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ELECTRONICS INSTALLATION AND MAINTENANCE BOOK

INSTALLATION STANDARDS

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NOTES

(1) The number listed in this column indicates that this handbook issue incorporates information from EIB issues up to and including the one shown. In addition to this column entry, a source reference code is inserted immediately following the last line of copy of pertinent articles picked up in EIMB handbooks. The following examples show the coding method used to identify origin of material used:

ORIGIN	CODE
EIB 750	(750)
EIB 13S (Shore Quarterly Supplement)	(13S)
Naval Ship Systems Command Technical News Vol 14, No. 6	(TN14-6)
CEIB 7 (Classified EIB)*	(C7)

*Only articles which have been revised to omit classified data but retain information of value and lasting interest.

(2) This change reserved for Tab Separator Package.

INSTRUCTION SHEET

1. The enclosed material constitutes a complete revision to the INSTALLATION STANDARDS HANDBOOK of the Electronics Installation and Maintenance Book.

2. Remove all existing pages of Sections 1 through 6, and the Front Matter of the Installation Standards Handbook, NAVSHIPS 0967-000-0110, and replace with this package, NAVSEA 0967-LP-000-0110.

3. Check each page of this package against the List of Effective Pages to be sure that all new pages are included. Missing pages should be reported to this office by using the Comment Sheets provided as the last pages of the handbook.

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MILITARY SPECIFICATIONS

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MIL-G-24211	Gaskets, Waveguide Flanges, General Specification for
MIL-C-24301	Cable, Special Purpose, Radio Frequency, Buoyant Type RG-374/U
MIL-P-24441	Paint, Epoxy-Polymide, General Specification for
MIL-C-26482	Connectors, Electric, Circular, Miniature, Quick Disconnect, Environment Resisting, General Specification for
MIL-C-28726	Cable, Special Purpose, Radio Frequency, Buoyant, Type RG-384/U
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MILITARY SPECIFICATIONS

MIL-C-39004	Coupling Assemblies, Quick-Disconnect, General Purpose, for Subminiature Waveguide Flanges, General Specification for
MIL-C-39012	Connectors, Coaxial, Radio Frequency, General Specification for
MIL-C-39024	Connectors, Electrical: Jacks, Tip (Test Point, Panel or Printed Wiring Type), General Specification for
MIL-R-46089	Rubber, Sponge, Silicone, Closed Cell
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MIL-R-46846	Rubber, Synthetic, Heat Shrinkable
MIL-A-55339	Adapters, Connector, Coaxial, Radio Frequency, (Between Series and Within Series), General Specification for
MIL-T-55619	Tools, Crimping, For Coaxial, Radio Frequency, Connectors, General Specification for
MIL-C-81302	Cleaning Compound, Solvent Trichlorotrifluorethane, General Specification for
MIL-C-81511	Connectors, Electrical, Circular, High Density, Quick Disconnect, Environment Resisting; and Accessories, General Specification for
MIL-C-81703	Connectors, Electric, Circular, Miniature, Rack and Panel or Push-Pull Coupling, Environment Resisting; General Specification for
MIL-T-81969	Installing and Removal Tools, Connector Electrical Contact, General Specification for

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FEDERAL SPECIFICATIONS

L-P-387	Plastic Sheet, Laminated, Thermosetting (For Design Plates)
L-P-535	Plastic Sheet (Sheeting); Plastic Strip, Vinyl Chloride Polymer and Vinyl Chloride-Vinyl Acetate Copolymer, Rigid
W-S-570	Soldering Iron, Electric
FF-N-836	Nut: Square, Hexagon, Cap, Slotted, Castellated, Clinch, Knurled, Welding and Single Ball Seat
FF-S-85	Screw, Cap, Slotted and Hexagon Head
FF-S-86	Screw, Cap, Socket-Head
FF-W-84	Washers, Lock (Spring)
FF-W-92	Washers, Metal, Flat (Plain)
FF-W-100	Washers, Lock, Tooth

MILITARY STANDARDS

MIL-STD-12	Abbreviation for use on Drawings and in Technical Type Publications
MIL-STD-130	Identification Marking of U.S. Military Property
MIL-STD-242	Electronic Equipment Parts Selected Standards
MIL-STD-454	Standard General Requirements for Electronic Equipment
MIL-STD-645	Dip Brazing of Aluminum Alloys
MIL-STD-1277	Splices, Clips, Terminals, Terminal Boards, Binding Posts; Electrical
MIL-STD-1310	Shipboard Bonding, Grounding, and Other Techniques for Electromagnetic Compatibility and Safety

MILITARY STANDARDS

MIL-STD-1327	Flanges, Coaxial and Waveguide; and Coupling Assemblies, Selection of
MIL-STD-1353	Electrical Connectors and Associated Hardware, Selection and Use of
MIL-STD-1358	Waveguide, Rectangular, Ridged and Circular, Selection of
MIL-STD-1399	Interface Standards for Shipboard Systems
MIL-STD-1646	Servicing Tools for Electric Contacts and Connections, Selection and Use of
MIL-STD-1680	Installation Criteria for Shipboard Secure Electrical Information Processing Systems
MIL-STD-1683	Connectors and Jacketed Cable, Electric, Selection Standard for Shipboard Use
MS3188	Backshells, 90°, Cable Sealing and Shield Termination Connector, Electric
MS3189	Backshells, 45°, Cable Sealing and Shield Termination Connector, Electric
MS3400	Connectors, Receptacle, Electric, Wall Mounting, Front Release, Crimp Contact, AN Type
MS3401	Connectors, Receptacle, Electric, Cable Connecting, Front Release, Crimp Contact, AN Type
MS3406	Connectors, Plug, Electric, Front Release, Crimp Contact, AN Type
MS3408	Connectors, Plug, Electric, 90° Assembly, Crimp Contact, AN Type
MS3409	Connectors, Plug, Electric, 45° Assembly, Crimp Contact, AN Type

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MS3437	Backshells, Straight, Cable Sealing and Shield Termination, Connector, Electric
MS3480	Tool, Connector Assembly for MIL-C-5015 Connectors
MS3481	Tool, Connector Assembly for MIL-C-26482 Connectors
MS3482	Tool, Connector Assembly for MIL-C-81511 Connectors
MS18297	Cable, Navy, Insulation Resistance
MS90387	Tool, Hand Adjustable, for Plastic Tiedown Straps

NAVSEA DRAWINGS

9000-S6202-73980	Electric Plant Installation Standard Methods
805-1639213	Card Holder
805-1749000	Visible File, Bulkhead Mounted
RE-D2697984	Safety Shorting Probe Fabrication Detail
RE-F2698743	Cable Data Cross Reference
RE-E2699993	Radar Set AN/SPS-48 Series RF Transmission Line Diagram (Elliptical)
5003000	Safety Shorting Probe Set and Stowage Assembly

MILITARY PUBLICATIONS

0900-LP-005-8000	Radio Frequency Radiation Harzards, Technical Manual for
0900-LP-033-0010	Standard and Type Drawing Index
0901-LP-600-0002	Naval Ships Technical Manual Chapter 9600 Electric Plant-General

MILITARY PUBLICATIONS

0902-LP-001-5000	General Specifications for Ships of the United States Navy
0960-LP-000-4000	Standard Electrical Symbol List
0967-LP-000-0100	Electronics Installation and Maintenance Book-General
0967-LP-000 0130	Electronic Installation and Maintenance Book - Test Methods and Practices
0967-LP-034-4010	Index, Electronic Equipment and Systems Installation Control Drawings-Volume 1
0967-LP-034-4020	Index, Electronic Equipment and Systems Installation Control Drawings-Volume 2
0967-LP-034-4030	Index, Electronic Equipment and Systems Installation Control Drawings-Volume 3
0967-LP-177-3010	Communication Antenna Fundamentals, Volume 1
0967-LP-177-3020	Installation Details, Communication Antenna Systems, Volume 2
0967-LP-177-3040	Shipboard Antenna Systems, Testing and Maintenance, Communication Antenna Systems, Volume 4
0967-LP-177-3050	Shipboard Antenna Systems, Antenna Data Sheets, Volume 5
0967-LP-317-7010	Radio Frequency Burn Hazard Reduction, Technical Manual for
0981-LP-052-8090	Cable Comparison Guide
MIL-HDBK-216	RF Transmission Lines and Fittings
MIL-HDBK-660	Fabrication of Rigid Waveguide Assemblies (Sweep Bends and Twists)

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MILITARY PUBLICATIONS

DDS304-2	Electrical Cables, Ratings and Characteristics

OTHER PUBLICATIONS

ANSI 235.1	Specifications for Accident Prevention Signs

PREFACE

POLICY AND PURPOSE

The Electronics Installation and Maintenance Book (EIMB) was established as the medium for collecting, publishing, and distributing, in one convenient source document, those subordinate maintenance and repair policies, installation practices, and overall electronic equipment and material-handling procedures required to implement the major policies set forth in Chapter 400 of the Naval Ships' Technical Manual. All data contained within the EIMB derive their authority from Chapter 400 of the Naval Ships' Technical Manual, as established in accordance with Article 1201, U.S. Navy Regulations.

Since its inception the EIMB has been expanded to include selected information of general interest to electronic installation and maintenance personnel. These items are such as would generally be contained in textbooks, periodicals, or technical papers, and form (along with the information cited above) a comprehensive reference document. In application, the EIMB is to be used for information and guidance by all military and civilian personnel involved in the installation, maintenance, and repair of electronic equipment under cognizance, or technical control, of the Naval Sea Systems Command (NAVSEA). The information, instructions, and procedures, in the EIMB supplement instructions and data supplied in equipment technical manuals and other approved maintenance publications.

INFORMATION SOURCES

Periodic revisions are made to provide the best current data in the EIMB and keep abreast of new developments. In doing this, many source documents are researched to obtain pertinent information. Some of these sources include the Electronics Information Bulletin (EIB), the NAVSEA Journal, electronics and other textbooks, industry magazines and periodicals, and various military installation and maintenance-related publications. In certain cases, NAVSEA publications have been incorporated into the EIMB in their entirety and, as a result, have been cancelled. A list of the documents which have been superseded by the EIMB and are no longer available is given in Section 1 of the General Handbook.

ORGANIZATION

The EIMB is organized into a series of handbooks to afford maximum flexibility and ease in handling. The handbooks are stocked and issued as separate items so that individual handbooks may be obtained as needed.

The handbooks fall within two categories: general information handbooks, and equipment-oriented handbooks. The general information handbooks contain data which are of interest to all personnel involved in installation and maintenance, regardless of their equipment specialty. The titles of the various general information handbooks give an overall idea of their data content; the General Handbook includes more complete descriptions of each handbook.

The equipment handbooks are devoted to information about particular classes of equipment. They include general test procedures, adjustments, general servicing information, and field change identification data.

All handbooks of the series are listed below with their NAVSEA numbers. The NAVSEA numbers serve also as the stock numbers to be used on any requisitions submitted.

HANDBOOK TITLE	NAVSEA NUMBER
EIMB General Information Handbooks	
General	0967-LP-000-0100
Installation Standards	0967-LP-000-0110
Electronic Circuits	0967-LP-000-0120
Test Methods & Practices	0967-LP-000-0130
Reference Data	0967-LP-000-0140
EMI Reduction	0967-LP-000-0150
General Maintenance	0967-LP-000-0160
EIMB Equipment-Oriented Handbooks	
Communications	0967-LP-000-0010
Radar	0967-LP-000-0020
Sonar	0967-LP-000-0030
Test Equipment	0967-LP-000-0040
Radiac	0967-LP-000-0050
Countermeasures	0967-LP-000-0070

PREFACE

DISTRIBUTION

Initial Set: An "AF" Restriction Code has been assigned to NAVSEA 0967-LP-000-0000 to control the over-requisitioning of the EIMB Series. Fleet and shore activities requiring an initial set of the EIMB Series (13 handbooks with all changes and heavy-duty binders) should submit their requisition (DD Form 1348 with written justification) through their Supply Officer or area, for issue approval to:

Naval Publications & Printing Service
Code SC, Building 157-3
Washington Navy Yard
Washington, D.C. 20374

or

Commander
Naval Ship Engineering Center
SEC 6181C03
Washington, D.C. 20362

Use the following data on the DD-1348,

Block A - 288 NAVPUBFORMCEN PHILA
Stock No. - 0967-LP-000-0000
Unit of Issue - SE
Fund - 00

All other blocks are to be filled in as normally done by the requisitioner when ordering publications.

Changes and Revisions: The EIMB is continuously being updated. For efficiency these changes and revisions are automatically distributed to using activities who are on the Automatic Distribution List for the EIMB.

Requests and/or changes to the EIMB Automatic Distribution List and any problems in requisitioning should be directed to:

Commander
Naval Ship Engineering Center
SEC 6181C03
Washington, D.C. 20362

Individual Handbooks: To order individual handbooks and changes, use the stock numbers listed in the Box Score on page ii. Using the stock number for the "BASIC" provides the handbook (with vinyl cover) and all applicable changes.

SUGGESTIONS / CORRECTIONS

NAVSEA recognizes that users of the EIMB will have occasion to offer corrections or suggestions. To encourage more active participation, a pre-addressed comment sheet is provided in the back of each handbook change. Complete information should be given when preparing suggestions. Suggestors are encouraged to include their names and addresses so that clarifying correspondence can be initiated when necessary. Such correspondence will be by letter directly to the individual concerned.

If a comment sheet is not available, or if correspondence is lengthy, corrections or suggestions should be directed to the following:

Commander
Naval Ship Engineering Center
SEC 6181C03
Washington, D.C. 20362

SECTION 1
GENERAL

SECTION 1
GENERAL

1-1 PURPOSE

The purpose of the Installation Standards Handbook is to provide guidance and instructions pertinent to the proper installation of electronic equipments and systems aboard Naval ships. This handbook is published for the guidance of all personnel, military activities and private industry responsible for or engaged in the installation of electronic equipments and systems.

1-2 SCOPE

The information contained in the Installation Standards Handbook has been carefully selected and arranged so that it is easily identified and retrieved. To ensure current and correct information is always available to the user of this handbook, the referencing of appropriate documents and publications is utilized where practicable in lieu of reproducing data from existing documents.

The handbook consists of the following:

Section 1	General
Section 2	Cable Information
Section 3	Special Purpose Equipment
Section 4	Antennas
Section 5	Radio Frequency Transmission Lines (Waveguides and Rigid Coaxial)
Section 6	Equipment Installation

1-3 USE AND APPLICATION

When properly used, the Installation Standards Handbook is a quick and convenient source of information for shipboard installation of electronics equipments and systems. The design, procurement, fabrication, procedures and methods required to properly install electronic equipment encompass a large number of specifications, standards, handbooks, publications and drawings. Through the compilation of data not covered by these documents and the referencing of these documents in the appropriate text the Installation Standards Handbook becomes a single vital instrument that should be used by every individual, military activity, or commercial enterprise involved with Naval shipboard electronic installations. For this handbook to be complete, the Installing Activity should maintain a repository of the referenced documents. The Installing Activity should ensure the referenced documents are kept updated and are the correct revision referenced by a specific contract.

1-4 DEFINITIONS

The definition of words, terms and phrases can vary depending upon the document subject, context, and connotation. To assist the user in understanding this document, the following definitions shall apply.

1-4.1 INSTALLING ACTIVITY/ INSTALLER

Installing Activity and/or Installer is defined as any military, commercial or industrial establishment or individual involved with electronic equipment/systems installations aboard Naval ships.

1-4.2 INSTALL/INSTALLING/ INSTALLATION

The words "install", "installing" and "installation" as used in this document includes whatever design, procurement, fabrication, material handling, labor, material mounting/fastening, inspection, testing, repair, maintenance and etc. that is required to install and make operational any electronic equipment/system aboard Naval ships.

1-4.3 INTERCONNECTING CABLE/S

The term "interconnecting cable/s" as used in the Installation Standards Handbook shall mean any jacketed (single and multiconductor) cable, both electrical and radio frequency, that is used to electrically interface any two separately enclosed electrical/electronic units including terminal and distribution boxes.

1-4.4 INSTALLATION CONTROL DRAWINGS (ICDs)

Installation Control Drawings (normally called ICDs) are Department of the Navy drawings that provide shipboard installation data for electronic equipment and/or systems.

1-4.5 AUTHORIZED APPROVAL

The term "Authorized Approval" as used in the Installation Standards Handbook shall mean that when required written approval shall be obtained, through proper government channels, from the cognizant Navy Department Command, Center, Activity, Office or Division.

1-4.6 ENCLOSURE

The word "enclosure" as used in this document shall mean any equipment cabinet or case, connection box, distribution panel or box, switch box, jack box, console, radio or radar or NTDS switchboard, transfer panel, control panel, and any other device used in electronic systems aboard Navy ships.

1-5 PRECEDENCE

Conflicting statements between the Installation Standards Handbook and any document referenced herein shall be resolved by appropriate Government authority with NAVSEA 0902-LP-001-5000, General Specifications for Ships of the United States Navy, taking precedence over all other documents where applicable.

1-6 SAFETY

Safety is a subject about which many documents have been written, and since the purpose of the Installation Standards Handbook is to cover requirements, methods and procedures for the installing of electronic equipment aboard Naval ships, the safety information contained herein is limited to general topics that assist the installer in accomplishing the installation task in a safe manner in addition to providing a shipboard installation that meets safety requirements for Navy operating and maintenance personnel.

1-6.1 PERSONNEL SAFETY

Ensure that prescribed safety precautions applicable to a specific installation task are understood and strictly enforced.

It is the individual's responsibility to himself and his fellow worker to adhere to the safety precautions prescribed by the parent organization.

1-6.2 INSTALLATION SAFETY REQUIREMENTS

To ensure a safe environment for operational and maintenance personnel, the Installing Activity shall comply with the following requirements.

(a) Electronic equipment installed aboard Naval ships shall comply with MIL-STD-454, requirement 1.

(b) Materials and procedures required in the installation of electronic equipment aboard Naval ships shall comply with the requirements of NAVSEA 0967-LP-000-0100 Section 3 and the specific ship specifications.

(c) Grounding of electronic equipment, including cabling, installed aboard Naval ships shall comply with the requirements of MIL-STD-1310.

(d) Safety warning and instruction signs shall be installed in areas containing electronic equipment in accordance with the requirements of NAVSEA 0967-LP-000-0100, Section 3 and the specific ships specifications.

(e) Portable electronic equipment received with ungrounded two contact cable assemblies shall be modified for a grounded three-contact cable assembly in accordance with MIL-C-28777.

1-7 WORKMANSHIP

Workmanship shall be first class in every respect and shall be in accordance with the applicable requirements stated throughout the Installation Standards Handbook, ships specifications, applicable instructions promulgated for electronic equipment and ancillary components, quality assurance manuals, and the following general requirements.

1-7.1 SKILLS

All personnel involved with a specific installation shall be properly trained and capable of accomplishing the functions of their respective skills.

1-7.2 EQUIPMENT AND MATERIAL PROTECTION

Equipment and materials required for a specific installation shall be protected from possible damage that could be caused by careless handling and storage, bad housekeeping, congested work areas and exposure to undesirable environmental conditions.

1-7.3 GOOD HOUSEKEEPING PRACTICES

Good housekeeping shall be practiced at all times during the installation process.

The interior of equipment shall be kept free of dust, dirt, grime, moisture, and foreign objects that could be caused by chipping, welding, grinding, torch brazing or burning, painting and similar work functions encountered during ship construction, repair, overhaul or alterations.

After the shipboard installation is complete, the Installing Activity shall ensure that all units are thoroughly cleaned internally and externally, and the external finish, if damaged, is repaired to a condition comparable to the original finish.

1-8 GOVERNMENT DRAWINGS

The list of government drawings relative to shipboard electronic installations has become too extensive to continue listing in this document. Information concerning the source and indexes of these drawings is covered in the following subparagraphs.

1-8.1 INSTALLATION CONTROL DRAWINGS

The Installation Control Drawing Index consists of three volumes. Volume 1, NAVSEA 0967-LP-034-4010 provides a complete listing of all available ICDs and is published semi-annually with update supplements distributed monthly. Volume 1 lists the drawings both alphanumerically by nomenclature and numerically by the "RE" number. Volume 2, NAVSEA 0967-LP-034-4020, provides a cross reference between old drawings numbers to new drawing numbers. Volume 3, NAVSEA 0967-LP-034-4030 consists of a listing of mono detail drawings arranged both alphanumerically by nomenclature and numerically by drawing number.

Requests for Index copies should be addressed to Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120 for action.

Information for requesting copies of ICDs is contained in Volume 1, NAVSEA 0967-LP-034-4010.

1-8.2 STANDARD AND TYPE DRAWINGS

The Standard and Type Drawing Index, NAVSEA 0900-LP-033-0010 provides a complete listing of available standard and type drawings and is published annually. The index is in three sections, mechanical, hull, and electrical. The drawings within each section are listed alphabetically by title and numerically by NAVSEA drawing number and revision symbol.

Requests for index copies shall be addressed to Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120, for action.

Information for requesting copies of drawings is contained in the notes of NAVSEA 0900-LP-033-0010.

1-9 QUALITY ASSURANCE

The Installing Activity shall be responsible for implementing a quality assurance program that will ensure the following:

1-9.1 EQUIPMENT AND MATERIAL

Government furnished equipment and material required for shipboard electronic installations will be:

1. Protected from weather and physical damage during storage and handling.
2. Equipment and material installed is that which is called for by ships specifications, and applicable documents.
3. Equipment and material is installed in accordance with ships specification and applicable documents.
4. The completed installation is operational in accordance with ships specification and applicable documents.

1-9.2 TOOLS AND PLANT EQUIPMENT

Tools and plant equipment required for the installation of shipboard electronic systems are to be:

1. Maintained in good working condition at all times.
2. Tested and calibrated where applicable.
3. Appropriately used and applicable to the intended function.

1-9.3 PERSONNEL

Personnel are to be trained in the use and application of all tools, plant equipment, methods and procedures required for the installation of electronic systems aboard Navy ships.

SECTION 2
CABLE,FLEXIBLE AND SEMI-RIGID

SECTION 2
CABLE, FLEXIBLE AND SEMI-RIGID

2-1 INTRODUCTION

The effectiveness of an electronic system is dependent on many factors. Circuit design, durability of the equipment in its environment, suitable location of the components and proper installation of the interconnecting cables are but a few of these factors. One of the most critical of these factors is the installation of interconnecting cables which involves cable handling, hanging, structural penetrations, terminations, connector attachments and proper shielding where applicable. A good installation of interconnecting cables giving a high degree of reliability can be accomplished with proper planning guidance, the use of correct materials and tools and a desire to give good workmanship

2-2 SCOPE

This section describes, illustrates, and references data, handbooks, standards and specifications for approved materials and methods required for the installation of interconnecting cables used in shipboard electronic systems. Included in this section is data for coaxial cables and coaxial connectors. Fabrication and installation of rectangular waveguide, rigid coaxial lines and elliptical waveguide components are covered in section 5 of this document.

2-3 CABLE SELECTION

Cables for use in shipboard electronic installations shall be selected in accordance with MIL-STD-242 and comply with the requirements stated herein. Cables referenced in ICD's, ShipAlts, Guidance plans, Technical Manuals, and ship installation drawings shall not be replaced with substitute cables without authorized approval.

2-3.1 ELECTRICAL CABLES

Electrical cables required for power, lighting, control, communications, instrumentation and electronic application shall comply with Military Specification MIL-C-915.

2-3.2 PORTABLE POWER AND CONTROL CABLES

Portable power and control cables shall comply with Military Specification MIL-C-3432. Power cable assemblies for use with portable test equipment requiring 125VDC or 125VAC shall comply with Military Specification MIL-C-28777.

2-3.3 COAXIAL CABLES, FLEXIBLE AND SEMI-RIGID

Coaxial cables required for radio frequency application shall comply with the following military specifications:

1. MIL-C-17 for flexible and semi-rigid coaxial cables.
2. MIL-C-22931 for semi-rigid, semi-air-dielectric coaxial cables.
3. MIL-C-23806 for semi-rigid, foam filled dielectric coaxial cables.
4. MIL-C-23020 coaxial cables for submarine use.
5. MIL-C-22667 , MIL-C-24301 and MIL-C-28726 for Buoyant cable applications.

2-3.4 CABLE TYPE AND SIZE

The type and size of cables used in shipboard electronic installations shall be as follows:

(a) Navy cable types and sizes shall be as shown on ICDs. Deviation from cable types and sizes shown on ICDs can be made only with authorized approval from the cognizant equipment activity. Where electrical cables classed as discontinued and/or obsolete are shown on ICDs, the current replacement cable type shown on Installation Control Drawing RE-F2698743 or MIL-HDBK-216 shall be used.

(b) NAVSEA 0981-LP-052-8090 and DDS304-2 shall be used for guidance where the Installing Activity design section is responsible for determining the correct electrical cable type and size to be used in a specific installation.

(c) MIL-STD-242 and MIL-HDBK-216 shall be used for guidance where the Installing Activity design section is responsible for determining the correct RF coaxial cable type and size to be used in a specific installation.

(d) Jacketed cables without metal armor shall be used in electronic installations aboard Naval ships. Armored cables may be used where there is no equivalent cables of the unarmored type.

(e) Electrical cable types shall be selected in accordance with the intended application such as power and lighting, control, or electronic, communication and instrumentation. NAVSEA 0981-LP-052-8090 shall be used for guidance in selecting the correct type cable for a specific application.

(f) Electrical cable types shall be selected in accordance with the intended service such as non-flexing service or repeated flexing service. NAVSEA 0981-LP-052-8090 shall be used for guidance in

selecting the correct type cable for a specific service.

(g) Electrical cables are classified as either watertight or nonwatertight. The nonwatertight cables may be used for applications within a watertight compartment and noncritical areas above the ship watertightness level. NAVSEA 0981-LP-052-8090 shall be used for guidance in determining which cables are watertight or nonwatertight.

(h) The ambient temperature a cable will experience in a shipboard installation will determine if a high temperature cable is required. Where possible cables shall be routed around high heat areas. Where electrical cables must pass through a high temperature area, NAVSEA 0981-LP-052-8090 may be used for determining the correct cable type and conductor size for use in an area whose ambient temperature does not exceed 50° Celsius. For ambient temperatures of either 60° Celsius or 70° Celsius the ampacity derating factors shown in Table 3 of DDS304-2 shall be used for determining the correct cable type and size for a specific installation. Where RF coaxial cables must pass through a high temperature area, MIL-STD-242 and MIL-HDBK-216 shall be used for guidance in the selection of the correct high temperature cable for a specific installation.

(i) The ampacity of a specific cable shall not exceed the values given in NAVSEA 0981-LP-053-8090. Conductors in multiconductor cables shall not be paralleled to obtain current carrying capacity. Conductors in multiconductor cables may be paralleled to meet the voltage drop limitations. The allowable voltage drop for multiconductor cables used for interconnecting various units of electronic equipment shall conform with circuit requirements.

(j) The requirement for shielded conductors or shielded cables is controlled by the type of information to be carried in the cable conductors. The appropriate ICDs and MIL-STD-1680 shall be referred to for specific information regarding which circuits require shielding.

(k) The interface characteristics of cables, connectors, equipment cable entrance areas, and equipment electrical terminal connections shall be considered when selecting cables for shipboard electronics installations. The compatibility between cables and equipment shall be such that a high degree of reliability is maintained during a ships normal operational period.

(l) Characteristic impedance, capacitance, frequency, maximum operating voltages, VSWR, attenuation, type of dielectric, type of outer conductor and type of approved connectors are critical factors that shall be considered in selecting an RF coaxial cable that will correctly interface electronic equipments. MIL-STD-242, MIL-HDBK-216 and coaxial cable specification sheets shall be referred to for technical information to assist in selecting the correct flexible coaxial or semi-rigid coaxial cable for a specific installation.

(m) Semi-rigid coaxial cable shall include jacketed outer conductors.

2-4 CABLE STORAGE

Cable shall be stored in a dry place, which is not subject to accidental flooding, protected from the weather, and subjected to a minimum variation of temperature. Flammable materials and chemicals shall not be stored in the same area with cables.

Coaxial cables shall be stored in an area where the ambient temperature is less than 66° Celsius. If the cable is exposed to higher temperature, the attenuation and VSWR shall be tested in accordance with MIL-C-17 prior to installation. If the attenuation exceeds the maximum value shown on the specification sheet, the cable shall be rejected.

Cables that have been in storage for a prolonged period may be installed provided a visual inspection shows that it has sustained no mechanical damage that would impair the watertight integrity of its outer sheath.

Cables, especially coaxial, shall be stored so that damaging pressure is not applied. Cables should be stored on reels whenever possible. Cable shall not be stored by hanging on hooks, dowels, or pegs.

When cables are stored or set aside for installation, the ends of the cable shall be sealed against moisture absorption by one of the cable end sealing methods shown on NAVSEA Drawing Number 9000-S6202-73980, preferably method 4934 using heat shrinkable rubber end caps.

Sealing cable ends may be omitted when the interval between cutting a length of cable and the termination made to connectors or equipment is 48 hours or less, and the exposed ends are not subjected to moisture during excessive temperature changes.

Transfer of cables from a cold to a warm, high humidity location, which would cause moisture absorption, shall be avoided.

2-5 CABLE HANDLING

The handling of cable is just as important to a good shipboard installation as any other phase of the overall installation.

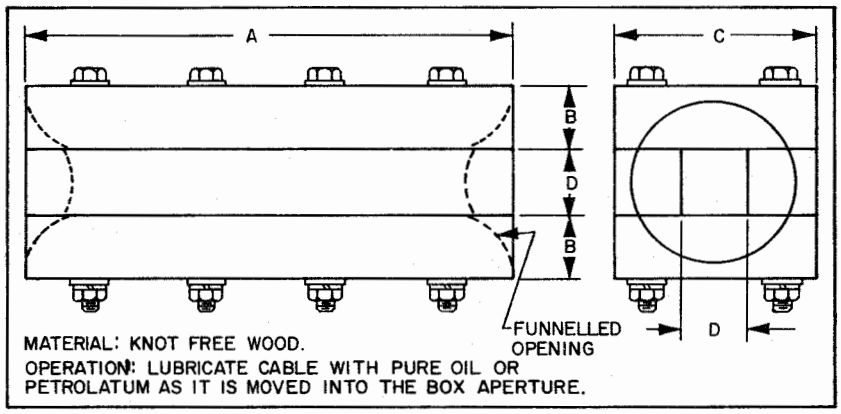
When handling cables, both before and during installation, avoid abrasion, crushing, twisting or kinking. Twisting or kinking is most likely to occur when a cable is removed from a reel or unwound from a coil.

The use of block and tackle, chain falls, or other mechanical devices to pull interconnecting cables or coaxial cables in electronic installations

shall be prohibited. Cables shall not be left laying on decks where they are subjected to damage. Cables and cable ends shall be kept coiled and suspended above the deck until installation can be completed.

Special care shall be given to the handling of coaxial cables in order to comply with the above requirements. Kinks, twists, sharp bends, stretching by applying excessive pressure to pull-in, crushing caused by being walked on or other heavy objects can easily change the dimensions of the dielectric in a coaxial cable. This in turn changes the characteristic impedance of the cable at the damaged area causing increased VSWR and signal loss during system operation.

A straightening device similar to that shown in Figure 2-1 shall be used for straightening semi-rigid coaxial cable as it is removed from a shipping/storage reel. Figure 2-2 illustrates the use of a straightening device on semi-rigid cable.



DIMENSIONS IN INCHES

APPLICABLE CABLE RG-NUMBER	CABLE STRAIGHTENING BOX DIMENSIONS			
	A	B	C	D
237, 245, 253, 331 335, 385, 399	12	2	4	0.687
232, 247, 318 306, 333, 360	24	2	4	1.187
233, 258, 319, 378	40	2	6	2.125
234, 251, 322	60	2	8	3.375

Figure 2-1. Typical Semi-rigid Cable Straightening Device

2-6 CABLE BENDS

Cables may be easily damaged during installation by careless shaping or forming that could result in an unreliable operational system.

Cables shall be formed in a sweep bend and should be made over a mandrel, if practicable. Bends at terminal entrances, where stuffing tubes are required, shall be made via angle stuffing tubes. Straight stuffing tubes may be used in place of angle stuffing tubes if the bend in the cable is not less than the minimum bend radius specified for that cable.

The minimum bend radius for electrical cable shall be as specified in DDS304-2 or NAVSEA 0981-LP-052-8090.

The minimum bend radius for flexible coaxial cables shall be 10 times the cable diameter, except when the cable is subject to repeated flexure; in which case, the minimum bend radius shall be 20 times the cable diameter.

Although these coaxial cables are called flexible coaxial cables, they are not designed primarily for continuous flexure or twisting. If a limited degree of flexure is necessary, the cable should be installed so that the radius of bend changes in one direction only, rather than undergoing a reversal.

Bends and offsets in semi-rigid coaxial cables

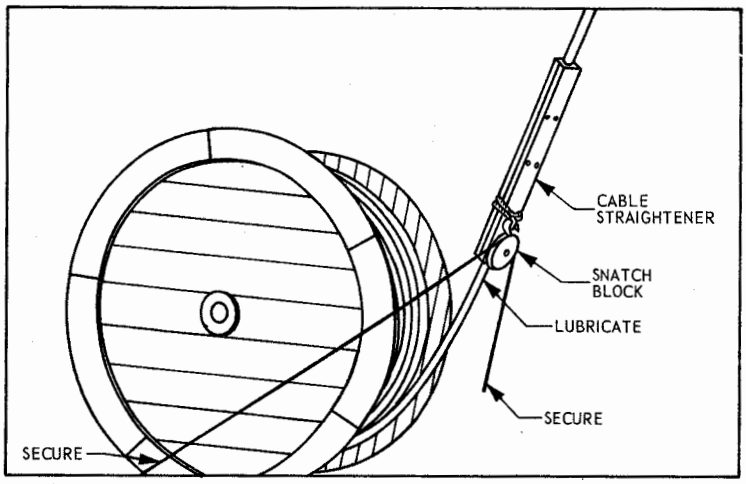


Figure 2-2. Simplified Rigging for Semi-rigid Cable Straightening Device

shall have the largest curvature possible. Bends and offsets shall be formed with a mandrel capable of providing a smooth bend without ripples or ridges appearing in the outer conductor. The inside bend radius shall be not less than those listed in the following table for semi-rigid coaxial cables.

Nominal Cable O.D.	Min. bend radius
0.375	4 inches
0.500	5 inches
0.875	10 inches
1.625	25 inches
3.125	50 inches

2-7 CABLE PROTECTION

Interconnecting cables shall be properly protected, mechanically and electrically, by approved protective materials and methods in those cases where possible damage of any type is apparent or suspected.

Coaxial cables installed on masts, in the beam pattern of radars operating in the 200 MHz-450 MHz range, shall be shielded from radiation in accordance with the requirements of MIL-STD-1310.

2-8 CABLE TESTING

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).

2-8.1 VISUAL INSPECTION

Cables shall be visually inspected for signs of physical damage and dampness prior to shipboard installation. Cable showing signs of physical damage shall not be installed. Cables that have been subjected to dampness shall, prior to installation, receive an insulation resistance test in accordance with paragraph 2-8.3 of this document. Cables that cannot be brought to the minimum acceptable insulation resistance values shall be rejected.

Cables shall be visually inspected for physical damage after shipboard installation is completed. 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.

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 of the new cable.

2-8.2 CONTINUITY CHECKS

Continuity checks shall be made on all conductors in all cables after the installation is completed including the attachment of connectors and/or terminal lugs. This is to certify that there are no open or shorted conductors inside the cable sheath and that the connectors are correctely terminated and identified.

2-8.3 INSULATION RESISTANCE TESTS

NAVSEA 0901-LP-000-0002, Chapter 9600, may be used as a guide for methods of conducting insulation resistance tests on all cables in accordance

with the following categories:

2-8.3.1 Power, Lighting and Control Cables

Insulation resistance measurements for power, lighting and control cables used in electronic installations shall be made between each conductor and all other conductors of the same cable, and between each conductor and ground. Minimum insulation resistance values shall be determined from Military Standard MS-18297.

2-8.3.2 Multiconductor Cables

Insulation resistance measurements for multiconductor cables with conductors of less than 1700 circular mil area in size shall be made between each conductor and all other conductors of the same cable, and between each conductor and ground. These cables include twisted pair, triads, shielded and unshielded, that are normally used in interior communications and instrumentation systems. The minimum insulation resistance values for these cables shall be 50,000 ohms.

2-8.3.3 Coaxial Cables

Insulation resistance tests shall be made on coaxial cables prior to shipboard 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.

Acceptable insulation resistance values for cables with polyethylene or polytetrafluorethylene (Teflon) dielectric shall equal or exceed the following:

Length (feet)	Insulation resistance (megohms)
100 (or less)	40,000
200	20,000
500	8,000
1,000	4,000

Insulation resistance values of coaxial cables with synthetic rubber dielectric shall equal or exceed 1,000 megohms for lengths up to 1,000 feet.

Insulation resistance values of cables with dielectric material arranged in layers of conducting and non-conducting rubber shall equal or exceed 500 megohms for lengths up to 1,000 feet.

Insulation resistance values of cables with magnesium oxide dielectric shall equal or exceed 10,000 megohms for lengths up to 1,000 feet.

Cables not meeting the minimum insulation resistance values shall be replaced.

2-8.3.4 Moisture Absorption

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.

2-8.4 ATTENUATION AND VOLTAGE STANDING-WAVE-RATIO MEASUREMENTS

Attenuation and 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 0967-LP-000-0130 may be used for test methods and guidance for testing of coaxial cables. Technical data is available in MIL-HDBK-216 in addition to the coaxial cable general specifications.

2-9 CABLE CLASSIFICATION

All shipboard cables are classified as to their construction, service and application to ensure an optimum installation and still maintain the ships structural integrity. To assist the installer in selecting the correct cables, the different classifications are discussed in the following subparagraphs.

2-9.1 CONSTRUCTION

The construction of shipboard cables is classified as either watertight or nonwatertight. Nonwatertight cables may be used for runs that are either totally within one compartment or totally within two contiguous compartments. In either case nonwatertight cable shall not be used where a watertight deck or watertight bulkhead below Flooding Water Level II, is penetrated.

2-9.2 SERVICE

The service of shipboard cables is classified as either flexing or nonflexing. Nonflexing cables are used for interconnecting permanently installed equipment, such as consoles, transmitters, receivers, panels, junction boxes and switchboards. Cables for flexing service are used for connection to portable equipment, or to permanently installed equipment where cables are required to withstand repeated flexing or twisting, such as rotating directors, gun mounts, or missile launchers.

2-9.3 APPLICATION

Shipboard cables are classified in three general application groups; power and lighting circuits, control circuits, and communications, instrumentation and electronic circuits.

2-9.4 COAXIAL CABLES

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. MIL-STD-242 and MIL-HDBK-216 shall be used for guidance in determining the correct coaxial cable for a specific installation.

The three basic types of flexible coaxial cables are single conductor, two conductor and triaxial. Construction of typical coaxial cables of each type are shown in Figures 2-3, 2-4, and 2-5 with identification of individual components.

Figure 2-6 through Figure 2-9 shows how the different types of semi-rigid coaxial cables are constructed. It is readily observed that any distortion in the outer conductor of these cables will change its characteristic impedance resulting in an operational degradation of the cable.

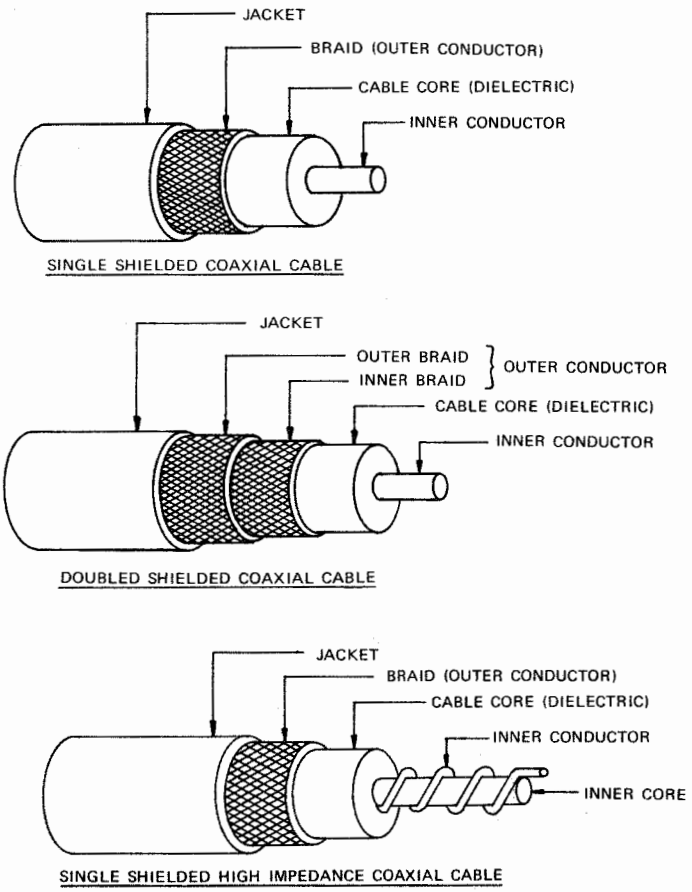


Figure 2-3. Typical Flexible Coaxial Cable Construction

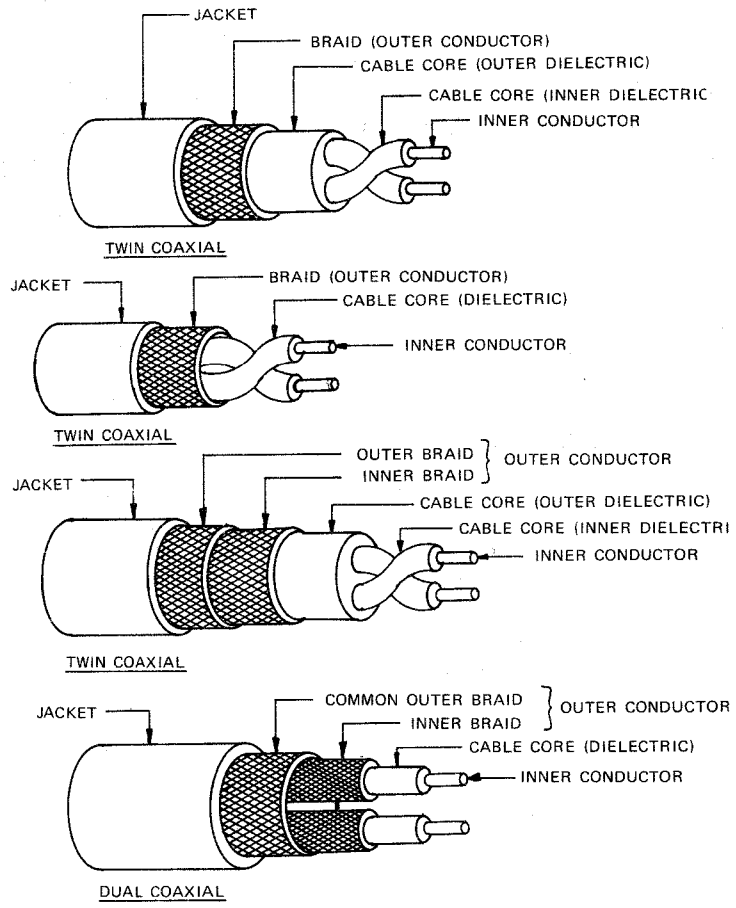


Figure 2-4. Typical Flexible Two-Conductor Coaxial Cable Construction

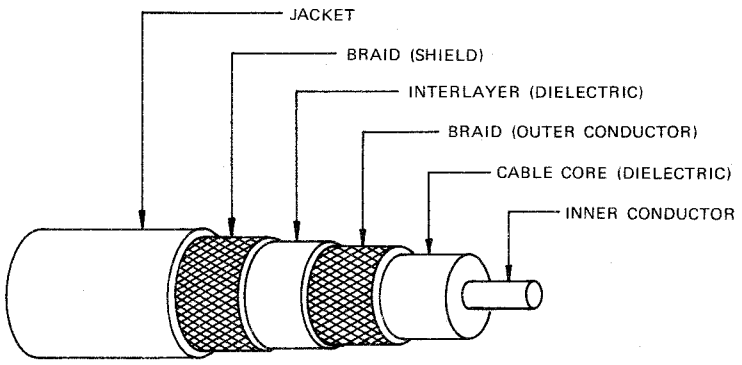


Figure 2-5. Typical Flexible Triaxial Cable Construction

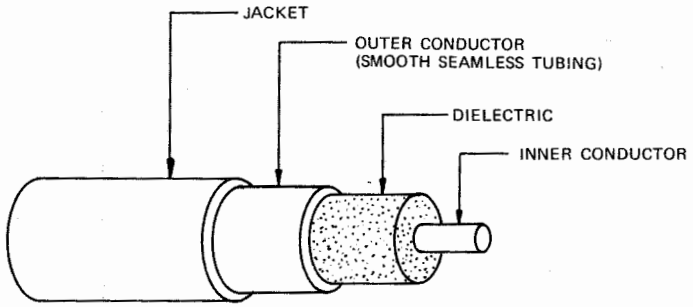


Figure 2-6. Typical Semi-rigid Foam Dielectric Coaxial Cable Construction

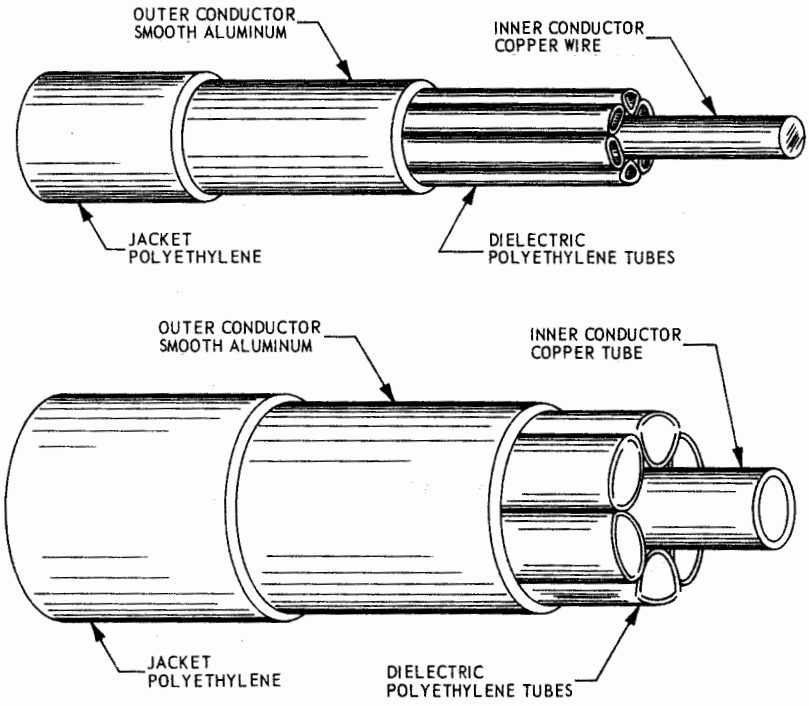


Figure 2-7. Typical Semi-rigid Semi-air-dielectric (Plastic Tubes) Coaxial Cable Construction

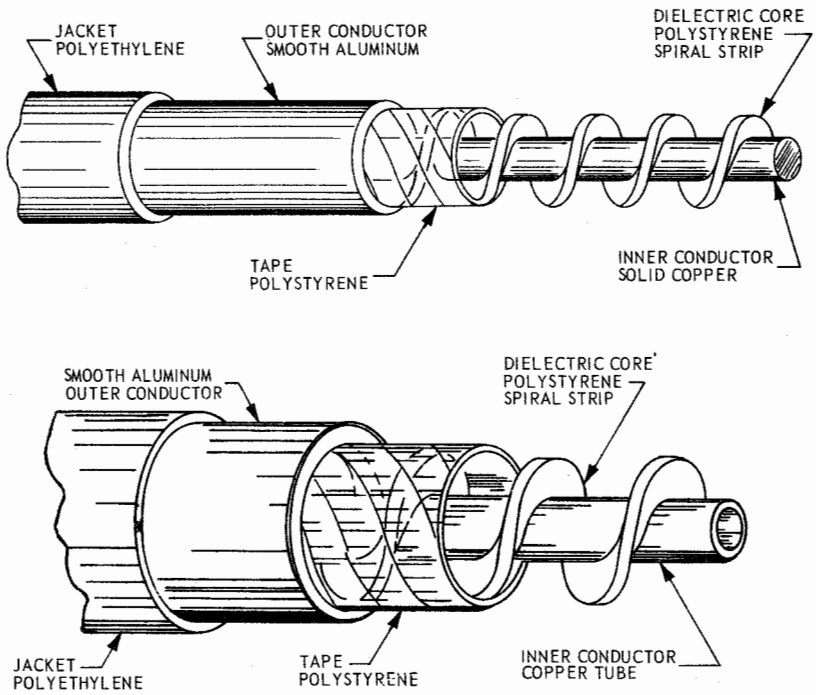


Figure 2-8. Typical Semi-rigid Semi-air-dielectric (Spiral Strip) Coaxial Cable Construction

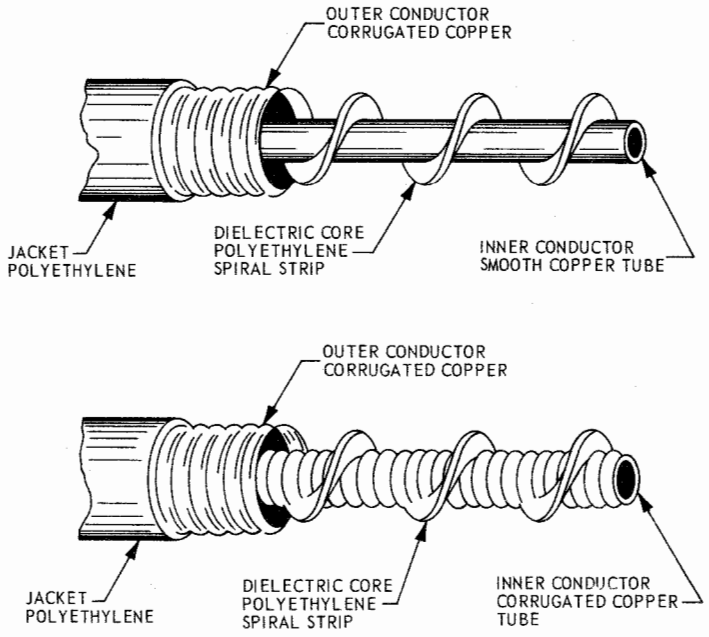


Figure 2-9. Typical Semi-rigid Semi-air-dielectric (Spiral Strip) Coaxial Cable Construction Utilizing Corrugated Tubes

2-10 CABLE ROUTING/GROUPING/ SPACING

It is necessary during the planning stage and throughout the installation, to route, group, space, segregate and isolate the cables in categories to provide proper protection and operation of cables and circuits comprising the electronics system.

For routing, grouping and spacing of electrical and coaxial cables used in electronic installations, the methods of NAVSEA drawing 9000-S6202-73980 and the following general guidelines shall apply:

1. Locate and arrange cables to permit maximum heat dissipation.
2. Spaces harmful to cable or subject to explosion hazards shall be avoided.
3. Locate cableways so that cables will not be disturbed by disassembly or removal of machinery or equipment.
4. Cables not associated with an equipment shall not be fastened to electronic equipment cabinets.
5. Route cables so as not to impair the airtightness or watertight integrity of decks or bulkheads.
6. Cable runs shall not be routed across sections of ships structure subject to removal for shipment of machinery or equipment.
7. Cables crossing expansion joints shall have slack allowances at such points at least equal to the maximum movement of the expansion joint.
8. Cables from electronic equipment shall enter cableways in a curve of sufficient radius to prevent transmission of stresses to the equipment during severe cableway deflection.
9. Cables exposed to the weather shall be kept to a minimum.
10. Cables shall be installed so that slack exists to allow for deflection of bulkheads.
11. Cables shall be routed so as to avoid physical and electrical interference with other cables and equipment, and to minimize damage from battle action.
12. Main runs of electronic cable should follow the cable runs of lighting and power installations when possible.
13. Where possible coaxial cables shall be routed so that the overall length is kept to a minimum.
14. Coaxial cable runs near hydraulic fluid piping shall have drip proof shields or other barriers installed for protection from leak damage.
15. Coaxial cables shall be routed on inboard sides of beams or other supporting structures to provide protection from battle damage.
16. Coaxial cables shall not be secured directly to ballistic decks, ballistic bulkheads or shell plating. When crossing such structures is required, the cables shall be secured to beams or supported on hangers.
17. Radar Modulator cables, radio transmitter antenna cables and sonar transducer cables shall be separated at least 18 inches from all other cables except at the area where they enter the equipment. Sonar hydrophone cables shall be separated at least 6 inches from all other cables or installed in flexible conduit.

2-11 STANDARD METHODS FOR CABLING INSTALLATION

Cables required for shipboard electronic systems shall be installed using the appropriate standard methods shown on drawing NAVSEA No. 9000-S6202-73980 for the following:

1. Supporting and securing cables to decks and bulkheads.
2. Cable penetration of decks and bulkheads on surface ships.
3. Cable penetration of interior subdivision bulkheads in submarines.
4. Installation of stuffing tubes, multicable transits, and riser boxes.
5. Cables passing through stowage spaces and tanks.
6. Protection of cables against heat, condensation, moisture and mechanical damage.
7. Cable end sealing.
8. Splicing of MIL-C-915 jacketed cable.
9. Preparation of cable ends.

Coaxial cables should be supported by preformed hangers whenever practicable and spaced along the cable to maintain minimum stress and strain on cable and connectors.

As a preventive measure against the spread of fire, all cables penetrating non-airtight and non-fume tight bulkheads shall have sealing compound in accordance with MIL-I-3064 formed in the openings between cables and the bulkhead.

2-12 CABLE SUBSTITUTION/REPLACEMENT

Advances in the state-of-the-art have brought about a considerable change in cable construction and application. This has resulted in cables being classed as obsolete, cancelled, discontinued or no longer required for a specific system or installation. One of the major changes in cable construction is the deletion of armor which is no longer required in shipboard installations. Another major change is the generation of a new family of nonwatertight lower cost cables for applications within watertight compartments and noncritical areas.

NAVSEA 0981-LP-052-8090 and NAVSEA drawing RE-F2698743 shall be used as guidance for substitution or replacement of cancelled, discontinued or obsolete cable types shown on ICDs, ShipAlts, or ships installation plans.

Electrical and dimensional parameters of the replacement cable should be checked for compatibility with the system and terminations before deciding on substitution shown.

2-13 CABLE AND CONDUCTOR IDENTIFICATION

Interconnecting cables, including the individual conductors, shall be identified and marked in accordance with the following.

2-13.1 CABLE TAGS

Cable identification tags shall be installed as close as practicable to each point of termination and on both sides of decks and bulkheads except for the following conditions.

Where through cable runs within a space are direct and traceable such as a vertical run between decks, only one cable tag is required.

Local cable runs within a space that can be easily traced should have only one cable tag.

Additional cable tags shall be installed where necessary for tracing cables through congested areas.

Cable tags shall be of soft aluminum material and secured to the cable with soft aluminum strips as shown in Figure 2-10 or other suitable means to ensure permanent attachment. Where cables are subjected to rough handling, the aluminum securing strip should be reinforced with a wrap of insulation tape.

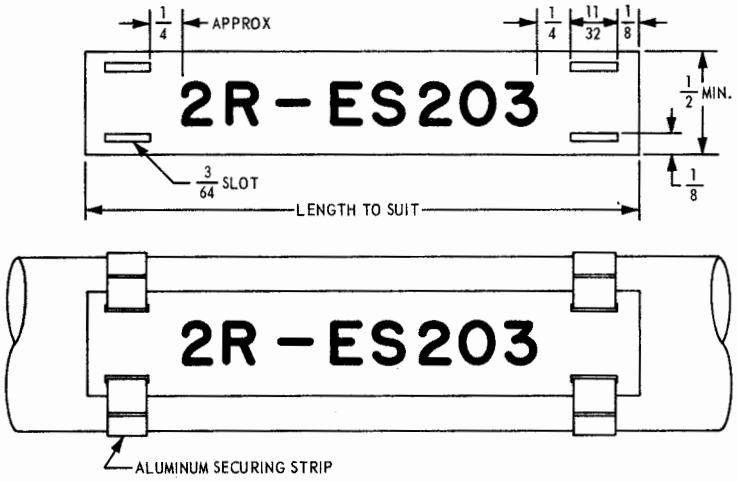


Figure 2-10. Typical Cable Tag

2-13.2 CONNECTOR DESTINATION TAGS

Electronic equipment/system cables that terminate in a connector shall have a tag placed on the cable next to the connector, designating the jack number to which the connector is attached. When cables connect to an antenna, the antenna number and type shall be indicated on the tag located at the equipment end of the cable. Material, tag dimensions and lettering shall be the same as that for cable tags and installed as shown on Figure 2-11.

2-13.3 CIRCUIT OR SYSTEM DESIGNATIONS

Electronic system cables shall be assigned circuit and/or system designations in accordance with the following:

(a) Cables supplying power to electronic equipment shall be designated as specified for power and lighting circuits up to the first unit of electronic equipment or to the receptacle to which the electronic equipment connects. Power cables between units of electronic equipment shall have electronic designations.

(b) Where electronic equipment is energized directly from an interior communication or fire control switchboard, the cable between the switchboard and the electronic equipment shall carry an electronic designation with the cable number preceded by a cipher; for example, R-ES-01, R-ES-02.

(c) Where electronic equipment is energized from an interior communication or fire control switchboard by way of a local cutout switch, the cable between the switchboard and the local switch shall carry an electronic designation with the cable number preceded by an additional cipher; for example, R-ES-001, R-ES-002.

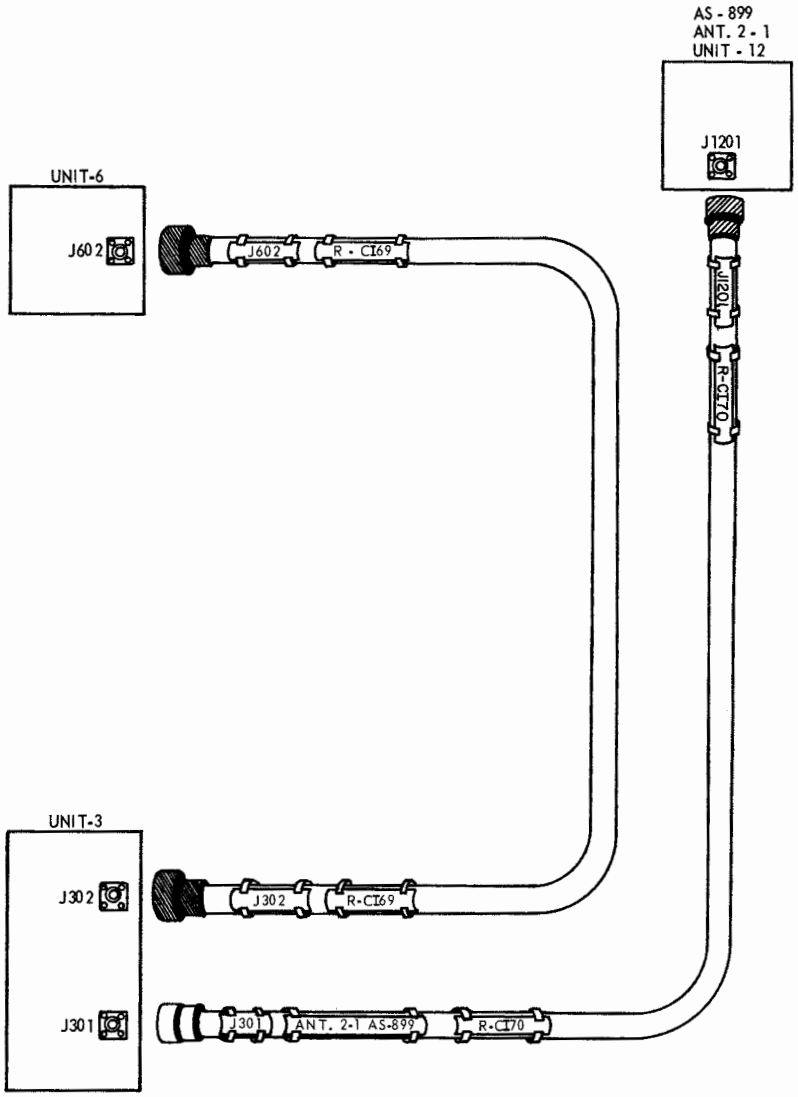


Figure 2-11. Typical Method for Connector and Antenna Cable Identification Tags.

(d) Cables supplying IC, Navigational or Fire Control data to electronic equipment shall be designated as specified for IC, Navigational or Fire Control Circuits up to the first unit of electronic equipment.

(e) Where two or more systems or circuits are installed requiring identical designating letters, differentiating numbers in sequence beginning with the number 1 shall precede the first designating letter; for example 1R-ES4, 2R-ES4.

(f) Circuit or system letter designations shall be selected from the following list:

Meteorological equipments (R-A)

R-AW	Meteorological circuits

Beacons (R-B)

R-BC	Radio beacons
R-BN	Infrared beacons
R-BR	Radar beacons
R-BS	Sonar beacons

Countermeasures (R-C)

R-CI	Electronic countermeasures intercept and analysis
R-CS	Sonar countermeasures systems
R-CT	Electronic countermeasures jamming and deception

Data (R-D)

R-DA	Data, analog
R-DAD	Analog to digital converters
R-DC	Radar and sonar data converters
R-DD	Data, digital
R-DDA	Digital to analog converters
R-DR	Data Display

Radar (R-E)

R-EA	Air search radar
R-EC	Carrier-controlled approach radar
R-ED	Radar identification
R-EE	Air search with height determining capability
R-EF	Height determining radars
R-EG	Guided missile tracking radar
R-EI	Instrumentation radar
R-EM	Mortar locator radar
R-ER	Radar remote indicators
R-ES	Surface search radars
R-ET	Radar trainer
R-EW	Aircraft early warning radar
R-EZ	Three coordinate radar

Weapon control radar (R-F)

R-FB	Guided missile weapon control radar
R-FES	Combined missile and gun control radar
R-FG	Heavy machine gun battery weapon control radar
R-FL	Light machine-gun control radar
R-FM	Surface battery weapon control radar
R-FS	Double purpose battery weapon control radar

Telemetering systems or remote control electronics guidance ((R-G)

R-GA	Telemetry receiver functions
R-GB	Telemetry data reduction systems (analog)
R-GC	Telemetry data reduction systems (digital)
R-GD	Telemetry data reduction systems (combination digital and analog)
R-GE	Telemetry data receive and reduction capability, reduction portion-analog
R-GF	Telemetry data receive and reduction capability, reduction portion-digital
R-GG	Telemetry data receive and reduction capability, reduction portion-analog and digital
R-GM	Electronic guidance remote control or remote telemetering

CW passive tracking equipments (R-H)

R-HA	CW passive tracking

IFF equipments (R-I)

R-IA	IFF used with air search radar
R-IC	Radar recognition
R-IE	Circuits of IFF equipments operating in conjunction with instrumentation radar
R-IF	IFF used with weapons control radar
R-IM	IFF test equipment
R-IR	IFF used with surface search radar
R-IT	IFF transponder circuits
R-IU	IFF used with sonar
R-IZ	IFF used with three coordinate scanning radar

Timing functions (R-K)

R-KT	Precision timing

Automatic vectoring (R-L)

R-LA	Automatic vectoring

Missile support circuits (R-M)

R-MA	Command control equipment
R-MB	Camera systems
R-MC	Missile control
R-MD	Missile tracking
R-MF	Drone control
R-MH	Impact prediction
R-MQ	Target acquisition
R-MT	Drone tracking

Infrared equipment (R-N)

R-NC	Infrared communication
R-ND	Infrared detection
R-NR	Infrared receiving circuits
R-NT	Infrared transmitting circuits
R-NX	Infrared facsimile circuits
R-NY	Infrared teletype circuits

Optical equipment (R-C)

R-OC	Optical communication

Special purpose circuits (R-P)

R-PA	Radiation monitoring
R-PB	Target simulation equipment
R-PC	Trunking cables
R-PD	Radiometric sextant
R-PE	Automatic test and monitor system (for external cable marking, see "T" designator below)

Radio communications (R-R)

R-RA	Radio antenna (including frequency meter extension circuits)
R-RB	Radio entertainment receiving circuits

R-RC	Radio channel selection
R-RD	Radio direction finder circuits
R-RH	Hicapcom
R-RN	Radio navigation
R-RQ	Combination radio receiver and transmitter control circuits (transceiver)
R-RR	Radio receiving circuits including cables between units of a receiver set
R-RS	Radio synchronization
R-RT	Radio transmitter control (including cables between units of a transmitter set)
R-RX	Radio facsimile

Teletype (R-)

R-RY	Radio
R-ISR	IC

Sonar (R-S)

R-SA	Azimuth echo ranging sonar
R-SB	Underwater communications
R-SC	Sonar computing
R-SD	Depth determining equipment
R-SE	Depth charge direction indicator and range estimator
R-SG	Active ranging
R-SH	Sonar hoist-lower control
R-SI	Sonar identification
R-SK	Scanning sonar
R-SL	Listening sonar
R-SM	Sonar monitoring
R-SN	Passive ranging
R-SQ	Combination depth-azimuth sonar
R-SO	Bathythermograph
R-SR	Sonar remote indicator
R-SS	Sounding sonar
R-ST	Attack teacher and sonar trainer
R-SU	Underwater object locator
R-SV	Variable depth sonar
R-SW	Sonar intercept
R-SX	Doppler sonar

Television (R-T)

R-TC	Television, closed circuit
R-TM	Television, monitoring
R-TV	Television, entertainment

(g) Red designated cables shall have the symbol "/Q" added to the circuit or system designation; for example R-RY/Q.

(h) Cables installed between R-PE systems and monitored equipments shall have the symbol "/T" added to the circuit or system designation; for example R-ES/T.

(i) Cables used with experimental circuits, equipments or systems shall have the symbol "/E" added to the circuit or system designation; for example R-ES/E.

2-13.4 CONDUCTOR MARKING

Cables used in electronic circuits shall have identification markers on each conductor at their point of termination. The identification markers (marked sleeving) shall contain marking information in accordance with the following.

(a) The sleeving on each conductor used in electronic systems, other than sonar, shall be marked in the following sequence: (1) the terminal to which the conductor will be connected, (2) the unit and terminal board to which the conductor is connected on the opposite end, (3) the terminal to which the conductor is connected on the opposite end. Each of these designations will be separated by a dash. The order of marking is such that the first appearing set of numbers and letters reading from left to right will be the designation corresponding to the terminal to which the conductor will be connected. The center marking will indicate the unit and terminal board on the opposite end of the conductor and the third group indicates the terminal to which the conductor is connected on the opposite end.

(b) The opposite side of the sleeving shall indicate the cable circuit designation and cable number, for example R-ES10.

Inactive conductors shall have identification markers with "SPARE" stamped on one side and the circuit designation and cable number stamped on the opposite side.

(c) The identification marker shall always be installed with the left hand marking group next to the lug or terminal connection. The sleeving shall be positioned so that it can be easily read without disturbing equipment circuitry. Figures 2-12 through 2-14 are examples of conductor identification (marked sleeving) and cable identification (cable tags).

(d) Conductor marked sleeving for sonar systems shall have the identification marking in accordance with the requirements of MIL-S-21294.

2-13.5 CONDUCTOR COLOR CODING

Color coding of the individual conductors of multiconductor cables (except 3-conductor cables for portable tools and equipment) shall comply with MIL-C-915. NAVSEA 0981-LP-052-8090 may be used for guidance in the determination and assignment of conductor terminations by color code.

Conductor color coding is not applicable to coaxial cables.

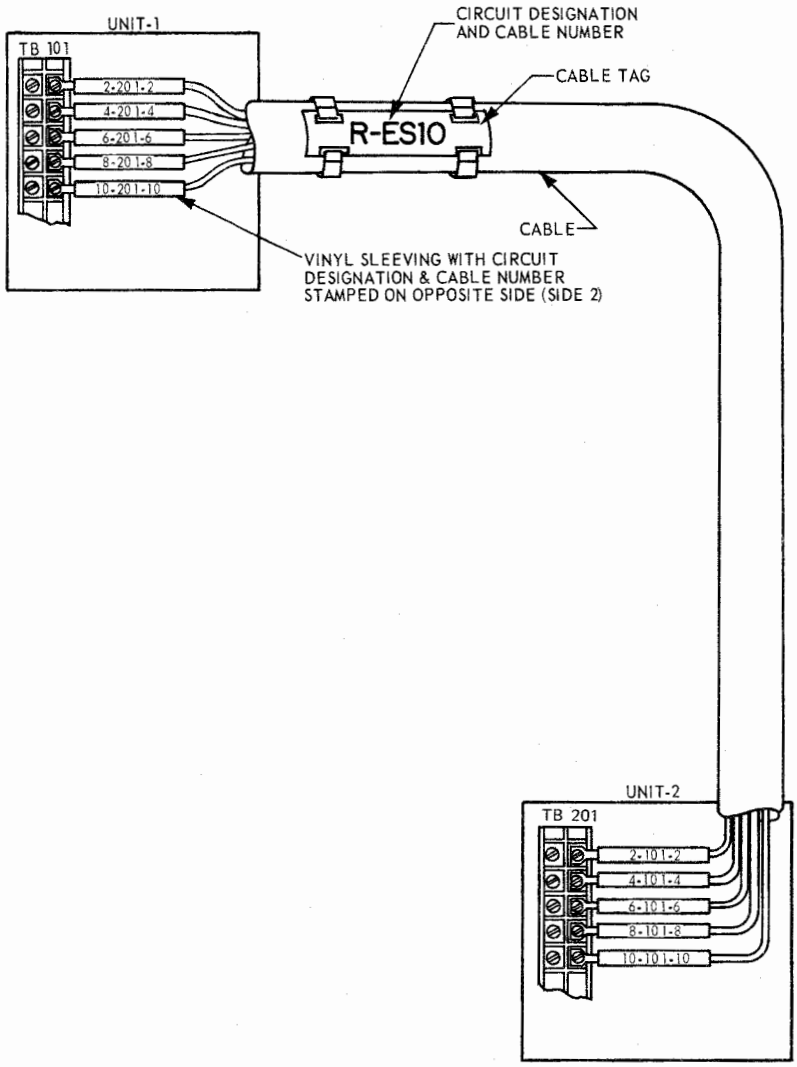


Figure 2-12. Conductor Marking Between Like Terminals

2-14 CABLE BONDING AND GROUNDING

Bonding and grounding of cables used in shipboard electronics installations shall be in accordance with MIL-STD-1310, MIL-STD-1680, NAVSEA Drawing Number 9000-S6202-73980 and the applicable ICDs. In case of a conflict of methods, MIL-STD-1310 shall take precedence over other documents for all installations except secure spaces, in which MIL-STD-1680 shall be the controlling document.

The braids (outer conductor) of single conductor and two conductor coaxial cables, and the outer braid (shield) of triaxial cables shall be connected to ground potential points only.

The outer conductor of semi-rigid coaxial cables shall be connected to ground potential points only.

2-15 CONDUCTOR FORMING AND SHAPING WITHIN ENCLOSURES

It is important that the installer perform high quality workmanship in the forming and shaping of conductors within equipment enclosures used in electronic installations. Bad workmanship such as cut conductor insulation, kinked conductors, conductors rubbing against sharp edges, or conductors pulled tight to reach terminals can result in shorted, open or intermittent circuits developing from ship vibration.

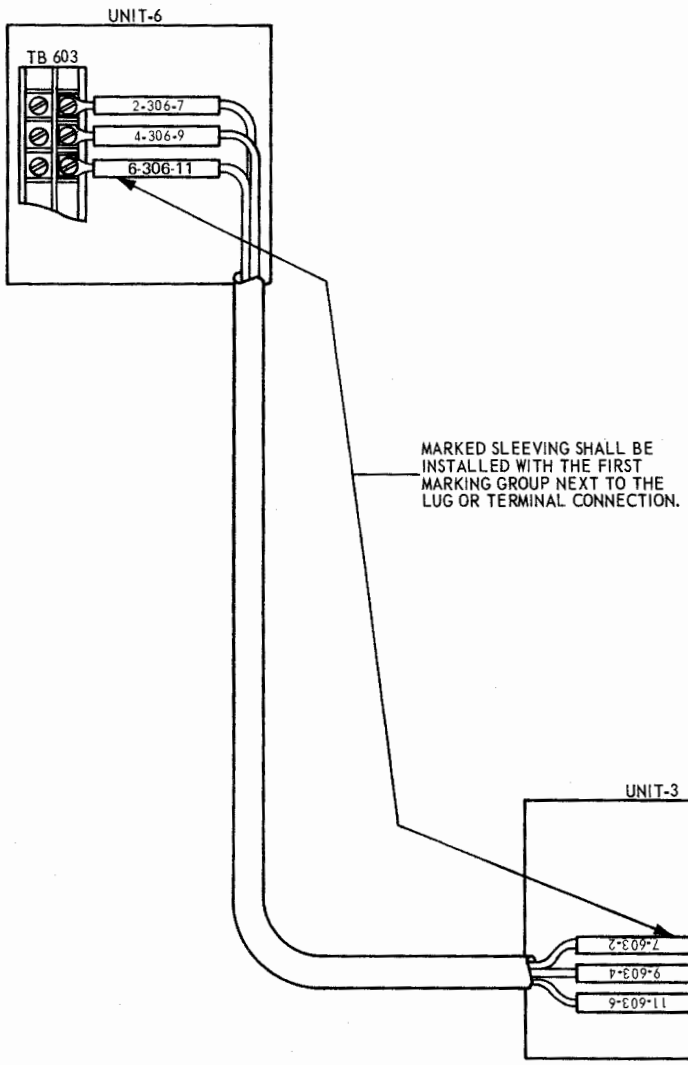


Figure 2-13. Conductor Marking Between Unlike Terminals

In order to reduce or eliminate circuit malfunctions resulting from bad workmanship, the following guidelines shall be used for conductor forming, shaping and routing within enclosures of equipments used in shipboard electronic installations.

2-15.1 GENERAL GUIDELINES

The workmanship procedures and methods used by the installer shall be equal to or exceed the following general guidelines:

(a) Conductors shall be thoroughly cleaned and visually examined for cuts, nicks, kinks or twists in the insulation covering prior to forming into groups.

(b) Individual conductors of multiconductor cables DSGU, TSGU, FSGU, MSCU, DNW, TNW, FNW, MNW and similar types shall be straightened and the conductors shall lay in a straight line in the overall group.

(c) The individual conductors of twisted pair and twisted triad cables shall not be separated until the termination point has been reached. The pairs or triads shall be straightened and lay in a straight line in the overall group.

(d) The shield and jacket on shielded single conductors, shielded pairs and shielded triads shall remain on the conductor/s until the termination point has been reached.

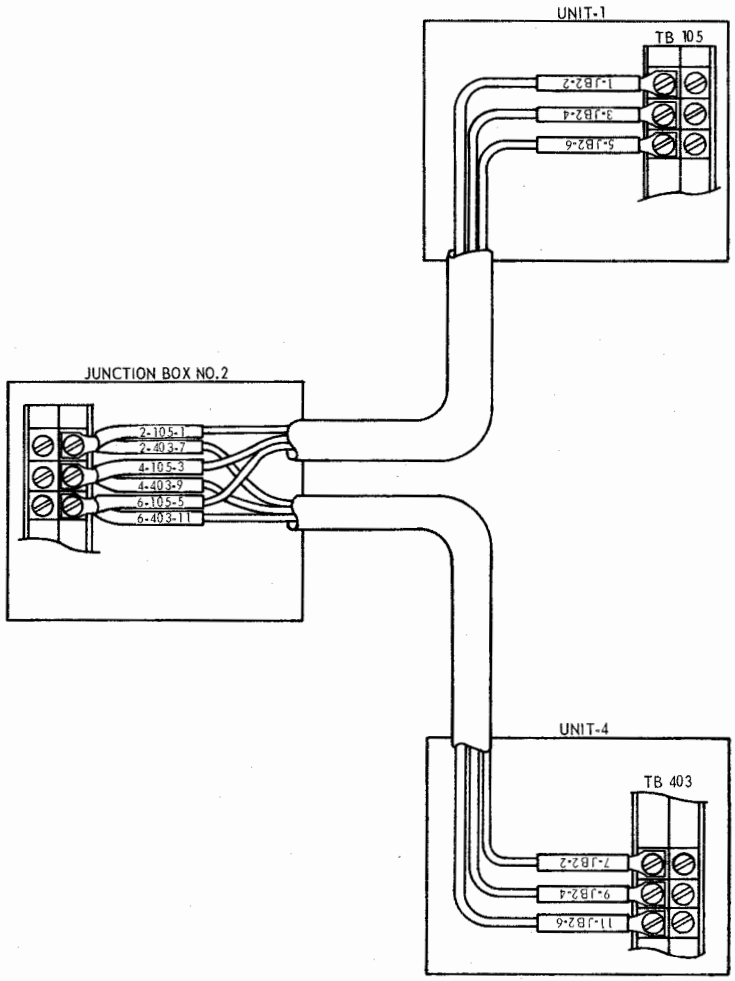


Figure 2-14. Conductor Marking Between Equipment Units and Junction Box

(e) The conductor groups shall be formed by the use of lacing or self-clinching straps in accordance with paragraphs 2-15.2 or 2-15.3 respectively.

(f) The active conductors of each cable shall be formed into a group and shaped so as not to interfere with equipment maintenance and troubleshooting.

(g) The spare conductors of a specific cable shall be of sufficient length to reach the farthermost terminal served by any active conductor in that cable. The spare conductors shall be grouped together, beginning at the point of entry to the equipment, by the same method used for forming the active groups. The ends of spare conductors shall be insulated from each other as well as being insulated from possible contact with the enclosure or any internal component. The spare conductor group shall be placed so as not to interfere with servicing maintenance, troubleshooting or equipment operation. Where there are twisted pairs or triads, shielded and unshielded, that consist of active conductors and spares, the spare conductors shall remain in the pair or triad until the termination point is reached, at which time the end of the spare conductor will be properly identified and insulated from possible contact with terminal points or metal surfaces. For secure installations, all spare conductors shall be grounded in accordance with the requirements of MIL-STD-1680.

(h) If more than one cable enters an enclosure the individual cable groups may be bunched together forming a bundle.

(i) Nylon lace shall be doubled when used for forming conductors within an enclosure of an

electronic systems installation.

(j) No group should be routed in such a manner as to cross a terminal block or in any way obstruct access to the terminals.

(k) Where the terminals are close to the point of entry for a specific group and a direct route would result in too rigid a form, an indirect route should be used. It would be better practice to route the group around the enclosure and approach the terminals from the side farthest from the point of entry.

(l) The group or bundle shall be protected from possible damage on sharp edges by the use of supporting clamps, synthetic tubing, several wrappings of electrical tape, or an equivalent method in the area of the sharp edges.

(m) Where supports are required for keeping the conductor group or bundle in place, the support shall be plastic clamps or tie down straps in accordance with MIL-S-23190. The conductor group shall be routed and the support clamp installed in such a manner that the conductor and form are not distorted nor the airtight or watertight integrity of the enclosure is changed.

2-15.2 CONDUCTOR FORMING WITH LACING CORD

Where lacing tape is used for forming conductors within an enclosure, the lacing tape shall be of a non-nutrient material such as nylon. Where temperatures may exceed 121° Celsius or where flame resistance is specified, the lacing material shall conform to MIL-Y-1140 glass tape treated with silicone resin. The lacing procedure shall be in accordance with Figures 2-15, 2-16, 2-17 and the following:

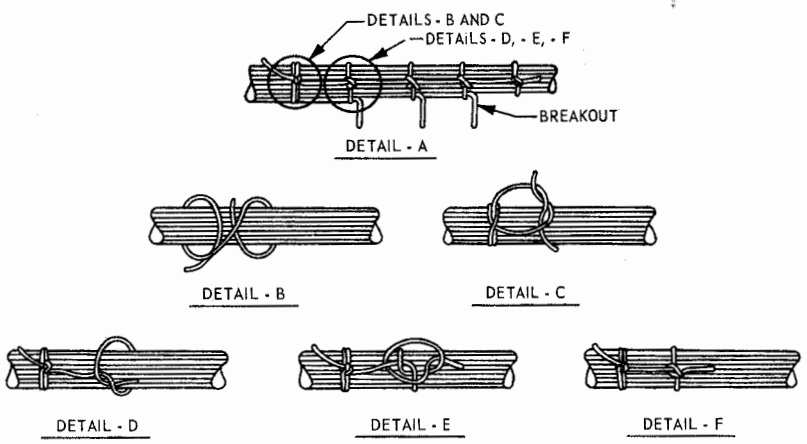


Figure 2-15. Typical Method of Conductor Forming with Lacing Tape

(a) A double wrap of lacing tape shall be used in all electronic installations. A single tape is shown in Figure 2-15 for explanation purposes.

(b) The lacing of the main cable auxiliary lines and final breakouts shall be started with a clove hitch as shown in detail "B" of Figure 2-15. An overhand knot shall be tied over the clove hitch as indicated in detail "C" of Figure 2-15.

(c) A lockstitch shall then be tied as shown in details "D", "E", and "F" of Figure 2-15. The conductors shall be laced its entire length using the lock stitch as shown in detail "A" of Figure 2-15. The lacing shall be terminated with two lockstitches.

(d) Lockstitching on the main line and auxiliary lines shall be placed immediately adjacent to and on both sides of breakouts that are to be laced.

(e) The lacing of auxiliary lines and final breakouts shall be anchored to the main section by passing the lacing tape through the lockstitches on the main section and then using the starting hitch and knot shown in detail "B" and "C" of Figure 2-15

(f) The spacing between lockstitches on conductor sections 5/8 inch or smaller in diameter shall be 1/2 inch to 3/4 inch. On conductor sections larger than 5/8 inch in diameter, the spacing shall be 1/2 inch to 1 inch.

(g) If it is necessary to splice two pieces of lacing together, a knot as shown in figure 2-16 shall be used.

(h) A binder such as Glyptol shall be applied to all starting, terminating and splicing knots.

(i) Figure 2-17 shows a typical example of a wiring form correctly laced.

2-15.3 CONDUCTOR FORMING WITH PLASTIC STRAPS

Where plastic straps are used for forming conductors within an enclosure of an electronic installation, the straps shall be selected from MIL-STD-242, Part II, section 200. Plastic straps shall not

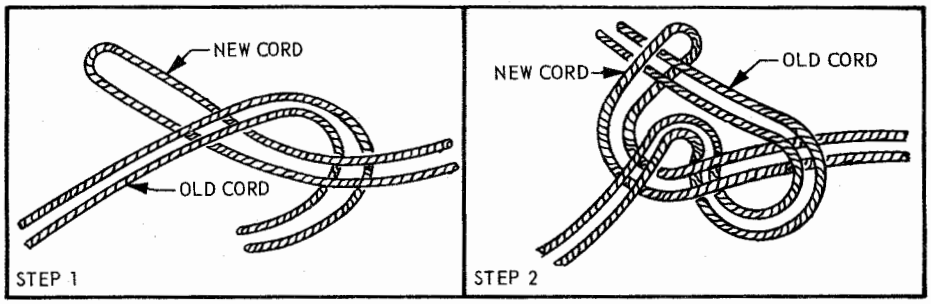
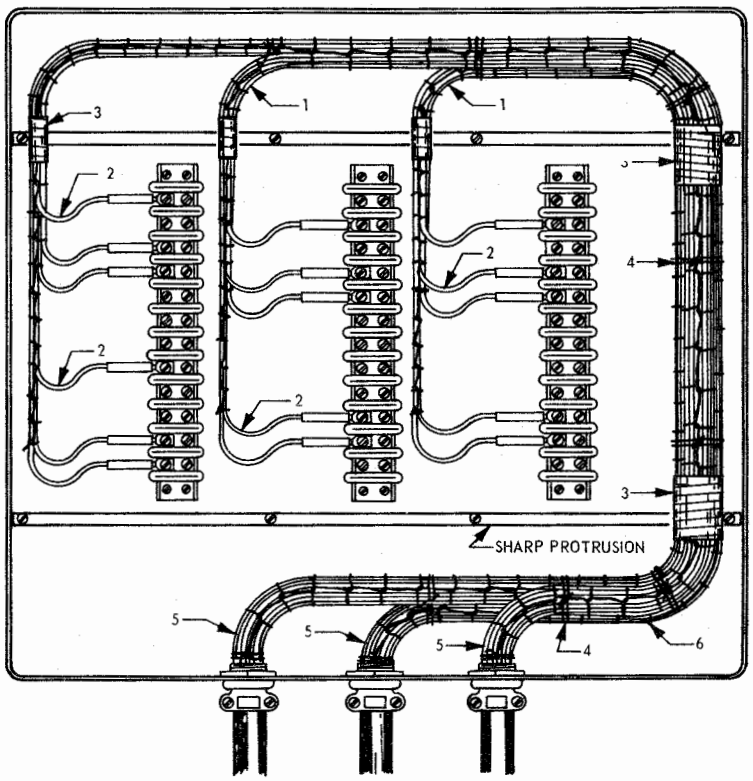


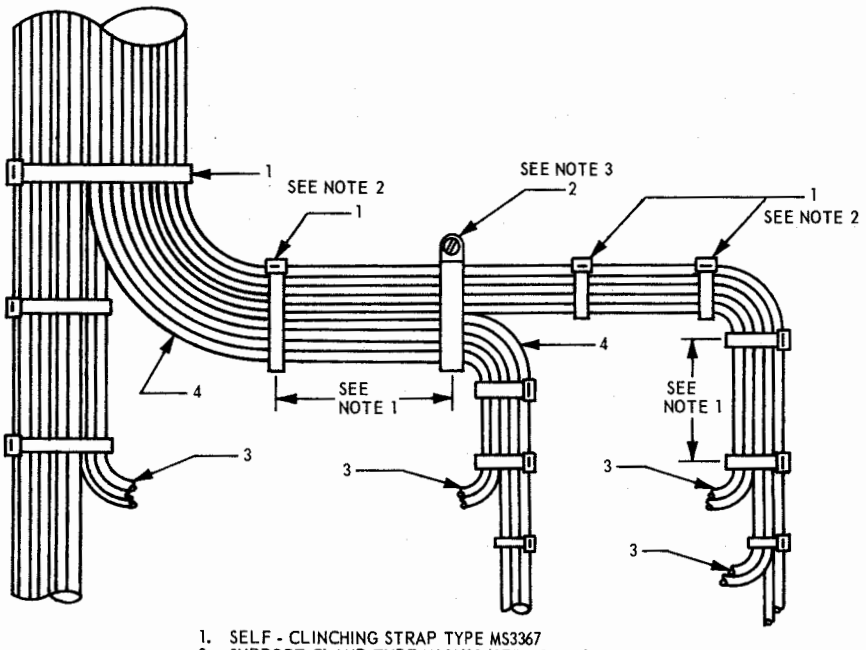
Figure 2-16. Method of Splicing Doubled Lacing Tape



1. AUXILIARY LINE BRANCH - OFF
2. BREAK - OUT
3. INSULATION PROTECTION
4. BUNDLE TYING OF MULTI - GROUPS
5. GROUP (AUXILIARY LINE)
6. BUNDLE (MAIN LINE)

Figure 2-17. Typical Completed Laced Form

be used in equipment having prolonged excessively high temperatures or in equipment whose temperature exceeds 85 ° Celsius. Where the temperature within an enclosure exceeds 85 ° Celsius the metal clamp without cushion shall be selected from MIL-STD-242, Part II, section 200. The acceptable method of conductor forming using plastic straps and clamps is shown in Figures 2-18 and 2-19. The general guidelines given in paragraph 2-15.1 shall apply when forming conductors with plastic straps. Only straps of natural color shall be used in electronic installations. Figures 2-20 and 2-21 show an acceptable tool for installing plastic straps. Care shall be taken to prevent cutting of conductor insulation when installing plastic straps. Where coaxial cables are included in the conductor bundle, ensure the tension setting on tool MS90387 is no greater than that required to prevent axial slippage.



1. SELF - CLINCHING STRAP TYPE MS3367
2. SUPPORT CLAMP TYPE MS25281 (SEE NOTE 3)
3. BREAK - OUT
4. BRANCH - OFF

NOTES:
1. SPACING BETWEEN STRAPS SHALL BE AS REQUIRED TO SUIT INSTALLATION, BUT NOT MORE THAN 2-1/2 TIMES THE BUNDLE DIAMETER, THE MAXIMUM DISTANCE BETWEEN STRAPS SHALL NOT EXCEED 10 INCHES.
2. SELF - CLINCHING STRAPS MAY BE HAND INSTALLED, BUT THE USE OF TOOL MS90387 IS RECOMMENDED.
3. MOUNTING BRACKETS MS3339, MS3340, OR MS3341 WITH MS3367 STRAPS MAY BE USED IN PLACE OF MS25281 CLAMP.

Figure 2-18. Acceptable Method of Conductor Forming with MIL-S-23190 Self-clinching Straps and MS25281 Support Clamps

2-15.4 CONDUCTOR FORMING ACROSS HINGED UNITS

Where one or more groups of conductors are terminated on a section of equipment that is hinged, care must be taken in routing the group across the hinge. If the group crosses the hinge directly, the conductors will be subject to excessive bending that would ultimately result in broken conductors. To avoid this, the group must be routed for as great a distance as possible in a direction parallel and close to the hinge. The conductors will be subjected to a slight twisting, rather than a bending motion, over a greater length of conductor and are less likely to fracture. Figure 2-22 shows the correct and incorrect way of routing groups over a hinge.

2-16 SOLDERING REQUIREMENTS AND PROCEDURES

It is imperative that the installer practice excellent workmanship and use only the correct materials and tools for a specific soldering job. Sloppy soldered connections can cause equipment malfunctions after a system has been in operation. This is especially true for a shipboard installation that is subject to ship vibration while at sea. Therefore, the procedures, material, tools and methods used for making soldered electrical and electronic connections shall comply with MIL-STD-454, requirement 5.

CAUTION

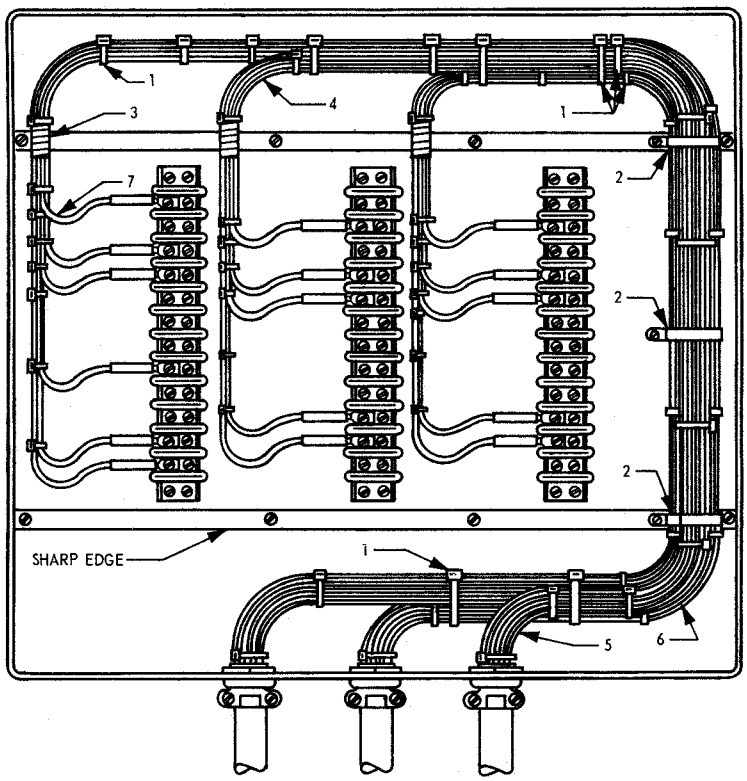
SOLDERING GUNS SHALL

NOT BE USED

2-16.1 SOLDERING IRONS

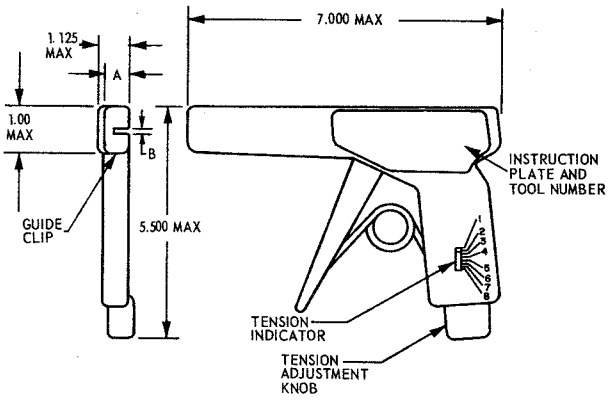
Soldering irons shall conform to W-S-570 and the requirements stated herein:

1. Soldering irons shall be of the tempera-



1. SELF - CLINCHING STRAPS TYPE MS3367
2. SUPPORT CLAMPS TYPE MS25281, MS3339, MS3340 OR MS3341
3. INSULATION PROTECTION
4. BRANCH - OFF
5. GROUP
6. BUNDLE
7. BREAK - OUT

Figure 2-19. Typical Completed Form using Plastic Straps



MILITARY PART NUMBER	A	B	FOR USE WITH PLASTIC STRAP MILITARY PART NUMBERS
MS90387-1	.630	.063/.055	MS3367-1, -2, -4, -5 MS3368-1, -2, -3, -4, -5
MS90387-2	.710	.088/.083	MS3367-3, MS3367-6

Figure 2-20. Tool MS90387 for use with MS23190 Straps

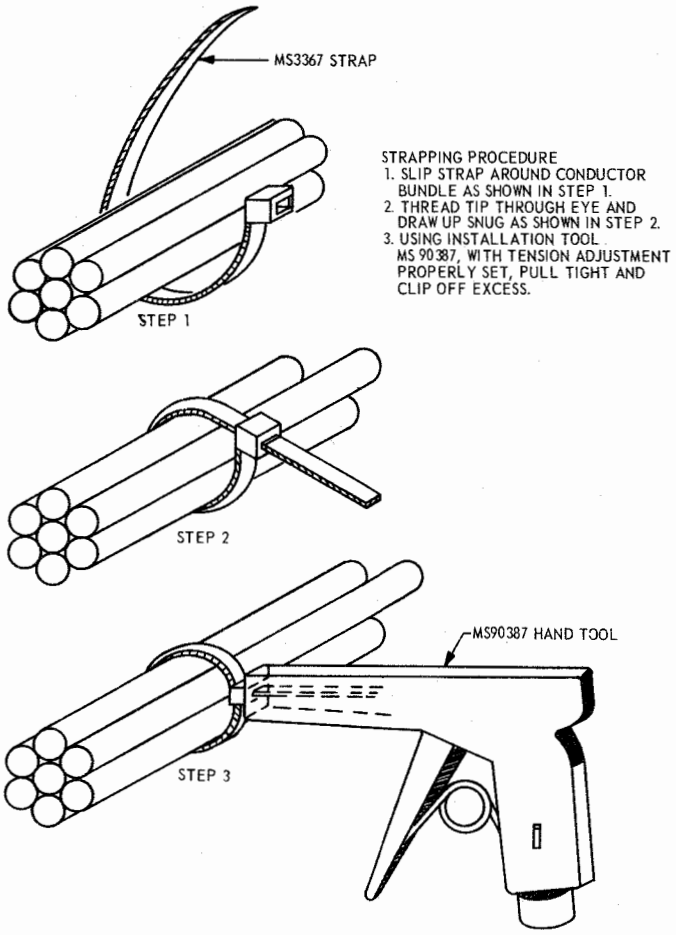


Figure 2-21. Conductor Bundle Strapping using Tool MS90387

ture controlled type.

2. Soldering irons shall have a three conductor cable with grounded type plug.

3. The size and shape of the soldering iron and tip shall permit soldering with maximum ease and control without causing damage to the adjacent areas or connections.

4. The soldering iron shall heat the joint area rapidly and maintain proper soldering temperature at the joint throughout the operation.

2-17 CABLE ENTRANCE TO EQUIPMENT

Cable entry into equipment enclosures shall comply with the following requirements and the applicable methods shown in NAVSEA drawing number 9000-S6202-73980.

1. Cable entry into bulkhead mounted non-watertight equipment shall be through the bottom or lower half of the side where practicable.

2. Where clamps are used for cable entry into equipment tops, the cable clamp shall be sealed with a plastic sealer.

3. Cable entry to equipment via connector plugs and receptacles shall be as designated and shown on applicable ICDs.

4. Where connectors are used for cable entrance to equipment, the cables shall be installed so that the connectors are easily removed for servicing and maintenance.

5. Where electronic equipment or enclosures have cable entrance plates, the cable shall enter the equipment through the plate designated on the applicable ICDs. If the cable is not designated to enter a specific entrance plate on the ICDs, the cable shall enter the entrance plate nearest to its termination point.

6. Cables shall not enter equipment through an access plate that is used to cover terminal boards or studs. If no other entrance plate is available, the terminal board access plate entrance shall be modified by the addition of a fabricated extension box that will permit cable entry through the edge of the extension box, as indicated in Figure 2-23. This

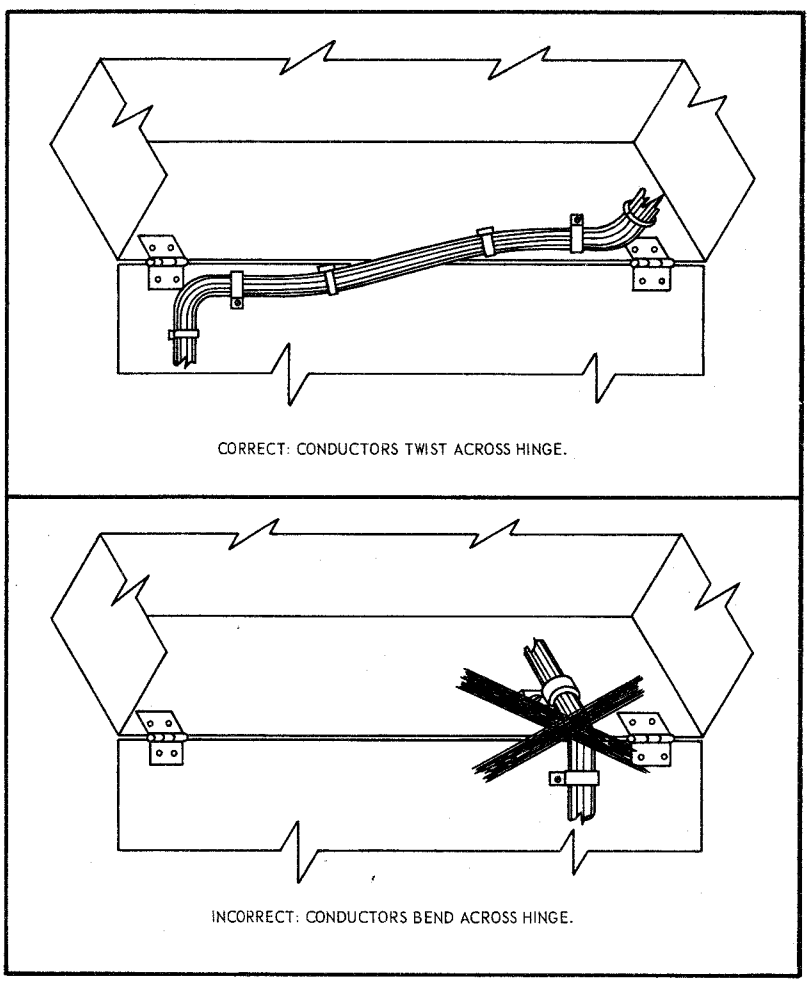


Figure 2-22. Routing of Conductor Bundle over Hinge

method may also be used for compact equipment where there is not sufficient room for cable trees and spare conductors within the enclosure.

7. Where cable entry to electronic equipment will be through nylon stuffing tubes, the tubes shall be installed using spanner wrenches similar to those shown in Figure 2-24.

2-18 PRESSURIZATION AND JACKET REPAIR INSTRUCTIONS

The following special instructions are intended as guidelines to assist the installer in obtaining the optimum installation.

2-18.1 PRESSURIZATION

Semi-rigid coaxial cables may be classed in two categories in reference to dielectric types. One category would be the solid or foam dielectric cables that do not require pressurization. The other category is the semi-air dielectric type that requires dry air pressurization.

Pressurization and purging of semi-rigid semi-air dielectric coaxial cables shall be via connectors with gas ports. The requirements for the dry air leakage, purging and pressurization of Section 5 of this document shall apply to semi-rigid semi-air dielectric coaxial cables. Although these cables are designed to withstand 30 psig, the recommended pressure for semi-rigid semi-air coaxial cables is 5-10 psig.

2-18.2 JACKET REPAIR

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. When applicable coaxial cable jackets shall be

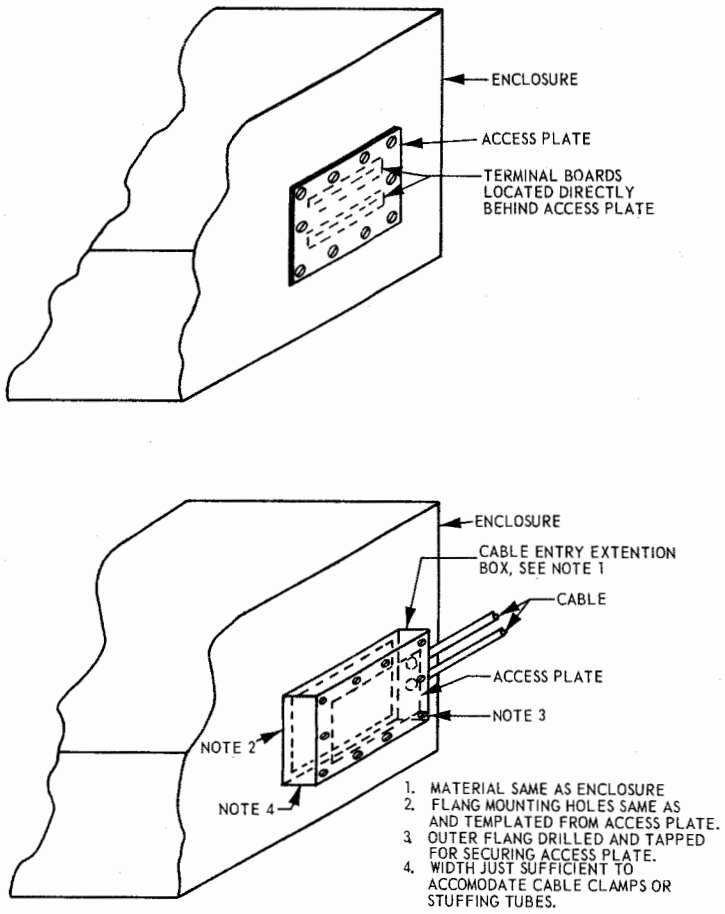
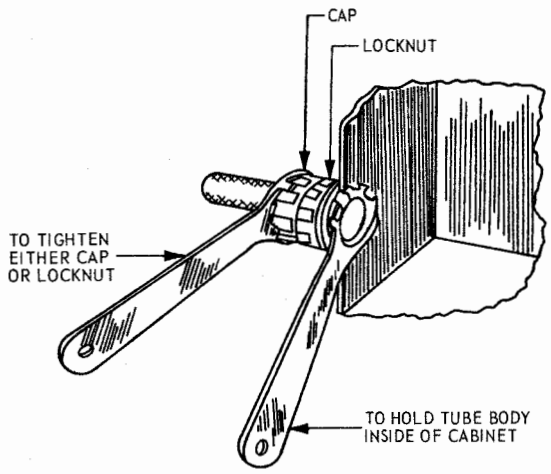


Figure 2-23. Typical Cable Entry Extension Box



FOR BEST RESULTS TWO WRENCHES AS SHOWN, SHOULD BE USED. ONE WRENCH TO HOLD TUBE BODY TO PREVENT TURNING, THE SECOND WRENCH TO TIGHTEN LOCKNUT OR CAP.

Figure 2-24. Nylon Stuffing Tube Assembly using Spanner Wrenches

repaired in accordance with the following procedures and materials.

2-18.2.1 Procedures for Repair of Coaxial Cables

Step 1. Remove all damaged jackets and, wherever possible, the intact jacket up to approximately 1 inch on each end of the damaged area. Scarf edges and sand and clean jacket with lint-free wiper over entire area to be repaired. Use a fine file or nonconductive abrasive strip to sand jacket. Care must be taken not to damage the braided outer conductor of the cable.

Step 2. Wrap a single quarter-lapped layer of corrugated polyester barrier tape over the braided outer conductor and approximately one half inch onto the scarfed jacket on both sides. The ends of the barrier tape should be held on the cable with short lengths of pressure sensitive vinyl tape.

Step 3. Wrap a single half-lapped layer of rubber tape over patch area and onto the scarfed area approximately one half inch beyond the barrier tape. Wrap multiple half-lapped layers of rubber tape over the area to build up low spots and make a uniform diameter over the patched area. The tape should be stretched while wrapping.

Step 4. Overwrap the entire patch with three half-lapped layers of pressure sensitive plastic tape. Be sure that the plastic tape overlaps the rubber tape by approximately one half inch. The tape should be applied with stretch but relax the last two turns. Air core coaxial cables require extra care so as not to distort the cable when wrapping with the tape.

Step 5. Cover the entire patch with three coats of liquid plastic coating material. The first coat should be lightly applied in an expeditious manner. Each coat should be allowed to dry tack free between applications.

CAUTION

ADEQUATE VENTILATION

SHOULD BE PROVIDED TO

AVOID EXPOSURE OF PERSONNEL

TO TOXIC VAPORS

2-18.2.2 List of Jacket Repair Materials

Description	Materials	Mfg
Barrier tape	Corrugated Polyester 0.00142 x 3/4"	Dupont or equal
Rubber tape	Self-fusing Ethylene Propylene Rubber	3M Co. or equal
	Based-Scotch 23	
Vinyl-plastic	Pressure sensitive, Flame retardant, Cold and weather resistance, 0.007 x 3/4" – Scotch 33	3M Co. or equal
Coating Compound	Liquid Plastic-Scotchkote (NSN 9G5970-000-962-3335)	

2-19 CABLE TERMINATIONS

For a shipboard electronics system to operate with a high reliability the low loss transfer of electrical, digital and radio frequency data is largely dependent upon the workmanship and type materials used in the installation of multiconductor and coaxial cables. Careful preparation of cables terminating either at terminal boards or in connectors shall be of primary concern to all installers. It is the intent of this subsection to assist the Installing Activity in properly terminating cables by discussions, illustrations and referencing of approved materials, components, tools, methods and requirements covered by specifications and standards.

2-19.1 GENERAL GUIDELINE AND REQUIREMENTS

The general guidelines and requirements for the terminating of shipboard electronic system cables shall be as follows:

(a) Cable entrance to enclosures shall comply with paragraph 2-17.

(b) Conductor forming and lacing within enclosures shall comply with paragraph 2-15.

(c) Cables terminating in connectors shall have connector identification tags in accordance with paragraph 2-13.

(d) Conductor identification (marked sleeving) shall comply with paragraph 2-11.

(e) Cable end sealing when required shall comply with paragraph 2-13.

(f) ICDs, ShipAlts and specific ship installation plans shall not be deviated from, as to type of connectors, lugs, terminal boards and similar components, without authorized approval.

(g) There shall be no stress or strain on the cable between the enclosure and cable supports. Provide only enough slack to allow for ships action such as vibration and equipment shock mount deflection.

(h) Terminating of coaxial cables shall comply with paragraphs 2-18 and 2-20.

(i) Terminating of multiconductor electrical cables with connectors shall comply with paragraph 2-21.

2-19.2 CABLE AND CONDUCTOR TERMINATION WITHIN AN ENCLOSURE

The procedures, methods and materials required for cable and conductor termination within an enclosure shall be as stated herein:

(a) Cable entrance clamps or stuffing tubes should be arranged and installed in the enclosure to give a neat and orderly appearance to the cable entrance.

(b) The cable end shall be of sufficient length to reach the farthest connection point within the enclosure.

(c) The point at which the cable jacket is cut and removed from conductor ends shall comply with the requirements of paragraphs 2-15 and 2-17.

(d) There shall be no cut or break in the conductor insulation resulting from jacket removal in the cable termination process.

(e) Terminal boards for use in enclosures of electronic systems shall be selected from MIL-STD-1277 in accordance with MIL-STD-242.

(f) Terminal lugs for use in terminating conductors of multiconductor cables in electronic systems shall be selected from MIL-STD-1277 in accordance with MIL-STD-242.

(g) The use and application of terminal boards and terminal lugs shall comply with MIL-STD-454, Requirements 19.

(h) Crimping tools used for crimping terminal lugs shall be the type recommended by the terminal lug specification or the equivalent.

(i) Wire stripping tools shall be of the type that will ensure against nicking, cutting or damaging the bare conductor in any way.

(j) There shall be no strands missing from a conductor end terminated in any enclosure of an electronic installation.

(k) There shall be only one conductor per lug. Under no circumstances shall there be two or more conductors crimped in the same terminal lug.

(l) Binding head screws and barrel nuts that are supplied with terminal boards shall not be replaced with different type screws or nuts.

(m) Lock washers and/or flat washers are not required for use with binding head screws or barrel nuts supplied with terminal boards selected from MIL-STD-1277.

(n) Marked sleeving installed on conductors in accordance with paragraph 2-13 shall fit snugly over the terminal lug barrel after crimping. This applies to both insulated and uninsulated lugs.

(o) The insulation may be cut or stripped from the conductor end by any suitable tool approved by the Installing Activity, providing a clean cut in the insulation is made perpendicular to the axis of the conductor and does not nick or cut any strands.

(p) The bare conductor strands shall be cleaned prior to attachment of lug and the bare conductor end shall extend all the way through the terminal lug barrel as shown in Figure 2-25.

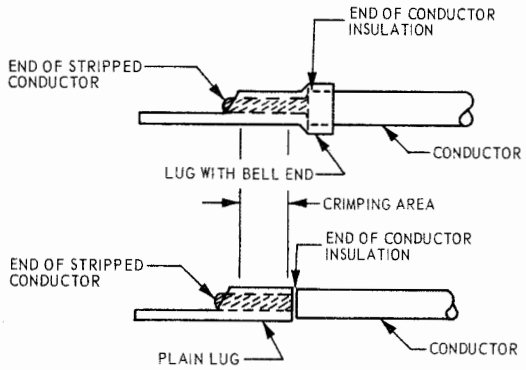


Figure 2-25. Conductors Properly Terminated in MIL-T-7928 Lugs

2-19.3 CABLE AND CONDUCTOR SHIELD TERMINATIONS

The shields of shielded single conductors, shielded pairs, shielded triads and cables with overall shields shall be terminated as stated herein.

(a) Shields of shielded conductors and/or cables shall be terminated only at the termination points indicated on ICDs, ShipAlts, Ship Installation Plans, and Equipment Technical Manuals.

(b) Shield termination within a multipin connector shall be in accordance with ICDs, ShipAlts, Equipment Technical Manuals and connector assembly instructions.

(c) Where shields are indicated as floating (no termination) they shall be insulated from possible contact with the enclosure, component parts or conductor terminations.

(d) Cables that are interfaced by means of

connection boxes and other equipment shall have the individual shields treated as continuous conductors. These shield shall be insulated to prevent touching other terminals or enclosure ground.

(e) Shields shall not be stripped off conductors where they enter an enclosure, but shall remain on the conductor/s to within 3 inches of the conductor/s termination point.

(f) Shield connectors, inner and outer ferrules, collector and compression rings and similar devices used to terminate shields shall meet the performance requirements of MIL-C-21608.

(g) Crimping tools used for shield termination shall comply with the requirements of MIL-C-22520.

(h) The conductor insulation at the point of shield termination shall show no signs of nicks, cuts or compressed areas.

(i) Insulation resistance tests shall be made on all shield terminations and conductors in accordance with paragraph 2-8 of this document.

(j) Figure 2-26 is a typical method of terminating conductor shields with MIL-F-21608 ferrules and a MIL-C-22520 crimping tool.

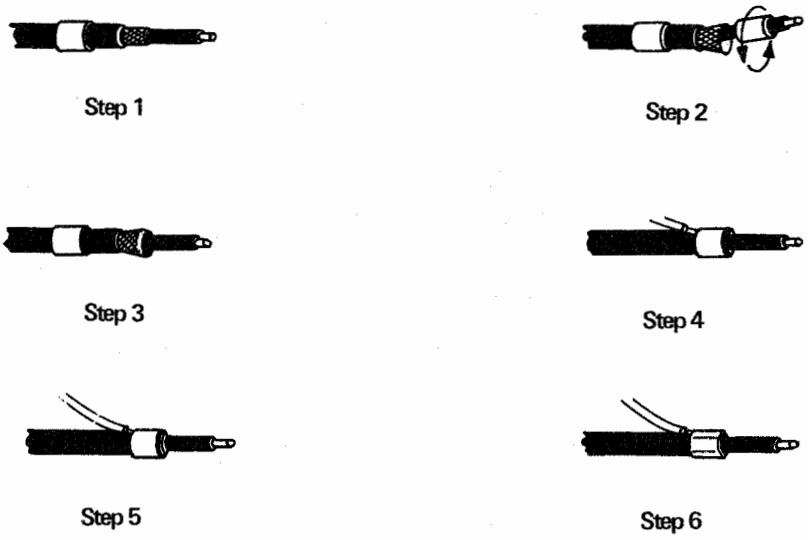


Figure 2-26. Typical Method of Termination Shields with MIL-F-21608 Ferrules and MIL-C-22520 Crimping Tool

The following instructional steps are to assist the installer.

Step 1. Slip outer sleeve over insulation jacket after stripping. Trim braid to within ½" of insulation as shown in *Step 1* Figure 2-26.

Step 2. Fan braid by rotating center conductor and slip inner sleeve under braid as shown in *Step 2* Figure 2-26.

Step 3. Position inner sleeve to extend about 1/16" beyond braid as shown in *Step 3* Figure 2-26.

Step 4. Slip ground lead under outer sleeve (Front or Back) and SLIDE outer sleeve over braid as shown in *Step 4* Figure 2-26. Two ground wires can be accommodated by selecting the proper size outer sleeve. For daisy chain grounding.

Step 5. Outer sleeve covers all exposed strands as shown in *Step 5* Figure 2-26.

Step 6. Compress in tool M22520/5 as shown in *Step 6* Figure 2-26. (Tool will not release until full compression stroke is completed).

(k) Within compact or congested enclosures with insufficient space for shield termination using ferrules and crimping tools, the alternate method shown in Figures 2-27 and 2-28 may be used. The following instructive steps are to assist the installer in removing the shield without damage to the conductors.

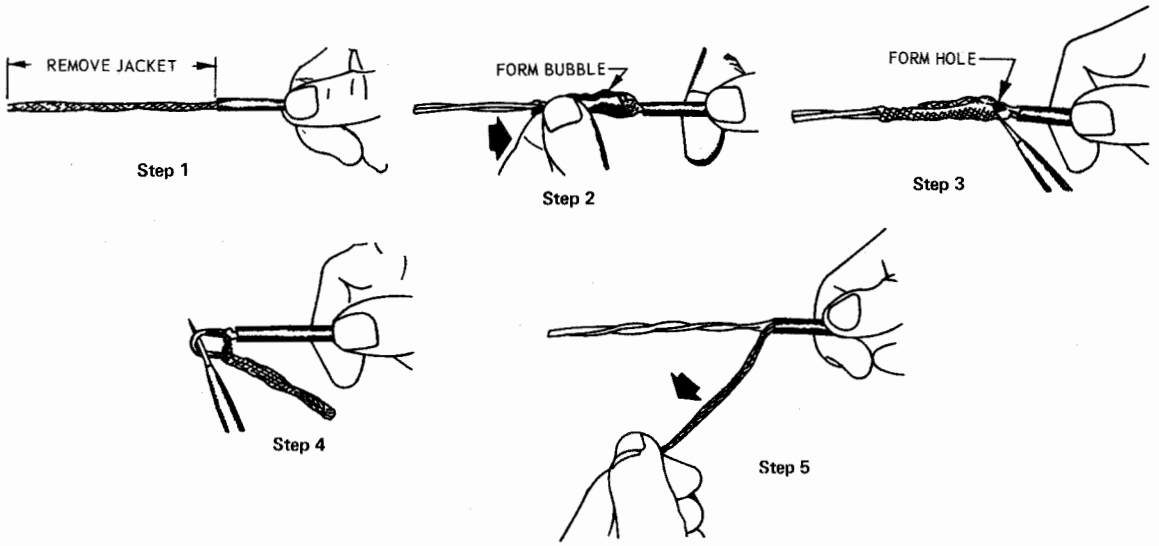


Figure 2-27. Pigtailing Method of Shield Termination

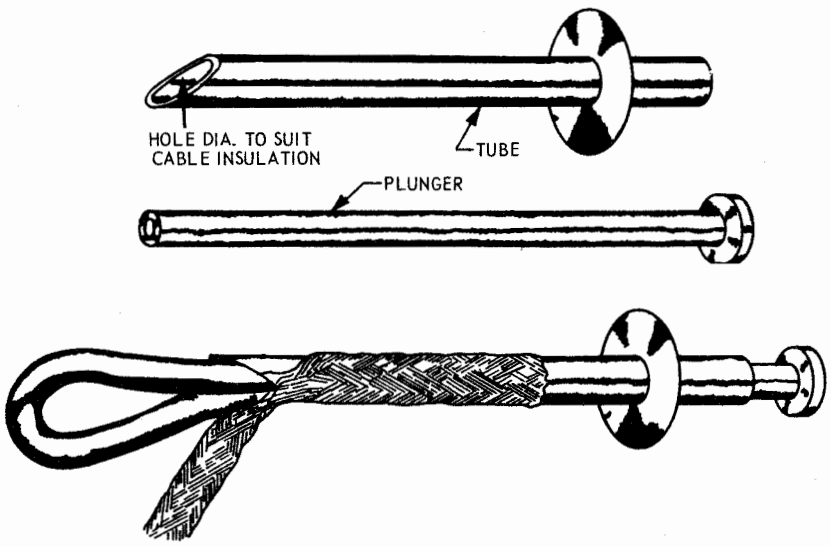


Figure 2-28. Typical Extractor Tool for Shield Terminations

Step 1. Determine length of pigtail required for termination. Cut and remove outer insulation jacket as illustrated in *Step 1* of Figure 2-27. Care shall be used to prevent cutting into braided shield or damaging it.

Step 2. Push shield back over conductor/s until a bubble forms at the jacket termination as illustrated in *Step 2* of Figure 2-27.

Step 3. Insert a pointed tool (pick) into the shield bubble as close to jacket termination as practicable. Move the tool with a circular motion until a hole is formed large enough to pass the doubled conductor/s as illustrated in *Step 3* of Figure 2-27. While forming the hole, care shall be taken not to break any of the shield strands.

Step 4. Carefully bend conductor/s and shield at the formed hole while inserting the pointed tool between conductor/s and shield as illustrated in *Step 4* of Figure 2-27, then pull the conductor/s completely through the formed hole.

Step 5. Stretch the empty section of shield and form it into a compact braided conductor as illustrated in *Step 5* of Figure 2-27.

Step 6. Insulate the braid with synthetic tubing to prevent contact with conductor terminations.

Figure 2-28 illustrates the same pigtailing method with the use of an extractor tool. These tools are commercially available or may be fabricated by the Installing Activity. The use of an extractor tool is described in the following steps:

Step 1. Determine length of pigtail required for termination. Cut and remove outer insulation jacket as illustrated in *Step 1* of Figure 2-27. Care shall be used to prevent cutting into braided shield or damaging it.

Step 2. Slide the pointed tube between shield and conductor/s insulation to the point of shield termination.

Step 3. Carefully bend shielded conductor/s at the end of pointed tube approximately 60 degrees and, with a back and forth sideways motion, work the point of the tube through the shield as illustrated in Figure 2-28.

Step 4. Enlarge the hole until it is of sufficient size to pass the double conductor/s. Be careful not to break any of the shield strands.

Step 5. Insert plunger into open end of tube and carefully push the conductor/s back through opening in shield as illustrated in Figure 2-30. Use extreme care so as not to damage conductor/s insulation.

Step 6. Remove tool from shield and form shield into a compact braided conductor as illustrated in *Step 5* of Figure 2-29.

Step 7. Insulate the braid with synthetic tubing to prevent contact with conductor terminations.

2-19.4 SEMI-RIGID CABLE END PREPARATION

Figures 2-29 and 2-30 are illustrative methods of semi-rigid cable end preparation to assist the installer working with semi-rigid cables. Variation in methods and technology by the installer is recommended, where it improves the end product and the completed installation meets all electrical and mechanical requirements for a specific cable.

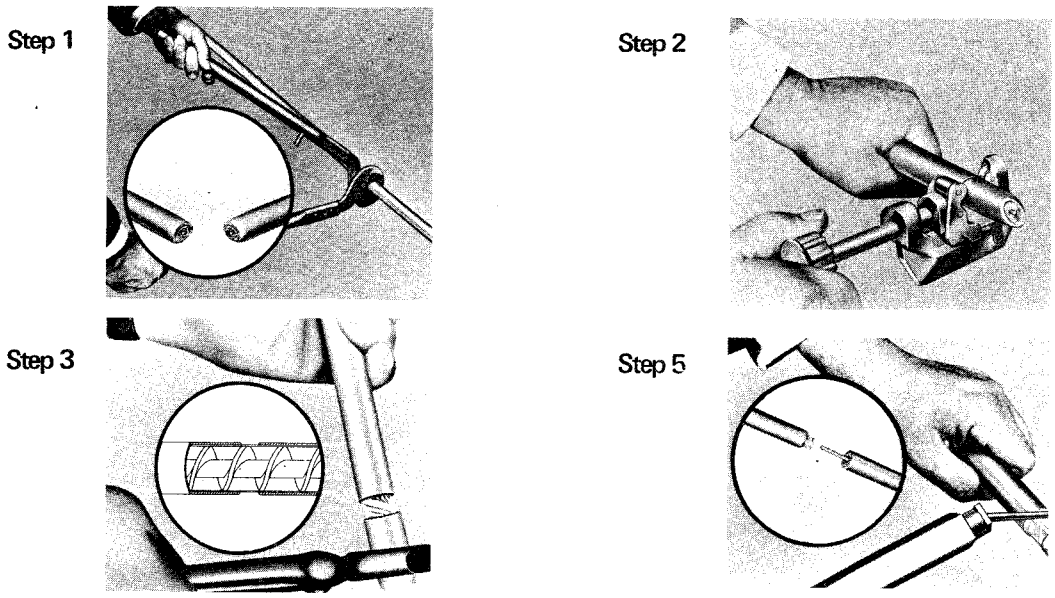
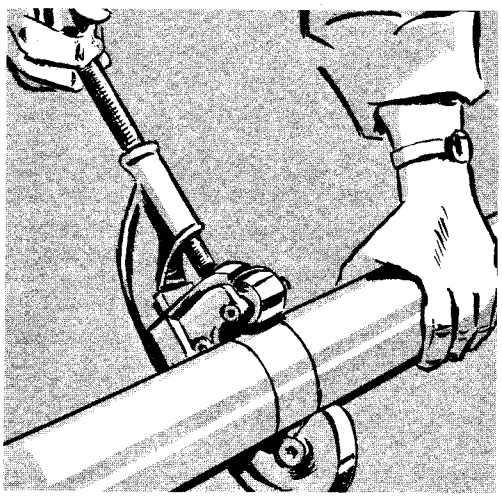
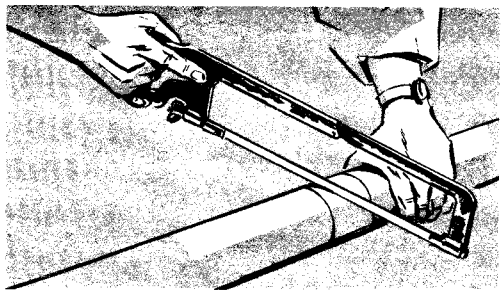


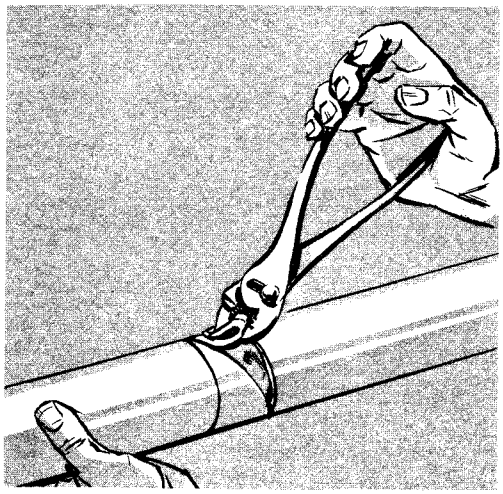
Figure 2-29. Small Semi-rigid Cable End Preparation



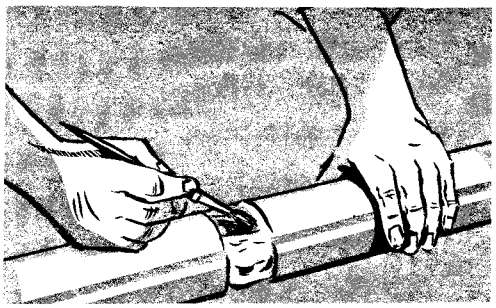
Step 1



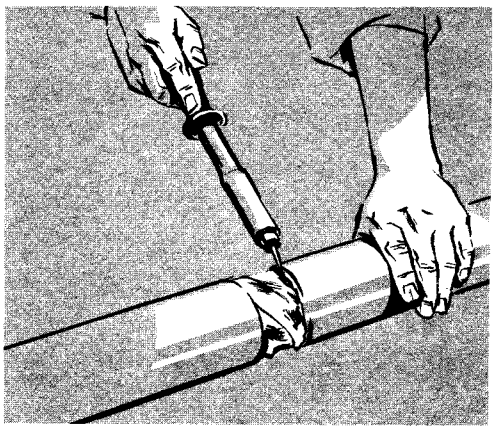
Step 2



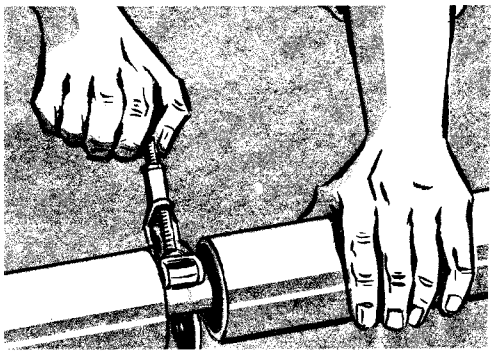
Step 3



Step 4



Step 5



Step 6

Figure 2-30. Large Semi-rigid Cable End Preparation

Step 1. Cut cable (sheath, insulation and inner conductor) with cable shears. These shears make use of specially shaped cutting blades to ensure minimum damage to cable. *Step 1*, Figure 2-29 shows the appearance of the cable after the cut has been made.

Step 2. Apply sheath cutter to cable placing cutting wheel approximately 1-½" from end of cable, as shown in *Step 2*, Figure 2-29. This cutter is only used to cut approximately one-half way through the outer sheath of the cable. In cutting this sheath be sure to advance the cutter roller slowly so that no burr is produced inside the cable sheath.

CAUTION

DO NOT FLEX SHEATH EXCESSIVELY

MAXIMUM DEFLECTION PERMISSIBLE

IS 1/16" AT CABLE END

Step 3. Using pliers carefully flex partially cut sheath end until the sheath parts at the cut line. Separate aluminum sheath at cut approximately ½". *Step 3*, Figure 2-29 cross-section shows the effect of cutting the cable sheath as described in *Steps 2* and *3*. The smooth radius produced at the sheath I.D. is a result of parting the sheath as specified in *Step 3* rather than cutting completely through and producing a large internal burr which would have to be removed. Do not remove cut sheath end.

Step 4. (Applicable to RG-253/U and RG-254/U) - Using a sharp razor knife cut through the polythylene tubes being careful not to nick the inner conductor. Keep the knife at right angles to the cable axis and the side of knife blade adjacent to the outer conductor.

Step 5. (Applicable to RG-232/U, RG-237/U and RG-245/U) - Using a hot knife cutting tool, carefully melt the polystyrene sheath and helix. Remove outer sheath cut end, polystyrene sheath and helix exposing the inner conductor as shown in *Step 5*, Figure 2-29. The inner polystyrene skin and helix which remain inside the cable are now fused into one solid mass.

The following procedures are to assist the installer in preparation of large semi-rigid cable.

Step 1. Apply Rotary cutter to cable and cut through aluminum sheath. In so doing advance the cutter rollers rapidly in order to throw a heavy burr on the inside surface of the sheath. Make a similar cut 2" from the first one thus producing a 2" section of sheath which is supported only by the Polystyrene helix and the insulating skin just inside the sheath, as shown in *Step 1*, Figure 2-30. The burrs formed hold the helix in place and prevent the thin laminations from unraveling.

Step 2. Using a fine tooth hacksaw carefully saw almost thru the section of sheath which has been parted from the cable in the previous step, cutting at a 45 degree angle to the center line of the cable, as shown in *Step 2*, Figure 2-30. Make certain that the saw does not cut thru the sheath as this would permit chips of aluminum to enter the cable interior.

Step 3. Place a small screw driver under a corner edge of the ring of sheath at the saw cut, pry upward and elevate further with pliers. Fold this corner piece back upon itself, take a new hold upon it with the pliers and fold the short section of sheath outward removing it from the cable thus exposing the insulating skin, as shown in *Step 3*, Figure 2-30.

Step 4. Since particles of aluminum might enter the interior of the cable during the next operation brush the entire surface of the Polystyrene skin, particularly the edge of the cable where it meets the skin, making certain that no chips are lodged in this area, as shown in *Step 4*, Figure 2-30.

Step 5. Using "hot knife" cut thru insulation skin and helix close to the ends of cable, as shown in *Step 5*, Figure 2-30. This operation will heat seal the laminations of the helix thus far retained in place by the burr formed in *Step No. 1.*

Step 6. Using smaller Rotary Cutter cut the inner conductor midway between the sheath ends, as shown in *Step 6*, Figure 2-30. This will produce two cable ends with the inner connecters projecting 1 inch beyond the outer conductors.

2-20 COAXIAL CONNECTORS

Radio frequency coaxial cables are normally terminated with what are commonly called coax connectors. These connectors are designed to match the cable characteristic impedance over a given frequency range, provide RF shielding, and when properly assembled on a coaxial cable and coupled to a mating connector will provide a stable RF circuit with low signal loss. The intent of this subsection is to provide information and guidance to the Installing Activity in the selection and installation of RF coaxial connectors required for shipboard electronic systems.

2-20.1 SELECTION

Coaxial connectors shall be selected from MIL-STD-1353 and MIL-C-39012 in accordance with MIL-STD-242 and as stated herein:

(a) MIL-HDBK-216 may be used for general technical guidance in the selection of coaxial connectors. For detailed technical data, the user should refer to the military specification for a specific coaxial connector.

(b) Deviation from the coaxial connector types shown on ICDs shall require authorized approval.

(c) Connectors for use on flexible coaxial cables shall be procured by the military specification part number, except where equipment receptacle interfacing dictates the use of connectors typed by the "UG" nomenclature and never assigned a new military specification part number, in which case procurement shall be by the "UG" number.

(d) Connectors for use on semi-rigid coaxial cables shall be procured by the military specification part number where applicable. Where there is no applicable military specification, the semi-rigid coaxial cable connectors should be the type recommended by the cable manufacturer.

(e) Category "D" connectors in accordance wtih MIL-C-39012 should be used wherever applicable.

(f) Coaxial connector adapters shall not be used to interface coaxial cables and/or equipment of permanently installed shipboard systems.

(g) Coaxial connector adapters may be used for temporary interface of coaxial cables and/or equipment for testing purposes or as an interim fix for returning equipment to an operational status until the correct interface can be accomplished.

(h) Coaxial connector adapters for use with shipboard electronic systems shall comply with the requirements of MIL-A-55339

(i) When selecting coaxial connectors, preference should be given to threaded type connectors for greater stability and better performance. Bayonet type connectors, such as "BNC" and "C" should be used only when the need for quick connect and disconnect outweigh the inherent advantages of the threaded type.

2-20.2 INSTALLATION

Coaxial connectors shall be installed as stated herein.

(a) Assembly instructions are supplied with coaxial connectors that comply with MIL-C-39012.

(b) The specification sheets of MIL-C 39012 provides cable stripping dimensions, crimping tool and die number for specific connectors.

(c) Crimping tools for crimp type coaxial connectors shall comply with MIL-C-22520 or MIL-T-55619.

(d) MIL-HDBK-216 may be used as assembly instruction guidance for coaxial connectors not covered by MIL-C-39012.

(e) Coaxial connectors when properly installed shall meet the applicable cable retention force requirements of MIL-C-39012.

(f) Coaxial connectors exposed to the weather, salt spray, moisture and stack gasses shall be weatherproofed within 24 hours after assembly.

(g) 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 paragraph 2-20.3.

2-20.3 WEATHERPROOFING METHODS

Deterioration of coaxial connectors due to the corrosive action resulting from moisture, salt and stack gasses is a serious problem aboard ships. Coaxial connectors exposed to the weather shall be weatherproofed by one of the following methods or the equivalent.

(a) Weatherproofing may be accomplished by encapsulating the connector and a portion of the cable with plastic electrical insulating adhesive tape sealed with three coatings of sealing compound complying with MIL-A-46106.

(b) Weatherproofing may be accomplished by encapsulating the connector and a portion of the cable with heat shrinkable self-sealing tape or heat shrinkable sleeving with the interior sleeve surface coated with an adhesive.

For additional protection apply three coats of sealing compound complying with MIL-A-46106 to the exterior surface after heating of the tape or sleeving. Manufacturers procedures for applying heat shrinkable tape and sleeves should be followed for obtaining the best weatherproof seal.

2-21 ELECTRICAL CONNECTORS

Along with the ever advancing state-of-the-art in electronic systems, the electrical connector has assumed a vast number of sizes, shapes, configurations and names. This large variety of connectors is required for the interfacing of complex electronic systems and functions. Electrical connectors required for shipboard electronic installations, in addition to being compatible with the electronic equipment, must meet the Navy requirements for compatibility with MIL-C-915 jacketed cable and rugged enough to withstand shock and vibration from the ships action at sea or in battle.

Electrical connectors incorrectly selected and improperly installed, play a major part in shipboard electronic equipment malfunctions. The installer should use care in his selection and installation of electrical connectors to ensure this will not be a weak point in the system that could possibly cause equipment downtime during a critical operation.

The requirements, guidelines, references and instructions stated herein shall apply to all shipboard

electronic installations requiring electrical connectors for interfacing MIL-C-915 cable to equipments.

2-21.1 SELECTION

Electrical connectors required for interconnecting shipboard cables to electronic equipment are normally supplied with the equipment. Where the cable connectors are not supplied with equipment and where the installer is required to fabricate consoles, connection boxes, panels, enclosures and similar equipment or to modify electronic equipment or systems, the following selection requirements shall apply:

(a) Where equipment, with electrical connector receptacles installed, is received without cable connectors, the cable connectors selected shall be compatible with Navy shipboard cable and shall be in accordance with the same military specification as are the equipment installed receptacles.

(b) Electrical connectors for use with MIL-C-915 jacketed cable in shipboard electronic installations shall be selected in accordance with MIL-STD-242.

(c) Where general duty MIL-C-5015 connectors other than class D, are referenced on ICDs or other military documents, and not supplied with the equipment, they shall be replaced with MIL-C-5015 class D or class DJ connectors. "DJ" is the identification given to class D connector assemblies that include the backshell assembly and cable strain relief clamp.

(d) Where general duty electrical connectors are required for equipment enclosures fabricated or modified by the Installing Activity, they shall be MIL-C-5015 class D or DJ connectors selected from MIL-STD-1353.

(e) Where heavy duty electrical connectors are required for equipment enclosures fabricated or modified by the Installing Activity, they shall be selected from MIL-C-22992. These connectors shall be used in circuits having a current flow that exceeds the requirements of MIL-C-5015 connectors.

(f) Where test point connectors are required for equipment enclosures fabricated or modified by the Installing Activity, they shall be selected from MIL-C-39024 in accordance with MIL-STD-242. Banana plugs and jacks shall not be used.

(g) Telephone-type plugs and jacks shall be selected from MIL-STD-242 and shall conform to MIL-J-641 and MIL-P-642.

(h) Connectors for use on portable power cables shall be the molded rubber type as directed in MIL-C-28777.

(i) MIL-STD-1683 shall be used for selecting MIL-C-5015 connector shell size and insert combination to fit a particular MIL-C-915 cable.

(j) To ensure installation of quality products, all connectors and/or accessories shall be specified, selected, procured and referenced by their military part number.

(k) Connector plugs or receptacles which continue to be energized after unmating shall have socket type contacts.

2-21.2 INSTALLATION REQUIREMENTS

The installation of electrical connectors used in shipboard electronic systems shall comply with the following requirements.

(a) The connector types shown on ICDs and ship installation plans shall not be deviated from, without authorized approval.

(b) The hookup configuration (pin-to-pin connection) of electrical connectors shall be in accordance with ICDs, Technical Manuals, ShipAlts and ship installation plans.

(c) Where connectors are installed on both ends of a cable, the conductors shall be connected to like contacts, for example, pin-A of one connector shall connect to pin-A of the other connector, except for special installations that require interfacing of equipments not normally designed for use in a common system.

(d) The assignment of conductors to connector pin numbers by color code or conductor number shall be in accordance with MIL-STD-1683. Where the conductor assignment shown on ICDs differs from that shown in MIL-STD-1683, the conductor assignment shall be as shown in MIL-STD-1683.

(e) Electrical connectors, once installed, become a part of the shipboard cable and shall be subjected to the applicable test requirements for that specific cable.

(f) Crimping tools, insertion and extraction tools shall be selected from MIL-STD-1646 and comply with the requirements of MIL-C-22520 and MIL-T-81969.

(g) Crimp contact connectors shall have contacts and sealing plugs installed in all unused positions.

(h) Assembly tools used to hold the coupling end of connectors shall comply with MS3480 for MIL-C-5015 connectors, MS3481 for MIL-C-26482 connectors and MS3482 for MIL-C-81511 connectors. Figure 2-31 is a representative drawing of MS3480 tools for MIL-C-5015 connectors.

(i) Assembly tools used to tighten the accessory hardware (backshell assemblies) should be cushion-jaw pliers or strap wrenches similar to those illustrated in Figure 2-32.

(j) Electrical connectors exposed to the weather, salt spray, moisture and stack gasses shall be weatherproofed within 24 hours after assembly.

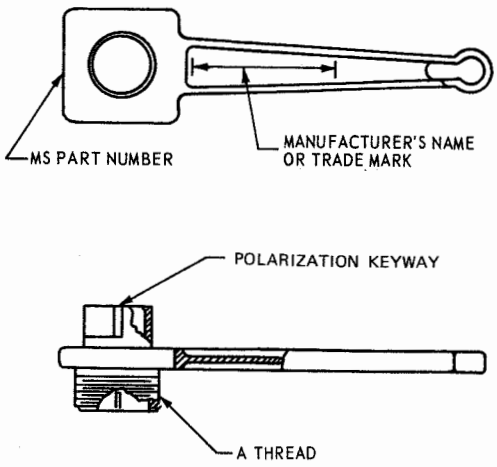


Figure 2-31. Connector Assembly Tool

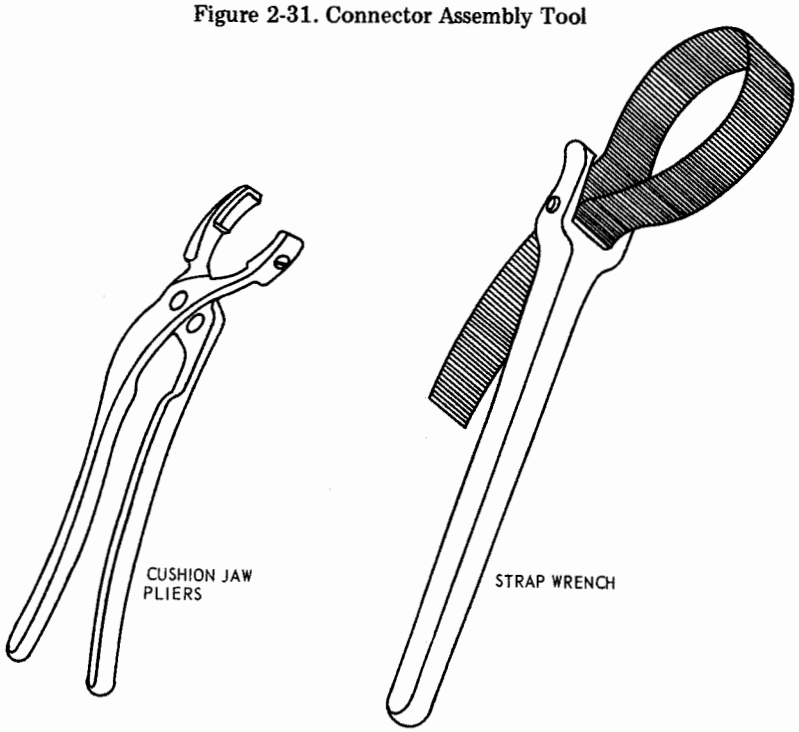


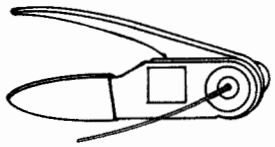
Figure 2-32. Connector Accessory Tools

The weatherproofing method used shall comply with paragraph 2-20.3.

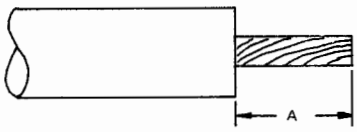
(k) Weatherproofed connectors shall be checked at least monthly for signs of deterioration. At the first signs of deterioration, the old weatherproofing shall be removed, the connectors checked for damage and replaced if necessary. The sealing area should be thoroughly cleaned and new weatherproofing applied.

2-21.3 CONTACT CRIMPING INSTRUCTIONS

The following instructions including Figure 2-33 provides guidance for the proper crimping of MIL-C-5015 connector contacts with MIL-C-22520 crimping tools.



MIL-C-22520 CRIMPING TOOL



MIL-C-915 CABLE CONDUCTOR

CONDUCTOR STRIPPING DIMENSIONS	
CONDUCTOR SIZE (AWG)	A DIMENSION (INCHES)
20	0.210
16	0.250
12	0.250
8	0.500
4	0.500
0	0.625

Figure 2-33. Crimp Contact Conductor Stripping Dimensions

Step 1. Remove a section of jacket from cable end to be terminated and clean conductors. The proper length of exposed conductors will depend upon type of connector and backshell assembly required for installation.

Step 2. Where cable being terminated has shielded conductors or an overall shield to be terminated in specified contacts, prepare the shields in accordance with the requirements of paragraph 2-19.3.

Step 3. Strip insulation from conductor ends in accordance with stripping dimensions shown in Figure 2-33 for the specified conductor size. Do not cut, nick or pick wire strands.

Step 4. Select the correct basic crimping tool and positioner (turret head) from MIL-STD-1646 for type contact to be crimped.

Step 5. Release the contact locator, rotate to correct contact size and push back into its latched position flush with body of crimping tool.

Step 6. Adjust the selector to the correct wire size to be crimped. Cycle the tool once to be sure the indentors are fully open.

Step 7. Before inserting the contact, inspect it to be sure it is not bent. Bent contacts should never be straightened and used. They should be replaced.

Step 8. Insert the contact, with stripped conductor in place, as far as it will go into the proper locator.

Step 9. Squeeze the tool handles together. The tool will not release the contact unless the indentors in the tool head have been fully actuated.

Step 10. Release the tool handles and remove the conductor with crimped on contact. Inspect the contact to see that the wire is visible through the inspection hole. The end of conductor insulation should be within 0.0625 inch of crimped contact.

Step 11. Check contact after crimping for distortion. If excess distortion occurs, change setting of crimp tool and recrimp a new contact on the conductor.

2-21.4 CONTACT INSERTION INSTRUCTION

The following instructions including Figure 2-34 provides guidance for the proper insertion of crimped contacts in MIL-C-5015 front release connectors.

Step 1. Remove the end bell assembly from the shell or barrel. Slide end bell and backshell assembly in the proper order over the prepared cable end for reassembly after all the required contacts are crimped.

Step 2. Insert a wired contact into the rear of the soft, integral rear grommet (see Figure 2-34). Push the contact forward until the shoulder of the contact is slightly exposed behind the grommet.

Step 3. Select the correct insertion tool for the connector being assembled from MIL-STD-1646. The same tool fits both pins and sockets.

Step 4. With the connector held secure, position the correct insertion tool over the rear of the contact with front of tool against rear contact shoulder. No insertion tool is required for size 8 contact and larger because the conductor is stiff enough to push contact into place.

Step 5. Apply firm, steady pressure pushing the contact through the resilient sealing barriers and into the hard insulator until the contact bottoms. Just prior to bottoming, a snap may be heard as the contact retaining spring snaps into the locking groove on the contact. Overinsertion is impossible. Remove insertion tool and pull on conductor to ensure contact has locked in place. If contact does not lock into position, check contact for correct size or malformation and replace if necessary.

Step 6. Repeat *steps 4* and *5* for remainder of contacts working from one side of insulator to the other.

Step 7. After all wired contacts have been installed, fill empty cavities with unwired contacts and sealing plugs. This assures a good seal and provides spare contacts for field use.

Step 8. Make a visual inspection to see that all contacts have been inserted fully and correctly in accordance with ICDs. Reassemble end bell and backshell assembly accordingly.

Figure 2-34. Insertion Tool Application for Crimp Contacts

2-21.5 CONTACT REMOVAL INSTRUCTIONS

The following instructions including Figure 2-35 provide guidance for the proper removal of crimped contacts from MIL-C-5015 front release connectors.

Step 1. Disassemble and slide backshell assembly back over the cable.

Step 2. Select the correct removal tool for the connector and being disassembled from MIL-STD-1646. The same tool fits over both pins and sockets.

CAUTION

When removing contacts crimped to AWG-4 size conductors and larger, all the connector contacts must be released with the removal tool and moved back enough to assure disengagement from the retaining spring. This is to counteract the rigidity and springback of the heavier conductor. When all contacts are released the connector is disengaged from the cable. The problem can now be corrected.

Step 3. Sheath the front of the contact with the proper size removal tool and push with rear of tool to fully bottom the tool tip by slightly rotating the rear of tool in a clockwise direction. This opens the contact retaining spring, releasing the contact. (No added pressure on the rear of the tool will aid removal.) With the tip bottomed, push the thrust sleeve forward moving contact back through the sealing barriers. When removing contacts crimped to No.-8 size conductors and larger, you must assist the tool. After the tool has bottomed on these larger sizes, releasing the contact, pull back on the wire at the rear of the connector to overcome wire rigidity while using the thrust sleeve.

Step 4. To reassemble, repeat *steps 3* through *8* of the contact insertion instructions in paragraph 2-21.4.

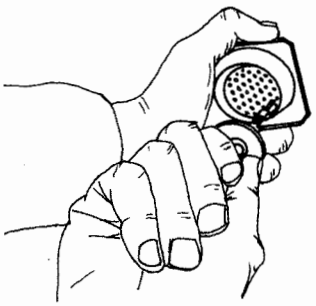


Figure 2-35. Removal Tool Application for Crimp Contacts

2-21.6 STYLE 1 - TYPE A SHIELD ENVIRONMENTAL BACKSHELL ASSEMBLY INSTRUCTIONS

The following instructions including Figure 2-36 provide guidance for the proper assembling of style 1 - type A shield environmental backshells. These instructions are applicable to MS3437 straight backshells, MS3188 ninety degree backshells and

MS3189 forty-five degrees backshells for MIL-C-5015 crimp connectors, MIL-C-81703 series 3 crimp connectors and MIL-C-26482 series 2 crimp connectors. The MS3437 straight backshell assembly is shown in Figure 2-36 for ease of identification.

These instructions are applicable to installations requiring the overall shield of a multiconductor cable to be terminated (grounded) to the connector housing (backshell) and be environmentally sealed.

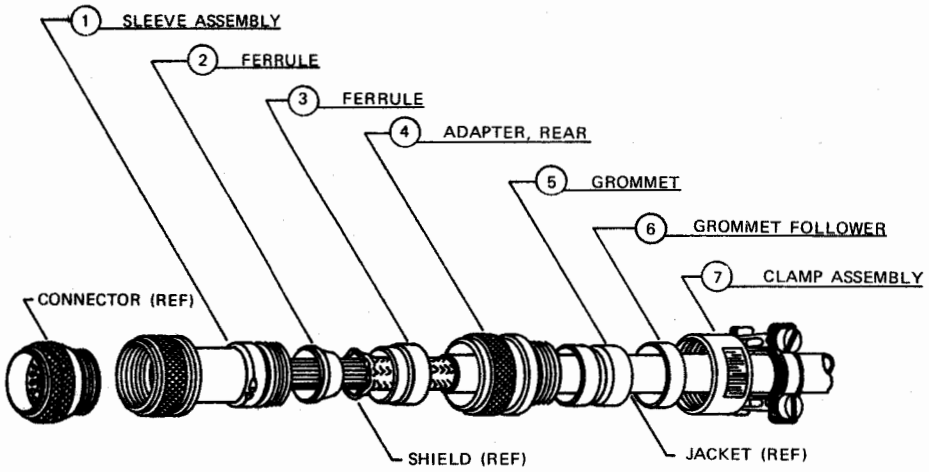


Figure 2-36. Style 1 - Type A Shield Environmental Backshell Assembly Breakdown

The numbers in parentheses refer to the component numbers shown in Figure 2-36.

Step 1. Temporarily assemble sleeve (1) to connector.

Step 2. Place remaining backshell assembly components (2) through (7) on cable in sequence shown in Figure 2-36. Keep these components at a convenient distance from end of cable, so they will not interfere with subsequent assembly steps.

Step 3. Insert cable into sleeve (1) and bottom against connector. Hold cable in position and mark cable jacket at rear end of sleeve (1).

Step 4. Remove sleeve (1) from connector and place on cable with components in *step 2* above.

Step 5. Trim cable jacket and shield at mark made in *step 3*. See MIL-STD-1683 for specific conductor to contact assignments and allow sufficient length for conductor crossovers.

Step 6. Strip jacket 0.5 inch back from trim point in *step 5* to expose shield.

Step 7. Prepare and terminate conductors in accordance with contact crimping instructions of paragraph 2-21.3 and MIL-STD-1683.

Step 8. Insert the conductors with crimped contacts in connector in accordance with contact insertion instructions of paragraph 2-21.4.

Step 9. Assemble sleeve (1) to connector and tighten securely using applicable tools in accordance with paragraphs 2-21.2(h) and 2-21.2(i).

Step 10. Flare shield over tapered end of ferrule (2) and slide the other ferrule (3) into place over shield. Trim any exposed ends of shield strands.

Step 11. Engage ferrule (3) with sleeve (1) and tighten securely. Ensure that there is no stress on terminated conductors.

Step 12. Engage rear adapter (4) on sleeve (1) and tighten securely.

Step 13. Insert grommet (5) and grommet follower (6) into rear adapter (4).

Step 14. Engage clamp assembly (7) to rear adapter (4) and tighten securely.

Step 15. Tighten saddle clamps securely around cable jacket.

Step 16. Test for correctness of hookup, continuity, and insulation resistance.

2-21.7 STYLE 1 - TYPE A ARMOR ENVIRONMENTAL BACKSHELL ASSEMBLY INSTRUCTIONS

The following instructions including Figure 2-37 provide guidance for the proper assembling of style 1 - type A armor environmental backshells. These instructions are applicable to MS3437 straight backshells, MS3188 ninety degree backshells, and MS3189 forty-five degree backshells for MIL-C-5015 crimp connectors, MIL-C-81703 series 3 crimp connectors and MIL-C-26482 series 2 crimp connectors. The MS3437 straight backshell assembly is shown in Figure 2-37 for ease of identification.

These instructions are applicable to special installations requiring armored cable.

The numbers in parentheses refer to the component numbers shown in Figure 2-37.

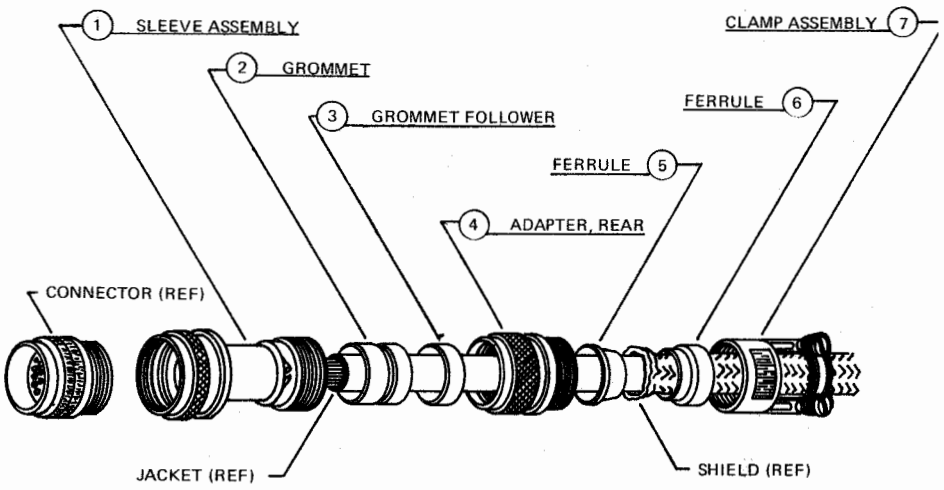


Figure 2-37. Style 1 - Type A Armor Environmental Backshell Assembly Breakdown

Step 1. Temporarily assemble sleeve (1) to connector.

Step 2. Place remaining backshell assembly components (2) through (7) on cable in sequence shown in Figure 2-37. Keep these components at a convenient distance from end of cable, so they will not interfere with subsequent assembly steps.

Step 3. Insert cable into sleeve (1) and bottom against connector. Hold cable in position and mark cable armor 0.250 inch from rear end of sleeve (1).

Step 4. Remove sleeve (1) from connector and place on cable with components in *step 2* above.

Step 5. To expose individual cable conductors, trim jacket as follows: For clamp sizes 8 and smaller, trim jacket at a point 0.375 inch forward (toward connector) from mark made in *step 3*. For clamp sizes 10 and larger, trim jacket 0.50 inch forward of mark made in *step 3*. See MIL-STD-1683 for specific conductor to contact assignments and allow sufficient length for conductor crossovers.

Step 6. Trim armor as follows: For clamp sizes 8 and smaller, trim armor 1.125 inches from end of jacket (0.750 inch from *step 3* mark). For clamp sizes 10 and larger, trim armor 1.50 inches from end of jacket (1 inch from *step 3* mark).

Step 7. Prepare and terminate conductors in accordance with contact crimping instructions of paragraph 2-21.3 and MIL-STD-1683.

Step 8. Insert the conductors with crimped contacts in connector in accordance with contact insertion instructions of paragraph 2-21.4.

Step 9. Assemble sleeve (1) to connector and tighten securely using applicable tools in accordance with paragraphs 2-21.1(h) and 2-21.2(i).

Step 10. Slide grommet (2) and grommet follower (3) into sleeve (1).

Step 11. Engage rear adapter (4) with sleeve (1) and tighten securely.

Step 12. Slide inner ferrule (5) into rear adapter (4).

Step 13. Flare armor over inner ferrule (5) and slide outer ferrule (6) into place over armor. Trim excess armor strands.

Step 14. Loosen rear adapter (4) slightly and gently force cable towards connector until inner ferrule bottoms out inside rear adapter (4). Retighten rear adapter (4).

Step 15. With outer ferrule (6) in place as in *step 13*, engage clamp (7) and tighten securely.

Step 16. Tighten saddle clamps securely around cable armor.

Step 17. Test for correctness of hookup, continuity, and insulation resistance.

2-21.8 STYLE 1 - TYPE B ENVIRONMENTAL BACKSHELL ASSEMBLY INSTRUCTIONS

The following instructions including Figure 2-38 provide guidance for the proper assembling of style 1 - type B environmental backshells. These instructions are applicable to MS3437 straight backshells, MS3188 ninety degree backshells, and MS3189 forty-five degree backshells for MIL-C-5015 crimp connectors, MIL-C-81703 series 3 crimp connectors and MIL-C-26482 series 2 crimp connectors. These instructions are also applicable to MS3400DJ, MS3401DJ, MS3406DJ, MS3408DJ and MS3409DJ connector assemblies. The type B environmental backshell assembly is the most widely used assembly because of its applicability to shielded and unshielded MIL-C-915 cables.

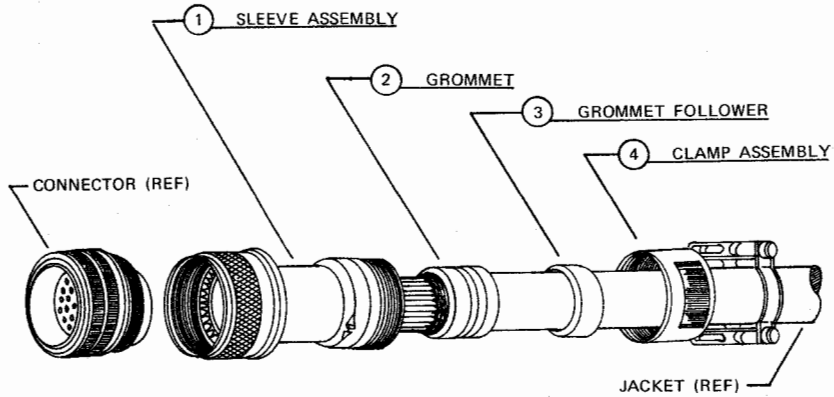


Figure 2-38. Style 1 - Type B Environmental Backshell Assembly Breakdown

The numbers in parentheses refer to the component numbers shown in Figure 2-38.

Step 1. Temporarily assemble sleeve (1) to connector.

Step 2. Place grommet (2), grommet follower (3) and clamp (4) on cable in sequence shown in Figure 2-38. Keep these components at a convenient distance from end of cable, so they will not interfere with subsequent assembly steps.

Step 3. Insert cable into sleeve (1) and bottom against connector. Hold cable in position and mark cable jacket at rear end of sleeve (1).

Step 4. Remove sleeve (1) from connector and place on cable with components in *step 2* above.

Step 5. Trim cable jacket at mark made in *step 3* above. Depending on type of connector contact termination (solder, crimp, etc.) the length of individual conductors may require shortening by 0.750 inch to assure that the cable jacket will be in proper position when grommet (2) is clamped. See MIL-STD-1683 for specific conductor to contact assignments and allow sufficient length for conductor crossovers.

Step 6. Prepare and terminate conductors, and shields where applicable, in accordance with contact crimping instructions of paragraph 2-21.3.

Step 7. Insert the terminated conductors, and shields where applicable, in connector in accordance with contact insertion instructions of paragraph 2-21.4 and MIL-STD-1683.

Step 8. Assemble sleeve (1) to connector and tighten securely using applicable tools in accordance with paragraphs 2-21.2(h) and 2-21.2(i).

Step 9. Slide grommet (2) into sleeve (1) and position grommet follower (3) on grommet (2).

Step 10. Attach clamp (4) to sleeve and tighten securely.

Step 11. Tighten saddle clamps securely around cable jacket.

Step 12. Test for correctness of hookup, continuity, and insulation resistance.

2-21.9 STYLE 1 - TYPE C SHIELD TERMINATED TO BACKSHELL ASSEMBLY INSTRUCTIONS

The following instructions including Figures 2-39 and 2-40 provide guidance for the proper assembling of style 1 - type C shield terminating backshells. These instructions are applicable to MS3437 straight backshells, MS3188 ninety degree backshells for MIL-C-5015 crimp connectors, MIL-C-81703 series 3 crimp connectors and MIL-C-26482 series 2 crimp connectors.

These instructions are applicable to installations requiring the overall shield or individual conductor shields of a multiconductor cable to be terminated (grounded) to the conductor housing (backshell) without being environmentally sealed.

The numbers in parentheses refer to the component numbers shown in Figures 2-39 and 2-40.

Step 1. Temporarily assemble sleeve (1) to connector.

Step 2. Place ferrules (2 and 3) and clamp (4) on cable in sequence shown. Keep these components at a convenient distance from end of cable, so they will not interfere with subsequent assembly steps.

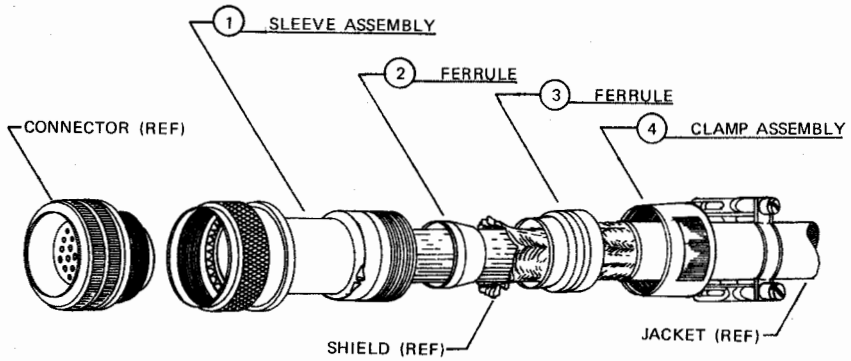


Figure 2-39. Style 1 - Type C Overall Shield Termination to Backshell - Assembly Breakdown

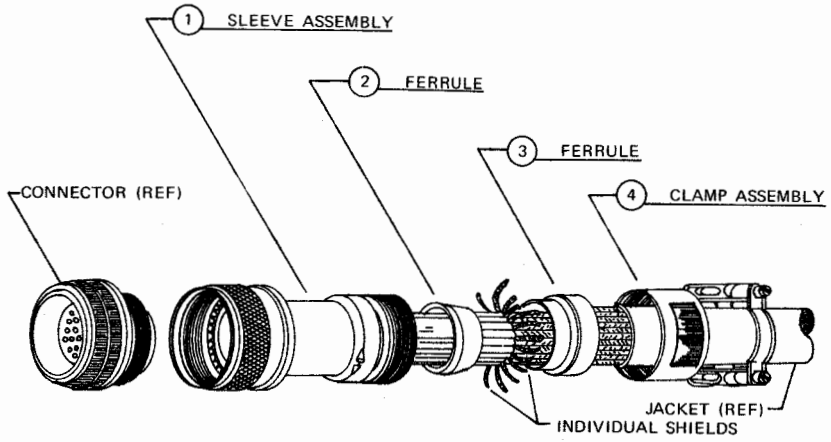


Figure 2-40. Style 1 - Type C Individual Shield Termination to Backshell - Assembly Breakdown

Step 3. Insert cable into sleeve (1) and bottom against connector. Hold cable in position and mark cable jacket at rear end of sleeve (1).

Step 4. Remove sleeve (1) from connector and place on cable with components in *step 2* above.

NOTE

For cables with overall shields do steps 5 and 6 and skip steps 7 through 9 and continue with steps 10 through 18. For cables with individual conductor shields skip steps 5 and 6 and continue with steps 7 through 18.

Step 5. Trim cable jacket and overall shield at mark made in *step 3* above.

Step 6. Strip cable jacket to expose shield: For clamp size 8 and smaller, strip jacket 0.375 inch from trim point made in *step 5*; for clamp sizes 10 and larger strip jacket 0.50 inch from trim point made in *step 5*.

NOTE

Steps 7 through 9 apply to cables with individually shielded conductors.

Step 7. Trim jacket 0.50 inch back from

mark made in *step 3*.

Step 8. Prepare each conductor shield by the pigtail method described in paragraph 2-19.3(k).

Step 9. Cut off excess shield pigtails and comb out, arranging strands for uniform distribution around circumference of tapered end of inner ferrule (2). Where cables have both individual shields and an overall shield, care should be used to ensure that all shields make firm contact between the inner ferrule (2) and outer ferrule (3).

Step 10. Prepare and terminate conductors in accordance with crimping instructions of paragraph 2-21.3.

Step 11. Insert the terminated conductors in connector in accordance with contact insertion instructions of paragraph 2-21.4 and MIL-STD-1683.

Step 12. Assemble sleeve (1) to connector and tighten securely using applicable tools in accordance with paragraph 2-21.2(h) and 2-21.2(i).

Step 13. Slide inner ferrule (2) into sleeve (1) and bottom out.

Step 14. Flare shield (prepared in *steps 5* and *6*) or shields (prepared in *steps 7, 8* and *9*) over tapered end of inner ferrule (2) and gently force cable toward connector until shield or shields cover taper on ferrule (2).

Step 15. Insert outer ferrule (3) into sleeve (1) over shield or shields.

Step 16. Attach clamp (4) to sleeve (1) and tighten securely.

Step 17. Tighten saddle clamps securely around cable jacket.

Step 18. Test for correctness of hookup, continuity and insulation resistance.

2-21.10 STYLE 2 ADAPTER TRANSITION BACKSHELL ASSEMBLIES

The following instructions including Figure 2-41 provides guidance for the proper assembling of style 2 adapter transitions to type B backshell assemblies. The adapter transition assembly is required where the existing shell size is too small for interfacing with a backshell assembly selected for a specific cable diameter. These instructions are written for use with the backshell assembly described in paragraph 2-21.8 but are easily adaptable to the instructions covered in paragraphs 2-21.6, 2-21.7 and 2-21.9.

Procurement information for style 2 adapter transition backshell assemblies can be found on MS3437, MS3188, and MS3189 standard drawings.

The numbers in parentheses refer to the component numbers shown in Figure 2-41.

Step 1. Temporarily assemble sleeve (1) to adapter transition assembly and adapter transition assembly to connector.

Step 2. Place grommet (2), grommet follower (3) and clamp (4) on cable in sequence shown in Figure 2-41. Keep these components at a convenient distance from end of cable, so they will not interfere with subsequent assembly steps.

NOTE

When assembling other type backshells, substitute the appropriate step in lieu of the above.

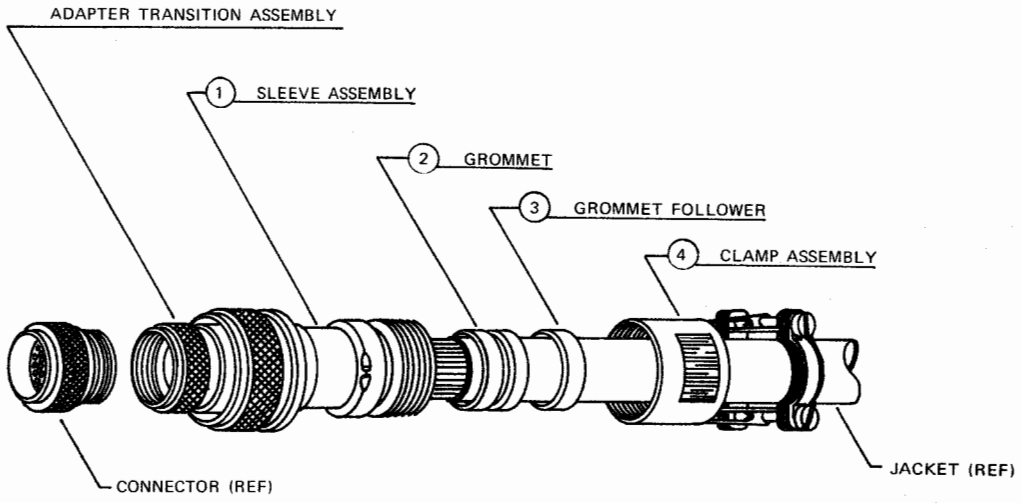


Figure 2-41. Style 2 - Type B Environmental Backshell Assembly Breakdown

Step 3. Cut back cable jacket approximately 1.50 inches from cable end. This is to reduce overall cable diameter so the conductors can bottom against connector.

Step 4. Insert cable end prepared in *step 3* into sleeve (1) and adapter transition assembly and bottom against connector. Hold cable in position and mark cable jacket at rear end of sleeve.

Step 5. Remove sleeve (1) from adapter transition assembly and place on cable with components in *step 2* above.

Step 6. Trim cable jacket at mark made in *step 4* above. Depending on type of connector contact termination, the length of individual conductors may require shortening by 0.750 inch to assure that the cable jacket will be in proper position when grommet (2) is clamped. See MIL-STD-1683 for specific conductor to contact assignments and allow sufficient length for conductor crossovers.

Step 7. Prepare and terminate conductors, and shields where applicable, in accordance with contact crimping instruction of paragraph 2-21.3 and MIL-STD-1683.

Step 8. Remove adapter transition assembly from connector and place on cable with components in *step 2* above.

Step 9. Insert the terminated conductors, and shields where applicable, in connector in accordance with contact insertion instructions of paragraph 2-21.4.

Step 10. Assemble adapter transition assembly to connector and sleeve (1) to adapter transition assembly and tighten securely using applicable tools in accordance with paragraphs 2-21.2 (h) and 2-21.2 (i).

Step 11. Slide grommet (2) into sleeve (1) and position grommet follower (3) on grommet (2)

Step 12. Attach clamp (4) to sleeve and tighten securely.

Step 13. Tighten saddle clamps securely around cable jacket.

Step 14. Test for correctness of hookup, continuity and insulation resistance.

SECTION 3
SUPPORT EQUIPMENT

SECTION 3
SUPPORT EQUIPMENT

3-1 INTRODUCTION

A shipboard electronic system installation involves much more than installing the electronic enclosures and associated cabling. The complexity, design and operational functions of an electronic system or equipment determines the type of support equipment or systems required to complete the shipboard installation. For some fire control system installations the electronic equipment installation is considered as the support equipment. Regardless of the classification (support or otherwise) placed on an equipment or system, if it interfaces with electronic equipments or is required for use with electronic equipment (such as test equipment, shorting probes or warning signs) the installation requirements, methods and procedures either referenced or stated throughout this handbook shall apply.

3-2 PURPOSE

The purpose of this section is to make the Installer aware of the importance of electronic support equipment or systems, and the Installer's responsibility to ensure the installation of support equipment is comparable with the associated electronic equipment or system and does not degrade either system.

3-3 SCOPE

The intent of this section is to assist the Installing Activity in obtaining the optimum installation through the referencing of appropriate documentation and general requirements. Where conflict arises the requirements of NAVSEA 0902-LP-001—5000 shall take precedence over all other documents referenced or requirements stated herein.

3-4 SELECTION

The selection of support equipment/systems and items for shipboard electronic installations is determined by the cognizant Government activity based on the electronic equipment/system requirements, type ship and its function in the fleet. The Government either provides the equipment or item to the Installing Activity, or provides sufficient parameters for procurement and/or fabrication by the Installing Activity through guidance documents such as ICDs, ShipAlts and Standard Drawings.

3-5 SUPPORT EQUIPMENT/SYSTEMS INSTALLATION REQUIREMENTS

Support equipment/systems shall provide the functional capabilities required by the ICDs, Standard Drawings, and/or equipment Technical Manuals for a specific electronic equipment/system.

The Installing Activity shall ensure the support equipment/systems installation complies with the methods, materials, procedures, and requirements stated and/or referenced herein.

3-5.1 COMPRESSED AIR SYSTEMS

Compressed air systems that interface with electronic equipment shall comply with the requirements of MIL-STD-1399 Section 106.

3-5.2 DRY AIR SYSTEMS

Dry air systems that interface with electronic equipment shall comply with the requirements of MIL-STD-1399 Section 102.

Dry air systems that interface with RF transmission lines shall comply with the requirements of Section 5 of this document.

3-5.3 COOLING WATER SYSTEMS

Cooling water systems that interface with electronic equipment shall comply with the requirements of MIL-STD-1399 Section 101.

3-5.4 FIRE CONTROL SYSTEMS

Fire control systems that interface with electronic equipment shall comply with the requirements of MIL-STD-1399 Section 501.

3-5.5 CONNECTION BOXES

Connection boxes are required in complex shipboard electronics systems to provide multiple data paths through interconnecting cables to or from equipment with limited connections.

Connection boxes, often referred to as juction, branch, terminal or distribution boxes, consisting of an enclosure containing terminal board/s, provides a means of terminating jacketed cable in an approved method that will keep signal loss at a minimum and still provide multiple signal data paths.

Connection boxes shall be installed when specified in ICDs, ShipAlts, Technical Manuals or ships installation drawings.

Some electronic systems supply special connection boxes as a part of the equipment or have the capability for multiple inputs or outputs designed

into the system. For electronic systems requiring connection boxes, and they are not supplied with the equipment, the Installing Activity shall select, locate and install the required connection boxes in accordance with the following requirements.

(a) Connection boxes shall be selected from NAVSEA Standard Drawings, utilizing NAVSEA 0960-LP-000-4000 as a selection tool, and applied into the system as dictated by the function and arrangement of the distribution circuits.

(b) The size of connection boxes selected for the electronics system shall be the nearest standard size box suitable to accommodate the actual number of installled circuits unless specified otherwise on ICDs or Standard Drawings. No provision shall be made for spare circuits in such boxes, other than excess box capacity resulting from the above selection.

For complex systems of which there is no standard connection box of sufficient size, the Installing Activity shall fabricate or procure a connection box in accordance with the applicable specifications of MIL-E-24142.

(c) Connection boxes shall be fitted with terminal tubes to maintain their watertightness except where the wiring equipment is located in enclosed spaces above the watertightness level, or where the wiring equipment is located in a compartment below the watertightness level and the omission of the terminal tubes would not result in the loss of otherwise operable portions of a system in the event the compartment was flooded.

Connection boxes located below access coaming or false decks shall be watertight.

(d) The methods of NAVSEA Drawing 9000-S6202-73980 shall be used for the installation of connection boxes.

(e) Connection boxes shall be installed for ready access to conductor connections.

(f) Connection boxes shall be located within the ships structure where possible.

(g) Where possible, cable should enter through bulkhead and mounting surface for connection boxes that must be located outside ships' structure.

(h) Wiring diagrams showing terminal board configurations, conductor terminations and jumpers where applicable shall be provided inside all connection boxes.

3-6 SAFETY SUPPORT EQUIPMENT/ ITEMS

Safety support equipment or items shall provide the functional capabilities required by the ICDs, Standard Drawings, and/or Technical Manuals for the applicable electronic installation.

The Installing Activity shall ensure safety support equipment or items are installed in accordance with the methods, materials, procedures and requirements stated and/or referenced herein.

3-6.1 SAFETY DISCONNECT SWITCHES

Each item of electronic equipment connected directly to the ships' electrical power distribution system shall be provided with switches for disconnecting the equipment from the electrical power distribution system and any other power sources. These disconnect switches shall be located within the compartment or space in which the equipment is located. When practicable electronic equipment distribution panels or boxes with switches,when located within the compartment or space, shall be used as the disconnecting means. Where the electronic equipment distribution panel or box is located outside the compartment or space it serves, single disconnect switches located as close as practicable to the equipment it serves shall be used. All remotely located items of an electronic system shall have safety disconnect switches that will allow independent disconnect of the electrical power in the associated equipment.

3-6.2 CIRCUIT DISABLEMENT

Each item of electronic equipment with inputs of 30 (rms) volts or greater existing within the equipment which cannot be disabled by that system's main power switch, shall have disconnect switches or protective devices and special warning signs (label plates). Radar indicators are included in this requirement. The maintenance (input signal) disconnect switch for radar indicators shall be installed as close as practicable to its associated indicator.

3-6.3 ANTENNA SAFETY DISCONNECT SWITCH

Safety disconnect switches shall be installed for all rotatable antennas (except submarine and ECM antennas) that will disable antenna rotation and equipment radiation prior to personnel entering the antenna swing circle. The antenna safety disconnect switch shall be located as near the antenna as practicable and easily accessible. The antenna safety disconnect switch shall not have by-pass capabilities except for systems that require a battle short switch.

3-6.4 BATTLE SHORT SWITCH

When required by the individual equipment specifications, a battle short switch shall be provided on the main operating console or assembly to short circuit all safety interlocks and antenna safety disconnect switches where applicable. An indicator light readily visible to personnel shall indicate that the battle short switch is ON. The battle short switch

shall also illuminate all interlock indicator lights. Battle short switches shall not be added to any system by the Installing Activity without written authorized approval.

3-6.5 CONVENIENCE RECEPTACLES

Electronic equipment, including portable test equipment, installed aboard Naval ships shall not have convenience receptacles built into the system or unit. Government furnished and Installing Activity furnished electronic equipment which has an electrical convenience receptacle shall have the circuit de-energized and the receptacle covered with a blanking plate by the Installing Activity.

3-6.6 WARNING SIGNS

Warning signs are for the purpose of warning personnel of dangerous voltages, poisonous effects of stack gases, possible presence of explosive vapors, electromagnetic radiation hazards and other dangers which may cause injuries to personnel.

NAVSEA 0967-LP-000-0100 Section 3 may be used for guidance in the selection and procurement of warning signs. ANSI Z35.1 shall be used for design guidance for warning signs not covered by NAVSEA 0967-LP-000-0100.

3-6.7 SAFETY SHORTING PROBES

A general purpose safety shorting probe set shall be installed in each compartment or space containing electronic equipments. The safety shorting probe set including two probe tips and a stowage assembly shall comply with the latest revision of NAVSEA Drawing No. 5003000. The stowage assembly shall be located in a readily accessible area and the view shall not be blocked from the normal traffic or work area of the space.

The safety shorting probe, NSN No. 6625-00-146-1797, in accordance with NAVSEA Drawing RE-D2697984 has been superseded by the safety shorting probe that complies with NAVSEA Drawing No. 5003000-revision A, and shall not be installed in electronic compartments or spaces.

Special purpose shorting probes supplied with certain electronics equipments are not considered general purpose safety shorting probes and are to be used only with the equipment with which they are provided. The existence of these special purpose shorting probes do not relieve the requirements for a general purpose safety shorting probe set in each electronic equipment compartment or space.

The requirements of this paragraph are applicable to all new construction and ShipAlts in which the approved safety shorting probe set has not been previously installed.

SECTION 4
ANTENNAS

SECTION 4
ANTENNAS

4-1 INTRODUCTION

An antenna may be defined as a conductor or system of conductors used to radiate or receive electromagnetic energy. An efficient antenna system is an important link in the propagation and reception of this energy and the intelligence it conveys. This becomes very evident when an antenna failure occurs.

The radio frequency energy that is generated by the transmitter serves a useful purpose only when it is radiated into space in the form of electromagnetic energy. The antenna, as the interface between the transmitter and free space, is required to convert the power from the transmitter into electromagnetic energy as efficiently as possible and to direct this energy where it will be useful. Since the majority of antennas are used both for transmitting and receiving, the various properties of individual antennas apply to both modes of operation. Thus it is apparent that the antenna is a major element of the transmitting/receiving system, and it is of great importance that the best methods be used in the design and installation of shipboard antennas.

The complex structures of ships and their operational requirements necessitate the use of various types of antennas. These types include wire rope fans, whips, cages, dipoles, probes and trussed monopoles for communication systems as well as a wide variety of rotating antennas of all shapes and sizes required for radar, ECM, and fire control systems, not to mention the specially designed antennas for submarine installations. The selection and use of the different types is often governed by the limited space aboard ships. Because of these limitations, shipboard antennas are often compromises that provide the most efficient performance within imposed limitations.

4-2 PURPOSE

The purpose of this section is to make the installer aware of the limitations and constraints placed upon the overall antenna systems installed aboard Navy ships, and the installing activity's responsibility to ensure that antennas are located and installed in accordance with the latest approved documents referenced by a specific ship's specification or ShipAlt.

4-3 SCOPE

The intent of this section is to assist the installing activity in obtaining the optimum installation through the referencing of appropriate documentation and general requirements. Where conflict arises the requirements of NAVSEA 0902-LP-001-5000 shall take precedence over all documents referenced or requirements stated herein.

4-4 GENERAL REQUIREMENTS

The general requirements stated herein are applicable to shipboard installations of all types of antennas.

4-4.1 SELECTION

Antennas installed aboard Navy ships shall be the types shown on ICDs, equipment technical manuals, NAVSEA fire control drawings or ShipAlts. There shall be no deviation from the antennas types shown without authorized approval from NAVSEC 6170. For communication type antennas and associated equipment under the cognizance of Naval Electronic Systems Command, joint authorized approval shall be obtained from NAVSEC 6170 and NAVELEX 510.

4-4.2 LOCATION

The locating of antennas aboard Navy ships is a critical procedure and shall be accomplished only by qualified design activities. All shipboard antenna locations shall be approved by the Naval Ship Engineering Center SEC 6170. The locating of communication type antennas and associated equipment under the cognizance of Naval Electronic Systems Command, shall be jointly approved by NAVSEC 6170 and NAVELEX 510. There shall be no deviation of antenna locations without written approval of cognizant authority.

4-4.3 INSTALLATION

Shipboard antennas shall be installed in accordance with the following:

(a) Installation of communication antennas shall comply with the requirements of NAVSEA 0967-LP-177-3020.

(b) Installation of radar, fire control and ECM antennas shall comply with the applicable ICDs, technical manuals, ordnance drawings and specific antenna installation manuals.

4-4.4 FOUNDATIONS

Antenna foundations, brackets and supports shall comply with the applicable requirements of ICDs, ordnance drawings, and technical manuals. Communication antenna foundations, brackets and supports shall comply with the requirements of NAVSEA 0967-LP-177-3020 and the applicable requirements listed above.

4-4.5 PRESERVATION

The cleaning and painting of applicable antenna components shall comply with the applicable requirements of NAVSEA 0967-LP-177-3020, ICDs and ordnance drawings, technical manuals and specific antenna installation manuals.

4-4.6 PERSONNEL PROTECTION

Safeguards against RF radiation hazards and RF burn hazards, including the posting of warning signs at dangerous radiation areas, shall be provided in accordance with NAVSEA 0900-LP-005-8000 and NAVSEA 0967-LP-317-7010.

SECTION 5
WAVEGUIDES AND RIGID COAXIAL LINES

SECTION 5
WAVEGUIDES AND RIGID COAXIAL LINES

This section contains information and illustrations for shop fabrication and shipboard installation of rigid transmission lines. Guidance is provided to select transmission lines and fittings from Military Standards. Military Specifications are referenced for use in obtaining technical data.

This section shall be used with the standards and specifications referenced herein. The value of this section will be greatly decreased if copies of the standards and specifications referenced are not made a part of each appendix. Index cover sheets for each appendix are provided for the standards and specifications referenced herein.

The fabrication and illustration procedures shown in this section are for all approved shipboard rigid transmission lines. Exceptions or additions are covered where necessary for different metals.

All references made to military documents and nomenclature throughout this section were made to the basic document or nomenclature number. Unless otherwise stated the current issue, revision or modification shall prevail.

Section 5 is divided into six subsections as follows:

5-1 and 5-2 covers rectangular waveguide shop fabrication and shipboard installation.

5-3 and 5-4 covers rigid coaxial air dielectric transmission line shop fabrication and shipboard installation.

5-5 and 5-6 covers elliptical waveguide shop fabrication and shipboard installation.

The materials methods and procedures in subsections 5-1, 5-3 and 5-5 are for use by shore activity fabrication shops (military and commercial) and are not applicable for shipboard shops.

5-1 RECTANGULAR WAVEGUIDE

5-1.1 INTRODUCTION

A waveguide is a means of transferring electrical energy. Any material or combination of material, which will confine and propagate electrical and magnetic fields of radio frequency energy may be called a waveguide. See MIL-STD-242, Section 500, for selection of approved waveguide. For dimensions and details see MIL-W-85 or other specified documents.

A complete understanding of the wave propagation in a waveguide is not necessary for fabrication and installation. However, a general familiarity with the nomenclature and fabrication methods aid in understanding why emphasis should be placed on what appears to be insignificant points in waveguide fabrication. The proper type and size of waveguide is determined by the equipment designer and government. Any changes to types, parts or installation plans shall not be made without authorization.

In a typical shipboard installation, in relation to the transmittter the associated radiating antenna is remotely located. Therefore a transmission line is required to couple the transmitter to the antenna. The transmission line can be either rigid and flexible coaxial cable or rigid and flexible rectangular waveguide. Rectangular waveguide is preferable due to its higher energy handling capabilities and lower energy losses at certain frequencies. Rigid rectangular waveguide transmission line is fabricated from drawn tubing made of aluminum, bronze, copper, or silver. The waveguide is normally supplied in 10-foot to 14-foot sections. These sections are connected together by the use of the flanges which may or may not be attached when delivered.

When the transmitter or receiver is separated from the antenna which is usually located high on the superstructure or a mast, there are often many obstacles that have to be moved or bypassed. This results in the requirement for varying straight lengths, bends, twists, and flexible sections, when required, that will have to be procured or fabricated depending on their availability or the capabilities of the installer.

Although waveguide has a comparatively low inherent loss, other losses resulting from interior dimensional variance and surface finish discontinuities at bends, twists, and flanges, can be introduced which reduce efficiency of an electronic system. These variations in most cases are due to the equipment used in bending and twisting waveguide or the lack of knowledge or experience. When planning a waveguide run, it is important that it be short and as straight as possible. This means installing the minimum of bends, twists and flanges. This along with ensuring that the bends, twists, and flanges are properly fabricated and installed will help ensure the equipment performing as it was designed. This section will be devoted primarily to giving the fabricator and installer a better idea of the problems he will encounter and how to plan and estimate the work required in waveguide installation. Further, it will show which standards are used for selection of material and which military specifications are used for details for any given item or work process required. This information would supplement ship installation plans which are developed from the Installation Control Drawings(ICD) for specific equipments.

5-1.1.1. Waveguide Accessories

To facilitate installing straight sections of waveguide the following accessories are available. For selection of approved accessories see MIL-STD-242 or other specified documents.

5-1.1.1.1 Bend Assemblies

Waveguide bend assemblies shall not be indiscriminately installed for alignment purposes or to clear an object that is blocking the waveguide run. If relocating the interfering object is impossible or impracticable, then bends may be installed. These shall be 45°, 60°, or 90° degree bends procured in accordance with MIL-W-3970 (see Appendix 5-E). Where bends of a different angle or radius are required, or the number of waveguide joints is reduced as a result of fabricating a section of waveguide with multiple bends, they shall be fabricated in accordance with the procedures outlined in this document and shall meet the requirements of MIL-W-3970. The procedures of this document for bending waveguide are not applicable to waveguides of 6.5 inches or greater in width. Large waveguide bend assemblies shall be procured and meet the requirements of MIL-W-3970.

Fabricated bends shall be designed so that their physical bend length is an integral multiple of the half wavelength of the mid-frequency of the associated equipment. The extremities of a bend shall not be closer than one inch to the flange.

5-1.1.1. 2 Flexible Assemblies

Flexible waveguide assemblies shall be used only to compensate or eliminate excessive stress caused by different expansion and contraction rates of the ships structure, or excessive movement caused by vibration and shock. Flexible sections, when required, shall be as short as possible and installed at right angles to the direction in which the greatest movement shall occur. Flexible waveguides assemblies shall not be used for alignment purposes or to take up fixed slack in a run. Flexible sections shall be in a normal free state after installation, they shall not be stretched or compressed in order to mate with their interfacing components. Flexible sections shall meet the requirements of MIL-W-287 (see appendix 5-E).

5-1.1.1.3 Twist Assemblies

Twist assemblies shall be installed only when it is necessary to change the plane of the transmission

line run for interfacing with equipment that cannot be relocated. Standard twist assemblies in accordance with MIL-W-3970 shall be used wherever practicable (see Appendix 5-E). Where twist assemblies of a special length or degree of twist is not available through MIL-W-3970, and the waveguide wide dimension does not exceed 6.5 inches, they shall be fabricated in accordance with the procedures outlined in this document and shall meet the requirements of MIL-W-3970.

Fabricated twists shall be designed so that the twist does not exceed 90 degrees and the physical length is an integral multiple of the half wavelength of the mid-frequency of the associated equipment. The extremities of a twist shall not be closer than one inch to the flange.

5-1.1.1.4 Adapter Assemblies

Adapters are designed to allow changing from waveguide to coaxial cable when required. For types available and design data required see MIL-HDBK-216 and MIL-A-22641 (see Appendix 5-E).

5-1.1.1.5 Flanges

Flanges are used to connect waveguide and assemblies together. They are provided separately or supplied with various waveguide assemblies. For types and design data of the flange and gasket see MIL-F-3922 and MIL-G-24211 (see Appendix 5-C and 5-E). When flanges must be brazed on waveguide follow procedures outlined in 5-1.8 and 5-1.9.

5-1.1.1.6 Waveguide Pressure Windows

Pressure windows are required when waveguide is pressurized and the equipment it connects to is not pressurized. For types and design details of windows, if required, see a manufacturer's catalog for the waveguide specified.

5-1.2 TECHNICAL CAPABILITIES

The activity performing waveguide fabrication and shipboard installation shall have the following:

1. Ship or class waveguide installation plans.
2. Technical capability to bend, twist and flange waveguide.
3. Training programs for all trades involved in the process of fabricating, painting, and installing.
4. Area which can be protected and set up to suit waveguide fabrication (cleaning, annealing, bending, and painting).
5. Form bending machine or equal with metal shims or metal alloy.
6. Two support type twisting machines using metal alloy.
7. Quartz lamp brazing furnace or dip brazing equipment and appropriate alignment jigs for brazing flanges to waveguide.
8. Adequate facilities for brazing, cleaning, rinsing, and chemical conversion.
9. Procedures for inspecting dimensional and surface finishes of incoming and fabricated waveguide for compliance with MIL-W-85 or other documents as specified.
10. Procedures, facilities, and equipment for electrically and electronically testing fabricated waveguide.
11. Clean, dust-free paint area.
12. Procedures for handling waveguide while in storage, fabrication, and delivery to prevent damage; protection for inside finish, flange surfaces, and against distortion or denting the waveguide.

5-1.3 SHOP PREFABRICATION GUIDELINES

The inspection, storage, handling and layout design shall be in accordance with the following guidelines.

5-1.3.1 Inspection

Boxes containing waveguide shall be examined for breaks immediately upon receipt. A broken box is an indication that the contents could be damaged and shall be opened carefully in order to see that there is no appararent damage. Insure that the waveguide is supported properly and that waveguide ends of flanges are sealed to keep dirt and air out, and are protected against rough handling.

5-1.3.2 Storage

Whether left crated or uncrated, waveguide sections and components shall be stored in a cool, dry location to reduce minimum oxidation, and discoloration. Packed and unpacked sections shall be stored in a horizontal position and shall be supported to prevent distortion. Stored waveguide sections, fittings, parts, flange faces, and coupling edges shall be covered with heavy paper caps or lintless cloth to prevent damage and entrance of dust or other foreign matter.

5-1.3.3 Handling

When unpacking or handling waveguide, the box shall be placed so that it is resting firmly in a horizontal position. Box cover nails shall be removed with nail puller. Prying the cover off the box may dent some of the waveguide sections. Carefully remove collar blocks to avoid damaging. One of the end seals may be removed in order to examine a waveguide section before installation and shall be replaced after examination. The same protective care also applies to fittings, assemblies, and accessories. Rubber O-rings and other small parts and pieces are packed separately.

NOTE

Human perspiration and acid

from the skin have a detrimental effect on conductive surface. Therefore, conducting surfaces shall not be touched with bare hands. Clean cotton gloves shall be worn at all times when handling waveguide and fittings.

5-1.3.4 Layout of Waveguide Run

The design of a waveguide run shall be attempted only by qualified design personnel. No substitution or modification is to be made from Waveguide Installation Control Drawings and Installation Manuals without approval. The following factors should be kept in mind:

1. Waveguide run to be short and direct as possible.
2. Two "E" or two "H" bends shall not be connected directly together unless no other arrangement is possible.
3. Use as few bends and twists as possible.
4. Waveguide takes priority over vents, wireways, piping, lighting and similar obstructions.
5. Bends shall have the largest radius possible consistent with waveguide used. In no case must the bend radii or length of twist be less than that shown on ICDs or in MIL-HDBK-660. Prefabricated bends in accordance with MIL-W-3970 should be used if a very tight bend is required or if the installing activity does not possess either the skill or facilities required in MIL-HDBK-660 (see Appendix 5-E).
6. After receipt of ship waveguide installation plan showing the design and location of waveguide run, a template shall be made. This along with the waveguide installation plan, will provide the fabrication shop with accurate information as to length, shape, and angle of straight sections, bends and twists. Template fabrication details are defined in paragraph 5-2.3.

5-1.4 ANNEALING

Prior to bending waveguide it must be annealed. Annealing serves to soften and reduce brittleness in the waveguide. After annealing, the waveguide shall be allowed to cool at room temperature.

It should be noted that, depending upon the bend radius and size of waveguide and on method of bending, the cross section of the waveguide may become distorted with a thinner outside curved wall and wrinkled inside wall with trapezoidal shaped walls parallel to the plane of the bend, sometimes appearing as a buckle. The annealing process coupled with the proper use of mandrels can help prevent distortion. Annealing of waveguide shall be as specified in MIL-HDBK-660 (see Appendix 5-D).

5-1.5 MANDRELS AND FILLERS

Electrically the interior dimension and surface finish of the waveguide are the critical areas. Mandrels and fillers are used to keep distortion of the interior dimensions, or damage to the surface finish to a minimum during the bending or twisting process. For detailed bending and twisting information using mandrels and fillers see MIL-HDBK-660.

5-1.6 BENDING

All waveguide shall conform to MIL-W-85 or other documents specified for dimension and surface finish requirements prior to fabrication. Waveguide should not be bent unless interfering items cannot be relocated or factory bends cannot be used or are not available at the correct angle. Waveguide is bent in the "E" plane which is parallel to the short dimensions of the rectangular cross section or the "H" plane which is parallel to the long dimensions of the cross section (see Figure 5-1). Bends are more easily remembered by "E" for "EASY" and "H" for "HARD".

For minimum bend radius refer to MIL-HDBK-660 and Installation Control Drawings. Minimum bend radius and type of bends allowed may vary with the same waveguide depending on mid-frequency of the associated equipment. All bending shall be in accordance with MIL-HDBK-660 and the completed assembly shall meet the requirements of MIL-W-3970.

5-1.7 TWISTING

Twisting the waveguide is sometimes required in addition to bending because of clearance and support problems, and the relative position of equipment. As in the case of the bending process, waveguide walls will collapse if twisted without using a mandrel. Again the interior dimensions of the waveguide are, electrically, the critical dimensions. For minimum twist length refer to MIL-HDBK-660 and ICDs. There are several types of equipment used in fabricating twists in waveguide. The required annealing, use of twisting mandrels, and method of twisting shall be in accordance with MIL-HDBK-660. The completed assembly shall meet the requirements of MIL-W-3970.

5-1.8 FLANGES

Flanges for use with rectangular waveguide shall be selected from MIL-STD-1327 and meet the

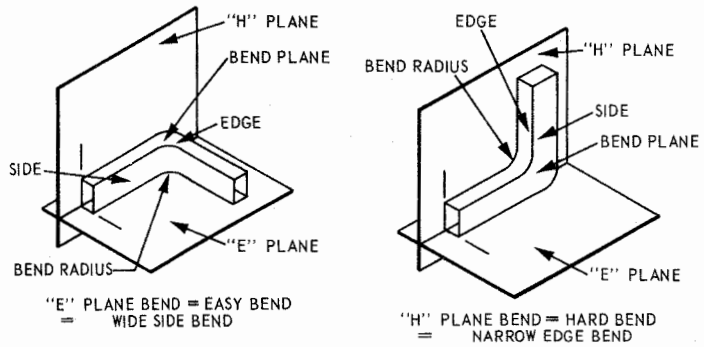


Figure 5-1. Waveguide Side and Bend Identification

requirements of MIL-F-3922.

Flanges shall be attached to rectangular waveguide in accordance with MIL-HDBK-660 and MIL-B-7883. Flanges are designed for attachment to waveguide by two general methods. One is the "through" type which allows the waveguide to pass all the way through the flange until it is flush with the flange face. The other type, called "socket", varies in that the waveguide does not pass through the flange but fits into a socket on the opposite side from the flange face.

Where an aluminum flange must mate with copper or brass flanges, zinc plate the copper or brass flange to prevent corrosion from electrolysis between dissimilar metals.

Flanges are classed into three general types as to the design of the flange mating face.

5-1.8.1 Contact Flanges

Contact flanges are designed with two types of mating surfaces. The flat faced type contact flange requires a gasket in accordance with MIL-G-24211 when used with a pressurized line. The grooved face type contact flange is supplied with a pressure seal in accordance with MIL-F-3922. Contact flanges are available in both the through type and socket type methods of attaching to the waveguide.

A contact flange mates with another contact flange with the same military part number or "UG" nomenclature. Contact flanges cannot be mated with a choke flange or cover flange.

5-1.8.2 Choke Flanges

Choke flanges are designed with a cavity between the choke and its associated cover flange that constitutes a half-wave shorted line in series with the waveguide, which presents a minimum electrical discontinuity. These flanges use the socket type method of attaching to the waveguide.

A gasket (pressure seal) is supplied with each choke flange.

Choke flanges must be mated with a cover flange designed with the same interface characteristics. See MIL-STD-1327, MIL-F-3922 and MIL-HDBK-216 for the mating choke and cover flanges assigned for a specific waveguide.

5-1.8.3 Cover Flanges

Cover flanges are designed as a mating flange for use with its assigned choke flange having the same interface characteristics. These flanges are attached to the waveguide either by the socket type method or the through method.

Gaskets for use with cover flanges are supplied as a part of the associated choke flange.

5-1.9 BRAZING

The general brazing requirements shall conform to MIL-HDBK-660 and MIL-B-7883 (see Appendix 5-D).

5-1.10 CLEANING AGENTS

The cleaning agents used to remove oil, grease, paint, scale, oxide, flux, conversion coatings, dirt or the neutralizer after acid baths shall not remove the parent metal or leave residue that would cause waveguide interior dimensions to exceed tolerances specified in the waveguide military specifications.

For cleaning details see MIL-HDBK-660, MIL-B-7883 and MIL-STD-645.

Observe the safety precautions for those coming in contact with, handling or using chemicals. Personnel handling alkaline or acidic cleaners shall wear protective face shields, rubber gloves and aprons. In case of contact with skin or clothing, flush with water immediately. In case of acid contact with skin or eyes, get medical attention as soon as possible.

5-1.11 CLEANING REQUIREMENTS

The installing activity shall comply with the following general requirements for cleaning waveguide during the fabrication process of waveguide assemblies.

(a) Bending alloy, if used, shall be thoroughly removed immediately after completion of the bending or twisting process and prior to the flange brazing process.

(b) All grease, oil, dirt, scale and chemical conversion coatings shall be removed from the brazing areas of the waveguide and flange prior to the attachment of flange to waveguide by the bracing process.

(c) After all fabrication work is completed, and prior to chemical conversion application, the waveguide assembly shall be thoroughly cleaned, rinsed and dried.

(d) The chemical conversion coating shall be applied immediately after the final cleaning has been accomplished.

5-1.12 SEALING AND PAINTING

The waveguide assembly shall be sealed against corrosion and receive a protective paint coating in accordance with the following.

5-1.12.1 Chemical Conversion

All interior and exterior surfaces of waveguide assemblies shall receive a chemical conversion coating. Aluminum waveguide assemblies shall have a chemical conversion coating in accordance with MIL-C-5541, class 3. Copper waveguide assemblies shall have a chemical conversion coating in accordance with Iridite No. 7P Mixture C, or the equivalent (see Appendix 5-D).

Prior to the application of the chemical conversion, ensure the waveguide assembly has been properly cleaned. The waveguide assembly shall be carefully handled throughout the coating process. Mechanical damage or contamination from uncovered hands or soiled gloves shall be avoided. Soiled areas shall be recleaned with either organic or inorganic solvent, or both, as required. Damaged areas from which the chemical conversion coating has been removed shall be repaired, recleaned and recoated.

5-1.12.2 Protection by Painting

The waveguide assembly, after completion of chemical conversion process, shall have the exterior surfaces (excluding flange faces) protected with an epoxy coating as shown in paragraph 5-1.13.16.

Ensure the waveguide assembly does not become contaminated or soiled between the chemical conversion process and the painting process. The waveguide assembly shall be sealed to prevent any paint getting on the interior surface of assembly or on the flange faces during the painting process.

5-1.13 SHOP FABRICATION PROCEDURE

Waveguide assembly fabrication is broken down into step by step procedures in the following subparagraphs in order to facilitate planning and quality control. For details on annealing, filler mandrels, bending, twisting, cutting and attaching flanges see MIL-HDBK-660 and MIL-B-7883 (see Appendix 5-D). For details on cleaning, sealing and painting requirements see paragraphs 5-1.10, 5-1.11, and 5-1.12.

5-1.13.1 Fabrication Data Procurement

Procure the necessary design information, plans or sketches required to install the waveguide run. Using ships installation plan, template waveguide run to determine exact dimensions of bends, twists and straight sections.

5-1.13.2 Annealing

Anneal the sections of waveguide that require bending or twisting. Check for proper annealing temperatures for type of metal being annealed.

5-1.13.3 Mandrel Selection

After completion of annealing process, select the correct mandrel or bending alloy required for the type of bend or twist to be made and the type of bending or twisting equipment used.

5-1.13.4 Bending and Twisting

Carefully bend or twist the specified section of waveguide to match the template dimensions. Ensure waveguide has been bent or twisted in accordance with design plans.

5-1.13.5 Surface Check

Check the quality of the waveguide surface that has been bent or twisted to ensure it has not been distorted with bulges, puckers and/or wrinkles.

5-1.13.6 Cutting

After completion of bending and twisting process, cut waveguide sections to the exact length determined from templates. Straight sections not requiring annealing, bending and twisting shall be cut to the proper length as determined by the waveguide run template.

5-1.13.7 Quality Assurance Check

Perform a quality assurance check, prior to cleaning for brazing, to inspect the waveguide as specified in paragraph 5-1.13.17 and 5-1.13.18.

5-1.13.8 Cleaning for Brazing

After satisfactory acceptance of the quality assurance check, clean the mating surfaces and adjacent areas of the waveguide and flanges of any foreign substance such as oil, paint, dirt, or scale that might interfere wtih the brazing. See paragraphs 5-1.10 and 5-1.11.

5-1.13.9 Flange to Waveguide Fit

Ensure the waveguide end is square in all three planes to within ±1/2 degree as shown in Figure 5-2. Fit the selected flanges to the waveguide. Ensure the choke flange, when used, is installed on the assembly in such a manner that the choke end faces the transmitter. When the flange is fitted to the waveguide in preparation for brazing, the clearance between mating surfaces shall be 0.002 inch to 0.010 inch for laps less than 0.250 inch long. Longer laps may require clearance up to 0.025 inch. The alignment fit between flange and waveguide shall not exceed 0.004 inch on the step. See Figure 5-3 for explanation of lap clearance and step alignment. Clearances and alignment shall be maintained during

the brazing operation.

When flanges designed for heavywall waveguide are not available, then either the waveguide or the selected flange shall be modified similar to the method shown in MIL-HDBK-660.

5-1.13.10 Brazing Operation

Brazing of flanges to waveguide shall be in accordance with MIL-HDBK-660, MIL-STD-645 and MIL-B-7883. The brazing method used should be determined by type of material to be brazed, physical size of material to be brazed and the type of shop equipment. Ensure the required clearance and alignment dimensions are maintained until the brazing operation is completed.

5-1.13.11 Hydrostatic Test

The waveguide assembly, after completion of brazing operation, shall be subjected to the internal air pressure in pounds force per square inch gage specified, while immersed in water. The air pressure shall not exceed the design specified pressure.

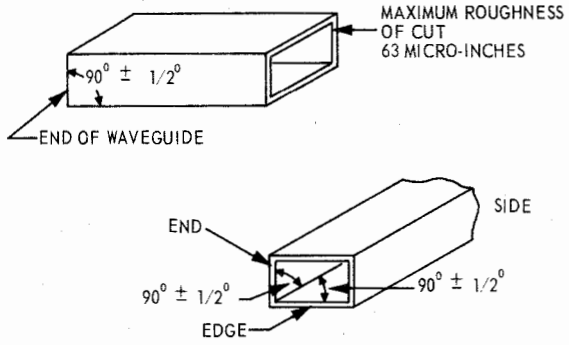


Figure 5-2. End View of Waveguide Showing Cutting Requirements

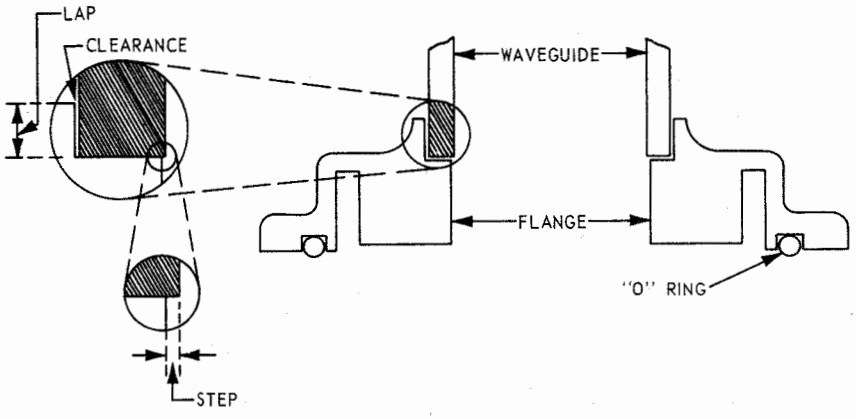


Figure 5-3. Alignment of Flange to Waveguide

NOTE

Excessive pressure will deform waveguide walls. The temperature of the water used for this test shall be 20°±5°C. Any bubbles coming from within the assembly shall be considered as leakage. Bubbles which are the result of entrapped air on the exterior parts of the assembly shall not be considered as leaks. The assembly under test shall remain immersed for a minimum of five minutes. Any indication of leakage during this time shall be reason for rejection of assembly.

5-1.13.12 Post Braze Cleaning

Post braze cleaning shall be accomplished immediately after the hydrostatic test and shall be in accordance with paragraphs 5-1.10 and 5-1.11.

5-1.13.13 Post Fabrication Inspection

A post fabrication inspection shall be conducted immediately after the post braze cleaning operation, for material condition, in accordance with paragraphs 5-1.13.17 and 5-1.13.18

5-1.13.14 Chemical Conversion Application

The chemical conversion coating shall be applied to the waveguide assembly upon satisfactory completion of post braze inspection. The chemical conversion coating shall be applied in accordance with paragraph 5-1.12.

5-1.13.15 Chemical Conversion Inspection

Inspect the chemical conversion coating for proper application to the interior and exterior surfaces, including flanges, of the waveguide assembly. Ensure the coating is in accordance with MIL-C-5541 for aluminum assemblies, and the coating manufacturers' instructions for copper alloy assemblies.

5-1.13.16 Painting of Assembly

Upon acceptance, and prior to shipboard installation, the waveguide assembly shall be painted in accordance with the following guidelines:

(a) Seal both flange surfaces to prevent paint accumulation on interior surface and on flange faces. A rubber gasket with blanking plate secured by utilizing the flange bolting holes is suggested.

(b) Clean surfaces with mineral spirits to remove dirt, grease, or other contaminants, being careful not to remove MIL-C-5541 chemically treated surfaces.

(c) Apply MIL-P-24441 epoxy polyamide coating system in accordance with the following:
The coating system shall consist of one coat of Formula 150 Primer - 2 to 4 mils dry film thickness; and two coats of Formula 151 (Haze Gray) - each coat 2 to 3 mils dry film thickness. Total minimum dry film thickness for coating system shall be 8.0 mils.

(d) Remove any trace of paint that may be on the flanges with a solvent and lint-free cloth. It is easier to remove the paint while it is still wet. Do not allow solvent to come in contact with the interior surface of the waveguide.

(e) When paint is dry, remove the flange covers.

(f) Do touch-up painting or other painting on board ship.

(g) Inspect paint finish.

(h) Seal both ends of waveguide assembly to prevent intrusion of moisture and foreign matter.

(i) Exercise extreme care when transporting the waveguide assembly.

(j) Store or ship the waveguide assembly to the point of installation.

NOTE

It is of prime importance that the waveguide be protected from physical damage and/or contamination during all phases of fabrication, shipping and installation. To ignore this may result in electronic malfunction or the rejection of the waveguide.

5-1.13.17 Fabrication Inspection

During the fabrication process and upon completion of all work, the waveguide assembly should be inspected for quality using the following guidelines and MIL-W-85 (see Appendix 5-A).

(a) The interior and exterior surfaces of the waveguide shall be bright, smooth, dry, and free of scales and oxides.

(b) The maximum bow that the waveguide may display is not more than 0.010 inch edgewise and 0.020 inch flatwise between any two points located two feet apart on the concave external surface of the waveguide. The waveguide shall be so positioned during the measurement that gravity will not tend to increase the amount of bow.

(c) The maximum twist along the longitudinal axis shall not exceed one degree per foot of length on face of the exterior surface. The waveguide shall be placed on a flat, horizontal, reference plane. One end shall be held in physical contact by a suitable means while the other end of the waveguide remains free. By the use of an engraved transport protractor segment, determine the angle line on the protractor which coincides to the nearest degree with the surface of the waveguide while the edge of the protractor is kept parallel to the reference plane.

NOTE

Waveguide with a noticeable, but acceptable, flatwise bow shall be positioned with the side of the convex curvature in contact with the reference plane.

(d) The maximum interior surface roughness shall not exceed 63 microinches for waveguide with a major interior cross-sectional dimension up to 4 inches, and 125 microinches for all waveguide with a major interior cross-sectional dimension of more than 4 inches. See MIL-W-85 (see Appendix 5-A) for waveguide other than aluminum.

(e) Scratches not more than one mil (0.001 inch) deep will be permitted in the longitudinal direction of the waveguide with internal measurements of 0.622 by 0.311 inch or larger.

(f) The waveguide shall exhibit good commercial manufacturing practices, straightness from end to end, smoothness throughout, the absence of burrs, die marks, chatter marks, dirt, grease, scales and splinters, or any other defect that will change the inside dimensions.

5-1.13.18 Pre-Brazing Inspection

After the bending and twisting process and prior to brazing, the waveguide assembly shall be inspected using the following guidelines:

(a) Check minimum radius allowed for the waveguide installed, allowing for "E" and "H" bends.

(b) Check twist so it does not exceed 90 degrees in a minumum length allowed for the waveguide installed.

(c) The extremities of a bend or twist shall not be closer than one inch to flange.

(d) The interior surfaces of the waveguide, particularly in the area of bends and twists, shall not show evidence of compression rings, stretch marks, crack, deposits of bending alloy, or any irregularities mentioned in paragraph 5-1.13.17.

NOTE

In order to adequately inspect the interior of the waveguide, an instrument such as a borescope may be required.

5-1.13.19 Post-Brazing Inspection

After the brazing process is complete and all flux has been removed from the waveguide assembly, it must be inspected for quality using MIL-STD-645 and MIL-B-7883 (Appendix 5-D) and the following guidelines.

5-1.13.19.1 Interior of Waveguide

(a) The joint must be smooth and completely filled. There shall be no voids, laps, porosity, excess filler metal.

(b) The fit between the waveguide tubing and the flange shall be 0.002 inch to 0.010 inch for laps less than 1/4 inch long. Clearance up to 0.025 inch are allowable for laps greater than 1/4 inch. The maximum surface roughness for all surfaces that will constitute a portion of the joint is 63 microinches.

(c) Misalignment between the tubing and the flange (called the step) at their junction shall not exceed 0.004 inch after the flange is in the final position.

5-1.13.19.2 Exterior of Waveguide

(a) The maximum allowable diameter of any porosity indication is 0.015 inch. The maximum allowable depth of any porosity is 10 percent of the braze depth. Per each linear inch of braze fillet, one porosity indication of maximum size is permitted.

(b) Porosity cluster indications are permitted, providing the sum of all the porosity diameters do not exceed 0.015 inch and/or the diameter of the cluster is not greater than 50 percent of the braze fillet width. No more than one cluster of maximum size, or 2 or more clusters that, if combined, would equal the maximum size, is permitted per linear inch of braze fillet.

(c) The term "Linear Porosity" is applicable when the minority of the porosity is oriented in a line. The maximum length of linear porosity is 3/16 inch in each linear inch of braze fillet.

(d) For the purpose of this procedure, a crack is defined as a discontinuity viewed under 10 power magnification which is revealed as being a continuous void with a discernible length. The maximum allowable size of a crack shall not be longer than 3/32 of an inch and not deeper than 10 percent of the braze fillet depth. The maximum number of the maximum allowable size cracks is one per each linear inch of braze fillet. More cracks, smaller than the maximum allowable size per linear inch of braze fillet, are acceptable, providing they are randomly dispersed around the circumference of the joint, and that the sum of their lengths does not total more than 3/32 of an inch per each linear inch of braze fillet.

(e) Blisters in the base metal, residual flux, unmelted brazing metal, excess brazing metal to the extent that it may interfere with the function of the assembly, or under cutting of the base metal to an extent greater than five percent of the base metal thickness and/or 15 percent cumulative of the braze length, is cause for rejection of the assembly.

5-1.13.20 Post Chemical Conversion Inspection

After the assembly has received the chemical conversion, it shall be inspected to ensure that 100 percent of the interior and exterior surface has received adequate coverage. The waveguide shall be inspected at this time for physical irregularities, such as ridges, stretch marks, cracks, etc., because the chemical film tends to make the irregularities more visible. Such irregularities shall be located.

5-1.13.21 Post Painting Inspection

After the waveguide assembly has been

painted on the exterior, inspect for the following:

1. The interior of the waveguide must exhibit a smooth, highly reflective surface. The surface must be free from ripples, bubbles, fish hooks, dust, or conditions that would degrade the excellence of the finish.

2. Ensure the exterior of the waveguide coverage is adequate.

3. Ensure there is no paint on the faces of the flanges.

4. Inspect the position of the flanges to ensure that the matched flanges of the opposite waveguide cannot be misaligned at the time of installation.

5. Ensure each piece of waveguide is properly identified, as per applicable plans.

6. Ensure the waveguide interior is clean, that the waveguide ends are sealed.

5-1.14 PRESSURIZING AND PURGING

Transmission lines should be pressurized with dry air and shall be capable of being purged in accordance with Installation Control Drawings or as specified. The transmission line will be more efficient if the interior is dry. Moisture increases the attenuation of the system and reduces the maximum permissible operating voltages. To remove the moisture from the line it must be purged with clean dry air. Purging should be done after installation, or when transmission line has been opened for repairs or has been inoperative. Dry air is air which has had sufficient moisture removed from it so that the remaining moisture does not condense, on the inner surface of the transmission line, over the temperature range and pressure variations the line will be exposed to. The air within the line must be sufficiently dry so that its dewpoint is below the temperature limit to which it may be subjected. Several methods are available both for the supply of dry air and introducing it to the transmission line. Some electronic equipments provide units and fittings for dry air service. Other electronic equipments make no provisisions and the dry air system on board ship is used or supplemented (see paragraph 5-2.7).

5-1.14.1 Dry Air Systems

Dry air is obtained by using a compressor and a desiccant dehydrator, to dry the air, or from the ship's Service Dry Air Main. The electronics dry air system improvement program currently being accomplished by shipalts, provides a central dry air system arrangement. This system consists of a refrigerant dehydrator, oil filters, desiccant dehydrator of the electric heater self reactivating type, and a particulate filter. A dewpoint indicator with audible and visible alarms is an integral part of the desiccant dehydrator, electrical contacts are provided for connections to actuate remote audible and visual alarms in the radar power room and C.I.C. The rated capability of the dehydrator is to deliver air at a minimum of -40° C. dewpoint at 80 PSIG. This dry air is supplied the control panels and then to the waveguide. The control panel consists of an inlet and outlet pressure gage, a flow meter, moisture indicator, two pressure reducing valves, inlet and outlet shut-off valves and a relief valve sized to provide adequate pressure relieving capacity to insure that waveguides will not be overpressurized by malfunction. See the Electronic Dry Air System Operation and Maintenance Manual and applicable ShipAlts for details.

5-1.14.2 Air Connections

Electronic equipments which have no dry air system designed into it, shall have the dry air input installed via an air fitting on the gas barrier, waveguide adapter, waveguide flange or the side wall of the waveguide. When the fittings for input air or purge valve is installed on the side wall of the waveguide, precautions must be taken to insure a smooth surface on waveguide interior where the fitting is attached to the waveguide.

5-1.14.3 Purging

A purge valve shall be installed at the lowest point in the transmission line adjacent to the transmitter, where the waveguide can be purged of moist air, or the accumulation of water.

5-2 RECTANGULAR WAVEGUIDE INSTALLATION PROCEDURES

5-2.1 GENERAL REQUIREMENTS

The installation of waveguide runs shall meet the following requirements.

5-2.1.1 Length of Run

The Run shall be as short and as direct as possible with a minimum amount of bends, twists and joints.

5-2.1.2 Location of Run

The location of the waveguide run shall take precedence over piping, ventilation, ducting, cable hangers, wireways and lighting fixtures. The waveguide run shall be located so it will not be disturbed by removal of deck plates, gratings, machinery or service areas. Locate the waveguide run to avoid electrical interference from equipment cables or other transmission lines.

5-2.1.3 Sequence of Installation

The complexity of the system, equipment location and physical size of waveguide will determine the sequence of installation. Where practicable, the sequence of installation should begin at the antenna. When assembly sequence is from transmitter to antenna the top section should be covered at all times to prevent intrusion of foreign matter.

5-2.1.4 Clearance

A clearance of two inches minimum shall be provided from all objects to which the waveguide is

not connected, to prevent damage when subjected to underway movement, shock or vibration. Clearance between the underside of the waveguide installation and the deck shall not be less than seventy-seven inches in areas where normal passage occurs.

5-2.1.5 Protection of Waveguide

The transmission line run for each installation shall be protected from pedestrian traffic or where accidental damage is most likely to occur. Protective guards shall be removable and of sufficient size and strength to insure that the waveguide cannot be struck, attached to, or accidentally damaged. Expanded metal construction is preferred. These protective guards shall be installed around waveguide at platforms, catwalks, ladders and on the overhead as required. The waveguide shall be protected against physical damage from battle action, heat and water.

5-2.1.6 Welding to Ships Structure

Waveguides shall not be welded to ship's structure or any assembly to be mounted in ship's structure.

5-2.1.7 Precautions against Moisture and Dirt

Care shall be taken to prevent the entrance of moisture and dirt into the waveguide at all times during installation.

5-2.1.8 Structural Fouling

Waveguide runs shall be located so they will not be disturbed by the removal of deck plates, gratings or machinery.

5-2.1.9 Galvanic Action

Waveguides shall be isolated from supports to prevent galvanic action.

5-2.1.10 Types of Waveguide Supports (Hangers)

Waveguide runs shall be installed with alignment type supports in such a manner so that no stress or strain shall be placed on any joint or section. Paragraph 5-2.4 provides general design information for acceptable type waveguide supports.

5-2.1.11 Penetrations, Deck and Bulkhead

Deck and bulkhead penetrations shall comply with the ships structural requirements and permit the installing or removal of waveguide sections including the attached flange. Paragraph 5-2.5 provides general design information for acceptable type deck and bulkhead penetrations.

5-2.1.12 Waveguide Markings

The finished waveguide components shall be identified per MIL-STD-130, paragraph 4.1, except metal stamping shall not be used. The identification shall be in a progressive manner to ensure correct remating of the matched flanges during installation and/or maintenance. Warning labels shall be applied to a visible area of the waveguide, approximately three feet apart after the transmission line has been painted or touched-up. Spray labels with weatherproof lacquer. Labels shall read "DO NOT STRIKE".

5-2.1.13 Grounding of Waveguide

Waveguide runs shall be grounded in accordance with MIL-STD-1310(NAVY).

5-2.1.14 Hardware

Flange assembly hardware shall be that which is supplied with the flange. Where replacement of missing hardware is required, the hardware shall be in accordance with the specific flange specification. Waveguide support hardware shall comply with paragraph 5-2.4.11 of this document.

5-2.1.15 Restrictions for Parallel Runs

When parallel transmission line runs are installed for the same system, and there is a possibility of interference from flange joint RF leakage, the flange connections shall be staggered so that no two flange connections will be located within six inches of each other.

5-2.1.16 Straightness of Runs

Waveguide runs shall not deviate from a straight line by more than 1/4 inch at any point

5-2.1.17 Alignment of Flange Joints

To prevent stresses being applied to the waveguide or the flanges, waveguide joints shall be arranged so that flanges will mate with bolt holes in alignment within 1/32 inch and flange faces shall be parallel and not separated by more than 1/64 inch prior to bolting.

5-2.1.18 Pressurization

All waveguide runs shall be pressurized to prevent corrosion and maintain equipment performance parameters. Check ship installation plans or shipalt for requirements.

5-2.1.19 Flexible Waveguide

Short sections of flexible waveguide when designated shall be used where excessive expansion from thermal or ship structural members may be anticipated. Flexible waveguide shall not be used for alignment of waveguide.

5-2.1.20 Expansion Joints

Compensation for expansion and contraction must be made when waveguide runs cross expansion joints. A flexible section will be used only as designated on ships installation plans and shall be installed parallel to the expansion joint.

5-2.1.21 Preservation

No waveguide shall be installed without the interior and exterior being finished as directed herein.

5-2.2 PROTECTION OF WAVEGUIDE

Protection of waveguide from shop to ship and during installation shall be in accordance with the following requirements:

5-2.2.1 Sealing of Individual Sections

Waveguide sections and assemblies shall remain sealed against moisture and foreign matter intrusion until they are installed aboard ship. The sealing caps or plates shall be removed from each section or assembly as it is installed in the waveguide run.

5-2.2.2 Sealing of Assembled Sections

During installation the ends of partially assembled runs shall be kept sealed against moisture and dirt.

5-2.2.3 Flange Face Protection

Flange faces shall be protected against physical damage during shipping and installation.

5-2.2.4 Transporting Waveguide Sections and Components

Waveguide sections and components shall be transported from shop to ship in cradles that will prevent bending, warping, and physical damage.

5-2.2.5 Warping of Long Waveguide Sections

Care should be taken in handling long sections of waveguide to prevent bending or warping. Never lift a long section by the ends only.

5-2.3 LAYOUT OF WAVEGUIDE RUNS

After the design and exact location of the waveguide run has been determined, the first step in actual installation is the layout of the shipboard run by the use of templates. The entire waveguide run shall be templated, so the fabrication shop can be provided with accurate information as to bends, twists, flanges, sectional lengths, flange positions and overall length of run.

5-2.3.1 Templates

The waveguide templates shall be made from 1/2 inch pipe and the flange templates made from 1/2 inch plate steel cut to the specific flange dimensions. The 1/2 inch pipe can be cut and shaped to give the optimum waveguide run. The pipe will retain its shape and provide a more accurate guideline for shop fabrication. The flange templates can be adjusted to indicate the true bend and/or twist information required by the fabrication shop. Details for fabricating flange templates can be obtained from MIL-STD-1327 and MIL-F-3922 (see appendix 5-C).

5-2.3.2 Layout

A typical layout using 1/2 inch pipe for waveguide templates and 1/2 inch mild steel blocks for flange templates is shown in Figure 5-4.

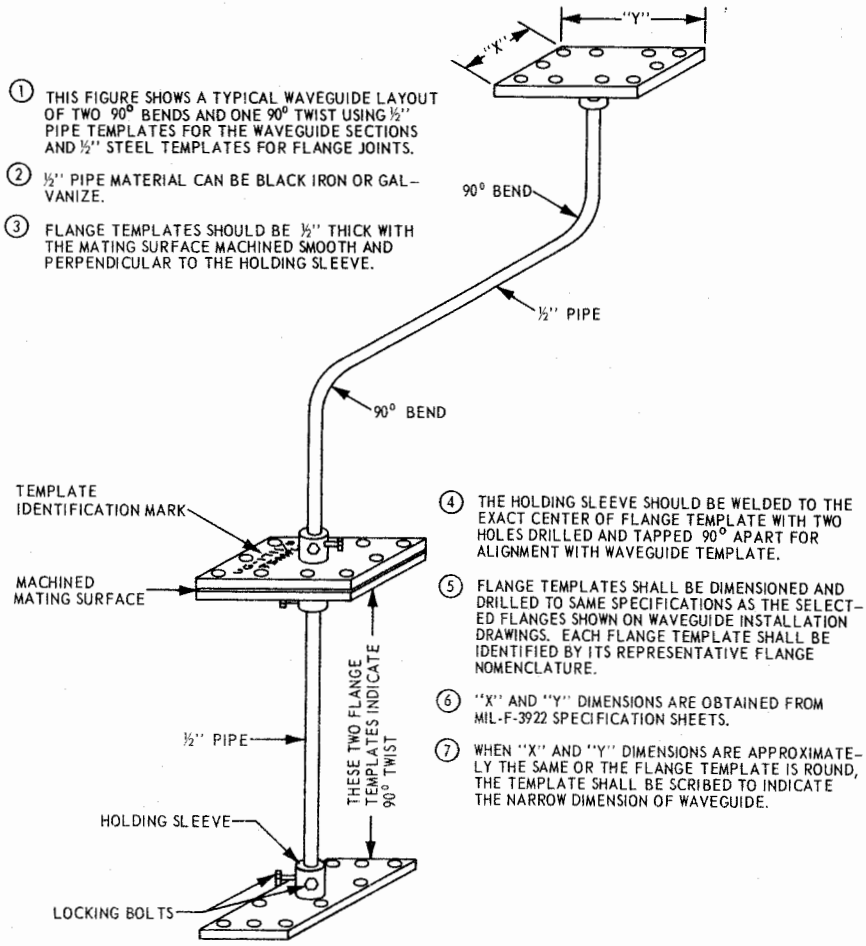


Figure 5-4. Waveguide Template Fabrication Details

5-2.3.3 Penetrations, Deck and Bulkhead

Deck and bulkhead openings should be cut and penetration assemblies fabricated at the time the templates are made (See 5-2.5).

5-2.3.4 Supports, Waveguide

Basic information needed for waveguide supports can also be obtained at the time of templating the waveguide run.

5-2.3.5 Double Ogee Curve

Whenever there is an obstruction in the preferred waveguide run that cannot be relocated, a large radius "E" plane double ogee curve (Figure 5-5) is recommended. The templates for this should be carefully made so the shop fabricated bends when assembled will absorb ship motion, expansion and contraction without excessive strain on joints or distortion of waveguide.

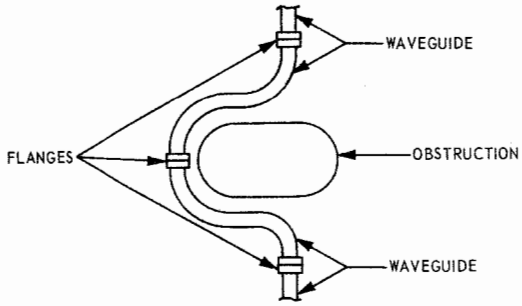


Figure 5-5. Double Ogee Curve Around Obstruction

5-2.4 WAVEGUIDE SUPPORTS (HANGERS)

Waveguide supports shall meet the following requirements.

5-2.4.1 Type of Material

Waveguide support material shall be compatible with ships structure. Galvanic action between dissimilar metals shall be prevented by isolating the waveguide from the support in accordance with paragraph 5-2.4.9. See Figures 5-6 and 5-7 for fabrication details.

5-2.4.2 Size of Material

Supports shall be of sufficient width and thickness to support the waveguide against damage from vibration or shock (see Figure 5-6 Note 4).

5-2.4.3 Support Damage to Waveguide Wall

Supports shall provide a snug fit but never tight enough to cause deformation or damage to the waveguide wall.

5-2.4.4 Fitting Support to Waveguide

Supports installed for each section of waveguide shall fit snug enough to hold the waveguide, allowing for isolation material thickness covered in 5-2.4.9. For outside dimensions of waveguide see MIL-W-85.

5-2.4.5 Isolation of Waveguide and Support

Supports shall be isolated from the waveguide by the method outlined in paragraph 5-2.4.9.

5-2.4.6 Adjustable Supports

All supports shall be fabricated to be adjustable in two directions (See Figures 5-6 and 5-7).

5-2.4.7 Location of Supports

Never force the waveguide to the support position, always locate the supports in such a manner as to prevent any stress, strain or bind on any segment of the overall waveguide run.

5-2.4.8 Spacing of Supports

Distance between waveguide supports shall never exceed 5 feet. There shall be a minimum of 2 supports for each waveguide section that exceeds 24 inches in length. The supports shall not be installed closer than 6 inches to any flange connection. Figure 5-8 shows typically installed waveguide supports.

5-2.4.9 Isolation Methods

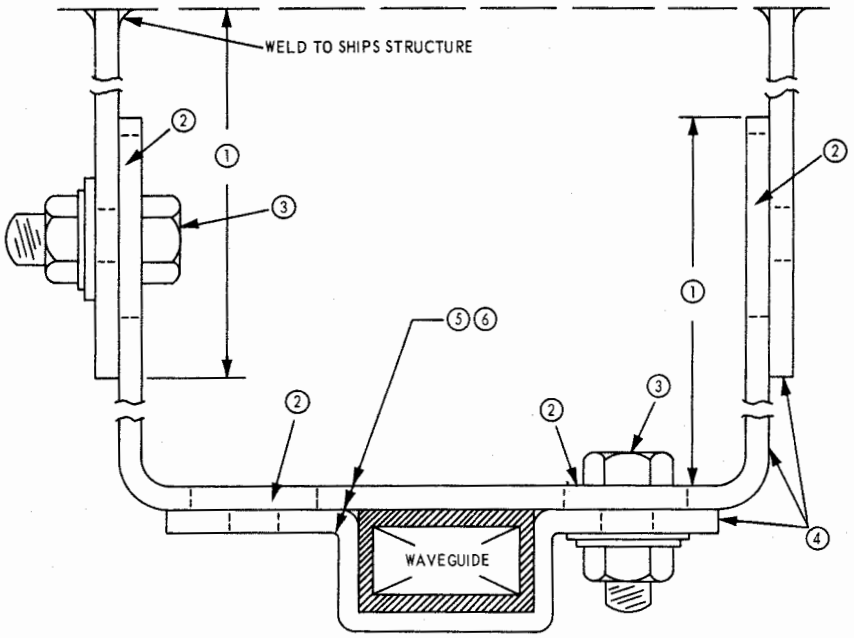
To prevent electrolytic corrosion between the waveguide and waveguide support, one of the following methods of isolation shall be used.

(a) Coat pieces that ordinarily would contact waveguide with vinyl plastic (PLASTISOL) not less than 1/16 inch thick. The outside surface of the coated support shall then be scraped clean in the area of the hole used for bolting hanger sections together. This is to assure a good bond to ground. See Figure 5-9 for Plastisol application. The Plastisol method shall not be used unless the Installing Activity has the facilities and expertise that will produce a quality product with smooth surfaces and accurate dimensions that will not damage the waveguide.

(b) Use 3/16 inch thick Neoprene, MIL-R-6855, Class II, Grade 30 as a liner between waveguide and waveguide support.

(c) With this method, isolation is obtained by using a sealer, putty and plastic tape applied around the waveguide at point where waveguide support will be attached. The method of application should be as follows:

Step 1. Apply one coat of skotchkote sealer to waveguide at point of support contact. Width of area covered should be approximately



1. LENGTHS DETERMINED BY INSTALLING ACTIVITY.
2. SLOTTED HOLES FOR ADJUSTING SUPPORT TO WAVEGUIDE.
3. SIZE OF HARDWARE DETERMINED BY TYPE OF WAVEGUIDE INSTALLATION.
4. TYPE, WIDTH AND THICKNESS OF SUPPORT DETERMINED BY SHIPS STRUCTURE, LOCATION OF WAVEGUIDE RUN AND TYPE OF WAVEGUIDE.
5. FOR ISOLATION DETAILS SEE 5-2d (9).
6. SUPPORTS INSTALLED SHALL FIT SNUG ENOUGH TO SUPPORT WAVEGUIDE, BUT NOT TIGHT ENOUGH TO CAUSE COMPRESSION OF WAVEGUIDE WALLS. INSIDE DIMENSIONS OF WAVEGUIDE BRACKET TO ALLOW FOR THICKNESS OF ISOLATION MATERIAL USED.

Figure 5-6. Adjustable Waveguide Support Fabrication Details

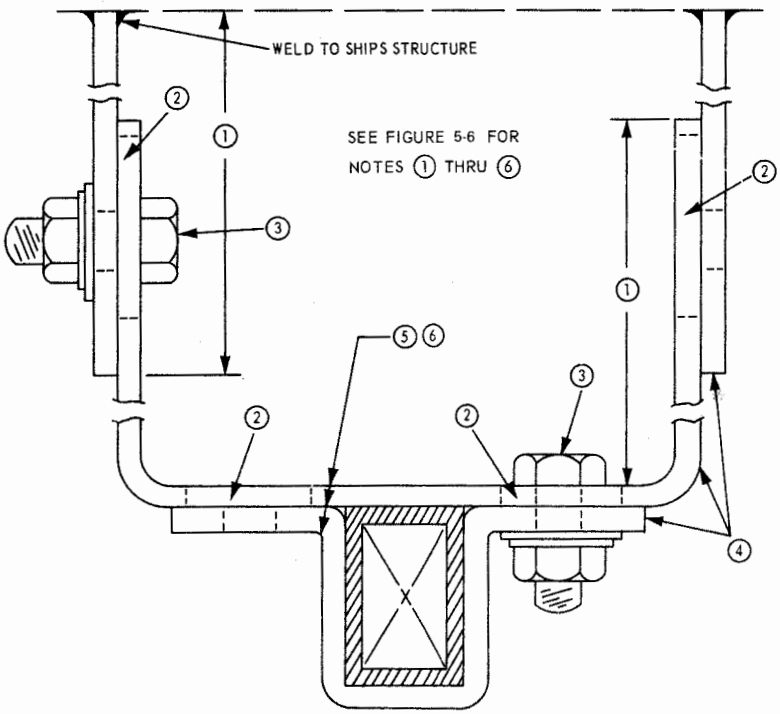


Figure 5-7. Adjustable Waveguide Support

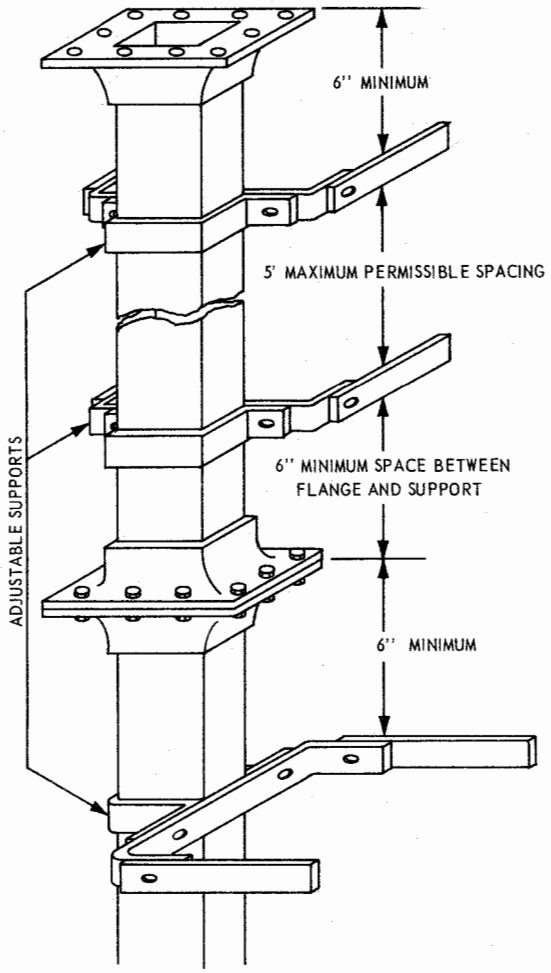


Figure 5-8. Waveguide Support Spacing

0.5 inch wider than waveguide support.

Step 2. Apply one layer of skotchfil putty to waveguide at point of support contact. Thickness of putty should be approximately 0.125 inch and width should extend approximately 0.125 inch beyond each edge of support clamps.

Step 3. Apply skotch # 33 plastic tape over the putty until the waveguide fits snugly within the support clamp.

Step 4. After the waveguide support clamp is bolted in place, apply one coat of skotchkote sealer over clamp assembly to provide a weathertight seal.

Step 5. Paint completed assembly in accordance with ships requirements for the specific area involved.

5-2.4.10 Plastisol Coating Procedures

Supports that are to be coated with Plastisol shall be in accordance with the following procedures.

5-2.4.10.1 Surface Preparation

Surfaces to be coated with plastisol must be free of all traces of oil, rust, scale, and dirt. All welds must be chipped and all flux from soldering or brazing must be removed. All loose joints, small holes, and porous welds must be eliminated as they trap air and cause blistering of the coating during cure. It is not necessary to grind welds and metal as smooth as in sheet-lining work since the plastisol will assume the contour of the metal and, to some degree, fill in and smooth over a rough surface. The surfaces should be cleaned by abrasive blasting as this method provides a surface for maximum bond strength. (For soft metals such as aluminum, suitable alkali cleaning agents made up as specified in 5-1.10 may be used in lieu of sandblasting. Chemical residues must be thoroughly removed by hot water rinse). After abrasives blasting or chemical cleaning and immediately prior to application of the primer the surfaces should be degreased by solvent washing.

5-2.4.10.2 Priming

Plastisol when applied to bare metal has little or no adhesion and can easily be stripped off. How-

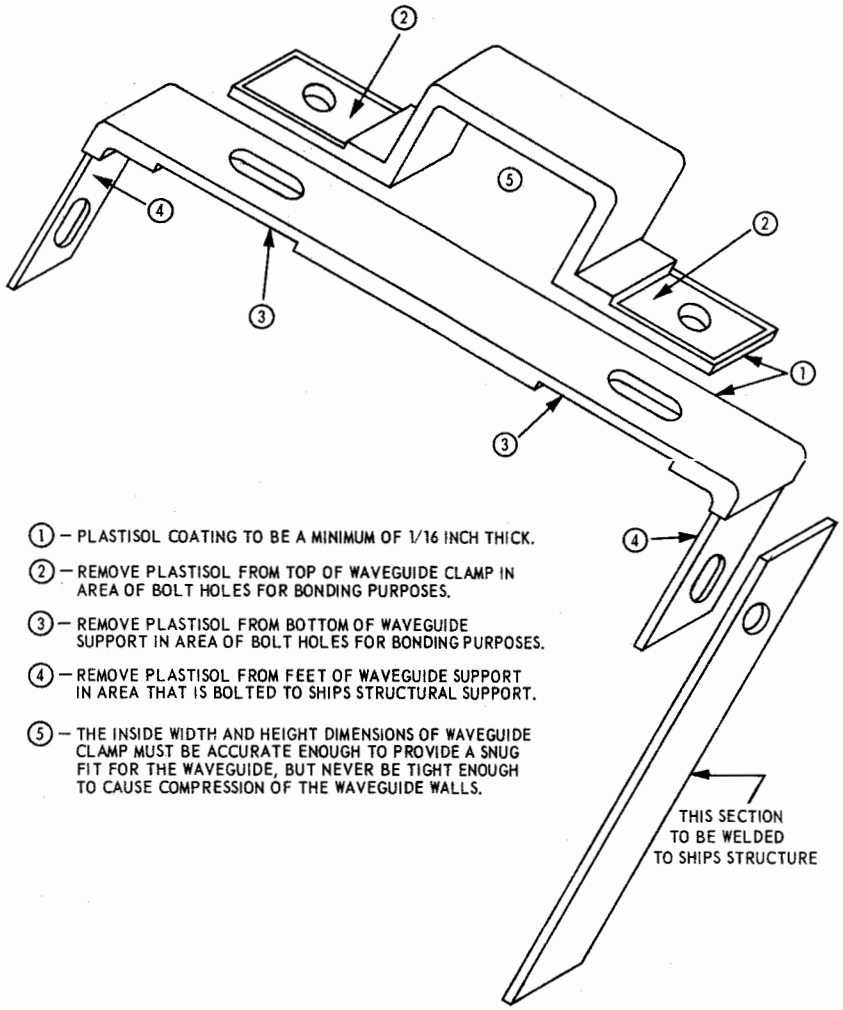


Figure 5-9. Typical Plastisol Coated Waveguide Support

ever, Plastisol applied over an approved primer (specified by the Plastisol manufacturer) has excellent adhesion. Therefore, when applying the primer, do not apply it to surfaces from which the plastisol coating will be removed, such as the bolt hole areas used for grounding purposes. Primers contain solvents; therefore, the proper safety precautions pertaining to the use of solvents should be followed. The primer can be applied by brushing, spraying, or dipping, as follows:

(a) Over aluminum: Apply one coat of pretreatment, formula 117, and allow to dry for 10 minutes. Then apply one coat of Plastisol primer and air dry for 20 minutes minimum, but not more than 16 hours.

(b) Other metals: Apply a single coat of Plastisol primer directly to the metal surface and allow to dry for a minimum of 20 minutes, but not more than 16 hours.

5-2.4.10.3 Application of Plastisol

Suspend the primed article in a forced-draft air oven at 177°celcius for 10 to 20 minutes or until the metal reaches the oven temperature. Remove the article from the oven and immediately immerse it in the plastisol, leaving it completely immersed for 30 to 60 seconds, depending upon the thickness of coating desired. Withdraw the article slowly from the Plastisol tank in such a manner that the excess fluid-compound can run off at a single point which will not be readily visible on the finished article. Allow the article to drain until all dripping has stopped. Return the article to the oven at 177°celcius to 190°celcius for 10 to 20 minutes, or until dense fumes are emitted from the coated article, indicating complete fusion. Remove the article from the oven and suspend it on a rack until it is cooled to room temperature. Trim all drip marks and excess plastisol from areas which are not supposed to be covered. Plastisol coatings, if damaged, can be patched with a heat-curing putty or an air drying vinyl putty which is

available from the Plastisol manufacturers. Because of differences of specific heat, cooling rate, mass, etc. of the materials to be coated, dip coating of various articles with Plastisol requires that the process be precisely tailored to the article. The above procedure is adequate for the average product. However, specific instructions should be obtained for special products.

5-2.4.11 Hardware

Waveguide support hardware shall meet the following requirements.

(a) Waveguide supports exposed to weather shall be assembled with corrosion resistant steel hardware that meets the following specifications:

FF-N-836 Nuts
FF-S-85 Cap Screw, slotted and hex head
FF-W-84 Washers, lock (spring)
FF-W-100 Washers, lock (tooth)
MIL-B-857 Bolt, Nut, and Stud.

(b) Waveguide supports installed inside ship's structure and not exposed to weather may be assembled with standard type cadmium plated hardware, unless otherwise specified on Installation Control Drawings.

5-2.5 PENETRATIONS, DECK AND BULKHEADS

Transmission line penetrations in ships structure shall meet the following requirements.

5-2.5.1 Non-Watertight Bulkheads and Decks

Where a waveguide run passes through a non-watertight/non-airtight bulkhead, a clearance hole is all that is required. The clearance hole shall be of sufficient size to pass the waveguide section complete with attached flanges. The location and size of bulkhead openings including coamings and/or doubler plates shall meet the structural requirements of the ship.

Where a waveguide run passes through a bulkhead with air/dust/fume tight requirements, a coaming should be installed in the bulkhead. The inside diameter of the coaming shall be of sufficient size to pass the waveguide section complete with attached flanges. The void space between waveguide and coaming should be filled with a silicone sponge rubber barrier complying with MIL-R-46089. Figure 5-10 illustrates a typical non-watertight bulkhead penetration with air/dust/fume tight requirements.

Where a waveguide run passes through a non-watertight deck, a protective sleeve shall be installed. The sleeve shall be fabricated from material compatible with ships structure and with the inside dimensions sufficient to pass the waveguide section complete with attached flanges. The sleeve height above the non-watertight deck shall be greater than all other coamings within the area. This is to minimize damage to waveguide from flooding. When air-tightness is required, the void space between waveguide and sleeve shall be filled with a plastic sealer complying with MIL-I-3064.

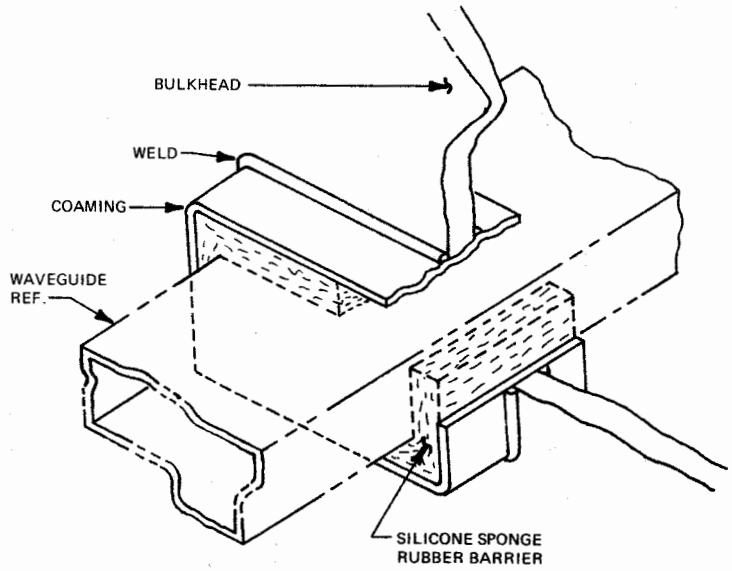


Figure 5-10. Typical Method of Penetrating Airtight Bulkheads

5-2.5.2 Watertight Deck and Bulkheads

Where a waveguide passes through a watertight bulkhead or deck the fittings used shall be watertight and comply with the structural requirements of the ship. The watertight fittings shall not be welded, brazed or soldered to the waveguide and shall be capable of disassembly for removal of waveguide section complete with flange.

5-2.5.3 Typical Methods

Split sleeve assemblies and multi-cable transit devices are typical methods of passing transmission lines through watertight decks and bulkheads. The split sleeve assembly method is preferred over the multi-cable transit device and is the most widely used. Alignment to the waveguide is much easier with the split sleeve assembly than with the multi-cable transit device. Multi-cable transit devices should only be used in congested areas where there is not sufficient space for passing cables and waveguides through the deck or bulkhead with separate penetration devices.

These methods, discussed in detail in paragraphs 5-2.5.4 through 5-2.5.7, are to be used as guidance by the Installing Activity in designing, fabricating and improving deck and bulkhead penetrations that will meet or surpass the requirements of this document.

5-2.5.4 Split Sleeve Assemblies for Rectangular Waveguides

A split sleeve assembly used for passing rectangular waveguide through watertight decks or bulkheads will provide the means for removal and replacement of a waveguide section without the previously required shop brazing and fabrication.

The Installing Activity shall design, fabricate and install split sleeve assemblies for waveguide runs that meet the structural and shock requirements for each specific installation and the requirements stated herein.

Figures 5-11, 5-12 and 5-13 are typical deck/bulkhead split sleeve assemblies provided for guidance to the Installing Activity. Material type and thickness, hardware type and size, dimensions and shapes will vary depending on the waveguide type, location, type of deck or bulkhead being penetrated and the ships function in the fleet. The following basic requirements are provided to assist the Installing Activity in designing, fabricating and installing the correct split sleeve assembly.

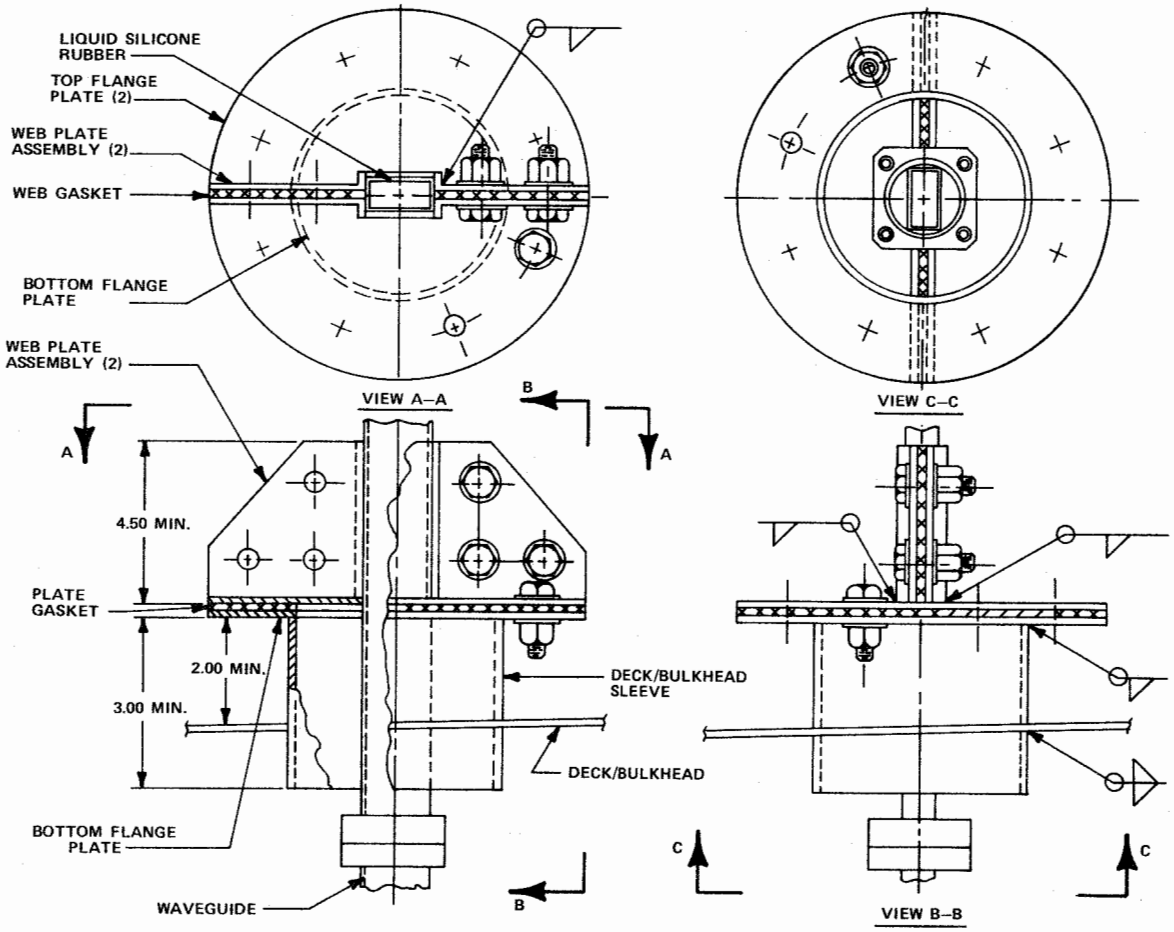


Figure 5-11. Typical Split Sleeve Assembly for Small Waveguide

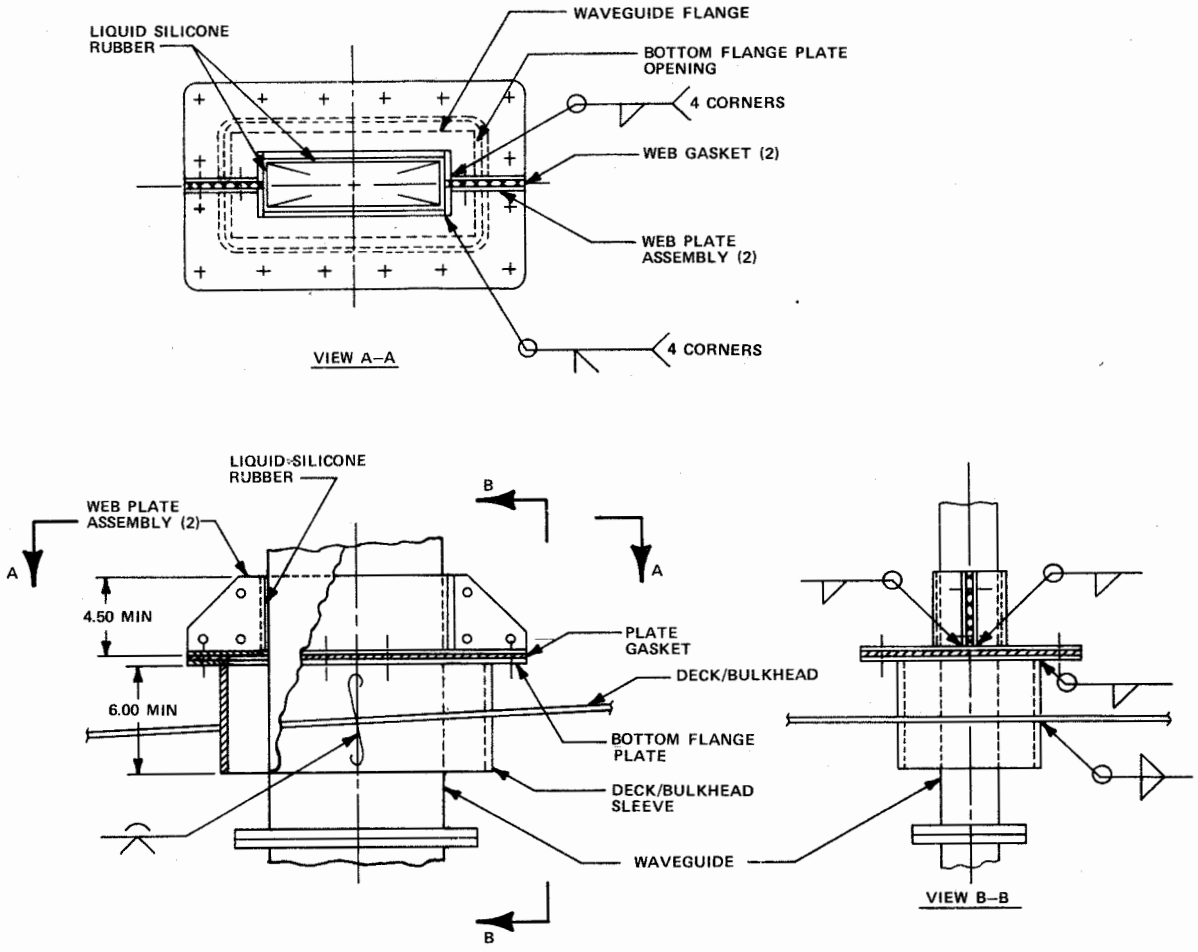


Figure 5-12. Typical Split Sleeve Assembly for Large Waveguide

(a) Material for the deck/bulkhead sleeve and the bottom flange plate shall be selected for compatibility with ships structure.

(b) Material for the top flange plate and web plate assemblies shall be selected for compatibility with the waveguide.

(c) Material for the web gaskets and plate gaskets shall comply with MIL-R-6855, class 2, Type A.

(d) The liquid silicone rubber shall comply with MIL-A-46106, Type 2. Refer to Figures 5-11, 5-12 and 5-13 for component part identification.

(e) The deck/bulkhead sleeve may be rectangular, oval or round and the inside dimensions shall be sufficient for passing the waveguide with attached flanges.

(f) The quantity and size of fastening holes through flange plates, plate gaskets, web plates and web gaskets shall be determined by the overall size of the split sleeve assembly to meet the watertight and shock requirements for a specific installation.

(g) The size and shape of web plate assemblies shall be determined by the size and shape of the waveguide and shall be of sufficient height to ensure a watertight seal. The inside dimensions of the web plate assemblies that surround the waveguide shall be 0.125 inch larger than the outside dimensions of the specified waveguide. This is required for forming a watertight seal with the liquid silicone rubber.

(h) Web plate assemblies, when fabricated from aluminum, shall have a chemical conversion coating in accordance with MIL-C-5541.

(i) Fastening hardware shall be corrosion resistant steel and comply with specifications referenced in 5-2.4.11.

(j) The split sleeve assembly shall be fabricated and installed in the deck or bulkhead parallel to the waveguide run so that the completed assembly will not place any stress or strain on the waveguide run or deform the waveguide wall in any manner.

(k) Liquid silicone rubber shall be applied to the complete area between the waveguide and adjacent surfaces of both web plate assemblies. After

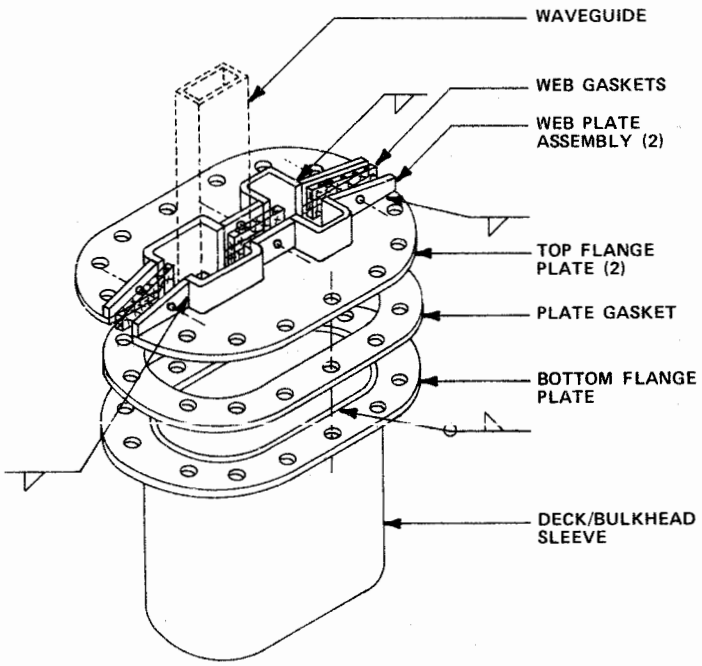


Figure 5-13. Typical Split Sleeve Assembly for Multiple Waveguide Run

web plates are bolted in place, remove excess rubber from exterior surfaces. Ensure there are no gaps or holes in the sealant between waveguide and web plates.

(1) Figure 5-11 is a typical split sleeve assembly for a small waveguide utilizing a section of pipe for the deck/bulkhead sleeve.

Figure 5-12 is a typical split sleeve assembly for a large waveguide utilizing a welded rectangular deck/bulkhead sleeve.

Figure 5-13 is a typical split sleeve assembly with a large oval deck/bulkhead sleeve that will accommodate two parallel waveguide runs.

5-2.5.5 Multi-Cable Transit Devices

The multi-cable transit device is a modular system that utilizes standard units and dimensions to allow maximum flexibility and compatibility with various numbers and sizes of cables. Final sealed units will provide watertight, airtight and fireproof bulkhead or deck penetrations.

Complete installation and assembly instructions for multi-cable transit devices are covered in NAVSEA Drawing No. 9000-S6202-73980 Section 4.

The multi-cable transit device can be used for passing waveguide and/or rigid coaxial lines through watertight decks or bulkheads with minor modifications as described in paragraphs 5-2.5.6 and 5-2.5.7. Figure 5-14 identifies components of an assembled multi-cable transit device modified to accept rectangular waveguide and rigid coaxial transmission lines.

5-2.5.6 Transit Device Modification for Rigid Coaxial Lines

When using multi-cable transit devices for passing rigid coaxial lines through watertight decks or bulkheads, the insert blocks shall be selected with the inside diameter of the hole approximately 0.125 inch larger than the rigid coaxial line outside diameter. This is to prevent outer wall collapse during the compression process. Liquid silicone rubber complying with MIL-A-46106, Type 2, shall be used to make an airtight seal between the rigid coaxial line and the insert block.

5-2.5.7 Transit Device Modification for Rectangular Waveguide

When using multi-cable transit devices for passing rectangular waveguide through watertight decks or bulkheads, two braceplates are required to prevent wall cave-in or distortion of the waveguide during the compression process. These braceplates shall be carefully fabricated to provide a close fit around the waveguide with the braceplate edges cut on an angle to prevent excessive pressure being applied to the waveguide.

For aluminum waveguide the braceplates shall be fabricated from 0.125 inch aluminum sheet and from 0.125 mild steel sheet for use with copper waveguide. The width of the braceplates shall be 2.362 inches (same as length of insert blocks). Braceplates shall have a chemical conversion coating to prevent galvanic action with the waveguide. The exterior surface of braceplates shall be coated with

liquid silicone rubber. The space between the waveguide and braceplates shall be filled with liquid silicone rubber. Liquid silicone rubber shall comply with MIL-A-46106, Type 2.

Figure 5-15 illustrates typical braceplates for use with rectangular waveguide and multi-cable transit devices. Figures 5-16 through 5-21 are typical installations of multi-cable transit devices modified for rectangular waveguide.

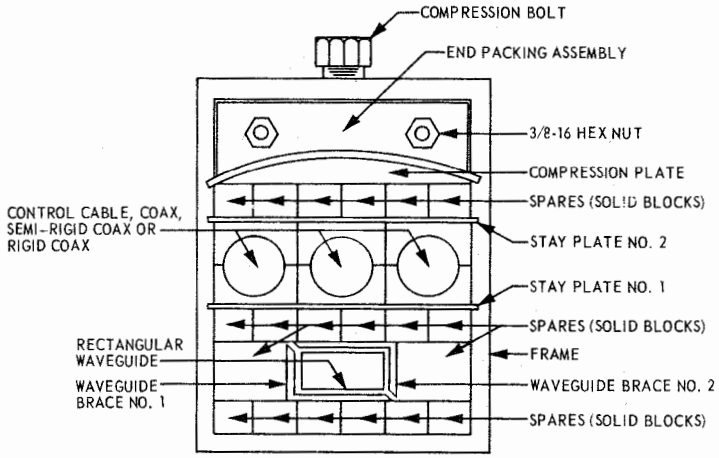


Figure 5-14. Multi-Cable Transit Device Assembly Identification

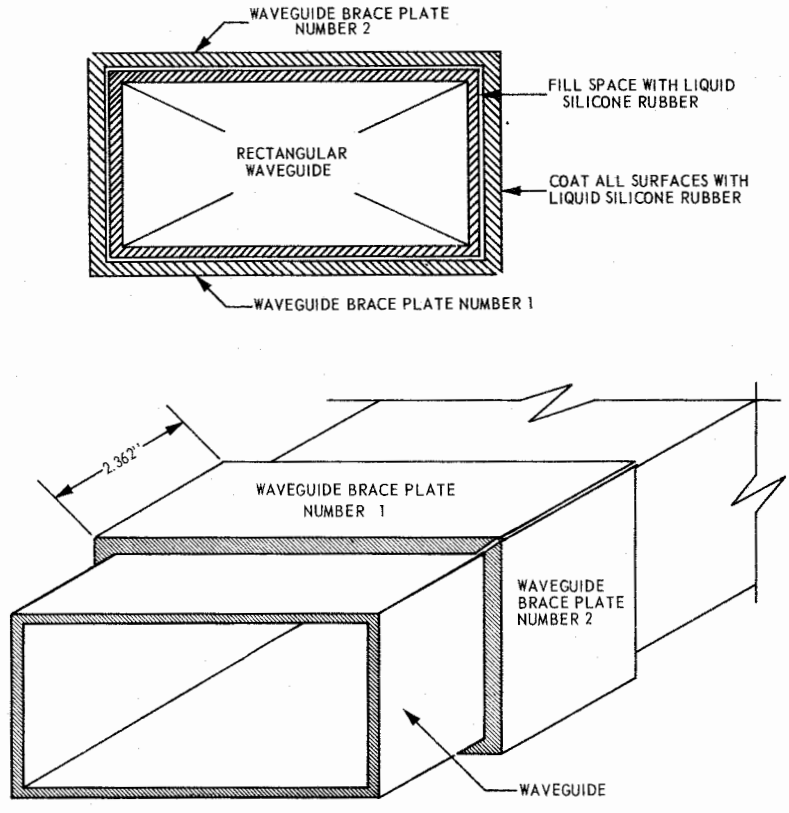


Figure 5-15. Waveguide Brace Plates for Use with Multi-Cable Transit Device

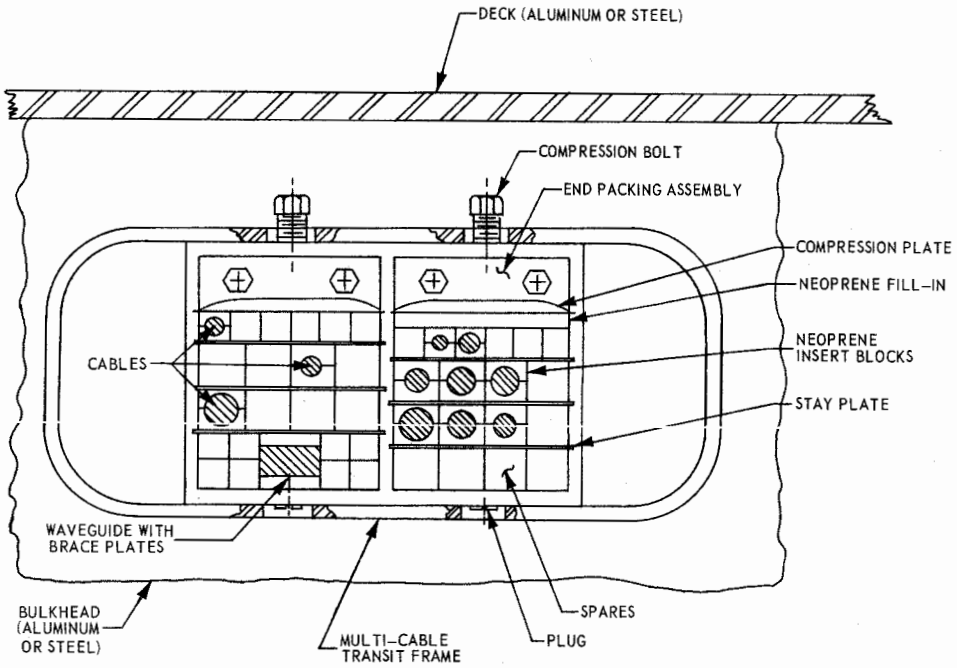


Figure 5-16. Two-Frame Multi-Cable Transit Device, Bulkhead Installed-Front View

5-2.6 OVERALL WAVEGUIDE RUN ASSEMBLY PROCEDURES

The assembly and installation of waveguide run aboard ship shall be in accordance with the following requirements and procedures.

5-2.6.1 Shipboard Installation Pre-Requirements

The actual shipboard installation assembly of waveguide sections and components shall not begin until all shop fabrication work has been completed, all bulkhead and deck cuts have been made, deck/bulkhead sleeves tack welded in place and electronic equipment installed.

NOTE

The deck/bulkhead sleeve should be tack welded in such a manner that it can be easily aligned with waveguide run prior to final welding.

5-2.6.2 Assembly Sequence

The sequence of assembly of waveguide sections and components will vary depending on the complexity of the system, physical size and weight of waveguide sections and length of vertical run. The preferred sequence of assembly would begin at the antenna and terminate at the transmitter. This would prevent unnoticed foreign objects from falling into the assembled sections. Since this sequence is not always practical, the Installer should use extreme care when assembling the waveguide run to prevent foreign matter from entering the assembled sections.

Ensure the flange faces are clean and gaskets or "O" rings are properly seated. The flange bolts shall be tightened in a staggered sequence to ensure a smooth tight fit with even pressure around the entire perimeter of the flange.

Only gaskets supplied with the flanges or those purchased in accordance with MIL-F-3922 or MIL-G-24211 shall be used. See paragraph 5-2.1 for alignment requirements.

5-2.6.3 Material Ordering Sequence

Waveguide sections should be requested from shop storage in sequence of ship assembly and installed on ship when received. Waveguide sections should never be left laying around aboard ship. Waveguide sections shall be received at installation site sealed against moisture and dirt.

5-2.6.4 Inspection Prior to Assembly

The ship installer shall visually inspect each waveguide section prior to placing in waveguide run. Any section of waveguide shall be rejected and returned to shop for rework or replacement if found to contain any of the following defects.

1. Dents in waveguide surface or flange face surface.
2. Deep scratches in flange face surface.
3. Unsealed.

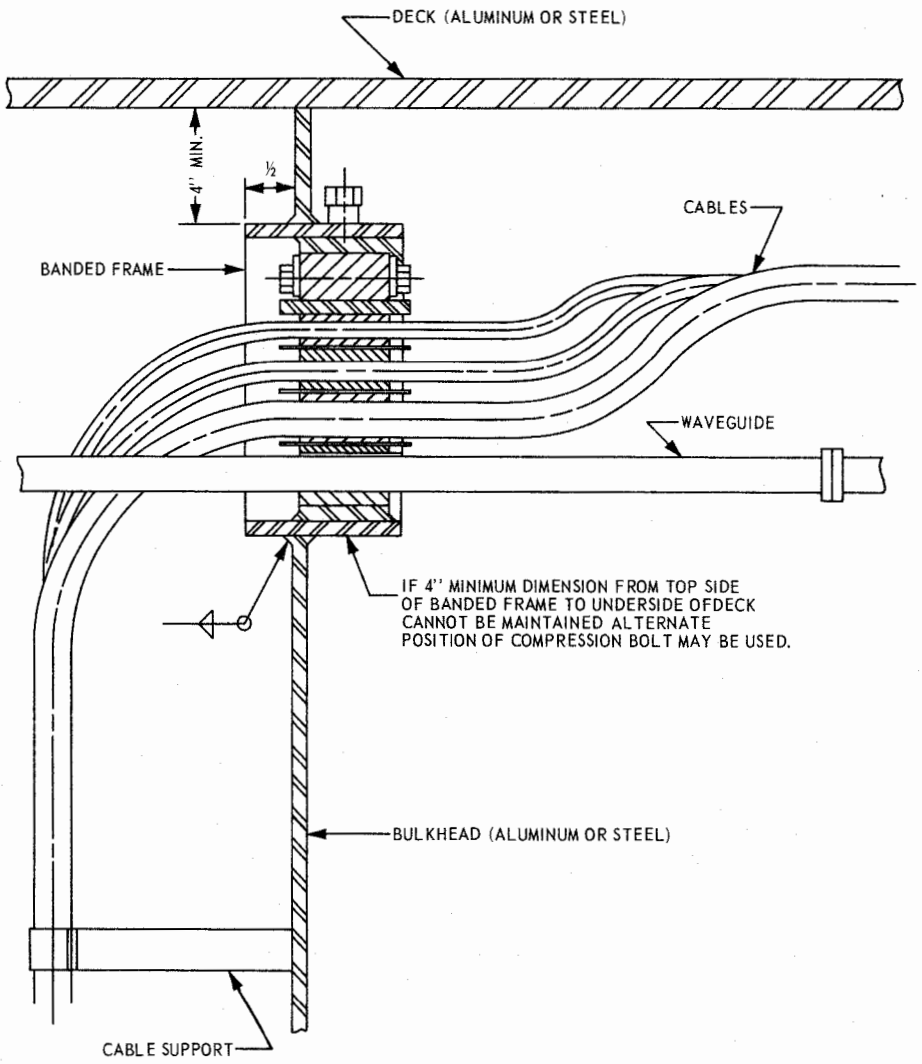


Figure 5-17. Two-Frame Multi-Cable Transit Device, Bulkhead Installed-Side View

4. Dirt or grease inside waveguide or on flange face.
5. Ripple in waveguide surface.

5-2.6.5 Installing Waveguide Supports (Hangers)

Whenever possible the complete waveguide run shall be assembled and held in place by temporary means before securing to waveguide supports or assembling to the deck/bulkhead penetration device. This is to ensure no stress, strain or bind is placed on any flange connection. After the waveguide run has been properly aligned the supports should be installed and adjusted to the waveguide. The waveguide should be protected from possible damage while welding the supports to ships structure. Equal care should be given to the assembly of deck or bulkhead fittings that is given to the waveguide support installations.

5-2.6.6 Pressurization During Assembly

The assembled waveguide run should be pressurized with dry air or nitrogen to the specified PSIG for the particular waveguide being installed, and maintained at that level until system is ready for operation. Whenever a complete waveguide run cannot be installed in one work shift, the partially installed sections should be pressurized with dry air or nitrogen at the end of the work shift and maintained under pressure until installation of the run is resumed.

5-2.6.7 Waveguide Hardware

All sections of the waveguide assembly shall be put together with corrosion resistent steel hardware. The hardware shall conform to the following

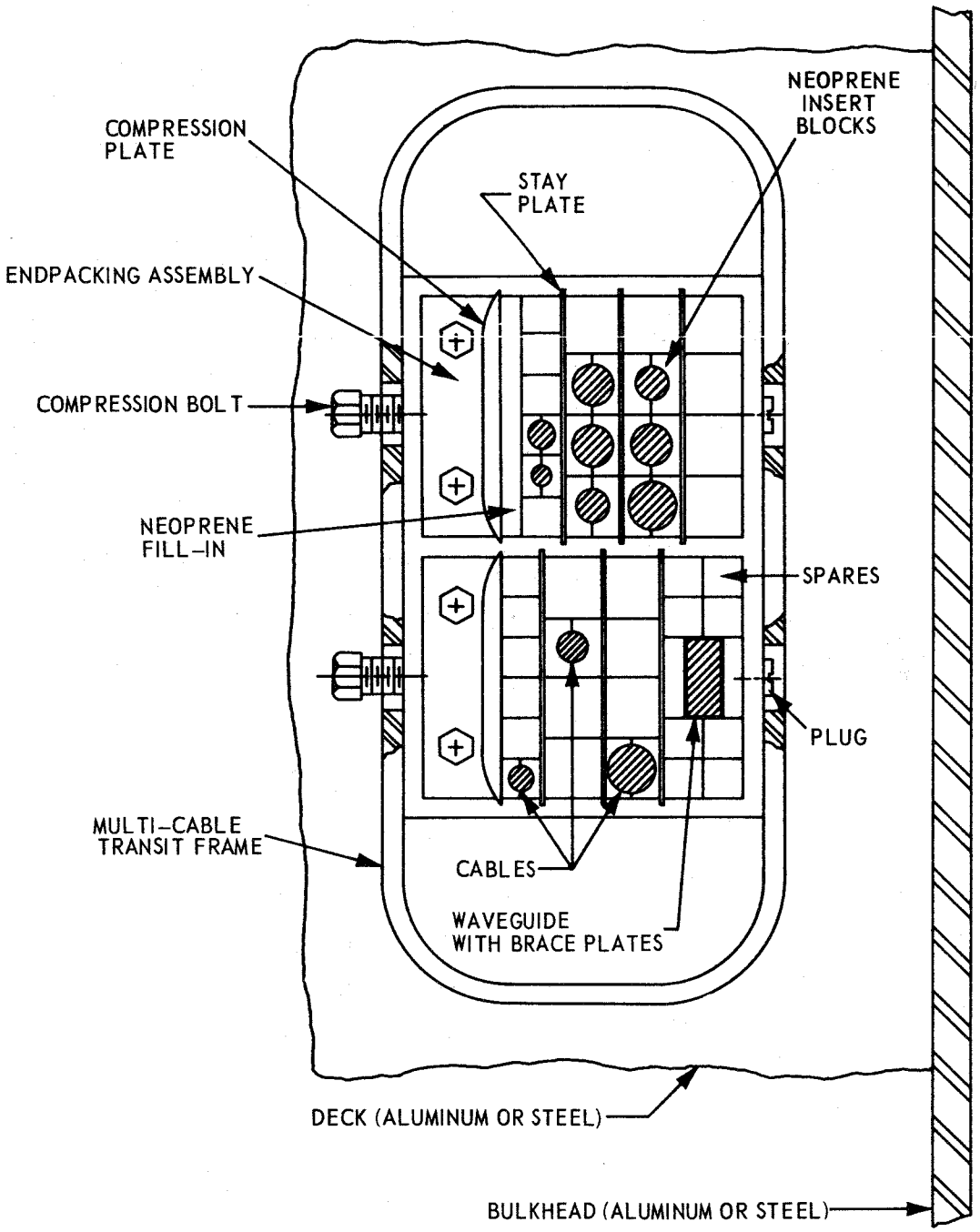


Figure 5-18. Two-Frame Multi-Cable Transit Device, Deck Installed-Plan View

specifications:

MIL-B-857 Nuts and Bolts
FF-W-84 Lock Washers (Spring)
FF-W-100 Lock Washers (Tooth)
FF-S-85 Cap Screw, slotted and hex head
FF-S-86 Cap Screw, Socket Head
FF-N-836 Nut, Plain

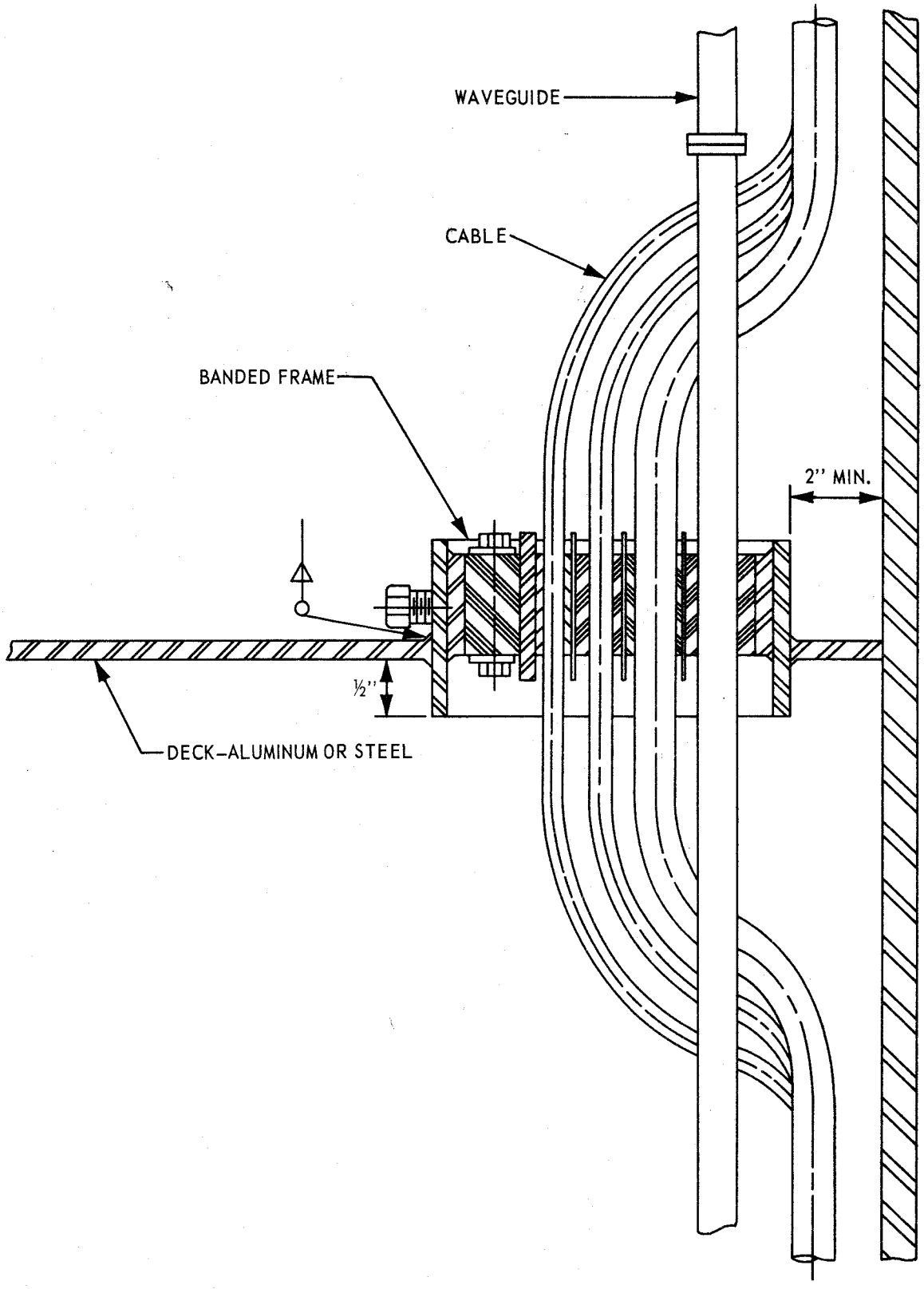


Figure 5-19. Two-Frame Multi-Cable Transit Device, Deck Installed-Side View

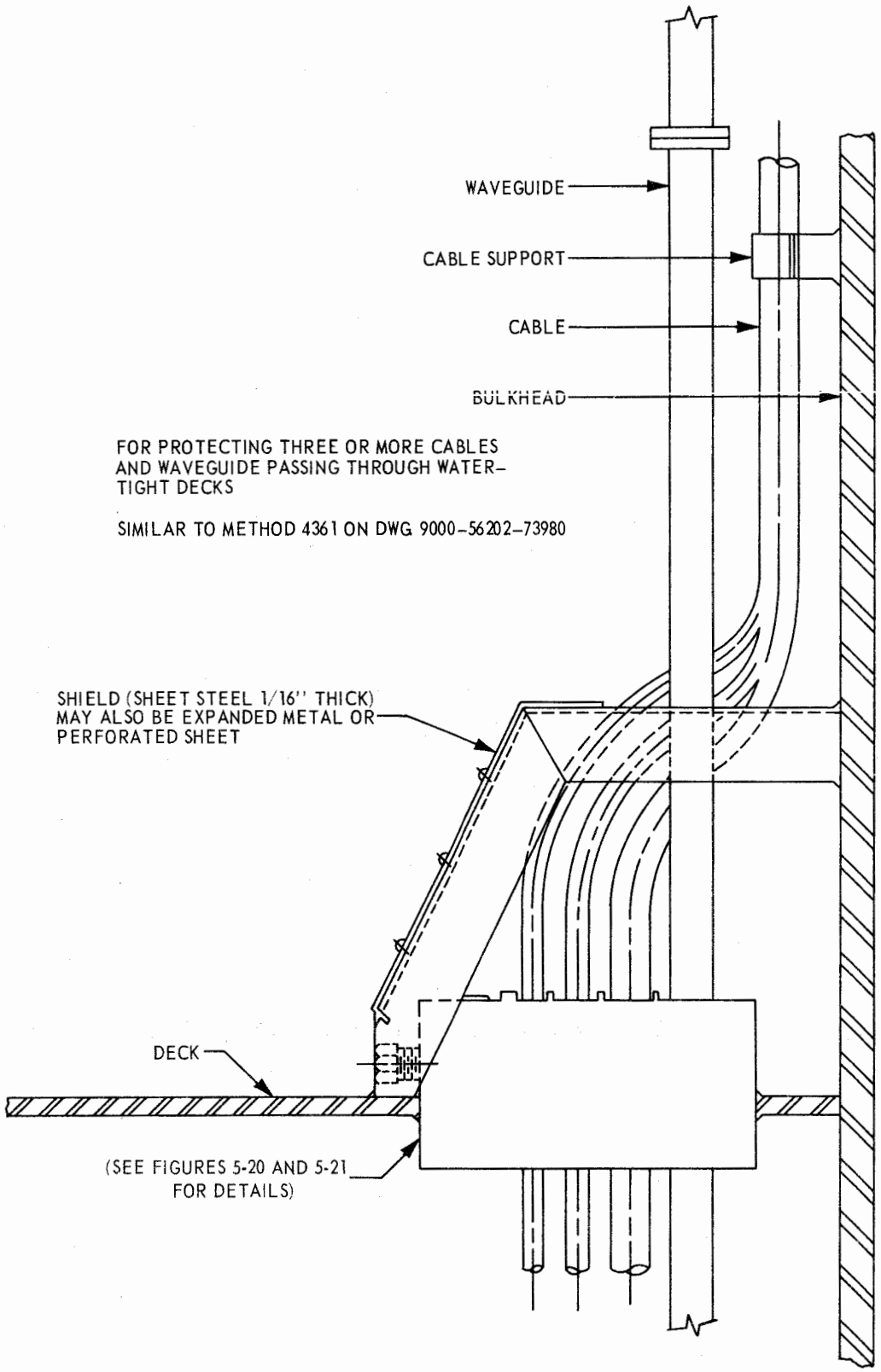


Figure 5-20. Protective Enclosure for Deck Penetration-Side View

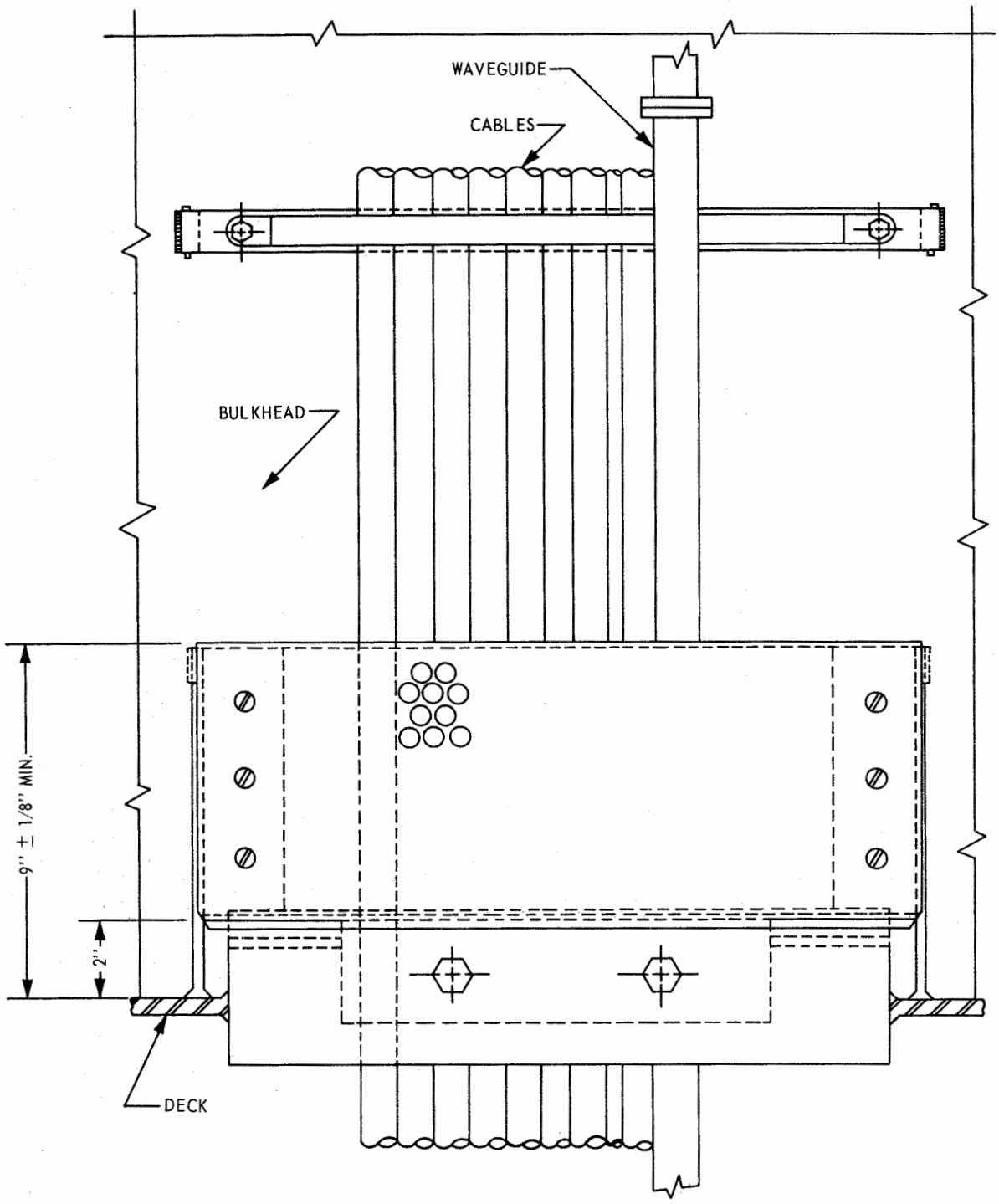


Figure 5-21. Protective Enclosure for Deck Penetration-Front Elevation View

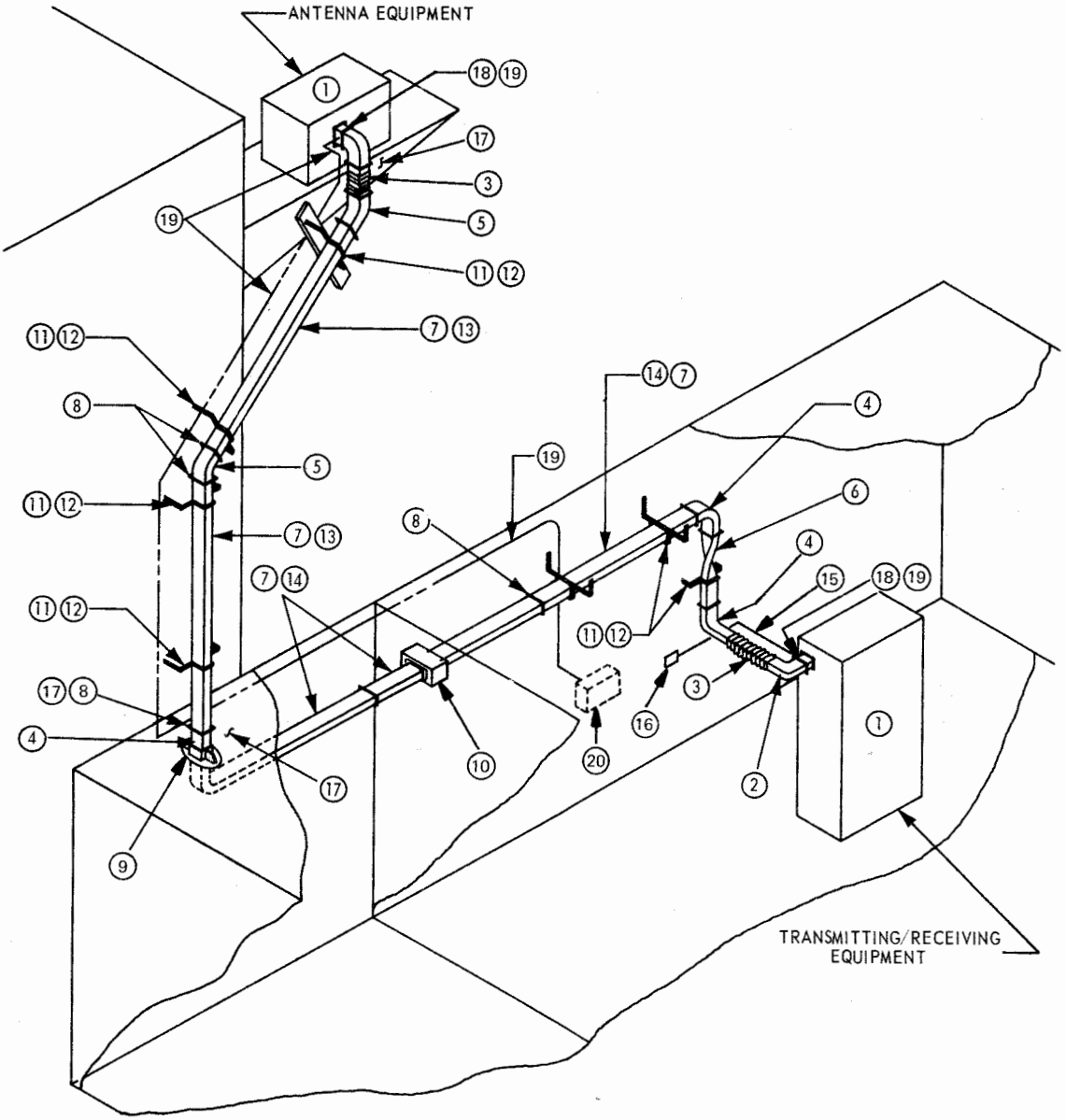


Figure 5-22. Illustrative Reference Guide with Reference Notes 1 through 20

5-2.6.8 Illustrative Installation Explanations

Figure 5-22 is an illustrative installation that can be used as a reference guide for solving problems. Figure 5-22 was drawn to show as many installation conditions as possible. An actual waveguide installation should always be as short and straight as possible with all bends, twists and flange connections kept to a minimum.

Refer to Figure 5-22 when using the following reference notes 1-20.

(1) Electronic equipment shown as simplified block diagrams. Antennas, waveguide switches, duplexers, filters, transmitter/receivers and other equipment shall be installed in accordance with ships guidance plans, and installation control drawings.

(2) 90° H Bends

For Selection of Electrical and Mechanical Details - See:
MIL-HDBK-216 Section 8A
For Detail Dimensions - See: MIL-W-3970
For Fabrication of - See: MIL-HDBK-660
EIMB Section 5
Paragraph 5-1

(3) Flexible Section
For Selection of Electrical and Mechanical Details - See:
MIL-STD-242 Section 502
MIL-HDBK-216 Section 8A
EIMB Section 5, Paragraph 5-2.1.19
For Detail Dimensions - See: MIL-W-287

(4) 90° E Bends
For Selection of Electrical and Mechanical Details - See:
MIL-HDBK-216 Section 8A
For Detail Dimensions - See: MIL-W-3970
For Fabrication of - See: MIL-HDBK-660
EIMB Section 5, Paragraph 5-1

(5) 45° Bends
For Selection of Electrical and Mechanical Details - See:
MIL-HDBK-216 Section 8A
For Detail Dimensions - See: MIL-W-3970
For Fabrication of - See: MIL-HDBK-660
EIMB Section 5, Paragraph 5-1

(6) Waveguide Twists
For Fabrication of - See: MIL-HDBK-660
EIMB Section 5, Paragraph 5-1

(7) Waveguide Sections, Straight
For Selection of Electrical and Mechanical Details - Theory - See:
MIL-STD-242F Section 501
MIL-HDBK-216 Section 6A
MIL-STD-1358
For Detail Dimensions, Electrical and Mechanical Details - See:
MIL-W-85 (Rigid, Rectangular)
MIL-W-23351 (Ridged)
MIL-W-23068 (Circular, Rigid)

(8) Flanges
For Selection of Electrical and Mechanical Details - Theory - See:
MIL-STD-242 Sections 601 & 602
MIL-HDBK-216 Section 7A
MIL-STD-1327
For Detail Dimensions Electrical and Mechanical Details - See:
MIL-F-3922 (For Rectangular W/G)
MIL-F-39000 (For Ridged W/G)
MIL-C-39004 (Subminiature W/G Disconnects)
For Assembly to W/G - See: MIL-HDBK-660
EIMB Section 5, Paragraph 5-1

(9) Watertight Penetrations
See: EIMB Section 5, Paragraphs 5-2.1.11, 5-2.3.3 and 5-2.5.
EIMB Section 5, Figures 5-11 thru 5-21
NAVSEA DWG 9000-S6202-73980, Section 4, Shts 170-180

(10) Non-Watertight Penetrations
See: EIMB Section 5, Paragraphs 5-2.1.11, 5-2.3.3 and 5-2.5.
EIMB Section 5, Figure 5-10

(11) Waveguide Supports
See: EIMB Section 5, Paragraphs 5-2.1.9, 5-2.1.10 and 5-2.4.
EIMB Section 5, Figures 5-6, 5-7 and 5-8

(12) Waveguide Support Isolation
See: EIMB Section 5, Paragraphs 5-2.1.9 and 5-2.4.9
EIMB Section 5, Figure 5-9

(13) Painting of Waveguide Exposed to Weather
See: EIMB Section 5, Paragraphs 5-1.13.16 and 5-2.9.

(14) Painting of Waveguide Not Exposed to Weather
See: EIMB Section 5, Paragraphs 5-1.13.16 and 5-2.9.

(15) Purge Line - 1/4 Diameter tube installed to comply with standard piping specifications.

(16) Bleeder Valve - Located in Radar Room in an area accessible to maintenance personnel but not to interfere with equipment operation. Installation of valve shall comply with all piping specifications.

(17) Ground Straps
See: MIL-STD-1310(NAVY)
EIMB Section 5, Paragraph 5-2.8

(18) Pressure Window
See: EIMB Section 5, Paragraph 5-1.1.1.6.
ICDs for a specific system requirement.

(19) Dry Air Connection to Waveguide
See: EIMB Section 5, Paragraph 5-1.14.2
ICDs for a specific system requirement.

(20) Electronic Dry Air System and Components
See: EIMB Section 5, Paragraphs 5-1.14, 5-2.7, 5-2.10.13.
ICDs for a specific system requirement.

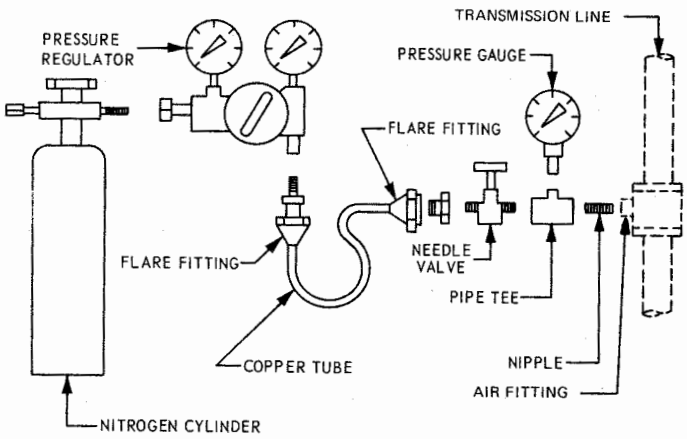


Figure 5-23. Method for Temporary Pressurization

5-2.7 PURGING AND PRESSURIZING (SHIPBOARD)

Dry air installation to be in accordance with Paragraph 5-1.14 and the following:

5-2.7.1 Temporary Pressurization

Temporary pressurizing of waveguide may be used for protection against moisture during shipboard installation, testing for air leaks, purging and maintaining a pressurized waveguide run until the ships electronic equipment dry air system is operational. Figure 5-23 shows a typical temporary dry air system using bottled nitrogen that can be used for testing, purging and maintaining temporary pressurization.

CAUTION

Do not exceed the specified PSIG for the particular waveguide being installed.

5-2.7.2 Tightness Test

Immediately upon completion of the transmission line installation a tightness test shall be conducted to determine if leakage exists at any flange connections. The transmission line shall be pressurized to its specified pressure. The compressed dry air or nitrogen shall be allowed to stand in the transmission line until its temperature equalizes. The pressure drop, corrected for temperature changes, shall not exceed five percent of the test pressure after a test period of six hours. If, after the expiration of the test period, the pressure drop exceeds the permissible five percent drop, the system shall be examined and leaks eliminated, and the tightness test repeated. Waveguide sections that have leaks through the brazed flange joints shall be rejected. They may be returned for shop refabrication in accordance with paragraph 5-1.13 or replaced with a new section. Epoxy or plastic type sealers shall not be used for sealing leaks in transmission lines.

5-2.7.3 Method for Detecting Leaks

A typical method of detecting leaks is to apply undiluted liquid shampoo to the flange connection, or suspected area. With pressure inside the waveguide, bubbles will appear where the nitrogen is escaping.

5-2.7.4 Purging Procedures

Purging of the waveguide run shall be accomplished as soon as all leaks have been repaired. The following procedure is recommended for purging a waveguide run.

Step 1. Pressurize the system to the required PSIG and maintain this pressure for 2 hours.

Step 2. Bleed the waveguide run very slowly through the gas escape valve at the end of the purge line, maintaining a constant pressure from the dry air or nitrogen source. Bleeding the line should continue for a minimum of 2 hours.

Step 3. Close the gas escape valve and check to insure that the waveguide is pressurized to the required PSIG.

5-2.7.5 Purging Requirements

Purging of the waveguide run shall be repeated every time the line is opened for any reason. If the line is opened for minor checks or inspection that takes only a few minutes to complete, then the time limit specified in *Step 1* of paragraph 5-2.7.4 can be omitted.

5-2.8 GROUNDING OF WAVEGUIDE RUNS

Waveguide runs shall be considered to be at ground potential unless proven otherwise by Electromagnetic Interference (EMI) Tests. When additional

grounding is required, the bonding methods, materials, surface preparation and sealing shall be in accordance with MIL-STD-1310.

5-2.9 PRESERVATION OF WAVEGUIDE

The Preservation of waveguides to prevent corrosion and contamination from weather or ozone shall be in accordance with the following.

5-2.9.1 Exterior Surface Painting

After installation, touch-up exterior surfaces of waveguides (including areas exposed to, and not exposed to, the weather) with the MIL-P-24441 epoxy-polyamide coating system described in Paragraph 5-1.13.16. To improve adhesion of epoxy-polyamide, lightly sand surfaces to be painted, fair paint edges, and clean with mineral spirits to remove dirt, grease and other contaminants. Apply thin coat of Formula 151, and while still tacky, apply one or two coats of Formula 151 to a total minimum dry film thickness of 8.0 mils. After completion of the touch-up process, the transmission line may receive, if desired, an additional coat of paint to match the surrounding areas.

5-2.9.2 Waveguide Requiring Additional Heat Dissipation

Where a flat black finish is needed to assist in heat dissipation generated by the transmission line, apply one coat of Formula 153-Rol. 8 black epoxy-polyamide paint. Prior to application, lightly sand existing epoxy-polyamide paint, clean with mineral spirits, and apply a thin coat of Formula 153-Rol. 8, and while still tacky, apply a full coat of Formula 153-Rol. 8 approximately 2 mils dry film thickness.

5-2.9.3 Flange Joint Protection after Installation

Flange joints, including fastening hardware, shall be coated with a sealer after installation and all testing is completed. This sealer is to prevent corrosive build-up caused by sea water seepage into flange faces and mating hardware.

An acceptable seal can be obtained with a spray coating of clear polyurethane resin solution such as Dexter Corporation's Laminar 48-C-24 or the equivalent. Using a narrow spray pattern, the polyurethane coating should be applied in such a manner as to assure an adequate flow of material over the outer edges of flange joints and fastener hardware. This method of sealing is preferred since it provides a clear transparent coating, and early detection of corrosive build-up is possible through periodic visual inspections.

Another method of sealing transmission line flange joints is with heat shrinkable tubing. When used, the heat shrinkable tubing shall comply with MIL-R-46846 and should be slipped on the transmission line at each flange connection during the assembly process. The tubing must be protected from damage until it can be shrunk into place after all testing is completed. The method of installing heat shrinkable tubing is a disadvantage as compared to the ease and simplicity of applying Laminar 48-C-24. Another disadvantage is that periodic visual inspections of flange joints for corrosive build-up cannot be accomplished without destroying the tubing and replacing with new ones.

5-2.10 QUALITY CONTROL INSPECTION

Quality Control Inspections shall be conducted during the installation process and after completion of all work to ensure the transmission line installation conforms to the ships installation drawings and this document.

The following subparagraphs provide guidlines to assist the Installing Activity in ensuring an optimum installation.

5-2.10.1 Straight Line Deviation

Ensure the transmission line run, excluding bends, twists, offsets and flexible sections does not deviate more than 0.250 inch from a straight line.

5-2.10.2 Penetration Alignment

The deck and/or bulkhead penetration assemblies shall meet the requirements of paragraph 5-2.5 and place no stress or strain on the transmission line. Ensure the assembly is sealed against water and/or air.

5-2.10.3 Support Alignment

Transmission line supports (hangers) shall meet the requirements of paragraph 5-2.4 and, when loosened, shall cause no resulting movement in the transmission line that indicates improper alignment.

5-2.10.4 Flange Joint Alignment

Flange bolts, when loosened, shall cause no movement in either mating section that indicates improper flange fabrication or transmission line alignment. The flange bolting holes shall be aligned within 0.0313 of an inch and the flange faces shall be parallel and not separated by more than 0.0156 of an inch.

5-2.10.5 Dents and Cuts

The overall outer surface of the transmission line shall be checked for dents and deep cuts that may possibly cause deformation of inner surfaces resulting in reduced system performance. Dents and cuts that would cause a change in the electrical characteristics shown in the procurement specification for the specific transmission line shall be cause for rejection of that specific section of transmission line.

5-2.10.6 Isolation

Transmission line supports shall be properly isolated to prevent galvanic action in accordance with paragraph 5-2.4.

5-2.10.7 Support Fit

Supports (hangers) shall provide a snug fit

with the transmission line. There shall be no deformation of the transmission line.

5-2.10.8 Support Spacing

Spacing between transmission line supports shall not exceed five feet. The spacing of supports from a flange connection shall be a minimum of six inches for all transmission lines, except large heavy waveguide requiring special flange supports such as the AN/SPS-49 waveguide.

5-2.10.9 Quantity of Supports

A minimum of two supports shall be installed on any section that exceeds 24 inches in length.

5-2.10.10 Protective Guards

Protective Guards shall be installed around the transmission line in accordance with the requirements of paragraph 5-2.1.

5-2.10.11 Flange Faces

Flange faces shall be free of any paint or scratches. Exposed flanges shall remain covered with protective caps until time of interfacing with mating flange.

5-2.10.12 Protective Labels and Markings

Ensure "DO NOT STRIKE" labels and identification markings are in accordance with the requirements of paragraph 5-2.1.

5-2.10.13 Pressurization

Ensure the transmission line is pressurized to the correct PSI and that the dry air being supplied meets the requirements of MIL-STD-1399 Section 102. Insure that operating instructions and labels for the dry air system are posted near applicable equipment. Ensure all valves of the dry air system are identified. Ensure the transmission line has been properly purged and the tightness test successfully completed in accordance with the requirements of paragraph 5-2.7.

5-2.10.14 Component Certification

Ensure, when applicable, that bend assemblies, twist assemblies, flexible assemblies, transmission line type, fastener hardware and flanges are the type shown on ships installation drawings and comply with the requirements of this document.

5-2.10.15 Clearance and Access

Ensure the transmission line run has a minimum clearance of two inches from all objects as specified in paragraph 5-2.1.4. Ensure sufficient access has been provided for the assembly, installation, maintenance, and repair of the transmission line.

Ensure the transmission line is not welded to any deck, bulkhead, assembly or support.

5-2.10.16 Preservation

Ensure all flange joints have been sealed in accordance with paragraph 5-2.9.3. Ensure the transmission line run including supports and deck/bulkhead penetrations are properly painted in accordance with the applicable paragraphs of this document.

5-2.10.17 Parallel Transmission Line Runs

Ensure parallel transmission line runs, when installed, are in accordance with the requirements of paragraph 5-2.1.15.

5-2.10.18 Grounding

Where applicable ensure transmission line grounding complies with the requirements of MIL-STD-1310.

5-2.11 ELECTRICAL REQUIREMENTS AND TESTS

After satisfactory completion of installation, visual inspections, tightness tests and final pressurization, and prior to initial equipment turn-on, the transmission line shall be electrically tested in accordance with the following requirements.

5-2.11.1 Test Equipment Requirements

The type of test equipment and accessories required for transmission line electrical tests shall be determined by the installing activity. The selection shall be based on the type of electrical test to be conducted, type of transmission line to be tested, system configuration, transmission line and system frequency band, and the test report requirements. Test equipment used shall carry a current calibration certification and be operational in accordance with the test equipment technical manual.

Where applicable, the ships test equipment shall be used. This will permit duplicating of tests by ships force when complying with the system/equipment maintenance requirements.

5-2.11.2 Insertion Loss Measurements

In general, the insertion loss, which is a function of frequency, of an overall transmission line is the product of the theoretical attenuation and a "fabrication factor" added to the mismatch loss for the line and the insertion losses of microwave components such as switches, circulators, isolators, filters and directional couplers.

The transmission line theoretical attenuation values and the maximum allowable insertion loss values must be computed prior to the insertion loss test.

5-2.11.2.1 Theoretical Attenuation

MIL-HDBK-216, Section 6 should be used for computing the attenuation of rectangular waveguide and plotting the attenuation curve. A minimum of ten points should be plotted across the frequency band to obtain a more accurate curve.

The attenuation in dB per unit length as computed in MIL-HDBK-216 will be dB/inch. This is easily converted to dB/foot.

When computing for the constant "K" using the equation in MIL-HDBK-216, the magnetic permeability of waveguide metal should be $4\pi X10^{-7}$ (henry/meter).

Attenuation measurements greater than twenty percent of the computed values shall be corrected.

5-2.11.2.2 Maximum Allowable Insertion Loss

The following equation should be used for computing the maximum allowable insertion loss for a transmission line run. Values should be computed for both the low and high end of the required operating frequency band for comparison with the measured values.

IL = A(1.2)(L) + .06 + N

where:

IL = maximum allowable insertion loss in dB for a specific frequency.

A = Theoretical attenuation in dB/ft determined from the attenuation curve for the specified transmission line at a specific frequency.

1.2 = Fabrication factor (This allows for fabrication and installation imperfections of the transmission line).

L = Actual measured length in feet of the installed transmission line.

.06 = Transmission line mismatch loss based on a VSWR of 1.25:1 (the maximum allowable for a shipboard installation).

N = Sum of the insertion losses (stated in dB) of all microwave components such as switches, couplers and filters that may be in the transmission line between transmitter and antenna.

The measured insertion loss should not exceed the computed maximum allowable insertion loss for the overall transmission line run.

Information on insertion loss test methods and practices may be found in NAVSEA 0967-LP-000-0130.

5-2.11.3 Voltage Standing Wave Ratio Measurements

Voltage standing wave ratio (VSWR) measurements shall be made on all transmission line installations. Transmission lines having a VSWR greater than 1.25:1, when terminated in a dummy load presenting a VSWR of no greater than 1.05:1 to the line, shall be corrected.

The test procedures and test set up for time domain reflectometry (TDR) and frequency domain reflectometry (FDR) measurements will vary depending on the system complexity for the transmission line under test.

In addition to the general requirements for test reports required by paragraph 5-2.11.4 the VSWR measurements shall include a block diagram of the actual test set up identifying the test equipment and accessories used.

Figures 5-24 and 5-25 are simplified block diagrams for making swept frequency composite VSWR and return loss measurements and recording these measurements in the form of graphs.

The test procedures should be divided into two parts; (1) composite VSWR versus frequency and (2) return loss versus distance along the line. The composite VSWR measurements will provide a VSWR signature of the transmission line over the frequency range of the system and show whether or not it is within VSWR specifications. The return loss measurements will provide return loss signatures of the line and, if made just after the line is initially installed, are useful for historical reference purposes. If the composite VSWR measurements show the line to be above 1.25:1, the return loss measuring equipment may be set up to the appropriate problem frequency(s) in an attempt to isolate the location(s) of the discontinuity(s) creating the out-of-spec condition.

5-2.11.4 Test Reports

In general, test reports shall contain both computed and measured insertion loss and VSWR values at the specified frequencies; identification of the transmission line under test by its assigned designator; the type, make and model of test equipment used; and any variation from detailed test procedures, so that the test may be duplicated at a later date.

5-3 RIGID COAXIAL LINES

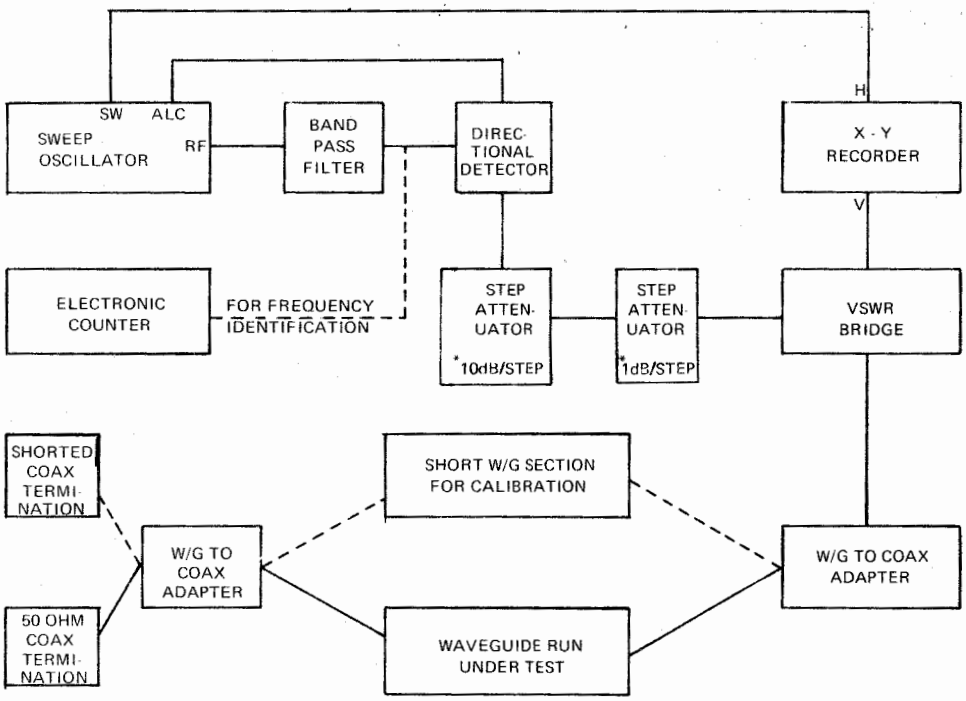
5-3.1 INTRODUCTION

A radio frequency transmission line which is pieced together using rigid coaxial cable sections, bends and accessories is known as a rigid coaxial transmission line. The word "rigid" refers to the coaxial cable sections, elbows and accessories which are rigid in that they are primarily designed not to be bent nor formed at the installation site. The completed rigid transmission line is not an inflexible or unyielding metallic channel, since it is continually expanding or contracting and therefore, provisions must be made to allow for these changes.

5-3.2 PRE-FABRICATION

The fabrication of a rigid coaxial cable sections and parts into a rigid transmission line requires care and precision. This includes physical care for the cable's metallic tubes which will not perform their function properly as a radio frequency transmission line if dented or deformed in any way, and also personal care exercised to be sure that no foreign matter is inadvertently left within the transmission line assembly.

To assist in producing the best transmission line installation, the installer will follow the manufacturer's instructions on the care and handling of rigid transmission line sections, along with recommended procedures of this section and 5-4 for Installation. These procedures will cover rigid coaxial cable handling and care; starting with receipt of shipping container, through uncrating, inspection, storage, on-the-job fabrication, installation purging and pressurizing procedures, preservation, and the electrical requirements and tests. The design of the rigid coaxial run shall be attempted by qualified design personnel. No substitutions or modifications



*PRE-DETERMINED VALUES OF ATTENUATION ARE SET ON THE STEP ATTENUATORS TO ESTABLISH VSWR REFERENCE LINES ON THE RECORDER DURING THE CALIBRATION CYCLE

Figure 5-24. Typical Test Set-up for Composite VSWR Measurements

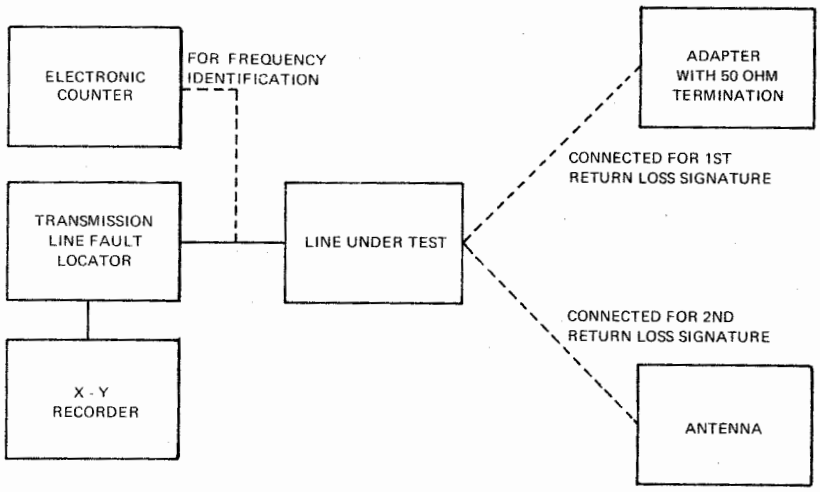


Figure 5-25. Typical Test Set-up for Return Loss Signature

are to made to Installation Control Drawings or other specified documents, without approval. In planning the layout of the Rigid Coaxial line the conditions in 5-4.1 shall be met.

5-3.3 INSPECTION

As soon as possible after receipt of the rigid coaxial transmission line shipping boxes, they should be examined for breaks in their walls. A broken box is an indication that the contents may be damaged. If the boxes are in good condition it is better to leave the sections in the shipping boxes until they are to be used. All lines and parts shall be inspected prior to fabrication for good workmanship and conformance with applicable specifications.

5-3.4 STORAGE

Whether left crated or unpacked, the coaxial cable sections, coupling fittings and associated parts shall be stored in a cool dry location. The cool dry air is to reduce corrosion to a minimum. Unpacked section shall be stored in a horizontal position and shall be adequately supported to prevent buckling and bowing. During stowing they should not be dropped into position, but should be carefully set in place. The ends of each stored section, fittings and assemblies shall be sealed with heavy paper or plastic caps or lintless cloth to prevent the entrance of dust or any foreign material. Flange faces and edges of coupling shall be protected by a cover to prevent their becoming damaged.

5-3.5 HANDLING

When unpacking the coaxial sections, each shipping box shall be placed so that it is resting solidly in a horizontal position. Nails in the box cover shall be removed with a nail puller. Prying the cover off the box may dent some of the coaxial sections. Carefully remove collar blocks to avoid damaging. If the section is encased in an individual cardboard tube, the tube should be left in place for protection. To examine the coaxial section, remove the protective fiber cover from one of the end flanges. After examination, replace the cover. The same care applies to angle sections, fittings, and parts. The gaskets, O-rings, inner coupling, etc., are usually packed separately. When unpacking these items, do not touch any conducting surface with the hands. Perspiration and acid on the skin of the hands is detrimental to electrical conductive surfaces.

5-3.6 STRAIGHT SECTIONS, INNER COUPLING AND FLANGES

Copper or aluminum straight sections are supplied in sizes 3/8 inch to 6-1/8 inches in diameter and in 20-foot lengths. Lines may be supplied with fixed flanges at each end, or one end only, or with no flanges. MIL-STD-242 Section 603/701, MIL-STD-1327, MIL-L-3890 and MIL-F-24044 provides details for the rigid coaxial line, gaskets, inner coupling and flanges. (See Appendixes 5-B and 5-C)

Regardless of length, if one or both ends are flanged, each section will be provided with one inner coupling, one O-ring gasket, bolts, lockwashers and nuts required for the size of line. If the section is delivered without flanges, the hardware (See 5-2.6.7) will not be included. The installation of a rigid coaxial transmission line consists of joining the flanged ends of two coaxial sections together and connecting the two inner conductors by means of an inner coupling commonly called a bullet. Detailed assembly instructions will be found in each box of coaxial sections or parts. They should be followed as closely as possible. Fabrication instructions are primarily included here as an aid to, and clarification of, the manufacturer's instructions, and secondly for use in the absence of such instructions. See 5-4.6.7 showing various size coaxial section, assembled with connectors and flanges. For detail assembly of flanged joints see 5-4.6.8.

NOTE

Ensure that transmission line meets specifications for roundness and wall thickness. Inspect line for dirt, corrosion and dents. Where an aluminum flange must join copper or brass flanges, plate the copper or brass flange with zinc to prevent corrosion from electrolysis between dissimilar metals.

5-3.7 ELBOW ASSEMBLIES

Rigid coaxial line sections may be connected together by 45 degree or 90 degree mitered elbows. Elbows are connected to straight section and other rigid coaxial accessories in the same manner as described in 5-4.6.8. All assemblies shall meet the requirements of MIL-L-28796 (See appendix 5-B).

5-3.8 GAS INLET AND GAS BARRIER COUPLINGS

These gas fittings are available for all sizes of transmission lines. The gas inlet is a 1/8 inch iron pipe size (IPS). The gas barrier is fitted between two flanges of adjacent assemblies. The assembly is similar to that described in 5-4.6.8. When installing the barrier, be sure the gas ports face the pressurized section of the transmission line. All assemblies shall meet the requirements of MIL-L-28796 (see appendix 5-B).

5-3.9 REDUCERS

Reducers connect larger size coaxial lines to smaller size lines in the following steps.

Size 7/8" to 3/8" coaxial transmission line
Size 1-5/8" to 7/8" coaxial transmission line
Size 3-1/8" to 1-5/8" coaxial transmission line
Size 6-1/8" to 3-1/8" coaxial transmission line

The assembly is very similar to that for two straight sections. All assemblies shall meet the requirements

of MIL-L-28796 (See appendix 5-B).

5-3.10 ADAPTERS

These are all used to join rigid coaxial line to flexible coaxial cable. One end of the adapter has a flange which mates with the flange of the rigid coaxial transmission line. The other end of the adapter is fitted with a coaxial connector which mates with the flexible coaxial cable. See Figure 5-26 and Table 5-1 for information. The connector on the adapter for the flexible coaxial cable can be either male (ML) or female (FL) plug. The adapter includes the flexible cable connector, the inner coupling, "O" ring gasket, hardware to complete the connection between adapter and the rigid coaxial transmission line. The mating connector for the flexible coaxial cable is not supplied. Adapters are available to connect all sizes of rigid coaxial cable to certain sizes of the flexible coaxial cable connectors. Refer to Figure 5-26 for adapter connector parts and nomenclature. All assemblies shall meet the requirements of MIL-L-3890 and MIL-HDBK-216 Section 3 (See appendix 5-B).

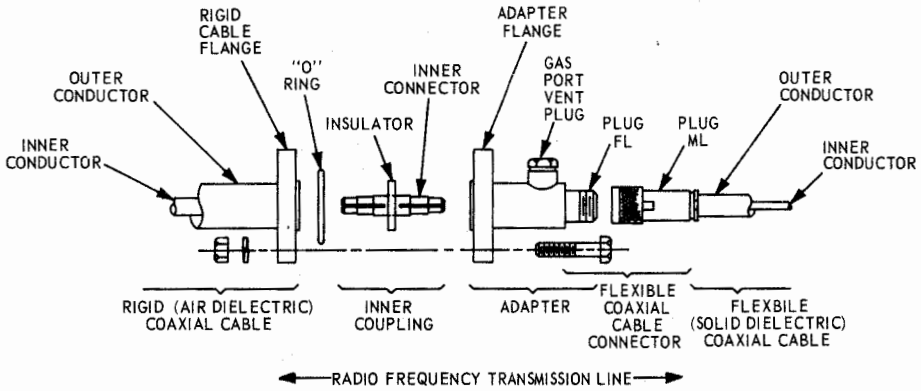


Figure 5-26. Adapter Connection Parts and Nomenclature

TABLE 5-1. RIGID COAXIAL LINE TO FLEXIBLE COAXIAL CABLE ADAPTER TERMINATION DATA

RIGID COAX CABLE SIZE	CONNECTOR SERIES	CONNECTOR FABRICATED WITH ADAPTER	CONNECTOR ATTACHED TO FLEXIBLE CABLE
7/8	N	Female Plug UG-23F/U	Male Plug UG-21F/U
7/8	LC	Female Plug UG-215A/U	Male Plug UG-154A/U
1-5/8	N	Female Plug UG-23F/U	Male Plug UG-21F/U
1-5/8	LC	Female Plug UG-215A/U	Male Plug UG-154A/U
3-1/8	N	Female Plug UG-23F/U	Male Plug UG-21F/U
3-1/8	C	Female Plug UG-570A/U	Male Plug UG-573B/U

5-3.11 FLEXIBLE COAXIAL ASSEMBLIES

Flexible coaxial assemblies with flanges are designed to compensate for undesirable stress caused by different expansion and contraction rates of the ships structure, vibration and shock. Flexible sections when necessary shall be as short as possible and installed at right angles to the direction in which the greatest movement shall occur. Flexible assemblies shall not be used for alignment purposes or to take up the fixed slack in a run. Flexible assemblies shall not be stretched or compressed when installed and shall be in a normal free state after installation. Flexible assemblies shall meet the requirements of MIL-L-28796 (see appendix 5-B).

5-3.12 STRAIGHT ASSEMBLIES

Rigid coaxial transmission line assemblies in 20 foot lengths, flanged on both ends or flanged on one end only to facilitate cutting length to suit final installation, can be procured in accordance with MIL-L-28796. Straight assemblies that require cutting and flange attachment shall comply with the fabrication requirements of paragraph 5-3.13. The completed assembly shall meet the requirements of MIL-L-27896 (see appendix 5-B).

5-3.13 FABRICATION

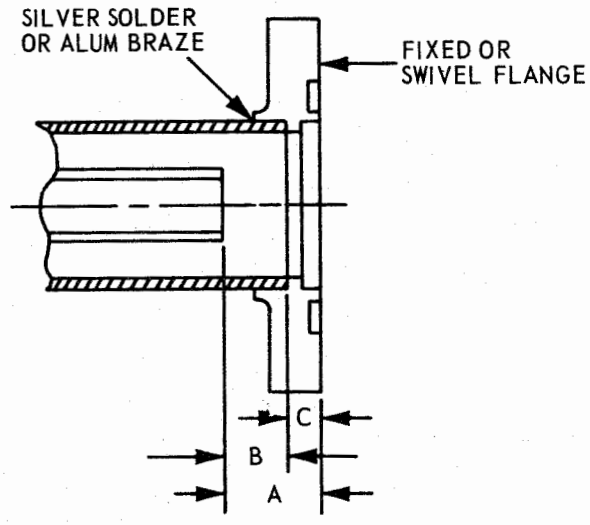
The fabrication of a section of rigid coaxial transmission line shall be in accordance with the following instructions and the specific manufacturer's instructions.

5-3.13.1 Cutting Outer Conductor

Step 1. Determine the exact length of coaxial line needed, then deduct the amount required for the flange. This is the cutting point. Flange thickness varies with the coaxial cable size. For cutting dimensions see Table 5-2.

TABLE 5-2. CUT-BACK DIMENSIONS FOR RIGID COAXIAL TRANSMISSION LINE

TRANSMISSION LINE SIZE AND TYPE		7/8"		1-5/8"		3-1/8"		4-1/8"		6-1/8"	
		Cu.	Al.	Cu.	Al.	Cu.	Al.	Cu.	Al.	Cu.	Al.
CUT BACK	"A"	1/2	1/2	5/8	5/8	1-1/64	1-1/64	1-1/64	1-1/64	1-11/32	1-11/32
	"B"	11/32	9/32	7/16	5/16	49/64	41/64	49/64	41/64	1-1/16	7/8
	"C"	5/32	7/32	3/16	5/16	1/4	3/8	1/4	3/8	9/32	15/32



Step 2. Prepare a wooden plug whose large diameter fits snugly inside the coaxial cable outer conductor, and whose center rod fits snugly inside the inner conductor as shown in Figure 5-27.

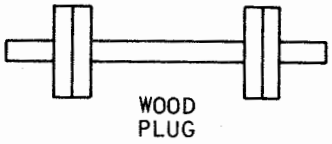


Figure 5-27. Wood Plug Used for Cutting Rigid Coaxial Line

Step 3. Slide back the inner conductor of the rigid coaxial section and insert wood plug into the outer conductor. Use the inner conductor to position plug under cutting line as shown in Figure 5-28.

NOTE

Lint free white cotton gloves must be worn when handling inner conductor and inner surface of outer conductor.

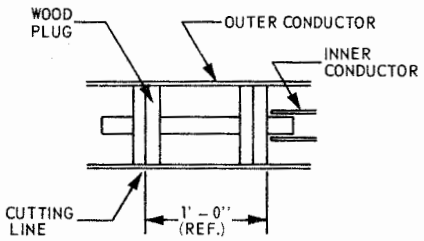


Figure 5-28. Wood Plug Shown Inserted in Outer Conductor of Rigid Coaxial Line

Step 4. Fit tube cutter with a standard cutting wheel. Score a complete circle around the outer conductor at the cutting point as shown in Figure 5-29. The recommended method for scribing the circle is to alternately swing the cutter through an arc of approximately 30 degrees at a time, until the circle is complete. This is a scoring operation only. Do not advance the cutting rollers.

Step 5. Remove the standard cutting wheel and insert a single sided cutting wheel. Reposition the tube cutter around the outer conductor with the flat side of the wheel toward the end of the coaxial section where the flange will rest.

Step 6. Cut through the outer conductor tube, advancing the roller wheels just a little at a time so as to not create a burr on the inside of the tube.

Step 7. Remove the wood plug and the inner conductor.

Step 8. Holding the outer conductor tube in a downward position remove burr on inside edge, if any, using a pocket knife or scraper.

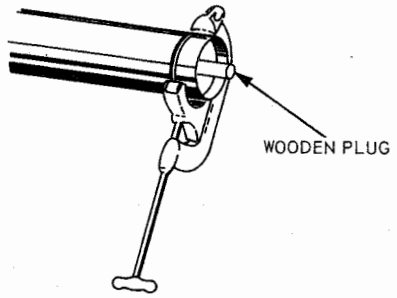


Figure 5-29. Tube Cutter With Single-Sided Wheel Used for Cutting Rigid Coaxial Line

5-3.13.2 Installing Flanges

Step 1. Clean end of outer conductor with a garnet paper or fine non-carbon sandpaper. Length to be cleaned will vary from 1-1/2 to 3 inches depending on the coaxial cable size. Keep all chips, dust, dirt, and any other foreign matter from entering tube. Always use cotton gloves when handling coaxial line and do not touch or contaminate cleaned sanded area.

NOTE

Cleaning, attachment of flange, removal of flux and application of chemical film shall be accomplished as one operation without time lapse between steps.

Step 2. Place the flange on the outer conductor with the flange recess facing the end of the outer conductor. Aluminum flanges may be joined to the outer conductor by dip brazing or by inert gas metal arc welding. Copper flanges shall be silver brazed to the outer conductor. In dip brazing, the filler metal is prepositioned in the joint and the work is dipped into a bath which transfers heat to the joint and melts the filler alloy. See 5-1.9, 5-1.13 and MIL-B-7883 (Appendix 5-D) for dip brazing of alloys and for process of cleaning parts prior to brazing, process of brazing, and post brazing treatment.

The flange shall be perpendicular to the outer conductor within 15 minutes for coaxial lines up to 1-5/8 inches in diameter, and within 30 minutes for lines 1-5/8 inches in diameter and larger.

Step 3. Remove all flux after brazing.

Step 4. Coat the sanded area, brazed area and flange with chemical film in accordance with paragraph 5-3.14.

Step 5. The complete assembly is ready for painting. See 5-3.15.

5-3.13.3 Cutting Inner Conductor

Step 1. Determine the length to be cut from the inner conductor. This will vary depending on the coaxial cable size and the make and type of inner coupling. (For cutting dimensions see Table 5-2.)

Step 2. Cut the inner conductor. It shall be cut as described in paragraph 5-3.13.1 for the outer conductor. The end must be as square as possible with the inner conductor length.

Step 3. File the cut end smooth. Remove all filings and any other foreign matter.

Step 4. Replace the inner conductor within the outer conductor.

5-3.13.4 Installing Field Flange (For Emergency Repair of Copper Lines)

Step 1. Place the free flange on the outer conductor tubing with its recess facing the end to be flanged (see Figure 5-30).

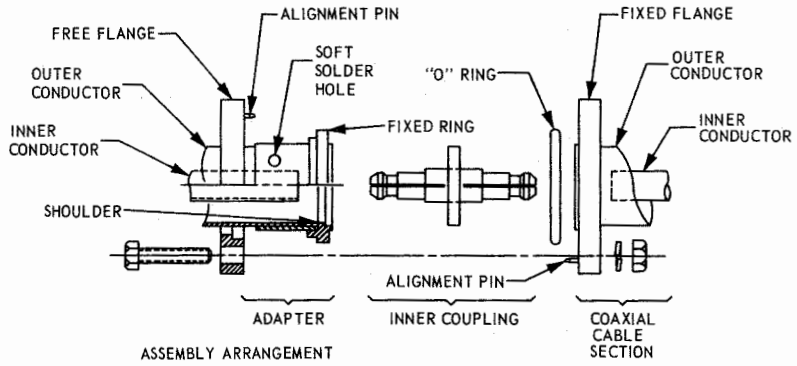


Figure 5-30. Free Flange Connection Parts and Nomenclature

Step 2. Smear rosin base flux on the cleaned area of the outer conductor tubing and on the inside of the adapter.

Step 3. Slide the adapter over the outer conductor tubing until its shoulder is flush against the tube end.

Step 4. Solder the adapter to the outer conductor tubing. Use a torch with a very small flame, and soft solder. Apply the heat evenly and uniformly around the adapter. Feed the solder into the solder hole. When the solder is flowing freely, use a glove, not pliers, and gently rotate adapter, at the same time pushing its shoulder flush against the tube end. Such a movement should permit a uniform distribution of the solder. Wipe away any excess solder.

Step 5. Remove heat and allow solder to cool. Approximately 1 minute.

Step 6. Remove excess flux with hot water.

Step 7. Clean adapter and tubing adjacent to it, inside and outside, thoroughly with fine sand paper. All sand, dust, dirt, flux, solder, and any other foreign matter must be wiped away.

5-3.14 CHEMICAL CONVERSION

All rigid coaxial transmission lines, assemblies and components shall receive chemical conversion protection. Copper lines shall be treated with Iridite #7P, Mixture C (or equal), while aluminum lines shall be treated with a chemical conversion in accordance with MIL-C-5541.

CAUTION

Flange faces shall receive the chemical conversion process and shall not be painted. The flange face is that part of a swivel flange that is attached to the outer conductor & makes physical contact with the mating flange. The part that is free & has fastening holes for hardware shall receive the painting prescribed for before installation.

5-3.14.1 Inspection of Coating

The chemical film shall be inspected to ensure it has been applied in accordance with MIL-C-5541

for aluminum, and the manufacturer's instructions for Iridite #7P for copper.

5-3.14.2 Removal of Chemical Film

Removal of chemical conversion film, when required, shall be in accordance with the instructions of MIL-C-5541 for aluminum or manufacturer's Iridite 7P instructions for copper.

5-3.15 PAINTING

All rigid coaxial transmission lines shall be painted in accordance with the following procedures and methods.

5-3.15.1 Before Installation

The chemically filmed external surfaces of all rigid coaxial transmission lines shall be painted in accordance with the three coat, MIL-P-24441 epoxy-polyamide coating system described in 5-1.13.16.

5-3.15.2 After Installation

Touch up external surfaces of rigid coaxial transmission lines as necessary with MIL-P-24441 epoxy-polyamide coating system as described in 5-3.9.

5-3.16 PRESSURIZING AND PURGING

Pressurizing and purging air systems for rigid coaxial transmission lines shall be as described in 5-1.14, except for air connections for which 5-3.8 and 5-4.6.8 applies.

5-4 RIGID COAXIAL LINES INSTALLATION PROCEDURES

5-4.1 GENERAL REQUIREMENTS

The installation of rigid coaxial transmission lines shall meet the following requirements.

5-4.1.1 Length of Run

The run shall be as short as possible with a minimum amount of mitered elbows and connections.

5-4.1.2 Location of Run

The location of the rigid coaxial transmission line run shall take precedence over piping, ventilation ducting, cable hangers, wireway runs and lighting fixtures. The transmission line run shall be located so it will not be disturbed by the removal of deck plates, gratings, machinery or service areas. Locate the rigid coaxial line to avoid electrical interference from equipment cables or other transmission lines.

5-4.1.3 Sequence of Installation

The complexity of the system, equipment location and the rigid coaxial transmission line run will determine the sequence of installation. Whatever the sequence may be, extreme care should be taken to prevent the inner conductor from slipping out of the outer conductor and being damaged during the assembly process.

5-4.1.4 Clearance

A clearance of two inches minimum shall be provided from all objects to which the rigid coaxial transmission line is not connected, to prevent damage when subjected to underway movement, shock or vibration. Clearance between the underside of the rigid coaxial line and the deck shall not be less than seventy-seven inches in areas where normal passage occurs.

5-4.1.5 Protection of Rigid Coaxial Lines

The rigid coaxial transmission line for each installation shall be protected from pedestrian traffic or where accidental damage is most likely to occur. Protective guards shall be removable and of sufficient size and strength to ensure the rigid coaxial line cannot be struck, attached to, or accidentally damaged. Expanded metal construction is preferred. These protective guards shall be installed around rigid coaxial lines where the line passes through a compartment in a vertical direction and where the rigid coaxial line penetrates the weather deck to a height above the deck as required to provide adequate protection. Protective guards shall be installed around rigid coaxial lines at platforms, catwalks, ladders and on the overhead, as required. The rigid coaxial line shall be protected against physical damage from battle action, heat and water.

5-4.1.6 Welding to Ship's Structure

Rigid coaxial transmission lines shall not be welded to ship's structure or any assembly to be mounted in ship's structure.

5-4.1.7 Protection against Moisture and Dirt

Precautions shall be taken to prevent the entrance of moisture and dirt into the transmission line during installation.

5-4.1.8 Structural Fouling

Rigid coaxial runs shall be located so they will not be disturbed by the removal of deck plates, gratings or machinery.

5-4.1.9 Galvanic Action

Rigid coaxial lines shall be isolated from supports to prevent galvanic action.

5-4.1.10 Type of Rigid Coaxial Line Supports (Hangers)

Rigid coaxial transmission lines shall be installed with alignment type supports in such a manner that no stress or strain will be placed on any joint or section.

5-4.1.11 Penetrations, Deck and Bulkhead

Deck and bulkhead penetrations shall comply with the ships structural requirements and permit the installing or removal of rigid coaxial sections including the attached flanges. Paragraph 5-4.5 provides general design information for acceptable type deck and bulkhead penetrations.

5-4.1.12 Transmission Line Markings

The finished rigid coaxial line components shall be identified per MIL-STD-130, paragraph 4.1, except metal stamping shall not be used. The identi-

fication shall be in a progressive manner to ensure correct remating of the matched flanges during installation and/or maintenance. Warning labels shall be applied to a visible area of the transmission line, approximately three feet apart after the transmission line has been painted or touched-up. Spray labels with weatherproof lacquer. Labels shall read "DO NOT STRIKE".

5-4.1.13 Grounding of Rigid Coaxial Transmission Lines

All rigid coaxial transmission lines shall be grounded in accordance with MIL-STD-1310(SHIPS).

5-4.1.14 Hardware

Flange assembly hardware shall be that which is supplied with the flange. Where replacement of missing hardware is required, the hardware shall be in accordance with the specific flange specification. Transmission line support hardware shall comply with paragraph 5-4.4.10 of this document.

5-4.1.15 Restrictions for Parallel Runs

When parallel transmission line runs are installed for the same system, and there is a possibility of interference from flange joint RF leakage, the flange connections shall be staggered so that no two flange connections will be located within six inches of each other.

5-4.1.16 Preservation

No rigid coaxial transmission line shall be installed without the interior and exterior being finished as directed in paragraph 5-4.9.

5-4.1.17 Straightness of Run

The transmission line shall not deviate from a straight line by more than 1/4 inch at any point to prevent stress on the inner conductor and the possibility of arcing.

5-4.1.18 Flange Joint Alignment

To prevent stresses being applied to the transmission line or the flanges, transmission line joints shall be arranged so that flanges will mate with bolt holes, during alignment within 1/32 inch and flange faces shall be parallel and not separated by more than 1/64 inch prior to bolting.

5-4.1.19 Pressurization

All rigid coaxial transmission lines shall be pressurized to prevent corrosion and maintain equipment performance parameters.

5-4.1.20 Expansion Joints

Compensation for expansion and contraction must be made when rigid coaxial runs cross expansion joints. A flexible section will be used only as designated on ship's installation plans and shall be installed parallel to the expansion joint.

5-4.2 HANDLING RIGID COAXIAL TRANSMISSION LINE GUIDELINES

Guidelines for the handling of rigid coaxial transmission lines from shop to ship, and during installation are as follows:

5-4.2.1 Sealing of Individual Sections

The ends of all sections shall be kept sealed against moisture and dirt, except during assembly of run aboard ship.

5-4.2.2 Sealing of Assembled Sections

The ends of partially assembled runs shall be kept sealed against moisture and dirt, except during assembly of run aboard ship.

5-4.2.3 Flange Face Protection

Flanges shall be protected against physical damage during shipping and installation.

5-4.2.4 Transporting Rigid Coaxial Sections and Components

Rigid coaxial transmission line sections shall be transported from shop to ship in cradles that will prevent bending, warping, and physical damage.

5-4.2.5 Warping of Long Rigid Coaxial Sections

Care should be taken in handling long sections of rigid coaxial lines to prevent distortion. Never lift a long section by the ends only.

5-4.2.6 Protection Against Hand Contamination

Lint free gloves shall be used whenever handling the inner conductor, inner coupling and flange mating surfaces.

5-4.3 LAYOUT OF RIGID COAXIAL RUNS

After the design and exact location of the rigid coaxial transmission line run has been determined, the first step in actual installation is the layout of the shipboard run by the use of templates. The entire transmission line run shall be templated, so that the fabrication shop can be provided with accurate information for flange assembly. By templating the complete run, all obstructions can be removed, hole cuts made in decks and bulkheads, mitered elbows reduced to a minimum, and most important the transmission line sections and elbows can remain in safe storage during this period of rough work.

5-4.3.1 Templates

The templates for rigid coaxial transmission lines need not be as accurate as those for waveguide. Elbows are obtainable in 45 degree and 90 degree mitered bends with rotatable flanges that can provide any desired angle needed. This eliminates the template requirement for different angle bends. Straight sections of rigid coaxial transmission lines are obtainable in 10 feet and 20 feet lengths with one end already flanged. The main requirement for the template is to provide the shop with accurate measurements for installing flanges on straight sections of rigid coaxial transmission lines. The assembly of these flanges on the line is a shop fabrication job and should never be accomplished aboard ship, except under an emergency condition. Templates for rigid

coaxial transmission lines may be made from any suitable material. Never use the transmission line itself for templating. It is too easily damaged and any small indentation or warping is justification for rejection.

5-4.3.2 Penetrations, Deck and Bulkhead

Deck and bulkhead penetrations should be carefully made at the time the templates are made, keeping in mind the overall run should be as straight and short as possible.

5-4.3.3 Supports, Rigid Coaxial Line

Basic information needed for transmission line supports shall be obtained at the time of templating the overall run (see Figures 5-31 and 5-32).

5-4.4 RIGID COAXIAL LINE SUPPORTS (HANGERS) REQUIREMENTS

Supports for rigid coaxial transmission lines shall be fabricated and installed to meet the following requirements.

5-4.4.1 Type of Material

Supports shall be made of material compatible to ship's structure.

5-4.4.2 Size of Material

Supports shall be of sufficient width and thickness to support the transmission line against damage due to vibration and shock.

5-4.4.3 Support Damage to Outer Conductor

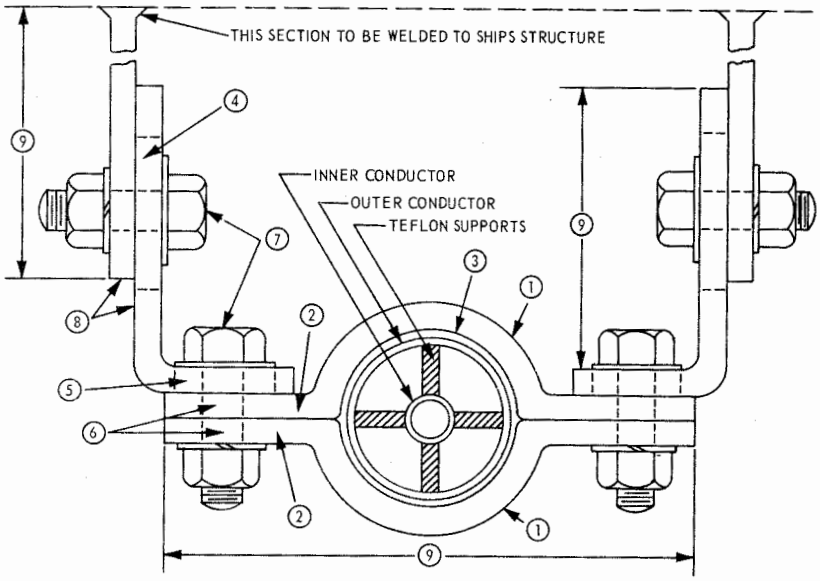
Supports shall provide a snug fit but not tight enough to cause deformation or damage to the outer conductor.

5-4.4.4 Isolation of Outer Conductor and Support

All supports shall be isolated from the transmission line by the method outlined in 5-2.4.9.

5-4.4.5 Adjustable Supports

All supports shall be fabricated to be adjustable in two directions (see Figures 5-31 and 5-32).



1. ISOLATION TO BE IN ACCORDANCE WITH 5-4d (9).
2. REMOVE ISOLATION OR PAINT FROM OUTSIDE OF EACH CLAMP IN AREA OF BOLT HOLES FOR BONDING PURPOSES.
3. SUPPORTS INSTALLED SHALL FIT SNUG ENOUGH TO SUPPORT TRANSMISSION LINES, BUT NOT TIGHT ENOUGH TO CAUSE COMPRESSION OF OUTER CONDUCTER.
4. HOLES SLOTTED FOR VERTICAL ALIGNMENT. (APPROX. 1½ INCH SLOT).
5. HOLES SLOTTED FOR HORIZONTAL ALIGNMENT. (APPROX. ¾ INCH SLOT).
6. MATCH DRILLED WITH 1 32 INCH CLEARENCE FOR BOLT, THIS IS REQUIRED FOR CORRECT FIT TO OUTER CONDUCTER.
7. SIZE OF HARDWARE DETERMINED BY TYPE OF RIGID COAXIAL LINE INSTALLED.
8. TYPE, WIDTH AND THICKNESS OF SUPPORT DETERMINED BY SHIPS STRUCTURE, LOCATION OF RUN AND TYPE OF RIGID COAXIAL LINE.
9. LENGTHS DETERMINED BY INSTALLING ACTIVITY.

Figure 5-31. Adjustable Support Fabrication Details for Rigid Coaxial Line

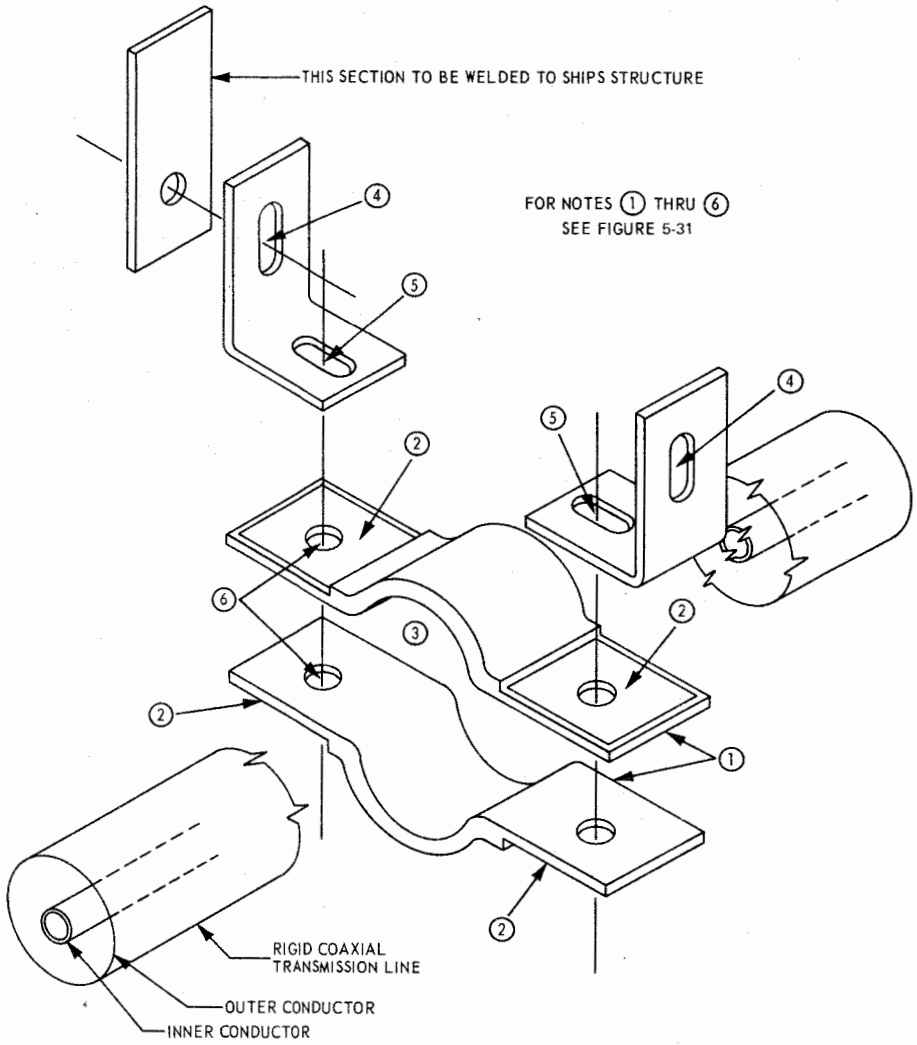


Figure 5-32. Typical Plastisol Coated Support for Rigid Coaxial Line

5-4.4.6 Location of Supports

Never force the transmission line to the support position, always locate the supports in such a manner as to prevent any stress, strain or bind on any segment of the overall transmission line installation.

5-4.4.7 Fitting Support to Rigid Coaxial Line

Supports installed shall fit snug enough to hold the transmission lines allowing for isolation material thickness covered in 5-2.4.9. For outside dimensions of rigid coaxial line see MIL-L-3890, Appendix 5-B.

5-4.4.8 Spacing of Supports

Spacing between supports shall not exceed 5 feet. Supports shall not be closer than 6 inches to any flange connection. There shall be a minimum of 2 supports for each section that exceeds 24 inches in length.

5-4.4.9 Isolation Methods

To prevent electrolytic corrosion between the transmission line and the support, the support shall be isolated as detailed in 5-2.4.9.

5-4.4.10 Hardware Requirements

Hardware required for rigid coaxial transmission line supports shall meet the following requirements.

(a) Supports exposed to weather shall be assembled with corrosion resistant steel hardware that meets the following specifications.

FF-N-836 Nuts
FF-S-85 Cap Screw, Slotted & Hex Head
FF-W-84 Washers, Lock (Spring)

FF-W-100 Washers, Lock (Tooth)
MIL-B-857, Nut and Stud

(b) Supports installed inside ship's structure and not exposed to weather shall be assembled with standard type cadmium plated hardware, unless otherwise specified on Installation Control Drawings.

5-4.5 PENETRATIONS, DECK AND BULKHEAD

Where rigid coaxial transmission line runs penetrates decks and bulkheads, the methods and procedures used shall meet the following requirements.

5-4.5.1 Non-Watertight Decks and Bulkheads

The requirements for a rigid coaxial transmission line passing through a non-watertight/non-airtight deck or bulkhead or an air/dust/fume tight bulkhead are the same as those outlined in paragraph 5-2.5.1 for waveguide. The typical method shown in Figure 5-10 is applicable to rigid coaxial lines. The shape of the coaming would be dependent upon structural requirements.

5-4.5.2 Watertight Decks and Bulkheads

Where a rigid coaxial transmission line passes through a watertight bulkhead or deck the fittings shall be watertight and comply with the structural requirements of the ship. The watertight fittings shall not be welded, brazed or soldered to the transmission line, and shall be capable of disassembly for removal of transmission line complete with flange.

5-4.5.3 Typical Methods

The typical methods discussed in paragraphs 5-2.5.3 through 5-2.5.7 for rectangular waveguide are in general applicable to rigid coaxial transmission lines.

The fabrication and assembly information covered in paragraph 5-2.5.4 are applicable to the typical split sleeve assembly shown in Figure 5-33 for a rigid coaxial line.

Information for using multi-cable transit devices with rigid coaxial transmission lines is covered in paragraphs 5-2.5.5 and 5-2.5.6.

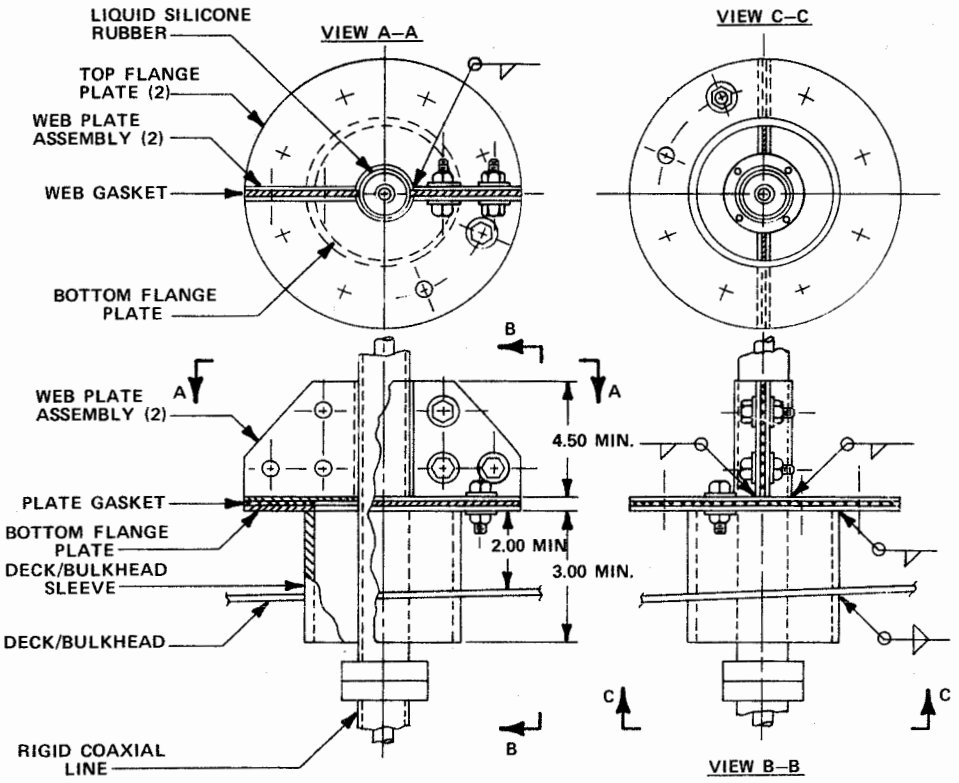


Figure 5-33. Typical Split Sleeve Assembly for Rigid Coaxial Line

5-4.6 OVERALL RIGID COAXIAL RUN INSTALLATION PROCEDURES

The assembly and installation of the rigid coaxial transmission line aboard ship shall be in accordance with the following requirements.

5-4.6.1 Shipboard Installation Pre-Requirements

The actual shipboard installation assembly of the rigid coaxial transmission line sections shall not begin until all shop fabrication work has been com-

pleted, all bulkhead and deck cuts have been made, deck/bulkhead sleeves tack welded in place and electronic equipment installed.

NOTE

The deck/bulkhead sleeve should be tack welded in such a manner that it can be easily aligned with the rigid coaxial transmission line prior to final welding.

5-4.6.2 Assembly Sequence

The assembly sequence for rigid coaxial transmission line runs will vary depending on the complexity of the system and equipment location. Because of the inner conductor construction, the preferred sequence of assembly for a rigid coaxial line would be from the transmitter to the antenna. This would make the vertical run easier to assemble and would not require special precautions to prevent the inner conductor from slipping out of the rigid coaxial assembly. The installer shall ensure the end of partially assembled runs remain covered, to prevent intrusion of foreign matter and moisture, until the next section is ready for assembly.

Ensure the flange faces are clean and "O" rings are properly seated. The flange bolts shall be tightened in a staggered sequence to ensure a smooth tight fit with even pressure around the entire parameter of the flange.

5-4.6.3 Material Ordering Sequence

Transmission line sections should be requested from shop storage in sequence of assembly and installed on ship when received. Transmission line sections should never be left laying around aboard ship. Transmission line sections shall be received at installation site sealed against moisture and dirt.

5-4.6.4 Inspection Prior to Installation

The ship installer shall visually inspect each transmission line section prior to assembling in run. Any section shall be rejected and returned to shop for re-work or replacement if found to contain any of the following defects.

1. Dents in outer conductor surface that would cause a change in the electrical characteristics specified in MIL-L-3890 (See Appendix 5-B).
2. Scratches in flange face surface that exceed those specified in MIL-F-24044 (See Appendix 5-C).
3. Unsealed.
4. Dirt or grease inside of transmission line, or on flange face.
5. Ripple in outer conductor surface indicating a warped condition.

5-4.6.5 Assembly Details

The complete rigid coaxial transmission line shall be assembled and held in place by temporary means before securing the transmission line supports or assembling the penetration transit device. This is to ensure no stress, strain, or bind is placed on any flange connection or section of the outer conductor.

5-4.6.6 Inner Coupling and Misalignment

Assembling sections of rigid coaxial transmission lines differ greatly from assembling of rigid waveguide transmission lines in that the installer must pay careful attention to inserting the inner coupling and also the installer can compensate for any slight misalignment of flanges made during brazing process.

5-4.6.7 Reference to Detail Illustrations

Figure 5-34 through 5-42 provides information that will help in obtaining an ideal installation.

5-4.6.8 Flange Joint Assembly

Refer to Figure 5-34. Extreme care must be maintained in handling and fitting of the coaxial line. The thin walled aluminum is susceptible to dents which will cause hot spots and consequently cause arcing. Check the inner connector to assure that the expansion spring is properly seated to provide maximum spread of the connector fingers and that the fingers are not bent. Check the inner conductor to assure that teflon supports are present and not damaged. As each section is installed, the inner conductor and inner coupling shall be wiped with FREON 113, Type I, MIL-C-81302A, and cheese cloth to remove moisture, oils or foreign material. Lint free gloves or cheese cloth shall be used when handling the inner conductor or inner couplings. Press fit one end of the inner connector into the inner conductor of a section of the transmission line. A twisting motion will aid in seating the shoulder of the inner connector snugly against the inner conductor of the transmission line. When the inner connector is properly seated, one half of the inner coupling insulator will be exposed. Place the "O" ring gasket in the flange groove. Be sure both gasket and groove are clean, as any foreign matter may prevent the assembly being pressure tight. A thin film of silicone lubricant, MIL-A-46106, on the gasket will help hold the gasket in place during assembly, and aid in retaining pressure. Use silicone lubricant very sparingly and do not permit any grease on mating inner conductor surface. Engage the inner connector (extending from one section) with the inner conductor of the next section. The inner connector must fit snugly. Push the assembly together making certain the gasket remains in place and the inner coupling

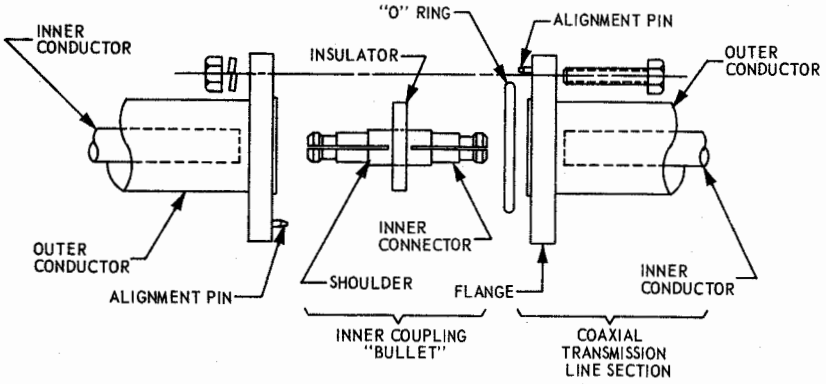


Figure 5-34. Rigid Coaxial Transmission Line Parts and Nomenclature

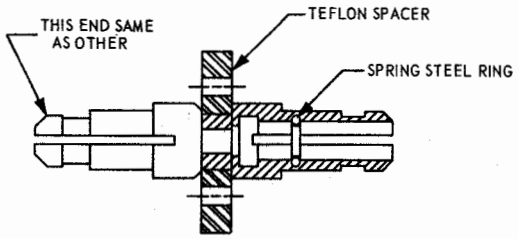


Figure 5-35. Cut-Away View of Inner Coupling (Bullet)

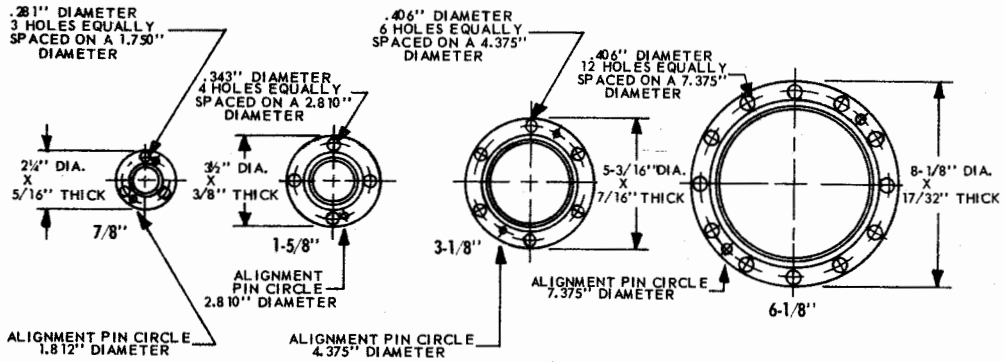


Figure 5-36. Flange Dimensions for Rigid Coaxial Transmission Line

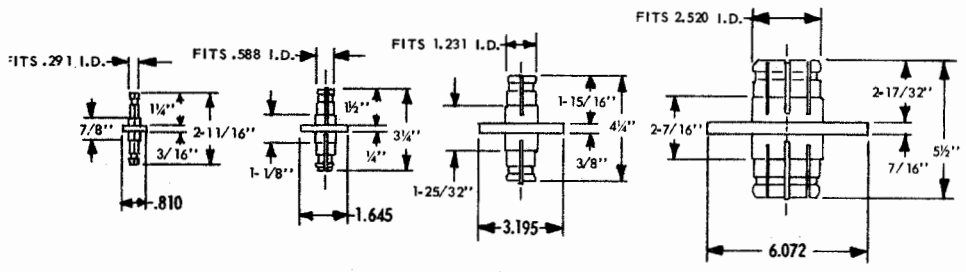


Figure 5-37. Inner Coupling (Bullet) Dimensions for Rigid Coaxial Transmission Line

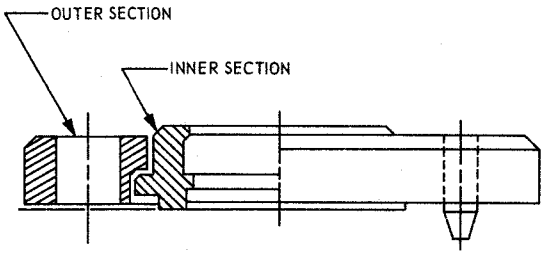


Figure 5-38. Cut-Away View of Rotatable (Swivel) Flange

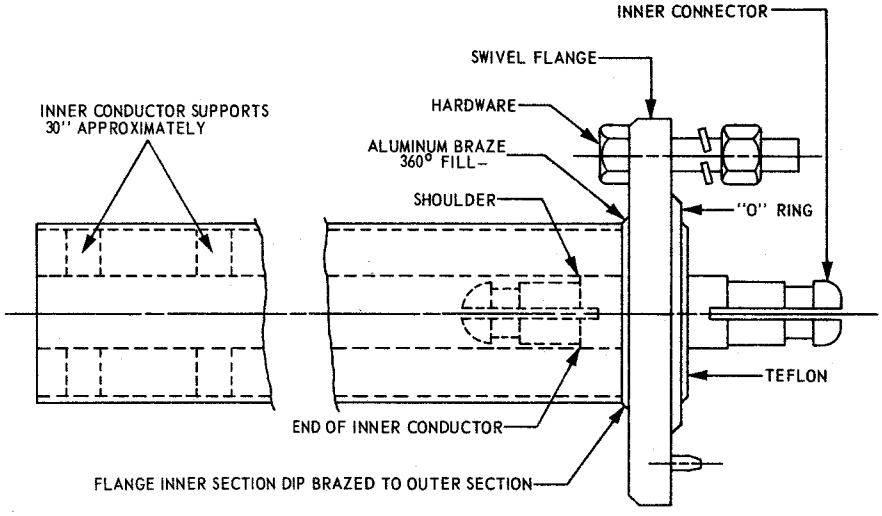


Figure 5-39. Cut-Away View of Rigid Coaxial Transmission Line with Swivel Flange, Inner Coupling and "O" Ring in Place

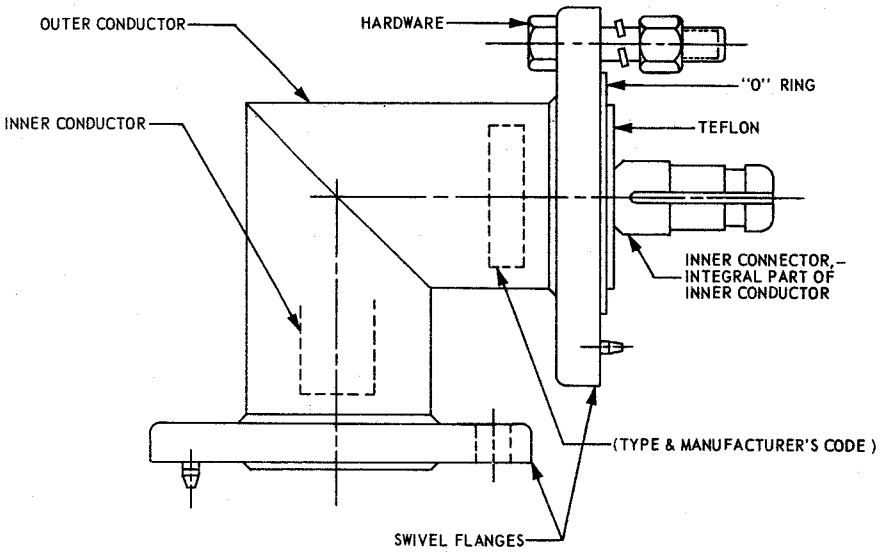


Figure 5-40. 90-Degree Mitered Elbow for Rigid Coaxial Transmission Line

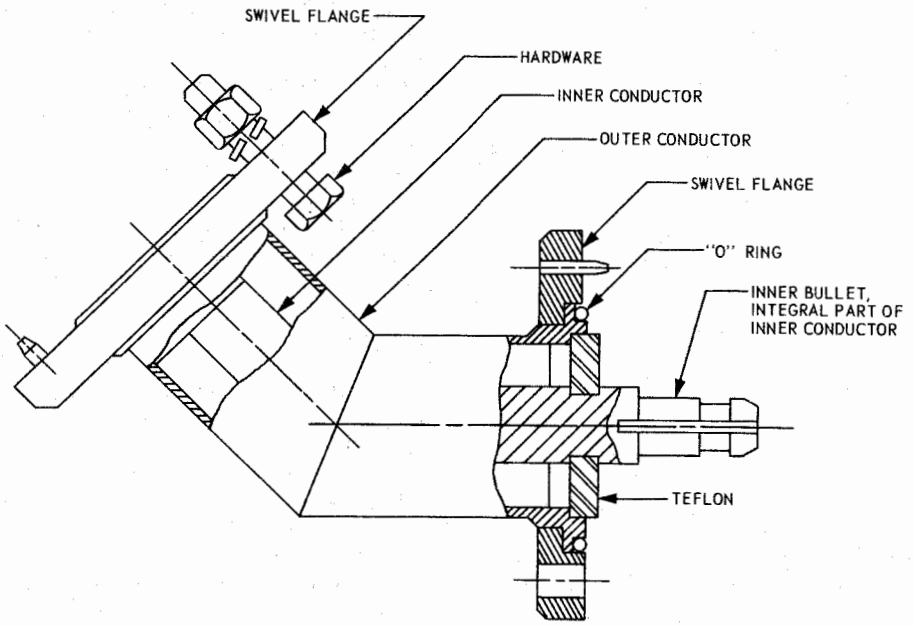


Figure 5-41. 45-Degree Mitered Elbow for Rigid Coaxial Transmission Line

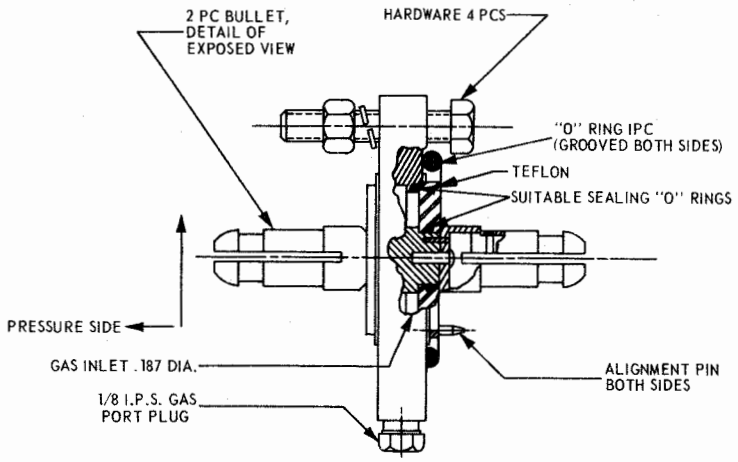


Figure 5-42. Cut-Away View of Gas Barrier for Rigid Coaxial Transmission Line

insulator seats properly in the flange. Turn the flanges so the alignment pins are opposite the alignment holes, then push the flanges together. Check to assure that the line is straight and that angles formed by installed elbows are maintained. Install the bolts, lockwashers and nuts, and bolt the flanges together by tightening the bolts evenly all around, applying torque listed in Table 5-3. Box end wrenches or sockets shall be used for tightening flange bolts. Open end wrenches or adjustable wrenches can slip off bolt head and damage the outer conductor; therefore, they shall not be used.

The assembly of a rigid coax to flexible coax adapter to the rigid coaxial line flange is similar to that outlined above. If the adapter is to be used as the pressurizing inlet for the rigid air dielectric line, remove the gas port vent plug and replace it with pressurizing fittings.

5-4.6.9 Misalignment Compensation

The assembled sections must form a straight line (excluding mitered elbows) and the inner connectors must be seated properly. If the flanges are not perfectly perpendicular to the line, the result will be a slight offset in the assembled sections. This can be

TABLE 5-3. FLANGE ASSEMBLY TORQUES

RIGID COAXIAL CABLE	FLANGE BOLTS			TORQUE
SIZE (INCHES	NUMBER REQ'D	SIZE	LENGTH (INCHES)	FT.-LBS.
3/8	3			
7/8	3	1/4-20	1	7-8
1-5/8	4	5/16-18	1-1/2	13-15
3-1/8	6	3/8-16	1-1/2	17
6-1/8	12	3/8-16	1-3/4	17

compensated for by using swivel flanges and rotating one section of the transmission line until the deviation from a straight line is less than 1/4 inch.

5-4.6.10 Mitered Elbows

Figures 5-40 and 5-41 are cut-away views of 90 degree and 45 degree mitered elbows respectively. Nonstandard elbows (other than 45 degree or 90 degree) shall not be used.

5-4.6.11 Swivel Flanges

Elbows with swivel flanges are capable of providing any combination of offset required for matching the slope of the transmission line run to the slope of a mast or mack.

5-4.6.12 Pressurization Requirement

The assembled transmission line shall be pressurized with dry air or nitrogen to the specified PSIG and maintained at that level until the system is ready for operation. Whenever a complete run cannot be installed in one work shift, the partially installed sections shall be pressurized with dry air or nitrogen at the end of the work shift and maintained under pressure until installation of the run is resumed.

5-4.6.13 Hardware

All sections of the transmission line assembly shall be put together with corrosion resistant steel hardware and shall conform to the specifications shown in 5-2.6.7.

5-4.6.14 Illustrative Installation Explanation

Figure 5-43 is an illustrative installation of rigid coaxial transmission line that can be used as a reference guide for solving problems and shows as many installation conditions as possible. An actual rigid coaxial transmission line run should always be as short and straight as possible with the number of elbows and connections kept to a minimum.

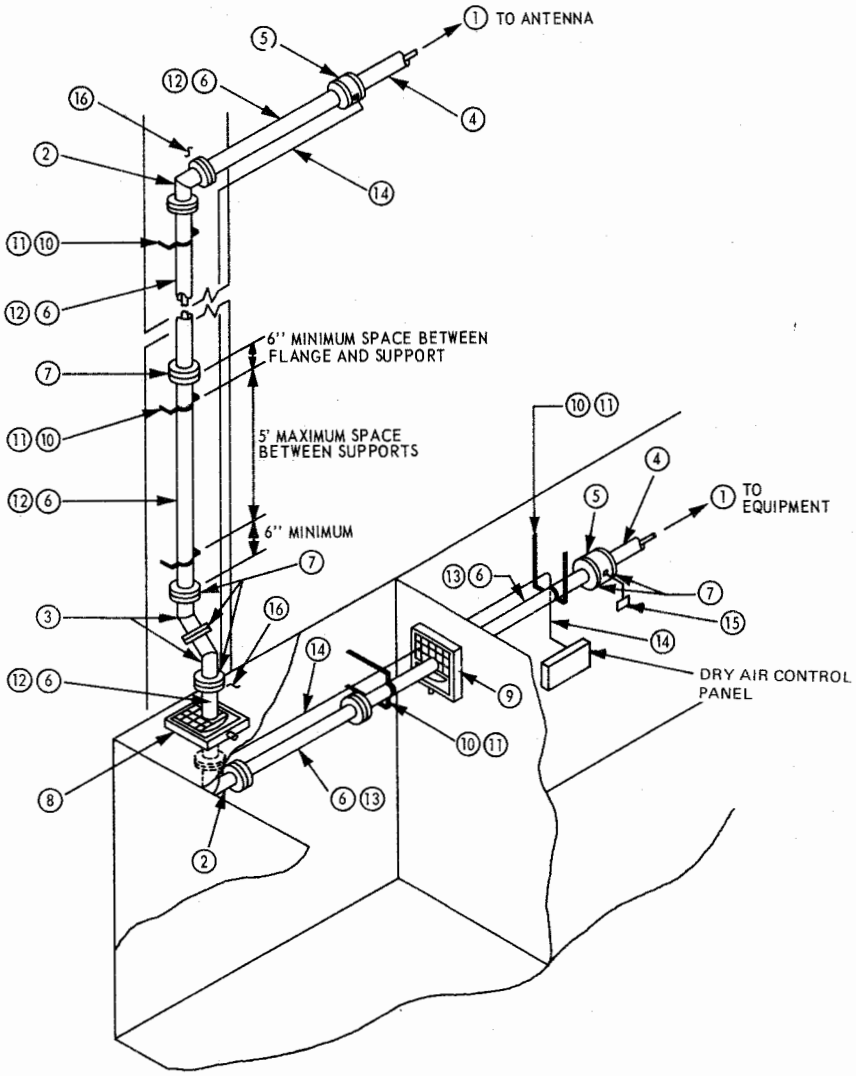


Figure 5-43. Illustrative Reference Guide with Reference Notes 1 through 16

① Antennas, duplexers, filters, switches, transmitters/receivers and other equipment shall be installed in accordance with guidance plans, installation control drawings and NAVSEA 0902-LP-001-5000, General Specification for Ships.

② 90° Mitered Elbows
③ 45° Mitered Elbows
④ Flexible Sections
⑤ Gas Barriers

For selection of, and detailed information on these items, see MIL-L-28796 and Manufacturers catalogs.

⑥ Rigid Coaxial Transmission Lines
For selection of - See: MIL-STD-242 Section 701
MIL-HDBK-216 Section 5A
For detail Dimensions - See: MIL-L-3890 and MIL-L-28796

⑦ Flanges
For selection of - See: MIL-STD-242 Section 603
MIL-STD-1327
MIL-HDBK-216 Section 11
For detail Dimensions - See: MIL-F-24044

(8) Deck Penetrations
See: EIMB Section 5, Paragraphs 5-4.1.11, 5-2.5, 5-4.5
EIMB Section 5, Figures 5-14, 5-16 thru 5-21, 5-33
NAVSEA DWG 9000-S6202-73980, Section 4, Shts 170-180

(9) Bulkhead Penetrations
See: EIMB Section 5, Paragraphs 5-2.5, 5-4.1.11, 5-4.5
EIMB Section 5, Figures 5-10, 5-14, 5-16 thru 5-21, 5-33
NAVSEA DWG 9000-S6202-73980, Section 4, Shts 170-180

(10) Transmission Line Supports
See: EIMB Section 5, Paragraphs 5-4.1.9, 5-4.1.10, 5-4.4
EIMB Section 5, Figures 5-31 and 5-32

(11) Support Isolation
See: EIMB Section 5, Paragraphs 5-2.4.9, 5-4.1.9, 5-4.4.9
EIMB Section 5, Figure 5-32
EIB #712

(12) Painting of Transmission Line Exposed to Weather
See: EIMB Section 5, Paragraphs 5-3.15 and 5-4.9

(13) Painting of Transmission Line Not Exposed to Weather
See: EIMB Section 5, Paragraphs 5-3.15 and 5-4.9

(14) Dry Air - 1/4" diameter tube installed to to comply with standard piping specifications. Connection to gas barrier at antenna shall be of material that will not create galvanic action.

(15) Purge Valve - Located in equipment room in an area accessible to maintenance personnel but not to interfere with equipment operation. Installation of valve shall comply with all piping specifications. Locate at lowest point in line adjacent to transmitter/receiver.

(16) Ground Straps
See: MIL-STD-1310(NAVY)
EIMB Section 5, Paragraph 5-4.8

5-4.7 PURGING AND PRESSURIZING

All rigid coaxial transmission lines shall be purged and pressurized in accordance with the following methods and procedures. Information on dry air systems can be found in 5-3.16.

5-4.7.1 Temporary Pressurization

The requirements for temporary pressurization of rigid coaxial transmission lines are the same as those in 5-2.7.1 for waveguide. The typical method of temporary pressurization shown in Figure 5-23 is applicable to rigid coaxial transmission lines.

5-4.7.2 Tightness Tests

Immediately upon completion of the rigid coaxial transmission line installation a tightness test shall be conducted. The tightness test shall comply with the requirements of 5-2.7.2.

5-4.7.3 Method for Detecting Leaks

A typical method of detecting leaks is to apply undiluted liquid shampoo to the flange connection, or suspected area. With pressure inside the transmission line, bubbles will appear where the dry air is escaping.

5-4.7.4 Purging Procedures

Purging of rigid coaxial transmission lines shall comply with the procedures outlined in 5-2.7.4 for rectangular waveguide.

5-4.7.5 Purging

Purging of the transmission line shall be repeated every time the line is opened for any reason. If the line is opened for minor checks or inspections that take only a few minutes to complete, then the time limit specified in Step 1 of 5-4.7.4 can be omitted.

5-4.8 GROUNDING OF RIGID COAXIAL TRANSMISSION LINE

Rigid coaxial transmission line runs shall be considered to be at ground potential unless proven otherwise by electromagnetic interference (EMI) tests. When additional grounding is required, the bonding, methods, materials, surface preparation and sealing shall be in accordance with MIL-STD-1310.

5-4.9 PRESERVATION OF RIGID COAXIAL RUNS

The final preservation of rigid coaxial transmission line runs shall be in accordance with the following requirements.

5-4.9.1 Exterior Surface Painting

Painting prior to installation and touch-up painting as necessary, subsequent to installation, shall be accomplished with MIL-P-24441 epoxy-polyamide coating system described in 5-1.13.16 and 5-2.9, respectively.

5-4.9.2 Rigid Coaxial Lines Requiring Additional Heat Dissipation

Where a flat black finish is needed to assist in heat dissipation generated by the transmission line, apply formula 153-Rol. 8 as described in 5-2.9.2.

5-4.9.3 Flange Joint Protection after Installation

Flange joints, including fastening hardware,

shall be coated with a sealer after installation and all testing is completed. The requirements, methods and material types of 5-2.9.3 for waveguide shall apply to rigid coaxial transmission lines.

5-4.10 QUALITY CONTROL INSPECTION

Quality control inspections shall be conducted during the installation process and after completion of all work to ensure the transmission line conforms to the ships installation drawings and this document.

The guidelines listed in 5-2.10 for waveguide shall apply to rigid coaxial transmission lines.

5-4.11 ELECTRICAL REQUIREMENTS AND TESTS

After satisfactory completion of installation, visual inspections, tightness tests and final pressurization, and prior to initial equipment turn-on, the transmission line shall be electrically tested in accordance with the following requirements:

5-4.11.1 Test Equipment Requirements

The requirements of paragraph 5-2.11.1 shall apply to the test equipment required for conducting the electrical tests for rigid coaxial transmission lines.

5-4.11.2 Continuity

A test of the installation to determine continuity of the center conductor shall be made. This test will determine if all inner connectors and inner conductors mate with a minimum of resistance.

5-4.11.3 Insertion Loss Measurements

The measured insertion loss for a rigid coaxial transmission line shall not exceed the computed maximum allowable insertion loss.

The maximum allowable insertion loss may be computed using the method of paragraph 5-2.11.2. The attenuation values can be obtained from plotting an attenuation curve using the theoretical values given in MIL-L-3890 for the specific transmission line under test.

5-4.11.4 Voltage Standing Wave Ratio Measurements

Voltage Standing Wave Ratio Measurements for rigid coaxial transmission lines shall be made and recorded in general agreement with paragraph 5-2.11.3. Test equipment types will vary based on the lower frequency band of rigid coaxial transmission lines. Figures 5-24 and 5-25 are applicable with the exception of adapters used to interface the test set-up to the transmission line under test.

5-4.11.5 Test Reports

Test reports for rigid coaxial transmission lines shall comply with the requirements of paragraph 5-2.11.4.

5-5 ELLIPTICAL WAVEGUIDE

5-5.1 INTRODUCTION

Elliptical waveguides are defined as transmission lines with elliptical inside cross sections. These waveguides offer slightly higher power handling capabilities and lower attenuation than the equivalent rectangular waveguide. Elliptical waveguide operates in the dominant E^{TE}_{11}mode of propagation which is similar to the TE_{10} mode for rectangular waveguide.

Some sizes of elliptical waveguide can be fabricated by an extrusion process in long continuous lengths (500 feet) of semi-rigid material wound onto reels, permitting the use of fewer joints and connectors in a typical installation with consequent reduced power loss, and less opportunity for voltage breakdown at junctions. The largest size of elliptical waveguide currently being extruded and wound onto reels is RG-395/U waveguide. However, RG-387/U elliptical waveguide is available in 20 feet lengths whereas the maximum length of equivalent size rectangular waveguide is available in only 14 foot lengths.

Elliptical waveguide is produced in long continuous lengths from corrugated copper or aluminum, and from smooth seamless aluminum. The only elliptical waveguide that is recognized for shipboard installation and discussed in this handbook will be the types that have been assigned military nomenclature. Additional information on elliptical waveguide may be found in MIL-HDBK-216 and the manufacturer's catalog.

5-5.2 ELLIPTICAL WAVEGUIDE CHARACTERISTICS

The information provided herein applies to semi-rigid, field formable elliptical waveguide produced from seamless pure aluminum.

5-5.2.1 Electrical Characteristics

Electrical characteristics for elliptical waveguide with assigned military nomenclature are shown in tabular form in table 5-4 as guidance for the installing activity. Attenuation and average power curves for these same elliptical waveguides can be found in MIL-HDBK-216.

5-5.2.2 Physical Characteristics

Physical characteristics for elliptical waveguide with assigned military nomenclature are shown in tabular form in table 5-5 as guidance for the installing activity. The elliptical waveguide is available in straight lengths of twenty feet or on reels up to five hundred feet in length with the exception of RG-387/U. Because of its physical size and weight, RG-387/U is available only in straight lengths of twenty feet or less.

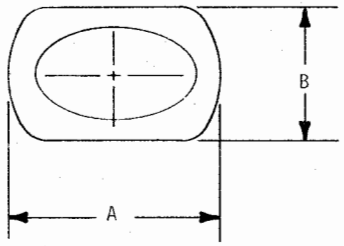
5-5.3 ACCESSORIES

Elliptical waveguide, although designed for in-

TABLE 5-4. ELLIPTICAL WAVEGUIDE ELECTRICAL CHARACTERISTICS

AN TYPE	SUGGESTED FREQUENCY	CUTOFF FREQUENCY	PEAK VSWR	AVERAGE VSWR	PEAK POWER MIDBAND	AVERAGE POWER MIDBAND
	GHZ	GHZ			MEGAWATTS	KILOWATTS
RG-387/U	2.7 - 3.2	2.024	1.10	1.06	4.51	39.8
RG-395/U	3.7 - 4.2	2.779	1.10	1.06	2.53	27.6
RG-381/U	4.4 - 5.0	3.433	1.06	1.03	1.66	20.6
RG-379/U	5.5 - 6.425	4.162	1.06	1.03	1.09	15.5
RG-396/U	7.1 - 8.5	5.658	1.10	1.06	0.601	9.5
RG-394/U	8.5 - 10.0	6.489	1.10	1.06	0.446	6.82
RG-380/U	6.0 - 11.0		1.08	1.03	1.10	14.9

TABLE 5-5. ELLIPTICAL WAVEGUIDE PHYSICAL CHARACTERISTICS



AN TYPE	DIMENSIONS (IN INCHES)		MINIMUM BEND RADII (IN INCHES)			WEIGHT LB/FT
			PLANE		90°	
	A	B	E	H	TWIST	
RG-387/U	4.07	2.50	20.0	42.0	180.0	4.10
RG-395/U	3.00	1.99	20.0	36.0	144.0	2.76
RG-379/U	2.48	1.56	18.0	30.0	96.0	1.12
RG-381/U	2.10	1.31	16.0	24.0	84.0	1.81
RG-396/U	1.64	1.05	12.0	18.0	48.0	0.97
RG-394/U	1.38	0.85	8.0	12.0	48.0	0.59
RG-380/U	1.83	1.35	36.0	48.0	120.0	1.22

stallation as one continuous length, can not always be installed aboard ship without bends and/or twists that would necessitate installing the line in two or more sections requiring the use of couplings. An elliptical waveguide run must be interfaced with electronic equipment that is designed for rectangular waveguide compatibility and this requires transition units as well as rectangular waveguide assemblies.

5-5.3.1 Couplings

Couplings are required for connecting two sections of elliptical waveguide and should be used only when it is impossible or impracticable to install the elliptical waveguide in one continuous length. These couplings can be assembled to the elliptical waveguide at the installation site using hand tools with no brazing or welding required. Figure 5-44 is an outline of a typical coupling for RG-379/U, RG-380/U, RG-381/U, RG-394/U and RG-396/U elliptical waveguide. Figure 5-45 is an outline of a typical coupling for RG-387/U and RG-395/U elliptical waveguide. These couplings are available from the manufacturer of the elliptical waveguide listed in Table 5-4. To ensure the proper fit, the manufacturer's assembly instructions should be followed.

5-5.3.2 Transitions

Transitions, available from the elliptical waveguide manufacturer, are required for interfacing with rectangular waveguide. These transitions have a coupling on one end for attachment to the elliptical waveguide and a MIL-F-3922 type flange on the

other end for attachment to a rectangular waveguide flange. The transitions can be assembled to the elliptical waveguide at the installation site using hand tools with no brazing or welding required. Figure 5-46 is an outline of typical transitions for interfacing rectangular waveguide to the elliptical waveguide listed in Table 5-4. To ensure the proper mechanical connection and maintain the required system operational capabilities, the manufacturers' assembly instructions should be followed.

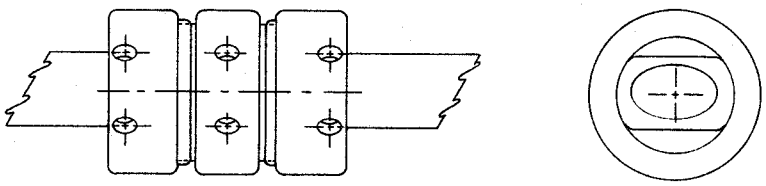


Figure 5-44. Coupling for use with Small Elliptical Waveguide

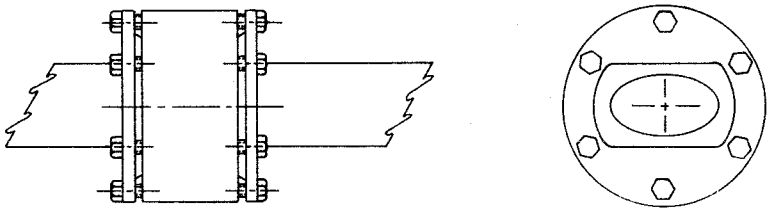


Figure 5-45. Coupling for use with Large Elliptical Waveguide

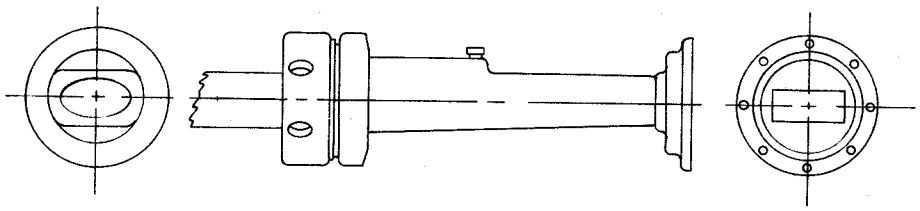


Figure 5-46. Transition for Interfacing Elliptical Waveguide to Rectangular Waveguide

5-5.3.3 Rectangular Waveguide Assemblies

Rectangular waveguide assemblies consisting of bend, twist, flexible and/or straight assemblies, when required for elliptical waveguide runs, shall comply with the requirements of 5-1 and 5-2. Rectangular waveguide assemblies selected shall be compatible to the elliptical waveguide based on frequency of operation, material type, equipment interface flanges, system power requirements and pressurization requirements.

5-5.4 TECHNICAL CAPABILITIES

Elliptical waveguide of the types shown in Tables 5-4 and 5-5 appear to be rugged, but care must be taken in handling and assembling to prevent denting or kinking since this would cause a degrading effect on its electrical performance. These elliptical waveguides (with the exception of RG-387/U) are easily unreeled and installed providing the proper tools and techniques are used. The correct hand and hydraulic bending and twisting tools are available from the elliptical waveguide manufacturer along with instructions for the proper bending, twisting, cutting and assembling of couplings and transitions.

5-5.5 SHOP PREFABRICATION GUIDELINES

The inspection, storage, handling and layout design for the elliptical waveguide shall be basically the same as that required in paragraph 5-1.3 for rectangular waveguide.

Elliptical waveguide shall be procured and installed in one continuous length where possible. Elliptical waveguide to rectangular waveguide transitions shall be installed on each end of the elliptical waveguide run. If for some valid reason the elliptical waveguide cannot be installed in one continuous run, elliptical waveguide couplings must be procured and

installed between each section of elliptical waveguide.

5-5.6 BENDING

Elliptical waveguide may be bent in either the "E" plane or "H" plane. The bend radius shall be not less than that shown in Table 5-5. unless a waveguide filler is used. When bending RG-387/U elliptical waveguide with filler (cerobend), the minimum bending radius for an "E" plane bend is 10 inches and the minimum bending radius for an "H" plane bend is 21 inches. The RG-387/U elliptical waveguide shall be annealed, prior to bending, by submersion in water at the melting point temperature of cerobend. The elliptical waveguide shall not be oiled. Bending of elliptical waveguide shall comply with the manufacturers' instructions for a specific size elliptical waveguide, utilizing the bending tools or equivalent recommended by the manufacturer. Bends shall not be indiscriminately installed for alignment purposes or to clear objects that can be moved. Rectangular waveguide bends, when required between the elliptical transition assembly and the associated electronic equipment, shall conform to the guidance for bends in paragraphs 5-1 and 5-2.

5-5.7 TWISTING

Elliptical waveguide may be twisted providing the twist does not exceed 90 degrees. The twist length shall be no less than that shown in Table 5-5 for a specific size elliptical waveguide. Where there is insufficient space for twisting the elliptical waveguide, a rectangular waveguide twist assembly in accordance with MIL-W-3970 may be installed between the elliptical waveguide transition assembly and the associated electronic equipment.

5-5.8 SUPPORTS

Elliptical waveguide shall be secured to the ships structure by supports (hangers) that comply with the requirements stated herein.

5-5.8.1 Design

Elliptical waveguide supports shall be designed so as to provide a snug fit, but shall not cause deformation to the waveguide. The inside dimension of the support bracket shall allow for the thickness of isolation material. The support shall be adjustable in two directions for alignment to the elliptical waveguide run. Figure 5-47 is a typical elliptical waveguide support.

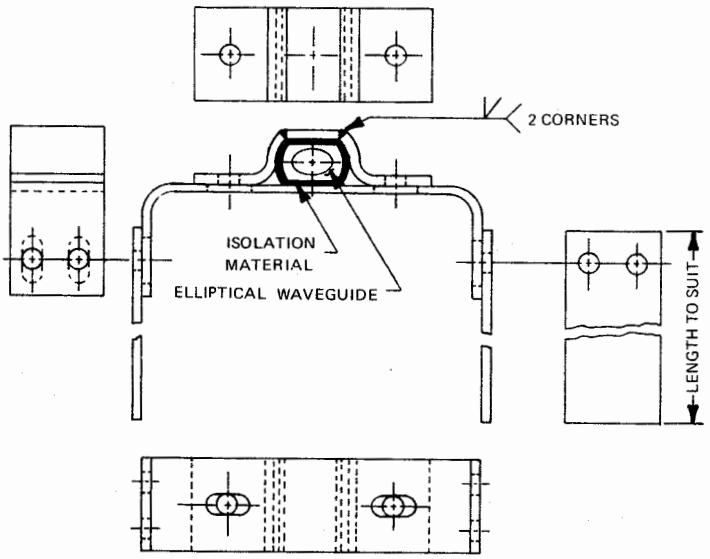


Figure 5-47. Typical Elliptical Waveguide Support

5-5.8.2 Material

The support material shall be of sufficient width and thickness to support the elliptical waveguide run. It shall support loading due to gun and missile blast, vertical keel shock factor, ice, wave action and wind. The material shall be compatible with the ships structure and isolated from the elliptical waveguide.

5-5.8.3 Location

The elliptical waveguide supports shall be positioned so as to prevent any stress, strain or bind on any segment of the elliptical waveguide run. Distance between supports shall not exceed five feet. There shall be a minimum of two supports for each waveguide section that exceeds two feet in length. Supports shall be installed not closer than six inches and not further than twelve inches from each side of any coupling or flange connection.

5-5.8.4 Isolation Material

Isolation material shall be installed between

the elliptical waveguide and the support to prevent electrolytic action and provide a snug fit. The isolation material and method of isolation shall comply with the appropriate requirements of paragraph 5-2.4.9.

5-5.8.5 Hardware

Fastener hardware for elliptical waveguide supports shall comply with the requirements of paragraph 5-2.4.11.

5-5.9 PENETRATIONS

Deck and bulkhead penetrations for elliptical waveguide runs shall comply with the requirements of paragraph 5-2.5 and the following exceptions:

5-5.9.1 Non-Watertight Penetrations

The clearance hole through a non-watertight bulkhead or deck shall be of sufficient size to pass the elliptical waveguide with coupling or transition assembly attached.

When penetrating an air/dust/fume tight bulkhead the method of penetration shall be similar to that shown in Figure 5-10.

5-5.9.2 Watertight Penetrations

Multi-cable Transit Devices shall not be used for passing elliptical waveguide through watertight decks or bulkheads.

Split sleeve assemblies, similar to those required in paragraph 5-2.5 and shown in Figure 5-48 shall be used for passing elliptical waveguide through watertight decks and bulkheads.

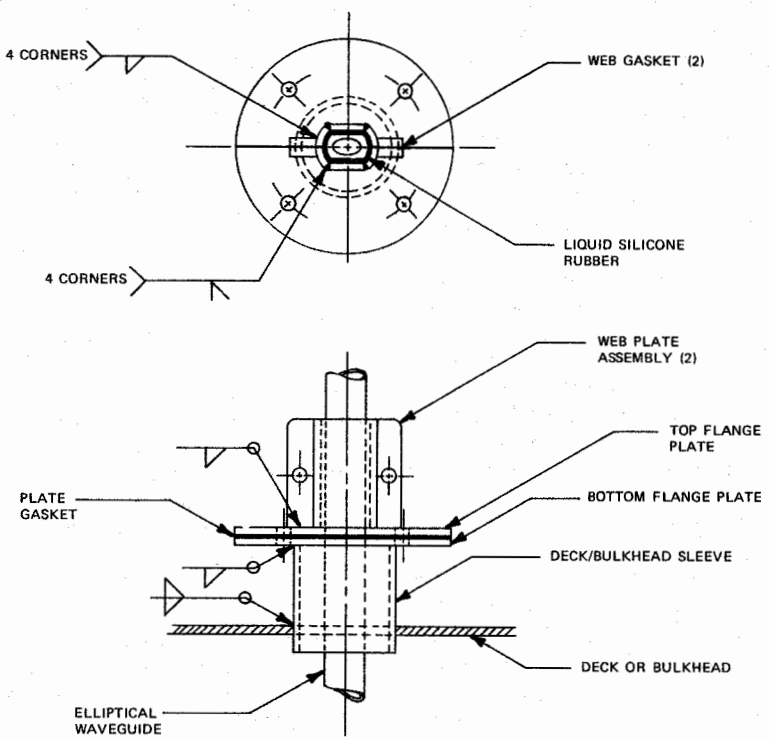


Figure 5-48. Typical Split Sleeve Assembly for Elliptical Waveguide

5-5.10 PRESERVATION

Preservation of elliptical waveguide and associated assemblies shall be as stated herein.

5-5.10.1 Chemical Conversion Coatings

The interior and exterior surfaces of all elliptical waveguide, transition assemblies including flanges, elliptical waveguide couplings and the associated rectangular waveguide assemblies required for shipboard installations shall have a chemical conversion coating to prevent corrosion. Aluminum components shall have a chemical conversion coating in accordance with MIL-C-5541, class 3. Copper components shall have an Iridite #7P, Mixture C (or equal) chemical conversion coating.

5-5.10.2 Protective Paint Coatings

The exterior surfaces of all elliptical waveguide, transition assemblies, couplings and associated rectangular waveguide assemblies shall have an epoxy polyamide protective paint in accordance with MIL-P-24441 and applied in accordance with the following:

The coating system shall consist of one coat of formula 150 primer, 2 to 4 mils thickness, and two coats of formula 151 (Haze gray), each coat 2 to 3 mils dry film thickness. The total minimum dry film thickness for the coating system shall be 8.0 mils. Where a flat black finish is needed to assist heat dissi-

pation generated by the transmission line, apply one coat of formula 153-Rol. 8 black epoxy-polyamide paint.

Ensure all flange mating surfaces, coupling mating surfaces, transition mating surfaces and threaded surfaces are completely free of any epoxy paint.

5-5.10.3 Mating Joint Protection

Mating joints, including fastening hardware, shall be coated with a sealer after installation and all testing is completed. This sealer is to prevent corrosive build-up caused by sea water seepage into mating joints and mating hardware. Mating joints include the couplings between two sections of elliptical waveguide, the coupling between a transition assembly and elliptical waveguide, the interface flange joint between a transition assembly and a rectangular waveguide assembly, and the flange joints of all associated rectangular waveguide assemblies.

An acceptable seal can be obtained with a spray coating of clear polyurethane resin solution such as Dexter Corporation's Laminar 48-C-24 or the equivalent. Using a narrow spray pattern, the polyruethane coating should be applied in such a manner to assure an adequate flow or run of material on the surface providing a maximum seal which will prevent seepage of salt water into mating surfaces and hardware.

5-5.11 DRY AIR REQUIREMENTS

Elliptical waveguide runs should be pressurized with dry air. The system design requirements shall comply with MIL-STD-1399, Section 102, and the following:

5-5.11.1 Air Connections

Dry air connections for elliptical waveguide runs should be via the air connection that is factory installed on the elliptical to waveguide transition assembly or at the transmitting device if applicable. Where this is not practicable, the air connection shall comply with the applicable requirements of 5-1.14.

5-5.11.2 Purging

Provision for purging the complete transmission line run shall be installed. A purge valve shall be installed at the lowest point in the transmission line adjacent to equipment it serves, where the transmission line can be purged of moist air, or the accumulation of water.

5-6 ELLIPTICAL WAVEGUIDE INSTALLATION PROCEDURES

5-6.1 GENERAL REQUIREMENTS

Installation of elliptical waveguide runs shall comply with the same general requirements as those for rectangular waveguide in paragraph 5-2.1.

5-6.2 PROTECTION OF ELLIPTICAL WAVEGUIDE

Protection of elliptical waveguide from time of receipt until completion of installation shall comply with the applicable protective requirements listed in paragraph 5-2.2 for rectangular waveguide.

5-6.3 LAYOUT OF ELLIPTICAL WAVEGUIDE

Templates are not required for elliptical waveguide runs as they are for rectangular waveguide runs with the exception of RG-387/U. Targeting of RG-387/U waveguide runs shall comply with the requirements of paragraph 5-2.3. The routing of elliptical waveguide runs should be determined, deck and bulkhead cuts made, waveguide supports and split sleeve assemblies fabricated, and any obstructions in way of the waveguide run relocated if possible. The deck/bulkhead sleeve portion of the split sleeve assembly should be tack-welded in place prior to removing the elliptical waveguide from storage.

5-6.4 ELLIPTICAL WAVEGUIDE SUPPORTS

Supports for elliptical waveguide shall be fabricated and installed in accordance with paragraph 5-5.8. The elliptical waveguide should be pulled-in and held in place by temporary means before installing the permanent supports. The supports should be installed and adjusted to the waveguide run so that no stress or strain is placed on the elliptical waveguide. The elliptical waveguide should be protected from possible damage while welding supports to ships structure.

Ensure the support material, isolation material, fastener hardware, location and alignment meets the requirements of paragraph 5-5.8.

5-6.5 PENETRATIONS

Bulkhead and deck penetrations for elliptical waveguide shall be fabricated and installed in accordance with paragraph 5-5.9. The deck/bulkhead sleeve part of the split sleeve assembly must be temporarily installed prior to pulling in the elliptical waveguide. After the elliptical waveguide has been temporarily secured in place, the split sleeve assembly should be aligned to the elliptical waveguide and then welded to ships structure. Precautions shall be taken to prevent damage to the waveguide during the welding process.

Ensure the deck or bulkhead penetration assembly material, fastener hardware, protective coating and alignment to the elliptical waveguide meets the requirements of paragraph 5-5.9.

5-6.6 INSTALLATION INSTRUCTIONS

The methods and procedures required to install an elliptical waveguide run will vary for each

installation based on the complexity of the electronic system, location of electronic equipment and the complexity of ships structure and other installed equipment between the electronic equipment room and antenna.

The installation instructions of the following subparagraph are general in nature and are intended as guidance to assist the Installing Activity when installing elliptical waveguide aboard Naval ships.

5-6.6.1 Site Preparation

Prior to starting the shipboard assembly of elliptical waveguide run, make a final inspection to ensure all bulkhead and deck cuts have been made, that obstructions have been relocated where possible and that interfacing electronic equipments are permanently mounted.

The deck or bulkhead sleeve portion of split sleeve assemblies should be tack welded in place at this time. Ensure that waveguide supports have been fabricated and are available for installation when needed.

5-6.6.2 On Site Handling and Storage

Adequate facilities must be available for handling and transportation of elliptical waveguide and associated components from storage to the installation site.

Elliptical waveguides RG-380/U and RG-387/U will be in straight lengths up to twenty feet long. A twenty foot length of RG-387/U would weigh 82 pounds not including the shipping crate. The other elliptical waveguide listed in Table 5-5 will be in coils or reels up to five hundred feet in length. A five hundred foot reel of RG-396/U would weigh 475 pounds not including the shipping reel weight.

The ends of elliptical waveguide and associated assemblies should remain sealed until actual assembly in the waveguide run. Small assemblies such as couplings, transitions, flexible sections and bend assemblies should be stored in a safe area until time of assembly in the waveguide run.

5-6.6.3 Temporary Support of Waveguide

The elliptical waveguide should be supported by temporary means while the complete run is being assembled. If possible the elliptical waveguide should be in one continuous length. Where this is not possible, the waveguide should be installed in such a manner as to keep the use of couplings to a minimum.

5-6.6.4 On Site Bending and Twisting

Bends and twists can be formed in the elliptical waveguide (RG-387/U excepted) as it is installed aboard ship. This should be kept to a minimum since the objective is to install a transmission line as straight and as short as possible.

Bending and twisting should be accomplished only with tools recommended by the elliptical waveguide manufacturer or their equivalent.

Bends and twists formed at the installation site shall show no signs of damage to the waveguide such as dents, puckers, wrinkles or cuts and the bend or twist radius shall be no less than the minimum radius listed in Table 5-5.

5-6.6.5 Cutting of Elliptical Waveguide

Preparation of the elliptical waveguide end for couplings and transitions are the same. When cutting elliptical waveguide, the manufacturers' instructions must be carefully followed. This is to ensure a square smooth cut and to prevent any intrusion of foreign matter into the waveguide. Cutting elliptical waveguide shall not be attempted without using the manufacturers' recommended cutting jigs or the equivalent.

5-6.6.6 Chemical Conversion Coating

A chemical conversion coating shall be applied to the elliptical waveguide end that has been cut in preparation for coupling or transition attachment. The chemical conversion coating shall be in accordance with MIL-C-5541.

5-6.6.7 Coupling and Transition Assembly

The assembly of couplings and transitions to elliptical waveguide is very similar. The transition end that mates with elliptical waveguide is identical to one-half of the coupling used for small size elliptical waveguide. Figure 5-49 shows a coupling in place on two sections of small elliptical waveguide and identifies the coupling components. Figure 5-50 shows a coupling in place on two sections of large elliptical waveguide and identifies the coupling components. Figure 5-51 provides a cut-away view and component identification of a transition coupling for large elliptical waveguide. Figure 5-52 is a typical assembled section showing a transition, a coupling and large elliptical waveguide. The manufacturers' assembly instructions should be carefully followed to ensure the proper mechanical and electrical fit. The completed assembly shall not have "RF" leaks or pressure leaks.

Coupling faces shall be parallel to each other within 0.015 inch. Prior to bolting, this alignment shall be checked with a feeler gage. Misalignment in excess of 0.015 inch shall be corrected by waveguide support adjustment or by additional bending or twisting. Do not use the bolts to pull the elliptical waveguide into alignment.

5-6.6.8 Split Sleeve Assembly

The split sleeve installation and assembly requirements and procedures of paragraph 5-2 for rectangular waveguide shall apply to the elliptical waveguide deck or bulkhead penetration devices. The only difference in the assemblies would be the shape of the web plate assemblies.

5-6.6.9 Elliptical Waveguide Support Installation

The installation and assembly of elliptical waveguide supports shall comply with the requirements and procedures of paragraph 5-2 for rectangular waveguide. The only difference in the waveguide

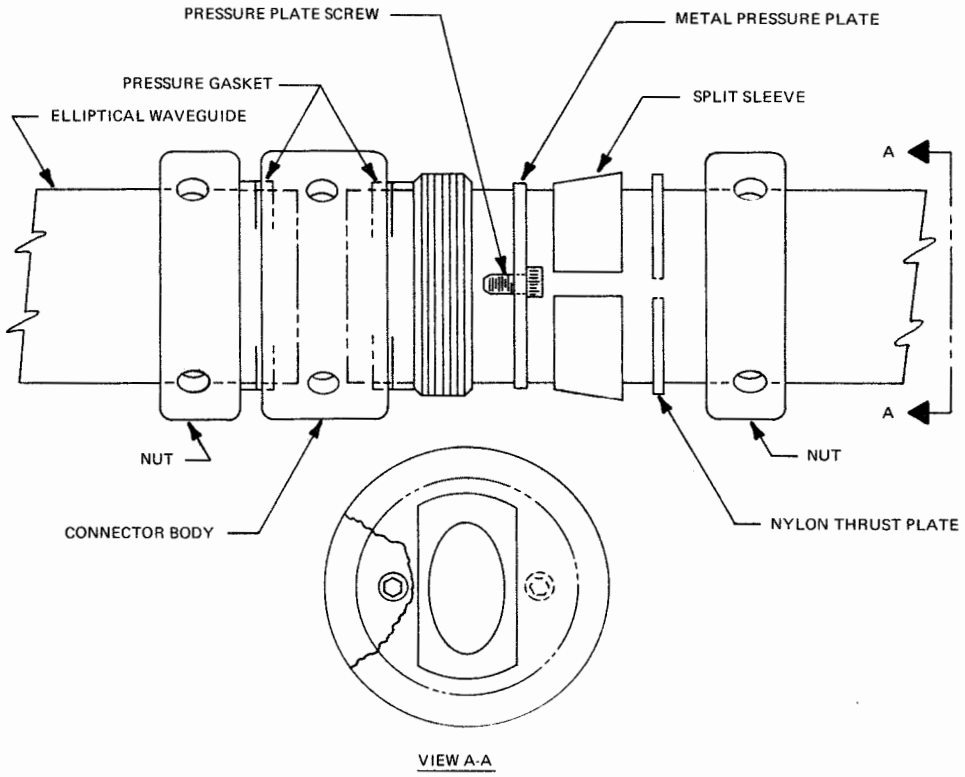


Figure 5-49. Coupling Assembly Identification for Small Elliptical Waveguide

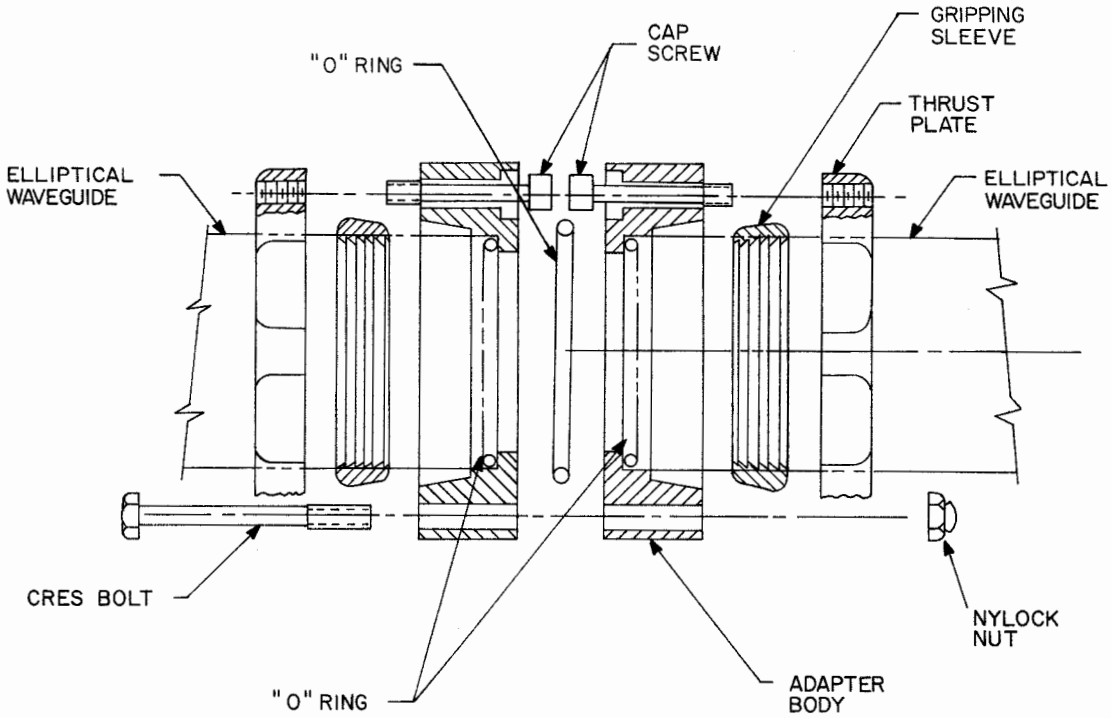


Figure 5-50. Coupling Assembly Identification for Large Elliptical Waveguide

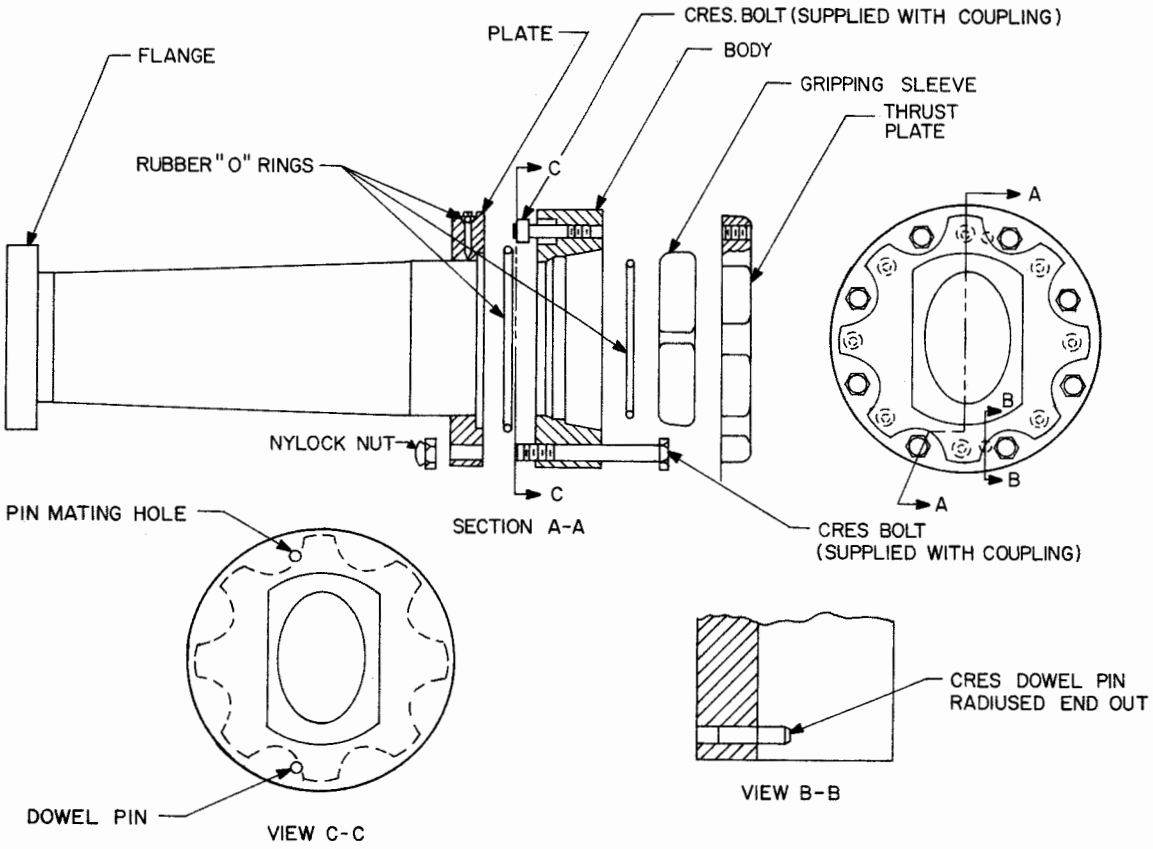


Figure 5-51. Transition Assembly Identification for Large Elliptical Waveguide

supports would be the shape of the bracket that surrounds the elliptical waveguide.

5-6.6.10 Installation of Rectangular Sections

An elliptical waveguide run must be interfaced with electronic equipment with rectangular waveguide assemblies. These may be short flexible sections, bend assemblies or short straight sections. The installation and assembly of these rectangular waveguide sections shall comply with the applicable installation requirements and procedures of this document for rectangular waveguide runs.

5-6.6.11 Overall Elliptical Waveguide Run

The overall elliptical waveguide run; after final assembly of couplings, transitions, rectangular waveguide sections, structural penetrations, waveguide supports; shall meet the same requirements for straightness of run, alignment of connections joints, alignment of split sleeve assemblies and supports to the waveguide that are required for rectangular waveguide runs in paragraph 5-2.

Figure 5-53 shows the relationship of elliptical waveguide components and rectangular waveguide components in an overall transmission line run. Figure 5-53 is not intended to be representative of a typical installation.

5-6.6.12 RG-387/U Special Installation Instructions

NAVSEA Drawing RE-E2699993 provides special installation instructions for RG-387/U elliptical waveguide when used with the AN/SPS-48 Radar Set.

5-6.7 PURGING AND PRESSURIZATION (SHIPBOARD)

The elliptical waveguide run, after completion of installation, should be purged, tested for leaks and pressurized in accordance with the requirements of paragraph 5-2.

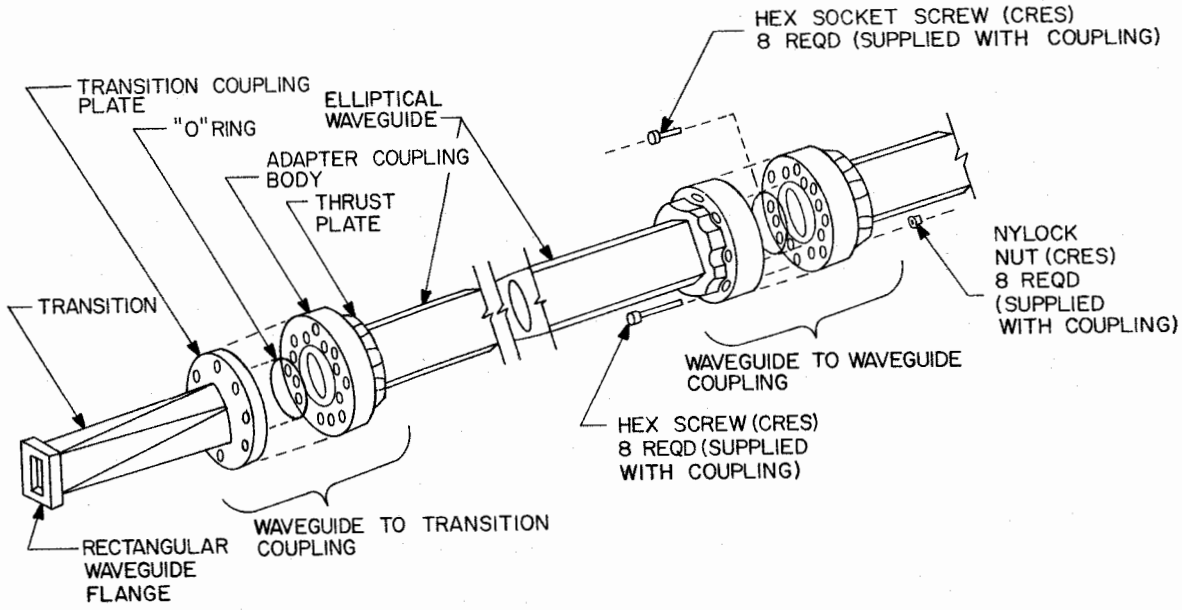


Figure 5-52. Typical Assembly Showing Transition, Coupling and Large Elliptical Waveguide

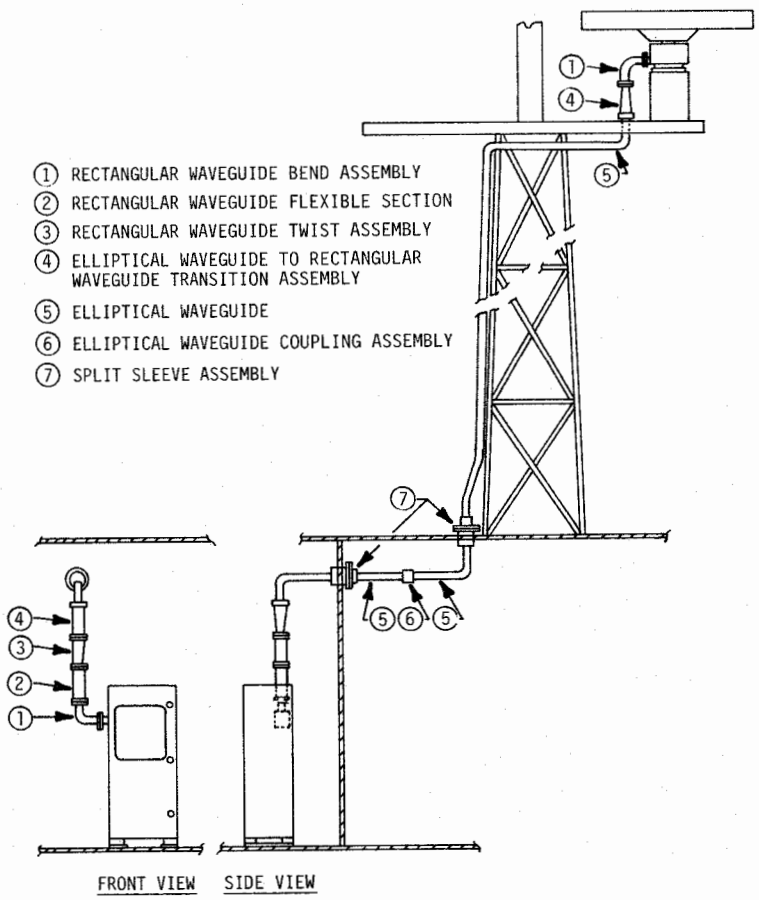


Figure 5-53. Typical Relationship of Elliptical to Rectangular Waveguide Components

5-6.8 GROUNDING OF ELLIPTICAL WAVEGUIDE RUNS

Grounding of elliptical waveguide runs, when required by Electromagnetic Interference Tests, shall comply with the requirements and methods of MIL-STD-1310.

5-6.9 PRESERVATION OF ELLIPTICAL WAVEGUIDE RUNS

The preservation of elliptical waveguide runs to prevent corrosion and contamination shall comply with the applicable requirements, methods and procedures that apply to rectangular waveguide in paragraph 5-2.9 and the following:

5-6.9.1 Coupling and Transition Sealing

After satisfactory completion of the elliptical waveguide run, coupling and transition joints including fastening hardware shall be spray coated with a narrow spray pattern using a polyurethane coating such as Laminar 48-C-24 or equivalent. This polyurethane coating shall be applied in such a manner to assure an adequate flow or run of material on the surface providing a maximum seal which will prevent seepage of sea water into mating surfaces and hardware.

5-6.10 QUALITY CONTROL INSPECTION

Quality control inspections shall be conducted during the installation process and after completion of all work to ensure the elliptical waveguide run conforms to the ships installation drawings and this document.

Quality control inspections shall comply with the guidelines of paragraph 5-2.10 and the following.

5-6.10.1 Couplings and Transitions

Ensure couplings and transitions for elliptical waveguide have been assembled and fastening bolts torqued according to manufacturers' instructions. Ensure alignment of coupling faces is in accordance with paragraph 5-6.6.7.

5-6.11 ELECTRICAL REQUIREMENTS AND TESTS

After satisfactory completion of installation, visual inspections, tightness tests, and prior to initial equipment turn-on, the transmission line shall be electrically tested in accordance with the requirements and tests of paragraph 5-2.11.

APPENDIX 5-A
TABLE OF CONTENTS

Military Documentation for Waveguide selection, requirements, design data and specifications are to be filed by users in the following sequence.

APPENDIX 5-B
TABLE OF CONTENTS

Military Documentation for Rigid Coaxial Transmission Line selection, requirements, design data, and specifications are to be filed by user in the following sequence.

APPENDIX 5-C TABLE OF CONTENTS

Military Documentation for Transmission Line Flange Selection, requirements, design data, and specifications are to be filed by user in the following sequence.

Document No.	Brief Description
MIL-STD-242, Part 1, SEC-601	Selection of Flanges for Rigid Rectangular Waveguide
MIL-STD-242, Part 1, SEC-602	Selection of Flanges for Ridged Waveguide
MIL-STD-242, Part 1, SEC-603	Selection of Flanges for Rigid Coaxial Transmission Lines
MIL-STD-1327	Selection of Flanges for Transmission Lines
MIL-HDBK-216, SEC-7 & 11	Flange Theory, Calculations, Frequencies and Dimensions
MIL-F-3922	Rectangular Rigid Waveguide Flange Specifications
MIL-F-39000	Ridged Waveguide Flange Specifications
MIL-F-24044	Rigid Coaxial Transmission Line Flange Specifications
MIL-C-39004	Quick-Disconnect Specifications for Sub-Miniature Waveguide Flanges

APPENDIX 5-D
TABLE OF CONTENTS

Military Documentation for Shop Fabrication and Preservation of Transmission Line Assemblies and Component Assemblies, are to be filed by user in the following sequence.

APPENDIX 5-E TABLE OF CONTENTS

Military Documentation for Transmission Line Assemblies and Components to be filed by user in the following sequence.

SECTION 6
EQUIPMENT INSTALLATION

SECTION 6
EQUIPMENT INSTALLATION

6-1 INTRODUCTION

The installation of electronic equipment enclosures aboard Navy ships is much more complicated than the installing of equipment in a land based installation. Some of the more critical factors that must be considered are; limited space, sea and battle conditions, normal ship reactions to sea conditions, effect of equipment weight and location on ships operational characteristics, habitability, accessibility, equipment reliability under severe sea conditions or battle conditions, RF interference interaction between equipments, and the interface compatibility with other equipments comprising a complex shipboard system. It becomes apparent from these factors that the Navy must and should expect the Installing Activity to use only the best in materials, methods and workmanship when installing electronic equipments aboard Naval ships.

6-2 PURPOSE

The purpose of this section is to make the Installer aware of the limitations and constraints placed upon the individual equipment unit as well as the overall electronic system installed aboard Navy ships, and the Installing Activity's responsibility to ensure each unit of equipment in electronic spaces is located and installed in accordance with the latest approved documents referenced by a specific ship's specification of ShipAlt.

6-3 SCOPE

The intent of this section is to assist the Installing Activity in obtaining the optimum equipment installation through the referencing of appropriate documentation and general requirements. Where conflict arises the requirements of NAVSEA 0902-LP-001-5000 shall take precedence over all other documents referenced or requirements stated herein.

6-4 SELECTION REQUIREMENTS

The selection of electronic equipments for ship installations is determined by the cognizant Government activity based on the type ship and its function in the fleet. The Government either provides the equipment to the Installing Activity or provides sufficient parameters for procurement and/or fabrication by the Installing Activity through guidance documents such as ShipAlts and Standard Drawings.

6-4.1 EQUIPMENT SUPPLIED BY THE GOVERNMENT

Government furnished equipment is defined as any equipment, system or system component that is provided by the Government to the Installing Activity for a specific installation. These equipments or components may be listed as individual units or as a system by the contract documents. The Installing Activity shall ensure the equipment or component installed aboard ship is the same equipment or component supplied by the Government for that specific function.

6-4.2 EQUIPMENT SUPPLIED BY THE INSTALLING ACTIVITY

Installing Activity furnished equipment is defined as any equipment, system or system component that is procured and installed by the Installing Activity in accordance with the government referenced documents for a specific installation. The Installing Activity shall ensure the equipment or component procured and installed aboard ship is in compliance with MIL-E-16400 and is the same equipment or component requested by the Government for a specific installation.

6-4.3 EQUIPMENT FABRICATED BY INSTALLING ACTIVITY

Installing Activity fabricated equipment is defined as any equipment, system or system component that is fabricated by, or under the direction of, the Installing Activity for shipboard installation in accordance with the government referenced documents for a specific installation.

Fabricated Electronic, Interior Communication and Navigation equipment shall comply with the requirements of MIL-E-16400.

Enclosures for electrical fittings and fixtures shall comply with the requirements of MIL-E-24142.

6-5 INSTALLATION REQUIREMENTS

The Installing Activity shall ensure electronic equipment, systems and components are installed aboard Navy Ships in accordance with the methods, materials, procedures, and requirements stated and/or referenced herein.

6-5.1 LOCATION

Electronic equipment shall be located in accordance with Government Arrangement guidance drawings, Installation Control Drawings and as stated

herein:

(a) The location of a unit or system shall be so that the added weight and movement does not adversely affect the ship's characteristics.

(b) Units shall be so located that the design ambient temperature is not exceeded. Particular attention should be given to the location of intake and exhaust vents with respect to adjacent units, so as not to dump exhaust heat from one unit into the intake of another.

(c) Units shall be raised above decks to preclude entry of water or dirt.

(d) Locating units with excessive noise levels in or near living or control spaces shall be avoided.

(e) Equipment located within the surface ships hull or superstructure shall be mounted by one of the following methods, listed in order of preference:

1. Deck mounted
2. Overhead (accessory items such as indicators, speakers and junction boxes).
3. Structural bulkheads only
4. Deck-mounted and braced to structural bulkheads.
5. Overhead and braced to structural bulkheads.

6-5.2 FOUNDATIONS

Installation Control Drawings, Navy Standard and Type Drawings, the methods of NAVSEA drawing 9000-S6202-73980 and Equipment Technical Manuals shall be used to obtain electrical, mechanical, and dimensional data including specific installation requirements and restraints required for the design, fabrication and installation of equipment foundations and supports.

6-5.3 FASTENERS

Installation Control Drawings, Navy Standard and Type Drawings, the methods of NAVSEA drawing 9000-S6202-73980 and Equipment Technical Manuals shall be used to obtain fastener data for the attachment of electronic equipment to foundations, supports or ship's structure.

6-5.4 HABITABILITY

Electronic equipment, associated cabling and other devices shall be located to present a neat appearance without unnecessarily obstructing passage or reducing headroom. Where practicable clear headroom in walking areas shall be six feet, three inches minimum, and the minimum clear width of passageways through living spaces shall be 36 inches.

6-5.5 ACCESSIBILITY

Electronic Equipment, associated cabling and other devices shall be located to provide space for operation, maintenance and repair. Equipment such as fuse boxes and panels shall be accessible for replacement of fuses, switching and testing. Hand operated devices such as switches and pushbuttons shall be located at least 1 foot and not more than 6 feet above the deck.

Permanently installed equipment shall be kept clear of routes required for removal of equipment or machinery.

6-5.6 GROUNDING AND BONDING

Electronic Equipment, associated cabling and other devices shall be electrically grounded and/or bonded in accordance with the requirements of MIL-STD-1310.

6-5.7 SAFETY

The equipment installation shall meet the safety requirements of MIL-STD-454, Requirement 1, necessary to protect the personnel installing, servicing and operating the equipment.

6-6 EQUIPMENT IDENTIFICATION

Units of electronic equipment (including antennas) shall be identified and labeled as stated herein:

6-6.1 UNIT IDENTITY

Identification plates for electronic equipment shall identify each unit by functional name and assigned number.

6-6.2 ANTENNA IDENTIFICATION PLATES

Identification plates for antennas shall include the antenna location in the assigned number.

6-6.3 ABBREVIATIONS

Abbreviations in accordance with MIL-STD-12 may be used on identification plates requiring long inscriptions.

6-6.4 ATTACHED COMPONENT IDENTIFICATION

Where an attached part of a component needs further identification, and the manufacturer has not provided an identification plate, the Installing Activity shall provide and install the necessary identification plate.

6-7 OPERATING INSTRUCTION CHARTS

Operating Instructions supplied with the equipment shall be mounted as stated herein. Operating Instructions provided by the Installing Activity shall comply with the following requirements and mounting instructions.

6-7.1 MATERIAL EXCEPTIONS

Type GCP-H plastic sheeting used for lithographed and laminated charts shall conform to Federal Specification L-P-387.

Clear transparent vinyl resin sheets used for laminating printed paper charts shall conform to Federal Specifications L-P-535.

6-7.2 FINISH

Operating Instruction Charts shall have a matte finish.

6-7.3 LETTERING

Operating Instruction Charts shall have black lettering printed in a clear and simple form with proportionally larger print for titles and paragraph headings.

6-7.4 SIZE

Chart size shall be 8 inches by 10.5 inches overall, where practicable. Smaller or larger sizes, preferable 5.25 inches by 8 inches or 10.5 inches by 16 inches, shall be used where more suitable for the proper display of the material.

6-7.5 LOCATION

Operating Instruction Charts shall be mounted in a conspicuous place on or near the equipment, or on or near the equipment control point by one of the following methods listed in order of preference

(a) Direct mounting on the subject equipment or on the adjacent structure providing they can be easily read from an advantageous position or operating station.

(b) Standard card holders that comply with NAVSEA drawing 805-1639213.

(c) Visible index file frames and brackets that comply with NAVSEA drawing 805-1749000. These are to be used for holding operating instructions and safety precaution cards in spaces where it would be impractical to make separate displays.

6-8 EQUIPMENT PROTECTION

The protection of electronic equipment against damage of any type shall be the responsibility of the Installing Activity from time of receipt through the installation process and until the equipment or system is turned over to the Navy. The methods and procedures used by the Installing Activity for electronic equipment protection shall comply with the requirements stated herein.

6-8.1 PROTECTION FROM RODENTS AND INSECTS

During the installation period suitable precautions such as, but not limited to, the following shall be taken to prevent equipment damage by rodents and insects.

(a) Cable openings and access doors on electric and electronic enclosures shall be kept closed or fitted with temporary covers at all times except during periods involving actual work on a specific enclosure/equipment.

(b) Unused openings in equipment shall be fitted with metal covers on completion of the installation.

(c) Cables shall be installed so as to avoid inaccessible pockets or ledges of sufficient size to harbor rodents and insects.

(d) Where practicable, the installation shall be completely accessible for inspection and cleaning.

(e) Where cables enter open ducts or trunks, the duct or trunk opening shall be fitted with metallic guards or screens.

(f) Where a choice exists between horizontal and vertical cable runs, the latter shall be selected when practicable.

6-8.2 CLEANLINESS--A FORM OF PROTECTION

During the installation period suitable precautions such as, but not limited to, the following shall be taken to prevent the damaging effects of dirt, grime and other foreign matter to electrical and electronic equipment.

(a) Equipment interior and exterior shall be vacuum cleaned only. Compressed air shall not be used.

(b) Areas where electrical and electronic equipments are being installed shall be kept clean and free of debris.

(c) Appropriate receptacles shall be provided for litter and scrap disposal.

(d) Tops of electrical and electronic equipment enclosures shall be kept free of all foreign objects.

(e) Tops of electrical and electronic equipment enclosures shall not be used as storage for installation material and tools.

(f) Flammable materials shall not be stored in areas containing electrical and electronic equipments.

(g) Electrical and electronic equipment shall be suitably covered to prevent damage from welding splatter, dust, flying particles, falling objects, spillages and other sources of possible damage.

(h) Tools and installation materials such as fastener hardware, tape, sleeving and lugs shall not be placed on ledges within equipment where they may be inadvertently left to fall into the equipment circuitry.

(i) Ventilation air filters to equipment shall be cleaned or replaced as appropriate prior to initial energizing of the equipment.

(j) Equipment surfaces and finish shall be protected from scarring, bending, denting and other damages.

(k) Work areas shall be adequately lighted to further ensure good workmanship.

6-8.3 DAMAGED EQUIPMENT REPAIR OR REPLACEMENT

The Installing Activity shall be responsible for the repair or replacement of equipment or equipment components damaged between the time of receipt and time of turn over to the Navy as stated herein.

(a) Replaced equipment or components shall be the same as the original.

(b) Workmanship of fabricated replacement components shall be comparable to the original component workmanship.

(c) Painting or refinishing of electrical and electronic equipment shall be comparable to the original finish.

6-8.4 PROTECTION FROM VANDALISM

The Installing Activity shall be responsible for the protection of electronic equipment from vandalism and possible damage from knob twisters during the installation period as stated herein.

(a) Prior to installation aboard ship, electronic equipment shall be stored in controlled areas with access by authorized personnel only.

(b) Electronic equipment in transit from point of receipt and/or storage area to the shipboard installation site shall not be left unattended.

(c) During the shipboard installation period, spaces containing electronic equipment shall be controlled by suitable means that will prevent access by unauthorized personnel during unmanned conditions.

(d) When electronic equipment installers are working in spaces containing electronic equipment, it shall be their responsibility to prevent vandalism or equipment damage by unauthorized personnel.

6-9 SECURE EQUIPMENT

The installation of secure equipment, including the spaces in which they are located, shall comply with the requirements of MIL-STD-1680.

6-10 INTERFACE COMPATIBILITY

The interface compatibility of shipboard installed electronic equipments between units of the same system, units of other electronic systems and with ancillary equipment/systems shall comply with the applicable requirements of MIL-STD-1399 for a specific installation.