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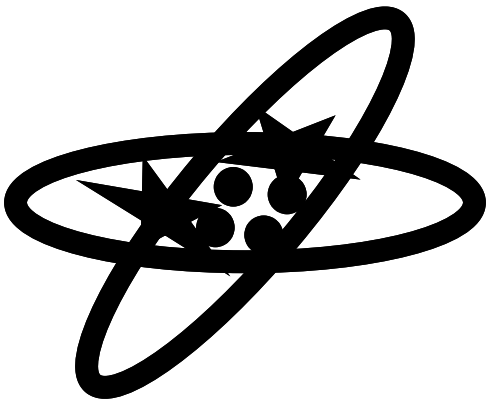
United States
Coast Guard

ET2 UNIT 2: PERFORMANCE AND TRAINING



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ET2 UNIT 2: PERFORMANCE AND TRAINING

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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

TABLE OF CONTENTS

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

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ETCS Aaron Cordell

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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)
- Cutter Training and Qualification Manual, COMDTINST M3502.4 (series)
- Enclosures 4, 5, 6, and 7 of DODINST 6055.11
- Navy Electronics Installation and Maintenance Book, General NAVSEA SE000-00-EIM-100/SE004-AK-TRS-10/2M

Notice to Students

Purpose

This pamphlet serves as a training aid to provide you with a general knowledge of Performance and Training tasks required of an ET2.

Important Note

This text has been complied 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 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 four lessons:

Lesson 1: How to Conduct a safety brief on the following:

- Personnel working in and around installed electronics
- Personnel in RF hazards to HERF
- Personnel in RF hazards to HERO
- Personnel in RF hazards to HERP

Lesson 2: How to Identify a cable fault using a TDR

Lesson 3: How to Measure impedance of a coaxial cable or HF antenna

Lesson 4: How to Train personnel in the construction of multi pin and RF connectors

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 Performance Qualifications version (03-2009).

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

Lesson 1

HOW TO CONDUCT A SAFETY BRIEF ON PERSONNEL AND RF HAZARDS

Overview

Introduction

This lesson describes the procedures in place to properly give a safety brief on installed electronics equipment and RF hazards. As an ET2 you will be expected to take on a greater responsibility for training ET shop personnel (and other unit members as appropriate) in certain topics related to the work that you do, and equipment you use, on a regular basis. This lesson is intended to give the information you need to conduct safety briefs over various different platforms.

Objectives

Given instructional materials, access to tools and equipment, and an appropriate audience, **CONDUCT** a safety brief to electronics personnel in the following topics IAW relevant Navy/Coast Guard technical references and equipment manufacturer's guidelines:

- Personnel working in and around installed electronic equipment
- Personnel in RF Hazards of Electro-Magnetic Radiation to Fuel (HERF)
- Personnel in RF Hazards of Electro-Magnetic Radiation to Ordnance (HERO)
- Personnel in RF Hazards of Electro-Magnetic Radiation to Personnel (HERP)

References

The following references were used for this lesson:

- Electronics Manual, COMDTINST M10550.25 (series)
- Cutter Training and Qualification Manual, COMDTINST M3502.4 (series)
- Enclosures 4, 5, 6, and 7 of DODINST 6055.11 "Protection of DOD Personnel from Exposure to RF Radiation and Military Exempt Lasers

Safety Responsibilities

Introduction

This topic describes the safety responsibilities of:

- Commanding Officers (COs)
- Unit safety officers
- Unit supervisors
- Unit technical personnel

Commanding Officer

The chief responsibility of the Commanding Officer (CO) is to ensure the safety and health of all personnel under his/her command.

This responsibility includes:

- Issuing orders as necessary to ensure the safety and health of personnel
- Requiring that Electronics Material Officers (EMOs), Electronics Technicians (ETs), and other personnel authorized to engage in electrical and electronics repair and maintenance, are thoroughly familiar with the safety practices contained in this chapter

Unit Safety Officer Responsibility

The Unit Safety Officer is responsible for ensuring that all new reporting personnel receive safety and familiarization training before engaging in the operation, repair, and maintenance of electrical and electronics equipment.

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Safety Responsibilities (Continued)

Unit Supervisor

The Unit Supervisor must be thoroughly familiar with the safety practices contained in this part and is responsible for ensuring that all safety and health precautions are strictly observed in work areas.

The specific responsibilities of the Unit Supervisor are described in the table below:

Unit Supervisor Responsibility	Description
Familiarization of personnel with safety and health precautions	Ensures that unit personnel are: • Familiar with the location and proper use of personal protective equipment, safety equipment, equipment power switches, and power line circuit breakers • Trained in the current methods of first aid and CPR
Observation of safety precautions	Ensures that: • Rubber floor matting is placed around electrical and electronic equipment • Hazard warning signs are posted
Reporting of injuries and hazardous conditions	Ensures that injuries (even if minor) and any hazardous conditions in a work area are reported to his/her immediate supervisor. ***Note:*** Supervisory personnel are responsible through the Chain of Command to the CO

Unit Personnel

Unit technical personnel who engage in electrical and electronics repair and maintenance work must be:

- Thoroughly familiar with the safety practices contained in this part
- Constantly aware of health and safety precautions to protect themselves from injury or possible death

General Safety Practices

Introduction

This topic contains information on:

- The major causes of accidents from energized electrical equipment
- The training required before working on electrical and electronic equipment
- Personal protective equipment
- Restrictions on personal apparel
- Repair and maintenance safety rules
- Wire and antenna safety
- Prevention of high voltage and power line filter electrical hazards
- The required use of electrical equipment tag out/lock out procedures

Note: The safety practices in this topic and the corresponding Commandant Instructions are applicable to all units. When there is a conflict, however, OSHA requirements take precedence.

Major Causes of Accidents

Most of the injuries and fatalities that occur when working on, or in the vicinity of, energized electrical equipment are attributed to human failure.

Following are some of the major causes of accidents:

- Failure to observe posted safety observations
- Failure to *immediately* repair unsafe equipment
- Use of unauthorized test equipment for repair work
- Installation of unauthorized equipment modifications
- Failure to test equipment after repair to ensure that it is safe to operate
- Failure to remove unused or obsolete cabling and equipment hardware after completion of new installation or field changes.

Safety Training

Before working on electrical or electronic equipment, personnel must receive training in:

- The hazards inherent in working with electrical and electronic equipment
- Accident prevention, CPR, and first aid procedures

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General Safety Practices (Continued)

Personal Protective Equipment

Personal protective equipment must be available for use in work areas and is *required* for working on electrical and electronics equipment

See 4.1.3 Personal Protective Equipment in the Electronics Manual, COMDTINST M10550.25 (series) for details on eye, face, and body protection.

Clothing Restrictions

Restrictions on the personal apparel that may be worn when working on electrical and electronic equipment are identified in the table below:

Personal Apparel	Restrictions
Clothing	Do *not* wear: • Loose or wet clothing • Clothing with *exposed* metal zippers, buttons, or fasteners
Shoes	Do *not* wear: • Thin-soled shoes • Shoes with *exposed* metal parts or hobnails
Metal jewelry, metal framed eyewear, and other similar metal items	*When working within four feet* of exposed energized circuits, do not wear metal items, such as: • Rings • Watches • Bracelets • Dog tags • Metal-framed eyewear

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General Safety Practices (Continued)

General Maintenance and Repair

The general safety rules for all repair and maintenance jobs are described in the table below:

Safety Rule	Description
Do not work alone	A safety observer, qualified in CPR and first aid, must: • Be present at all times • Have unobstructed access to the power panel circuit breakers for the equipment being repaired or maintained
Ensure that the safety observer is provided with the necessary information and instructions	The safety observer must: • Know where the circuits and switches are that control the equipment • Have instructions to disconnect the controls *immediately* if necessary
Inform your supervisor, or those in authority, about the work to be done	Your supervisor, or those in authority, should be informed of the: • Location of the work to be done • Equipment to be repaired or maintained • Estimated length of time to complete the work • Actual time you begin and complete the work

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General Safety Practices (Continued)

Wire and Antnna Safety

The rules for working with, or in the vicinity of, wires and antennas are described in the table below:

Equipment Type	Safety Rules
Wires	• Insulate all wires and lead-ins • Ensure that screw threads, label plates, hinges and all electrical fittings are paint free in order to maintain electrical contact and keep information readable *Do not:* • Place energized bare wires in close proximity to flammable fuels and chemicals or in the path of personnel • Use metal pike poles, pruning poles, or ladders in the vicinity of energized open wires or antennas.
Antennas	*Do not:* • Lean against or grasp an antenna • Touch a radio or television antenna lead-in • Touch an antenna lightning arrestor while in contact with electrical ground • Pass under power lines when operating vehicular equipment if the antenna on the vehicle does not have adequate clearance

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General Safety Practices (Continued)

Working Around RF or High Voltage

All safety practices must be followed when working in the vicinity of:

- High Voltage circuits
- Ship riggings and structures where Radio Frequency (RF) voltages may be induced

For safety precautions specific to these operations, see the following sections in the Electronics Manual, COMDTINST M10550.25 (series):

- 4.1.3 Personal Protective Equipment
- 4.5 Working with Energized Electrical Equipment
- 4.9 Radio Frequency (RF) Radiation hazards

Tag-Out Procedures

The use of standard electrical equipment tag out procedures for Coast Guard cutters and boats are required to prevent improper operation of any systems or equipment that are isolated or are in an abnormal condition because of preventative maintenance or a casualty.

Locking out equipment is the preferred safeguard to prevent inadvertent operation of control switches.

Reference: For more detail on the standard procedures, caution and danger tags, refer to Equipment Tag-Out Procedures, COMDTINST 9077.1 (series), Chapter 077 found on CG CENTRAL (http://cgcentral.uscg.mil).

Note: The standard procedures may be customized for each unit.

Personal Protective Equipment

Inspecting Rubber Gloves

Rubber insulating gloves must be:

- Inspected before using
- Discarded and replaced if any defects are found
- Stored properly

Note: Rubber gloves should be inspected by filling each glove with air and checking for pinholes. They should also be visually inspected for cracks, blisters, and chemical damage. Reference: ASTM D1700 at http://www.astm.org for any and all questions.

Protective Footwear

Electrically insulated shoes must be worn when working with electrical and electronic equipment.

When working on live electrical circuits of 30 volts or more, non-conductive shoes that meet American National Standards Institute (ANSI)-Z41 requirements must be worn.

Note: For more detail on protective footwear, refer to Personnel Protection, Protective Footwear, ANSI-Z41.

Safety Equipment

Introduction

This topic contains information on:

- Shorting probes
- Antenna safety equipment
- Safety devices incorporated in some electrical equipment
- Rubber Matting
- High Voltage and Warning signs
- Working aloft
- Working in cold weather

Shorting Probes

Shorting probes, rated at 25,000 volts, must be located conspicuously in all spaces where electronic equipment is installed.

The General Services Administration (GSA) order information for shorting probes is National Stock Number (NSN) 5975-01-029-4176.

Antenna Safety

Antenna safety equipment includes protection cages and fences. High voltage signs must be displayed on, or immediately next to, protection cages and fences.

See 4.2.3 High Voltage, Danger, and Warning Signs in the Electronics Manual, COMDTINST 10550.25 (series) for details on requirements for high voltage signs.

Electrical Equipment Safety Devices

Various safety devices (such as interlock switches) are incorporated in some electrical equipment. These devices automatically interrupt the power source to the equipment when the access door, cover, or plate is removed.

Safety devices must be inspected and tested periodically to ensure that they are functioning properly.

Reference: For more detail on safety devices, refer to Electronics Plant-General, Naval Ships' Technical Manual (NSTM), Chapter 300 found on CG CENTRAL (http://cgcentral.uscg.mil).

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Safety Equipment (Continued)

Floor Matting

Rubber floor matting must be installed in open spaces around electrical and electronic equipment aboard ships and at shore facilities.

The seams between the matting must be sealed according to manufacturer instructions. At a minimum, four-inch wide 3M electrical insulating tape should be used for sealing the seams.

Matting with cracks, tears, or any type of deterioration must be replaced. There are two types of matting that are authorized for CG use. They are blue/marbleized blue and green/marbleized green. CG authorized rubber matting is rated for no more than 3,000 volts.

Multiple Power Sources

A labeling plate must be affixed to equipment with more than one power source that is 12 volts or more.

The labeling plate must indicate that the equipment has multiple power sources and be affixed to the equipment in a conspicuous place.

Reference: For more detail on labeling equipment with multiple power sources, refer to Electronics Plant-General, Naval Ships' Technical Manual (NSTM), Chapter 300 on CG CENTRAL (http://cgcentral.uscg.mil).

Work on Energized Circuits

A 7 ½ inch by 4 inch cardboard safety tag, with an attached cord, must be attached to equipment when personnel are working on circuits.

An example of the required wording for safety tags is shown below:

"Do Not Throw Switch, Men At Work On Circuits"

Continued on next page

Safety Equipment (Continued)

Working Aloft Warning Sign

A danger sign for working aloft must be posted whenever personnel are servicing equipment on masts or towers.

The size and material requirements for this sign are listed below:

- Size: 10 inches by 18 ½ inches
- Material: Steel with a baked enamel finish

Working Aloft

Personnel working aloft must be aware of the hazards, which include

- Falling
- Exposure to excessive Electro-Magnetic Radiation (EMR)
- Radio Frequency (RF) burns.

Permission and Notification Requirements

Permission to work aloft is *required* and must be obtained from the Officer of the Deck (OOD).

After permission is given to work aloft, the OOD notifies the applicable personnel so that safety practices will be followed.

Note: The common practice is to notify personnel by sending a "man aloft chit" signed by the OOD and supervisory personnel.

The personnel notified and the safety practices followed are described in the table below.

Personnel to Notify	Purpose
Radio and radar operators	Rotation and radiation must be suspended while personnel are working aloft.
Engineering watch	Stack gas must be minimized while personnel are working aloft.
All personnel on deck	Personnel must avoid deck areas under which work is being done.
Other units in the vicinity	Radiation must be suspended and stack gas minimized.

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Safety Equipment (Continued)

Personal Fall Arrest System

Personnel must:

- Use the personal fall arrest system approved for use by the Coast Guard whenever they work aloft
- Be familiar with the proper use of each component of the system

A personal fall arrest system consists of the following components:

- Full body harness, which includes a parachute harness, safety harness, and safety line
- Deceleration lanyard
- Safety climbing device

Reference: For details on the proper use of a personal fall arrest system, refer to the Tower Manual, COMDTINST M11000.4 (series) on CG CENTRAL (http://cgcentral.uscg.mil).

Cold Weather

Guidelines for dressing safely for cold weather are described in the table below:

Guidelines	Reason
Wear several layers of thin clothing	To avoid becoming overheated, you can remove a layer of clothing when your body heat rises.
Avoid becoming overheated	Perspiration from overheating causes your: • Body to cool as it evaporates • Clothing to become damp resulting in poor insulation ***Note:*** It is better to be slightly chilly than to perspire heavily.
Wear loose clothing and footwear	Tight clothing and footwear can restrict blood circulation putting you at risk for frostbite and trench foot.
Wear water-repellent outer clothing	In the event of rain or snow, your inner clothing will remain dry.

Working on Energized Equipment

Introduction

This topic contains the:

- Procedures for closing electrical power and lighting circuits before working on the circuits
- Safety precautions to follow when working with fuses or other types of wiring equipment
- Safety practices for working on energized circuits rated at 30 to 300 volts
- Procedures for measuring voltages of 300 volts or more prior to work
- Safety practices for working on damaged electrical equipment or circuits.

Safety Precautions

Before working on electrical power and lighting circuits, switches and circuit breakers designed as a means of disconnection must be used to close the circuits.

The procedure for closing electrical power and lighting circuits is described in the table below:

Step	Action
1.	Before you begin, notify all personnel in the immediate area of the circuit.
2.	Install the appropriate fuses to protect the circuit from damage.
3.	Ensure that the circuit is ready and all parts are free from contact with personnel.
4.	Place one hand behind you, away from the circuit.
5.	Use the other hand to touch the switch or circuit breaker, and turn your face away while closing the circuit to prevent an eye injury from flashover.

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Working on Energized Equipment (Continued)

Working on Equipment Over 300 Volts

Before working on energized circuits rated at more than 300 volts, tests to measure the voltages must be performed.

The procedure for measuring voltages in excess of 300 volts is described in the table below.

Step	Action
1.	De-energize the equipment to be tested
2.	• Attach the appropriate warning signs to the equipment • Lock out the equipment See the following sections in the Electronics Manual, COMDTINST M10550.25 (series): • 4.2.3 High Voltage, Danger, and Warning Signs for more on high voltage signs and safety tags for working on circuits. • 4.1.2.9 Electrical Equipment Tag Out/Lock Out Procedures for more on locking out equipment.
3.	Use an approved safety shorting probe to discharge the high voltage capacitors. See 4.2.1.2 Shorting Probes in the Electronics Manual for more detail.
4.	Attach the test leads for measurement.
5.	Ensure that the controls of the measurement device are properly configured for the voltage level and polarity being measured.
6.	Stand clear of the equipment, but in a position that allows you to read the measurement.
7.	• Energize the equipment • Take the measurement
8.	• De-energize the equipment • Discharge the high-voltage capacitors
9.	Remove the test leads

RF Hazards

Introduction

This portion of the lesson describes the:

- Radio Frequency (RF) hazards that exist at Coast Guard units
- Responsibilities for radiation hazard training and compliance
- Safety practices to limit exposure to RF radiation
- Use of the appropriate warning signs in areas where an RF radiation hazard exists

Responsibility

The Command is responsible for ensuring that:

- RF radiation hazard awareness training is provided to Coast Guard personnel and contractors before they are assigned to areas where RF radiation levels exceed the maximum permissible exposure (MPE) limits
- RF radiation levels are measured
- Permissible exposure limit (PEL) boundaries are established and consistently maintained

Radiation Awareness

Personnel must receive radiation awareness training before being assigned to work in an environment, or directly with equipment, where RF radiation levels exceed the MPE limits.

The training provides information on the:

- Potential hazards of RF radiation exposure
- Established procedures and restrictions to control exposure
- Responsibility of personnel to limit their own exposure

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RF Hazards (Continued)

Responsibility

The responsibilities for identification of radiation hazards and compliance with radiation hazard standards are described in the table below:

Who is Responsible	Description
Maintenance and Logistics Command (MLC)	Identifies radiation hazards in the unit.
Telecommunications and Information Systems Command (TISCOM)	Creates Permissible Exposure Limit (PEL) boundaries.
Unit contractor (for units requiring RF measurements)	• Installs RF measurement system • Completes electro-magnetic interference (EMI) and radiation hazard (RADHAZ) surveys • Ensures compliance with the standards contained in the: - Protection of DoD personnel from exposure to RF Radiation and Military Exempt Lasers, DODINST 6055.1 (series) - Navy Occupational Safety and Health Program Manual, OPNAVINST 5100.23 (series)

RF Radiation Exposure Hazards

Introduction

This topic contains information on:

- The hazards of RF radiation
- Safety practices for preventing injury

Hazards

The hazards of exposure to RF radiation are described in the table below:

RF Radiation Hazard	Description
Thermal effect	The thermal effect on the human body from high levels of RF radiation is tissue damage. Tissue damage results primarily from the body's inability to cope with or dissipate excessive heat. The eyes and testes are particularly susceptible to tissue damage from high frequencies.
Potential biological effects	Evidence from experimental research indicates that immunological, neurological, and behavioral changes may result from lower levels of RF radiation.
Burns	RF radiation can induce a current on improperly grounded, or ungrounded conductors, such as metal objects (poles, fences, or wires) or wet objects.
Electric Shock	Electric shock (and possibly burns) can occur when the: • Voltages at the transmitter, antenna feed line, and the antenna, are large enough to create a discharge path • The distance between two conductors (that is, the antenna and your body) exceed the breakdown voltage of the dielectric (air)

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RF Radiation Exposure Hazards (Continued)

Safety Practices for Preventing Injury

The safety practices for preventing injury from related hazards are described in the table below:

Safety Practice	Reason
Avoid extended exposure, even if exposure is at lower power levels and frequencies. ***Note:*** The electromagnetic frequency of RF radiation is as important as the radiation level in determining the magnitude of the hazard.	The maximum rate of absorption by the human body can occur within the maximum permissible exposure (MPE) limit frequency range of 30 – 300 MHz (VHF band). Extended exposure at the frequency range of 30 – 300 MHz is dangerous. See 4.9.5 Maximum Permissible Exposure (MPE) Limits in the Electronics Manual, COMDTINST M10550.25 (series) for more detail.
Use extreme caution when working near energized broadcast equipment.	Various hazards exist within the proximity of broadcast antennas. Although these hazards become greater the closer you are to an antenna, you assume that hazards exist wherever MPE limits are exceeded.
The most effective way to prevent the "startle" effect is to be aware of all hazards involved in working with energized broadcast equipment.	Addition injuries can occur from a reflexive reaction (startle effect) after sustaining burns or electric shock. ***Example:*** Injuries from falling off a ladder after sustaining a shock.

HERF and HERO Safety Practices

Introduction

This topic contains information on the:

- Occurrence of Hazards of Electro-Magnetic Radiation to Fuel (HERF), and Hazards of Electro-Magnetic Radiation to Ordnance (HERO)
- HERF safety instructions in each unit
- HERO safety plans in applicable units
- HERF/HERO safety practices for fueling aircraft and vehicles and conducting an evolution.

Occurrence of HERF and HERO

HERF and HERO occur when the operation of electronic transmitters used for radio and radar:

- Induce RF voltages in the standing rigging, parts of the superstructure, and other antennas and/or cables
- Arc between closely spaced conductive metal objects or cause sparks when contact is made or broken by personnel
- Contain sufficient energy so that the heat of the arc (or spark) ignites fuel vapors or other explosive mixtures.

HERF Safety Instructions

A HERO safety plan should be in place in applicable units to limit the exposure of ordnance to RF energy.

During loading and unloading of ordnance, RF energy can enter a weapon as a wave radiated through a hole or crack or be conducted into the weapon by the firing leads or other wires penetrating the weapon enclosure.

Although the most likely effect is duding and reduction of reliability, there is a low probability of detonation.

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HERF and HERO Safety Practices (Continued)

Safety Practices for Fueling

The HERF/HERO safety practices for fueling aircraft or vehicles are described in the table below.

HERF/HERO Safety Practice	Description
Make connections *before* the vehicle or aircraft is fueled.	Electrical, static ground wire, tie-down, or any other metallic connections must be made before the aircraft or vehicle is fueled.
Do *not* energize a radar or communications transmitter during fueling.	A radar or communications transmitter on an aircraft or vehicle being fueled, or an adjacent aircraft or vehicle, must not be energized during the fueling.
Break connections *after* fueling is completed.	Do not break electrical, static ground wire, tie-down, or any other metallic connections to the aircraft or vehicle while it is being fueled.

Safety Practices During an Evolution

HERF/HERO safety practices must be followed when conducting an evolution hat requires the handling of ammunition and volatile liquids or gases.

The procedure for safely conducting an evolution is described in the table below.

Step	Action
1.	Inform the personnel involved with the evolution of the potential hazards of HERF/HERO.
2.	Secure all transmitting antennas located within the quadrant of the ship in which the evolution will be conducted.
3.	Ensure that the area is adequately ventilated.
4.	Request that the use or presence of tools and metal objects in area be minimized.
5.	If possible, insulate the loading hook from the crane with manila rope or RF insulators.
6.	Use an insulated steering hook to guide boom or hook cables.

RF Hazards of Electro-Magnetic Radiation to Personnel (HERP)

Introduction

The topic contains information on:

- Maximum Permissible Exposure (MPE) limits
- The averaging exposure time limits for individuals in the occupational and general population categories to be exposed to RF radiation without injury
- Maximum permissible electric and magnetic fields and power densities from which the averaging exposure time limits are derived
- Compliance with the averaging exposure time limits for the occupational and general population categories.

MPE Limits

Maximum Permissible Exposure (MPE) limits define the maximum time and intensity of RF fields that an individual can be exposed to without sustaining injury.

The Federal Communications Commission (FCC) has published guidelines to be used for evaluating human exposure to RF emissions, which include MPE limits for the following categories:

- For equipment operating at frequencies between 300 KHz and 100 GHz
- In terms of electric and magnetic field strengths
- In terms of power density

The MPE limits are based on:

- Recommendations of the National Council on Radiation Protection and Measurements (NCRP)
- Limits developed by the Institute of Electrical and Electronics Engineers (IEEE) that were adopted by the American National Standards Institute (ANSI)

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RF Hazards of Electro-Magnetic Radiation to Personnel (HERP) (Continued)

Averaging Exposure Time Limits

The averaging exposure time limits – that is, maximum time that an individual can be exposed to RF radiation without injury – for individuals in the occupational and general population categories are described in the table below:

Population Cat.	Description	Time Limit
Occupational Population/Controlled Exposure	This category applies to all Coast Guard personnel who: • Work near RF fields • May be exposed to radiation due to their employment • Are fully aware of the risk • Are able to exercise control over their exposure	6 minutes
General Population/Uncontrolled Exposure	This category is used for the general public or employees (as a result of their employment) who: • Do not work, or will not work, near RF radiation • May be exposed to radiation • May not be aware of the risks • Cannot exercise control over their exposure	30 minutes

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RF Hazards of Electro-Magnetic Radiation to Personnel (HERP) (Continued)

Compliance

Because MPE time limits are very restrictive for higher powers and frequencies, extensive work cannot be accomplished while equipment is energized.

The planned maintenance system (PMS) procedures must be adapted to comply with the MPE time limits.

Example: The procedure could be adapted to:

- Restrict the time near the RF field
- Require that work on or near the RF field is performed when the power is appropriately reduced
- Exposure to an electric or magnetic field or power density higher than the occupational population MPE limits cannot exceed 6 minutes

Examples

Examples of how to comply with the averaging exposure time limit are provided in the table below:

When a worker is exposed to a power density limit…	**Then the worker must be away from the field for…**
Two times higher than the limit	3 minutes before or after exposure
Three times higher than the limit	4 minutes before or after exposure

Permissible Exposure Limit (PEL) Boundaries

Introduction

This topic contains information on:

- The permissible exposure limit (PEL) boundaries established at shore units and on board ships
- PEL fences used at shore units and broadcast sites
- Typical PEL boundaries for different classes of ships and Coast Guard/Navy supported radar antennas
- How PEL boundaries are determined for ships, radar antennas, and broadcast sites

PEL Definition

A permissible exposure limit (PEL) boundary physically marks an area as a radiation hazard zone.

A PEL boundary is used to:

- Define and restrict areas where RF radiation may exceed the general population MPE limits
- Alert ET's of their averaging time limits

Important: **RF radiation hazard (RADHAZ) warning signs must be posted at all PEL boundaries.**

See 4.9.7.1 in the Electronics Manual for requirements for posting RF warning signs at PEL boundaries.

PEL Boundaries at Shore Units

PEL boundaries at shore units should restrict access to areas where exposure exceeds the MPE limits for the general population.

The methods for restriction access include:

- Locking doors to the restricted areas
- Installing a PEL fence with a lockable gate

Notes:

- At remote sites, not generally visited by the general population, an RF RADHAZ sign may be considered as the PEL boundary
- PEL fences are generally used at shore-based broadcast sites, such as DGPS broadcast sites, VTS radar sites, and communication stations (COMMSTAs)

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Review Quiz

Questions

1. What is the primary cause of injuries and fatalities that occur while working on energized equipment?

   _____

   _____

2. What restrictions have been placed on personal apparel when working on energized electrical equipment?

   _____

   _____

3. You should NOT wear metal jewelry when working within ____ feet of energized circuits.

   A. four
   B. six
   C. two
   D. three

4. The shorting probes used by CG units rated for _____?

   A. 5,000 Volts
   B. 15,000 Volts
   C. 20,000 Volts
   D. 25,000 Volts

5. At a minimum, what type of material must be used when sealing the seams of electrical matting?

   _____

   _____

6. What is the maximum allowable exposure limit for personnel working in or near an RF field?

   A. 8 minutes
   B. 6 minutes
   C. 30 minutes
   D. 15 minutes

Review Quiz Answers

Block Label

Question	Answer	Reference
1.	Human Failure	1-4
2.	Do not wear loose or wet clothing w/ exposed zippers, buttons or fasteners.	1-5
3.	A	1-5
4.	D	1-10
5.	4 in. wide electrical insulating tape	1-11
6.	B	1-23

Lesson 2

HOW TO IDENTIFY A CABLE FAULT USING A TDR

Overview

Introduction

This lesson describes the procedures in place to properly use a Time Domain Reflectometer (TDR) to identify a cable fault. The TDR is widely used across all platforms to identify faults in numerous types of cable.

Lesson Objectives

Given instructional materials, **TRAIN** personnel in the operation of the Time Domain Reflectometer (TDR) to identify cable faults IAW with the Electronics Manual, M10550.25 (series) and manufacturer's technical manuals.

References

The following references were used for this lesson:

- Electronics Manual, COMDTINST M10550.25 (series)
- Test Equipment Technical Manual

Time Domain Reflectometer

TDR

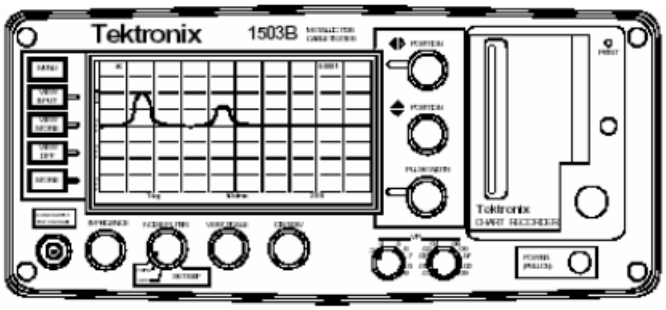
The Time Domain Reflectometer (TDR) is capable of sending a pulse down a cable and measuring the reflected pulse back. This measurement provides:

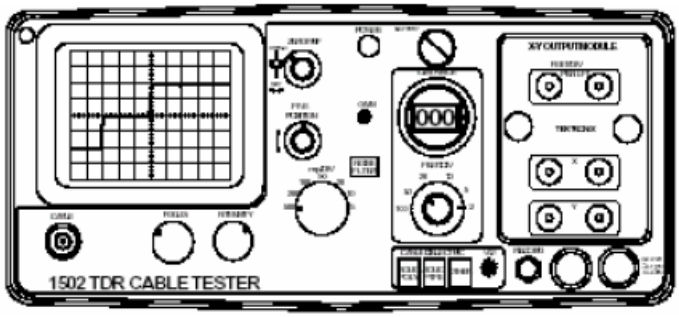
- The cable's impedance
- Distance of the cable
- Visual indication of sharp bends, or kinks
- Visual indication of cuts or nicks
- Visual indication of end of the cable

Common Types of TDR

There are several types of TDR's available for Coast Guard use. We will discuss two in this lesson. The two types of TDR's most widely used in the USCG are the:

- Tektronix Model 1503B
- Tektronix Model 1502 TDR Cable Tester





The 1502 is an analog TDR and 1503B is digital. Both models provide the same information.

TDR Operation

Introduction

To complete the procedures in this section you will need:

- A TDR
- The technical or operators manual
- A 6-ft length of RG-58 cable to connect to your TDR

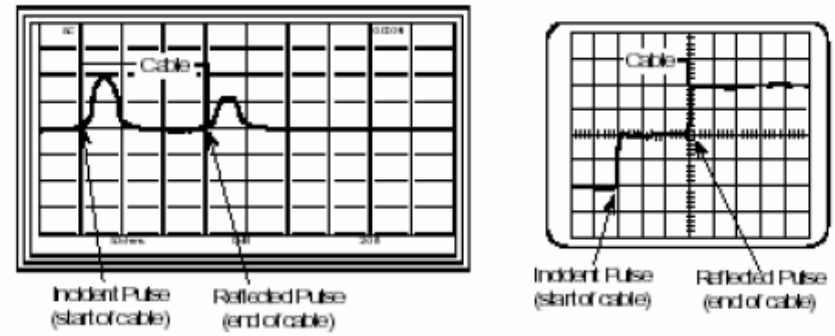
TDR Set Up

Refer to your TDR operator's manual and the steps below to set up your TDR:

Step	Action
1.	Turn the TDR on.
2.	Adjust the display controls for a clear, bright trace.
3.	Adjust the vertical position control to center the display.
4.	Line up the rise of the incident pulse (if available) on a vertical line.
5.	Connect your six ft. length of RG-58 cable to your TDR.
6.	Adjust the amplitude control to full screen display
7.	Adjust the feet/division to see both the incident and reflected pulse.

TDR Display

After you have completed the set up, your TDR display should look like one of the following:



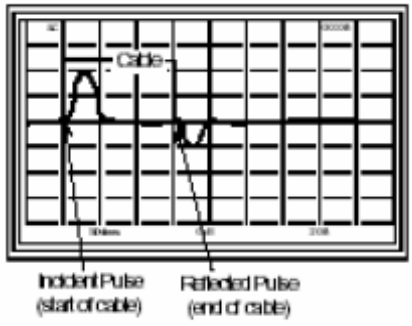
The differences in the displays depend on the type of TDR. While they may not look the same, they provide the same information.

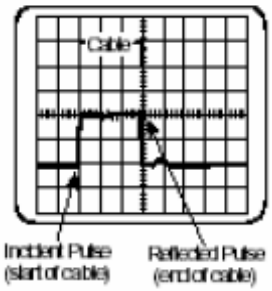
Continued on next page

TDR Operation (Continued)

Displaying a Short

Once you have obtained the correct display, short the end of the cable. The display should look like one of the following pictures:



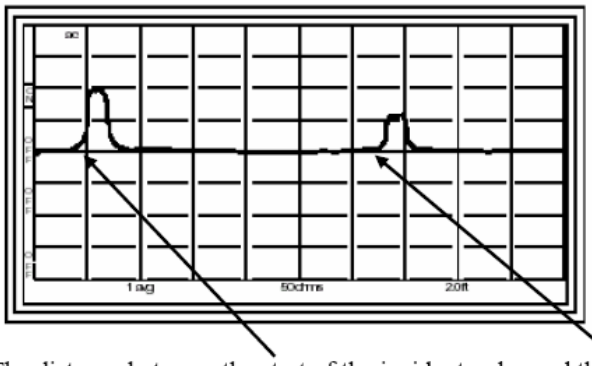


Interpreting the Display

Now that you have something displayed on the CRT, what does it mean? Changes in the cable impedance are represented by bumps and dips on the display. If the cable impedance goes up, as in an open cable, so does the display. Likewise, if the impedance goes down, as in a short, so does the display.

To calculate the distance to the end of a cable, multiply the distance, per division, by the number of vertical lines between the start of the incident pulse and the start of the reflected pulse.

Example:



The distance between the start of the incident pulse and the start of the reflected pulse is 5 ½ units. Multiply this by 2 feet per unit for a total of 11 feet.

TDR Operation (Continued)

Control Functions

Now that you have a cable displayed on your TDR, you need to manipulate the display. Familiarize yourself with the operator's manual to complete the following tasks:

Step	Action
1.	Adjust the power of your transmitted pulse. You should see the size of the display pulse change. Less power will reduce noise. More power will enable you to measure longer cables.
2.	Decrease the value of your distance/division. You should see the reflected pulse moved to the right. This control allows you to stretch the length of the cable across the display.

Locating Cable Problems

Your supervisor informs you that there is a problem in a transmission line that is causing a high VSWR (Voltage Standing Wave Ratio). Initial troubleshooting results show that the transmitter and antenna are operating normally. The problem appears to be within the transmission line, which runs from the transmitter room to the antenna located several hundred feet away. In the next section, you will learn how to set up and use the TDR to locate faults in the cable.

Gathering Information

Before troubleshooting the cable, gather all of the information you can about the cable. The information you should look for includes:

- Type of cable (size, impedance)
- Length of cable
- Routing path of the cable, including bends and bulkhead feed-through (using diagrams, blueprints, etc.)
- Any known connectors or splices in the cable run
- Any prior TDR recording on the cable in question

Note: The above information should be included on the NAVSHIP-531 (Resistance Test Record) card for that transmission line.

Continued on next page

TDR Operation (Continued)

Set Up Procedure for Line Test

Follow the procedure below to locate a problem in a transmission line:

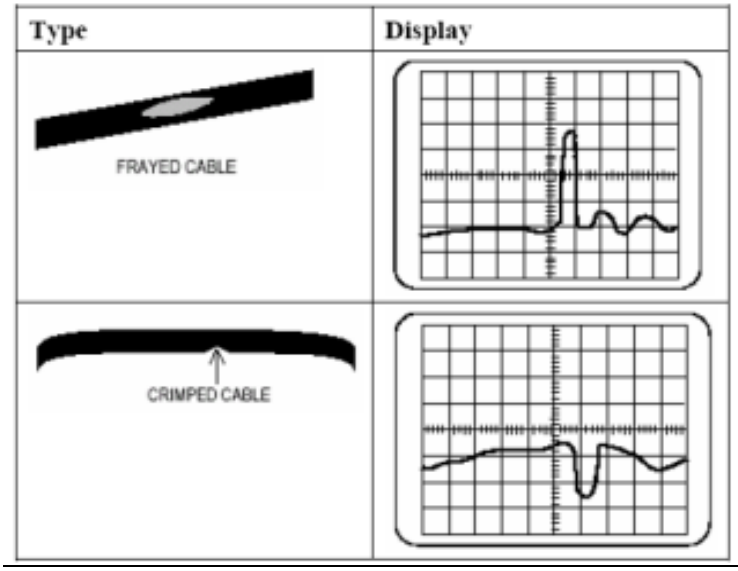
Step	Action
1.	Set up your TDR as described in the "TDR set up" section.
2.	Disconnect the transmission cable under test at both ends. ***Note:*** Bleeding cables of their static charge prior to hooking them up to a TDR will prevent damage. You can bleed cables by connecting a termination matching the impedance of the cable.
3.	Connect one end of the cable to the TDR and leave the other end open. ***Note:*** An adapter may be required to connect a transmission cable to the TDR.
4.	Set up the screen on the TDR to display the full length of cable. There should be an open displayed on the TDR. To ensure that you're looking at the end of the cable, short the open end and notice a short displayed on the screen. ***Note:*** If no shorts are displayed, you have an open in the cable!
5.	Study the trace displayed on the TDR and enlarge the areas of concern.
6.	Determine the type of problem. The most common cable problems include: • Opens • Frayed, cut, or damaged areas • Shorts • Crimps or excessive bends • Faulty connectors • Moisture
7.	Determine the location of the problem.

Continued on next page

TDR Operation (Continued)

Frayed and Crimped Cable

The displays for an open and a shorted cable are shown in the "TDR Display" and the "Displaying a Short" sections. The displays for a frayed and crimped cable are shown below:



Locating Problems

You now have an idea of where the fault is located in the transmission line based on the TDR readings. Remember, cable does not necessarily run in a straight line. There could be bends and bulkhead connections along the routing path. Use any available diagrams or blueprints showing how the cable is routed to assist in locating the problems.

Note: After completing a TDR test on a transmission line, you should make a recording of the display screen and attach it to the NAVSHIP-531 (Resistance Test Record) card.

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Review Quiz

Review Questions

1. When using a TDR, how do you calculate the distance to the end of a cable?

   _____

   _____

2. When using the controls on your TDR, what is the purpose of applying more power?

   A. Enables you to measure shorter cable runs
   B. Enables you to measure longer cable runs
   C. Enables you to measure cable up to 50 ft. in length
   D. Enables you to measure cable up to 25 ft. in length

3. After gathering all the information on the transmission line under test, where should this information be recorded?

   A. DD-1149
   B. DOT F 4200.1.2CG
   C. NAVSHIP-531
   D. CG-5269

4. If you have a downward spike on your display at 30ft in the line under test, what does that mean?

   A. You have a short 30ft into the transmission line.
   B. You have an open 30ft into the transmission line.
   C. You have short 60ft into the transmission line.
   D. You have an open 60ft into the transmission line.

5. Why would you ever have to lower the power level on your TDR?

   _____

   _____

Review Quiz Answers

Answers

Question	Answer	Reference
1.	Multiply the distance, per division, by the number of vertical lines between the start of the incident pulse and the start of the reflected pulse.	2-4
2.	B	2-5
3.	C	2-7
4.	A	2-7
5.	For noise reduction	2-5

Lesson 3

HOW TO MEASURE IMPEDANCE OF A CABLE OR HF ANTENNA USING A MEGGER

Overview

Introduction

This lesson contains information on testing cable transmission lines and HF antennas using a megger. You will learn that the megger is the preferred testing option for many types of cabling and antennas, but is not an option for some others.

Lesson Objectives

Given instructional materials, **MEASURE** dielectric impedance of a coaxial cable or HF antenna using a megger IAW with the Electronics Manual, M10550.25 (series) and Navy Electronics Installation and Maintenance Book, General, NAVSEA SE000-00-EIM-100.

References

The following references were used for this lesson:

- Electronics Manual, COMDTINST M10550.25 (series)
- Navy Electronics Installation and Maintenance Book, General, NAVSEA SE000-00-EIM-100

Antennas and Transmission Lines Testing Intervals

Testing Intervals

Coast Guard equipment should be inspected and tested on a regular basis.

The table below contains basic guidelines for determining the maximum interval for testing your equipment:

If the equipment is..	**Then test the equipment at least…**
On a shore unit	Quarterly or as the local environment dictates.
On a floating unit	Monthly or at the end of each extended period at sea.
Submarine cable	Annually.

Using a Megger

Introduction

Megger - high voltage, high resistance ohmmeter testing:

- Is the most convenient test of an antenna system
- Due to high voltage, which is sufficient in many cases to break down faults in the insulation, exposes any weak spots

Below are some exceptions for using a megger with alternate testing methods:

If the equipment is…..	Then….
VHF/UHF antenna	Refer to technical manuals or contact NAVSEA. ***Note:*** Due to their high operating frequency, the DC resistance of VHF/UHF antennas is near zero, therefore megger testing is impractical and inconclusive.
Wave-guide	Use VSWR testing. See section 7.3.2.4.7 in the Electronics Manual, COMDTINST M10550.25 (series).
Whip antenna	Refer to technical manual. ***Note:*** Some whip antennas may contain discrete components or exhibit the characteristics of an electrical short and should not be tested with a megger.
Wire antenna	Use a Time Domain Reflectometer (TDR).

NAVSHIP-531 Resistance Test Record Card

Use the NAVSHIP-531 Resistance Test Record Card to record the results of megger testing on transmitting and receiving antenna systems and submarine cables. This includes antennas, insulators, and transmission lines.

Continued on next page

Using a Megger (Continued)

Megger Testing Procedure

The megger generates high voltage (approximately 500 volts DC), which is usually sufficient to break down faults in the insulation (causing conduction), thereby exposing any weak spots in the insulation of antenna systems and transmission lines. ET's perform megger testing by completing the procedure below:

Step	Action
1.	Disconnect all equipment, including the coupler, from the antenna and transmission line. ***Important:*** Test antenna and transmission lines separately because, • The voltage developed by the megger can cause circuit damage in equipment left connected • A true reading of the antenna/transmission line cannot be obtained when equipment is left connected due to the circuit providing a path to ground
2.	Connect the megger ground lead to ground or the shield of the transmission line.
3.	Connect the hot lead to the antenna connection or the transmission line center conductor.
4.	Perform the test.
5.	Record the megger reading on Form NAVSHIP-531, Resistance Test Record. ***Note:*** A separate NAVSHIP-531 should be used for each transmission line or antenna.
6.	Evaluate the results of the reading in comparison to past tests. ***Note:*** Maintenance is needed under the circumstances describes below: • The Resistance Test Record indicates a pattern of slowly deteriorating readings or sudden changes • The reading shows a resistance of 200 Megaohms or less ***Important:*** A resistance of 5 megaohms or less indicates an immediate and urgent need to correct the problem.

Review Quiz

Review Questions

1. What is the time interval between tests on antennas or transmission lines if you are stationed on shore?

   _____

   _____

2. What is the time interval between tests on antennas or transmission lines if stationed on a CG Cutter?

   _____

   _____

3. What is the time interval between tests on submarine cable?

   A. Annually
   B. Semiannually
   C. Quarterly
   D. Monthly

4. Where should you record your readings after each test?

   A. DOT F 4200.1.2
   B. NAVSHIP-531
   C. DD-1149
   D. CG-5269

5. What types of antennas or transmission lines do you avoid using a megger on?

   _____

   _____

Review Quiz Answers

Answers

Question	Answer	Reference
1.	Quarterly or as the environment dictates.	3-2
2.	Monthly or at the end of extended periods at sea.	3-2
3.	A	3-2
4.	B	3-3
5.	VHF/UHF antennas, wave-guide, Whip and wire antennas.	3-3

Lesson 4

HOW TO TRAIN PERSONNEL IN THE CONSTRUCTION OF MULTI-PIN AND RF CONNECTORS

Overview

Introduction

As an ET you will have to select and install connectors. The reasons vary, from making test cables, to replacing the connector that got pulled off while sliding a piece of equipment out from the rack. It is not the intent of this chapter to teach you about every connector used in the Coast Guard, but to introduce you to the two most commonly used types. Once you've assembled these connectors you will be able to install any connector set you are likely to encounter.

Lesson Objectives

Upon completion of this section you will be able to:

- Select and install multi-pin connectors
- Select and install RF connectors
- Weatherproof a connector

References

The following references were used in this chapter:

- Electronics Manual, COMDTINST M10550.25 (series)
- Navy Electronics Installation and Maintenance Book, General, NAVSEA SE000-00-EIM-100, SE004-AK-TRS-10/2M
- Manufacturers guidelines

Types of Connectors

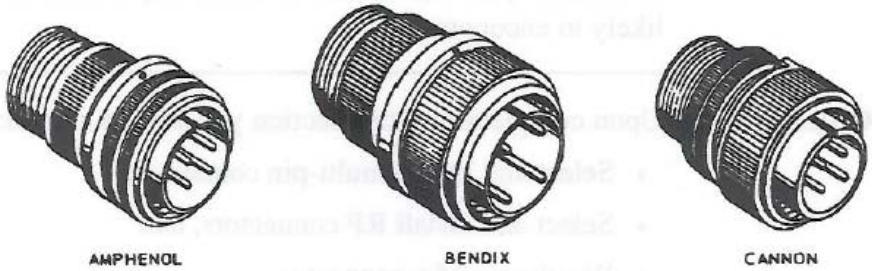
Introduction

The Coast Guard basically uses two types of connectors for electronics. They are:

- Multi-pin connectors
- RF connectors

Multi-pin Connectors

There are various types of multi-pin connectors in use. They are used with multi-conductor cables. The following picture shows some typical multi-pin connectors. They are referred to as Cannon, Bendix, Amphenol and DB connectors. These names refer to the manufacturer and the various types of connectors.



9 pin DB connector

15 pin DB connector

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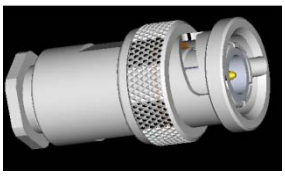
Types of Connectors (Continued)

RF Connectors

RF connectors are used with RF cables. Below are pictures of the most common types:



BNC

UHF

N-Type

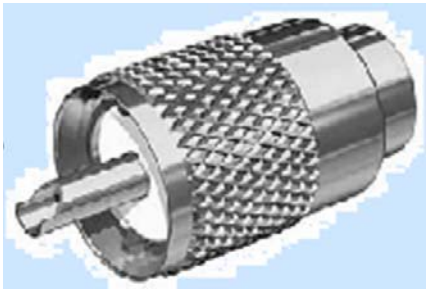
SMA – Used in Microwave applications

Continued on next page

Types of Connectors (Continued)

RF Connectors (Cont'd)

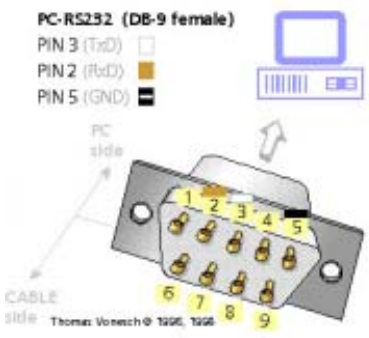
A PL-259 connector is depicted below:



Connector Assembly

Multi-pin Assembly

Below are the steps in the construction of a DB connector:

Step	Action
1.	Locate the body of your DB connector. Example: 
2.	Locate multi-conductor cable to install the connector on.
3.	With your cable strippers, strip approximately ¼” from the end of each multi-conductor cable.
4.	With your soldering iron and solder, clean and tin each cable end.
5.	Locate the pin-out for the DB connector. ***Note:*** If no pin-out is present, then you can verify your pin-out by copying from the other connector that this connector will be attached to. Ask your supervisor if you have any questions.
6.	With your soldering iron and solder, place a bead of solder in each cup on the connector that a cable will be installed on.
7.	One at a time, solder each cable into its correct position.
8.	Apply the shell to the connector body and tighten the screws to hold the connector together.

Note: Some DB connectors are constructed using crimped on pins. In the event you have to use a crimp connector, follow manufacturer guidelines.

Continued on next page

Connector Assembly (Continued)

RF Connector Assembly

Below is a step by step example for constructing a PL-259 connector:

Step	Example
1. Strip the outer insulation of the coax for about ¾" (the length of the adapter tube).	
2. Flip the exposed braid back over the insulated part of the coax. Be careful doing this as the braid has to lay smoothly over the coax or the next step will be impossible.	
3. Force the coax into the adapter so that the braid is inside the tube as shown. The front edge should be even with the inner edge of the adapter tube. The easiest way is to treat the coax like it's threaded and twist the adapter on using downward pressure.	
4. Dress the inner conductor of your coax as shown. There should be only a small amount of the inner insulation left projecting forward from the end of the adapter. Tin, but do not cut the center conductor at this time.	
5. Assemble the connector. First, slip the threaded outer sleeve over the cable. Next, making sure the center wire goes through the center pin of the connector, screw the adapter into the back of the connector housing. Tighten the adapter with pliers. Finally, solder the wire into the center pin.	

Continued on next page

Connector Assembly (Continued)

RF Connector Assembly (Cont'd)

6. Clip away the excess center wire and spin the outer ring forward over the connector housing and the connector is now ready to use.	

Note: The steps above take you through the steps for the construction of a PL-259 connector. Most, if not all, RF connectors will be similar in construction with just a couple minor changes. Again, if you have any questions or need assistance then ask your supervisor for help or follow manufacturer guidelines.

Testing Your Connector

Testing Multi-Pin Connectors

Testing a multi-pin connector is very simple. All you will need is a multi-meter set to check continuity. Place one lead of your multi-meter on one of the newly created pins and hold it there. On the other side of the connector, you will need to take the other lead and touch each pin individually and hold for a second to ensure there is no change in your meter. You should only show a short between one path the rest of your readings should be open. If you show more than one short, or low resistance, then your connector must be repaired as it will not work if installed.

Testing RF Connectors

Testing an RF connector is also very simple. You will need a multi-meter set to check continuity. Place one lead on the center conductor of the connector and place the other lead on the outer shell of the connector. You should read an open. If you get a short or low resistance then your connector will not work properly and will have to be redone.

Connector Maintenance

Introduction

Maintaining connectors consists of inspecting them for signs of corrosion, ensuring they are making good connections, and protecting them from weather.

Weather-Proofing

All connectors that are not indoors must be weatherproofed. Electrical connectors shall be weatherproofed within 24 hours of assembly.

Below is the preferred method of weatherproofing a connector:

Step	Action
1.	Apply one layer of self vulcanizing tape.
2.	Apply one layer of electrical tape.
3.	For added protection apply Scotch Coat over the electrical tape.

Connector Inspection

Weatherproofed multi-pin connectors should be visually inspected monthly for signs of deterioration. Perform the following steps if signs of deterioration are discovered:

Step	Action
1.	Remove the old weatherproofing by carefully cutting it with a knife or another sharp object.
2.	Disconnect the connector and check for signs of corrosion.
3.	If corrosion is found, clean the pin or pins and perform a continuity check.
4.	If corrosion is extensive, or you have a bad continuity test, install a new connector.
5.	Once the connector is repaired or replaced, reapply the weatherproofing.

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Review Quiz

Questions

1. What are the two basic types of connectors used in Coast Guard electronics?

_____

_____

2. Describe the process for testing a multi-pin connector.

_____

_____

Review Quiz Answers

Answers

Question	Answer	Reference
1.	RF and Multi-pin	4-2
2.	With a multi-meter hold one test lead to the newly constructed pin. On the other side of the connector take the other test lead and touch each pin checking for continuity. You should have only one short for the pin.	4-5

Appendix A

Pamphlet Quiz Questions

1. What is the primary concern for technical personnel who engage in electrical and electronics repair and maintenance work?

_____

_____

2. What is the primary cause of injuries and fatalities that occur while working on energized equipment

_____

_____

3. What is the time interval between tests on submarine cable?

   A. Annually
   B. Semiannually
   C. Quarterly
   D. Monthly

4. Where should you record your readings after each megger test?

   A. DOT F 4200.1.2
   B. NAVSHIP-531
   C. DD-1149
   D. CG-5269

5. What types of antennas or transmission lines should you avoid when using a megger?

_____

_____

6. When using the controls on your TDR, what is the purpose of applying more power?

_____

_____

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Appendix B

Answers

Question	Answer	Reference
1.	Familiar with safety practices.	1-3
2.	Human Failure	1-4
3.	B	3-2
4.	B	3-3
5.	VHF/UHF antennas, wave-guide, whip and wire antennas.	3-3
6.	Testing longer cable	2-5

Request for Feedback – Performance and Training

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.

To Contact You

Please provide the following so that we can contact you if needed.

Name	Unit	Phone
		( )

Mail, Fax, or Call

Please mail, fax, or call your information to:

Commanding Officer (CED)
U.S. Coast Guard
Training Center Petaluma
599 Tomales Rd.

ATTN: ET Subject Matter Specialist

PHONE: (707) 765-7129
FAX: (707) 765-7033

LIST OF MATERIALS FURNISHED

COURSE TITLE: **ET2** COURSE CODE: **0222** EDITION: **3**

1. The materials for the course you requested are listed below. If any item listed is not enclosed in this package, report that fact to your Educational Service Officer (ESO).

2. If you enrolled in this course for credit, you have **36 months** to complete the course. If you requested course materials only, you will not receive an End-of-Course Test (EOCT) and will not receive credit for the course.

COMPONENT	NUMBER	QTY
PQG Certification Pamphlet	P22201	01
Administration	P22202	01
Performance and Training	P22203	01
Special and Emergency Procedures	P22204	01
Electronic Installation Standards	P22205	01
Electronic Systems Planned Maintenance	P22206	01
Electronic Systems Corrective Maintenance	P22207	01