrity and electrical performance.

Positive Stop Connectors are waterproof , even when unmated:

- No special tools required
- Fully tightens in less than ne rotation
- Visual and mechanical verification
- Integrated sealing mechanism
- Faster, simpler installation
- Excellent electrical performance

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Review Quiz

Questions

1. What are the two types of Heliax cables? Choose two answers.

   A. Waveguide
   B. RG 25
   C. RG 58
   D. Coaxial (Heliax 2.0)

2. Who is the manufacturer of Heliax products?

   A. Motorola
   B. Raytheon
   C. Andrews
   D. Sperry

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Review Quiz Answers

Answers

Question	Answer	Reference
1.	A & D	4-1
2.	C	4-1

Lesson 5

HOW TO EVALUATE HELIAX CABLES

Overview

Introduction

HELIAX® is the brand name given to a type of coaxial cable manufactured by the Andrew® Corporation. In this lesson you will learn how to effectively evaluate a cable.

Lesson Objectives

Given a Heliax cable, **EVALUATE** the cable for:

- Signs of corrosion
- Cuts and nicks
- VSWR loss
- High attenuation

References

The following references were used for this lesson:

- Electronics Manual, COMDTINST M10550.25 (series)
- Navy Electronics Installation and Maintenance Book, Installation Standards, SE000-00-EIM-110
- Manufacturers publications

Note: You are encouraged to visit the Andrew® website and familiarize yourself with the information and materials available to you regarding their particular brand of coax cable. This information is available at the web link below:

http://www.andrew.com/products/trans_line/heliax/default.aspx

Evaluating Heliax Coaxial Cable

General Inspection Requirements

Refer to Navy Electronics Installation and Maintenance Book, Installation Standards, SE000-00-EIM-110, which states in Section 2.8 that

"Cables installed in shipboard electronic systems shall receive visual inspections, continuity checks and insulation resistance tests prior to energizing of equipment. Coaxial cables shall, in addition to the above, be tested for attenuation and voltage standing wave ratio (VSWR). This requirement may be relaxed for certain types of coaxial cables when used for such purposes as video and audio circuits."

Visual Inspection

Cables shall be visually inspected for signs of physical damage and dampness prior to and after installation is completed. Cable showing signs of physical damage shall not be installed.

- Any indication that the cable has been subjected to excessive heat, damaged by heavy or sharp objects, or permanently twisted or kinked shall be justification for replacement of cable
- Coaxial cable that has had the dielectric deformed or changed by any condition shall be replaced
- Coaxial cables showing any signs of deformity, such as kinks, flatness, twists, split jackets or indentations shall be rejected. in those cases where possible damage of any type is apparent or suspected

The Installing Activity shall, at the time of visual inspection, determine what caused the cable damage and take the necessary corrective action prior to replacement.

Repair or Replace Cables?

Flexible and semi-rigid coaxial cables that have had their jackets damaged during or after installation shall be replaced where practicable:

- The cable jacket may be repaired if cable replacement is cost prohibitive or replacement time would delay ship departure
- Coaxial cables that have a damaged shield as well as a damaged jacket shall be replaced and not repaired
- Authorized approval shall be obtained prior to repairing of coaxial cable jackets

Note: You should refer to Section 2-18.2.1 of EIM-110 to find correct procedures for repair of coaxial cables.

Evaluating Heliax Coaxial Cabling (Continued)

Continuity Checks

Continuity checks shall be made on all conductors in all cables after installation is completed, including the attachment of connectors and/or terminal lugs.

Note: This is to certify that there are no open or shorted conductors inside the cable sheath and that the connectors are correctly terminated and identified.

Cable Testing

Insulation resistance tests shall be made on coaxial cables prior to installation and upon completion of installation:

- The tests conducted after completion of installation shall include the installed connectors but with the cables disconnected from the equipment
- The 500-volt megohmeter used for these tests shall have a resistance range capable of accurately indicating the values required by this test.

The following table shows the acceptable insulation resistance value for various types of coax cable. Cables not meeting the minimum insulation resistance values shall be replaced.

Coax cable with…	Length (feet)	Insulation resistance in megohms (To equal or exceed)
Polyethylene or polytetrafluorethylene (Teflon) dielectric	100 (or less)	40,000
	200	20,000
	500	8,000
	1,000	4,000
Synthetic rubber dielectric	Up to 1,000	1,000
Magnesium Oxide Dielectric	Up to 1,000	10,000
Dielectric material arranged in layers of conducting and non conducting rubber	Up to 1,000	500

Continued on next page

Evaluating Heliax Coaxial Cabling (Continued)

Attenuation and VSWR Measurements

Coaxial cables are classified as flexible and semi-rigid as to their construction and grouped according to their use and function in the radio frequency range. Attenuation and Voltage Standing-Wave Ratio (VSWR) tests shall be conducted on all flexible and semi-rigid coaxial cables.

- Test readings shall not exceed those specified in MIL-C-17 or by the cable manufacturer for a specified cable
- NAVSEA SE000-00-EIM-130 may be used for test methods and guidance for testing of coaxial cables

Semi-Rigid

Semi-rigid coaxial cables may be classed in two categories in reference to dielectric types:

1. Solid or foam dielectric cables that do not require pressurization.
2. Semi-air dielectric type that requires dry air pressurization.

For the latter type of hollow, pressure-type coaxial cables (employed in shipboard and shore station equipment), there is usually a dehydrator installed to maintain a constant pressure of dry air on the line, thus keeping out moisture:

- These dehydrators consist of an air compressor and a drying system whereby dry air is furnished under pressure to the line
- An indicator is provided to warn of the presence of moisture
- Constant vigilance must be kept to insure that the line is tight; furthermore, the proper functioning of the dehydrator must be checked regularly

If there are any leaks or if the air is not being properly dried, moisture will form in the line and a great deal of trouble will be encountered in drying it again:

- If a line of this type will not hold pressure, all joints should be checked with a soap solution
- The presence of bubbles will indicate a leak at this point, which should be repaired immediately

Continued on next page

Evaluating Heliax Coaxial Cabling (Continued)

Moisture and Damp Cable Repair

Cables that have been subjected to dampness shall, prior to installation, receive an insulation resistance test as noted previously. Cables that cannot be brought to the minimum acceptable insulation resistance values shall be rejected.

For cables that have an unsatisfactory insulation resistance value due to moisture absorption, the installing activity may either replace the cable or take corrective action similar to the following methods.

a. If it is determined that the moisture penetration is confined to the cable ends, a length not greater than four feet may be cut from each end and a new measurement of insulation resistance shall be made:

- If this method does not raise the insulation resistance to the acceptable value, but does show a definite improvement, proceed to the following method

b. Moisture intrusion localized at the cable ends can usually be driven out by passing a current not greater than that for which the cable is rated, through the cable for a few hours.

- Check for temperature rise in the cable sheath, and after approximately four hours of treatment, run another insulation test
- If the cable shows a marked improvement continue the current treatment until the cable meets the required insulation resistance value
- If no improvement is shown after four hours of treatment, the cable shall be replaced

Weather-Proofing

Deterioration of coaxial connectors due to the corrosive action resulting from moisture, salt, and stack gasses is a serious problem aboard ships.

Weatherproofed connections shall be checked at least monthly for signs of deterioration.

At the first signs of deterioration, the old weatherproofing shall be removed, the connectors checked for damage and replaced if necessary.

The sealing area should be thoroughly cleaned and new weatherproofing applied by one of the methods of EIM-110 2-20.3.

Rigid Coaxial Transmission Line Inspect.

The guidelines listed in EIM-110 5-2.10 for Quality Control inspections of waveguides shall apply to rigid coaxial transmission lines.

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Review Quiz

Questions

1. What reference should you use for information on repair of coaxial cables?

   A. MIL-STD-1148 Section 2
   B. MIL-STD-1480 Section 3
   C. Section 3-16. 1 of EIM-100
   D. Section 2-18.2.1 of EIM-110

2. Why do you need to make continuity checks after each connector install?

   ____

   ____

3. What are the two types of coaxial cable?

   ____

   ____

4. If you discover that your transmission line isn't being dried properly, how would you go about finding the leak?

   ____

   ____

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Review Quiz Answers

Answers

Question	Answer	Reference
1.	D	5-2
2.	To certify that there are no opens or shorts inside the cable sheath.	5-3
3.	Flexible and Semi-rigid	5-4
4.	All joints should be checked with a soap solution, the presence of bubbles will indicate a leak at this point, which should be repaired immediately	5-4

Lesson 6

HOW TO INSTALL STUFFING TUBES

Overview

Introduction

A stuffing tube is a transit device that is used to route cable through bulkheads, decks or enclosures. This lesson covers the following types of transient devices and the conditions in which they are used:

- Metal stuffing tubes
- Nylon stuffing tubes

Objectives

Given the authority and parts, **INSTALL** stuffing tubes:

- Install and route a cable through a metal stuffing tube
- Install and route a cable through a nylon stuffing tube

References

The following references were used in the development of this lesson:

- Electronics Manual, COMDTINST M10550.25 (series)
- Navy Electronics Installation and Maintenance Book, SE000-00-EIM-110
- Manufacturer's technical manuals

Metal Stuffing Tubes

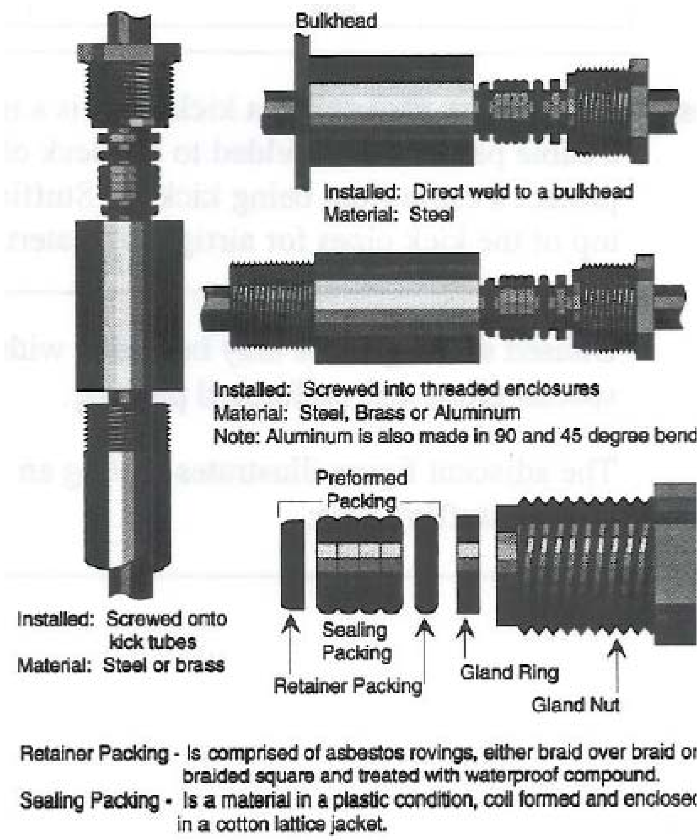
Introduction

A metal stuffing tube must be used in cable installations requiring:

- Airtight Integrity
- Watertight Integrity

Types

There are different types of metal stuffing tubes. The types are determined by how they are installed, and what material they are made of. The following figures illustrated the three different types of body styles, and the order in which they are to be installed:



Installation

Assemble stuffing tubes as shown above. If the gland nut tightens all the way, but the cable is not secure, remove the gland nut and add additional sealing packing around the cable. You will not be able to pull out the cable on a properly installed stuffing tube.

Sealing Packing Material

The sealing packing material used inside stuffing tubes come in rolls and must be ordered separately.

Continued on next page

Metal Stuffing Tubes (Continued)

Electrolytic Action

When you select a metal stuffing tube, care must be taken not to install different metals together that will produce an electrolytic action resulting in corrosion. The following table shows metals that may be used together without the danger of electrolytic action:

Enclosure, Deck or Bulkhead Material	Stuffing Tube Material
Steel	Steel and Brass
Brass	Steel and Brass
Aluminum	Steel and Aluminum
Zinc	Steel

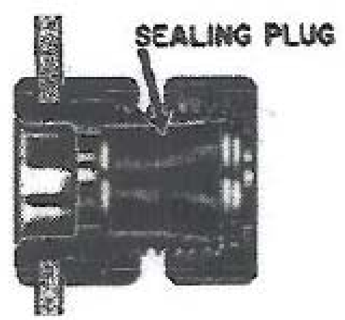
Kick Tubes

A kick tube, also called a kick pipe, is a metal pipe through which a cable passes. It is welded to the deck of a ship and is used to protect a cable from being kicked. Stuffing tubes are threaded on top of the kick pipes for airtight or watertight integrity.

Use of Sealing Plugs

Unused stuffing tubes may be sealed with special plugs and preformed packing.

The figure below illustrates sealing an unused stuffing tube:



Special Instructions

Important:

Before installing any stuffing tube, a hole must be drilled by the appropriate personnel IAW the engineering change. This will usually be done by either a DC or by a civilian contractor. You must ensure that the hole was drilled in the appropriate position and that your stuffing tube will not cause electrolytic action.

Nylon Stuffing Tubes

Introduction

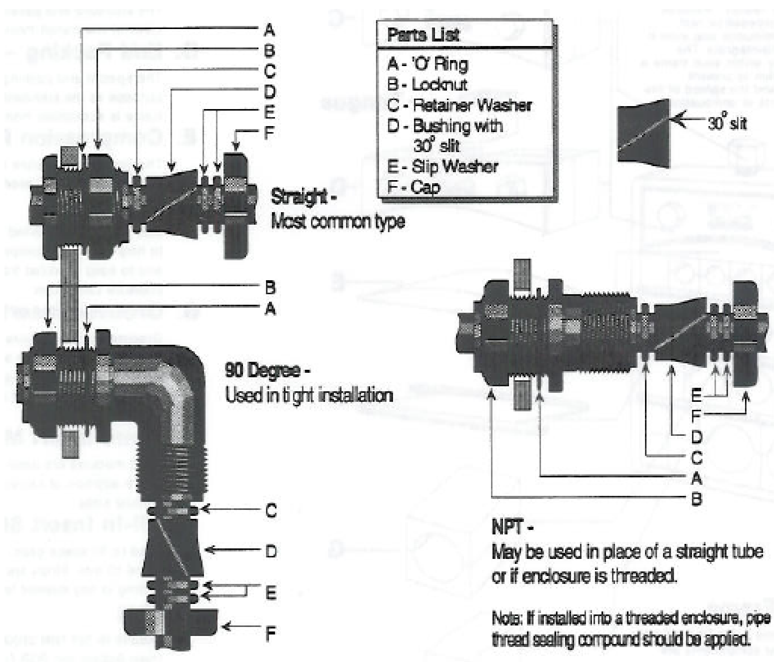
Nylon stuffing tubes can be used instead of metal stuffing tubes under the following conditions:

- Enclosure entries – where the enclosure is required to be watertight, and airtight. A battery box for aids to navigation would be a good example of this application
- Bulkheads – where the thickness is 3/16" or less being difficult to weld to, and the bulkhead is required to be airtight

---

Types

The following pictures illustrate the three different types of nylon stuffing tubes:



Special Instructions

Rubber bushings sometimes need to be replaced inside stuffing tubes. Since the cable already runs through the stuffing tube you have to alter the bushing. This is done by cutting a 30 degree slit on one side of the bushing so you can get it around the cable. The previous picture of stuffing tubes shows a 30 degree slit in the bushings.

If the cable will not fit a standard bushing you can drill a hole to the desired size in the sealing plug.

When the time comes to seal unused stuffing tubes, ensure a sealing plug is used.

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Review Quiz

Questions

1. What are the two types of stuffing tubes? Choose two answers.

   A. Polyester
   B. Metal
   C. Nylon
   D. Plastic

2. If you are going to install a stuffing tube through a zinc metal enclosure, what material should the stuffing tube be made of?

   A. Tin
   B. Aluminum
   C. Nylon
   D. Steel

3. When replacing a bushing in a stuffing tube with a cable already running through it, what angle of slit should you cut the bushing to be installed?

   A. 20 degree
   B. 25 degree
   C. 30 degree
   D. 35 degree

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Review Quiz Answers

Answers

Question	Answer	Reference
1.	B and C	6-1
2.	D	6-3
3.	C	6-4

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Appendix A

Pamphlet Review Questions

1. Cable placement tags should be no longer than _____ feet apart from each other?

   A. 20
   B. 30
   C. 40
   D. 50

2. What does the third group of numbers on a cable tag represent?

   A. System Cable Number
   B. Identical System Number
   C. System Cable Number
   D. System Designation Number

3. On a cable tag what do the letters RY after the hyphen represent?

   A. Radio Teletype
   B. Radio Synchronization
   C. Surface Search Radar
   D. Radio Navigation

4. A class B bond involves _____ two metals together?

   A. Welding and Clamping
   B. Strapping
   C. Bolting or Clamping
   D. Welding

5. Which device has a very fast response time, high sensitivity to detection of fault currents, and is used for protection of personnel called?

   A. GFCI
   B. Fuse
   C. Circuit Breaker
   D. Ground Fault Sensor

6. Metal objects should be grounded when they are within _____ feet of a lightning down conductor?

   A. 3
   B. 6
   C. 9
   D. 12

Continued on next page

Appendix A (Continued)

Questions

7. Which of the following is not a lightning protection device?

   A. Air terminal
   B. Bonding strap
   C. Down conductors
   D. Grounding rods

8. How many different sections are contained in MIL-STD-2003?

   A. Four
   B. Six
   C. Three
   D. Five

9. Which type of Heliax cable solves wireless communication problems?

   A. Braided
   B. Radiax
   C. Rectangular Waveguide
   D. Elliptical Waveguide

10. Cables shall be visually inspected for signs of physical damage and dampness _____ installation?

   A. before
   B. after
   C. during
   D. before and after

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Appendix B

Answers

Question	Answer	Reference
1.	D	1-2
2.	C	1-3
3.	A	1-4
4.	C	2-5
5.	A	2-12
6.	C	2-20
7.	B	2-22
8.	D	3-3
9.	B	4-3
10.	D	5-2

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Suggestions and Corrections

Please note your suggestions, corrections, and comments below.

Page	Location on Page	What Correction is Needed

Your Comments

If you were writing this pamphlet, what improvements would you make? What was good about it? What did you not like about it? Please be specific in your comments/suggestions.

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COMPONENT	NUMBER	QTY
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Administration	P22202	01
Special and Emergency Procedures	P22203	01
Performance and Training	P22204	01
Electronic Installation Standards	P22205	01
Electronic Systems Planned Maintenance	P22206	01
Electronic Systems Corrective Maintenance	P22207	01