

INCH-POUND

MIL-DTL-3970E
 24 September 2007
 SUPERSEDING
 MIL-DTL-3970D
 25 November 1998

DETAIL SPECIFICATION

 WAVEGUIDE ASSEMBLIES, RIGID,
 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 rigid waveguide assemblies, hereinafter referred to as "assemblies" ([see 6.1](#)).

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4, or 5 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements documents cited in sections 3, 4, or 5 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications and standards. The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract ([see 6.2](#)).

DEPARTMENT OF DEFENSE SPECIFICATIONS

- | | | |
|---------------|---|---|
| MIL-DTL-85 | - | Waveguides, Rigid, Rectangular, General Specification for. |
| MIL-DTL-3922 | - | Flanges, Waveguide, General Purpose, General Specification for. |
| MIL-DTL-14072 | - | Finishes for Ground Based Electronic Equipment. |

DEPARTMENT OF DEFENSE STANDARD

- | | | |
|-------------|---|--|
| MIL-STD-202 | - | Electronic and Electrical Component Parts. |
|-------------|---|--|

(Copies of these documents are available online at <http://assist.daps.dla.mil/quicksearch/> or <http://assist.daps.dla.mil/> or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents are those cited in the solicitation or contract ([see 6.2](#)).

ASME INTERNATIONAL (ASME)

- | | | |
|--------|---|---|
| Y14.5M | - | Dimensioning and Tolerancing (DOD adopted). |
|--------|---|---|

(Copies of this document are available online at <http://www.asme.org> or from ASME INTERNATIONAL, Three Park Avenue, New York, NY 10018.)

Comments, suggestions, or questions on this document should be addressed Defense Supply Center Columbus, ATTN: DSCC-VAT, P.O. Box 3990, Columbus, OH 43218-3990, or e-mailed to TubesAmps@dsccl.dla.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at <http://assist.daps.dla.mil>.

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NATIONAL CONFERENCE OF STANDARDS LABORATORIES (NCSL)

NCSL-Z540.1

- Calibration Laboratories and Measuring and Test Equipment (DoD adopted).

(Copies of the above document are available online at <http://www.ncsli.org> or from National Conference of Standards Laboratories (NCSL), 2995 Wilderness Place, Suite 107, Boulder CO 80301-5404.)

2.4 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, except for related specification sheets, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

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

3.2 First article. Assemblies furnished under this specification shall be products that have been tested and passed first article inspection ([see 4.5](#) and [6.3](#)).

3.3 Materials. Materials shall be as specified herein ([see 3.1](#)); 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 ([see 4.7.1](#)).

3.3.1 Aluminum and aluminum alloy surfaces. Except for interior and mating surfaces, all aluminum or aluminum alloy surfaces must be finished in accordance with MIL-DTL-14072, type I, finish P513B.

3.3.2 Copper or copper alloy surfaces. Except for interior and mating surfaces, all copper or copper alloy surfaces must be finished in accordance with MIL-DTL-14072, type I, finish P213B.

3.3.3 Dissimilar metals. Unless suitably protected against electrolytic corrosion, dissimilar metals shall not be used in intimate contact with each other ([see 6.4.1](#)).

3.3.4 Pure tin. The use of pure tin, as an underplate or final finish, is prohibited both internally and externally. Tin content of rigid waveguide assembly components and solder shall not exceed 97 percent, by mass. Tin shall be alloyed with a minimum of 3 percent lead, by mass ([see 6.7](#)).

3.4 Interface and physical dimensions. Assemblies shall be of the design, interface, and physical dimensions specified ([see 3.1](#) and [4.7.1](#)). Dimensions and tolerances shall be interpreted in accordance with ASME-Y14.5M.

3.4.1 Flanges. Flanges used as a part of the assembly ([see 3.1](#)) shall conform to the requirements of MIL-DTL-3922.

3.4.2 Waveguides. Waveguides used as a part of the assembly ([see 3.1](#)) shall conform to the requirements of MIL-DTL-85.

3.5 Voltage standing wave ratio (VSWR). When assemblies are tested as specified in [4.7.2](#), the VSWR shall not exceed the value specified ([see 3.1](#)).

3.6 Insertion loss. When assemblies are tested as specified in [4.7.3](#), the insertion loss shall not exceed the value specified ([see 3.1](#)).

3.7 Pressurization. When assemblies are tested as specified in [4.7.4](#), there shall be no leakage. Following the test, VSWR shall be as specified in [3.5](#).

3.8 Salt spray (corrosion). When assemblies are tested as specified in [4.7.5](#), there shall be no evidence of destructive corrosion. Following this test, VSWR and insertion loss shall be as specified in [3.5](#) and [3.6](#), respectively. Destructive corrosion shall be construed as any type of corrosion that interferes with mechanical or electrical performance.

3.9 Vibration, high frequency. When assemblies are tested as specified in [4.7.6](#), there shall be no physical damage to the assembly. Following this test, VSWR, insertion loss, and pressurization shall be as specified in [3.5](#), [3.6](#), and [3.7](#), respectively.

3.10 Shock (specified pulse). When assemblies are tested as specified in [4.7.7](#), there shall be no physical damage to the assembly. Following this test, VSWR, insertion loss, and pressurization shall be as specified in [3.5](#), [3.6](#), and [3.7](#), respectively.

3.11 Power handling capability (when specified, [see 3.1](#)). When assemblies are tested as specified in [4.7.8](#), there shall be no evidence of arcing, flashover, charring, breakdown, or overheating. After this test, VSWR and insertion loss shall be as specified in [3.5](#) and [3.6](#), respectively.

3.12 Recycled, recovered, or environmentally preferable materials. Recycled, recovered, or environmentally preferable materials should be used to the maximum extent possible provided that the material meets or exceeds the operational and maintenance requirements, and promotes economically advantageous life cycle costs.

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

4. VERIFICATION

4.1 Test equipment and inspection facilities. Test equipment and inspection facilities of sufficient accuracy and quantity to permit performance of the required inspections shall be the responsibility of the manufacturer. Establishment and maintenance of a calibration system to control the accuracy of the measuring and test equipment shall be in accordance with NCSL-Z540.1.

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

- a. Materials inspection ([see 4.3](#)).
- b. First article inspection ([see 4.5](#)).
- c. Conformance inspection ([see 4.6](#)).

4.3 Materials inspection. Materials inspection shall consist of certification that the materials ([see 3.3 through 3.3.3](#)) 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.

4.4.1 Equivalent test methods. The use of equivalent test methods is allowed provided it is demonstrated to the preparing activity or their agent that the equivalent test methods in no way relax the requirements of this specification and that the equivalent test methods are approved by the preparing activity for use by that manufacturer before testing is performed ([see 6.3.1](#)).

4.5 First article inspection. First article inspection shall be performed by the manufacturer after award of contract and prior to production at a location acceptable to the Government on sample units produced with equipment and procedures normally used in production. This inspection consists of meeting all requirements of [4.5.1 through 4.5.4](#) inclusive and of table I. First article approval is valid only on the contract or purchase order under which it is granted.

TABLE I. First article approval inspection.

Inspection	Requirement paragraph	Method paragraph
Visual and mechanical inspection - - - - -	3.1, 3.3 through 3.4, 3.13, and 6.6	4.7.1
VSWR - - - - -	3.5	4.7.2
Insertion loss - - - - -	3.6	4.7.3
Pressurization - - - - -	3.7	4.7.4
Salt spray (corrosion) - - - - -	3.8	4.7.5
Vibration, high frequency - - - - -	3.9	4.7.6
Shock (specified pulse) - - - - -	3.10	4.7.7
Power handling capability (when specified) - - - -	3.11	4.7.8

4.5.1 Sample size. One each of the first article approval Part of Identifying Numbers (PIN) for which first article approval is sought, shall be subjected to first article inspection.

4.5.2 Inspection routine. Sample units shall be subjected to the first article approval inspections specified in table I, in the order shown.

4.5.3 Failures. One or more failures shall be cause for refusal to grant first article approval.

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

4.6 Conformance inspection.

4.6.1 Inspection of product for delivery. Inspection of product for delivery shall consist of group A and B inspections.

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

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4.6.1.2 Group A inspection. Group A inspection shall consist of the inspections specified in table II in the order shown.

TABLE II. Group A inspection.

Inspection	Requirement paragraph	Method paragraph
Visual and mechanical inspection -----	3.1, 3.3 through 3.4, 3.13, and 6.6	4.7.1
VSWR -----	3.5	4.7.2

4.6.1.2.1 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.

4.6.1.2.2 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. Such lots shall be separate from new lots and shall be clearly identified as reinspected lots.

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

TABLE III. Group B inspection.

Inspection	Requirement paragraph	Method paragraph
Insertion loss -----	3.6	4.7.3
Pressurization -----	3.7	4.7.4

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

TABLE IV. Group B sampling plan.

Quantity	Units tested
1 - 5	0 ^{1/}
6 - 50	1
51 - 99	2
100 and greater	2%

^{1/} 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.

4.6.1.3.2 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.

4.6.1.3.3 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 Methods of inspection.

4.7.1 Visual and mechanical inspection. Assemblies shall be inspected to verify that the materials, design, interface, physical dimensions, finish, marking, and workmanship are in accordance with the applicable requirements (see 3.1, 3.3 through 3.4, 3.13, and 6.6).

4.7.2 VSWR (see 3.5). The VSWR of the assembly shall be measured over the specified frequency range (see 3.1), using the test set-up of figure 1 or figure 2 (or equivalent). Test equipment shall be capable of providing a continuous measurement of VSWR over required frequency ranges. A means shall be provided for producing permanent records 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 worst case VSWR numerically for each frequency band and shall provide the calculation used to obtain the calculated VSWR. The measurement system and permanent record shall provide a minimum accuracy of 0.04 dB over the frequency ranges below 26.5 GHz and a minimum accuracy of 0.08 dB over the frequency ranges 26.5 GHz and above.

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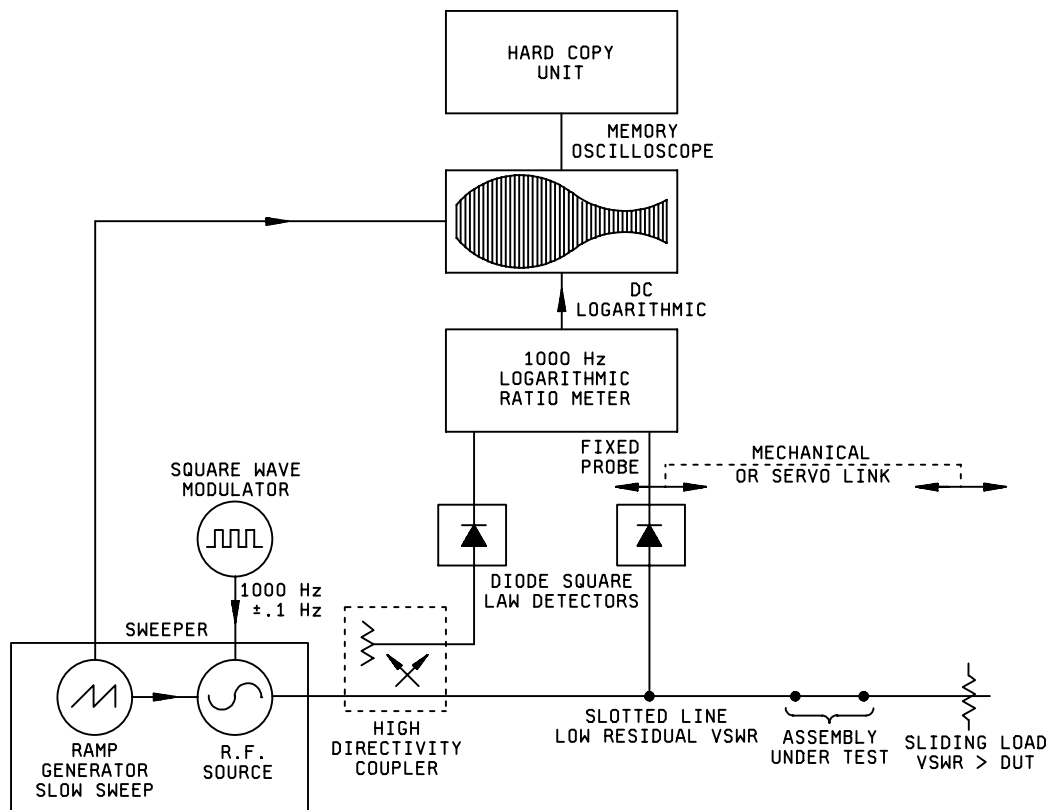
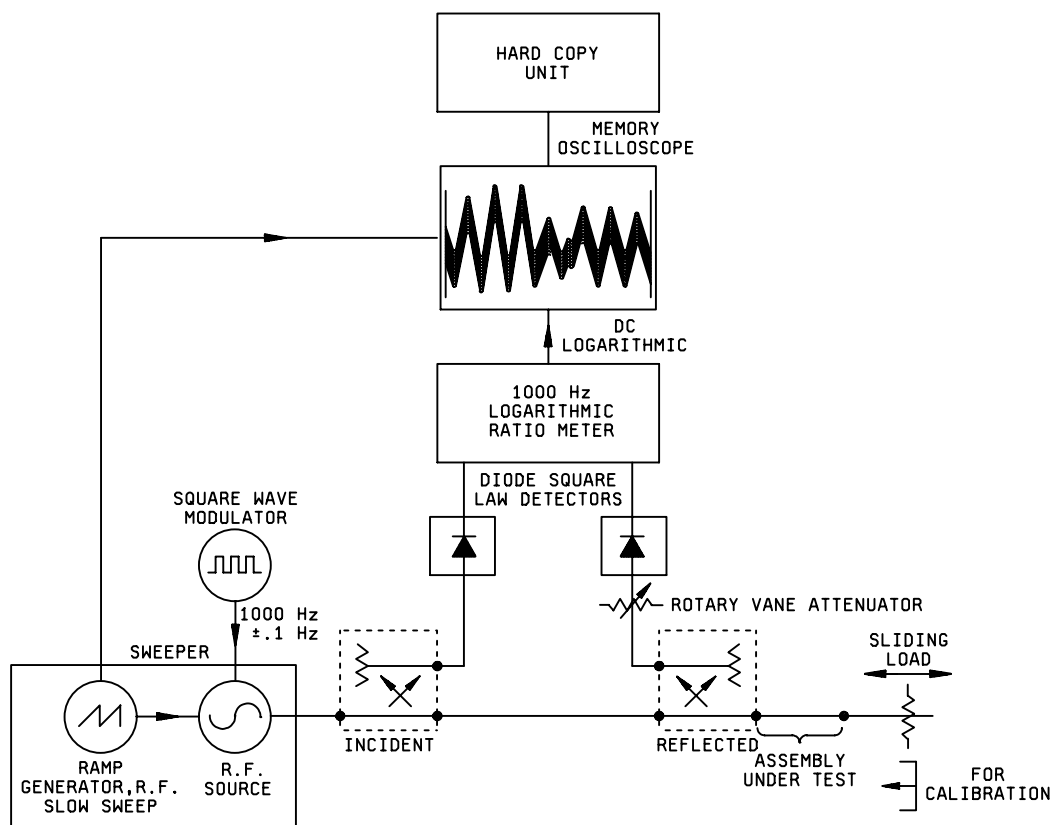


FIGURE 1. VSWR test setup using coupled sliding load (or equivalent).

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FIGURE 2. VSWR test setup using reflectometer with sliding load (or equivalent).

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4.7.3 Insertion loss ([see 3.6](#)). The insertion loss of the assembly shall be measured over the specified frequency range ([see 3.1](#)), using the test set-up of [figure 3](#) (or equivalent). Test equipment 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 measurement system and permanent record shall provide minimum accuracy of 0.08 dB over the frequency ranges 0.32 through 2.6 GHz and above 26.5 GHz and 0.04 dB over the frequency ranges 2.6 through 26.5 GHz.

4.7.4 Pressurization ([see 3.7](#)). The assembly shall be subjected to the internal air pressure in pound-force (lbf) specified ([see 3.1](#)), while immersed in water. The temperature of the water shall be $20^{\circ}\text{C} \pm 5^{\circ}\text{C}$. 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. After the test VSWR shall be measured as specified in [4.7.2](#).

4.7.5 Salt spray (corrosion) ([see 3.8](#)). 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. Measurement after exposure: VSWR and insertion loss shall be measured as specified in [4.7.2](#) and [4.7.3](#), respectively. The assembly shall be visually inspected for evidence of destructive corrosion.

4.7.6 Vibration, high frequency ([see 3.9](#)). Assemblies shall be tested in accordance with MIL-STD-202, method 204. The following details shall apply:

- a. Mounting: Rigidly mounted to an appropriate nonresonant mounting table.
- b. Electrical load: Not applicable.
- c. Test condition letter: A.
- d. Resonance: Not applicable.
- e. Measurements after vibration. VSWR insertion loss, and pressurization shall be measured in [4.7.2](#), [4.7.3](#), and [4.7.4](#), respectively.

4.7.7 Shock (specified pulse) ([see 3.10](#)). Assemblies shall be tested in accordance with MIL-STD-202, method 213. The following details shall apply:

- a. Mounting: Rigidly mounted to test platform.
- b. Test condition letter: G.
- c. Measurements after shock: VSWR, insertion loss, and pressurization shall be measured as specified in [4.7.2](#), [4.7.3](#), and [4.7.4](#), respectively.

4.7.8 Power handling capability (when specified, see 3.1) ([see 3.11](#)). Assemblies shall be subjected to the radio frequency (RF) power level specified ([see 3.1](#)) at the frequency, simulated altitude, and temperature specified ([see 3.1](#)). Power shall be maintained for 1 hour after the temperature of the assembly has reached equilibrium (equilibrium has been attained when the assembly temperature does not change more than 5°C within a 15-minute period). During the test the assembly shall be terminated in a matched load (1.1 VSWR maximum). After the test VSWR and insertion loss shall be measured as specified in [4.7.2](#) and [4.7.3](#), respectively.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or purchase order ([see 6.2](#)). When packaging of materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain requisite packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the military service's system commands. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

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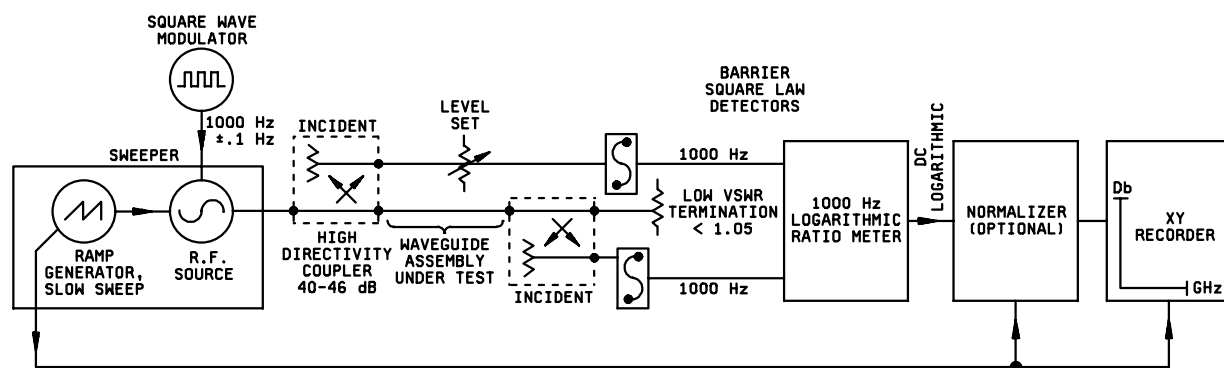


FIGURE 3. Insertion loss test setup (or equivalent).

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6. NOTES

(This section contains information of a general or explanatory nature which may be helpful, but is not mandatory.)

6.1 Intended use. Rigid waveguide assemblies are intended for use as bends, corners, and twists in rigid waveguide transmission lines to facilitate permanent direction or field orientation changes in the transmission line. The waveguide assemblies herein specified are military unique because they must function within and withstand for prolonged periods worldwide military unique environments. Commercial electronic components are not designed to withstand such extreme environmental conditions. Military uniqueness is also due to the costs required to change fielded systems to accommodate other than these standard military components.

6.2 Ordering data. Acquisition 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 PIN.
- c. Packaging ([see 5.1](#)).
- d. If special or other identification marking is required.

6.3 First article inspection. Information pertaining to first article inspection of products covered by this specification should be obtained from the acquiring activity for the specific contracts involved ([see 3.2](#)).

6.3.1 Alternate (equivalent) test methods. The use of equivalent test methods is allowed ([see 4.4.1](#)). Results for alternate test methods must be submitted to the qualifying activity and to the preparing activity for prior approval. The manufacturer must have conducted both test methods and have submitted complete test data to the preparing activity verifying the equivalency of each alternate test method proposed. For proposed alternate test methods, test method comparative error analysis must be made available for examination by the preparing activity and by the qualifying activity.

6.4 Definitions. For the purpose of this specification, the following definition applies.

6.4.1 Dissimilar metals. Dissimilar metals are defined in MIL-STD-889.

6.5 Marking. Assemblies must be marked in accordance with MIL-STD-1285, method I, on the external surface, with the military part or identifying number (PIN) ([see 3.1](#)), and the manufacturer's source code. Marking characters must be approximately .125 inch (3.18 mm) in height for assemblies covering frequencies up to 26.5 GHz and approximately .063 inch (1.60 mm) 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 PIN:	M3970/1-XX-XXXX
	Manufacturer source code:	ZZZZZ
Permissible	M3970/ 1-XX-XXXX ZZZZZ	

6.6 Subject term (key word) listing.

Bends	Pressurization
Corners	Radio frequency
Dissimilar metals	Transmission lines
Flanges	Twists
Insertion loss	Voltage standing wave ratio (VSWR)

6.7 Tin whisker growth. The use of alloys with tin content greater than 97 percent, by mass, may exhibit tin whisker growth problems after manufacture. Tin whiskers may occur anytime from a day to years after manufacture and can develop under typical operating conditions, on products that use such materials. Conformance coatings applied over top of a whisker-prone surface will not prevent the formation of tin whiskers. Alloys of 3 percent lead, by mass, have shown to inhibit the growth of tin whiskers ([see 3.3.4](#)). For additional information, refer to ASTM-545 (Standard Specification for Electrodeposited Coatings of Tin).

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6.8 Environmentally preferable material. Environmentally preferable materials should be used to the maximum extent possible to meet the requirements of this specification. Table V lists the Environmental Protection Agency (EPA) top seventeen hazardous materials targeted for major usage reduction. Use of these materials should be minimized or eliminated unless needed to meet the requirements specified herein ([see Section 3](#)).

TABLE V. EPA top seventeen hazardous materials.

Benzene	Dichloromethane	Tetrachloromethylene
Cadmium and Compounds	Lead and Compounds	Toluene
Carbon Tetrachloride	Mercury and Compounds	1, 1, 1 - Trichloroethane
Chloroform	Methyl Ethyl Ketone	Trichloroethylene
Chromium and Compounds	Methyl Isobutyl Ketone	Xylenes
Cyanide and Compounds	Nickel and Compounds	

6.9 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

Custodians:

Army - CR
Navy - EC
Air Force - 11
DLA - CC

Preparing activity:

DLA - CC

(Project 5985-2007-020)

Review activities:

Army - AR, MI
Navy - AS, CG, MC, OS, SH
Air Force - 99

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at <http://assist.daps.dla.mil>.