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 SUPERSEDING
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MILITARY SPECIFICATION

WAVEGUIDE ASSEMBLIES, FLEXIBLE, TWISTABLE AND NONTWISTABLE, GENERAL SPECIFICATION FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the general requirements for twistable and nontwistable, flexible waveguide assemblies (hereinafter referred to as "assemblies") (see 6.1).

1.2 Classification. Assemblies shall be of the following classes, as specified (see 3.1 and 6.4)

<u>Class</u>	<u>Performance characteristics</u>
1	- Twistable (mates with rigid rectangular waveguide components).
2	- Nontwistable (mates with rigid rectangular waveguide components)
3	- Extra-flexible, twistable (mates with rigid rectangular waveguide components).
4	- Twistable (mates with single ridged waveguide components).
5	- Twistable (mates with double ridged waveguide components).
6	- Nontwistable (mates with single ridged waveguide components).
7	- Nontwistable (mates with double ridged waveguide components).
8	- Nontwistable flexible millimeter waveguide (mates with rigid rectangular waveguide components).

1.2.1 Military part number. The military part number shall consist of the letter "M" followed by the basic number of the specification sheet, an assigned dash number (see 3.1), and a coded four-digit number indicating the length.

Example

M287/1-01-0071

Military designator and
specification sheet No.

Dash number designated on
specification sheet

Length (in inches) (see
NOTE)

NOTE. The four digits indicate the nominal relaxed length of the assembly based on the requirements of 3.5.4. Example. "-0071" is the number used to identify a length of 7-1/2 inches.

2. APPLICABLE DOCUMENTS

2.1 Issues of documents. The following documents of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to Naval Electronic Systems Command, ATTN ELEX 5043, Department of the Navy, Washington, DC 20360 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.
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SPECIFICATIONS

FEDERAL

- NN-P-71 - Pallets, Material Handling, Wood, Double Faced, Stringer Construction.
- QQ-S-365 - Silver Plating, Electrodeposited, General Requirements For.
- QQ-S-781 - Strapping, Steel, Flat and Seals.
- ZZ-R-765 - Rubber, Silicone.
- PPP-B-566 - Boxes, Folding, Paperboard.
- PPP-B-585 - Boxes, Wood, Wirebound.
- PPP-B-601 - Boxes, Wood, Cleated-Plywood.
- PPP-B-621 - Boxes, Wood, Nailed and Lock-Corner.
- PPP-B-636 - Boxes, Shipping, Fiberboard.
- PPP-B-676 - Boxes, Setup.
- PPP-T-60 - Tape Packaging, Waterproof.
- PPP-T-66 - Tape Pressure-Sensitive Adhesive, Vinyl Plastic Film.
- PPP-T-76 - Tape, Pressure-Sensitive Adhesive, Paper (For Carton Sealing).
- PPP-T-495 - Tubes, Mailing, and Filing

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- MIL-W-85 - Waveguides, Rigid, Rectangular, General Specification For.
- MIL-P-116 - Preservation, Methods of.
- MIL-B-131 - Barrier Materials, Watervaporproof, Flexible, Heat-Sealable.
- MIL-F-3922 - Flanges, Waveguide, General Purpose, General Specification For.
- MIL-C-5541 - Chemical Conversion Coatings on Aluminum and Aluminum Alloys.
- MIL-S-8802 - Sealing Compound, Temperature-Resistant, Integral Fuel Tanks and Fuel Cell Cavities, High-Adhesion.
- MIL-W-23351 - Waveguides, Single Ridged and Double Ridged (Bandwidth Ratios 3.6:1 and 2.4:1), General Specification For.
- MIL-R-25988 - Rubber, Fluorosilicone Elastomer, Oil and Fuel-Resistant, Sheets, Strips, Molded Parts, and Extruded Shapes.
- MIL-F-39000 - Flanges, Waveguide, Ridge, General Specification For.
- MIL-C-45662 - Calibration System Requirements.

(See supplement 1 for list of associated specification sheets.)

STANDARDS

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- MIL-STD-129 - Marking for Shipment and Storage.
- MIL-STD-147 - Palletized Unit Loads for 40" x 48" Pallets.
- MIL-STD-202 - Test Methods For Electronic and Electrical Component Parts
- MIL-STD-417 - Rubber Compositions, Vulcanized General Purpose, Solid (Symbols and Tests).
- MIL-STD-794 - Part and Equipment, Procedures For Packaging and Packing of
- MIL-STD-889 - Dissimilar Metals.
- MIL-STD-1186 - Customing, Anchoring, Bracing, Blocking, and Waterproofing, With Appropriate Test Methods.
- MIL-STD-1188 - Commercial Packaging of Supplies and Equipment
- MIL-STD-1285 - Marking of Electrical and Electronic Parts.

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

3. REQUIREMENTS

3.1 Specification sheets. The individual item requirements shall be as specified herein and in accordance with the applicable specification sheets. In the event of any conflict between requirements of this specification and the specification sheets, the latter shall govern.

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3.2 Qualification. Assemblies furnished under this specification shall be products which are qualified for listing on the applicable qualified products list at the time set for the opening of bids (see 4.5 and 6.3).

3.3 First article. Assemblies furnished under this specification which are not listed on qualified products list shall be products that have been tested and passed first article inspection (see 4.6 and 6.4).

3.4 Materials (see 4.8.1). Materials shall be as specified herein; however, when a definite material is not specified, a material shall be used which will enable the assemblies to meet the performance requirements of this specification. Acceptance or approval of any constituent material shall not be construed as a guaranty of the acceptance of the finished product.

3.4.1 Flange. The material for the assembly flange shall be selected from the material of MIL-F-3922 or MIL-F-39000.

3.4.2 Jacket (when applicable). Unless otherwise specified (see 3.1), the jacket material shall be in accordance with 3.4.2.1, 3.4.2.2, 3.4.2.3, or 3.4.2.4.

3.4.2.1 Neoprene. Neoprene jackets shall be in accordance with MIL-STD-417, class B and shall be molded at least one-sixteenth inch thick.

3.4.2.2 Plastic. Plastic jackets shall be in accordance with MIL-S-8802, class A-1/2 or A-2.

3.4.2.3 Silicone rubber. Silicone rubber jackets shall be in accordance with ZZ-R-765, class 2A.

3.4.2.4 Fluorosilicone rubber. Fluorosilicone rubber jackets shall be in accordance with MIL-R-25988.

3.4.3 Dissimilar metals. Unless suitably protected against electrolytic corrosion, dissimilar metals shall not be used in intimate contact with each other. Dissimilar metals are defined in MIL-STD-889.

3.5 Design and construction (see 4.8.1). Assemblies shall be of the design, construction, and physical dimensions specified (see 3.1).

3.5.1 Flange. All assemblies shall be terminated by flanges. Unless otherwise specified (see 3.1), the flange shall mate electrically and mechanically with flanges covered by MIL-F-3922 or MIL-F-39000. The flange face shall make an angle of 90° ±15' with the E-plane and H-plane of the internal surfaces of the assembly.

3.5.1.1 Finish for copper alloy flanges. Unless otherwise specified (see 3.1), all copper alloy flanges shall be silver plated at least .0003-inch thick in accordance with QQ-S-365, grade A.

3.5.1.2 Finish for aluminum or aluminum alloy flanges. Unless otherwise specified (see 3.1), all aluminum or aluminum alloy flanges which are used with copper alloy, OFHC copper, or beryllium copper flexible waveguides shall be copper or electroless nickel plated in the recess of the flange or where the waveguide interfaces with the flange. After the waveguide and flange are soldered or brazed together, the solder point and flange shall be chemically treated in accordance with MIL-C-5541.

3.5.2 Flexible waveguides. The physical dimensions of the flexible waveguides shall be such that the operating frequency range is equal to that of the mating rigid or ridged waveguides of MIL-W-85 and MIL-W-23351, respectively.

3.5.2.1 Finish. With the exception of OFHC, all copper alloy, or beryllium copper flexible waveguides internal surfaces shall be silver plated in accordance with QQ-S-365, grade A, at least .0003-inch thick. OFHC copper shall be chemically treated with copper iridite, all aluminum or aluminum alloy flexible waveguides surfaces shall be chemically treated in accordance with MIL-C-5541.

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3.5.3 Assembly finish. Specified finish may be applied after assembly of flanges to flexible waveguides.

3.5.4 Assembly length. The nominal relaxed length of an assembly shall be measured from the face of one flange to the face of the other and shall be measured in inches and halves of an inch. Assembly length tolerances shall be in accordance with table I.

TABLE I. Length tolerances.

Assembly length	Tolerance
<u>Inches</u>	<u>Inch</u>
Up to 36, incl	$\pm .090$
over 36 and up to 72, incl	$\pm .125$
over 72	$\pm .250$

For indicating the length in the military part number (see 1.2.1), the following shall apply

- a. When the required length is less than 10 inches, the number shall be preceded by 2 zeros.
- b. When the required length is from 10 to 100 inches, the number shall be preceded by 1 zero.

3.6 Performance requirements.

3.6.1 Insertion loss. When assemblies are tested as specified in 4.8.2, the insertion loss shall not exceed the value specified (see 3.1).

3.6.2 Stability of insertion loss. When assemblies are tested as specified in 4.8.3, the maximum insertion loss shall not exceed the value specified (see 3.1) by more than 25 percent.

3.6.3 Voltage standing wave ratio (VSWR). When assemblies are tested as specified in 4.8.4, the VSWR shall not exceed the value specified (see 3.1).

3.6.4 Pressurization. When assemblies are tested as specified in 4.8.5, there shall be no leakage or, when applicable, loss of adherence of the jacket. Following this test, the stability of insertion loss and VSWR shall be as specified in 3.6.2 and 3.6.3, respectively.

3.6.5 Cold bending. When assemblies are tested as specified in 4.8.6, there shall be no checks, cracks, fractures, or other flaws in the jacket or the metal structure, as applicable. Following this test, the pressurization shall be as specified in 3.6.4.

3.6.6 Vibration, high frequency. When assemblies are tested as specified in 4.8.7, there shall be no mechanical damage to the jacket or the metal structure, as applicable. Following this test, the insertion loss and VSWR shall be as specified in 3.6.1 and 3.6.3, respectively.

3.6.7 Retention. When assemblies are tested as specified in 4.8.8, to the force specified (see 3.1), there shall be no physical damage to the assembly. The length of the assembly shall not change by more than .060 inch per foot of assembly length (see 3.5.4). Following this test, the VSWR and pressurization shall be as specified in 3.6.3 and 3.6.4, respectively.

3.6.8 Shock. When assemblies are tested as specified in 4.8.9, there shall be no physical damage to the assembly. Following this test, the insertion loss and VSWR shall be as specified in 3.6.1 and 3.6.3, respectively.

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3.6.9 Salt spray (corrosion). When assemblies are tested as specified in 4.8.10, there shall be no evidence of destructive corrosion and the insertion loss, stability of insertion loss, and VSWR shall be as specified in 3.6.1, 3.6.2, and 3.6.3, respectively. Destructive corrosion shall be construed as any type of corrosion which in any way interferes with mechanical or electrical performance.

3.6.10 Moisture resistance. When assemblies are tested as specified in 4.8.11, there shall be no evidence of cracking or, if applicable, separation of the jacket. Following this test, insertion loss, stability of insertion loss, and VSWR shall be as specified in 3.6.1, 3.6.2, and 3.6.3, respectively.

3.6.11 Thermal shock. When assemblies are tested as specified in 4.8.12, there shall be no evidence of cracking or, if applicable, separation of the jacket. Following this test, pressurization, insertion loss, and VSWR shall be as specified in 3.6.4, 3.6.1, and 3.6.3, respectively.

3.6.12 Power handling capability (when specified, see 3.1). When assemblies are tested as specified in 4.8.13, there shall be no cracks, fractures, or other flaws in the jacket or metal structure, as applicable. After this test, the insertion loss and VSWR shall be as specified in 3.6.1 and 3.6.3, respectively.

3.6.13 Bending test. When assemblies are tested as specified in 4.8.14, there shall be no mechanical damage. After this test the measured stability of insertion loss and VSWR shall be as specified in 3.6.2 and 3.6.3, respectively.

3.6.14 Flexure. When assemblies are tested as specified in 4.8.15, there shall be no mechanical damage. After this test the measured stability of insertion loss and VSWR shall be as specified in 3.6.2 and 3.6.3, respectively.

3.6.15 Axial twist (applicable only to twistable type). When assemblies are tested as specified in 4.8.16, there shall be no mechanical damage. After this test the measured stability of insertion loss and VSWR shall be as specified in 3.6.2 and 3.6.3, respectively.

3.6.16 Repeated twist (applicable only to twistable type). When assemblies are tested as specified in 4.8.17, there shall be no mechanical damage. After this test the measured stability of insertion loss and VSWR shall be as specified in 3.6.2 and 3.6.3, respectively.

3.7 Marking (see 4.8.1). Assemblies shall be marked in accordance with MIL-STD-1285, method I, on the external surface, with the military part number (see 3.1), and the manufacturer's source code. Marking characters shall be approximately 1/8 inch in height for assemblies covering frequencies up to 26.5 GHz and approximately 1/16 inch in height for assemblies covering frequencies above 26.5 GHz. The manufacturer's name or trademark may also be marked on the assembly provided such letters are not expressly forbidden in the contract or purchase order. The preferred and permissible marking is as follows:

Preferred	Military part number	M287/1-XX-XXXX
	Manufacturer's source code	ZZZZ
Permissible	M287/	
	1-XX-XXXX	
	ZZZZ	

3.8 Workmanship (see 4.8.1). Assemblies shall be manufactured in such a manner as to be uniform in quality and the assembly shall be free from tool marks, burrs, scratches, pits, corrosion, cracks, rough edges, chips, and other defects that will affect life, serviceability, or appearance.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless

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disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Test equipment and inspection facilities. Test and measuring equipment and inspection facilities of sufficient accuracy, quality and quantity to permit performance of the required inspection shall be established and maintained by the contractor. The establishment and maintenance of a calibration system to control the accuracy of the measuring and test equipment shall be in accordance with MIL-C-45662.

4.2 Classification of inspection. The inspections specified herein are classified as follows:

- a. Materials inspection (see 4.3).
- b. Qualification inspection (see 4.5).
- c. First article inspection (see 4.6).
- d. Quality conformance inspection (see 4.7)

4.3 Materials inspection. Materials inspection shall consist of certification supported by verifying data that the materials (see 3.4) used in fabricating the assembly are in accordance with the applicable referenced specifications or requirements prior to such fabrication.

4.4 Inspection conditions. Unless otherwise specified herein, all inspections shall be performed in accordance with the test conditions specified in the "GENERAL REQUIREMENTS" of MIL-STD-202.

4.5 Qualification inspection. Qualification inspection shall be performed at a laboratory acceptable to the Government (see 6.3) on sample units produced with equipment and procedures normally used in production. Group qualification can be obtained by submitting the proper item with the group (see 3.1) for inspection and successfully passing these tests.

4.5.1 Sample size. Four assemblies covered by each specification sheet, for which qualification is sought, shall be subjected to qualification inspection.

4.5.2 Inspection routine. Sample units shall be subjected to the qualification inspection specified in table II, in the order shown.

4.5.3 Failures. One or more failures shall be cause for refusal to grant qualification.

4.5.4 Disposition of qualification sample units. Sample units which have been subjected to qualification testing shall not be delivered on any contract or purchase order. The Government reserves the right to retain the sample units or to require the contractor to furnish the sample units with the qualification inspection report.

4.5.5 Retention of qualification. The contractor shall forward a report at 36-month intervals to the qualifying activity. The qualifying activity shall establish the initial reporting date. The report shall consist of

- a. A summary of the results of the tests performed for inspection of product for delivery, groups A and B, indicating as a minimum the number of lots that have passed and the number that have failed. The results of tests of all reworked lots shall be identified and accounted for.

Failure to submit the report within 90 days after the end of each 36-month period may result in loss of qualification for the product. In addition to the periodic submission of inspection data, the contractor shall immediately notify the qualifying activity at any time during the 36-month period that the inspection data indicates failure of the qualified product to meet the requirements of this specification.

In the event that no production occurred during the reporting period, a report shall be submitted certifying that the company still has the capabilities and facilities necessary to produce the item.

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4.6 First article inspection. First article inspection shall be performed by the contractor after award of contract and prior to production, at a location acceptable to the Government. This inspection consists of meeting all the qualification requirements of 4.5 through 4.5.4 inclusive and table II. First article approval is valid only on the contract or purchase order under which it is granted. The grouping of 4.5 does not apply for first article inspection.

TABLE II. Qualification inspection.

Inspection	Requirement paragraph	Method paragraph
<u>Group I (all sample units)</u>		
Visual and mechanical examination - - - - -	3.1, 3.4 thru 3.5.4, 3.7, and 3.8	4.8.1
Insertion loss - - - - -	3.6.1	4.8.2
Voltage standing wave ratio (VSWR) - - - - -	3.6.3	4.8.4
<u>Group II (2 sample units)</u>		
Stability of insertion loss - - - - -	3.6.2	4.8.3
Pressurization - - - - -	3.6.4	4.8.5
Cold bending - - - - -	3.6.5	4.8.6
Vibration, high frequency - - - - -	3.6.6	4.8.7
Retention - - - - -	3.6.7	4.8.8
Shock - - - - -	3.6.8	4.8.9
Salt spray (corrosion) - - - - -	3.6.9	4.8.10
Moisture resistance - - - - -	3.6.10	4.8.11
Thermal shock - - - - -	3.6.11	4.8.12
Power handling capability <u>1/</u> - - - - -	3.6.12	4.8.13
<u>Group III (2 sample units)</u>		
Bending test - - - - -	3.6.13	4.8.14
Flexure - - - - -	3.6.14	4.8.15
Axial twist <u>2/</u> - - - - -	3.6.15	4.8.16
Repeated twist <u>2/</u> - - - - -	3.6.16	4.8.17
Pressurization - - - - -	3.6.4	4.8.5

1/ When specified, see 3.1

2/ For twistable type only.

4.7 Quality conformance inspection.

4.7.1 Inspection of product for delivery. Inspection of product for delivery shall consist of groups A and B inspections.

4.7.1.1 Inspection lot. An inspection lot shall consist of all assemblies of the same military part number produced under essentially the same condition, and offered for inspection at one time.

4.7.1.2 Group A inspection. Group A inspection shall consist of the inspections specified in table III, in the order shown.

4.7.1.2.1 Sampling plan. All units shall be subjected to group A inspection. No failures are allowed. If one or more sample units fail, the sample shall be considered to have failed.

4.7.1.2.2 Rejected lots (group A inspection). If an inspection lot is rejected, the contractor may rework it to correct the defects or screen out the defective units, and resubmit for reinspection. Resubmitted lots shall be inspected using tightened inspection. Such lots shall be separate from new lots and shall be clearly identified as reinspected lots.

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TABLE III. Group A inspection.

Inspection	Requirement paragraph	Test method paragraph
Visual and mechanical - - - - -	3.1, 3.4 thru 3.5.4, 3.7, and 3.8	4.8.1
Insertion loss - - - - -	3.6.1	4.8.2
Voltage standing wave ratio (VSWR)-	3.6.3	4.8.4
Pressurization - - - - -	3.6.4	4.8.5

4.7.1.3 Group B inspection. Group B inspection shall consist of the tests specified in table IV, in the order shown, and shall be made on units which have been subjected to and have passed group A inspection.

TABLE IV. Group B inspection.

Test	Requirement paragraph	Method paragraph
Retention - - - - -	3.6.7	4.8.8
Bending test - - - - -	3.6.13	4.8.14
Flexure - - - - -	3.6.14	4.8.15
Axial twist (applicable only to twistable type) - - - - -	3.6.15	4.8.16
Repeated twist (applicable only to twistable type one-way twisting)-	3.6.16	4.8.17

4.7.1.3.1 Sampling plan (group B inspection). The sampling plan shall be as specified in table V.

TABLE V. Group B. Sampling plan.

Quantity	Units tested
1 - 5	0 $\frac{1}{5}$
6 - 50	1
51 - 99	2
100 and greater	22

$\frac{1}{5}$ After three consecutive buys of five units or less over a period of 18 months, at least one unit shall be subjected to group B inspection on the fourth buy.

4.7.1.3.2 Rejected lots (group B inspection). If an inspection lot is rejected, the contractor may rework it to correct the defects, or screen out the defective units, and resubmit for reinspection. Such lots shall be separate from new lots, and shall be clearly identified as reinspected lots.

4.7.1.3.3 Disposition of sample units. Sample units which have been subjected to group B inspection shall not be delivered on the contract or purchase order.

4.7.2 Inspection of packaging Except when commercial packaging is specified, the sampling and inspection of the preservation and interior package marking shall be in accordance with the group A and B quality conformance inspection requirements of MIL-P-116. The sampling and inspection of the packing and marking for shipment and storage shall be in accordance with the quality assurance provisions of the applicable container specification and the marking requirements of MIL-STD-129. The inspection of commercial packaging shall be as specified in the contract. (see 6.2)

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4.8 Methods of inspection.

4.8.1 Visual and mechanical examination. Assemblies shall be examined to verify that the materials, design, construction, physical dimensions, finish, marking, and workmanship are in accordance with the applicable requirements (see 3.1, 3.4 thru 3.5.4, 3.7, and 3.8).

4.8.2 Insertion loss (see 3.6.1). The insertion loss of the assembly shall be measured over the specified frequency range (see 3.1), using the test setup of figure 1. If the test must be made at fixed frequencies, the test shall be made at not less than 10 equally spaced points evenly distributed across the frequency range of the assemblies (see 3.1). The test equipment(s) shall be capable of providing a continuous measurement of insertion loss over the required frequency ranges. A means shall be provided for producing a permanent record of the assembly's insertion loss versus frequency. The permanent record of each assembly shall be packaged with the unit when shipped. The measurement system and permanent record shall provide a minimum accuracy of .02 dB over the frequency ranges 1.12 through 2.6 GHz and above 26.5 GHz and .01 dB over the frequency ranges 2.6 through 26.5 GHz.

4.8.3 Stability of insertion loss (see 3.6.2). Stability of insertion loss shall be determined by measuring insertion loss as specified in 4.8.2 during the time the assembly is being deformed to the bending angle specified (see 3.1). When repeated twist is specified (see 3.1), the assembly shall be slowly twisted, either clockwise or counterclockwise, whichever is the lower, to an average angle equal to the value specified (see 3.1). A record shall be made of the maximum insertion loss observed for any deformed position. The permanent record of each assembly shall be packaged with the unit when shipped.

4.8.4 VSWR (see 3.6.3). The VSWR of the assembly shall be measured over the specified frequency range and length (see 3.1), using the test setup of figure 2 or figure 3. If the test must be made at fixed frequencies, the test shall be made at not less than 10 equally spaced points evenly distributed across the frequency range of the assemblies (see 3.1). The test equipment(s) shall be capable of providing a continuous measurement of VSWR over the required frequency ranges. A means shall be provided for producing a permanent record of the assembly's VSWR versus frequency. If VSWR is not directly measured, that is, if return loss is measured and VSWR is calculated from that measurement, the permanent record shall indicate the worse case VSWR numerically for each frequency band and shall provide the calculation used to obtain the calculated VSWR. The permanent record of each assembly shall be packaged with the unit when shipped. The measurement system and permanent record shall provide a minimum accuracy of .01 over the frequency ranges below 26.5 GHz and a minimum accuracy of .02 over the frequency ranges 26.5 GHz and above. The length of the assembly to be used for the VSWR measurements shall be as specified in 4.8.4.1 or 4.8.4.2, as applicable.

4.8.4.1 For qualification inspection. For assemblies that operate up to 12.4 GHz inclusive, the lengths shall be 12 inches and 24 inches. For assemblies that operate above 12.4 GHz and through 26.5 GHz, the lengths shall be 6 inches and 12 inches. For assemblies that operate above 26.5 GHz, the lengths shall be 1 inch and 2 1/4 inches.

4.8.4.2 For group A inspection. The VSWR measurements under group A inspection shall be performed on the actual length that is being procured.

4.8.5 Pressurization (see 3.6.4). The assembly shall be subjected to the internal air pressure in pounds force per square inch gage (lb_f/in^2) specified (see 3.1), while immersed in water. The longitudinal axis of the assembly shall be nominally parallel to the surface of the water, and the uppermost portion of the assembly shall not be less than 6 inches and not more than 12 inches below the surface. The temperature of the water shall be $20^\circ \pm 5^\circ\text{C}$. 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 stability of insertion loss and VSWR shall be measured while under pressure as specified in 4.8.3 and 4.8.4, respectively. Any areas of nonadherence of the jacket (if applicable) should be noted after the assembly has been under the pressure for 5 minutes. Ridges in the rubber that show under pressure are to be discounted, and, in general, nonadherent areas 1/8-inch square or smaller may be disregarded. In case of doubt, any nonadherent area which does not visibly increase in size when the assembly is subjected to the applicable pressure for 24 hours will be acceptable.

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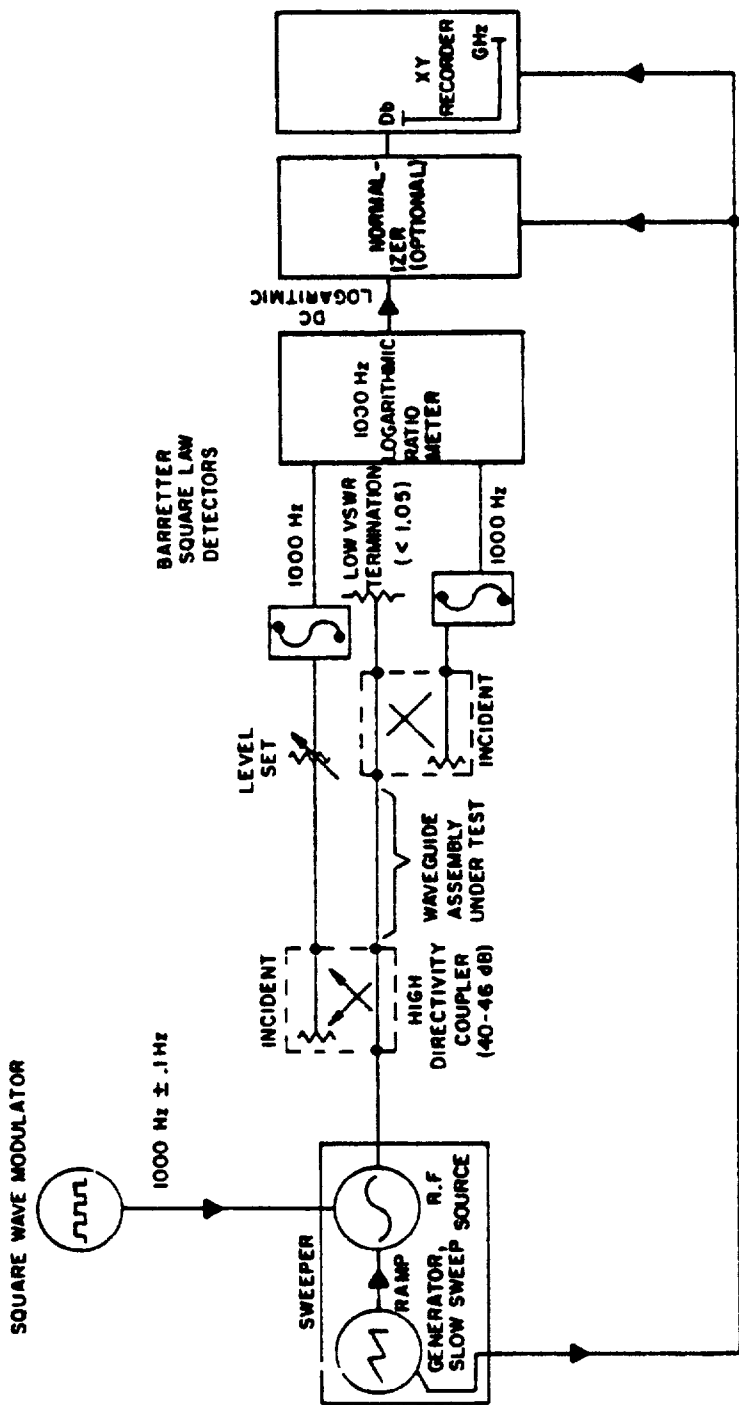


FIGURE 1. Insertion loss test setup.

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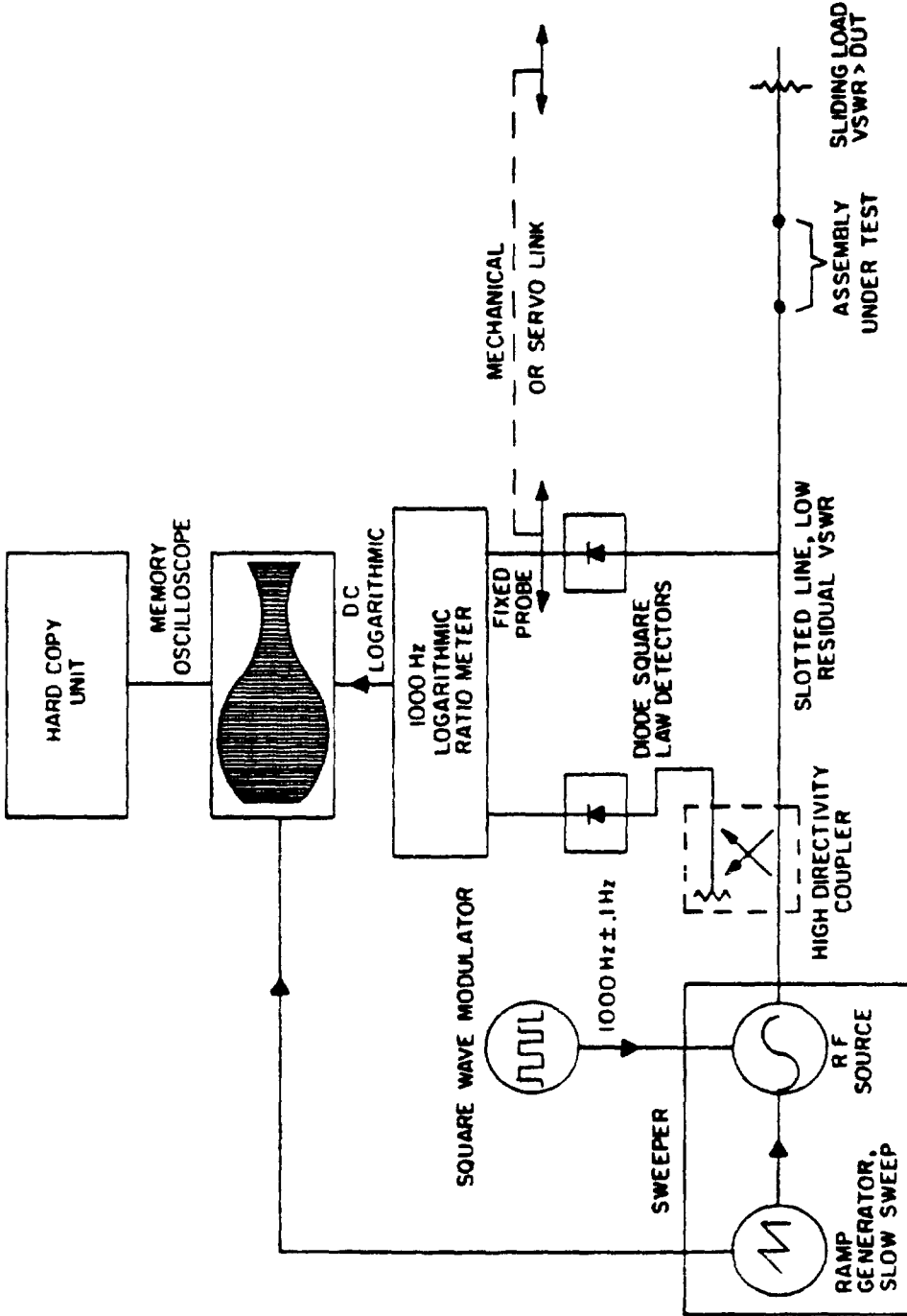


FIGURE 2 VSWR test using coupled sliding load.

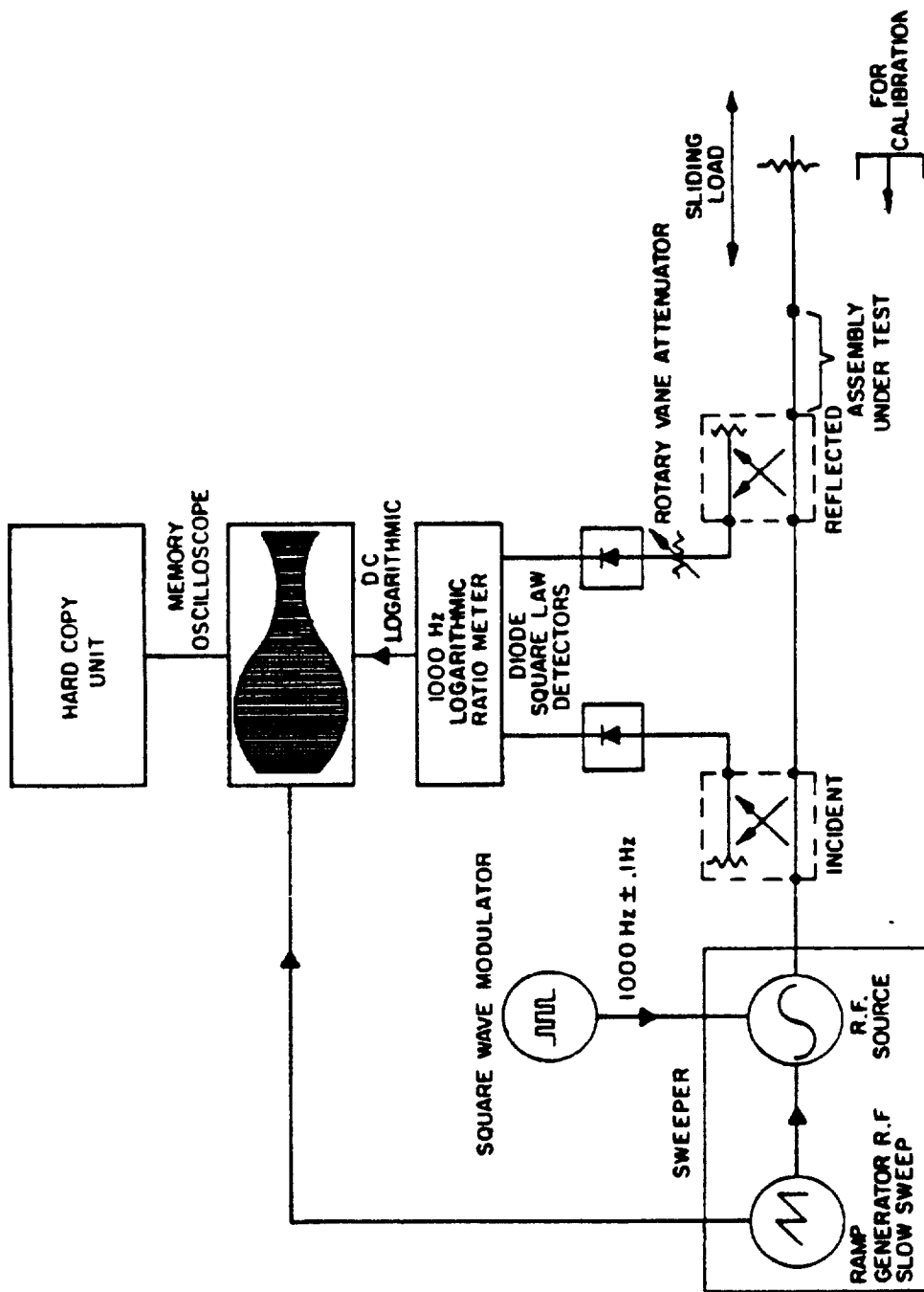


FIGURE 3 VSWR test using reflectometer with sliding load.

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4.8.6 Cold bending (see 3.6.5). The assembly shall be placed in an oven at a temperature of $100^{\circ} \pm 2^{\circ}\text{C}$, unless otherwise specified (see 3.1), for a period of 7 days. At the end of this period, the assembly shall be cooled to room temperature (approximately 20°C) for a period of 2 hours. The assembly shall then be placed in a cold chamber at a temperature of $-55^{\circ} \pm 5^{\circ}\text{C}$, unless otherwise specified (see 3.1), for a period of 20 hours. The assembly shall then be bent three times as specified in 4.8.15 at a rate not to exceed 5 degrees per second, first in one direction and then in the other, at the temperature of the chamber. The assembly shall then be moved from the chamber and examined for checks, cracks, fractures, or other flaws in the jacket or metal structure, as applicable. The assembly shall then be subjected to the pressurization test specified in 4.8.3 as a means of determining the mechanical uniformity of the assembly after it has been brought back to room temperature.

4.8.7 Vibration, high frequency (see 3.6.6). Assemblies shall be tested in accordance with MIL-STD-202, method 204. The following details shall apply:

- a. Mounting - Unless otherwise specified (see 3.1), rigidly mounted by flanges only to an appropriate nonresonant mounting table.
- b. Electrical load - Not applicable.
- c. Test-condition letter - A.
- d. Resonance - Not applicable.
- e. Measurements after vibration - Insertion loss and VSWR shall be measured as specified in 4.8.2 and 4.8.4, respectively.

4.8.8 Retention (see 3.6.7). Both flanges of the assembly shall be subjected to the retention test. The flange under test shall be secured to a stationary plate and the specified force (see 3.1) shall be applied in a straight line pull between the flange under test and the remaining flange. Spring scales or other appropriate means of measuring mechanical force shall be used to measure the applied force. Force measurement instruments shall be accurate within 0.5 lb_f. The force shall be gradually applied, held for 10 seconds, and released. The cycle shall be repeated four additional times. Following the test, pressurization and VSWR shall be measured as specified in 4.8.5 and 4.8.4, respectively.

4.8.9 Shock (see 3.6.8). Assemblies shall be tested in accordance with MIL-STD-202, method 213. The following details shall apply:

- a. Mounting - Unless otherwise specified (see 3.1), rigidly mounted by flanges only to test platform.
- b. Test-condition letter - C.
- c. Measurements after shock - Insertion loss and VSWR shall be measured as specified in 4.8.2 and 4.8.4, respectively.

4.8.10 Salt spray (corrosion) (see 3.6.9). Assemblies shall be tested in accordance with MIL-STD-202, method 101. The waveguide ends should be capped prior to this test. The following details shall apply:

- a. Special mounting - Not applicable.
- b. Test-condition letter - B.
- c. Measurements after exposure - Insertion loss, stability of insertion loss, and VSWR shall be measured as specified in 4.8.2, 4.8.3, and 4.8.4, respectively. The assembly shall be visually examined for evidence of destructive corrosion.

4.8.11 Moisture resistance (see 3.6.10). Assemblies shall be tested in accordance with MIL-STD-202, method 106. The following details shall apply:

- a. Initial measurements - Not applicable.
- b. Polarization voltage - Not applicable.
- c. Loading voltage - Not applicable.
- d. Measurements after test - Insertion loss, stability of insertion loss, and VSWR shall be measured as specified in 4.8.2, 4.8.3, and 4.8.4, respectively.

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4.8.12 Thermal shock (see 3.6.11). Assemblies shall be tested in accordance with MIL-STD-202, method 107. The following details and exception shall apply.

- a. Special mounting - Not applicable.
- b. Test-condition letter - A.
- c. Measurements before test - Not applicable.
- d. Measurements after test - Pressurization, insertion loss, and VSWR shall be measured as specified in 4.8.3, 4.8.2, and 4.8.4, respectively.

4.8.13 Power handling capability (when specified, see 3.1) (see 3.6.12). Assemblies shall be subjected to the RF power level specified (see 3.1) at the frequency, simulated altitude, and temperature specified (see 3.1). Power shall be maintained for a period of 1 hour after the temperature of the assembly has reached equilibrium. This condition is reached when the assembly temperature shall not vary more than 5°C within a 15-minute period. During the test, the assembly shall be terminated in a suitable load. After the test, insertion loss and VSWR shall be measured as specified in 4.8.2 and 4.8.4, respectively.

4.8.14 Bending test (see 3.6.13). One end of the assembly shall be firmly fixed to a stationary platform, and a guide or mandrel having a set radius of curvature for the assembly to be tested shall be attached on the same end. The assembly shall be mounted in a straight position in such a manner that it will be neither tension nor compression. An even and smooth oscillating motion shall then be applied to the free end so that the portion near the fixed end will bend around the mandrel. The assembly shall be bent to one side of the relaxed position to the centerline radius and in the planes specified (see 3.1). An appropriate length shall be used which will allow the bend to be accomplished in one revolution or less. The centerline of the assembly shall be normal to the stationary platform when in the relaxed position. The assembly shall be subjected to five complete cycles of bend in each plane from the relaxed position. One cycle is completed when the assembly is bent from the relaxed position to the specified bend and back to the relaxed position. The stability of insertion loss and VSWR shall then be measured as specified in 4.8.3 and 4.8.4, respectively.

4.8.15 Flexure (see 3.6.14). The method of flexure testing shall be as follows using the test machine as shown on figure 4. For assemblies that operate up to 12.4 GHz inclusive, a 24 inch (nominal) long representative sample of the same size and type as the assembly under test may be used for the flexure test. For assemblies that operate above 12.4 GHz and through 26.5 GHz, a 12 inch (nominal) long representative sample of the same size and type as the assembly under test may be used for the flexure test. For assemblies that operate above 26.5 GHz, a 2 inch (nominal) long representative sample of the same size and type as the assembly under test may be used for the flexure test. The pivot point of the test machine shall be located under the geometrical center of the waveguide in the relaxed position as shown on figure 4. The stationary end of the waveguide shall be rigidly secured to an adapter which is motionless throughout the test. A wooden form shall be used to assure that the test sample will take the intended bend. Enough tension shall be applied to cause the test sample to take the radius of the wooden form and return to the straight condition on the reverse stroke. The moving end of the machine shall contain an adapter which will allow the flexed end of the waveguide to move in the radial direction. The apparatus shall be set for the desired flexure angle and a counter installed to record the number of cycles. The planes of bending, angle of bending, and number of cycles shall be as specified (see 3.1). This bend shall be in two directions, 50 percent of the angle on one side of the relaxed position and 50 percent of the angle on the opposite side of relaxed position. The cycling rate shall be 40 cycles per minute. The stability of insertion loss and VSWR shall then be measured as specified in 4.8.3 and 4.8.4, respectively.

4.8.16 Axial twist (applicable only to twistable type) (see 3.6.15). One flange of the assembly shall be securely fastened to a stationary platform. To prevent the assembly from bending, a rigid shaft that extends through the long axis of the waveguide as an axis of rotation shall be mounted to the platform. The other flange shall be connected to this shaft and shall be free to rotate about it. Uniform alternating clockwise and counterclockwise twisting shall be applied to the assembly about the axis. The assembly shall be subjected to five complete cycles of clockwise and counterclockwise twist from the relaxed position to the angle appropriate for the length under test (see 3.1). Twisting shall be performed uniformly at a rate of approximately 1 cycle per 10 seconds. As the end of the test cycle, the assembly shall be under neither tension nor compression. The stability of insertion loss and VSWR shall then be measured as specified in 4.8.3 and 4.8.4, respectively.

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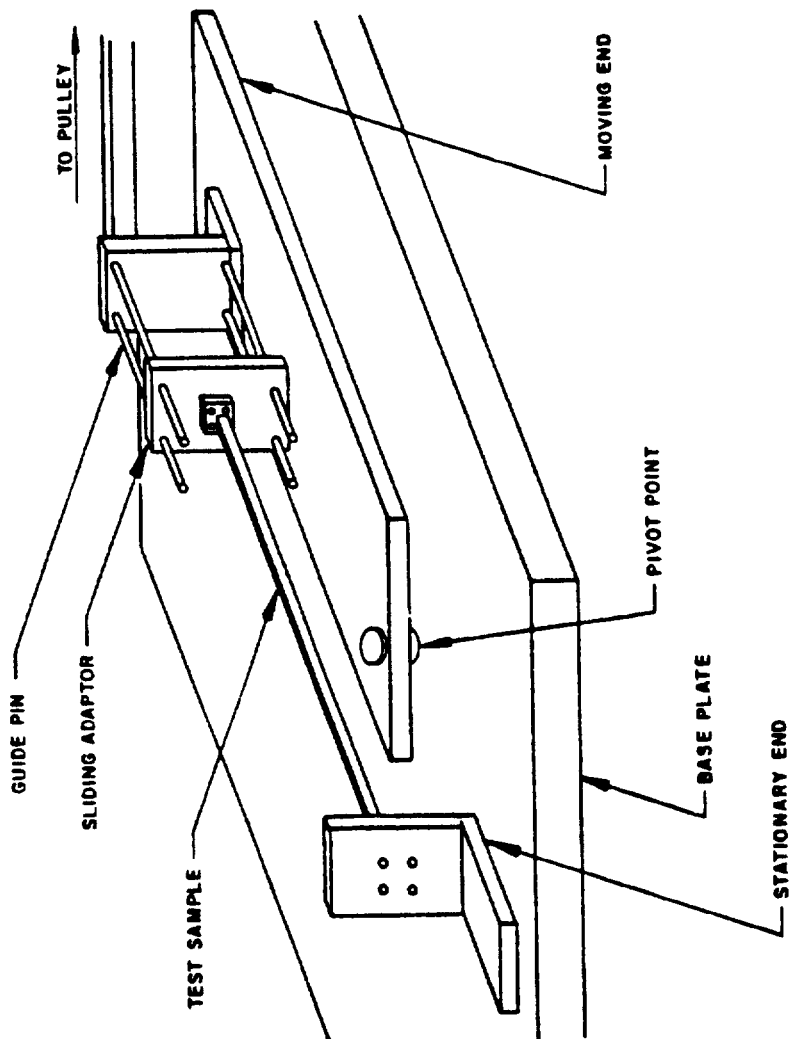


FIGURE 4. Flexure test figure.

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4.8.17 Repeated twist (applicable only to twistable type one-way twisting) (see 3.6.16). Repeated twist test shall be performed as specified in 4.8.16, except the number of cycles shall be as specified (see 3.1). For Assemblies that operate up to 12.4 GHz inclusive, a 24 inch (nominal) long representative sample of the same size and type as the assembly under test may be used for the repeated twist test. For assemblies that operate above 12.4 GHz and through 26.5 GHz, a 12 inch (nominal) long representative sample of the same size and type as the assembly under test may be used for the repeated twist test. For assemblies that operate above 26.5 GHz, a 2 inch (nominal) long representative sample of the same size and type as the assembly under test may be used for the repeated twist test. The stability of insertion loss and VSWR shall then be measured as specified in 4.8.3 and 4.8.4, respectively.

5. PACKAGING

5.1 Preservation. Preservation shall be level A, C or as specified (see 6.2).

5.1.1 Level A.

5.1.1.1 Cleaning. Assemblies shall be cleaned in accordance with MIL-P-116, process C-1.

5.1.1.2 Drying. Assemblies shall be dried in accordance with MIL-P-116

5.1.1.3 Preservative application. Preservatives shall, not be used.

5.1.1.4 Unit packs.

5.1.1.4.1 Assemblies 36 inches or less in length. Assemblies 36 inches or less in length shall be individually unit packed in accordance with MIL-P-116, submethod IA-8 insuring compliance with the applicable requirements of that specification. Each unit pack shall be placed in a supplementary container conforming to PPP-B-566, PPP-B-676, PPP-T-495 or PPP-B-636. However, assemblies exceeding 12 inches in length shall be restricted to supplementary containers conforming to PPP-B-636.

5.1.1.4.2 Assemblies exceeding 36 inches in length. Assemblies exceeding 36 inches in length shall be individually unit packed in accordance with MIL-P-116, method IA as follows. The open ends of each assembly shall be covered by a water-vaporproof barrier material conforming to MIL-B-131, class 1. This barrier material shall extend a minimum of 6 inches back from each open end and shall be secured and sealed with tape conforming to PPP-T-66, type I. When the opening exceeds the width of the tape, cross strips shall be used to reinforce the barrier material. Alternately, the openings shall be sealed with cover plates or caps and plugs secured with tape conforming to PPP-T-66, type I. All sealing devices shall meet the water-vaporproof requirements of MIL-B-131. The unit container shall conform to the level of packing specified (see 5.2).

5.1.1.5 Intermediate packs. Not required.

5.1.2 Level C. The level C preservation for assemblies shall conform to the MIL-STD-794 requirements for this level.

5.2 Packing. Packing shall be level A, B, C or as specified (see 6.2).

5.2.1 Level A.

5.2.1.1 Assemblies 36 inches or less in length. These assemblies shall be packed in fiberboard containers conforming to PPP-B-636, class weather resistant, style optional, special requirements. In lieu of the closure and waterproofing requirement in the appendix of PPP-B-636, closure and waterproofing shall be accomplished by sealing all seams, corners, and manufacturer's joints with tape, 2 inches minimum width, conforming to PPP-T-60, class 1 or PPP-T-76. Banding (reinforcement requirements) shall be applied in accordance with the appendix to PPP-B-636 using nonmetallic or tape banding only.

5.2.1.2 Assemblies 36 to 72 inches in length. These assemblies shall be individually packed in a fiberboard container conforming to PPP-B-636, class weather resistant, style optional, special requirements. Blocking and bracing shall be provided as necessary in accordance with MIL-STD-1186 to prevent movement of the

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assembly within the container. In lieu of the closure and waterproofing requirements in the appendix of PPP-B-636, closure and waterproofing shall be accomplished by sealing all seams, corners, and manufacturer's joints with tape, 2 inches minimum width, conforming to PPP-T-60, class 1 or PPP-T-76. Banding (reinforcement requirements) shall be applied in accordance with the appendix of PPP-B-636 using nonmetallic or tape banding only.

5.2.1.3 Assemblies over 72 inches in length. These assemblies shall be individually packed in a wood box conforming to PPP-B-601, overseas type, grade A or PPP-B-621, class 2, grade A. Blocking and bracing shall be provided as necessary in accordance with MIL-STD-1186 to prevent movement of the waveguide within the container. Closure and strapping requirements shall be as specified in the applicable specification.

5.2.2 Level B. Packing shall be as specified in 5.2.1.1, 5.2.1.2 and 5.2.1.3 except that the container shall conform to the domestic type or class of the respective specification.

5.2.3 Level C. The level C packing for assemblies shall conform to the MIL-STD-794 requirements for this level.

5.2.4 Unitized loads. Unitized loads, commensurate with the level of packing specified in the contract or purchase order, shall be used whenever total quantities for shipment to one destination equal 40 cubic feet or more. Quantities less than 40 cubic feet need not be unitized. Unitized loads shall be uniform in size and quantities to the greatest extent practicable.

5.2.4.1 Level A. Assemblies, packed as specified in 5.2.1, shall be unitized on pallets in conformance with MIL-STD-147, load type I, with a fiberboard cap (storage aid 4) positioned over the load.

5.2.4.2 Level B. Assemblies, packed as specified in 5.2.2, shall be unitized as specified in 5.2.4.1 except that the fiberboard caps shall be class domestic.

5.2.4.3 Level C. Assemblies, packed as specified in 5.2.3, shall be unitized as specified in MIL-STD-794 except that conformance to MIL-STD-147 is not required.

5.3 Marking. In addition to any special marking required by the contract (see 6.2), each unit pack, supplementary and exterior container shall be marked in accordance with MIL-STD-129.

5.4 General.

5.4.1 Exterior containers. Exterior containers (see 5.2.1, 5.2.2, and 5.2.3) shall be of a minimum tare and cube consistent with the protection required and shall contain equal quantities of identical stock numbered items to the greatest extent practicable.

5.4.2 Packaging inspection. The inspection of these packaging requirements shall be in accordance with 4.7.2.

5.4.3 Army procurements.

5.4.3.1 Level A unit packs. All supplementary containers shall be either weather (or water) resistant or overwrapped with waterproof barrier materials (see 5.1.1.4.1).

5.4.3.2 Level A and level B packing. For level A packing the fiberboard containers shall not be banded but shall be placed in a close fitting box conforming to PPP-B-601, overseas type; PPP-B-621, class 2, style 4 or PPP-B-585, class 3, style 2 or 3. Closure and strapping shall be in accordance with applicable container specification except that metal strapping shall conform to QQ-S-781, type I, finish A. When the gross weight exceeds 200 pounds or the container length and width is 48 x 24 inches or more and the weight exceeds 100 pounds, 3 x 4 inch skids (laid flat) shall be applied in accordance with the requirements of the container specification. If not described in the container specification, the skids shall be applied in a manner which will adequately support the item and facilitate the use of material handling equipment. For level B packing, fiberboard boxes shall be weather resistant as specified in level A and the containers shall be banded (see 5.2.1 and 5.2.2).

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5.4.3.3 Level A and B unitization. For level A and B unitization, softwood pallets conforming to MN-P-71, Type IV, size 2 shall be used. Weather resistant fiberboard caps shall also be used for level B unitization. The loads for both levels shall be bonded to the pallets by strapping conforming to QQ-S-781, type I, finish A or shrink film (see 5.2.4.1 and 5.2.4.2).

5.4.3.4 Commercial packaging. Commercial packaging, including unit packs, packing and marking shall be in accordance with MIL-STD-1188.

6. NOTES

6.1 Intended use. Twistable and nontwistable, flexible waveguide assemblies are intended for operation in the microwave region of the spectrum, to facilitate complex installations, provide for misalignments, and permit relative motion between connected components. They have satisfactory electrical as well as mechanical characteristics to supplement rigid waveguide assemblies.

6.2 Ordering data. Procurement documents should specify the following.

- a. Title, number, and date of this specification.
- b. Title, number, and date of applicable specification sheet and the complete part number.
- c. Inspection of commercial packaging.
- d. Levels of preservation and packing required (see 5.1 and 5.2).
- e. Special marking, if required (see 5.3).

6.3 Qualification. With respect to products requiring qualification, awards will be made only for products which are at the time set for opening of bids, qualified for inclusion in applicable qualified products list, whether or not such products have actually been so listed by that date. The attention of the contractors is called to this requirement, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts for the products covered by this specification. The activity responsible for the qualified products list is the Naval Electronic Systems Command, ELEX 5043, Department of the Navy, Washington, DC 20360, however, information pertaining to qualification of products may be obtained from the Defense Electronics Supply Center (DESC-E), Dayton, OH 45444.

6.3.1 Copies of "Provisions Governing Qualification" SD-6. Copies of "Provisions Governing Qualification" SD-6 may be obtained upon application to Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

6.4 First article inspection. Information pertaining to first article inspection of products covered by this specification should be obtained from the procuring activity for the specific contracts involved (see 3.3).

6.5 Definitions. For the purpose of this specification, the following definitions shall apply:

6.5.1 Twistable and nontwistable, flexible waveguide assemblies. A twistable or nontwistable, flexible waveguide assembly consists of a section of twistable or nontwistable, flexible waveguide with all associated fittings attached thereto and which mates electrically and mechanically with a matched standard rectangular or ridged waveguide. A twistable assembly is capable of withstanding bending, tensile, compressive, or torsional stresses without causing mechanical damage or causing the electrical properties to exceed the values specified (see 3.1). A nontwistable assembly is capable of withstanding bending, tensile, or compressive stresses without causing mechanical damage or causing the electrical properties to exceed the values specified (see 3.1).

6.5.2 Relaxed position. An assembly is in the relaxed position when it is restrained only by a horizontal surface on which it rests subject to no stress except that imposed by gravity.

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6.5.3 Minimum centerline (C_L) bending radius. The minimum centerline bending radius is the specified radius measured to the centerline of the assembly to which an assembly can be bent in the appropriate plane and under the appropriate conditions without causing mechanical damage or causing the electrical properties to exceed the values specified (see 3.1).

6.5.4 E-plane. The E-plane is a plane perpendicular to the wide faces of the waveguide and parallel to the narrow faces for rectangular waveguides.

6.5.5 H-plane. The H-plane is a plane perpendicular to the narrow faces of the waveguide and parallel to the wide faces for rectangular waveguides.

6.5.6 Flexure. Flexure is the number of cycles through which an assembly can be bent without causing mechanical damage or causing the electrical properties to exceed the values specified (see 3.1).

6.5.7 Axial twist. Axial twist is the maximum angle through which one flange of an assembly of a given length can be rotated with respect to the other flange without causing mechanical damage or causing the electrical properties to exceed the values specified (see 3.1). Axial twist is measured in degrees per foot.

6.5.8 Repeated twist. Repeated twist is the number of cycles through which an assembly can be twisted without causing mechanical damage or causing the electrical properties to exceed the values specified (see 3.1).

6.5.9 Bending angle. The bending angle in degree/foot can be derived from the minimum centerline radius (in inches) in 6.5.3 as follows
The arc length (l) for an arc of "a" degree is

$$l = \frac{\pi r a}{180^\circ}$$

$$\text{Transposing } a = \frac{180^\circ \times l}{\pi r} = \frac{57.3^\circ \times l}{r}$$

but since r is in inches and we wish degree/foot,

multiply $\frac{57.3^\circ \times l}{r}$ by 12 and get

$$"a" = \frac{57.3}{r} (12) = \frac{687.54}{r}$$

Custodians

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Navy - EC
Air Force - 85

Preparing activity

Navy - EC

Agent

DLA - ES

Review activities

Army - AV, MI
Navy - OS
Air Force - 17, 99
DLA - ES

(Project 5985-0919)

User activities

Army - AR
Navy - MC, CG, AS
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