INCH-POUND

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SUPERSEDING
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DETAIL SPECIFICATION

WAVEGUIDES, RIGID, RECTANGULAR

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 performance requirements for seamless or fabricated rigid waveguides with rectangular inside configurations (see 6.1).

1.2 PIN. The military PIN consists of the letter "M" followed by the basic number of the specification sheet, an assigned dash number (see 3.1), and a coded 3-digit number indicating the length (in inches, see 3.3.2.).

Example:	M85/1-	001-	096
	Military designator and specification sheet number	Dash number designated as specification sheet (see 3.1)	Length (in inches, see 3.3.2)

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 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 of documents cited in sections 3 and 4 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks 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.

Comments, suggestions, or questions on this document should be addressed to DLA Land and Maritime, ATTN: VAT, P.O. Box 3990, Columbus, OH 43218-3990 or e-mailed to TubesAmps@dla.mil. Since contact information can change, you may want to verify the currency of address information using the ASSIST Online database at https://assist.daps.dla.mil.

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-202	-	Electronic and Electrical Component Parts.
MIL-STD-1285	-	Marking of Electrical and Electronic Parts.

(Copies of these documents are available online at https://assist.daps.dla.mil/quicksearch 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 these documents are those cited in the solicitation or contract.

ASTM INTERNATIONAL

ASTM-B107/107M	-	Magnesium-Alloy Extruded Bars, Rods, Shapes, Tubes and wire
ASTM-B210	-	Aluminum and Aluminum-Alloy Drawn Seamless Tubes and Wire
ASTM-B372	-	Copper and Copper-Alloy Seamless Rectangular Waveguide Tube

(Copies are available through ASTM INTERNATIONAL, 100 Barr Harbor Drive, West Conshohocken, PA 19428; or at http://www.astm.org/.)

ASME INTERNATIONAL

ASME-B46.1	-	Surface Texture, (Surface Roughness, Waviness and Lay).

(Copies are available through ASME International, Three Park Ave., New York, NY 10016; or http://www.asme.org/.)

2.4 Order of precedence. Unless otherwise noted herein or in the contract, 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 specified sheet. In the event of any conflict between the requirements of this specification and the specification sheet, the latter shall govern.

3.2 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 waveguide to meet the performance requirements of this specification (see 4.2 and 4.5.1). Acceptance or approval of any constituent material shall not be construed as a guaranty of the acceptance of the finished product.

3.2.1 Aluminum alloy. Aluminum alloys 1100, 6061, and 6063 shall conform to the chemical composition limits of ASTM-B210. Alloy 1100 waveguides 3.000 by 1.500 inches and under in outside dimension shall be furnished in the H151 temper with a tensile strength of 17,000 pound-force per square inch (lb_f/in^2) minimum. Alloy 1100 waveguides over 3.000 x 1.500 inches outside dimension shall be furnished in the H112 temper with a tensile strength of 11,000 lb_f/in^2 minimum. Alloys 6061 and 6063 waveguides shall be furnished in the F temper.

3.2.2 Copper. Copper shall conform to type OF of DLP of ASTM-B372.

3.2.2.1 Copper alloy. Copper alloy shall conform to commercial bronze, 90 percent, of ASTM-B372.

3.2.3 Magnesium alloy. Magnesium alloy shall conform to the chemical composition and tensile property requirements for alloy AZ31B of ASTM-B107/B107M.

3.2.4 Silver alloy. Silver alloy shall conform to the chemical composition requirements for coin silver. In addition, silver alloy waveguides shall be furnished in the drawn temper with a Rockwell hardness of 45.0 to 80.00 on the “B” scale.

3.2.5 Silver-lined copper or copper alloy. Silver-lined copper or copper alloy shall be copper (see 3.2.2) or copper alloy (see 3.2.2.1) laminated with a minimum of .005 inch of fine silver.

3.2.6 Copper-clad invar. Copper-clad plating shall be of .003 to .007-inch thickness on both inside and outside surfaces.

3.2.7 Dissimilar metals. Unless suitably protected against electrolytic corrosion, dissimilar metals shall not be used in intimate contact with each other.

3.2.8 Pure tin. The use of pure tin, as an underplate or final finish, is prohibited both internally and externally. Tin content of waveguide components and solder shall not exceed 97 percent, by mass. Tin shall be alloyed with a minimum of 3 percent lead,

3.3 Design and construction. Waveguides shall be of the design, construction, and physical dimensions specified (see 3.1).

3.3.1 Finish. The interior and exterior surfaces of the waveguide shall be bright, smooth, dry, and free of scales or oxide.

3.3.2 Length. The finished waveguide shall be furnished in 96, 120, 144, and 168 inches (8,10,12, and 14 feet) straight lengths (see 3.1) with ends. The shortest permissible length of the ends shall not be less than 60 percent of the nominal length (specific and stock) and the maximum permissible weight of ends shall not exceed 25 percent of the lot weight. Waveguide tube, ordered to specific or stock lengths, with or without ends (see 6.2), shall conform to the tolerances in table I.

TABLE I. Length tolerances.
(Applicable only to full length pieces)

Length	Tolerance, inch (all plus)
Standard (stock) - - - - - - - -	1
Specific	
Up to 14 foot, inclusive- - -	.25
Over 14 foot - - - - - - - - -	.50

3.3.3 Perpendicularity. Perpendicularity is the deviation from a right angle of two adjacent interior waveguide surfaces. The deviation shall not exceed .008 inches per inch (0.5 degree) when measured at each end of the waveguide length (see 4.5.1).

3.4 Bow. Unless otherwise specified (see 3.1), when measured as specified in 4.5.2, the bow between any two points 2 feet apart on the concave external surface shall not be more than .010 inch on the narrow surface (E-plane) and .020 inch on the wide surface (H-plane). If the waveguide is less than 2 feet long, the allowable bow shall be proportionate to the above requirements.

3.5 Twist. When waveguides are measured as specified in 4.5.3, the maximum twist along the longitudinal axis shall not exceed 1 degree per foot of length on the face of the interior or exterior surfaces.

3.6 Squareness of cut. When measured as specified in 4.5.4, the departure from squareness of the end of any waveguide shall not exceed 0.010 inch (0.25 mm) for waveguides up to .625 inch (15.88 mm) maximum inside waveguide dimension, inclusive, and 0.016 Inch (0.41 mm) (1 degree) for waveguides over .625 inch (15.88 mm) maximum inside waveguide dimension.

3.7 Surface roughness. When measured as specified in 4.5.5, the interior surface roughness of the waveguide shall not exceed the values shown in table II.

TABLE II. Surface roughness tolerances of waveguides.

Specified major inner dimension (inches)	(Microinch RMS) Allowable surface roughness maximum arithmetic average (AA)	
	Aluminum, aluminum alloy and magnesium alloy	Copper, copper alloy, silver alloy, silver-lined copper, silver-lined copper alloy, and copper-clad invar
Up to 4, exclusive - - - - -	63	32
4 and over- - - - - - - - - -	125	63

3.8 Pressurization (unless otherwise specified (see 3.1), applicable to fabricated waveguides only). When assemblies are tested as specified in 4.5.6, there shall be no leakage from the edge seams of the waveguide.

3.9 Voltage standing wave ratio (VSWR) (unless otherwise specified (see 3.1) applicable to fabricated waveguides only). When waveguides are tested as specified in 4.5.7, the VSWR shall not exceed 1.02.

3.10 Scratches. When measured as specified in 4.5.8, scratches shall not be more than 1 mil deep in the longitudinal direction of waveguides with internal measurements of .622 by .311 inch or larger. For waveguides less than .622 by .311 inch internal measurement, the depth of scratches shall not exceed 12 percent of the width of the scratch.

3.11 Marking. Each length of waveguide shall be marked in accordance with method I of MIL-STD-1285, with the Part or Identifying Number (PIN see 1.2 and 3.1) and the manufacturer's source code. The manufacturer's name or trademark may also be marked on the waveguide, provided such letters are not expressly forbidden in the contract or order, and their height does not exceed 50 percent of the outside dimension of the waveguide. The markings shall be applied with a permanent ink or paint. Not more than 6-inch intervals shall be permitted from the end of one marking to the beginning of the next marking.

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.

3.13 Workmanship. The waveguide shall be free from defects of a nature that may interfere with normal military applications. The waveguide shall be uniform in composition and wall thickness, straight and smooth from end to end and shall be free from internal and external mechanical imperfections, and shall have a clean, bright appearance in accordance with good commercial practice. In addition, the interior surface of the waveguide shall be free from burrs, die marks, chatter marks, dirt, grease, scales, and splinters (see 4.5.1).

4. VERIFICATION

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

a. Materials inspection (see 4.2).

b. Conformance inspection (see 4.4).

4.2 Materials inspection. Materials inspection shall consist of certification that the materials listed in table III, used in fabricating the waveguides, are in accordance with the applicable referenced specifications or requirements prior to fabrication.

TABLE III. Materials inspection.

Material	Requirement paragraph	Applicable specification
Aluminum	3.2.1	ASTM-B210
Aluminum alloy	3.2.1	ASTM-B210
Copper	3.2.2	ASTM-B372
Copper alloy	3.2.2.1	ASTM-B372
Magnesium alloy	3.2.3	ASTM-B107/B107M
Silver alloy	3.2.4	Coin silver
Silver-lined copper	3.2.5	ASTM-B372 and Fine silver
Copper-clad invar	3.2.6	ASTM-B372

4.3 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 Conformance inspection.

4.4.1 Inspection of product for delivery. Inspection of product for delivery shall consist of groups A, B, and C inspections.

4.4.1.1 Inspection lot. An inspection lot shall consist of all the waveguides of the same PIN, produced under essentially the same conditions, and offered for inspection at one time.

4.4.1.2 Group A inspection. Group A inspection shall consist of inspections specified in 4.5.1 and 4.5.1.1.

4.4.1.2.1 Sampling plan. Statistical sampling and inspection shall be performed on an inspection lot basis with a random sample of waveguides selected in accordance with table IV. The acceptance levels shall be based upon the zero defective sampling plan. No failures shall be permitted.

TABLE IV. Group A Sampling Plan.

Lot size	Sample size
1-13	100 percent
14-125	13
126-150	13
151-280	20
281-500	29
501-1200	34
1201-3200	42
3201-10,000	50
10,001-35,000	60
35,001-150,000	74
150,001-500,000	90
500,001 and over	102

4.4.1.2.2 Rejected lots. 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 to the table IV sampling plan. Resubmitted lots shall be inspected using tightened inspection. Such lots shall be separate from new lots, and shall be clearly identified as reinspected lots. If one or more defects are found in the second sample, the lot is rejected and shall not be supplied to this specification. (NOTE: This corrective action applies to the original defect found. If another defect type is found in the second sample, rescreen for that defect is also permitted.)

4.4.1.3 Group B inspection. Group B inspection shall consist of the inspections specified in table V, in the order shown, and the sample shall be selected from inspection lots that have passed group A inspection.

TABLE V. Group B inspection.

Examination or test	Requirement paragraph	Test method paragraph
Bow	3.4	4.5.2
Twist	3.5	4.5.3
Squareness of cut	3.6	4.5.4
Pressurization 1/	3.8	4.5.6
VSWR 1/	3.9	4.5.7

1/ Unless otherwise specified (see 3.1) for fabricated waveguides.

4.4.1.3.1 Sampling plan. The sampling plan shall be based upon a zero defective sampling plan. The sample size shall be based on the inspection lot size from which the sample was selected for group A inspection. Acceptance shall be based upon a zero defective sampling plan.

4.4.1.3.2 Rejected lots. 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.

4.4.1.3.3 Disposition of sample units. Sample units which have passed all the group B inspection may be delivered on the contract.

4.4.1.4 Group C inspection. Group C inspection shall consist of the examinations and tests specified in table VI, in the order shown. Group C inspection shall be made on sample units selected from inspection lots which have passed group A and group B inspections.

TABLE VI. Group C inspection.

Examination or test	Requirement paragraph	Test method paragraph
Surface roughness- - - - - - - - - - - - Scratches - - - - - - - - - - - - - - - - - -	3.7 3.10	4.5.5 4.5.8

4.4.1.4.1 Sampling plan. The first two lengths of the production lot shall be tested. Thereafter one out of each 25 lengths shall be tested.

4.4.1.4.2 Failures. If one or more sample units fail to pass group C inspection, the lot shall be considered to have failed.

4.4.1.4.3 Disposition of sample units. Sample units which have been subjected to group C inspection shall not be delivered on the contract.

4.5 Methods of examination and test.

4.5.1 Visual and mechanical examination. Waveguides shall be examined to verify that the materials, design, construction, physical dimensions, finish, length, marking, perpendicularity, and workmanship are in accordance with the applicable requirements (see 3.2 through 3.3.3, 3.11 and 3.13).

4.5.1.1 Dimensions. Waveguides with 1-inch major outside dimension and over shall be measured at a point at least 1 inch from the end; waveguides with less than 1-inch major outside dimension shall be measured at least .5 inch from the end to ascertain that all dimensions are as specified (see 3.1) and that the waveguide is of the specified length (see 3.1). Eccentricity may be measured at any point around the periphery. For the purpose of determining conformance with the dimensional requirements prescribed herein, any measured value outside the specified limiting values for any dimension shall be construed as failing to meet specification requirements.

4.5.2 Bow (see 3.4). Bow is the departure from a straight longitudinal line connecting any two points 2 feet apart on the external surface of the waveguide without the effect of gravity or any other force. The waveguide shall be so positioned during measurement that gravity will not tend to increase or decrease the amount of bow. Measurements shall be made along any 2-foot portion of the total length.

4.5.3 Twist (see 3.5). The angle of twist of waveguide shall be measured as shown on figure 1 and as follows:

a. The waveguide shall be placed on a flat, horizontal reference plane. Waveguides with noticeable, flatwise, bow shall be positioned with the waveguide surface on the side of the convex curvature in contact with the reference plane.

b. One end of the waveguide surface shall be held in intimate contact with the reference plane by suitable means while the other end of the waveguide remains free.

c. Using an engraved, transparent, protractor segment, determine the angle line on the protractor which coincides to the nearest degree with the surface of the waveguide, while one edge of the protractor segment contacts, or is kept parallel to the reference plane by means of parallel face blocks.

4.5.4 Squareness of cut (see 3.6). The squareness of the cut of the waveguide shall be measured using an adjustable protractor.

4.5.5 Surface roughness (see 3.7). The average interior surface roughness of the waveguide shall be measured in accordance with ASME- B46.1, except flaws shall be included in the surface roughness measurement and the corner radius shall not be included in the measurement. Unless otherwise specified (see 3.1 and 6.2), surface roughness shall be measured across the grain over the full width of the waveguide interior surface, at the center of the waveguide length and 6 inches from the end of each length.

4.5.6 Pressurization (see 3.8) (unless otherwise specified (see 3.1), applicable to fabricated waveguide only). The waveguide shall be subjected to the internal air pressure, in pounds-force per square inch (lb_f/in^2), specified in table VII while immersed in water for at least 5 minutes. The water temperature shall be 68°F ± 10°F. Any bubbles coming from the edge seams of the waveguide shall be considered as leakage. Bubbles that are the result of entrapped air on the exterior surface of the waveguide shall not be considered as leakage.

TABLE VII. Pressurization.

Inside width (nominal)	Wall thickness (nominal)	Pressure
Inches	Inches	lbs-force/square inch
23.000	0.188	0.25
21.000	0.188	0.25
18.000	0.125	0.25
15.000	0.125	0.25
11.500	0.125	0.50
9.750	0.125	0.50
7.700	0.125	1.0
6.500	0.125	1.5
5.100	0.080	2.0
4.300	0.080	3.0

4.5.7 Voltage standing wave ratio (see 3.9) (unless otherwise specified (see 3.1) applicable to fabricated waveguide only). The voltage standing wave ratio (VSWR) of the waveguide shall be measured over the frequency range specified in table VIII. The test equipment shall be capable of providing a continuous measurement of VSWR over the required frequency ranges. A means shall be provided to produce a permanent record of the waveguide'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 provide the calculation used to obtain the calculated VSWR. The measurement system and permanent record shall be capable of differentiating a VSWR change of at least 0.02

TABLE VIII. Frequency range.

Inside width (nominal)	Frequency range	Inside width (nominal)	Frequency range
Inches	GHz	Inches	GHz
23.000	0.32 - 0.49	9.750	0.75 - 1.12
21.000	0.35 - 0.53	7.700	0.96 - 1.45
18.000	0.410 - 0.625	6.500	1.12 - 1.70
15.000	0.490 - 0.750	5.100	1.45 - 2.20
11.500	0.64 - 0.96	4.300	1.70 - 2.60

4.5.8 Scratches (see 3.10). Examination for scratches shall be 6 inches from each end and at the middle of the length.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When actual packaging of materiel is to be performed by DoD 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 activity within the Military Department or Defense Agency, or within the Military Department's System Command. 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.

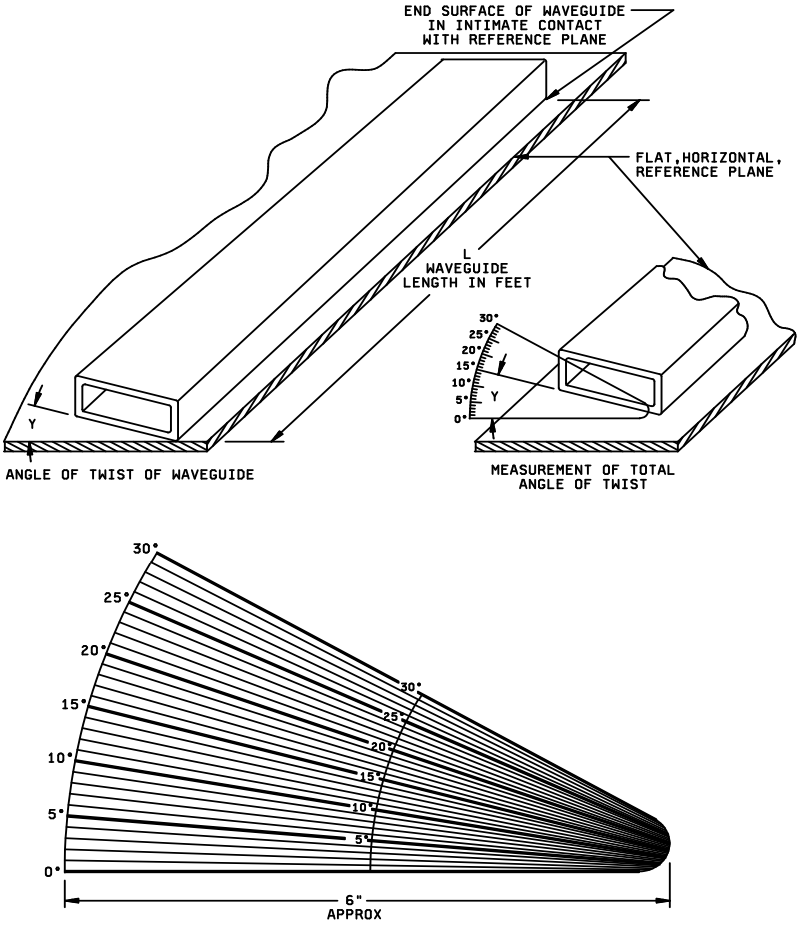

FIGURE 1. Method of determining twist.

6. NOTES:

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

6.1 Intended use. Waveguides covered by this specification are intended for use as transmission lines in military service radio and electronic equipment. For Naval applications, magnesium waveguides are for aeronautical use only. The waveguides herein specified must function in and withstand for prolonged periods worldwide military unique environments. These waveguides are military unique because the technology was pioneered by the military, and these devices are required for compatibility of form, fit and function with the many devices currently fielded. These devices are used because expensive changes to application systems would be required, if other than these standard military components were used. This specification is also subject to terms of international standardization agreement (see 6.4).

6.2 Ordering data. Acquisition documents should specify the following:

a. Title, number, and date of this specification.

b. ASSIST Online database at https://assist.daps.dla.mil/ should be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.1).

c. Packaging requirements (see 5.1).

d. The complete PIN (see 3.1 and 1.2).

e. Stock lengths (with or without ends) or specific lengths of waveguides required (see 3.3.2).

f. Special methods or increased frequency of checking surface roughness (see 4.5.5).

6.3 Engineering information. Additional engineering information for waveguides is available in MIL-HDBK-216, “RF Transmission Lines and Fittings,” copies are available upon request from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094; or at https://assist.daps.dla.mil/.)

6.4 International standardization agreement. Certain provisions of this specification are the subject of international standardization agreement NATO STANAG 4035. When amendment, revision, or cancellation of this specification is proposed which affects or violates the international agreement concerned, the preparing activity will take appropriate reconciliation action through international standardization channels including departmental standardization offices, if required. The United States, by international agreement (STANAG) has agreed to the use of the types of waveguides designated by NATO nomenclature, i.e., NWG-XXXX, in new equipment design. These NATO types are shown in the associated specification sheet, and should be used whenever possible.

6.5 Subject term (key word) listing.

Alloy
Bow
Electronic
Finish
Frequency range
GHz
Perpendicularity
Pressurization
Radio
Squareness
Surface roughness
Transmission lines
Twist
VSWR

6.6 Environmentally preferable material. Environmentally preferable materials should be used to the maximum extent possible to meet the requirements of this specification. As of the dating of this document, the U.S. Environmentally Protection Agency (EPA) is focusing efforts on reducing 31 priority chemicals. The list of chemicals and additional information is available on their website at http://www.epa.gov/osw/hazard/wastemin/priority.htm. Included in the list of 31 priority chemicals are cadmium, lead, and mercury. Use of the materials on the list should be minimized or eliminated unless needed to meet the requirements specified herein (see section 3).

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. Conformal 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 been shown to inhibit the growth of tin whiskers (see 3.2.8). For additional information on this matter, refer to ASTM-B545 (Standard Specification for Electrodeposited Coatings of Tin).

6.8 Changes from previous issue. The margins of this specification are marked with vertical lines to indicate modifications generated by this revision. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations.

Custodians:
Army - CR
Navy - EC
Air Force - 85
DLA - CC

Preparing activity:
DLA - CC

(Project 5985-2011-024)

Review activities:
Army - AR, AT, CR4, MI
Navy - AS, CG, MC, OS
Air Force - 19, 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 https://assist.daps.dla.mil.