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NAVSHIPS 0967-000-0110
(Formerly NAVSHIPS 900, 000. 101)

NON-REGISTERED

ELECTRONICS INSTALLATION AND MAINTENANCE BOOK

INSTALLATION STANDARDS

DEPARTMENT OF THE NAVY
NAVAL SHIP ENGINEERING CENTER

PUBLISHED: AUGUST 1963

Change 5: May 1966 (0967-000-0115)

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ELECTRONICS INSTALLATION AND MAINTENANCE BOOK

INSTALLATION STANDARDS

DEPARTMENT OF THE NAVY
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PUBLISHED: AUGUST 1963

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EFFECTIVE PAGES

PAGE NUMBER AND TITLE	CHANGE IN EFFECT
Title Page	Change 4
ii Effective Pages	Change 4
iii Preface	Change 1
iv Correction Page	Original
v-x Table of Contents	Change 1
xi Table of Contents	Change 4
xii-xiii Table of Contents	Change 3
Section 1 - General	
Title Page	Change 1
1-1	Original
Section 2 - Equipment Handling	
Title Page	Change 1
2-1-1 to 2-4-1	Original
Section 3 - Equipment Location And Mounting	
Title Page	Change
3-1-1 to 3-4-3	Original
Section 4 - Interconnection Cable And Wiring	
Title Page	Change 1
4-1-1 to 4-32-14	Original
Section 5 - Radio Frequency Transmission Lines	
Title Page	Change 1
5-1-1 to 5-3-4	Original
5-4-1 to 5-4-3	Change 1
5-5-1 to 5-5-32	Original
5-6-1 to 5-6-7	Change 1
5-7-1	Change 1
5-8-1 to 5-8-14	Change 1
5-9-i to 5-9-58	Change 2
5-10-1 to 5-10-33	Change 2
5-11-1 to 5-11-26	Change 3
5-12-1 to 5-12-13	Change 3
5-13-1 to 5-13-172	Change 3
5-14-1 to 5-14-10	Change 2
5-15-i	Change 4
5-15-1 to 5-15-14	Change 4
5-16-1 to 5-16-14	Original
Section 6 - Antennas And Detection Devices	
Title Page	Change 1
6-2-1 to 6-6-1	Original
Section 7 - Electromechanical Mechanisms	
Title Page	Change 1
(To be issued in later changes)	
Section 8 - Soldering, Brazing, And Welding	
Title Page	Change 1
8-1-1 to 8-5-6	Original
Section 9 - Interconnection Cabling And Wiring	
Title Page	Change 1
9-1-1 to 9-1-9	Original

CHANGE 5 TO
NAVSHIPS 0967-000-0110

May 1966

INSTRUCTION SHEET

This sheet provides instructions for inserting CHANGE 5 (0967-000-0115) to the Installation Standards Handbook, NAVSHIPS 0967-000-0110.

The purpose of this change is to replace and to reorganize material in the handbook.

It should take approximately 10 minutes to complete this change.

1. Remove superseded pages and insert revised pages as indicated below:

Page	Remove	Insert
	FRONT MATTER	
TP/ii	Change 4/Change 4	Change 5/Change 5
iii/iv	Original/Original	Change 5/Change 5
v/vi	Change 1/Change 1	Change 5/Blank
vii/viii	Change 1/Change 1	Change 5/Change 5
ix/x	Change 1/Change 1	Change 5/Change 5
xi/xii	Change 4/Change 3	Change 5/Change 5
xiii/xiv	Change 3/Blank	Change 5/Change 5
xv/xvi	-/-	Change 5/Blank

SECTION 5 - Radio Frequency Transmission Lines

Remove pages 5-14-1 through 5-14-10, CHANGE 2, and insert CHANGE 5 pages 5-14-i through 5-14-5.

Remove page 5-15-i, CHANGE 4, and insert page 5-15-i, CHANGE 5.

2. Insert the User Activity Technical Manual Comment Sheet NAVSHIPS 4914, as the last page of the handbook.

3. Record the insertion of this change on the Correction Page.

PREFACE EIMB

POLICY AND PURPOSE

The Electronics Installation and Maintenance Book (EIMB) has been established as the means for collecting, publishing, and distributing, in one convenient documentation source, those subordinate maintenance and repair policies, installation practices, and overall electronics equipment and material-handling procedures required to implement the major policies set forth in Chapter 67 of the Bureau of Ships Technical Manual. All data contained within the EIMB are authoritative, and derive their authority from Chapter 67 of the Bureau of Ships Technical Manual, as established in accordance with Article 1201, U. S. Navy Regulations.

Since its inception, however, EIMB has been expanded to include selected information items of general interest to electronics installation and maintenance personnel. These items are such as would generally be contained in text books, periodicals, or technical papers, and form (along with the information cited above) a comprehensive, single-source 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, or repair of electronic equipment under cognizance, or technical control, of the Naval Ship Systems Command (NAVSHIPS). All information, instructions, and procedures in the EIMB supplement such instructions and data supplied in equipment technical manuals and other approved maintenance publications.

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 activities requiring extra copies of any handbook may obtain them with relative ease.

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 only an overall idea of their data content; a more complete description of each handbook is provided in the General and Index handbook.

The equipment handbooks are devoted to information on a particular equipment class and provide general test procedures, adjustments, general servicing information, and field change identification data.

The following table lists all handbooks of the series, together with their old and new NAVSHIPS numbers. (The old NAVSHIPS numbers are shown in parentheses in the table).

The new NAVSHIPS numbers, although not presently imprinted on all handbooks of the EIMB series, serve also as the stock numbers which are to be used on any requisitions submitted.

HANDBOOK TITLE	NAVSHIPS NUMBER
(General Information Handbooks)	
General and Index	0967-000-0100 (900,000.100)
Installation Standards	0967-000-0110 (900,000.101)
Electronic Circuits	0967-000-0120 (900,000.102)
Test Methods and Practices	0967-000-0130 (900,000.103)
Reference Data	0967-000-0140 (900,000.104)
RFI Reduction	0967-000-0150 (900,000.105)
General Maintenance	0967-000-0160
(Equipment Oriented Handbooks)	
Communications	0967-000-0010 (900,000.1)
Radar	0967-000-0020 (900,000.2)
Sonar	0967-000-0030 (900,000.3)
Test Equipment	0967-000-0040 (900,000.4)
Radiac	0967-000-0050 (900,000.5)
Countermeasures	0967-000-0070 (900,000.7)

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 Naval Ship Systems Command News, electronics and other text books, industry magazines and periodicals, and various military installation- and maintenance-related publications. In certain cases, NAVSHIPS 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 and Index handbook.

SUGGESTIONS

NAVSHIPS recognizes that users of the EIMB will have occasion to offer comments or suggestions. To encourage more active participation, a self-addressed comment sheet is provided in the back of each handbook change. Complete information should be given when preparing suggestions. It is most desirable that the suggestor include his name and mailing address on the form to facilitate direct correspondence in the event clarification is required and an immediate reply can be supplied regarding the suggestion. Any communication will be made through a personal letter to the individual concerned.

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

Commander; Naval Ship Engineering Center
Department of the Navy
Washington, D. C. 20360
Attn: Fleet Electronics Effectiveness
Branch, Code 6678

CORRECTIONS

Report all inaccuracies and deficiencies noted in all NAVSHIPS technical publications (including this manual, ship information books, equipment manuals, drawings, and such) by a "Planned Maintenance System (PMS) Feedback Report, OPNAV 4700.7 (REV. 5-65)" or superseding form. If PMS is not yet installed in this ship, report technical publication deficiencies by any convenient means.

DISTRIBUTION

The Electronics Installation and Maintenance Book is transmitted to using activities through automatic distribution procedures. Activities not already on the EIMB distribution list and those requiring changes to the list should submit correspondence to the following:

Commander; Naval Ship Engineering Center
Department of the Navy
Washington, D. C. 20360
Attn: Code 6679A2b

Activities desiring extra copies of EIMB handbooks or binders should submit requisitions directly to Naval Supply Depot, Philadelphia, Pennsylvania. Complete instructions for ordering publications are given in the Navy Stock List of Forms and Publications, NAVSANDA Publication 2002.

RECORD OF CORRECTIONS MADE

CHANGE NO.	DATE	CHANGES MADE	SIGNATURE

PAGE NUMBER AND TITLE		CHANGE IN EFFECT
Title Page		Change 5
ii, iii	Preface	Change 5
iv	Correction Page	Change 5
v, vi	Effective Pages	Change 5
vii to xvi	Table of Contents	Change 5
	Section 1 - General	
Title Page		Change 1
1-1		Original
	Section 2 - Equipment Handling	
Title Page		Change 1
2-1-1 to 2-5-2		Original
	Section 3 - Equipment Location And Mounting	
Title Page		Change 1
3-1-1 to 3-4-3		Original
	Section 4 - Interconnection Cabling And Wiring	
Title Page		Change 1
4-1-1 to 4-32-14		Original
	Section 5 - Radio Frequency Transmission Lines	
Title Page		Change 1
5-1-1 to 5-3-4		Original
5-4-1 to 5-4-3		Change 1
5-5-1 to 5-5-32		Original
5-6-1 to 5-6-7		Change 1
5-7-1		Change 1
5-8-1 to 5-8-14		Change 1
5-9-i to 5-9-58		Change 2
5-10-1 to 5-10-33		Change 2
5-11-1 to 5-11-26		Change 3
5-12-1 to 5-12-13		Change 3
5-13-1 to 5-13-172		Change 3
5-14-i to 5-14-5		Change 5
5-15-i		Change 5
5-15-1 to 5-15-14		Change 4
5-16-1 to 5-16-14		Original
	Section 6 - Antennas And Detection Devices	
Title Page		Change 1
6-1-1 to 6-6-1		Original
	Section 7 - Electromechanical Mechanisms	
Title Page		Change 1
(To be issued in later changes)		
	Section 8 - Soldering, Brazing, And Welding	
Title Page		Change 1
8-1-1 to 8-5-6		Original
	Section 9 - Special Tools and Jigs	
Title Page		Change 1
9-1-1 to 9-1-9		Original

TABLE OF CONTENTS

Paragraph		Page
	SECTION 1 - GENERAL	
1-1	Policy	1-1
1-2	Documentation	1-1
1-3	Objective	1-1
1-4	Compilation of Material	1-1
1-5	Corrections	1-1
1-6	Additions	1-1
1-7	Revisions	1-1
	SECTION 2 - EQUIPMENT HANDLING	
2-1	General	
	a. Purpose	2-1-1
	b. Scope	2-1-1
	c. Reference Documents	2-1-1
	d. Definitions	2-1-1
2-2	Crate Marking	2-1-1
	a. Service Symbols	2-2-1
	b. Service Colors	2-2-1
	c. Opening Side	2-2-1
	d. Set of Boxes	2-2-1
	e. Navy Electronic Marking Symbols	2-2-1
	f. Fragile Items	2-2-1
	g. Top Marking	2-2-1
	h. Batteries	2-2-1
	i. Electrolyte	2-2-1
	j. Center of Balance and Sling Points	2-2-1
	k. Magnetic Materials	2-2-4
	l. Radiation Hazard	2-2-4
	m. Use No Hooks	2-2-4
	n. Abbreviations	2-2-4
	o. Basic Marking	2-2-4
2-3	Uncrating	2-3-1
	a. Unpacking Sequence	2-3-1
	b. Crate Handling	2-3-1
	c. Strap Band and Nail Removal	2-3-1
	d. Inventories	2-3-1
	e. Storage	2-3-1
	f. Salvage	2-3-1
2-4	Carrying	2-4-1
	a. Forces	2-4-1
	b. Exposure	2-4-1
	c. Cushioning	2-4-1
	d. Precautions	2-4-1
2-5	Hoisting	2-5-1
	a. Rigging	2-5-1
	b. Equipment Transfer	2-5-1
	c. Scaffolding	2-5-1
	SECTION 3 - EQUIPMENT LOCATION AND MOUNTING	
3-1	General	3-1-1
	a. Purpose	3-1-1
	b. Scope	3-1-1

TABLE OF CONTENTS

Paragraph		Page
3-2	Equipment Location	3-2-1
	a. Accessibility	3-2-1
	b. Heat Zones	3-2-1
	c. Habitability	3-2-1
	d. View Obstruction	3-2-1
	e. Manually Operated Units	3-2-1
	f. Motors and Generators	3-2-1
	g. Service Receptacles	3-2-1
	h. Operating Controls and Equipment	3-2-1
	i. Bearing Indicating Equipment	3-2-1
	j. Test Equipment	3-2-1
	k. Control Stations	3-2-1
	l. Battle Damage	3-2-1
	m. Cathode Ray Tubes	3-2-1
	n. Magnetic Compass	3-2-1
	o. Flood Protection	3-2-2
	p. Water Spray Protection	3-2-2
	q. Other Considerations	3-2-2
	r. Installation Plans	3-3-1
3-3	Equipment Mounting	3-3-1
	a. Within Ballistic Structure	3-3-1
	b. Outside Ballistic Structure	3-3-1
	c. Top Bracing	3-3-1
	d. Shock Mounts	3-3-1
	e. Rodent and Insect Proofing	3-3-1
	f. Cleanliness and Equipment Protection	3-4-1
3-4	Warning Signs and Guards	3-4-1
	a. Doctrine	3-4-1
	b. Procurement	3-4-1
	c. Available Drawings	

SECTION 4 - INTERCONNECTION, CABLING AND WIRING

4-1	General	4-1-1
	a. Purpose	4-1-1
	b. Scope	4-1-1
	c. Reference Documents	4-1-1
	d. Definitions	4-1-1
4-2	Cable Types and Selection	4-2-1
	a. Cable Type and Size	4-2-1
	b. Spare Conductors	4-2-2
	c. Cable Selection	4-2-2
	d. Thermocouple Cable Color Code	4-2-6
	e. Cable Data Tables	4-2-6
4-3	Cable Inspection and Testing	4-3-1
	a. Inspection	4-3-1
	b. Electrical Testing	4-3-1
	c. Corrective Measures	4-3-1
	d. End Sealing	4-3-1
	e. Preparation for Electrical Testing	4-3-1
	f. Electrical Testing	4-3-1
	g. Minimum Insulation Resistance	4-3-2
	h. Corrective Measures	4-3-2
	i. Cable Sealing	4-3-4
4-4	Cable Routing	4-4-1
	a. General	4-4-1
	b. Cable Grouping	4-4-2

TABLE OF CONTENTS

Paragraph		Page
4-5	Cable Cleaning	
	a. General	4-5-1
	b. Cleaning Methods	4-5-1
	c. Safety Precautions	4-5-1
4-6	Cable Protection	4-5-1
	a. Temperature Consideration	4-6-1
	b. Mechanical Damage	4-6-1
4-7	Hanger Types	4-6-1
	a. General	4-7-1
	b. Spacing	4-7-1
	c. Cable Support Material	4-7-1
	d. Installation Methods	4-7-1
	e. References	4-7-1
4-8	Banding Straps	4-7-1
	a. General	4-8-1
	b. Banding Materials	4-8-1
	c. Banding Requirements	4-8-1
	d. Banding Tension	4-8-1
	e. Banding Tools	4-8-1
4-9	Contour Straps	4-8-1
	a. General	4-9-1
	b. Strap Material	4-9-1
	c. Fabrication	4-9-1
	d. Installation	4-9-1
4-10	General Purpose Metal Stuffing Tubes	4-9-1
	a. Stuffing Tube Types	4-10-1
	b. Metal Combinations	4-10-1
	c. Stuffing Tube Use	4-10-1
	d. Preformed Packing	4-10-3
	e. Plastic Sealer	4-10-3
	f. Altered Stuffing Tubes	4-10-5
	g. Sealing Unused Stuffing Tubes	4-10-5
	h. Sealing Unused Kickpipes	4-10-5
	i. Kickpipe and Stuffing Tube Spacing	4-10-5
4-11	(To Be Supplied)	4-10-5
4-12	Nylon Stuffing Tubes	
	a. Authorized Installation Use	4-12-1
	b. Types and Sizes	4-12-1
	c. Packing Assemblies	4-12-1
	d. "O" Rings	4-12-1
	e. Nylon Stuffing Tube Installation	4-12-2
	f. Grounding	4-12-2
	g. Stuffing Tube Extension	4-12-4
4-13	Box Connectors	4-12-5
	a. Type I and II	4-13-1
	b. Greenfield Type	4-13-1
4-14	(To Be Supplied)	4-13-3
4-15	Cable Termination	
	a. Protective Material Removal	4-15-1
	b. Stripping Length	4-15-1
	c. Reduced Diameter Cables	4-15-1
	d. Armor Removal	4-15-2
	e. Jacket Length	4-15-3
	f. Jacket Removal	4-15-4
	g. Jacket Removal - Reduced Diameter Cables	4-15-4
	h. Jacket Tapering and Finishing	4-15-6
4-16	Cable Marking	4-15-7
	a. Tagging	4-16-1
	b. Cable Identification	4-16-1
		4-16-1

TABLE OF CONTENTS

Paragraph		Page
	c. Cable Segregation	4-16-1
	d. Cable Segregation Marking	4-16-1
	e. Cable Marking Examples	4-16-1
	f. Cable Tagging	4-16-1
4-17	Cable Bonding and Grounding	4-17-1
	a. General	4-17-1
	b. Purpose for Bonding and Grounding	4-17-1
	c. Requirement for Bonding	4-17-1
	d. Methods of Bonding	4-17-1
	e. Additional Grounding	4-17-1
4-18	Routing and Forming of Wiring	4-18-1
	a. Wire Length	4-18-1
	b. Twisted Pairs	4-18-1
	c. Individual Wires	4-18-1
	d. Cable Groups	4-18-1
	e. Temporary Ties	4-18-1
	f. Routing	4-18-1
	g. Hinge Protection	4-18-1
	h. Support	4-18-1
	i. Routing and Forming a Group	4-18-2
	j. Disposition of Spares	4-18-2
	k. Completing the Form	4-19-1
4-19	Protection of Wire Forms	4-19-1
	a. Protective Tape	4-19-1
	b. Sleeving Size	4-19-1
	c. Bare Conductors	4-19-1
	d. HFA Wires	4-19-1
	e. Sleeving	4-19-1
	f. Moveable Wire Protection	4-19-1
	g. Protection From Oil	4-20-1
4-20	Wire Stripping	4-20-1
	a. General	4-20-1
	b. Jones Cable Stripper	4-20-3
	c. Ideal Wire Stripper	4-20-3
	d. Huff Cable Stripper	4-21-1
4-21	Lacing and Tying Wire Forms	4-21-1
	a. General Procedures	4-21-3
	b. Lacing Shuttle	4-21-3
	c. Single Cord Lacing	4-21-4
	d. Double Cord Lacing	4-21-5
	e. Branch-Off Lacing	4-21-5
	f. Break-Out Lacing	4-21-5
	g. Multiple Group Tying	4-21-5
	h. Splicing of Lacing Cord	4-21-7
	i. Complete Laced Insulation	4-21-7
	j. Wire Tying	4-22-1
4-22	Wire Clamps	4-22-1
	a. General	4-22-1
	b. Requirements	4-22-1
	c. Cable Clamp Types	4-22-1
	d. Lock Nuts	4-23-1
4-23	Nylon Bands and Spiral Wrap	4-23-1
	a. Band Material	4-23-1
	b. Band Construction	4-23-1
	c. Band Tightness	4-23-1
	d. Detailed Procedures	4-24-1
4-24	Wire Color Codes	4-24-1
	a. Color Code Methods	4-24-1
	b. Color Sequence	

TABLE OF CONTENTS

Paragraph		Page
	c. Power Cables	4-24-1
	d. Multiple Conductor Cable	4-24-3
	e. Twisted Pair Telephone Cable	4-24-3
	f. Special Purpose Cable	4-24-6
4-25	Wire Marking	4-25-1
	a. Marking Method	4-25-1
	b. Marking Between "Like" Terminals	4-25-5
	c. Marking Between "Unlike" Terminals	4-25-5
	d. Marking Between Unit and Junction Box	4-25-5
	e. Marking Between Equipment Unit and Power Source	4-25-5
	f. Sonar System Wire Marking	4-25-5
4-26	Solder Lug Terminals	4-26-1
	a. Lug Terminal Selection	4-26-1
	b. Wire Preparation	4-26-1
	c. Lug Terminal Soldering	4-26-1
	d. Inspection	4-26-3
4-27	Crimp Lug Terminals	4-27-1
	a. Lug Terminals, Crimp Type	4-27-1
	b. Lug Size Identification	4-27-5
	c. Wire Size Identification	4-27-5
	d. General Precautions	4-27-5
	e. Crimp Lug Terminal Installations	4-27-7
	f. Lug Terminal Standardization	4-27-14
4-28	Shielded Wires and Twisted Pairs	4-28-1
	a. Ferrule Termination	4-28-1
	b. Preparation	4-28-1
	c. Termination With Ferrules	4-28-2
	d. Tool #47750 Crimping Procedure	4-28-7
	e. Not Used	
	f. Shield Dead Ending	4-28-24
	g. Visual Inspection of Crimped Ferrules	4-28-25
	h. Electrical Tests	4-28-25
	i. Mechanical Tests	4-28-26
4-29	Connection to Terminals	4-29-1
	a. Screw or Stud Terminals	4-29-1
	b. Wire Connection	4-29-1
	c. Sequence of Connection	4-29-1
	d. Connection Torque	4-29-1
	e. Screw Terminal	4-29-1
	f. Stud Terminal	4-29-1
	g. Completed Connection	4-29-1
	h. Placement of Lug Terminals	4-29-1
4-30	Pigtail Splice Connectors	4-30-1
	a. Connector Types	4-30-1
	b. Ideal Connectors	4-30-1
	c. Burndy Connectors	4-30-2
	d. Scotchlok Connectors	4-30-3
4-31	Cable Splicing	4-31-1
	a. Policy	4-31-1
	b. Methods Approved for Splicing	4-31-1
	c. Advantages of Cable Splices	4-31-1
	d. Materials	4-31-1
	e. Personnel Assigned Splicing	4-31-1
	f. References	4-31-1
4-32	Cable End Sealing	4-32-1
	a. Purpose	4-32-1
	b. Requirements	4-32-1
	c. End Sealing Procedures	4-32-1
	d. Cable Supports	4-32-12

TABLE OF CONTENTS

Paragraph		Page
	SECTION 5 - RADIO FREQUENCY TRANSMISSION LINES	
		5-1-1
5-1	General	5-1-1
	a. Scope	5-1-1
	b. Multiwire Line	5-1-1
	c. Coaxial Line	5-1-2
	d. Waveguide	5-1-2
	e. General Consideration	5-2-1
5-2	Flexible Coaxial Cables and Connectors	5-2-1
	a. Scope	5-2-1
	b. Procurement	5-2-1
	c. Cable Elements	5-2-2
	d. Electrical Characteristics	5-2-4
	e. Installation Notes	5-2-4
	f. Connectors	5-2-6
	g. Cable Data Tables	5-2-8
	h. Cable Data Sheets	5-2-8
	i. Connector Assembly Instructions	5-3-1
5-3	Coaxial Cable Inspection and Testing	5-3-1
	a. Cable Without Connectors Installed	5-3-3
	b. Connector Testing	5-3-4
	c. Cable Testing - Connectors Installed	5-4-1
5-4	Flexible Coaxial Cable Installation	5-4-1
	a. Scope	5-4-1
	b. General Requirements	5-4-1
	c. Plans	5-4-1
	d. Grouping	5-4-1
	e. Routing	5-4-2
	f. Temperature	5-4-2
	g. Handling	5-4-2
	h. Storage	5-4-2
	i. Insulation Resistance	5-4-2
	j. Standard Plans	5-4-2
	k. Ballistic Decks	5-4-3
	l. Penetration	5-4-3
	m. Enclosures	5-4-3
	n. Riser Boxes	5-4-3
	o. Straps - Banding	5-4-3
	p. Sag	5-4-3
	q. Bending	5-4-3
	r. Splicing	5-4-3
	s. Connectors	5-4-3
	t. Spare or Unused Cable	5-4-3
	u. References	5-5-1
5-5	Pressureproof Fittings	5-5-1
	a. O-Ring Watertight Seals	5-5-3
	b. O-Ring Grooves	5-5-4
	c. Assembly Tools	5-5-4
	d. Assembly of Fittings	5-6-1
5-6	Receptacle Mounting	5-6-1
	a. Scope	5-6-1
	b. Mounting Terminology	5-6-1
	c. Mounting Design	5-6-1
	d. Selection of Mounting	5-6-2
	e. Summation	5-7-1
5-7	Cable Terminations	5-7-1
	a. Scope	5-7-1
	b. Cable Preparation	

TABLE OF CONTENTS

Paragraph		Page
5-8	Connector Adapters	
	a. Scope	5-8-1
	b. Purpose	5-8-1
	c. Nomenclature	5-8-1
	d. Listings	5-8-1
	e. Cross Section Views	5-8-1
5-9	Semirigid Coaxial Cables	5-8-1
	a. Scope	5-9-i
	b. Cable Elements	5-9-ii
	c. Cable Qualities	5-9-ii
	d. Cable Data Sheets	5-9-1
5-10	Semirigid Coaxial Cable Installation	5-9-3
	a. Purpose	5-10-1
	b. Scope	5-10-1
	c. Preparation for Unreeling	5-10-1
	d. Unreeling the Cable	5-10-1
	e. Cable Cutting	5-10-2
	f. Cable Bending (Forming)	5-10-5
	g. Installation	5-10-14
	h. Purging and Pressurizing	5-10-17
	i. Cable-Connector Assembly Instructions	5-10-20
	j. Electrical Requirements and Tests	5-10-21
5-11	Rigid Coaxial Cables	5-10-33
	a. Scope	5-11-1
	b. Cable Elements	5-11-1
	c. Physical Qualities	5-11-1
	d. Electrical Qualities	5-11-1
	e. Cable Data Sheet	5-11-3
5-12	Rigid Coaxial Cable Installation	5-11-8
	a. Purpose	5-12-1
	b. Scope	5-12-1
	c. Pre-Installation	5-12-1
	d. Installation	5-12-1
	e. Transmission Line Composition	5-12-2
	f. Purging and Pressurizing	5-12-11
	g. Electrical Requirements and Test	5-12-13
5-13	Waveguide: Fittings, Assemblies, and Accessories	5-12-13
	a. Introduction	5-13-1
	b. Purpose	5-13-1
	c. Scope	5-13-1
	d. Waveguide	5-13-1
	e. Fittings	5-13-1
	f. Assemblies	5-13-118
	g. Accessories	5-13-134
5-14	Waveguide Preservation	5-13-162
	a. Scope	5-14-1
	b. Reference Documents	5-14-1
	c. Definitions	5-14-1
	d. General Requirements	5-14-1
	e. Detail Requirements	5-14-1
5-15	Waveguide Installation	5-14-2
	a. Purpose	5-15-1
	b. Scope	5-15-1
	c. Acquisition and Handling	5-15-1
	d. Fabrication	5-15-1
	e. Installation	5-15-2
	f. Transmission Line Composition	5-15-7
	g. Purging and Pressurizing	5-15-13
	h. Electrical Requirements and Tests	5-15-13
		5-15-13

TABLE OF CONTENTS

Paragraph		Page
5-16	Antenna Trunks	5-16-1
	a. Antenna Trunk Sizes	5-16-1
	b. Material Specifications	5-16-1
	c. Insulators	5-16-4
	d. Antenna Switches	5-16-4
	e. Installation	5-16-12

SECTION 6 - ANTENNAS AND DETECTION DEVICES

6-1	Introduction	6-1-1
	a. General Consideration	6-1-1
	b. Purpose	6-1-1
	c. Scope	6-1-1
	d. Reference Documents	6-2-1
6-2	Antennas	6-2-1
	a. General	6-2-1
	b. Shipboard Antenna Orientation	6-3-1
6-3	Wire Antennas	6-3-1
	a. Materials Used	6-3-4
	b. Antenna Fabrication	6-4-1
6-4	Whip Antennas	6-4-1
	a. General	6-4-1
	b. Whip Assembly	6-4-1
	c. Whip Mounting	6-5-1
6-5	Single and Multi-Element Arrays	6-5-1
	a. General	6-5-1
	b. Assembling the Array	6-5-1
	c. Mounting the Array	6-6-1
6-6	Directional Antennas	6-6-1
	a. General Considerations	6-6-1
	b. Installation Techniques	

SECTION 7 - ELECTROMECHANICAL MECHANISMS

7-1	(To Be Supplied)	

SECTION 8 - SOLDERING, BRAZING, AND WELDING

8-1	General	8-1-1
	a. Safety	8-1-1
	b. Welder Qualifications	8-1-1
	c. Preparation of Parts	8-1-1
	d. Post Heat Treatment	8-1-1
	e. Inspection of Finished Joints	8-1-2
	f. Cleaning Finished Joints	8-2-1
8-2	Soft Soldering	8-2-1
	a. General	8-2-1
	b. Soldering Equipment	8-2-3
	c. Types of Soldering	8-2-6
	d. Solders	8-2-6
	e. Fluxes	8-2-7
	f. Mechanical Connections	8-2-8
	g. Soldering to Special Surfaces	8-3-1
8-3	Brazing	8-3-1
	a. Types of Brazing	8-3-1
	b. Filler Metals	8-3-1
	c. Fluxes	

TABLE OF CONTENTS

Paragraph		Page
	d. Braze Joints	8-3-1
	e. Brazing Techniques	8-3-2
8-4	Welding	8-4-1
	a. Types of Welding	8-4-1
	b. Welding Rods	8-4-1
	c. Welding Fluxes	8-4-1
	d. Joint Selection	8-4-1
	e. Welding Technique	8-4-1
	f. Repair of Castings	8-4-7
	g. Metal Cutting With Heat	8-4-7
8-5	Submarine Pressure Hull Welding	8-5-1
	a. Hole Location	8-5-1
	b. Fitting Inspection	8-5-1
	c. Fitting Installation	8-5-1
	d. Welding Electrodes	8-5-1
	e. Patching	8-5-2
	f. Temporary Fitting Closures	8-5-3
	g. Weld Inspections	8-5-3

SECTION 9 - SPECIAL TOOLS AND JIGS

	a. Objectives	9-1-1
	b. Additions	9-1-1
	c. Special Tools and Jigs	9-1-1

5-14. WAVEGUIDE PRESERVATION

Table of Contents

Paragraph	Page
a. Scope	5-14-1
b. Referenced Documents	5-14-1
c. Definitions	5-14-1
d. General Requirements	5-14-1
(1) Waveguides Other Than Aluminum	5-14-1
(2) Aluminum Waveguides	5-14-1
e. Detail Requirements	5-14-2
(1) Waveguide Cleaning	5-14-2
(a) Heavy oil or grease deposit	5-14-2
(b) Painted surfaces	5-14-2
(c) Removal of organic material	5-14-2
(d) Removal of inorganic material	5-14-3
(e) Rinsing	5-14-3
(f) Conclusion of cleaning	5-14-3
(2) Chromate Conversion Film	5-14-3
(3) Protection by Painting	5-14-3
(a) Surface preparation	5-14-3
(b) Interior surfaces	5-14-3
(c) Exterior surfaces – Before installation	5-14-4
(d) Exterior surfaces – After installation	5-14-4
(4) Precedure for Painting Interior of Waveguides	5-14-4
(a) Equipment fabrication	5-14-4
(b) Paint application	5-14-4
(c) Pressurizing	5-14-4
(d) Draining	5-14-4
(e) Drying	5-14-4
(f) Faying surfaces	5-14-4

List of Illustrations

Figure		Page
14–1	Device for Painting Interior of Waveguide	5–14–5

5-14. WAVEGUIDE PRESERVATION.

a. **SCOPE.**–This subsection describes and discusses approved methods and practices whereby waveguides and waveguide fittings shall be protected against oxidation and corrosion.

b. **REFERENCED DOCUMENTS.**–The issues of the following documents in effect form a part of this subsection to the extent specified herein.

Military

MIL-C-5541 Chemical Films for Aluminum and Aluminum Alloys.
MIL-P-15328 Primer, Pretreatment (Formula No. 117 for Metals).

Federal

TT-P-645 Primer, Zinc-Chromate, Alkyd Type.

c. **DEFINITIONS.**–Not applicable.

d. **GENERAL REQUIREMENTS.**–The type of chemical protection to be given a waveguide depends upon the fabrication of the waveguide and its location with respect to weather. Refer to Table 14-1.

(1) **WAVEGUIDES OTHER THAN ALUMINUM.**–Waveguides fabricated from materials other than aluminum shall be protected against corrosion and oxidation by painting both the interior and exterior surfaces in accordance with paragraphs 5-14e(3) and 5-14e(4).

(2) **ALUMINUM WAVEGUIDES.**–Waveguides fabricated from aluminum require a more extensive process for effective protection. The interior and exterior surfaces of aluminum waveguides shall receive a protective chemical film by a process known as chromate conversion (paragraph 5-14e(2)). Following the chromate conversion process, the exterior only of aluminum waveguides shall be painted in accordance with paragraphs 5-14e(3) (c) and 5-14e(3) (d).

TABLE 14-1. RESUME OF PRESERVATION REQUIREMENTS FOR WAVEGUIDES

Waveguide Material	Before Installation but After Fabrication		After Installation Outside of Waveguide	
	Inside of Waveguide	Outside of Waveguide	Installed Inside Not Exposed to Weather	Installed Outside Exposed to Weather
Aluminum alloy	Chromate Conversion, para. 5-14	Chromate Conversion, para. 5-14 e(2) Pretreatment Primer followed by Zinc Chromate Primer, para. 5-14e(3) (c)	2 coats Finish Paint, para. 5-14 e(3) (d)2 e(1) and	Zinc Chromate Primer followed by 2 coats Finish Paint, para. 5-14e(3) (d)1
Copper alloy, Brass, Magnesium alloy, Silver alloy, CRES	Zinc Primer, para. 5-14e(3) (b)	Pretreatment Primer followed by Zinc Chromate Primer, para. 5-14e (3) (c)	2 coats Finish Paint, para. 5-14e (3) (d)2	Zinc Chromate Primer followed by 2 coats Finish Paint, para. 5-14 e(3) (d)1

e. **DETAIL REQUIREMENTS.**–

(1) **WAVEGUIDE CLEANING.**[1]–Prior to the application of a chemical film to waveguide parts, all surface contamination shall be removed. Surface contaminants include all foreign matter such as, but not limited to, grease, oil, paint, oxide film, welding flux, dust, and metal particles.

The following paragraphs describe methods for removing various types of surface contamination.

(a) **HEAVY OIL OR GREASE DEPOSIT.**–When the metal parts have a heavy grease or oil deposit, they shall be precleaned. Methods of precleaning include solvent vapor degreasing, solvent washing, or solvent emulsion cleaning. Some solvents which are used for precleaning operations are naphtha, toluene, and lacquer thinner. Trichlorethylene is used in solvent emulsion cleaning with good results, but the installation must provide for the removal of its vapor, which is toxic. Buffing compounds are best removed in an emulsion cleaner or power washer.

(b) **PAINTED SURFACES.**–When a waveguide which is to be subjected to chromate conversion has been previously painted, the existing coat of paint shall be removed. The method of removal shall be by use of paint solvents, paint softeners, or paint removers applied with a soft, non-abrasive cloth. Wire brushing, scraping, sand or shot blasting, or other mechanical methods of removing paint shall not be used.

CAUTION

Removal of paint from a waveguide by mechanical methods may result in damage to the waveguide and degrading of the performance of the equipment with which it is to be used.

(c) **REMOVAL OF ORGANIC MATERIAL.**–All organic contamination shall be removed from the waveguide before applying a chemical film. The chemicals mentioned herein are for the removal of contaminants such as marking inks, light oils, and shop soils.

The cleaning chemical recommended by Amchem Products, Inc. for the removal of organic material prior to the use of their Alodine 600 Process is "Ridoline."

The cleaning chemical recommended by Allied Research Products, Inc. for the removal of organic material prior to the use of their Iridite 14 Process is "ARP # 160."

The manufacturer's directions for use of cleaning compounds shall be adhered to exactly.

(d) **REMOVAL OF INORGANIC MATERIAL.**–All inorganic contamination shall be removed from the waveguide before applying a chemical film. The chemicals mentioned herein are for the removal of oxides which are relatively closely bonded to the metal.[2]

The deoxidizing chemical recommended by Amchem Products, Inc. for the removal of inorganic oxides prior to the use of their Alodine 600 Process is Amchem Deoxidizer No. 4-14.

The deoxidizing chemical recommended by Allied Research Products, Inc. for the removal of inorganic oxides prior to the use of their Iridite 14 Process is "ARP # 170."

The manufacturer's directions for use of deoxidizing chemicals shall be followed exactly.

CAUTION – ACID SOLUTION

The deoxidizer is a mixture of acid salts containing chromates. The dry salts, or the solution, in contact with the skin should be washed off immediately, using water freely. Normal precautions for acid solutions shall be followed.

[1] All mechanical operations such as bending, cutting, brazing and drilling shall be completed prior to cleaning.
[2] Although inorganic contamination contains minute metallic or abrasive particles, it will be assumed here that they have been removed with the removal of the organic contamination previously discussed.

(e) **RINSING.**–The waveguide section or piece shall be thoroughly rinsed following both the cleansing and deoxidizing baths.[1] The rinse shall be by immersion in continuously running water or by positive spray which flushes the waveguide on all surfaces, inside and outside. The water used shall be potable, of good purity, and having less than 5 parts per million chloride content.

If the immersion type rinse is to be used, a steel tank lined with polyethylene or a polyethylene container is required.

(f) **CONCLUSION OF CLEANING.**–The aluminum waveguide at this stage is ready for the chemical process or any mechanical operation requiring a clean, oxide free surface. If a chemical film is to be placed on the aluminum at this time, the piece may be placed in the chromate conversion tank immediately after rinsing. If mechanical operations are necessary prior to the chromate conversion, the parts shall first be dried at a temperature not to exceed 110° F.

Following any mechanical operation, the waveguide part or section shall be recleaned prior to the chromate conversion or painting process.

(2) **CHROMATE CONVERSION FILM.**–Aluminum waveguides and waveguide fittings, after fabrication and prior to installation, shall be coated with a Type II, Grade C, Class 3, chemical film as specified in MIL-C-5541. The Alodine 600 Process, Iridite 14 Process, or equal[2] shall be used.

Prior to the application of the film, the waveguide or its fitting, piece, or part shall be cleaned in accordance with paragraph 5-14e(1). At all times throughout the process, the section, piece, or part shall be carefully handled. Mechanical damage or contamination from uncovered hands or soiled gloves shall be avoided. Soiled parts shall be recleaned with either organic or inorganic solvent, or both, as required. Damaged areas from which the coating has been removed shall be repaired, recleaned, and recoated.

The manufacturer's instructions for the particular process shall be studied and adhered to exactly. If doubt arises as to any phase of the process, a representative of the company which supplied the chemicals shall be consulted.

(3) **PROTECTION BY PAINTING.**–

(a) **SURFACE PREPARATION.**–The surfaces to be painted shall be completely free of rust, mill scale, oil, grease, oxides, paint, and other surface contaminants. The coating of paint shall be applied immediately after cleaning. The waveguide piece or part shall be cleaned by the methods stated in paragraph 5-14e(1).

(b) **INTERIOR SURFACES.**–Waveguides constructed of any metal other than aluminum alloy shall have the interior surfaces protected against corrosion by the application of a thin coating of zinc chromate primer, TT-P-645, Formula No. 84/47. The coat of primer shall be applied using the equipment and procedure described in paragraph (c) following. The interior surfaces of aluminum waveguides shall be coated with a chemical film as described in paragraph 5-14e(2) and shall not be painted.

(c) **EXTERIOR SURFACES – BEFORE INSTALLATION.**–The exterior surfaces of all waveguides, including aluminum alloy waveguides, shall be painted before being installed. The painting shall consist of a pretreatment primer followed by a zinc chromate primer. These primers shall be applied as follows.

1. **Pretreatment primer.**–After the waveguide has been cleaned (paragraph 5-14e(1)) and application of the interior chemical film (paragraph 5-14e(2)) or zinc chromate primer (paragraph 5-14e(3) (b)) has been completed, one coat of pretreatment primer, MIL-P-15328, Formula No. 117, shall be applied to the external surfaces of the waveguide. The pretreatment primer shall be mixed and applied in accordance with the "Instruction for Use" which forms a part of the label on the container.[3] Faying surfaces shall not be painted.

[1] A thorough rinsing is essential, since the chemicals used in the cleansing and deoxidizing baths are detrimental to the chemical film which is to follow.
[2] Equivalent processes require specific approval by the Naval Ship System Command.
[3] Pretreatment primer contains an acid component as an activator and must be used exactly as directed.

2. **ZINC CHROMATE PRIMER.**–After the pretreatment primer has dried (15 to 30 minutes), one coat of zinc chromate primer, TT-P-645, Formula 84/47, shall be applied, preferably within 24 hours. Standard practices for painting shall be followed. Faying surfaces shall not be painted.

(d) **EXTERIOR SURFACES – AFTER INSTALLATION.**–The exterior surfaces of all waveguides and fittings shall be painted after installation. The treatment depends upon whether or not the waveguide installation is exposed to weather [1] and shall be as follows:

1. **WAVEGUIDES EXPOSED TO WEATHER.**–The exterior surfaces of all waveguides installed exposed to weather shall, after installation, receive a second coat of zinc chromate primer, TT-P-645, Formula 84/47, followed by two coats of finish paint to match surrounding colors.

2. **WAVEGUIDES NOT EXPOSED TO WEATHER.**–The exterior surfaces of waveguides which are installed inside and not exposed to weather shall, after installation, receive two coats of finish paint to match surrounding colors.

(4) **PROCEDURE FOR PAINTING INTERIOR OF WAVEGUIDE.**

(a) **EQUIPMENT FABRICATION.**–Fabricate two cover plates to fit the ends of the waveguide section to be painted. One of the cover plates is to be equipped with a drain, drilled and tapped as shown in Figure 14-1. The drain hole diameter for the larger waveguide sizes, 6.5 inches by 3.25 inches, should be approximately 1/8 inch; waveguide dimensions of 4.3 inches by 2.15 inches should have approximately a 1/16 inch drain hole; waveguides 2.8 inches by 1.4 inches and smaller should have a drain hole of approximately 1/32 inch. The diameter of the drain hole is determined by the air pressure available (see paragraph 5-14e(4) (c)). The other cover plate is equipped with a pressure gauge and an appropriate air hose fitting, as shown in Figure 14-1. Install the flange with the drain hole onto one end of the waveguide section tight enough to prevent paint leakage.

(b) **PAINT APPLICATION.**–Suspend the waveguide section in a position so that the drain hole end is downward. Pour the zinc chromate, thinned to a good flowing consistency, into the upper end of the waveguide piece being painted. The consistency of the zinc chromate shall be such that a smooth even coat will be obtained with a maximum thickness of 1 mil (0.001 inch). Manipulate the guide section so that the liquid flows to the lower end.[2] When all the air has escaped from the lower end of the section, close the drain hole and completely fill the guide section with zinc chromate. To insure a smooth, even coat, it may be necessary to apply several coats, the total thickness of which shall not exceed 1 mil.

(c) **PRESSURIZING.**–Install the pressure gauge cover plate on the upper end of the guide section. Connect the air supply hose. Open the drain hole in the lower cover plate and apply air pressure to the upper cover plate, sufficient to allow the guide section to drain at a rate of 2 to 6 inches per minute. The amount of air pressure required to drain the guide will depend on the diameter of the drain hole, the configuration of the section being painted, and upon the consistency of the zinc chromate.

(d) **DRAINING.**–Draining will be an obvious procedure for the straight sections or simple bends, but will be more complicated for the complexly formed sections. Complexly formed sections shall be moved into various positions to assure that the zinc chromate drains from all the bends.

(e) **DRYING.**–When the guide section is completely drained, shut off the air pressure and remove the bottom cover plate. Apply sufficient air pressure at the upper cover plate to maintain a gentle flow of air completely through the guide section for a minimum of 30 minutes.

(f) **FAYING SURFACES.**–Faying or joining surfaces of waveguide sections or couplings shall not be painted.

[1] Any and all waveguide installations which are outside the ship hull or superstructure shall be considered exposed to weather.

[2] Complexly formal sections shall be moved to various positions to assure that the liquid flows to the lower end.

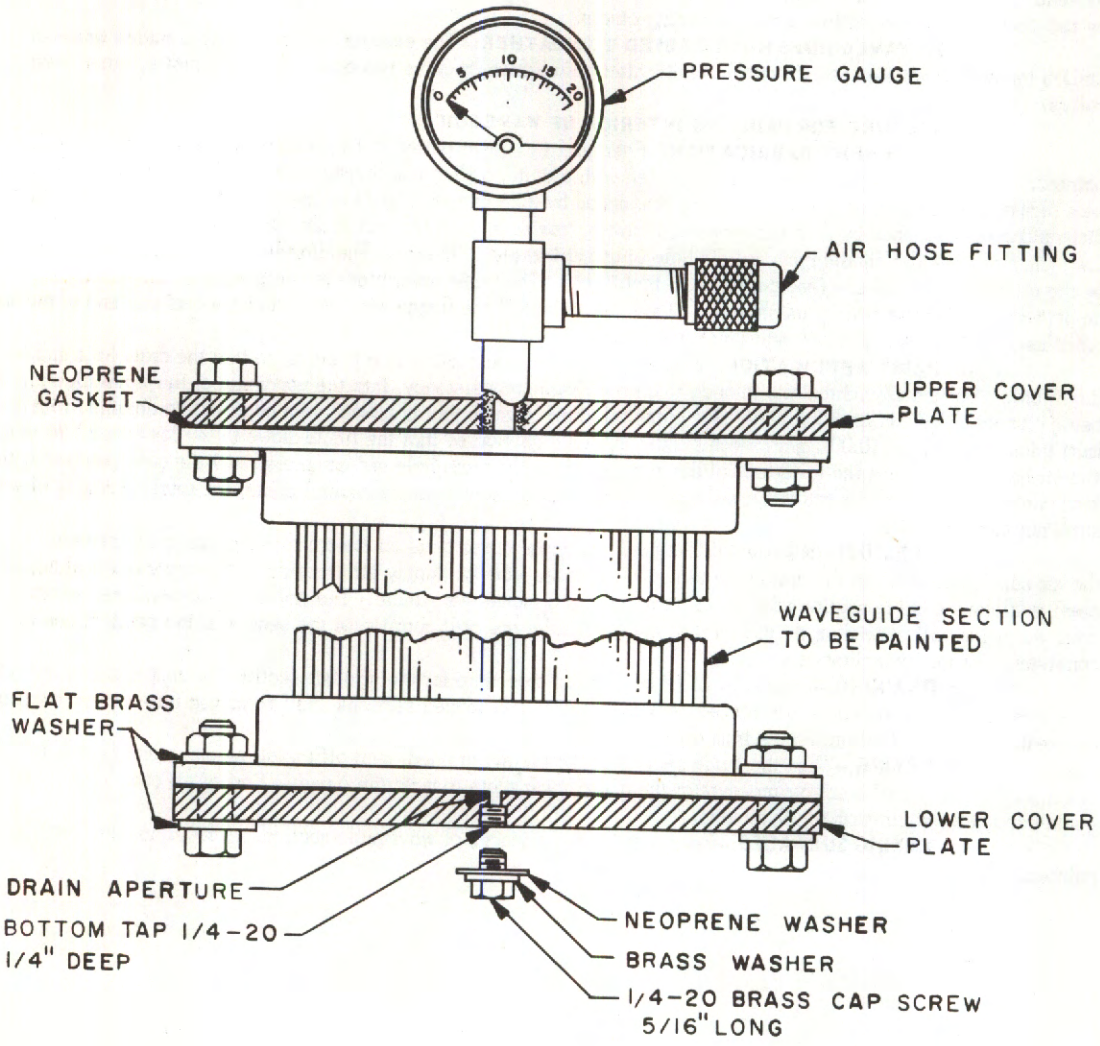

Figure 14–1. Device for Painting Interior of Waveguide

Table of Contents

Paragraph		Page
5-15	Waveguide Installation	5-15-1
	a. Purpose	5-15-1
	b. Scope	5-15-1
	c. Acquisition and Handling	5-15-1
	d. Fabrication	5-15-2
	e. Installation	5-15-7
	f. Transmission Line Composition	5-15-13
	g. Purging and Pressurizing	5-15-13
	h. Electrical Requirements and Tests	5-15-13

List of Illustrations

Figure		Page
15-1	Waveguide and Flange Assembly – Sleeve Design	5-15-4
15-2	Silver Soldering Waveguide and Flange – Sleeve Design	5-15-4
15-3	Waveguide and Flange Assembly – Butt Design	5-15-5
15-4	Silver Soldering Waveguide and Flange – Butt Design	5-15-6
15-5	Waveguide Antenna Support	5-15-10
15-6	Bulkhead or Deck Waveguide Sleeve	5-15-11
15-7	Method of Installing Waveguide thru Bulkhead or Deck	5-15-11
15-8	Waveguide Installed thru Bulkhead or Deck	5-15-12
15-9	Method of Passing Brass Waveguide thru Bulkhead or Deck	5-15-12
15-10	Illustrative Installation	5-15-14

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TABLE OF CONTENTS

Paragraph		Page
5-8	Connector Adapters	5-8-1
	a. Scope	5-8-1
	b. Purpose	5-8-1
	c. Nomenclature	5-8-1
	d. Listings	5-8-1
	e. Cross Section Views	5-8-1
5-9	Semirigid Coaxial Cables	5-9-i
	a. Scope	5-9-ii
	b. Cable Elements	5-9-ii
	c. Cable Qualities	5-9-1
	d. Cable Data Sheets	5-9-3
5-10	Semirigid Coaxial Cable Installation	5-10-1
	a. Purpose	5-10-1
	b. Scope	5-10-1
	c. Preparation for Unreeling	5-10-1
	d. Unreeling the Cable	5-10-2
	e. Cable Cutting	5-10-5
	f. Cable Bending (Forming)	5-10-14
	g. Installation	5-10-17
	h. Purging and Pressurizing	5-10-20
	i. Cable-Connector Assembly Instructions	5-10-21
	j. Electrical Requirements and Tests	5-10-
5-11	Rigid Coaxial Cables	5-11-1
	a. Scope	5-11-1
	b. Cable Elements	5-11-1
	c. Physical Qualities	5-11-1
	d. Electrical Qualities	5-11-3
	e. Cable Data Sheet	5-11-8
5-12	Rigid Coaxial Cable Installation	5-12-1
	a. Purpose	5-12-1
	b. Scope	5-12-1
	c. Pre-Installation	5-12-1
	d. Installation	5-12-2
	e. Transmission Line Composition	5-12-11
	f. Purging and Pressurizing	5-12-13
	g. Electrical Requirements and Test	5-12-13
5-13	Waveguide: Fittings, Assemblies, and Accessories	5-13-1
	a. Introduction	5-13-1
	b. Purpose	5-13-1
	c. Scope	5-13-1
	d. Waveguide	5-13-1
	e. Fittings	5-13-118
	f. Assemblies	5-13-134
	g. Accessories	5-13-162
5-14	Waveguide Protection	5-14-1
	a. Introduction	5-14-1
	b. Scope	5-14-1
	c. General Preservative Requirements	5-14-1
	d. Mechanical Protection	5-14-1
	e. Protection of Aluminum Wavequide By Chemical Process	5-14-2
	f. Protection by Painting	5-14-7
5-15	Waveguide Installation	5-15-1
	a. Purpose	5-15-1
	b. Scope	5-15-1
	c. Aquisition and Handling	5-15-1
	d. Fabrication	5-15-2
	e. Installation	5-15-7
	f. Transmission Line Composition	5-15-13
	g. Purging and Pressurizing	5-15-13
	h. Electrical Requirements and Tests	5-15-13

INSTALLATION STANDARDS

TABLE OF CONTENTS

Paragraph		Page
5-16	Antenna Trunks	5-16-1
	a. Antenna Trunk Sizes	5-16-1
	b. Material Specifications	5-16-1
	c. Insulators	5-16-4
	d. Antenna Switches	5-16-4
	e. Installation	5-16-12
	SECTION 6 - ANTENNAS AND DETECTION DEVICES	
6-1	Introduction	6-1-1
	a. General Consideration	6-1-1
	b. Purpose	6-1-1
	c. Scope	6-1-1
	d. Reference Documents	6-1-1
6-2	Antennas	6-2-1
	a. General	6-2-1
	b. Shipboard Antenna Orientation	6-2-1
6-3	Wire Antennas	6-3-1
	a. Materials Used	6-3-1
	b. Antenna Fabrication	6-3-4
6-4	Whip Antennas	6-4-1
	a. General	6-4-1
	b. Whip Assembly	6-4-1
	c. Whip Mounting	6-4-1
6-5	Single and Multi-Element Arrays	6-5-1
	a. General	6-5-1
	b. Assembling the Array	6-5-1
	c. Mounting the Array	6-5-1
6-6	Directional Antennas	6-6-1
	a. General Considerations	6-6-1
	b. Installation Techniques	6-6-1
	SECTION 7 - ELECTROMECHANICAL MECHANISMS	
7-1	(To Be Supplied)	
	SECTION 8 - SOLDERING, BRAZING, AND WELDING	
8-1	General	8-1-1
	a. Safety	8-1-1
	b. Welder Qualifications	8-1-1
	c. Preparation of Parts	8-1-1
	d. Post Heat Treatment	8-1-1
	e. Inspection of Finished Joints	8-1-1
	f. Cleaning Finished Joints	8-1-2
8-2	Soft Soldering	8-2-1
	a. General	8-2-1
	b. Soldering Equipment	8-2-1
	c. Types of Soldering	8-2-3
	d. Solders	8-2-6
	e. Fluxes	8-2-6
	f. Mechanical Connections	8-2-7
	g. Soldering to Special Surfaces	8-2-8

PUBLICATIONS PACKAGE FOR CHANGE 4 TO NAVSHIPS 900,000.101 (0967-000-0114)

CONTENTS: Publication material consisting of new and revised pages with instructions for accomplishing Change 4.

PURPOSE: The purpose of this change is to add new material which was not available when the handbook was initially published.

TIME REQUIRED: Approximately 5 minutes.

CHANGE 4 TO
NAVSHIPS 900,000.101
(0967-000-0114)

January 1966

INSTRUCTION SHEET

This sheet provides instructions for inserting Change 4 to the Installation Standards Handbook, NAVSHIPS 900,000.101. The purpose of this change is to add new material (Subsection 5-15) which was not available when the handbook was initially published.

It should take no more than 5 minutes to complete this change, if the following instructions are followed:

1. FRONT MATTER:

   Remove Title Page and page ii, CHANGE 3, and insert Title Page and page ii, CHANGE 4.
   Remove pages xi and xiii, CHANGE 3, and insert pages xi, CHANGE 4 and xii, CHANGE 3.

2. SECTION 5. Radio Frequency Transmission Lines

   Between pages 5-14-10 and 5-16-1, insert the following CHANGE 4 pages.

   5-15-i and 5-15-1 through 5-15-4.

3. Insert the User Activity Technical Manual Comment Sheet, NAVSHIPS 4914, as the last page of the handbook.

4. Record the insertion of this change on the RECORD OF CORRECTIONS MADE page.

(b) **Filling.** –Waveguide which is to be bent, twisted, or formed will retain its original dimensions better if it is filled (packed) with a solid material such as: bending alloy, sand, or thin metallic shims. The use of these fillers is standard procedure at fabrication shops.

(c) **Cold Bending or Twisting.** –Cold forming is done with the waveguide at shop temperature. A bending machine, hydraulic push press, portable pipe bending equipment, or a block and tackle may be used.

(d) **Hot Bends and Twists.** –Heating the area of waveguide which is to be formed facilitates bending or twisting. Sand is usually used as filler and the heat must be applied evenly over the area. Wrinkles which occur during the forming must be removed. After heating and working the waveguide should be returned to its original temper.

(4) **Cutting.** –Waveguides may be cut by a hand hacksaw or a powered metal cutting saw. A fine tooth blade (10 to 14 teeth/inch) is satisfactory for most soft metal waveguides. Stainless steel guide (14 AMC) should be cut with a blade having 20 to 24 teeth per inch. The cut should be square and at right angles to the length of the guide and edges should be filed smooth to produce a square end. All filings, chips, and other bits of metal must be removed from the guide.

(5) **Attaching Flanges.** –Flanges may either be torch brazed or silver soldered to the waveguide section. With the exception of aluminum waveguide, flanges are brazed with silver base alloy, MIL-C-15395, Grades IV or VI. Aluminum waveguide flanges are brazed with aluminum silicon alloy. Brazing and silver soldering should be done as described in Section 8 of this Handbook. Special attention should be given to paragraphs 8-3.e(1)(a) and 8-3.e(1)(b). The following general precautions should be observed:

1. The surfaces to be joined must be thoroughly cleaned with fine emery paper or crocus cloth. Make sure that all traces of emery are removed.
2. The end of the guide must be square.
3. The flange may be either contact or choke and cover type.

Contact type flanges require greater care than the choke and cover type. Make sure the correct mating flange is used. A contact flange mates only with a contact flange and it is not to be used as a cover flange for a choke and cover coupling.

See Subsection 5-13 for correct mating flanges.

(a) **Contact Flanges, Sleeve Design.** –Slide the flange over the waveguide, allowing not more than 0.01 inch of the guide to extend beyond the flat of the flange. See figure 15-1. If necessary, use clamps to hold the guide and flange in place. The flat of the flange must be at right angles to the length of the waveguide. Apply silver solder flux. Apply heat to the flat surface of the flange as shown in figure 15-2. Apply silver solder as shown and allow the liquid solder to flow thoroughly and evenly between the guide and the flange.

CAUTION

Silver solder flux is poisonous.
Avoid inhaling the fumes.

Insufficient heat will result in a weak joint and overheating will burn away the flux, warp flange, and cause oxidation. If there are gas escape vents in the wide side of the flange, fill them with silver solder. Remove all traces of flux. Grind or file flat of flange and guide end to a smooth surface (approximately 63 RMS finish) at right angles to guide long dimension.

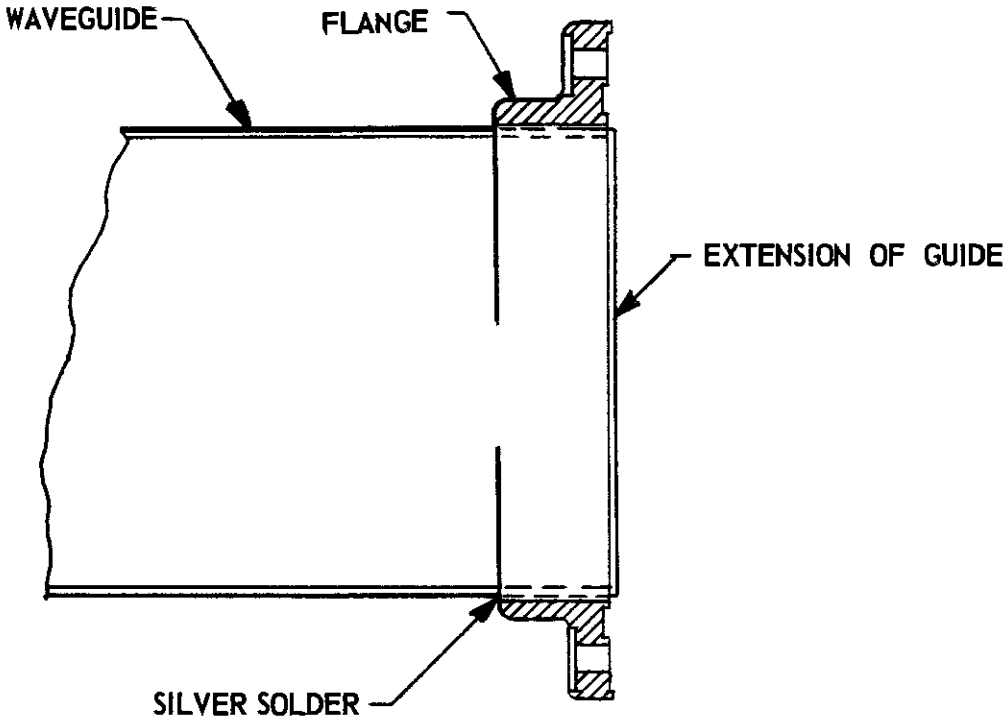


Figure 15-1. Waveguide and Flange Assembly – Sleeve Design

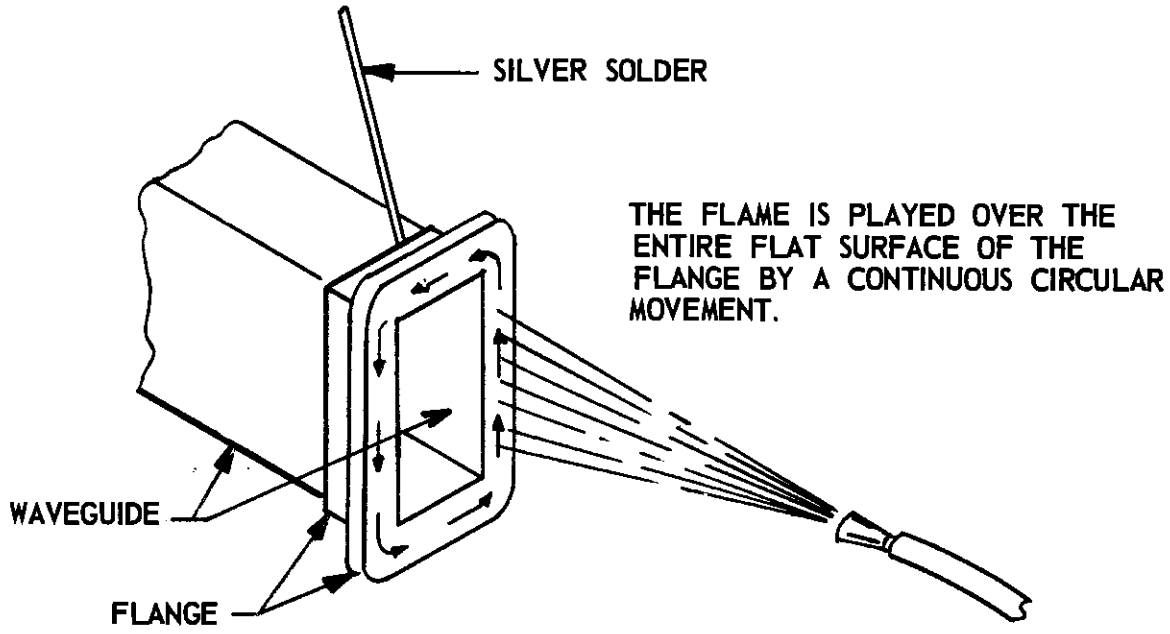


Figure 15-2. Silver Soldering Waveguide and Flange – Sleeve Design

(b) **Contact Flange, Butt Design.** –Slide the flange over the waveguide until they butt together. See figure 15.3. Make sure that the flange surface is at right angles to the long dimension of the guide. If necessary, use clamps to hold the guide and flange in place. Apply silver solder flux. Apply heat to the flat surface of the flange as shown in figure 15-4. Apply silver solder as shown and allow the liquid solder to flow thoroughly and evenly between the guide and the flange.

Insufficient heat will result in a weak joint. Overheating will burn away the flux, warp flange, and cause oxidation. Remove all traces of flux. Interior but between guide and flange must be smooth and continuous.

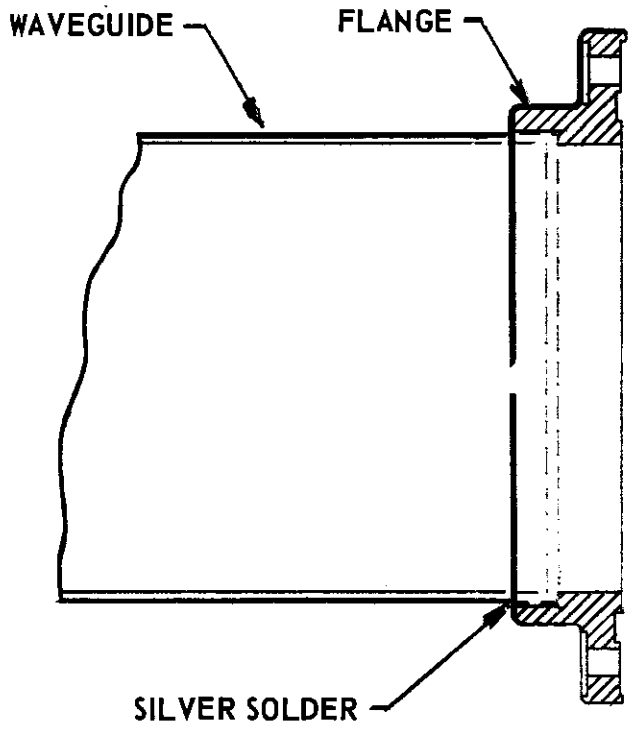


Figure 15-3. Waveguide and Flange Assembly –Butt Design

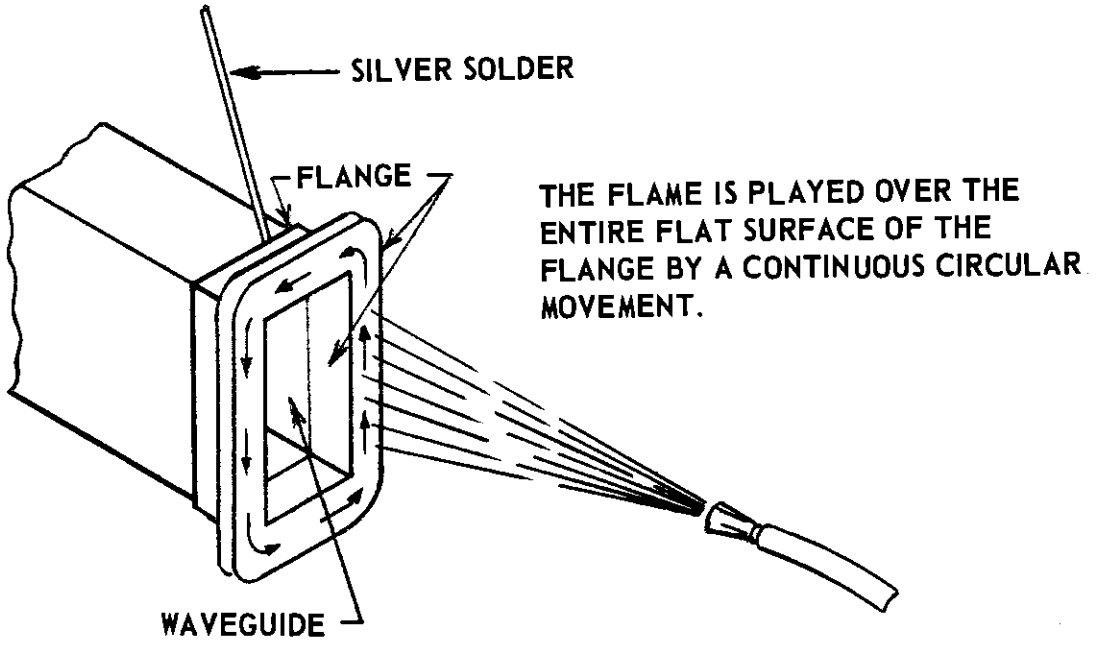


Figure 15-4. Silver Soldering Waveguide and Flange – Butt Design

(c) **Choke and Cover Flanges.** –Choke and cover flanges are assembled onto the waveguide in a manner similar to contact flanges. The right angle alignment of the broad surface of the flange to the long dimension of the guide is not critical, but there should be a uniform space clearance between the choke flange and its mating cover flange.

(6) **Smoothing.** –All puckers, wrinkles, or dents in the waveguide resulting from its fabrication must be removed. These are usually removed in the fabrication shop where the appropriate equipment is available. The general procedure is to fill the guide with air or water under a pressure of approximately 28 psi. The area to be smoothed is heated and the dent or wrinkle is removed by use of a flatter.

(7) **Squaring.** –The final fabrication check is to assure that the end of each section which is fitted with a flange is perfectly square and at right angles to the long dimension of the guide. This is important for contact type flanges which must mate squarely in order to function properly. Choke and cover type flanges must have the required uniform clearance between them for best operating results.

(8) **Cleaning and Preservation.** –Cleaning and preservation of waveguide is thoroughly covered in Subsection 5-14.

(a) **Aluminum Waveguide.** –The chromate conversion finish of aluminum guide should be a uniform golden yellow color. If the finish has been marred or in any way defaced, it should be removed and refinished in accordance with the instructions contained in subsection 5-14. The exterior should then be painted prior to installation.

(b) **Brass Waveguide.** –Brass waveguide may lose its bright finish as the result of storage, handling, or fabrication. The bright finish must be restored prior to painting and installation. See subsection 5-14. Finish may be restored by immersing the guide in a "bright dip". A common bright dip for brass is composed of:

Sulphuric acid	2 gallons
Nitric acid	1 gallon
Water	1 to 2 quarts
Hydrochloric acid	1/2 fluid ounce

Table of Contents

Paragraph		Page
5-15	Waveguide Installation	
	a. Purpose	
	b. Scope	
	c. Acquisition and Handling	
	d. Fabrication	
	e. Installation	
	f. Transmission Line Composition	
	g. Purging and Pressurizing	
	h. Electrical Requirements and Tests	

List of Illustrations

Figure		Page
15-1	Waveguide and Flange Assembly – Sleeve Design	
15-2	Silver Soldering Waveguide and Flange – Sleeve Design	
15-3	Waveguide and Flange Assembly – Butt Design	
15-4	Silver Soldering Waveguide and Flange – Butt Design	
15-5	Waveguide Antenna Support	
15-6	Bulkhead or Deck Waveguide Sleeve	
15-7	Method of Installing Waveguide thru Bulkhead or Deck	
15-8	Waveguide Installed thru Bulkhead or Deck	
15-9	Method of Passing Bross Waveguide thru Bulkhead or Deck	
15-10	Illustrative Installation	

5-15. WAVEGUIDE INSTALLATION. –

A radio frequency transmission line which is pieced together using waveguide sections, fittings, assemblies, and accessories is know as a waveguide transmission line. Most waveguide is rigid and expands or contracts with temperature changes. Provision must be made for variations in length resulting from this expansion and contraction. The installation of waveguide sections and fittings into a waveguide transmission line requires care and precision. This includes physical care for the waveguide's metal tubes which will not perform their function properly if dented or deformed in any way. Personal care must be exercised to assure that nothing is inadvertently left within the assembled system. To produce the best installation, the installer should study the manufacturer's instructions on the care and handling of waveguide. Recommended procedures should be followed as closely as possible.

a. PURPOSE. – The purpose of this subsection is to acquaint the installer with prescribed procedures for handling, installing, and testing the waveguide sections, fittings, assemblies, and accessories which are listed and described in subsection 5-13.

b. SCOPE. –This subsection discuss waveguide handling and care starting with receipt of the shipping container, through uncrating, identification, storage, on-the-job fabrication, locating in position, purging and pressurizing procedures, and electrical requirements and tests.

c. ACQUISITION AND HANDLING.

(1) **Receiving Material.** –Waveguide sections, fittings, assemblies, or accessories will be received in one of the following package types:

(a) Level A packing – Overseas type package.

(b) Level B packing – Domestic type package.

(c) Level C packing – Industrial or manufacturer type package.

The type of packing will depend upon the requirements of the contract or procurement specification.

Within the crate, waveguide lengths will be kept separate by wooden collar blocks, spaced not more than 24 inches apart, and secured to the crate to prevent movement. Each length will be sealed at the end to prevent the entrance of water vapor. Unless the weight of an individual length of waveguide exceeds 200 pounds, the gross weight of the crate will be less than 200 pounds. Skids should be provided for gross weights exceeding 200 pounds.

Smaller pieces, fittings, and assemblies will be individually protected and unit packaged. Packaging material in direct contact with metallic surfaces will be neutral with respect to the metal.

Boxes should be examined for breaks as soon as possible after their receipt. A break in the box could be an indication that the contents may be damaged. If the boxes are in good condition, they should be left unpacked until they are to be used.

(2) **Storing.** –Whether left crated or uncrated, waveguide sections and components should be stored in a cool, dry location. Cool, dry air reduces oxidation, corrosion and discoloration to a minimum. Unpocked sections shall be stored in a horizontal position and shall be adequately supported to prevent buckling and bowing. While being stowed they should not be dropped into position but should be carefully set in place. The ends of each stored section, fitting, or part shall be covered with heavy paper caps or lintless cloth to prevent the entrance of dust or other foreign matter. Fittings and parts, such as flange faces and coupling edges, shall be protected to prevent damage.

(3) **Unpacking.** –The waveguide box should be placed so that it is resting solidly in a horizontal position. Box cover nails should be removed with a nail puller. Do not pry the cover off the box because this may dent some of the waveguide sections. Carefully remove collar blocks to avoid damaging the sections. Leave the end seals in place as long as possible for protection. The protective seal from one of the ends may be removed in order to check a waveguide section. After checking, replace the end seal until the section is to be installed. This same protective care also applies to fittings, assemblies, and accessories. Rubber O-rings and other small parts and pieces are packed separately.

Prespiration and acid on the skin of the hands is electrically detrimental. Conducting surfaces should not be touched with the bare hands. Clean cotton gloves should be worn at all times when unpacking waveguides and components, or whenever it is necessary to handle a conducting surface.

(4) **Identification.** –Identification marks are placed directly on waveguide sections and associated components. The markings should be easily discernable and clearly identifiable. If doubt exists, or the marking is not clear, identification questions should be referred to the contractor or manufacturer. The installer should not alter or deface identification markings. The following information pertains to identification markings for various items:

(a) Straight Lengths. –Each length of finished waveguide will be marked with the type designation and the manufacturer's code. The markings are applied with water-soluble ink or paint at 6-inch intervals along the length of the guide. The manufacturer's name or trademark may also be marked on each length.

(b) Fittings. –Flanges are marked with the type designation and the manufacturer's code. Numerals will be marked in depressed or raised characters.

(c) Assemblies. –Assemblies are marked with the type designation and the manufacturer's code. Markings will be either decalcomania, permanent ink or paint, metal stamping, or identification plate. On castings, the characters may be raised or depressed. Depressed characters are filled with permanent white paint.

(d) Accessories. –Acessories are marked with the type designation and manufacturer's code symbol. Adapter end plates are marked with the frequency band and VSWR of the particular adapter when required by specification.

All markings are designed to withstand normal wear and should be legible for the life of the unit.

d. FABRICATION. –The waveguide radio frequency transmission line may have been completely designed and its various pieces and components fabricated prior to delivery to the assembly and installation yard. However, not all jobs are predesigned or prefabricated. Hence, waveguide fabrication may fall into any of the following categories: Prior to receipt at the installation yard, the transmission line has been completely designed and the waveguide and parts fabricated; the transmission line designed but waveguide and parts only partially fabricated; the transmission line partially designed and waveguide partially fabricated; neither transmission line designed nor waveguide or parts fabricated.

In the first two categories, system design is provided and may not be changed without approval of the Bureau of of Ships and the issuance of a modification order. In the latter categories, some or all design and fabrication is to be be accomplished at the yard. Yard fabrication is normally done in the appropriate yard shop and not at the installation site aboard ship. In some cases, however, fabrication must be accomplished at the installation site. If the line has not been predesigned, it will be necessary for the yard to provide partial or complete design.

(1) **Design.** –The design of a radio frequency transmission line should be attempted only by qualified personnel. The following factors are basic to r-f transmission line design:

(a) Transmission line length (generally referred to as the run) should be kept as short as possible.

(b) Avoid horizontal runs. One way is to locate the transmitter close to the base of the mast.

(c) Avoid low points in the line where moisture can gather. If a low point must be accepted, place a small drain hole at the lowest point. If the line is to be pressurized, it will be necessary to fill this hole with a plug. The plug must not extend within the waveguide. The interior surface of the waveguide must be kept smooth.

(d) Use the least possible number of couplings to avoid electrical losses.

(e) Use the least possible number of bends and twists.

(f) Bends should have the largest radius possible consistent with the wavelength to be used. In no case must bend radii be less than that recommended. Prefabricated bends use the minimum allowable bend radius. Bends formed from straight sections of guide with longer bend radii are preferred.

(2) **Template.** –When the design and location of the transmission line has been determined, the next step is to translate this information onto a template. The template is used to provide the configuration of the waveguide transmission line. It should provide the fabrication shop with accurate information for the shape and angle of all bends and twists, as well as bulkhead connections, flange holes, couplings, and the length of the line.

The template may be made of fairly heavy mild steel wire, wood, or plastic. Any material which will provide the shop with the configuration they need to produce the transmission line will be satisfactory. The material must be readily formed to provide ease of construction and it must be able to retain its shape. Steel wire will permit smooth bends and curves which cannot be achieved with wood. On the other hand, wood templates can be made to actual waveguide dimensions which would be difficult with steel wire. The template should be supplemented with notes and sketches as required.

When making templates and constructing the transmission line, as well as the actual installation, it is usually better to start at the antenna end and work down the mast to the deck and thence to the transmitter room.

(3) **Forming.** –Waveguide sections are usually annealled, filled, formed (bent or twisted), unfilled, squared, and cleaned in order to be formed into the configuration of the template. These processes are functions of the fabrication shop and usually are not done by the installer. The inner walls of waveguide transmission line must be smooth and continuous. Consequently, only the very best shop practices should be employed. A few general comments on each of these operations are provided as an aid to the installer when he gets the formed guide from the shop.

(a) **Annealling.** –Annealling is usually required if the guide is to be formed. The guide is also usually annealled before it is filled. After annealling the guide should be allowed to cool to shop temperature. Annealled guide is soft and will distort easily. Warped, formed aluminum guide has been cooled too quickly. Stainless steel guide (14 AMC) should not be annealled because excessive heat blisters the silver inlay and may ruin the stainless properties of the steel. Hence, stainless steel waveguide should not be formed, bent, or twisted. To prevent the oxidation which is usually caused by heating, the shop may fill the guide with carbon dioxide (CO_2) gas. Distortion of a guide, which was annealled while filled with CO_2, may have been caused by a plug which fit too tightly.

The bath and dipping operation are carried out at room temperature.

It should be pointed out that this dip may not suffice for all conditions. The composition of the brass will vary as will the chemical composition of the water used. If unsatisfactory results are obtained, it may be advisable to refer the matter to the manufacturer of the brass waveguide, or to the chemical company which supplied the chemicals.

When the bright finish has been restored, the guide should be painted internally and externally as described in subsection 5-14.

(c) **Stainless Steel Waveguide.** –Stainless steel (CRES) guide should not be cleaned with acid. A mild degreasing may be necessary before it is painted prior to installation. The removal of organic material, described in paragraph 5-14.e(2)(b)1, will normally suffice. If not, use stronger degreasing.

e. INSTALLATION.

(1) **General.** –The installation may be interior or exterior, or it may be a combination of interior and exterior work, and it may be vertical or horizontal (horizontal runs should be avoided whenever possible). Prior to doing any installation, the job should be thoroughly planned. Go over the entire route and check everything. Route prints are fine, but they may be outdated. Make sure that all hardware is present.

(a) **Requirements.** –Waveguide transmission line should meet the following general requirements:

1. Be kept to a minimum length.
2. Its location should be such that maximum protection is provided against mechanical abuse, battle damage, and heat damage.
3. Be located so as to avoid physical or electrical interference from equipment, cables, or other r-f transmission lines.
4. Be installed in such a manner that it will not be disturbed by the removal of deck plates, gratings, or machinery.
5. Be installed so that electrical mismatch is kept to a minimum.
6. Be installed so as to prevent the entrance of moisture and dirt.
7. Its installation should not impair the airtight or watertight integrity of decks or bulkheads. Penetration of ship's structure shall comply with the structural sections of the ship's specifications.

(b) **Routing.** –The route of a waveguide transmission line is extremely important. Do not assume that that the route proposed on a drawing or blueprint is the best and only one. Go over the route thoroughly, especially before a deck or bulkhead is pierced. It may be possible to propose an alternate route superior to the one originally planned. Perhaps a pipe or duct, whose location is not as critical as the transmission line, can be moved. Choose a transmission line route which is short, direct, and has the least number of bends. The run should not be longer than 100 feet. Waveguide should be placed over, rather than under obstructions. The route should permit access for repairs, servicing, and replacement – especially of fittings and joints. The run should always be pitched toward the equipment to avoid water being trapped within the line. The finished installation shall be electrically and mechanically continuous with a smooth inner surface throughout.

(c) **Vibration.** –Precautions should be taken to prevent the waveguide from being subjected to continuous vibration. Vibration causes metal fatigue that will eventually crack the metal structure of the waveguide.

(d) **Securing (Supporting Straps).** –Waveguide transmission line should be supported every six feet by hangers or roller supports. To secure a waveguide run to a mast, start at the top and work down. Supports shall not cause deformation or damage the waveguide finish. Waveguide supports and their method of installation shall not create galvanic action. Plastisol-dipped hangers may be used to prevent galvanic action and protect waveguides. Waveguides shall not be welded to any part of the ship's structure. For small size waveguide, brazing with silver solder as shown in figure 15-9, is acceptable.

(e) **Temperature (Expansion and Contraction).** –Waveguide can withstand short time operation in the presence of open flames. Contact with any metallic supporting structure will affect the heat dissipation of the guide. Temperature variations can cause the guide to expand or contract one inch for a 75-foot run with a 150 degree (F) change in temperature (–25 to 125 degrees F). Provision must be made for the change in length caused by temperature variations by the use of flexible waveguide sections.

(2) **Fittings.** –Straight sections, preformed bends and mitered corners, assemblies, and accessories are usually equipped with flanges. Most flanges are the choke and cover type for use with low and medium power system. When specified, and for high power systems, contact type flanges will be used.

Hardware is included with flanges attached to waveguide sections. Hardware includes an O-ring gasket (or other type if required) and the nuts, bolts, and lockwashers needed for section assembly.

Assembly is accomplished by joining the flanged ends of two waveguide sections. All parts must be correctly alined. Insert bolts, put lockwashers and nuts in place, and finger tighten the nuts. With a wrench, tighten the side nuts first, then tighten the corner nuts. This procedure tends to keep the coupling flanges in

alinement. A satisfactory assembly is one which makes good electrical contact between the joined flanges, and provides a tight junction at the coupling to permit pressurizing the transmission line.

The detailed assembly instruction provided by the manufacturer contained in the waveguide box should be studied and followed. Cleanliness and the special care required in the handling of conducting surfaces is again emphasized. The instructions contained herein are intended primarily to amplify or clarify the manufacturer's instructions, and secondarily for use in the absence of such instructions. Refer to subsection 5-13 for information on couplings, flanges, and mating flanges.

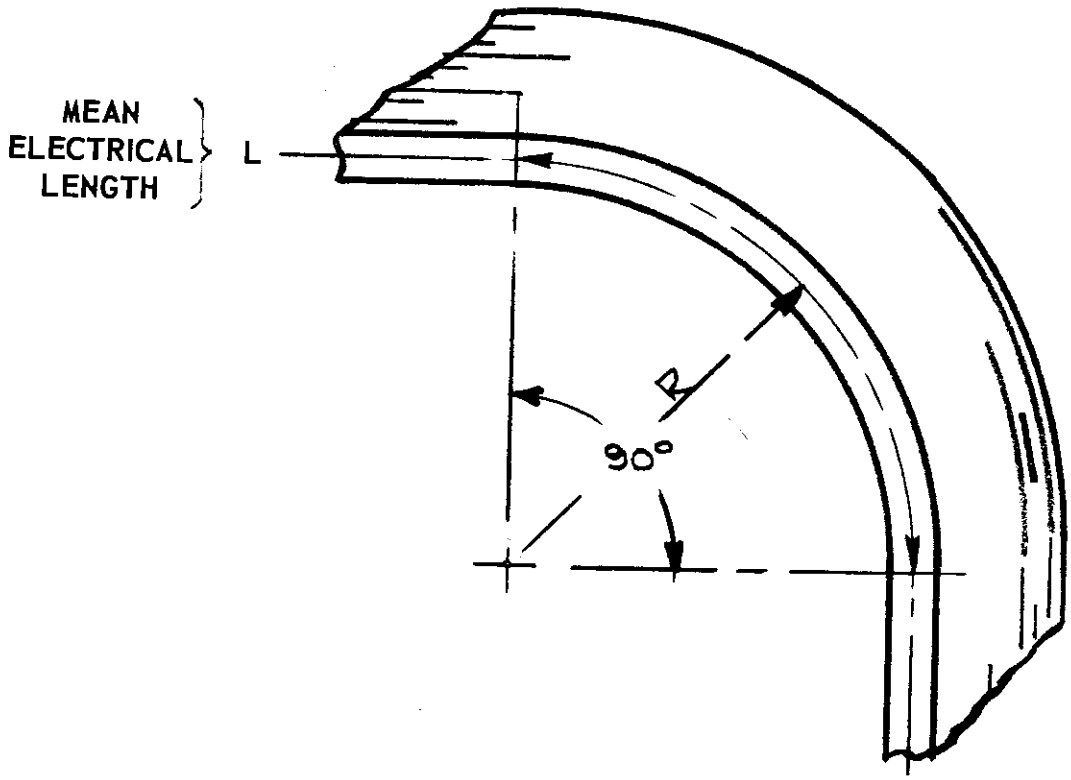
The installation may require that a straight section be cut to length, or that bends be formed from straight sections. It is better to use larger radius formed bends than preformed bends. In these cases, flanges must be installed on the guide as described in paragraph 5-15. d(5).

(3) **Assemblies.** –Assemblies include section of straight guide with attached flanges, flexible sections, curved pieces (bends or mitered corners), twisted section (straight or step twists), and size adapters. Most assemblies are equipped with flanges and they are installed as described in paragraph 5-15. e(2).

(a) **Straight Sections.** –Unless otherwise specified, straight sections will be received in standard 12-foot lengths. See paragraph 5-13. d(1)(b)5. If specified, they may be any length (Table 13-1), flanged at both ends, only one end, or with no flanges.

At the installation site, straight sections are cut to the precise length required, or they may be formed into bends or twists. Flanges must be fitted to both ends of the waveguide. Installation is accomplished as described in paragraph 5-15. e(2).

(b) **Curved Pieces, Bends and Mitered Corners.** –Bends and mitered corners may be preformed or they may be formed from straight sections. If they are preformed and flanged, they are installed in accordance with paragraph 5-15. e(2). General Specifications for Ships of the U. S. Navy states that: "Bends formed from straight sections of waveguide shall be used wherever practicable." And, "Formed bends shall be such that the mean electrical length of the bend is any exact multiple of half-wavelengths at the midfrequency of the equipment with which it will be used." The radius of formed bends shall be greater than the radius of preformed bends. For example: The radius of preformed bends for RG-48/U is 7-1/2 inches. Whereas, bends formed at the yard for RG-48/U must have a radius greater than 7-1/2 inches, and a mean electrical length which is a multiple of half wavelengths at the midfrequency. The RG-48/U TE_{10} mode wavelength range (lowest to highest recommended operating frequency) is from 7.54 to 3.51 inches. The mean wavelength is 5.525 inches and a half wavelength is 2.7625 inches. Any multiple of 2.7625 inches which generates a radius greater than 7.50 inches can be used at the mean electrical length of a formed bend for RG-48/U waveguide.



Circumference of circle with radius R= 4L= $2\pi R$

$$\text{Hence: } R = \frac{4L}{2\pi} = \frac{2L}{\pi} = 0.637L$$

Referring to RG-48/U, and the TE_{10} mode,
Where R> 7.50 inches
L is a multiple of $\lambda/2$
$\lambda = 5.525$ inches
$\lambda/2 = 2.7625$ inches
$R = 0.637L$
Let $L = 4 \times \lambda/2 = 4 \times 2.7625$
Then $R = 0.637 \times 4 \times 2.7625 = 7.06$ inches
Since this value is less than 7.50 inches, it cannot be used.
Based on similar computations,
When: $L = 5 \times \lambda/2 = 13.8125$, $R = 8.8$ inches
$L = 6 \times \lambda/2 = 16.575$, $R = 10.56$ inches
$L = 7 \times \lambda/2 = 19.3375$, $R = 12.32$ inches
etc., hence any of these radii may be used.

Flanges are attached to formed bends as explained in paragraph 5-15.d(5) and the formed assembly is installed in accordance with paragraph 5-15.e(2).

(c) **Twisted Pieces.** –Twisted assemblies may be either preformed or formed. Preformed assemblies are equipped with flanges and they are installed as explained in paragraph 5-15.e(2). Preformed twisted assemblies usually are 90-degree pieces.

Twists other than 90 degrees, where step twists are not desired, are formed in the yard shop. The overall length for 90-degree twists is given in tables 13-23 and 13-24 for various waveguide sizes. After the twist has been formed, flanges are added and the assembly is installed as previously described.

(4) **Accessories.** –Directional couplers are made with flanges and they are installed in the waveguide transmission line as described in paragraph 5-15.e(2). Waveguide-to-coaxial cable adapters are fabricated with a flange at one end which is installed in the usual manner. The coaxial cable end of the adapter is equipped with a coaxial cable connector which must be mated with an appropriate connector of the opposite sex. Details of coaxial cable connectors are contained in subsection 5-2 of this handbook.

(5) **Line Securing Auxiliaries.** –Waveguide sections and components when assembled to produce a radio frequency transmission line are held in place by specially designed hardware, including: fixed hangers, hangers which permit longitudinal movement of the guide, spring suspension hangers, lateral braces, and roller assemblies. Some of these are illustrated and commented upon here. Spring suspension hangers, when used, should be tension adjusted.

Waveguide must not be supported by or from the antenna. The uppermost support for the guide should be immediately below the lowest connection to the antenna assembly as illustrated in figure 15-5.

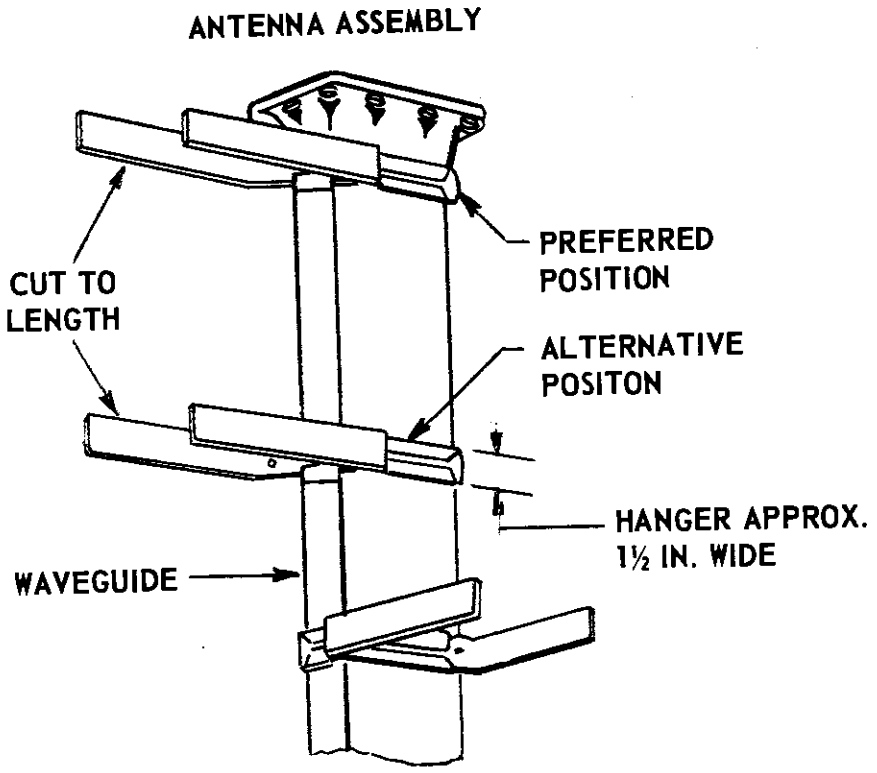


Figure 15-5. Waveguide Antenna Support

Where a waveguide passes through a watertight deck or bulkhead, the fitting must be watertight, otherwise a rectangular hole is all that is necessary. One for watertight installations method is to fabricate a sleeve as shown in fignre 15-6. The sleeve and waveguide are assembled as shown in figures 15-7 and 15-8. The sleeve should be made of the same material as the bulkhead or deck. Insulation between the sleeve and the waveguide should be provided to eliminate electrolysis. Smaller size, brass waveguide can be passed through a bulkhead or deck as shown in figure 15-9.

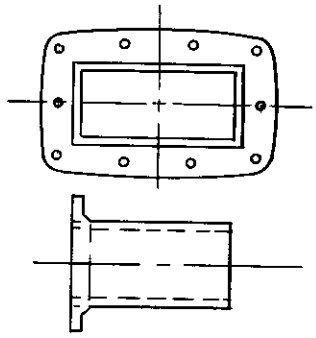


Figure 15-6. Bulkhead or Deck Waveguide Sleeve

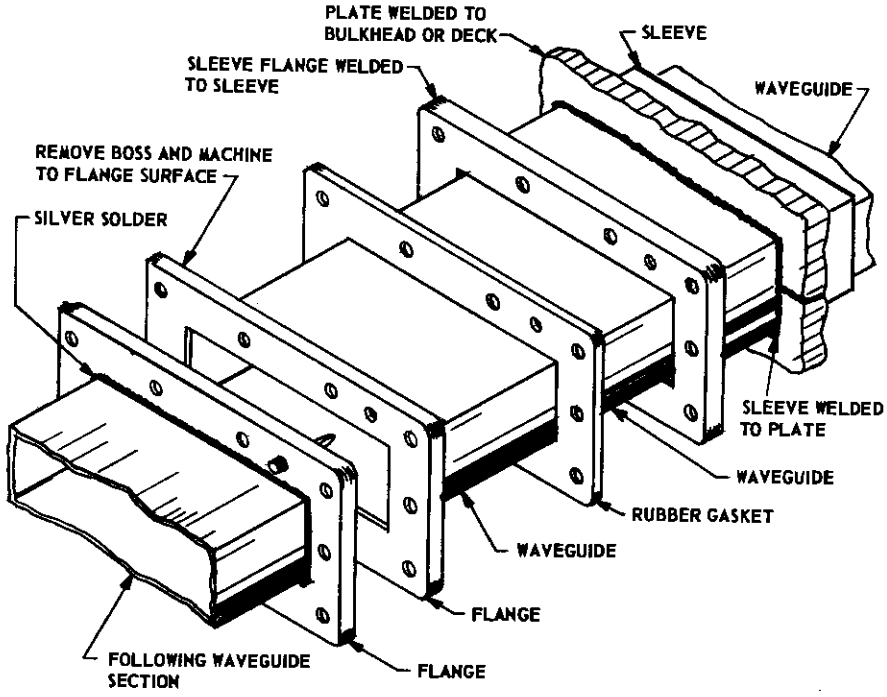


Figure 15-7. Method of Installing Waveguide Thru Bulkhead or Deck

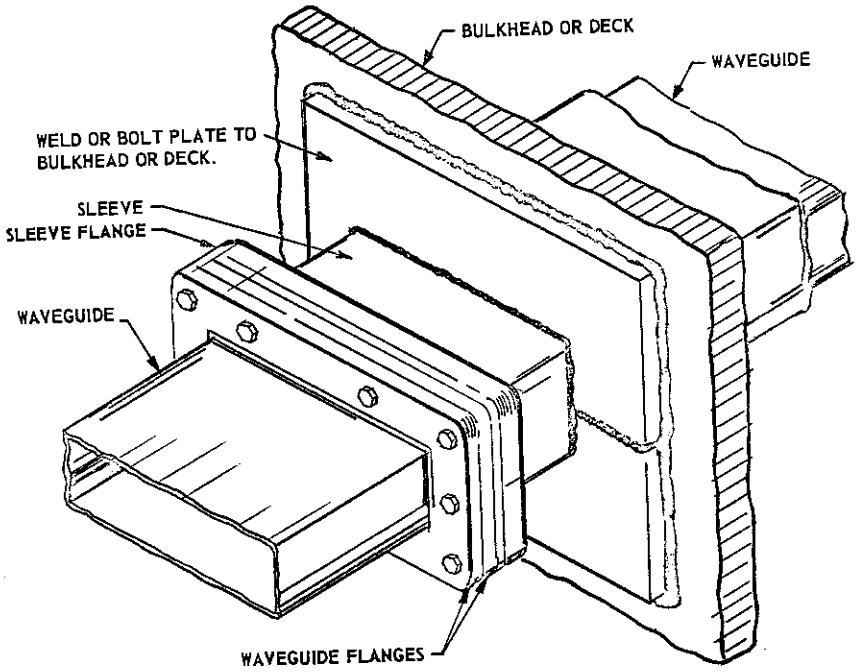


Figure 15-8. Waveguide Installed Thru Bulkhead or Deck

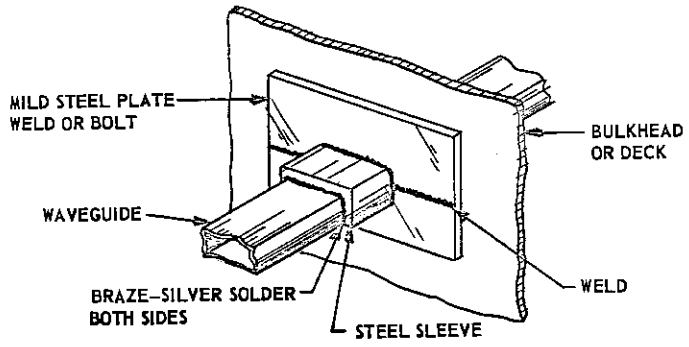


Figure 15-9. Method of Passing Brass Waveguide Thru Bulkhead or Deck

f. TRANSMISSION LINE COMPOSITION.

(1) **General.** –A waveguide transmission line is composed of straight sections and bends or elbows; flexible sections, twisted sections, adapters, switches, couplers, dummy loads and accessories are used as required. Waveguide securing hardware is used to hold the line in place to mast or bulkhead. Flexible sections, or spring hangers, permit expansion and contraction of the line. The line is firmly secured to the mast, bulkhead, or other supporting structure at only a few places. In many installations, only two are necessary. Expansion and contraction takes place between these fixed positions. Securing hardware must be strong to support the line, and still permit freedom of movement to allow for expansion and contraction as temperature changes are encountered.

(2) **Illustrative Installation.** –Keeping the general design in mind, consider an illustrative installation of a waveguide transmission line. This line runs from a transmitter located below deck to an antenna located atop a mast. Refer to figure 15-10. Usually it will be found advantageous to start the installation from the top of the mast at the antenna and work toward the transmitter.

This illustration showws a 90-degree 3-bend coming out of the antenna pedestal. Depending on the space available, there may be a short, straight section with a pressure adapter between the antenna base and the bend. A twist may be required directly following the bend; but in this case, straight sections are used until a predetermined position on the mast is reached. It may be desirable to follow the bend with a flexible section to provide correct alignment and to absorb the effects of expansion and contraction. Flexible waveguide is never installed under tension.

A 90-degree H-bend aligns the waveguide with the mast. A straight section is then attached and is supported by rigid hangars fastened to the most. Only one rigid hanger is shown, but more may be required. If so, they are placed six feet apart with the top hanger placed five feet from the top of the uppermost standard length of waveguide. Rigid hangers prevent movement of the transmission line from affecting the antenna feed line. Straight sections, each the maximum length for the waveguide size, are then added to the transmission line. These are supported by sliding hangers to permit expansion and contraction of the line. The lowest straight section may have to be cut to permit turning the transmission line as desired.

A 90-degree E-bend is installed at the base of the mast where the line is turned into its horizontal path. Lateral braces may have to be installed on each straight section, vertical and horizontal, near the elbaw to prevent lateral motion of the transmission line.

The horizontal portion of the line is supported by roller assemblies or slip hangers spaced five feet apart. These should not bind the line or cause interference with lengthwise movement which may be absorbed by another flexible section. When the transmitter room is reached, the line passes into it through an anchor plate which firmly holds the line to the transmitter room bulkhead.

For the purposes of this example, it will be noted that all expansion and contraction is absorbed by flexible sections. Therefore, flexible sections act as expansion joints for the entire line and both the vertical and horizontal legs of the line must be free to move toward them.

g. PURGING AND PRESSURIZING. -Waveguide transmission line is purged and pressurized at very low pressure in the same manner, and with the same type of equipment, as semirigid coaxial transmission line. Refer to paragraph 5-10.h.

h. ELECTRICAL REQUIREMENTS AND TESTS. –Waveguide transmission line should be given the same electrical tests as semirigid coaxial transmission line. Refer to paragraph 5-10.j.

NOTE

Sharp dents or pits are more degrading to the interior of a waveguide than larger gradual changes. Sharp dents are not to be tolerated.

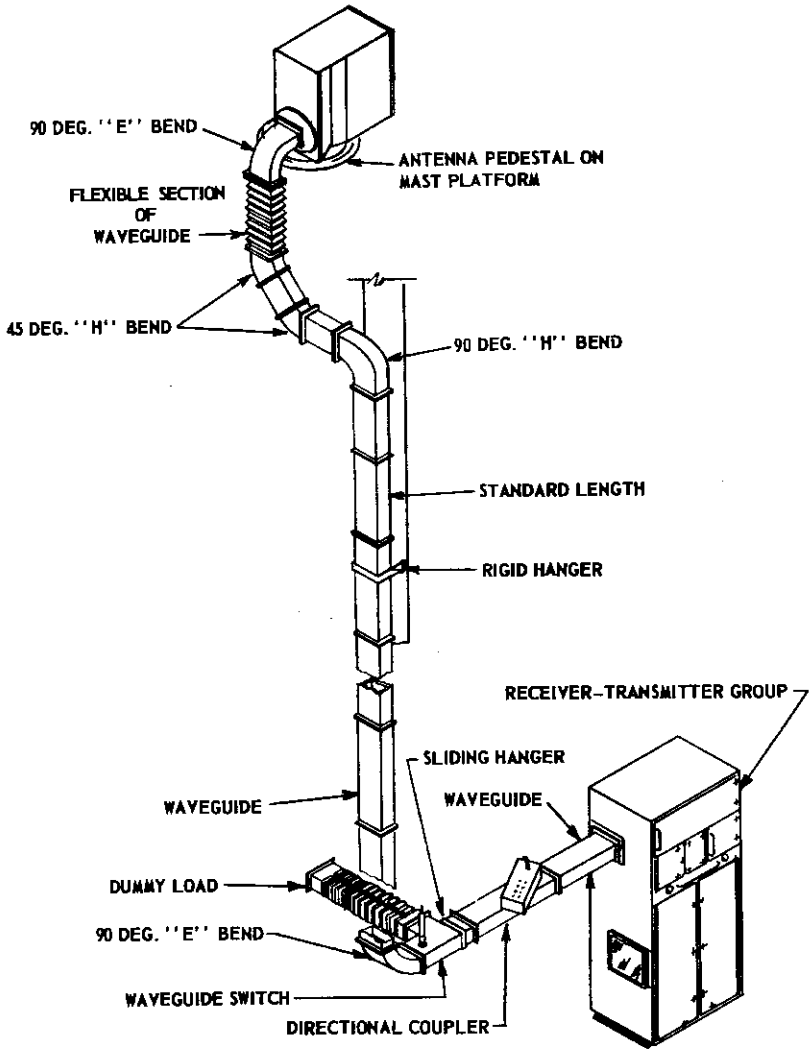


Figure 15-10. Illustrative Installation

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