

DETAIL SPECIFICATION

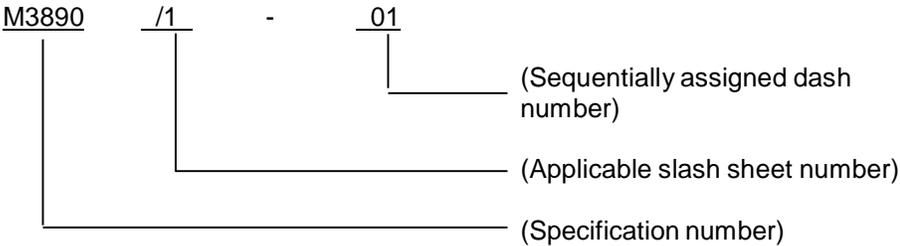
LINES, RADIO FREQUENCY TRANSMISSION
(COAXIAL, AIR DIELECTRIC), GENERAL
SPECIFICATION FOR

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

1. SCOPE

1.1 This specification covers the general requirements for radio frequency, coaxial, air dielectric copper and aluminum transmission lines (hereafter referred to as lines) (see 6.1).

1.2 Part or Identifying Number (PIN). The PIN consists of the letter “M” followed by the specification number, the associated slash sheet number and the sequentially assigned dash number.



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 cited in sections 3, 4 or 5 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 - VAI, P.O. Box 3990, Columbus OH 43218-3990 or email to RFconnectors@dsc.dla.mil
Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at <https://assist.dla.mil>.

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DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-DTL-5541 - Chemical Conversion Coating on Aluminum and Aluminum Alloys

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.dla.mil/> or from the Standardization Documents 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 B188 - Copper Bus Pipe and Tube, Seamless
ASTM B210 - Aluminum and Aluminum-Alloy Drawn Seamless Tubes
ASTM B372 - Copper and Copper-Alloy Seamless Rectangular Waveguide Tube

(Copies of these documents are available from <http://www.astm.org> or ASTM International, 100 Barr Harbor Dr., West Conshohocken, PA 19428-2959.)

SAE INTERNATIONAL

SAE-AMS-P-81728 - Plating, Tin-Lead (Electro-deposited)

(Copies of these documents are available at <http://www.sae.org> or SAE World Headquarters, 400 Commonwealth Drive, Warrendale, PA 15096-0001.)

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 conflict between the requirements of this specification and the specification sheet, the latter shall govern.

3.2 First article. When specified (see 6.2), a sample shall be subjected to first article inspection in accordance with 4.3.

3.3 Material. The material shall be as specified herein. However, when a definite material is not specified, a material shall be used which will enable the line 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.

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3.3.1 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.

3.3.1.1 Aluminum. Aluminum shall conform to 1100, temper H18 in accordance with SAE-AMS-WW-T-700/1 and shall be chemically treated inside and outside with class 3 chemical treatment in accordance with MIL-DTL-5541.

3.3.1.1.1 Aluminum alloy. Aluminum alloy shall conform to the chemical composition and tensile property requirements for 6061 or 6063 of ASTM B210.

3.3.1.2 Copper. Copper shall conform to type OF or DLP in accordance with ASTM B372 or ASTM B188.

3.3.1.2.1 Copper alloy. Copper alloy shall conform to commercial bronze, 90 percent, in accordance with ASTM B372.

3.4 Design and construction. Lines shall be of the design, construction, and overall physical dimensions specified (see 3.1).

3.4.1 Length. Unless otherwise specified (see 3.1), lines shall be furnished in 240-inch lengths. Lines ordered to specific or standard lengths shall conform to the tolerances in table I.

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

Length	Tolerance, inch (all plus)
Standard (20 ft)	0.5
Specific	
Up to 20 ft	0.25
Over 20 ft	0.75

3.4.2 Bow. The natural bow of the lines shall not depart from a straight line more than 0.5 inch (12.7mm) between any two points 10 feet apart on the external surface of the line. On lines less than 10 feet long, the allowable bow shall be .100 inch (2.54mm) between two points 2 feet apart.

3.4.3 Out-of-roundness. Unless otherwise specified (see 3.1), the outer and inner diameter of the conductors at any cross section shall not differ more than 1 percent from the specified diameter.

3.5 Attenuation. When lines are tested as specified in 4.5.2, the attenuation shall not exceed that specified (see 3.1).

3.6 Voltage standing wave ratio (VSWR). When lines are tested as specified in 4.5.3, the voltage standing wave ratio shall not exceed the value specified (see 3.1).

3.7 Characteristic impedance. When lines are tested as specified in 4.5.4, the characteristic impedance value shall not exceed the value specified (see 3.1).

3.8 Velocity of propagation. When lines are tested as specified in 4.5.5, the velocity of propagation value shall not be less than that specified (see 3.1).

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3.9 RF power handling capability (when specified, see 3.1). When tested as specified in 4.5.6, the lines shall meet the following requirements after each test:

Attenuation	Shall be as specified (see 3.1).
Voltage standing wave ratio	Shall be as specified (see 3.1).

3.10 Dielectric withstanding voltage. When tested as specified in 4.5.7, the lines shall show no evidence of voltage breakdown.

3.11 Vibration, high frequency. When tested as specified in 4.5.8, the lines shall meet the following requirements:

Attenuation	Shall be as specified (see 3.1).
Voltage standing wave ratio	Shall be as specified (see 3.1).

3.12 Pressurization (when specified, see 3.1). When lines are tested as specified in 4.5.9, there shall be no loss of pressurization as indicated by bubbles.

3.13 Marking. Marking shall be in accordance with MIL-STD-1285 and shall be on each length of line at intervals of not more than 1.5 feet. The manufacturer's name or trademark may also be marked on the lines provided such letters are not expressly forbidden in the contract or order, and their height does not exceed 0.5 inch (12.7mm).

3.14 Workmanship. Lines shall be processed in such a manner as to be uniform in quality and shall be free from pits, corrosion, cracks, rough edges, chips, burrs, scratches, flaws and other defects that will affect life, serviceability, or appearance. The ends shall be cut square.

4. VERIFICATION

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

- a. First article inspection (see 4.3).
- b. Conformance inspection (see 4.4).
- c. Materials inspection (see 4.2).

4.2 Materials inspection. Materials inspection shall consist of certification supported by verifying data that the materials listed in table II, used in fabricating the lines are in accordance with the applicable referenced specifications or requirements prior to such fabrication.

TABLE II. Materials inspection.

Material	Requirement paragraph	Applicable specification or publication
Aluminum	3.3.1.1	SAE-AMS-WW-T-700/1
Aluminum alloy	3.3.1.1.1	ASTM B210
Chemical treatment	3.3.1	MIL-DTL-5541
Copper	3.3.1.2	ASTM B372 or
Copper alloy	3.3.1.2.1	ASTMB188

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4.3 First article inspection. First article inspection shall be performed by the supplier, after award of contract and prior to production, at a location acceptable to the Government. First article inspection shall be performed on sample units which have been produced with equipment and procedures normally used in production. First article approval is valid only on the contract or purchase order under which it is granted unless extended by the Government to other contracts or purchase orders.

4.3.1 Sample size. Four lengths of a given size line shall be subjected to first article testing as follows:

.375 inch (9.52mm)
.875 inch (22.22mm)
1.625 inch (41.27mm)
3.125 inch (79.37mm)
6.125 inch (155.57mm)

4.3.2 Inspection routine. Sample units shall be subjected to first article inspection specified in table III in the order shown. All sample units shall be subjected to the inspection of group I. The sample units shall then be divided equally into two groups of two sample units each and subjected to the inspection for their particular group.

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

4.4 Conformance inspection.

4.4.1 Inspection of product for delivery. Inspection of product for delivery shall consist of groups A and B inspection.

4.4.1.1 Inspection lot. An inspection lot shall consist of all the lines 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 the examinations and tests specified in table IV and shall be made on the same set of sample units, in the order shown.

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TABLE III. First article inspection.

Examination or test	Requirement paragraph	Method paragraph
Group I (all sample units)		
Visual and mechanical examination	3.1, 3.3 thru 3.4 incl. 3.13 and 3.14	4.5.1
Attenuation	3.5	4.5.2
VSWR	3.6	4.5.3
Characteristic impedance	3.7	4.5.4
Velocity of propagation	3.8	4.5.5
Group II (two sample units)		
RF power handling capability (when specified)	3.9	4.5.6
Dielectric withstanding voltage	3.10	4.5.7
Group III (two sample units)		
Vibration, high frequency	3.11	4.5.8
Pressurization (when specified)	3.12	4.5.9

TABLE IV. Group A inspection.

Examination or test	Requirement paragraph	Method paragraph
Visual and mechanical examination	3.1, 3.3 thru 3.4 incl 3.13 and 3.14	4.5.1
Attenuation	3.5	4.5.2
VSWR	3.6	4.5.3
Characteristic impedance	3.7	4.5.4
Velocity of propagation	3.8	4.5.5

4.4.1.2.1 Sampling plan. Table IV tests shall be performed on a production lot basis. Samples shall be selected in accordance with table V. If one or more defects are found, the lot shall be screened for that particular defect and defects removed. A new sample of parts shall be selected in accordance with table V and all group A tests again performed. If one or more defects are found in the second sample, the lot shall be rejected and shall not be supplied to this specification.

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TABLE V. Inspection level.

Lot size	Visual and mechanical inspection	
1 to 15	Amount produced	
16 to 280		16
281 to 1,200		47
1,201 to 3,200		53
3,201 to 10,000		68
10,001 to 35,000		77
35,001 to 150,000		96
150,001 to 500,000		119
500,001 to over		143

4.4.1.2.1.1 Rejected lots. If an inspection lot is rejected after group A and B inspection, the lot shall not be supplied to the contract order or purchase order. In cases where the defect(s) are minor in nature, such as smudged marking, the contractor may contact the qualifying activity for permission to screen the lot to remove defective parts or rework the lot. The qualifying activity shall be contacted for guidance in such situations. Rejected lots shall be kept separate and shall not lose their identity.

4.4.1.3 Group B inspection. Group B inspection shall consist of the test specified in table VI and shall be made on sample units which have been subjected to and have passed the group A inspection.

TABLE VI. Group B inspection.

Test	Requirement paragraph	Method paragraph
Dielectric withstanding voltage	3.10	4.5.7

4.4.1.3.1 Sampling plan. A sample of parts shall be randomly selected in accordance with table VII. If one or more defects are found, the lot shall be screened for that particular defect and defects removed. After screening and removal of defects, a new sample of parts shall be randomly selected and subjected to all tests in accordance with table VII. If one or more defects are found in the second sample, the lot shall be rejected and shall not be supplied to this specification.

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TABLE VII. Inspection level.

Lot size	Sample size
1 to 8	Amount produced
9 to 90	5
91 to 150	11
151 to 280	13
281 to 500	16
501 to 1,200	19
1,201 to 3,200	23
3,201 to 10,000	29
10,001 to 35,000	35
35,001 to over	40

4.4.1.3.2 Disposition of sample units. Sample units which have passed all the group B inspection may be delivered on the contract or purchase order, if the lot is accepted.

4.4.2 Test equipment and inspection facilities. Test equipment and inspections facilities shall be of sufficient accuracy, reliability, and quantity to permit performance of the required inspection to the satisfaction of the Government.

4.5 Method of examination and test.

4.5.1 Visual and mechanical examination (see 3.1, 3.3 through 3.4 incl., 3.13 and 3.14). Lines shall be examined to verify that the material, design, construction, physical dimensions, marking, and workmanship are in accordance with the applicable requirements.

4.5.2 Attenuation (see 3.5). The attenuation of the lines shall be measured over the specified frequency range (see 3.1). The test equipment shall be capable of providing a continuous measurement of attenuation over the required frequency ranges. A means shall be provided for producing a permanent record of the line attenuation versus frequency. If attenuation is not directly measured; that is, if return loss is measured and attenuation is calculated from that measurement, the permanent record shall indicate the worst case attenuation numerically for each frequency band and shall provide the calculation used to obtain the calculated attenuation. The length of the test sample shall be 100 feet (minimum).

4.5.3 VSWR (see 3.6). The VSWR of the lines shall be measured over the specified frequency range (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 line 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 length of the test sample shall be 100 feet (minimum).

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4.5.4 Characteristic impedance (see 3.7). The characteristic impedance of the lines shall be measured with Time Domain Reflectometry (TDR) equipment or other methods that are approved by the procuring activity. The TDR equipment shall have a total system response of 150 pico-seconds and shall provide for a resolution of 0.1 ohm throughout the length of the line. The test results shall be displayed on calibrated rectangular coordinates and a permanent record of the test results shall be produced. A section of air line with a calibrated impedance of 50.0 ± 0.15 ohms is required as a reference.

4.5.5 Velocity of propagation (see 3.8). The velocity of propagation of the lines shall be determined as follows:

4.5.5.1 Test equipment. The following test equipment shall be utilized:

- a. A microwave sweep oscillator with a frequency range that covers the specified frequency range of the assembly.
- b. An analyzer with suitable readout features.
- c. A phase bridge with a measurement accuracy of ± 0.1 degree.
- d. A calibrated section of air line whose length equals the length of the line under test.

4.5.5.2 Test procedures:

- a. Calibrate the system over that portion of the specified frequency range of the line that will be within the limits of 4.5.5.1c with required adapters inserted in the leg of the phase bridge to be used for the line.
- b. Insert the line into the appropriate leg of the phase bridge and an equal length of air line in the other leg. Note the length (L) of the line.
- c. Using the phase bridge, adjust the electrical length of the air line leg to obtain a phase balance across the frequency range of 4.5.5.2a. Note the added length (ΔL).
- d. Calculate velocity of propagation (VP) of calibration line as follows:

$$VP = \left(\frac{L}{L + \Delta L} \right) \times 100\%$$

- e. Sweep over the specified frequency of the assembly. Note maximum deviation (ϕ in degrees) from calibration line.
- f. Calculate minimum velocity of propagation VP (min) as follows:

$$VP(\text{min}) = \frac{L}{L + \Delta L + \left(\frac{\phi c}{360 f} \right)}$$

where:

C is the velocity of propagation in free space

f is the frequency (in Hz) at which ϕ was measured

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4.5.6 RF power handling capability (see 3.9) (when specified, see 3.1). The power handling capability shall be determined by subjecting the lines to average RF power at the specified lowest frequency, VSWR of unity (as nearly as possible), one atmosphere of dry air (40% relative humidity maximum) pressure at sea level and the highest temperature continuously for 30 minutes or until the line temperature stabilizes, whichever comes first. The lines shall also be subjected to peak power at the specified lowest frequency and the highest temperature for 30 minutes or until the line temperature stabilizes, whichever comes first. The lines shall be terminated in a matched load. Following each power test, attenuation and VSWR shall be measured as specified in 4.5.2 and 4.5.3, respectively.

4.5.7 Dielectric withstanding voltage (see 3.10). The lines shall be tested in accordance with method 301 of MIL-STD-202. The following details shall apply:

- a. Conditions of test. One atmosphere of dry air (40% relative humidity) pressure at sea level.
- b. Duration of application. When the specified test voltage (see 3.1) is:
 - (1) Less than 1,500 volts rms, the voltage shall be instantaneously applied.
 - (2) Above 1,500 volts rms, the voltage shall be applied at approximately 500 volts per second until the rated test voltage is reached or breakdown occurs.
- c. Points of application. The 60-cycle voltage shall be applied between the inner conductor and the outer conductor of the line.

4.5.8 Vibration, high frequency (see 3.11). The lines shall be tested in accordance with method 204 of MIL-STD-202. The following details shall apply:

- a. Method of mounting – Clamp the lines to the table. No part of the lines shall touch any object other than the clamps (one clamp at each end and one in the middle if required).
- b. Test condition letter – B.
- c. Examination after test – Attenuation and VSWR shall be measured as specified in 4.5.2 and 4.5.3.

4.5.9 Pressurization (when specified) (see 3.12). With the line ends properly sealed, the line shall be subjected to the internal gas pressure specified (see 3.1) for at least 20 seconds while immersed in tap water at a temperature of approximately 20°C. Unless otherwise specified (see 3.1), the internal gas pressure shall be 30 ± 1 pound per square inch. During immersion, the lines shall be observed for evidence of leakage as indicated by escaping air bubbles.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When packaging of material is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain 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 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.

6. NOTES

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

6.1 Intended use. Transmission lines are used to transmit RF energy in the microwave region of the spectrum.

6.2 Acquisition requirements. Acquisition documents should specify the following:

- a. Title, number, and date of the specification.
- b. Issue of DoDISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.2 and 2.3).
- c. Packaging requirements (see 5.1).
- d. The supplier will not substitute for a specified material or combination of fabricated parts (see 3.3) unless he obtains approval from the Government. Evidence to substantiate his claim that such a substitution is suitable and is to be submitted with his request. Similar notification and substantiating evidence will be submitted at any later time if substitution becomes necessary or desirable. At the discretion of the Government, test sample units may be required to prove the suitability of the proposed substitute.

6.3 Subject term (key word) listing.

Copper

6.4 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. Environmental 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 EPA list of 31 priority chemicals are cadmium, lead, and mercury. Use of these materials should be minimized or eliminated unless needed to meet the requirements specified herein (see Section 3).

6.5 Changes from previous issue. The margins of this specification are marked with vertical lines to indicate where changes from the previous issue were made. 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 and relationship to the last previous issue.

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CONCLUDING MATERIAL

Custodians:

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

Preparing activity:

DLA - CC

(Project 5985-2013-022)

Review activities:

Army - AR, CR4, MI
Navy - AS, MC, OS, SH
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.dla.mil>.