AEROSPACE RECOMMENDED PRACTICE

ARP81490™	REV. B
Issued 2004-04 Revised 2016-01 Stabilized 2020-10 Superseding ARP81490A	

Transmission Lines, Transverse Electromagnetic Mode

RATIONALE

The SAE AE-8A Electrical Wiring & Fiber Optic Interconnect Systems Installation Committee has determined the ARP81490B recommended practice has well established technical requirements and no longer needs periodic review for currency.

STABILIZED NOTICE

This document has been declared "Stabilized" by the SAE AE-8A Elec Wiring and Fiber Optic Interconnect Sys Install Committee and will no longer be subjected to periodic reviews for currency. Users are responsible for verifying references and continued suitability of technical requirements. Newer technology may exist.

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1. SCOPE

This document covers the general recommendations for Transverse Electromagnetic Mode (TEM) Transmission Lines intended for use in airborne systems (see 6.2.14). For U.S military applications, TEM Transmission Lines shall meet the requirements in accordance with MIL-T-81490. The follow index lists the recommended requirements and methods covered by the Aerospace Recommended Practice (ARP):

Table 1 - TEM transmission lines recommended requirements

Examination or Test	Para.	Examination or Test	Para.
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Phase Characteristics	3.4.4.9	Marking	3.6
Vapor Leakage	3.4.5.1	Workmanship	3.7
Vibration	3.4.5.2	Quality Assurance Provisions	4.
Impact Shock	3.4.5.3	Methods of Inspection	4.8
Flexure	3.4.5.4	Calculation Method	Appx A

1.1 Classification

The TEM transmission lines covered by this specification should consist of the following types and classes (see 6.2.3).

1.1.1 Types

Type I - Designed for use in the 2.0 to 8.0 GHz range.

Type II - Designed for use in the 2.0 to 16.0 GHz range.

1.1.2 Classes

Class 1 - Flexible construction.

Class 2 - Semi flexible construction.

Class 3 - Rigid construction.

2. APPLICABLE DOCUMENTS

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AS4461	Assembly and Soldering Criteria for High Quality/High Reliability Soldering Wire and Cable Termination in Aerospace Vehicles
AS5756	Cable, Power, Electrical, Portable General Specification For
AIR6151	Torque, Threaded Application, Electrical Connector, Accessory and Terminal Board Installation
AMS2629	Fluid, Jet Reference
AMS-QQ-S-763	Steel, Corrosion Resistant, Bars, Wire, Shapes, and Forgings

2.2 Government Publications

Copies of these documents are available online at http://quicksearch.dla.mil.

MIL-STD-171	Finishing of Metal and Wood Surfaces
MIL-STD-202	Test Methods for Electronic and Electrical Component Parts
MIL-HDBK-454	General Guidelines for Electronic Equipment
MIL-HDBK-781	Reliability Test Methods, Plans, and Environments for Engineering Development, Qualification, and Production
MIL-STD-810	Environmental Engineering Considerations and Laboratory Tests

MIL-PRF-5606 Hydraulic Fluid, Petroleum Base, Aircraft, Missile, and Ordnance

MIL-DTL-5624 Turbine Fuel, Aviation, Grades JP-4 and JP-5

MIL-R-81294 Remover, Paint, Epoxy, Polysulfide and Polyurethane Systems

MIL-T-81490 Transmission Lines, Transverse Electromagnetic Mode

MIL-DTL-83113 Turbine Fuel, Aviation, Kerosene Type, JP-8 (NATO F-34), NATO F-35, and JP-8+100 (NATO F-37)

SAM System for Award Management*

*Available from https://www.sam.gov/portal/public/SAM/.

2.3 Non-Government Publications

ELECTRONIC COMPONENT INDUSTRY ASSOCIATION (ECIA) PUBLICATIONS

Available from Electronic Component Industry Association (ECIA), 1111 Alderman Drive, Suite 400, Alpharetta, GA 30005, Tel: 678-393-9990, www.ecianow.org.

EIA RS359 Standard Colors for Color Identification and Coding

ANSI ACCREDITED PUBLICATIONS

Copies of these documents are available online at http://webstore.ansi.org.

ANSI/NCSL-Z540.3 Calibration of Measuring and Test Equipment, Requirements for

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) PUBLICATIONS

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM B194 Copper-Beryllium Alloy Plate, Sheet, Strip and Rolled Bar

ASTM B196 Copper-Beryllium Alloy Rod and Bar

ASTM B197 Copper Beryllium Alloy Wire

ASQ PUBLICATIONS

Available from American Society for Quality, 600 North Plankinton Avenue, Milwaukee, WI 53203, Tel: 800-248-1946 (United States or Canada)), 001-800-514-1564 (Mexico) or +1-414-272-8575 (all other locations), www.asq.org.

ASQC-Z1.4 Sampling Procedures and Tables for Inspection by

3. REQUIREMENTS

3.1 Detail Drawings

The individual TEM transmission line recommended requirements should be as specified herein and in accordance with the applicable User detail drawings (see 6.4.4). In the event of any conflict between requirements of this specification and the detail drawings, the latter should govern.

3.2 Materials

Materials should be as specified herein or in the detail drawing; however, when a definite material is not specified, materials used are recommended to meet the performance requirements of this specification. When dissimilar metals are employed in intimate contact with each other, protection against electrolytic corrosion should be provided as specified in MIL-HDBK-454, Requirement 16.

3.2.1 Fungus-Inert Material

Materials should be fungus resistant and should be in accordance with MIL-HDBK-454, Requirement 4.

3.2.2 Solder and Soldering

Solder and soldering should be as specified in AS4461, except the solder should have a minimum solidus temperature of +450 °F (+234 °C).

3.2.3 Plating of Conductive Surfaces

Plating may be used on the conductive surfaces, except that silver surfaces should not be gold plated.

3.2.4 Contacts

3.2.4.1 Center Contacts

Center contacts should be made of suitable conductive material that meets the requirements of 3.2 when interfaced with copper-beryllium per ASTM B196, ASTM B197, or ASTM B194. The center contact, the dielectric material, and all other parts should be permanently captivated in both directions along the axis of the appropriate interfaces.

3.2.4.2 Outer Contacts

Outer contacts should be made of suitable conductive material that meets the requirements of 3.2 when interfaced with both copper-beryllium per ASTM B196, ASTM B197, or ASTM B194, and steel, corrosion resisting per AMS-QQ-S-763 that has been passivated per MIL-STD-171.

3.2.5 Coupling Nuts

Coupling nuts and outer structural members of the interface component, intermediate interface component, and replaceable interface component should be made of steel, corrosion resisting per AMS-QQ-S-763 that has been passivated per MIL-STD-171. Other metal parts used to assemble these items should meet the requirements of 3.2.

3.3 Design and Construction

The design, construction and physical dimensions of TEM transmission lines should be as specified herein and the detail drawings (see 3.1).

3.3.1 Interfaces and Interface Components

3.3.1.1 Primary Interfaces

Primary interfaces should be specified in accordance with the detail drawings and should conform to the requirements of Figures 9 through 14. The primary interfaces are recommended to be restricted to the following precision types listed in Table 2.

Table 2 - Primary interfaces

Type	Figure	Description
1 Male	9	Similar to TNC Male
1 Female	10	Similar to TNC Female
2 Male	11	
2 Female	12	Similar to SC Male
		Similar to SC Female
3 Male 1/	13	
3 Female 1/	14	Similar to N Male
		Similar to N Female

1/ Type 3 Male and Female primary interfaces are not recommended for use. These types are included in this document for the sole purpose of retrofitting existing equipment or systems.

3.3.1.2 Intermediate Interfaces

The design and construction of intermediate interfaces (see 6.2.8) should be the option of the manufacturer. The manufacturer is recommended to do the following:

3.3.1.2.1 The manufacturer should develop and standardize one size and configuration of intermediate interface for Type I TEM transmission lines. The intermediate interface should be compatible with all styles of replaceable interface components specified herein for Type I TEM transmission lines.

3.3.1.2.2 The manufacturer should develop and standardize one size and configuration of intermediate interface for Type II TEM transmission lines. The intermediate interface should be compatible with all styles of replaceable interface components specified herein for Type II TEM transmission lines.

3.3.1.2.3 Intermediate interfaces should be constructed so that the center contact does not extend beyond the coupling ring and is protected from damage during handling and installation.

3.3.1.3 Replaceable Interface Components

Replaceable interface components should be as specified in the detail drawing and should conform to the requirements of Figures 15, 16, and 17. In addition, replaceable interface components should have the required primary interfaces specified in the detail drawings. Replaceable interface component styles and descriptions are listed in Table 3.

Table 3 - Replaceable interface components

Style	Figure	Description
A	15	Straight
B	16	90 degree elbow
C	17	Angular

3.3.1.3.1 Unless otherwise specified in the detail drawing, replaceable interface components should not be used on TEM transmission lines less than 3 feet long.

3.3.1.3.2 Unless otherwise specified in the detail drawing, TEM transmission lines more than 3 feet but less than 10 feet long should be provided with replaceable interface components.

3.3.1.3.3 Replaceable interface components should be provided on TEM transmission lines that are greater than 10 feet long.

3.3.1.3.4 The User should mandate the required dimensions for styles A, B, and C replaceable interface components in the detail drawing. If the system requirements are such that a special replaceable interface component is required, the User should mandate the special replaceable interface component on the detail drawing. The special replaceable interface component should not compromise the serviceability, maintainability, or performance of the TEM transmission line as detailed in this document.

3.3.2 Weight

The TEM transmission line should be designed for minimal weight consistent with good engineering practices.

3.3.3 Bonding, Conductivity, Discontinuities

The mating surfaces between all metallic parts intentionally designed to be electrically continuous to RF currents should be clean and, as required, suitably plated metal surfaces free from anodic film, grease, paint, lacquer, or other high-resistance film.

3.3.4 Pressurization

Any design feature requiring the User to pressurize the TEM transmission line with air or any other gas is not recommended. For U.S. military application it prohibited unless specified by contract.

3.3.5 Surface Finish

Dimensions of metal parts should include any plating or finish applied to meet electrical, mechanical or service condition requirements. Surface roughness on machined surfaces should be 63 µin maximum.

3.3.6 Installation Design Features

3.3.6.1 Primary interfaces should be provided with torque wrench flats in accordance with Figure 18.

3.3.6.2 Intermediate interfaces should be provided with spanner wrench holes in accordance with Figure 19.

3.3.6.3 Primary interfaces should be provided with a minimum of three equally spaced safety wire holes whose diameters should be 0.027 minimum.

3.4 Performance

TEM transmission lines should meet the performance requirements specified herein and the detail drawing when tested in accordance with the methods of inspection specified in 4.8.

3.4.1 Inspection Criteria

The parameters specified herein and the detail drawing should be adjusted in accordance with the procedures specified in 4.1.

3.4.2 Coupled Components

Interface components and replaceable interface components should be capable of meeting all electrical, mechanical and service condition requirements recommended in this document when connected to mating EW precision counterparts with the coupling nuts torqued to the values specified in Table 4:

Table 4 - Coupling torqued

Type	Torque (in-lb)
1	23 ± 3
2	23 ± 3
3	23 ± 3

In addition, replaceable interface components should be capable of meeting all electrical, mechanical and service condition requirements recommended in this document when connected to mating intermediate interface components with the associated coupling nuts torqued to a value of 45 in-lb ± 5 in-lb. At this value, there should be metal-to-metal bottoming.

3.4.3 Center Contact Stability

In the unmated condition, center contacts of all interface components and replaceable interface components should be capable of withstanding an axial force of 6 pounds for 1 minute when applied in either direction without displacement outside the specified dimensions that locate the center contact.

3.4.4 Electrical

3.4.4.1 RF Insertion Loss

RF insertion loss requirements should be as recommended herein and in the detail drawing (see 6.2.4).

3.4.4.1.1 Insertion Loss

When tested in accordance with 4.8.3 Procedure I, the RF insertion loss should not exceed the values shown in the detail drawing.

3.4.4.1.2 Insertion Loss Uniformity (Fine Structure)

When tested in accordance with 4.8.3 Procedure II, the maximum fine structure variation (see 6.2.5) should not exceed the values of Table 5 for the indicated frequency ranges (see Figure 20) and, as required, the usage of replaceable interface components as recommended in the detail drawing.

Table 5 - Maximum allowable fine structure variation

Frequency Range (GHz)	TEM Transmission Lines with: Interface Components or Style A Replaceable Interface Components	TEM Transmission Lines with: One or Two Style B or C Replaceable Interface Components
2.0 - 8.0	0.15 dB	0.25 dB
8.0 - 16.0	0.20 dB	0.30 dB

3.4.4.1.3 Insertion Loss Stability

When tested in accordance with 4.8.3, Procedure III, the variation in insertion loss should not be greater than 0.1 dB.

3.4.4.1.4 Determination of Maximum Allowable RF Insertion Loss

The maximum allowable RF insertion loss for a TEM transmission line should be determined in accordance with the procedure set forth in Appendix A.

3.4.4.1.4.1 The maximum allowable RF insertion loss for TEM transmission lines less than 2 feet in length should be calculated as though the lines were 2 feet in length.

3.4.4.1.5 Plot of RF Insertion Loss Curve

The maximum allowable RF insertion loss values determined by the procedure in Appendix A should be plotted on the applicable graph form recommended in Appendix A for the required type of TEM transmission line. The two points should be connected by a straight line. The plot of the maximum allowable RF insertion loss should be shown in the detail drawing.

3.4.4.1.6 The RF insertion loss for replaceable interface components (Table 6) should not be greater than that specified throughout the applicable frequency range when tested as specified in 4.8.3 Procedure IV.

Table 6 - RF insertion loss - replaceable interface components

Primary Interface Type	Frequency Range	Maximum RF Insertion Loss	
		Style A	Styles B & C
1	2.0 - 8.0 GHz	0.15 dB	0.20 dB
1	8.0 - 16.0 GHz	0.20 dB	0.30 dB
2	2.0 - 8.0 GHz	0.15 dB	0.20 dB
3	2.0 - 8.0 GHz	0.15 dB	0.20 dB

3.4.4.2 Voltage Standing Wave Ratio (VSWR)

When tested in accordance with 4.8.4 Procedure I, the VSWR for TEM transmission lines should not exceed the values specified in Table 7.

Table 7 - Maximum allowable VSWR for TEM transmission lines

Frequency Range (GHz)	Interface Components or Style A Replaceable Interface Components	Style B or C Replaceable Interface Components
2.0 - 4.0	1.20:1.0	1.25:1.0
4.0 - 8.0	1.25:1.0	1.30:1.0
8.0 - 12.0	1.30:1.0	1.35:1.0
12.0 - 16.0	1.35:1.0	1.40:1.0

3.4.4.2.1 VSWR Stability

When tested in accordance with 4.8.4 Procedure II, the VSWR of the TEM transmission line should not vary more than 0.05.

3.4.4.2.2 The Voltage Standing Wave Ratio (VSWR) for replaceable interface components (Table 8) should not be greater than that recommended throughout the applicable frequency range when tested as specified in 4.8.4 Procedure III.

Table 8 - VSWR - replaceable interface components

Primary Interface Type	Frequency Range	Maximum VSWR	
		Style A	Styles B & C
1	2.0 - 8.0 GHz	1.05:1.0	1.07:1.0
1	8.0 - 16.0 GHz	1.08:1.0	1.12:1.0
2	2.0 - 8.0 GHz	1.05:1.0	1.07:1.0
3	2.0 - 8.0 GHz	1.05:1.0	1.07:1.0

3.4.4.3 Impedance

When tested in accordance with 4.8.5 Procedure I, the characteristic impedance of the TEM transmission line should be 50.0 Ω ± 1.0 Ω.

3.4.4.3.1 Impedance Uniformity (Peak to Peak Variation)

When tested in accordance with 4.8.5 Procedure II, the peak to peak variation of impedance (see 6.2.11) should not exceed 1.0 Ω.

3.4.4.4 Velocity of Propagation

Unless otherwise recommended in the detail drawing (see 6.2.4), the velocity of propagation should not be less than 72% when tested in accordance with 4.8.7.

3.4.4.5 Radio Frequency (RF) Leakage

When tested in accordance with 4.8.8 the RF leakage power ratio should not be greater than -90 dB per foot at any point on the TEM transmission line including connectors.

3.4.4.6 Power Handling Capability

3.4.4.6.1 Continuous Power Handling Capability

When tested in accordance with 4.8.13 Procedure I, the continuous power handling capability of the TEM transmission line should not be less than the value specified in Table 9.

Table 9 - Power handling capability

Cable Type (see 1.2)	Input Power Rating 1/		Test Frequency (GHz)
	Continuous Power	Peak Power	
I	450 W	12.0 KW	8.0
II	60 W	6.0 KW	16.0

1/ Ratings established for non-heat-sinked connector pairs exposed to +360 °F/ 70,000 feet altitude environment.

3.4.4.6.2 Peak Power Capability

When tested in accordance with 4.8.13 Procedure II, the peak power handling capability of the TEM transmission line should not be less than the value specified in Table 9.

3.4.4.7 High Potential Withstanding Voltage (HPWV)

The high potential withstanding voltage rating for TEM transmission lines should be as specified in Table 10. If two different interface types are required on the TEM transmission line, the high potential withstanding voltage rating of the TEM transmission line should be that of the interface type with the lower rating. When tested as specified in 4.8.24 Procedure I, there should be no evidence of voltage breakdown.

3.4.4.7.1 Replaceable interface components (see Table 11) should be capable of withstanding the listed voltages without evidence of breakdown when tested in accordance with the High Potential Withstand Voltage test method specified in 4.8.24, Procedure II.

Table 10 - High potential withstanding voltage ratings for TEM transmission lines

Interface Type (see 3.5.1)	Rating at Sea Level	Rating at 70,000 feet
1	3,000 V (RMS)	1,800 V (RMS)
2	5,000 V (RMS)	3,000 V (RMS)
3	2,500 V (RMS)	1,500 V (RMS)

Table 11 - HPWV - replaceable interface components

Primary Interface Type	Test Voltage
1	3.0 KV (RMS)
2	5.0 KV (RMS)
3	2.5 KV (RMS)

3.4.4.8 Explosive Atmosphere

When tested as specified in 4.8.21, the TEM transmission line should operate satisfactorily in an explosive atmosphere environment.

3.4.4.9 Phase Characteristics

When required, phase characteristics should be recommended in the detail drawing. Required test methods should also be recommended in the detail drawing and should be in accordance with the requirements of 4.7 (see 6.2.4).

3.4.5 Mechanical

3.4.5.1 Vapor Leakage

When tested as specified in 4.8.6, the TEM transmission line should have a leakage rate of less than 1 $cm^3/s/ft \times 10^{-5}$ $cm^3/s/ft$ of length.

3.4.5.2 Vibration

When tested as specified in 4.8.12, the TEM transmission line should meet the requirements of 3.4.4.1, 3.4.4.2, and 3.4.5.1.

3.4.5.3 Impact Shock

When tested as specified in 4.8.14, the TEM transmission line should meet the requirements of 3.4.4.1, 3.4.4.2, and 3.4.5.1.

3.4.5.4 Flexure

When tested as specified in 4.8.15, TEM transmission lines should meet the requirements of 3.4.4.1, 3.4.4.2, and 3.4.5.1.

3.4.5.5 Torque

When tested as specified in 4.8.16, the TEM transmission line should meet the requirements of 3.4.4.1, 3.4.4.2, and 3.4.5.1.

3.4.5.6 Tensile Load

When tested as specified in 4.8.17, the TEM transmission line should meet the requirements of 3.4.4.1, 3.4.4.2, and 3.4.5.1.

3.4.5.7 Concentrated Load

When tested as specified in 4.8.18, the TEM transmission line should meet the requirements of 3.4.4.1, 3.4.4.2, and 3.4.5.1.

3.4.5.8 Abrasion

When tested as specified in 4.8.19, the TEM transmission line should meet the requirements of 3.4.4.1, 3.4.4.2, and 3.4.5.1.

3.4.6 Environmental

3.4.6.1 Temperature

The operating temperature test conditions should be from -65 to +392 °F (-54 to +200 °C). When tested as specified in 4.8.9, the TEM transmission line should meet the requirements of 3.4.4.1, 3.4.4.2, and 3.4.5.1.

3.4.6.2 Altitude

The operating altitude test conditions should be from 0 to 70,000 feet (30.0 to 1.32 inches of mercury). When tested as specified in 4.8.10, the TEM transmission line should meet the requirements of 3.4.4.7.

3.4.6.3 Thermal Shock

When tested as specified in 4.8.11, the TEM transmission line should meet the requirements of 3.4.4.1, 3.4.4.2, and 3.4.5.1.

3.4.6.4 Chemical resistance

When tested as specified in 4.8.20, the TEM transmission line should meet the requirements of 3.4.4.1, 3.4.4.2, and 3.4.5.1.

3.4.6.5 Humidity

When tested as specified in 4.8.22, the TEM transmission line should meet the requirements of 3.4.4.1, 3.4.4.2, 3.4.4.7, and 3.4.5.1.

3.4.6.6 Salt-Fog

When tested as specified in 4.8.23, the TEM transmission line should meet the requirements of 3.4.4.1, 3.4.4.2, and 3.4.4.7.

3.5 Reliability

3.5.1 Reliability Assurance Tests

When requested by the User, the manufacturer should establish a reliability program in accordance with the requirements of MIL-HDBK-781. The manufacturer should specify the "Minimum Acceptable MTBF (θ_1)" or the "Specified MTBF (θ_0)".

3.5.1.1 The design goal for expected operating life of a TEM transmission line is 5 years minimum.

3.6 Marking

3.6.1 Marking Nomenclature

In addition to any special markings specified in the detail drawing, the TEM transmission line and replaceable interface components should be marked as follows:

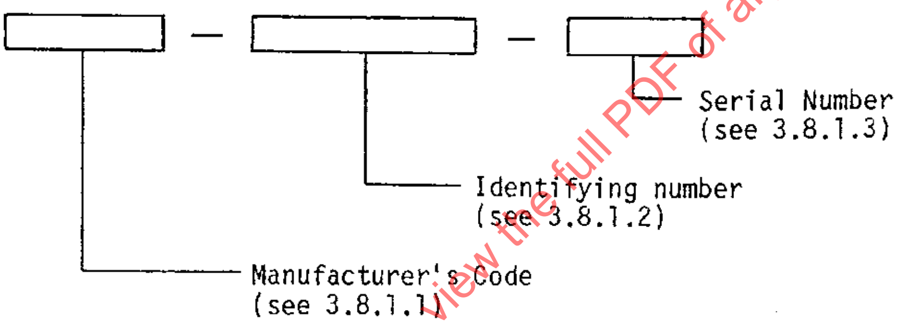


Figure 1 - Marking nomenclature

3.6.1.1 Manufacturer's Code

The applicable manufacturer's code as established in SAM should be used. The manufacturer is defined as the individual, firm, company or corporation engaged in the fabrication of finished TEM transmission lines or replaceable interface components.

3.6.1.2 Identifying Number

The identifying number should be assigned by the User and should be included in the detail drawing.

3.6.1.3 Serial Number

The serial number is generated by the manufacturer. It should consist of the following:

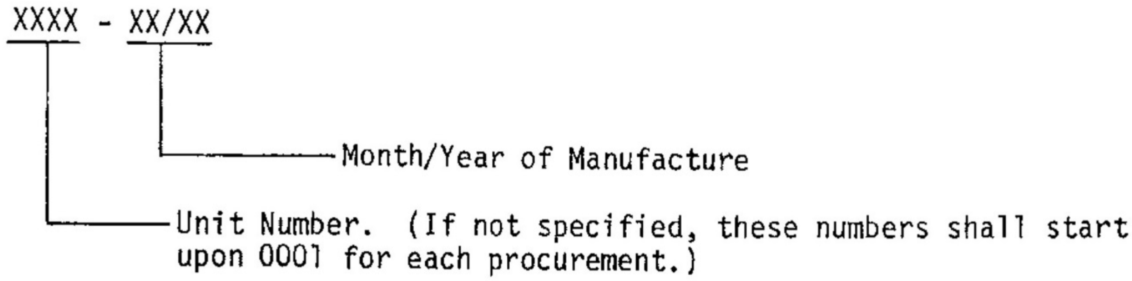


Figure 2 - Serial number

3.6.2 Method of Application

The required marking is applied to the product by a method selected by the manufacturer. The method selected should conform to the following:

a. Lettering types should be "Futura" or "Gothic" capitals and the numerals should be Arabic. Type size should be sufficient as to be clearly legible.

b. The markings should be of a permanent type and should be capable of withstanding the service conditions specified herein without degradation to itself or the required performances for the TEM transmission line.

c. Whenever practicable, the marking should be located so that it is visible when the TEM transmission line is installed. When the location of the marking is specified in the detail drawing, the marking should so be located.

3.6.3 Color-Coding

The outer covering of the TEM transmission line should be color-coded solid violet in accordance with EIA RS-359, preferred limits, throughout its entire length. Color-coding should be a permanent type and capable of withstanding the service conditions specified herein without degradation of required performances for the TEM transmission line.

3.7 Workmanship

The TEM transmission line should be processed in such a manner as to be uniform in quality and be free of defects that will affect performance, reliability or appearance.

3.7.1 Interfaces and associated metal parts should be free of sharp edges, burrs, damaged interface surfaces and contaminants.

3.7.2 The outer covering of the assembly should be free of cuts, dents, nicks, frayed or burned spot that might affect the appearance or performance of the TEM transmission line.

4. QUALITY ASSURANCE PROVISIONS

4.1 Establishment of Inspection Acceptance Criteria

The manufacturer is recommended to establish a inspection acceptance criteria for use in the performance of all inspection requirements herein. The following procedure is provided as a guide.

4.1.1 The manufacturer should prepare inspection plans that meet the requirements herein, the recommended quality conformance inspection (4.3) and methods of inspection (4.8). The plans should include the test equipment to be used for each test and should list the equipment brand names, model numbers and serial numbers (see 4.2).

4.1.2 The manufacturer should make an analysis of the test equipment, calibration system errors and measurement methods. From this analysis, can be calculated the maximum residual error band of uncertainly (6.2.1) of the measurement and test system.

4.1.3 The User should require the manufacturer to submit the inspection plans (see 4.1.1) and the analysis (see 4.1.2) to the User for review and establishment of inspection acceptance criteria.

4.1.4 The User mandate for TEM procurement the manufacturer's inspection acceptance criteria.

4.2 Test Equipment Calibration System

The manufacturer should establish and maintain a calibration system to control the accuracy of measurement and test equipment in accordance with the requirements of ANSI/NCSL-Z540.3 or equivalent.

4.3 Quality Conformance Inspection

A User should specify in every purchase order or contact Quality Conformance Inspection requirements. The following is recommended for TEM cable procurements (see 4.3.1 and 4.4 through 4.7).

4.3.1 Inspection of Product for Delivery

Inspection of TEM transmission lines for delivery is recommended to consist of Groups A and B inspection (see 4.4 and 4.5).

4.3.1.1 Inspection Lot

An inspection lot consist of all TEM transmission lines covered by one detail drawing, produced under the same conditions, and offered for inspection at one time.

4.3.1.2 Disposition of Sample Units

Sample units which have been subjected to the Group A inspection typically are delivered on the contract or order. Sample units which have been subjected to Group B inspection should not be delivered.

4.4 Group A Inspection

Group A inspection should consist of the examinations and tests specified in Table 12 and be performed in the order shown.

4.4.1 Sampling Plan

Statistical sampling and inspection should be in accordance with ASQC-Z1.4 for general inspection level II (see 6.2.16). The sample size should be as specified in Table 12.

Table 12 - Group A inspection quality conformance test plan

	Examination or Test	Requirement Paragraph	Test Paragraph	Sample Plan				
				AQL	100%	Lot size 1-50	51-99	100-Up
I	Examination of Product							
	Design and Construction	3.1, 3.5	4.8.1		X			
	Interface Gauging	3.5.1.1	4.8.2	0.4				
	Marking	3.8	4.8.1	1.0				
	Workmanship	3.9	4.8.1	1.0				
II	Electrical Tests							
	RF Insertion Loss	3.4.4.1	4.8.3		X			
	VSWR	3.4.4.2	4.8.4		X			
	Impedance	3.4.4.3	4.8.5			2	4	7
	Velocity of Propagation	3.4.4.4	4.8.7			2	4	7
	RF Leakage	3.4.4.5	4.8.8			2	4	7
III	Mechanical-Environmental							
	Vapor Leakage	3.4.5.1	4.8.6		X			
	Thermal Shock	3.4.6.3	4.8.11			2	4	7

4.4.2 Accept-Reject Criteria

Accept-reject criteria for each examination or test should be as specified in the applicable test paragraph. When specified, the acceptable quality level (AQL) should be as specified in Table 12. When discrete sample sizes are specified, the failure of a sample unit should constitute failure of the lot.

4.4.3 Rejected Lots

If an inspection lot is rejected, the manufacturer should withdraw the lot, rework it to correct the defects or screen out the defective units, as applicable, and reinspect. Such lots should be separate from new lots, and should be clearly identified as reinspected lots. Rejected lots should be reinspected using tightened inspection.

4.5 Group B Inspection

Group B inspection should consist of the applicable examinations and tests specified in Table 13, should be made on units previously inspected under Group A inspection, and should be performed in the sequence shown. Shipment should not be held up pending results of this inspection.

4.5.1 Sampling Plan

Each lot should be inspected with the sample size controlled by the requirements of Table 13.

Table 13 - Group B inspection quality conformance test plan

Examination or Test	Requirement Paragraph	Test Paragraph	Lot Size 1-24	25-49	50-74	75-99	100-Up
			Number of Samples Required 1	2	3	4	5
			Number of Samples To Be Tested				
Vibration	3.4.5.2	4.8.12	1	2	3	4	5
Flexure	3.4.5.4	4.8.15	1	2	3	4	5
Torque	3.4.5.5	4.8.16	1	2	3	4	5
Tensile Load	3.4.5.6	4.8.17	1	2	3	4	5
Chemical Resistance	3.4.6.4	4.8.20	1	2	2	2	2
Salt-Fog	3.4.6.6	4.8.23	1	2	2	2	2

4.5.2 Accept-Reject Criteria

Accept-reject criteria for each examination or test should be as specified in the applicable test paragraph. Failure of a sample unit should constitute failure of the lot.

4.5.3 Noncompliance

If a sample fails to pass Group B inspection should immediately contact the User, take corrective action on the materials or processes or both, as warranted, and on all units of product which can be corrected and which were manufactured under essentially the same conditions with essentially the same materials, processes, etc., and which are considered subject to the same failure. Acceptance of related lots should be discontinued until corrective action, acceptable to the User, has been taken. After the corrective action has been taken, Group B inspection should be repeated on new samples. Group A inspection is recommended to be reinstituted; however, final acceptance should be withheld until the Group B inspection has shown that the corrective action was successful.

4.6 Inspection of Preparation for Delivery

The level of inspection of packaging of TEM cables should always be specified in the User contact (see Section 5).

4.7 Special Tests

Any examination or test not specified herein, but required by the detail drawing, should be classified as a special test. These tests should be developed by the User and manufacturer together. Special tests should conform to the requirements herein and applicable tests should be included in quality conformance inspection.

4.8 Methods of Inspection

4.8.1 Examination of Product

TEM transmission lines should be examined in accordance with the procedures specified herein to ensure conformance with this specification. These procedures assure verification of conformance to the specified requirements for design and construction, marking, workmanship and corrosion and deterioration.

4.8.1.1 Test Equipment

Test equipment used to perform the examinations should be accurate and versatile.

4.8.1.2 Test Conditions

Unless otherwise specified, examinations should be made at normal ambient conditions.

4.8.1.3 Procedure I - Design and Construction

4.8.1.3.1 The TEM transmission line should conform to the physical dimensions as specified in the applicable detail drawing (3.1).

4.8.1.3.2 The TEM transmission line should be examined to verify that the primary interfaces and, if applicable, the replaceable interface components are as specified in the detail drawing. In addition, when replaceable interface components are used, the examination should ascertain that these are properly installed and are torqued to a range of 40 to 50 in-lb.

4.8.1.3.3 When specified, the TEM transmission line should conform to the weight requirement specified.

4.8.1.3.4 The TEM transmission line should be examined to determine that metallic mating surfaces meet the requirements of 3.3.3.

4.8.1.3.5 The TEM transmission line should be examined to ascertain that apertures or other devices for pressurization are not incorporated in the unit (see 3.3.4).

4.8.1.3.6 Accept-Reject Criteria

If the results of these examinations show that the TEM transmission line fails to meet the requirements for design and construction as set forth in this document, the TEM transmission line should be considered to have failed the test.

4.8.1.4 Procedure II - Markings

4.8.1.4.1 The markings on the TEM transmission line should conform to the requirements specified in the applicable detail drawing.

4.8.1.4.2 When markings are not specified in the detail drawing, markings should be in accordance with 3.6.

4.8.1.4.3 Accept-Reject Criteria

If the results of this examination show that the TEM transmission line fails to meet the specified marking requirements, the unit should be considered to have failed this test.

4.8.1.5 Procedure III - Workmanship

4.8.1.5.1 The outer covering of the TEM transmission line should be examined for cuts, nicks, dents and burned or frayed areas.

4.8.1.5.2 Interfaces and associated metal parts should be examined for sharp edges, burrs, damaged mating surfaces, and foreign objects or contaminants.

4.8.1.5.3 Accept-Reject Criteria

If the results of these examinations show that the TEM transmission line has workmanship defects which might affect performance or reliability, the unit should be considered to have failed this test.

4.8.1.6 Procedure IV - Corrosion and Deterioration

4.8.1.6.1 The primary interfaces of the TEM transmission line should be examined for evidence of corrosion, flaking, pitting or peeling of the electrical conductive surfaces and threaded coupling areas.

4.8.1.6.2 The interface component or replaceable interface component coupling rings should be examined for clogging or binding.

4.8.1.6.3 The dielectric material of the primary interfaces should be examined for displacement, shrinkage or swelling. Center contact and outer contact relationship to each other and to the dielectric material should be measured and recorded.

4.8.1.6.4 Accept-Reject Criteria

If the results of these examinations reveal that corrosion, damage, deterioration or change in physical relationship outside established tolerance limits has occurred, the unit should be considered to have failed the test.

4.8.2 Interface Gauging of Primary Interfaces

4.8.2.1 General

Gauging of primary interfaces is performed to determine compliance of the interfaces to required dimensions that insure proper mating to specified counterparts.

4.8.2.2 Apparatus

The apparatus required to perform the interface gauging should be determined by the manufacturer and should be approved by the User. The use of standardized gauging equipment and techniques is recommended.

4.8.2.3 Test Conditions

Unless otherwise specified, gauging should be conducted at normal ambient conditions.

4.8.2.4 Procedure

4.8.2.4.1 The gauging procedure should meet the requirements of 4.1.1.

4.8.2.4.2 The primary interface should be examined for sharp edges, burrs, damaged mating surfaces, corrosion and flaking, peeling, or pitting of the conductive surfaces.

4.8.2.4.3 The primary interfaces should be gauged for dimensional conformance in accordance with Table 14.

Table 14 - Primary interface gaging

EW Precision Interface
Type 1 - Male (see Figure 9 and Table 17)
Type 1 - Female (see Figure 10 and Table 18)
Type 2 - Male (see Figure 11 and Table 19)
Type 2 - Female (see Figure 12 and Table 20)
Type 3 - Male (see Figure 13 and Table 21)
Type 3 - Female (see Figure 14 and Table 22)

NOTE: Surface finish requirements may be inspected prior to assembly of the primary interface.

4.8.2.4.4 Male primary interfaces should be visually inspected to ascertain that the environmental seal is installed, properly located, and not damaged.

4.8.2.5 Accept-Reject Criteria

If the results of these examinations and gauging inspections reveal that corrosion, damage, deterioration or dimensional deficiencies exist, the unit should be considered to have failed the interface gauging examination.

4.8.3 RF Insertion Loss

4.8.3.1 General

Three tests are required to determine the RF insertion loss characteristics of a TEM transmission line. The tests are:

a. RF insertion loss. The RF insertion loss, which is defined as the ratio of the power (P_1) delivered to a load connected directly to a source and the power (P_2) delivered to a load when a test sample is inserted between the source and the load, is expressed in dB and is equal to 10 $\log_{10}$ (P_1/P_2). Procedure I describes the test requirements for RF insertion loss.

b. Insertion loss uniformity (fine structure variation). The fine structure variation is a periodic or abrupt change occurring in the plotted insertion loss that can be attributed to mismatches in the TEM transmission line. Procedure II describes the test requirements for insertion loss uniformity.

c. Insertion loss stability. This test is performed to determine the adequacy of the electrical mate between the cable and the interface components when they are subjected to side acting forces. Procedure III describes the test requirements for insertion loss stability.

4.8.3.2 Test Equipment and Apparatus

The test equipment used to perform these tests should meet the requirements of 4.1.2. The test equipment should be capable of providing a continuous measurement of RF insertion loss over the required frequency ranges. A means should be provided for producing a permanent record of the unit's RF insertion loss versus frequency on rectangular coordinates. The permanent record should be calibrated and capable of differentiating an insertion loss change of 0.05 dB. The measuring system response should be such that an insertion loss variation of 1.0 dB with a frequency width as narrow as 20 MHz will be displayed with degradation limited to less than 20%. In addition, Procedure III requires apparatus capable of applying a force to the cable component while the body of the interface component is rigidly supported.

4.8.3.3 Test Conditions

Unless otherwise specified, tests should be conducted at normal ambient conditions.

4.8.3.4 Procedure I - RF Insertion Loss

4.8.3.4.1 The TEM transmission line should be connected in the test system and measured for RF insertion loss over the required frequency ranges as specified in 3.4.4.1.1 and the detail drawing.

4.8.3.4.2 The permanent record should be marked with the maximum allowable RF insertion loss as specified in the detail drawing.

4.8.3.5 Accept-Reject Criteria - Procedure I

4.8.3.5.1 The RF insertion loss requirements specified in the detail drawing should be adjusted in accordance with 4.1 for use as accept-reject inspection criteria.

4.8.3.5.2 If the TEM transmission line fails to meet the accept-reject criteria established in 4.8.3.5.1, the unit should be considered to have failed the RF insertion loss test.

4.8.3.6 Procedure II - Insertion Loss Uniformity

4.8.3.6.1 The RF insertion loss uniformity should be determined by measuring the fine structure variation (see Figure 20) of the RF insertion loss. The permanent record obtained in Procedure I should be measured to determine the maximum value of fine structure variation within the specified bandwidth.

4.8.3.7 Accept-Reject Criteria - Procedure II

4.8.3.7.1 The insertion loss uniformity requirements specified in 3.4.4.1.1 for a particular frequency range and replaceable interface component style should be adjusted in accordance with 4.1 for use as accept-reject inspection criteria.

4.8.3.7.2 If the TEM transmission line fails to meet the accept-reject criteria established in 4.8.3.7.1, the unit should be considered to have failed the insertion loss uniformity (fine structure variation) test.

4.8.3.8 Procedure III - Insertion Loss Stability

4.8.3.8.1 Mount the TEM transmission line with the input interface rigidly supported so the applied side acting forces are not transmitted to the electrical interface between the test sample and the measurement system. Connect the test sample in the measurement system.

4.8.3.8.2 Perform an RF insertion loss measurement as specified in Procedure I.

4.8.3.8.3 Apply a force (in pounds) equal to ten times the outside diameter of the cable component (in inches) at a point whose distance (in inches) from the rear of the interface component equals two times the outside diameter of the cable component. This force should be applied perpendicular to the major axis of the cable component via a 1/2 inch x 1/2 inch rigid flat steel plate.

4.8.3.8.4 While the force specified in 4.8.3.8.3 is being applied, an RF insertion loss measurement should be made and recorded on the same permanent record as the measurement made in 4.8.3.8.2 was recorded.

4.8.3.8.5 Three additional RF insertion loss measurements should be made while the force specified in 4.8.3.8.3 is being applied except that the force should be applied in each of the three remaining quadrants. Each measurement should be recorded on the same permanent record made in 4.8.3.8.2. Therefore, when the required measurements are completed, the permanent record will show five RF insertion loss measurement traces.

4.8.3.8.6 Repeat 4.8.3.8.1 through 4.8.3.8.5 except the other primary interface of the TEM transmission line should be used as the input.

4.8.3.9 Accept-Reject Criteria - Procedure III

4.8.3.9.1 The insertion loss stability requirements specified in 3.4.4.1.3 should be adjusted in accordance with 4.1 for use as accept-reject inspection criteria.

4.8.3.9.2 If the RF insertion loss measurement traces vary from one to another by more than the accept-reject criteria established in 4.8.3.9.1, the TEM transmission line should be considered to have failed the insertion loss stability test.

4.8.3.10 Procedure IV - RF Insertion Loss for Replaceable Interface Components

4.8.3.10.1 The test equipment and test methods used for this procedure should be fully documented by the manufacturer and should be approved by the User.

4.8.3.10.2 The replaceable interface component should be connected in the test system and measured for RF insertion loss over the required frequency range(s) specified in 3.4.4.1.6.

4.8.3.11 Accept-Reject Criteria - Procedure IV

4.8.3.11.1 The RF insertion loss requirements specified in 3.4.4.1.6 should be adjusted in accordance with 4.1 for use as accept-reject criteria.

4.8.3.11.2 If the replaceable interface component fails to meet the accept-reject criteria established in 4.8.3.11.1, the unit should be considered to have failed the RF insertion loss test.

4.8.4 Voltage Standing Wave Ratio (VSWR)

4.8.4.1 General

The voltage standing wave ratio (VSWR) test (Procedure I) is performed to determine if the TEM transmission line meets its specified requirements. The VSWR stability test (Procedure II) is performed to determine the adequacy of the electrical mate between the cable and interface components when they are subjected to side acting forces. VSWR measurements are an indication of the power reflected back into a connected power source that is caused by mismatches in the TEM transmission line.

4.8.4.2 Test Equipment

The test equipment used to perform these tests should meet the requirements of 4.1. The test equipment should be capable of providing a continuous measurement of VSWR over the required frequency ranges. A means should be provided for producing a permanent record of the unit's VSWR versus frequency on calibrated rectangular coordinates. In the event VSWR is not directly measured, i.e., if return loss is measured and VSWR is calculated from that measurement, the permanent record should indicate the worst case VSWR numerically for each frequency band and should provide the calculation used to obtain the calculated VSWR. The permanent record should be able to differentiate a VSWR change of at least 0.02. In addition, Procedure II requires apparatus capable of applying a force to the cable component while the body of the interface is rigidly supported.

4.8.4.3 Test Conditions

Unless otherwise specified, tests should be conducted at normal ambient conditions.

4.8.4.4 Procedure I - VSWR

4.8.4.4.1 The TEM transmission line should be connected in the test system and measured for VSWR over the required frequency ranges as specified in 3.4.4.2.

4.8.4.4.2 Unless otherwise specified in the detail specification drawing, the TEM transmission line should have VSWR measurements made from both primary interfaces and the resulting permanent records should be marked to indicate which primary interface was used as the input.

4.8.4.4.3 The permanent record should be marked with the maximum allowable VSWR, or related parameter if VSWR is not directly measured, as specified in 3.4.4.2 for the type and interface configuration of TEM transmission line being tested.

4.8.4.5 Accept-Reject Criteria - Procedure I

4.8.4.5.1 The VSWR requirements specified in 3.4.4.2 for a particular type and interface configuration of TEM transmission line should be adjusted in accordance with 4.1 for use as accept-reject inspection criteria.

4.8.4.5.2 If the TEM transmission line fails to meet the accept-reject criteria established in 4.8.4.5.1, the unit should be considered to have failed the voltage standing wave ratio test.

4.8.4.6 Procedure II - VSWR Stability

4.8.4.6.1 Mount the TEM transmission line insuring the input primary interface is rigidly supported so that the applied side acting forces are not transmitted to the electrical interface between the test sample and the measurement system. Connect the test sample in the measurement system.

4.8.4.6.2 Perform a VSWR measurement as specified in Procedure I for the first input interface.

4.8.4.6.3 Apply a force (in pounds) equal to ten times the outside diameter of the cable component (in inches) at a point whose distance (in inches) from the rear of the interface component equals two times the outside diameter of the cable component. This force should be applied perpendicular to the major axis of the cable component via a 1/2 inch x 1/2 inch rigid flat steel plate.

4.8.4.6.4 While the force specified in 4.8.4.6.3 is being applied, a VSWR measurement should be made and recorded on the same permanent record as the measurement made and recorded in 4.8.4.6.2.

4.8.4.6.5 Three additional VSWR measurements should be made while the force specified in 4.8.4.6.3 is being applied except that the force should be applied in each of the three remaining quadrants. Each measurement should be recorded on the same permanent record made in 4.8.4.6.2. Therefore, when the required measurements are completed, the permanent record will show five VSWR measurement traces.

4.8.4.6.6 Repeat 4.8.4.6.1 through 4.8.4.6.5 except that the other primary interface of the TEM transmission line should be used as the input.

4.8.4.7 Accept-Reject Criteria - Procedure II

4.8.4.7.1 The VSWR stability requirements specified in 3.4.4.2.1 should be adjusted in accordance with 4.1 for use as accept-reject inspection criteria.

4.8.4.7.2 If the VSWR measurement traces vary from one to another by more than the accept-reject criteria established in 4.8.4.7.1, the TEM transmission line should be considered to have failed the VSWR stability test.

4.8.4.8 Procedure III - VSWR for Replaceable Interface Components

4.8.4.8.1 The test equipment and test methods used for this procedure should be fully documented by the manufacturer and should be approved by the User.

4.8.4.8.2 The replaceable interface component should be connected in the test system and measured for VSWR over the required frequency range(s) specified in 3.4.4.2.2.

4.8.4.9 Accept-Reject Criteria - Procedure III

4.8.4.9.1 The VSWR requirements specified in 3.4.4.2.2 should be adjusted in accordance with 4.1 for use as accept-reject criteria.

4.8.4.9.2 If the replaceable interface component fails to meet the accept-reject criteria established in 4.8.4.9.1, the unit should be considered to have failed the VSWR test.

4.8.5 Impedance Test

4.8.5.1 General

The purpose of the impedance test is to determine the characteristic impedance and the impedance uniformity (peak to peak variation) of the TEM transmission line. Variations in dimensions, dielectric material or manufacturing procedures can produce changes in the characteristic impedance or impedance uniformity. These changes generate reflections and degrade the electrical performance of the TEM transmission line.

4.8.5.2 Test Equipment

All test equipment used to perform the impedance test should meet the requirements of 4.1. The characteristic impedance should be measured with Time Domain Reflectometry (TDR) equipment. The TDR equipment should have a total system response of 150 ps and should provide for a resolution of 0.1 Ω throughout the length of the test sample. The test results should be displayed on calibrated rectangular coordinates and a permanent record of the test results should be produced. The permanent record should be capable of differentiating an impedance difference of at least 0.1 Ω. A section of air line with a calibrated impedance of 50.0 Ω ± 0.1 Ω is required as a reference.

4.8.5.3 Test Conditions

Unless otherwise specified, tests should be conducted at normal ambient conditions.

4.8.5.4 Procedure I - Characteristic Impedance

4.8.5.4.1 The test procedure should meet the requirements of 4.1.

4.8.5.4.2 The section of air-line used as a reference should be inserted between the test equipment and the input end of the test sample.

4.8.5.4.3 Either end of the test sample may be used as the input interface.

4.8.5.4.4 The permanent record of the impedance test should display the plots of the air-line reference, the input interface, the entire length of the test sample, the output interface and any required terminating network. The record should be marked to indicate these plots and should identify which primary interface was used as the input interface (see Figure 21 for marking requirements).

4.8.5.4.5 Examine the permanent record to ascertain the maximum and minimum points of the impedance plot for the TEM transmission line. Determine the values for these points.

4.8.5.5 Accept-Reject Criteria - Procedure I

4.8.5.5.1 The characteristic impedance requirements specified in 3.4.4.3 should be adjusted in accordance with the requirements of 4.1 for use as accept-reject inspection criteria.

4.8.5.5.2 If the TEM transmission line fails to meet the accept-reject criteria established in 4.8.5.5.1, the unit should be considered to have failed the characteristic impedance test.

4.8.5.6 Procedure II - Impedance Uniformity

4.8.5.6.1 The test procedure for impedance uniformity should be as specified in 4.8.5.4.1 through 4.8.5.4.4.

4.8.5.6.2 Examine the permanent record to ascertain the 12-inch segment of the TEM transmission line which exhibits the maximum peak to peak variation of the impedance plot (see Figure 21 for clarification). Determine the value of this peak to peak variation.

4.8.5.7 Accept-Reject Criteria - Procedure II

4.8.5.7.1 The impedance uniformity (peak to peak variation) specified in 3.4.4.3.1 should be adjusted in accordance with the requirements of 4.1 for use as accept-reject inspection criteria.

4.8.5.7.2 If the TEM transmission line fails to meet the accept-reject criteria established in 4.8.5.7.1, the unit should be considered to have failed the impedance uniformity test.

4.8.6 Vapor Leakage

4.8.6.1 General

The vapor leakage test is performed to determine the environmental seal integrity of a TEM transmission line. Leaks, both gross and minute, in combination with exposure to wide differentials in atmospheric pressure will cause the TEM transmission line to "breathe" and to absorb contaminants that could degrade the line's electrical performance to an unacceptable level. This test is applicable to all classes of TEM transmission lines except that Class 3 (rigid) assemblies may be tested prior to forming or bending. If tested prior to forming or bending, Class 3 assemblies should be further tested after forming or bending to verify conformance to the vapor leakage requirement. This verification test should be approved by the User.

4.8.6.2 Apparatus

The apparatus required to perform this test is shown in Figure 22. The mechanical pump, diffusion pump, bell jar, valves, controls, and gauges may be a self-contained vacuum system. The use of a multi-port connection between the bell jar and several sample tubes is recommended to conserve testing time; however, if this is done, each sample tube must have an individual isolation valve. Sample tube sizes should be selected so that the difference between sample tube and test sample volumes is approximately 500 cm^3. The bell jar volume should be at least 100 times greater than the aforementioned volume difference. Thermocouple gauge, M_1, should be capable of measuring pressure to within ±0.01 mm Hg.

4.8.6.3 Test Conditions

Tests should be conducted at normal ambient conditions.

4.8.6.4 Procedure

4.8.6.4.1 The test procedure should meet the requirements of 4.1.

4.8.6.4.2 Place the TEM transmission line in the sample tube. The primary interfaces should not be sealed, mated, or otherwise covered or protected. Seal the sample tube and shut the isolation valve.

4.8.6.4.3 Close the vent valve and start the evacuation of the bell jar with the mechanical pump. After reaching the optimum limits of evacuation with the mechanical pump, close the roughing valve. Evacuate the bell jar with the diffusion pump to 1 x 10^{-6} mm Hg or less. Close the high vacuum valve.

4.8.6.4.4 The isolation valve should be opened for 1 to 2 seconds and then should be closed. The test period should start at the time, (t_o), when the isolation valve is closed. At the same time, the starting pressure, (p_o), should be read on the thermocouple gauge, M_1. Record t_o and p_o.

4.8.6.4.5 At periodic intervals for the duration of the test, the pressure (p_x) should be read at M_1 and the time (t_x) of the observation recorded to the nearest second. A minimum of three readings should be made with a minimum elapsed time of 10 minutes between each reading. Additional readings may be required to ascertain leakage rates on TEM transmission lines less than 3 feet in length.

4.8.6.4.6 The vapor leakage rate, (K), for TEM transmission lines should be calculated by the following formula:

$$K\left(\frac{cm^3}{sec}\right) = \frac{p_x - p_o}{p_o\left(t_x - t_o\right)}\left[\frac{\left(V_2 - V_x\right)^2}{V_1}\right] \quad \text{(Eq. 1)}$$

where:

p_o = starting pressure (in mm Hg)

p_x = pressure (in mm Hg) at time t_x

t_o = starting time

t_x = time (in seconds) at which p_x was read

V_1 = bell jar volume in cm^3

V_2 = sample tube volume in cm^3

V_x = test sample volume in cm^3

4.8.6.4.7 When a multi-port connection is used, each sample should be subjected to the procedure described in 4.8.6.4.2 through 4.8.6.4.6.

4.8.6.4.8 If the quantity (p_x-p_o) remains constant throughout the test period, a gross leak may exist. The suspect test sample should be removed from the sample tube and should be visually inspected for seal ruptures. If none are found, the test sample should be set aside for a period of at least 1 hour prior to retesting. The retest cycle should consist of the procedure specified in 4.8.6.4.2 through 4.8.6.4.4. Record p_o and t_o.

4.8.6.4.9 Read and record p_x at 10 second intervals for a period of 2 minutes. Calculate the vapor leakage rate for the TEM transmission line in accordance with 4.8.6.4.6.

NOTE: The retest cycle is required on braided outer conductor constructions. For solid outer conductor constructions, an alternate test method, approved by the Agent Facility, may be used.

4.8.6.5 Accept-Reject Criteria

If at any time during the initial test cycle or, if applicable, the retest cycle, the TEM transmission line has a vapor leakage greater than that specified in 3.4.5.1, the unit should be considered to have failed the vapor leakage test.

4.8.7 Velocity of Propagation

4.8.7.1 General

This test is conducted to determine the velocity of propagation of a TEM transmission line over its specified design frequency range. The velocity of propagation of a TEM transmission line should be stated as a percentage of the velocity of propagation in free space.

4.8.7.2 Test Equipment

The test equipment used to perform this test should meet the requirements of 4.1 and should consist of the following:

a. A Microwave Sweep oscillator with a frequency range that covers the design frequency range of the test sample.

b. An analyzer with suitable readout features.

c. A phase bridge with a measurement accuracy of ±0.1%.

d. A calibrated section of air-line whose length equals the length of the test sample.

4.8.7.3 Test Conditions

Tests should be conducted at normal ambient conditions.

4.8.7.4 Procedure

4.8.7.4.1 The test procedure should meet the requirements of 4.1.

4.8.7.4.2 Calibrate the system over the design frequency range of the test sample with required adapters inserted in the leg of the phase bridge to be used for the test sample. Record calibration line.

4.8.7.4.3 Insert the test sample in the appropriate leg of the phase bridge and an equal length of air line in the other leg. Note the length (L) of the test sample.

4.8.7.4.4 Using the phase bridge, adjust the electrical length of the air-line leg to obtain a phase balance across the design frequency of the test sample. Note the added length (ΔL).

4.8.7.4.5 Calculate velocity of propagation (V_p) of calibration line as follows:

$$V_p = \frac{L}{L + \Delta L} \times 100\% \quad \text{(Eq. 2)}$$

4.8.7.4.6 Sweep over the design frequency of the test sample.

Note maximum deviation (ϕ in degrees) from calibration line.

4.8.7.4.7 Calculate minimum velocity of propagation V_p (MIN) as follows:

$$V_p\ (\text{MIN}) = \frac{L}{(L + \Delta L) + \frac{\phi C}{360\ f}} \times 100\% \quad \text{(Eq. 3)}$$

where C is the velocity of propagation in free space and f is the frequency (in Hz) as measured.

4.8.7.5 Accept-Reject Criteria

4.8.7.5.1 The velocity of propagation requirement specified in 3.4.4.4 or in the detail specification drawing should be adjusted in accordance with the requirements of 4.1 for use as accept-reject inspection criteria.

4.8.7.5.2 If the TEM transmission line fails to meet the accept-reject criteria established in 4.8.7.5.1, the unit should be considered to have failed the velocity of propagation test.

4.8.8 Radio Frequency (RF) Leakage

4.8.8.1 General

This test is performed for the purpose of determining that the RF energy leaked from a TEM transmission line is within the limits specified in 3.4.4.5.

4.8.8.2 Test Equipment and Apparatus

Test equipment used to perform the RF leakage test should meet the requirements of 4.1. The test equipment list specified in Figure 23, sheet 1, is required to perform this test and it should be capable of performing satisfactorily throughout the design frequency range of the TEM transmission line. The apparatus described in Figure 23, sheets 5 through 10, is also required.

4.8.8.3 Test Conditions

Tests should be conducted at normal ambient conditions.

4.8.8.4 Procedure

4.8.8.4.1 The test procedure should meet the requirements of 4.1.

4.8.8.4.2 Test frequencies should be selected to insure complete scanning of the TEM transmission line's design frequency range.

4.8.8.4.3 RF leakage measurements should be made at each interface and, for braid shield constructions, at a minimum of three points along the cable component of the TEM transmission line.

4.8.8.4.4 The test routine for a single test frequency at a particular point should be as follows:

RECORDER CALIBRATION

Step 1. Connect the test equipment as shown in Figure 23, sheet 2.

Step 2. With equipment warmed up and operating, set the sweep oscillator to sweep over a minimum 5% bandwidth containing the intended test frequency.

Step 3. With the sweep oscillator operating at a convenient output level and using the variable attenuators for test channel level set, record calibration traces on the x-y recorder corresponding to 40, 50, 60, 70, 80, 90, and 100 dB ratios of reference channel to test channel signal level versus frequency. If more than one leakage measurement is intended, remove the calibration record sheet from the recorder and retain for future use as a calibration overlay.

CAVITY ADJUSTMENT AND "Q" MEASUREMENT

Step 4. Install test unit or mated interface pair in the test cavity using appropriately sized short circuits (see Figure 23, sheets 6 through 10).

Step 5. Connect the equipment as shown in Figure 23, sheet 3. Set the variable attenuators to "0" dB.

Step 6. With the test equipment warmed up and operating, set the sweep oscillator to sweep over the same frequency range used for recorder calibration (see 4.8.8.4.3). Adjust oscillator output level and oscilloscope gain controls for usable scope presentation.

Step 7. Adjust spacing between cavity short circuits until TEM resonance as indicated by oscilloscope presentation is centered on test frequency. Keeping the spacing between the short circuits approximately constant, slide the combination with respect to the cavity coupling probe to obtain maximum amplitude of the selected resonance. Verify that the selected mode is TEM by holding one short circuit fixed and sliding the other while observing the oscilloscope. The electrical dimensions of the cavity are such that several TEM modes as well as TE and TM modes can exist within the frequency range being observed. TEM modes can be identified by (1) for a given change in cavity length they undergo a greater frequency shift than TE or TM modes and (2) they maintain a nearly constant amplitude for small changes in cavity length.

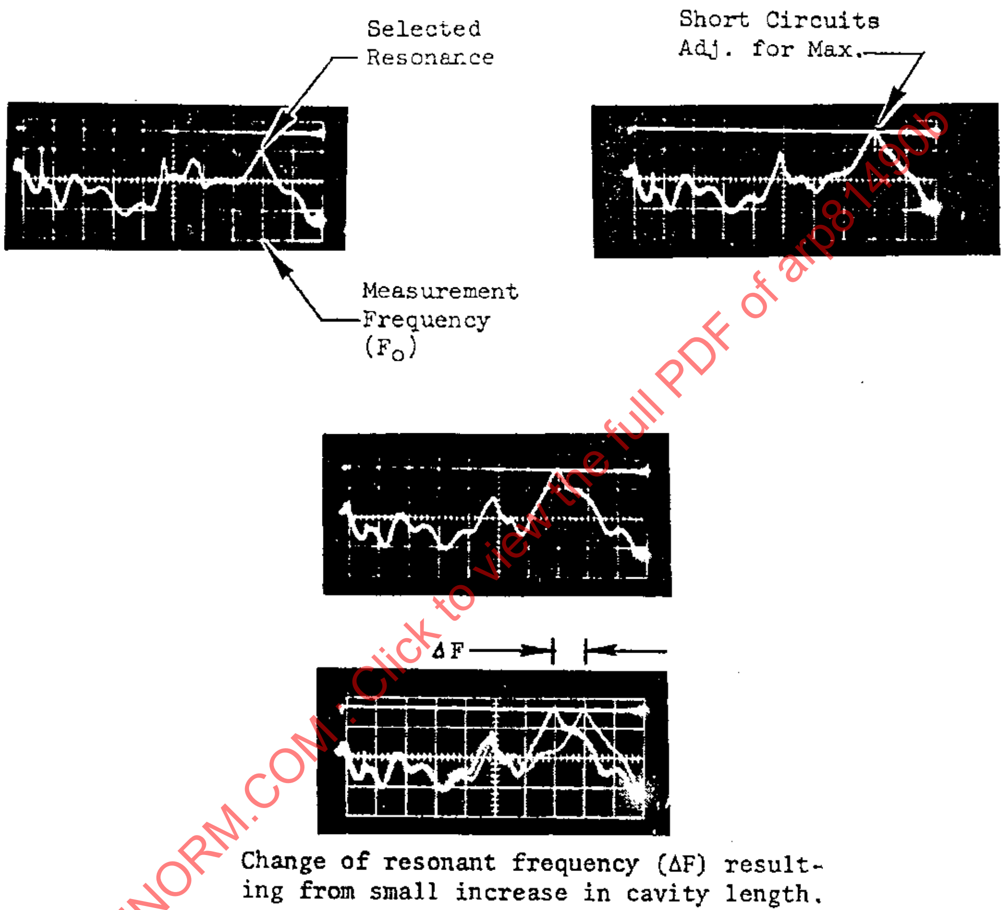


Figure 3 - Step 7 oscilloscope presentation

Step 8. After verifying that the selected mode is TEM, readjust the short circuit to center the mode at the test frequency.

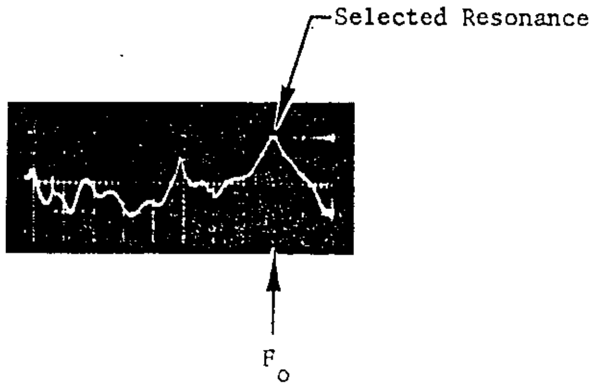


Figure 4 - Step 8 oscilloscope presentation

Step 9. Adjust oscilloscope controls to establish maximum deflection at a convenient level.

Step 10. Set sweep oscillator markers to coincide with "base" of selected resonance curve.

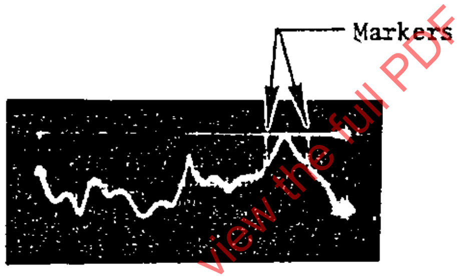


Figure 5 - Step 10 oscilloscope presentation

Step 11. Set sweep oscillator to "Marker Sweep" mode and adjust markers to yield symmetrical display of resonance curve on scope.

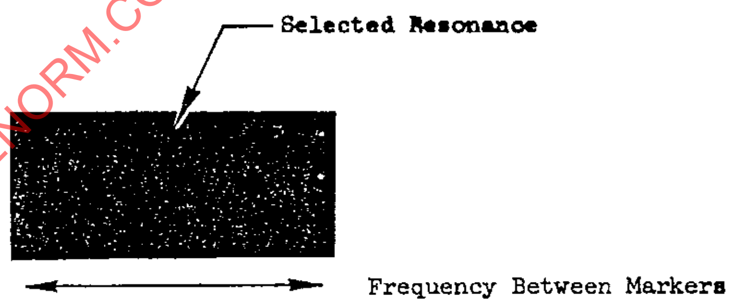


Figure 6 - Step 11 oscilloscope presentation

Step 12. Adjust variable attenuator to insert 3 dB attenuation and note level on oscilloscope corresponding to this condition. Remove 3 dB attenuation.

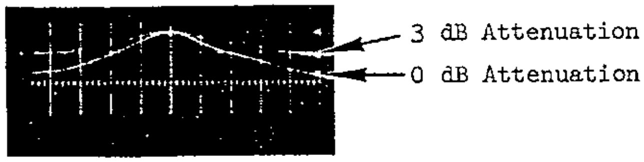


Figure 7 - Step 12 oscilloscope presentation

Step 13. Use frequency meter to determine the frequency spacing between the 3 dB points on the resonance curve.

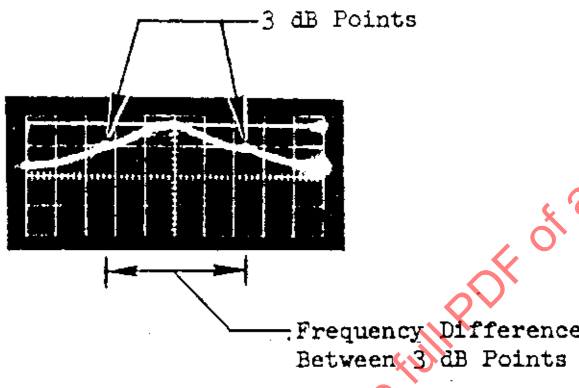


Figure 8 - Step 13 oscilloscope presentation

Step 14. Calculate the Q of the cavity for this condition by dividing the resonant frequency by the difference in frequency between the 3 dB points. Record this value for future calculation of test sample leakage.

CAUTION

Use extreme care not to disturb the cavity adjustment until leakage measurements are completed.

Step 15. Being careful not to disturb the test sample and cavity adjustment obtained in step 8, connect the test equipment as shown in Figure 23, sheet 4. Set the sweep oscillator to sweep the frequency range of step 2 and record a trace of leakage energy over this frequency range.

Step 16. Identify the recorded leakage level at the cavity resonant frequency.

Step 17. Determine and record the physical spacing between the faces of the short circuits. This determination may be made by measuring the distance between accessible locations on the adjustment handles and correcting by the distance from these locations to the face of the short circuits.

Step 18. Determine the dB value which corresponds to a power ratio equivalent to the cavity Q measured in step 14 by (dB = 10 log Q).

Step 19. Increase the numerical value measured in step 16 by the dB value determined in step 18. The resultant dB value represents the ratio of power flowing in the test sample to the energy "leaked" from the test sample over the length determined in step 17.

Step 20. Calculate the RF leakage power ratio for a 12 inch length of cable component by decreasing the numeric value determined in step 19 by the factor of:

$$10 \log \frac{12}{\text{length (inches) of spacing determined in step 17.}} \quad \text{(Eq. 4)}$$

Step 21. Mated interface pairs should be measured by the same procedure described above for cable with the measured value being corrected for the leakage attributable to the length of cable contained between the short circuits.

4.8.8.4.5 Measurements at each required test frequency should be made in accordance with the requirements of 4.8.8.4.3 and 4.8.8.4.4.

4.8.8.4.6 Record the RF leakage power ratio values determined in 4.8.8.4.4, steps 20 and 21, for each test frequency and each particular point on the TEM transmission line.

4.8.8.5 Accept-Reject Criteria

4.8.8.5.1 The RF leakage power ratio requirements specified in 3.4.4.5 should be adjusted in accordance with the requirements of 4.1 for use as accept-reject inspection criteria.

4.8.8.5.2 If the TEM transmission line fails to meet the accept-reject criteria established in 4.8.8.5.1, the unit should be considered to have failed the RF leakage test.

4.8.9 Temperature Test

4.8.9.1 General

The temperature test is conducted to determine the effects of extreme temperatures on TEM transmission lines during storage or service use (see 3.4.6.1).

4.8.9.2 Apparatus

A temperature chamber capable of reaching and maintaining temperatures of -54 °C and +200 °C to within ±2 degrees is required.

4.8.9.3 Test Conditions

Test conditions should be as specified in the procedures. The rate of temperature change for the test chamber should not exceed 5 °C per minute.

4.8.9.4 Procedure

4.8.9.4.1 The TEM transmission line should be subjected to the tests specified in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.6.

4.8.9.4.2 The TEM transmission line should be placed in the test chamber and the internal chamber temperature should be lowered to -54 °C.

4.8.9.4.3 The internal chamber temperature should be maintained at -54 °C ± 2 °C for a period of 4 hours.

4.8.9.4.4 After exposure at -54 °C for the specified time, the internal chamber temperature should be raised to +200 °C.

4.8.9.4.5 The internal chamber temperature should be maintained at +200 °C ± 2 °C for a period of 4 hours.

4.8.9.4.6 After exposure at +200 °C for the specified time, the internal chamber temperature should be lowered to +30 °C ± 5 °C and maintained for 1 hour.

4.8.9.4.7 The TEM transmission line should be removed from the test chamber and subjected to the tests specified in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.6.

4.8.9.5 Accept-Reject Criteria

If the TEM transmission line fails to meet accept-reject criteria established in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.6, the unit should be considered to have failed the temperature test.

4.8.10 Altitude Test

4.8.10.1 General

The altitude test is conducted to determine the ability of the TEM transmission line to withstand momentary overvoltage conditions in a high altitude condition.

4.8.10.2 Test Equipment

Test equipment should consist of an altitude chamber and the equipment required in 4.8.24.

4.8.10.3 Test Conditions

Test conditions should be as specified in the procedure.

4.8.10.4 Procedure

4.8.10.4.1 The TEM transmission line should be subjected to the tests specified in 4.8.24, Procedure I.

4.8.10.4.2 The TEM transmission line should be placed in the altitude chamber and connected as required in 4.8.24, Procedure I.

4.8.10.4.3 The internal pressure of the altitude chamber should be reduced to 33.5 mm of Hg (1.32 inches of Hg or 70,000 feet above sea level) and maintained for 1 hour.

4.8.10.4.4 After exposure to altitude for the specified period, the TEM transmission line should be subjected to the test specified in 4.8.24, Procedure I, with the magnitude of the test voltage as specified in 3.4.4.7.

4.8.10.4.5 After completion of the test specified in 4.8.24, Procedure I, return the test chamber internal pressure to standard ambient conditions.

4.8.10.5 Accept-Reject Criteria

If the TEM transmission line fails to meet the accept-reject criteria established in 4.8.24, Procedure I, the unit should be considered to have failed the test.

4.8.11 Thermal Shock

4.8.11.1 The purpose of the thermal shock test is to determine the TEM transmission line's resistance to exposure at extremes of high and low temperatures and to the shock of alternate exposures to these extremes (see 3.4.6.3).

4.8.11.2 Apparatus

The test apparatus should be in accordance with the requirements specified in MIL-STD-202, method 107.

4.8.11.3 Test Conditions

Test conditions should be in accordance with MIL-STD-202, method 107, test condition C-1, except the low test temperature should be -54 °C (+0 °C, -5 °C) for steps 1 and 3 only.

4.8.11.4 Procedure

4.8.11.4.1 The TEM transmission line should be subjected to the tests specified in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.6.

4.8.11.4.2 The TEM transmission line should be subjected to the test procedure specified in MIL-STD-202, method 107; test condition C-1, except exposure in steps 2 and 4 should be limited to 2 minutes maximum. The connectors should not be mated or otherwise protected.

4.8.11.4.3 Upon completion of the specified test cycles, the TEM transmission line should be allowed to return to thermal stability at ambient room temperature.

4.8.11.4.4 The TEM transmission line should be subjected to the tests specified in 4.8.1, Procedure IV, 4.8.3, 4.4, and 4.8.6.

4.8.11.5 Accept-Reject Criteria

If the TEM transmission line fails to meet the accept-reject criteria established in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.6, the unit should be considered to have failed the thermal shock test.

4.8.12 Vibration

4.8.12.1 General

The purpose of the vibration test is to determine the TEM transmission line's ability to withstand high-frequency vibrations without degradation of electrical performance (see 3.4.5.2).

4.8.12.2 Apparatus

The test apparatus should be capable of providing the required frequency range and vibration amplitude specified in MIL-STD-202, method 204, test condition B. Mounting fixtures should provide adequate clamping and orientation of test samples as shown in Figure 24.

4.8.12.3 Test Conditions

Test conditions should be in accordance with MIL-STD-202, method 204, test condition B.

4.8.12.4 Procedure

4.8.12.4.1 A pair of TEM transmission lines is required for this test. The lines should have a set of mating connectors. The TEM transmission lines should be subjected to the tests specified in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.6.

4.8.12.4.2 The pair of test samples should be mounted to the vibration fixture as required in Figure 24 with the mating connector pair coupled to the requirements of 3.4.2.

4.8.12.4.3 The TEM transmission lines should be subjected to the test procedure specified in MIL-STD-202, method 204, test condition B. While subjected to this test, the TEM transmission lines should be tested to the requirements of 4.8.3, Procedures I and II, and 4.8.4, Procedure I.

4.8.12.4.4 Upon completion of the vibration test, the TEM transmission lines should be removed from the test fixture and should be subjected to the tests specified in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.6.

4.8.12.5 Accept-Reject Criteria

If either TEM transmission line fails at any time to meet the accept-reject criteria established in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.6, the unit should be considered to have failed the vibration test.

4.8.13 Power Handling Capability

4.8.13.1 General

The power handling capability test is divided into two categories: (1) continuous power handling capability (Procedure I) and (2) peak power handling capability (Procedure II). These two tests are conducted to determine the TEM transmission line's ability to handle continuous and pulsed RF power under temperature and altitude conditions associated with high performance military aircraft. The primary failure modes for these tests are: (1) the accumulation of heat to the point where mechanical and electrical properties of the TEM transmission line are adversely affected and, (2) voltage breakdown or arcing and burning.

4.8.13.2 Test Equipment and Apparatus

The test equipment and apparatus should be as described below and should be connected as shown in Figure 25, continuous power test equipment setup, or Figure 26, peak power test equipment setup.

a. Continuous Power RF power source - The continuous power RF power source should be capable of supplying CW (continuous wave) power at a level and frequency required by the test. The power source should include the necessary controls to establish and maintain the required frequencies and power levels. A means of monitoring the operating frequency should be provided and the power source should be capable of providing a stable output over an extended period of time.

b. Peak Power RF power source - The peak power RF power source should be capable of supplying the peak pulse power at a level and frequency required for the test. The power source should include the necessary instrumentation and controls to establish and maintain the required power, RF frequency, pulse width, and pulse repetition frequency for extended periods of time.

c. Reverse Power Monitor - A reverse power monitor consisting of a directional coupler and an average power meter should be included in the test circuit to monitor the energy reflected by the TEM transmission line under test. The primary arm of the directional coupler should be capable of handling the average power levels involved, and the coupling value should be selected in accordance with the VSWR of the test item and the capability of the power meter. The coupler should have a constant coupling value over the range of environmental conditions involved while testing.

d. Forward Power Monitor - A forward power monitor consisting of a directional coupler and an average power meter should be included in the test circuit to monitor the input power to the test item. The equipment requirements should be the same as those listed in (c).

e. Test Chamber RF Feedthroughs - The test chamber RF feedthroughs should provide the test circuit a means of entry and exit from the test chamber and a transition from the TEM transmission line interfaces to the test circuit interfaces. The RF feedthrough should be sealed and not provide an air leak path into the interface of the test item. The RF feedthrough should not provide a good thermal path between the test specimen and the test chamber. The RF feedthrough interface dimensions and tolerances should be maintained during the test. VSWR and insertion loss should be as low as possible and should remain stable throughout the test.

f. RF Termination - The test circuit should be terminated with a device capable of dissipating the powers used and having a VSWR no greater than 1.5:1.0 at the frequency used.

g. RF Calorimeter - An RF calorimeter or other suitable device should be used to determine the level of applied power at the interface to the test item. The calorimeter should then be used to calibrate the forward power monitor.

h. Environmental Test Chamber - An environmental test chamber capable of operation at the specified environmental conditions should be provided. The chamber should be of a size so that the test item may be mounted in such a way that no point is closer than 6 inches from the chamber walls. The test item should be mounted with a minimum number of low thermal conductivity mounts and should not be placed in the air flow caused by the internal fan.

i. Temperature Recorder - A temperature recorder capable of sequentially monitoring a minimum of ten temperature sensors should be provided. Two temperature sensors should be used to monitor the chamber ambient temperature and should be located in free space 6 inches either side of the test item. One 6 inch below and one 6 inch above. Two temperature sensors should be used to monitor the RF feedthrough temperatures. The rest should be located along the test item with one at each test item interface and one, if applicable, at the most severe bend in the test item.

4.8.13.3 Test Conditions

Test conditions should be as specified in the applicable procedure.

4.8.13.4 Procedure I - Continuous Power Handling Capability

4.8.13.4.1 Two mated TEM transmission lines are required for this test. The units should be subjected to the examinations and tests specified in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.6.

4.8.13.4.2 Connect the required test equipment and apparatus as specified in Figure 25 except the continuous power RF power source should not be connected.

4.8.13.4.3 The mated TEM transmission lines should be installed in the test chamber and all RF connections inspected to assure proper electrical and mechanical mate. The VSWR of the completed test circuit should be measured at the frequency of operation prior to connection to the RF power source.

4.8.13.4.4 The RF calorimeter should be connected to the RF power source at the interface to the test items. After operating the RF power source for a minimum of 15 minutes stable operation, the calorimeter should be used to calibrate the forward power monitor for 90, 95, 100, 105, and 110% of the specified power. The RF circuit should then be returned to the required test configuration.

4.8.13.4.5 The test chamber should be brought to an internal temperature of 360 °F and chamber pressure should be reduced to simulate an altitude of 70,000 feet. The chamber should be stabilized for 30 minutes. The internal temperature should not vary more than 10 °F nor should the altitude vary more than ±5% over this period.

4.8.13.4.6 The continuous RF power to the test items should be slowly increased to the value specified in 3.4.4.6.1. The temperature of the test items and reverse power should be continuously monitored during the application of power to detect any catastrophic failure which may occur. Operation at the specified conditions should be continued for a minimum of 1 hour and, if by the end of that hour, the test items' temperatures have stabilized (if the temperature sensors do not show an increase in temperature of more than 5 °F in a 5 minute period) the test should be terminated. If the temperatures of the test items have not stabilized, the test should continue until stabilization is achieved. Note the maximum stabilized temperature along the length of the test samples.

4.8.13.4.7 The test items should be removed from the test chamber and returned to ambient temperature.

4.8.13.4.8 The TEM transmission lines should be subjected to the examinations and tests specified in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.6.

4.8.13.5 Accept-Reject Criteria - Procedure I

If arcing or other catastrophic failure occurs during the application of power, or if either of the TEM transmission lines fails to meet the accept-reject criteria established in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.6, the unit should be considered to have failed the continuous power handling capability test.

4.8.13.6 Procedure II - Peak Power Handling Capability

4.8.13.6.1 The peak power handling test should be performed on the same two mated TEM transmission lines used to perform the continuous power handling test (Procedure I).

4.8.13.6.2 The test samples should be subjected to the examinations and tests specified in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.6.

4.8.13.6.3 Connect the required test equipment and apparatus as specified in Figure 27 except the peak power RF power source should not be connected.

4.8.13.6.4 The mated TEM transmission lines should be installed in the test chamber and all RF connections inspected to assure proper electrical and mechanical mate. The VSWR of the completed test circuit should be measured at the frequency of operation prior to connection to the RF power source.

4.8.13.6.5 Set the peak power RF source for a minimum pulse width of 1.0 µs and a duty cycle of 0.001.

4.8.13.6.6 The RF calorimeter should be connected to the RF power source at the interface to the test items. After operating the RF power source for a minimum of 15 minutes stable operation, the calorimeter should be used to calibrate the forward power monitor for 90, 95, 100, 105, and 110% of the specified power. The RF circuit should then be returned to the required test configuration.

4.8.13.6.7 The test chamber should be brought to an internal temperature equal to the maximum stabilized temperature noted in 4.8.13.4.6 and the chamber pressure reduced to simulate an altitude of 70,000 feet. The chamber should be stabilized for 30 minutes. The internal temperature should not vary more than 10 °F nor should the altitude vary more than 5% over this period.

4.8.13.6.8 The peak RF power to the test items should be slowly increased to the value specified in 3.4.4.6.2. The temperature of the test items and reverse power should be continuously monitored during the application of power to detect any catastrophic failure which may occur. Operations at the specified conditions should be continued for a minimum of 1 hour and, if by the end of that hour, the test items' temperatures have stabilized (if the temperature sensors do not show an increase in temperature of more than 5 °F in a 5 minute period) the test should be terminated. If the temperatures of the test items have not stabilized, the test should continue until stabilization is achieved.

4.8.13.6.9 The test items should be removed from the test chamber and returned to ambient temperature.

4.8.13.6.10 The TEM transmission lines should be subjected to the examinations and tests specified in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.6.

4.8.13.7 Accept-Reject Criteria (Procedure II)

4.8.13.7.1 If arcing or other catastrophic failure occurs during the application of power, or if either of the TEM transmission lines does not meet the accept-reject criteria established in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.6, the unit should be considered to have failed the peak power handling test.

4.8.14 Impact Shock

4.8.14.1 General

The impact shock test is intended to simulate the effects of small hand tools striking or being dropped on a TEM transmission line. When struck by small objects, rigid lines may be bent and flexible lines may suffer outer braid damage which may cause impedance mismatches and degraded electrical performance.

4.8.14.2 Apparatus

The apparatus should consist of the test fixture as shown in Figure 27. The guides should be positioned so as to restrict the weight to vertical movement only, but should not retard the free movement of the weight when dropped during the test. A smooth metal base plate should support the guides and should provide appropriate clamps to hold the TEM transmission line in place during the test.

4.8.14.3 Test Conditions

Tests should be conducted at normal ambient conditions.

4.8.14.4 Procedure

4.8.14.4.1 The TEM transmission line should be subjected to the tests specified in 4.8.3, Procedure I and II, 4.8.4, Procedure I, 4.8.5 and 4.8.6. Note the connector used as the input.

4.8.14.4.2 The TEM transmission line should be located in the impact shock fixture so that a section of the line's cable component 29 to 30 inches from the input connector lies directly beneath the weight's impact surface.

4.8.14.4.3 Locate the weight within the guides with the impact surface of the weight toward the test sample and at right angles to the centerline of the line's cable component. The distance between the impact surface and the near point of the test sample should be 4.0 (+0.12, -0.0) inches. Drop the weight one time.

4.8.14.4.4 Repeat the test performed in 4.8.14.4.3 except the impact surface of the weight should be parallel to the centerline of the line's cable component.

4.8.14.4.5 The TEM transmission line should be removed from the impact shock fixture and should be subjected to the tests specified in 4.8.3, Procedure I and II, 4.4, Procedure I, 4.8.5 and 4.8.6. The connector used as the input should be the same as the one noted in 4.8.14.4.1.

4.8.14.5 Accept-Reject Criteria

If the TEM transmission line fails to meet the accept-reject criteria established in 4.8.3, Procedure I and II, 4.8.4, Procedure I, 4.8.5 and 4.8.6, the unit should be considered to have failed the impact shock test.

4.8.15 Flexure

4.8.15.1 General

This test is performed to determine the TEM transmission line's ability to withstand flexures that may be encountered during service use. Flexure is defined as the bending of a TEM transmission line at cyclic rates below 1 cps. This flexure can be divided into two basic categories: (1) a large angular displacement for a small number of cycles; (2) a small angular displacement for a very large number of cycles. Either type of flexure can fatigue the TEM transmission line's components which will cause electrical performance degradation. The ability to withstand one category of flexure does not imply that the unit will necessarily withstand the other. Class 1 TEM transmission lines should be subjected to the tests specified in Procedures I and II. Class 2 TEM transmission lines should be subjected to the tests specified in Procedure I only.

4.8.15.2 Apparatus

The flexure test fixture should be as specified herein and in Figures 28 and 29. The apparatus should consist of a motor driven arm capable of making repeated cycles of any arc up to 150 degrees at a maximum cyclic rate of 40 cpm. The apparatus should provide for rigid mounting of the TEM transmission line in two places and pivotal mounting of the unit's interface component along the length of the fixture's vertical arm. One cable clamp should be centered over the main pivot of the arm and should conform to Figure 28. The second clamp should be located from 6 to 18 inches below the first one and should hold the cable component firmly but should not have sharp edges that might cut or otherwise damage the unit during testing. The pivot clamp should be movable along the arm and should provide for mounting various interface components at a distance of 6 to 30 inches from the cable clamp centered over the main pivot. A temperature chamber capable of containing the fixture and of reaching and maintaining -20 °C and +60 °C is also required.

4.8.15.3 Test Conditions

Flexure tests may be performed at three ambient temperatures:

Test Condition A: +25 °C ± 5 °C
Test Condition B: -20 °C ± 5 °C
Test Condition C: +60 °C ± 5 °C

Unless otherwise specified, flexure tests should be performed at test condition A.

4.8.15.4 Procedure I - (Large Angular Flexures for Class 1 and Class 2 TEM Transmission Lines)

4.8.15.4.1 The TEM transmission line should be subjected to the tests specified in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.6.

4.8.15.4.2 The TEM transmission line should be loosely clamped in the fixture as shown in Figure 28. If the test sample has been subjected to impact shock (4.8.14), the unit should be mounted so that the area that received the impact shock is directly above the cable clamp over the main pivot of the arm. One end of the test sample should be left unmated; the other should be properly torqued to its mating interface that is mounted to the pivot clamp. The distance between the pivot clamp and the nearer cable clamp should be set at 30 inches for TEM transmission lines 5 feet or more in length. For lengths less than 5 feet, the distance between the pivot clamp and the nearer cable clamp should be set at the mid-point of the TEM transmission line's length. The lower cable clamp should be set at 18 inches if the test sample's length permits; otherwise, the lower cable clamp should be located so only the cable component is clamped. Tighten down the pivot clamp and the cable clamps.

4.8.15.4.3 A test cycle consists of a flexure arc starting at 0 degree to +75 degrees to -75 degrees and return to 0 degrees. Set the connecting rod adjusting clamp to attain this arc and adjust the motor speed to obtain 15 cpm.

4.8.15.4.4 Perform the large angular flexure test for 400 cycles at the specified test condition.

4.8.15.4.5 Remove the TEM transmission line from the fixture. Subject the unit to the tests specified in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.6.

4.8.15.5 Procedure II - (Small Angular Flexures for Class 1 TEM Transmission Lines)

4.8.15.5.1 The TEM transmission line should be subjected to the tests specified in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.6.

4.8.15.5.2 The TEM transmission line should be mounted in the fixture as described in 4.8.15.4.2.

4.8.15.5.3 A test cycle consists of a flexure arc starting at 0 degree to +25 degrees to -25 degrees and return to 0 degree. Set the connecting rod adjusting clamp to attain this arc and adjust the motor speed to obtain 40 cpm.

4.8.15.5.4 Perform the small angular flexure test for 100,000 cycles at the specified test condition.

4.8.15.5.5 Remove the TEM transmission line from the fixture. Subject the unit to the tests specified in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.6.

4.8.15.6 Accept-Reject Criteria - Procedures I and II

If the TEM transmission line fails to meet the accept-reject criteria established in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.6, the unit should be considered to have failed the flexure test.

4.8.16 Torque

4.8.16.1 General

The torque test is conducted to determine the mechanical strength and electrical stability of the cable component to connector component junction of a TEM transmission line. This test simulates the rotational forces that may be applied during in-service and maintenance periods. See AS6151 for torque values, methods, and recommending torque tools.

4.8.16.2 Apparatus

The apparatus should consist of the test fixture as shown in Figure 30 and should meet the following requirements:

a. Connector Clamp - This device should provide for uniform distribution of the applied force about the circumference of the connector component and should not interfere with electrical test equipment connection.

b. Cable Grip Fixture - This fixture should uniformly grip and hold the cable component for a minimum of 8 inches and should not deform or indent the test sample. A means, such as wrench flats, should be provided to allow torque to be applied by a standard torque wrench or other acceptable means.

c. Fixed Supports and Cable Guides - The supports should be rigid and should not flex during the application of force. The guides should support the test sample but should not restrict rotation of the test sample.

4.8.16.3 Test Conditions

Tests should be conducted at normal ambient conditions.

4.8.16.4 Procedure

4.8.16.4.1 The TEM transmission line should be subjected to the test specified in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.6. Note the input interface.

4.8.16.4.2 Mount the TEM transmission line in the torque test fixture so that the input interface will be subjected to the torque force. Connect the electrical test equipment required to perform the measurements specified in 4.8.16.4.5.

4.8.16.4.3 Apply 50 in-lb. of torque to the test sample in a clock-wise direction and maintain this force for 10 seconds. Release the force. Apply 50 in-lb of torque to the test sample in a counterclockwise direction and maintain this force for a period of 10 seconds. Release the force (this constitutes one test cycle).

4.8.16.4.4 The torque test consists of five test cycles described in 4.8.16.4.3. However, during the fifth cycle, the force should be maintained in each direction until the measurements specified in 4.8.16.4.5 are made.

4.8.16.4.5 While the force is being applied, the TEM transmission line should be subjected to the tests specified in 4.8.3, Procedures I and II and 4.8.4, Procedure I. Release the force and remove the TEM transmission line from the torque test fixture.

4.8.16.4.6 Repeat 4.8.16.4.1 through 4.8.16.4.5 except the other primary interface should be used as the input interface.

4.8.16.4.7 The TEM transmission line should be subjected to the tests specified in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.6. The input interface for these tests should be the same one as noted in 4.8.16.4.1.

4.8.16.5 Accept-Reject Criteria

If the TEM transmission line fails at any time to meet the accept-reject criteria established in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.6, the unit should be considered to have failed the torque test.

4.8.17 Tensile Load

4.8.17.1 General

The tensile load test is conducted to determine the mechanical strength and electrical stability of the cable component to connector component junction of a TEM transmission line. This test simulates the longitudinal forces that may be applied during in-service and maintenance periods.

4.8.17.2 Apparatus

The apparatus should consist of the test fixture as shown in Figure 31 and should meet the following requirements:

a. Linear Actuator - This should provide a means of applying and maintaining the required in-line force.

b. Force Measurement - This device should directly read the applied in-line force and should not introduce harmonic motion into the test system.

c. Movable Support - This support should provide a surface which will allow free horizontal motion (less than 0.1 pound drag) when vertical loads up to 10 pounds are applied.

d. Connector Clamp - This device should provide for uniform distribution of the applied force about the circumference of the connector component and should not interfere with electrical test equipment connection.

e. Fixed Support - This support should be capable of sustaining the test system without flexing during the application of the in-line force.

4.8.17.3 Test Conditions

Test conditions should be at normal ambient conditions.

4.8.17.4 Procedure

4.8.17.4.1 The TEM transmission line should be subjected to the tests specified in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.6.

4.8.17.4.2 Mount the TEM transmission line in the tensile load test fixture and connect the required electrical test equipment.

4.8.17.4.3 Apply 75.0 (+3.0, -0.0) pounds force to the TEM transmission line. Maintain this force while the tests specified in 4.8.3, Procedures I and II, and 4.8.4, Procedure I are performed on the unit under test.

4.8.17.4.4 Remove the in-line force. Remove the TEM transmission line from the test fixture and perform the tests specified in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.6.

4.8.17.5 Accept-Reject Criteria

If the TEM transmission line fails at any time to meet the accept-reject criteria established in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.6, the unit should be considered to have failed the tensile load test.

4.8.18 Concentrated Load

4.8.18.1 General

The purpose of the concentrated load test is to apply a force in a concentrated area to a TEM transmission line. This application of force simulates the condition that may occur if a person steps or kneels upon a TEM transmission line and makes a deformation that could cause a degradation in electrical performance.

4.8.18.2 Apparatus

The apparatus should consist of the test fixture as shown in Figure 32. The guides should be positioned so as to restrict the plate to vertical movement only, but should not prevent free movement. A flat metal base should support the guides and provide appropriate clamps so that the TEM transmission line will be positioned through the center of the plate. A means of applying 100 pounds ± 2 pounds force to the plate should be provided.

4.8.18.3 Test Conditions

Tests should be conducted at normal ambient conditions.

4.8.18.4 Procedure

4.8.18.4.1 The TEM transmission line should be subjected to the tests specified in 4.8.3, 4.8.4, 4.8.5, and 4.8.6. Note the connector used as the input.

4.8.18.4.2 Locate the TEM transmission line in the concentrated load fixture so that a section of the line's cable component 7 to 9 inches from the input connector lies directly beneath the center of the plate.

4.8.18.4.3 Apply force to the plate at the rate of 20 lb/s until the force reaches 100 pounds. Hold this value for 3 minutes. Release the force and remove the TEM transmission line from the fixture.

4.8.18.4.4 The TEM transmission line should be subjected to the tests specified in 4.8.3, 4.8.4, 4.8.5, and 4.8.6. The connector used as the input should be the same one noted in 4.8.18.4.1.

4.8.18.5 Accept-Reject Criteria

If the TEM transmission line fails to meet the accept-reject criteria established in 4.8.3, 4.8.4, 4.8.5, and 4.8.6, the unit should be considered to have failed the concentrated load test.

4.8.19 Abrasion Test

4.8.19.1 General

The purpose of this test is to ascertain the ability of the TEM transmission line to resist: (1) the effects of sand and dust as would be encountered in a dry dust-laden atmosphere or, (2) the effects of chafing as would be encountered in service conditions.

4.8.19.2 Apparatus and Materials

The apparatus and materials used to perform the sand and dust test (Procedure I) should be as specified in MIL-STD-202, method 110. The test apparatus used to perform the chafing test (Procedure II) should be as specified in AS5756 for abrasion test apparatus.

4.8.19.3 Test Conditions

Test conditions for the sand and dust test should be as specified in MIL-STD-202, method 110 with the sand and dust velocity through the test chamber between 2,000 and 3,000 ft/min. Test conditions for the chafing test should be at normal ambient conditions.

4.8.19.4 Procedure I - Sand and Dust

4.8.19.4.1 The TEM transmission line should be subjected to the examinations and tests specified in 4.8.1, Procedures II and IV, 4.8.3, 4.8.4, and 4.8.6.

4.8.19.4.2 The TEM transmission line should be located in the test chamber so as to expose the primary interfaces to the sand and dust flow. The primary interfaces should not be covered.

4.8.19.4.3 Conduct the sand and dust test in accordance with the requirements of MIL-STD-202, method 110; test condition B except the exposure period should be 15 minutes.

4.8.19.4.4 After the exposure period, the TEM transmission line should be cleaned as specified in MIL-STD-202, method 110.

4.8.19.4.5 The TEM transmission line should be subjected to the examinations and tests specified in 4.8.1, Procedures II and IV, 4.8.3, 4.8.4, and 4.8.6.

4.8.19.5 Accept-Reject Criteria - Procedure I

If the TEM transmission line fails to meet the accept-reject criteria established in 4.8.1, Procedures II and IV, 4.8.3, 4.8.4, and 4.8.6, the unit should be considered to have failed the sand and dust test.

4.8.19.6 Procedure II (Chafing)

4.8.19.6.1 This test is applicable to Class 1 and Class 2 TEM transmission lines.

4.8.19.6.2 The TEM transmission line should be subjected to the tests specified in 4.8.4 and 4.8.6.

4.8.19.6.3 The TEM transmission line should be securely mounted at one end and a freely suspended 3.0 pound weight attached to the other end with the TEM transmission line placed over the squirrel cage of the abrasion test apparatus.

4.8.19.6.4 The TEM transmission line should be subjected to 20 oscillations per minute ± 2 oscillations per minute. An oscillation should consist of 5 bars travel forward and backward from a given point. The total number of oscillations should be 500.

4.8.19.6.5 After exposure to 500 oscillations, the TEM transmission line should be subjected to the test specified in 4.8.4 and 4.8.6.

4.8.19.7 Accept-Reject Criteria - Procedure II

If the TEM transmission line fails to meet the accept-reject criteria established in 4.8.4 and 4.8.6, the unit should be considered to have failed the chafing test.

4.8.20 Chemical Resistance Test

4.8.20.1 General

The purpose of the chemical resistance test is to determine the TEM transmission line's resistance to corrosive materials. The test simulates the exposures experienced during normal service life.

4.8.20.2 Test Apparatus

The apparatus used to perform this test should consist of the following:

a. Exposure chamber with adequate ventilation and suitable containers for the required chemical materials.

b. Controlled container - Heating means capable of maintaining the temperature ±2 °F throughout the range of +90 to +150 °F.

c. Racks for air-drying test units.

4.8.20.3 Chemical Materials

The chemical solutions and fluids used in this test and their specified test temperatures are as follows:

Table 15 - Chemical materials

Solution or Fluid	Reference Document	Test Temperature
JP-4 or JP-8 Fuel	MIL-DTL-5624/MIL-T-83133	+100 °F ± 5 °F
Hydraulic Fluid	MIL-PRF-5606	+100 °F ± 5 °F
Epoxy Stripper	MIL-R-81294	+140 °F ± 5 °F
Jet Reference Fuel	AMS2629	+100 °F ± 5 °F

WARNING

Toxic materials are used in this procedure that may be harmful to health if suitable safety precautions are not taken.

4.8.20.4 Procedure

4.8.20.4.1 The TEM transmission line should be subjected to the examinations and tests specified in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.6.

4.8.20.4.2 The TEM transmission line should be exposed to the listed fluids and solutions in the sequence shown for the specified exposure period. Exposure to all solutions and drying period should constitute one test cycle.

Table 16

Solution or Fluid	Exposure Period
JP-4 or JP-8 Fuel	4 hours
Jet Reference Fuel	4 hours
Water Rinse	5 minutes
Hydraulic Fluid	4 hours
Water Rinse	5 minutes
Water Rinse	5 minutes
Epoxy Stripper	15 minutes
Water Rinse	5 minutes
Air Dry Storage	16-24 hours

The TEM transmission line should be immersed in each solution with no protective caps or coverings on the primary interfaces.

4.8.20.4.3 The chemical resistance test should consist of ten test cycles.

4.8.20.4.4 After completion of the ten test cycles, the TEM transmission line should be subjected to the examinations and tests as specified in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.6.

4.8.20.5 Accept-Reject Criteria

If the TEM transmission line fails to meet the accept-reject criteria established in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.6, the unit should be considered to have failed the chemical resistance test.

4.8.21 Explosive Atmosphere

4.8.21.1 General

The explosive atmosphere test is conducted to determine the ability of the TEM transmission line to operate in the presence of an explosive atmosphere.

4.8.21.2 Test Equipment

Test equipment should consist of an explosion-proof chamber as specified in MIL-STD-810, method 511, an RF power source and associated equipment.

4.8.21.3 Test Conditions

The test conditions should be as specified in MIL-STD-810, method 511.

4.8.21.4 Procedure

4.8.21.4.1 The TEM transmission line should be subjected to the test specified in 4.8.24, Procedure I.

4.8.21.4.2 The TEM transmission line should be subjected to the test specified in MIL-STD-810, method 511, Procedure I.

4.8.21.4.3 The TEM transmission line should be subjected to rated peak power for 2 minutes at the specified test frequency (see 3.4.4.6.2 and Table 9), while the TEM transmission line is exposed to the explosive mixture at each test altitude of 50,000, 40,000, 30,000, 20,000 and 10,000 feet.

4.8.21.5 Accept-Reject Criteria

If the TEM transmission line causes an explosion while being energized at any of the test altitudes, the unit should be considered to have failed the test.

4.8.22 Humidity Test

4.8.22.1 General

The humidity test should be conducted to determine the TEM transmission line's resistance to the effects of exposure to a warm, highly humid atmosphere. This imposes a vapor pressure on the item under test which constitutes the major force behind moisture migration and penetration.

4.8.22.2 Test Equipment

The apparatus used as test equipment should be as specified in MIL-STD-810, method 507.

4.8.22.3 Test Conditions

The test conditions should be as specified in MIL-STD-810, method 507.

4.8.22.4 Procedure

The test procedure should be as specified in MIL-STD-810, method 507, Procedure IV except as modified herein.

4.8.22.4.1 Prior to placing the TEM transmission line in the test chamber, the unit should be subjected to the test specified in 4.8.6. Measure and record the value of leakage rate found.

4.8.22.4.2 The initial measurements required in Step 4 of MIL-STD-810, method 507, Procedure IV should consist of the tests specified in 4.8.3, 4.8.4, and 4.8.24, Procedure I.

4.8.22.4.3 Measurements required during Steps 5, 6, and 8 of MIL-STD-810, method 507, Procedure IV should be those specified in 4.8.22.4.2.

4.8.22.4.4 In addition to the inspection specified in Step 9 of MIL-STD-810, method 507, Procedure IV, the TEM transmission line should be subjected to the test specified in 4.8.6.

4.8.22.5 Accept-Reject Criteria

If the TEM transmission line fails at any time during the humidity test to meet the accept-reject criteria established in 4.8.3, 4.8.4, 4.8.6, and 4.8.24, Procedure I, the unit should be considered to have failed the test.

4.8.23 Salt Fog Test

4.8.23.1 General

The salt fog test is conducted to determine the resistance of the TEM transmission line to the effects of a salt atmosphere.

4.8.23.2 Test Equipment

The apparatus used as test equipment should be as specified in MIL-STD-810, method 509.

4.8.23.3 Test Conditions

The test conditions should be as specified in MIL-STD-810, method 509.

4.8.23.4 Procedure

4.8.23.4.1 The TEM transmission line should be subjected to the tests as specified in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.24, Procedure I.

4.8.23.4.2 Prepare the TEM transmission line for test as required in MIL-STD-810, method 509, and install in the test chamber.

4.8.23.4.3 The test should be accomplished as specified in MIL-STD-810, method 509 except the test sample should be exposed to the salt fog for a period of not less than 96 hours. Primary interfaces should not be mated, covered, or otherwise protected during the exposure period.

4.8.23.4.4 At the conclusion of the exposure to the salt fog atmosphere the TEM transmission line should be removed from the chamber and subjected to the examinations and tests specified in 4.8.1, Procedure IV.

4.8.23.4.5 After the examinations and tests specified in 4.8.1, Procedure IV have been performed, the TEM transmission line should be washed and dried as specified in MIL-STD-810, method 509, and subjected to the tests specified in 4.8.24, Procedure I, 4.8.3 and 4.8.4 in the sequence listed.

4.8.23.5 Accept-Reject Criteria

If the TEM transmission line fails to meet the accept-reject criteria established in 4.8.1, Procedure IV, 4.8.3, 4.8.4, and 4.8.24, Procedure I, the unit should be considered as having failed the salt fog test.

4.8.24 High Potential Withstand Test

4.8.24.1 General

The high potential withstanding test should be conducted to determine the TEM transmission lines or the replaceable interface component's ability to operate safely at its rated voltage and withstand momentary over-potentials due to switching, surges, pulsing or other similar phenomena. The test serves to determine if insulating materials and fabrication methods are adequate.

4.8.24.2 Test Equipment

The apparatus used as test equipment should meet the requirements as specified in MIL-STD-202, method 301 except the fault indicator should be a suitable oscilloscope.

4.8.24.3 Test Conditions

Test conditions should be as specified in the applicable test method.

4.8.24.4 Procedure I - for TEM Transmission Lines

4.8.24.4.1 The primary interfaces of the TEM transmission line should be mated to EW precision counterparts that are part of the test equipment setup. Sealant materials should not be used in either the TEM transmission line interface components or their mating test equipment interface components.

4.8.24.4.2 The magnitude of the test voltage should be as specified in 3.4.4.7 and as required by the applicable test conditions.

4.8.24.4.3 The test voltage should be applied between the center conductor and the outer conductor of the TEM transmission line.

4.8.24.4.4 The test voltage should be raised from zero to the specified value at a uniform rate of 500 V (RMS) per second. The test voltage should be maintained at the specified value for a test period of 60 seconds.

4.8.24.4.5 During the test period, monitor the fault indicator oscilloscope for evidence of a disruptive discharge.

4.8.24.4.6 Upon completion of the test period, gradually reduce the test voltage to zero.

4.8.24.5 Accept-Reject Criteria - Procedure I

If any evidence of breakdown is indicated, or if the TEM transmission line fails to withstand the specified test voltage, the unit should be considered to have failed the test.

4.8.24.6 Procedure II - For Replaceable Interface Components

4.8.24.6.1 The interfaces of the replaceable interface component should be mated to counterparts that are part of the test equipment setup. Sealant materials should not be used in either the replaceable interface component or its mating test equipment interface components.

4.8.24.6.2 The magnitude of the test voltage should be as specified in 3.4.4.1.2 at normal ambient conditions.

4.8.24.6.3 The test voltage should be applied between the center conductor and the outer conductor of the replaceable interface component.

4.8.24.6.4 The test voltage should be raised from zero to the specified value at a uniform rate of 500 V (RMS) per second. The test voltage should be maintained at the specified value for a test period of 60 seconds.

4.8.24.6.5 During the test period, monitor the fault indicator oscilloscope for evidence of a disruptive discharge.

4.8.24.6.6 Upon completion of the test period, gradually reduce the test voltage to zero.

4.8.24.7 Accept-Reject Criteria - Procedure II

If any evidence of breakdown is indicated, or if the replaceable interface component fails to withstand the specified test voltage, the unit should be considered to have failed the test.

5. PACKAGING

TEM cable package should always be specified by User on the procurement contract. U.S. military users typically have unique packaging requirements to insure shelf life and cable protection during maintenance replacement cycle. When packaging the following should be considered:

5.1 Metallic surfaces of TEM transmission lines should be cleaned and dried.

5.2 Class I and Class II TEM transmission lines less than 10 feet long should not be coiled, and individually packaged.

5.3 Class I and Class II TEM transmission lines more than 10 feet long should be contained within a coil whose minimum diameter is 50 x the diameter of the cable, and individually packaged.

5.4 Class III TEM transmission lines should not be coiled, bent, or otherwise deformed except as specified in the detail drawing and should be individually packaged.

5.5. TEM transmission lines should be individually packaged in a manner that will afford adequate protection against corrosion, deterioration and physical damage during shipment from supply source to the first receiving activity.

5.6 Marking requirement for the packaging should always be included in the contract or purchase order.

In addition to any special marking required by the contract (see 6.2), each unit package, intermediate package and exterior container should be marked in accordance with MIL-STD-129.

5.7 Package inspection requirements should be included in the contract or purchase order (4.6).

6. NOTES

6.1 Intended Use

The Transverse Electromagnetic Mode (TEM) transmission lines covered herein are intended for use with Airborne Electronic Systems and any other system requiring high-quality low-loss coaxial transmission lines.

6.2 Definitions

The following definitions apply to this specification.

6.2.1 Band of Uncertainty

For the purpose of this specification, the "band of uncertainty" is defined as that portion of any measurement that is subject to doubt because of residual errors within the test and measurement system.

6.2.2 Cable Component

A coaxial device capable of transmitting RF energy in the TEM mode over distances large in comparison to the wave-length of the energy. A cable component may be terminated by either an interface component or an intermediate interface component.

6.2.3 Classification of Product

6.2.3.1 A Class 1 (flexible construction) transmission line is one where, during installation, bending is required to facilitate running long lengths, where attachment to shock mounted equipment is required, and where large angular displacements are encountered during service and maintenance conditions.

6.2.3.2 A Class 2 (semi-flexible construction) transmission line is one where, during installation, bending or forming is required to facilitate running long lengths but where attachment to shock-mounted equipment is not required. Class 2 TEM transmission lines are not intended for applications requiring continuous flexure in service.

6.2.3.3 A Class 3 (rigid construction) transmission line is one that is formed during manufacturing and cannot withstand further bending or forming during installation or service without performance degradation.

6.2.4 Detail Drawings

Drawings established by User or manufacturer (6.2.15 and 6.2.17) that delineate all of the individual requirements for a particular TEM transmission line not specifically defined in this document, or when exceptions are made to this document.

6.2.5 Fine Structure Variation

A periodic or abrupt change that appears in the plotted measurement of insertion loss versus frequency as illustrated in Figure 20.

6.2.6 Inspection Acceptance Criteria

This criteria will be dependent on the manufacturer's inspection plans, his "band of uncertainty," and the User's assumption of "risk." If a manufacturer has a zero "band of uncertainty," the inspection acceptance criteria would be the values specified herein. As the "band of uncertainty" increases, the manufacturer's inspection acceptance criteria would become more stringent than the values specified herein.

6.2.7 Interface Component

The part of a TEM transmission line which provides a mechanical and electrical mate between the cable component and other equipment. The interface component terminates in a primary interface and is permanently attached to its appropriate cable component.

6.2.8 Intermediate Interface

The electrical and mechanical transition between an intermediate interface component and a replaceable interface component. The intermediate interface does not provide the final transition from the cable component to external equipment.

6.2.9 Intermediate Interface Component

The part of a TEM transmission line which provides a mechanical and electrical mate between a cable component and a replaceable interface component. The intermediate interface component terminates in an intermediate interface and is permanently attached to its appropriate cable component.

6.2.10 Outline Dimensions

Outline dimensions, for the purpose of this document, are defined as those that describe the physical size and shape of a TEM transmission line and, if applicable, locate required markings.

6.2.11 Peak to Peak Variation

The variation in the characteristic impedance plot caused by mismatches or imperfections in the TEM transmission line. Figure 21 illustrates the peak-to-peak variation.

6.2.12 Primary Interface

The final electrical and mechanical transition between a TEM transmission line and external equipment. The primary interface may be part of an interface component or a replaceable interface component.

6.2.13 Replaceable Interface Component

The part of a TEM transmission line which provides a mechanical and electrical mate between an intermediate interface component and other equipment. The replaceable interface component is removable as a unit and terminates in an intermediate interface and a primary interface.

6.2.14 TEM Transmission Line

A Transverse Electromagnetic Mode (TEM) transmission line is defined, for the purpose of this document, as a complete assembly capable of mechanically and electrically interconnecting two units of a system. A TEM transmission line should consist of a cable component of finite length terminated at each end by the required electrical interfaces (see Figure 33).

6.2.15 User

A user is an Original Equipment Manufacturer or maintainer of fielded equipment that contains standard component/material defined by the specification or detail drawing.

6.2.16 Acceptable Quality Levels (AQL) Inspection Defects

6.2.16.1 Defect

A defect is any nonconformance of the unit of product with specified requirements.

6.2.16.2 Critical Defect

A critical defect is a defect that judgment and experience indicate would result in hazardous or unsafe conditions for individuals using, maintaining, or depending upon the product, or a defect that judgment and experience indicates is likely to prevent performance of the actual function of a major end item such as a ship, aircraft, tank, missile, or space vehicle.

6.2.16.3 Major Defect

A major defect is a defect, other than critical, that is likely to result in failure, or to reduce the usability of the unit of product for its intended purpose.

6.2.16.4 Minor Defect

A minor defect is a defect that is not likely to reduce materially the usability of the unit of product for its intended purpose, or is a departure from established standards having little bearing on the effective use or operation of the unit.

6.2.17 Manufacturer

A manufacturer is the individual, firm, company or corporation engaged in the fabrication of finished TEM transmission lines or replaceable interface components. A User may be a manufacturer (see 6.2.15).

6.3 A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications nor in documents that contain editorial changes only.

PREPARED BY SAE SUBCOMMITTEE AE-8A, ELECTRICAL WIRING & FIBER OPTIC
INTERCONNECT SYSTEMS INSTALLATION OF
COMMITTEE AE-8, AEROSPACE ELECTRICAL/ELECTRONIC DISTRIBUTION SYSTEMS

Table 17 - Interface gauging - Type 1 male primary interface (4.8.2.4.3)

Reference to Type 1 - Male Primary Interface (Figure 9)			
	Max.	Min.	Notes
Coupling Ring			
Thread Size 7/16-28 UNEF-2B			
Thread Length		0.156	
Thread Relief		0.440	
Relief Depth		0.063	
Outer Conductor			After forming
O.D. (slotted)	0.325	0.322	
O.D. (solid)	0.317	0.313	
Radius		0.005	
Ref. Plane Flat	0.018	0.012	
Ref. Plane Finish	32 √		
Center Pin			
Length (shoulder to tip)	0.192	0.182	
Length (contact surface)	0.045	0.035	
O.D. (contact surface)	0.054	0.053	-A-
Finish	32 √		
Dielectric			
I.D.	0.194	0.192	
Depth from Ref. Plane	0.212	0.209	
Recessed Below Ref. Plane	0.009	0.006	
Locating Dimensions			
Ref. Plane to Center Pin Shoulder	0.212	0.209	
Dielectric I.D. to Center Pin Contact Surface	0.002 TIR		
Outer Conductor to Ref. Plane	0.0005		⊥

Table 18 - Interface gauging - Type 1 female primary interface (4.8.2.4.3)

Reference to Type 1 - Female Primary Interface (Figure 10)			
	Max.	Min.	Notes
Outer Conductor			
O.D.	0.381	0.378	
Thread Size 7/16-28 UNEF-2A			
Thread Length		0.187	
Thread Relief	0.088	0.068	
I.D. Length	0.333	0.329	
I.D. (mating surface at ref. plane)	0.321	0.319	-A-
I.D. (at chamfer)	0.333	0.327	
Mating Surface (at ref. plane)	0.036	0.026	
Radius (at ref. plane)	0.004		
Ref. Plane Finish	32		
Dielectric			
Length (ref. plane to shoulder)	0.006	0.003	
Length (ref. plane to tip)	0.208	0.205	
Diameter (at ref. plane)	0.266	0.264	
Diameter (at tip)	0.186	0.184	
Center Contact			
O.D. (with pin gauge inserted)	0.086	0.085	
Finish (mating surface)	32		
I.D. Depth		0.200	
Locating Dimensions			
Dielectric O.D. (at tip) to Outer Conductor (mating surface)	0.002 TIR		
Center Contact (mating surface) to Outer Conductor (mating surface)	0.004 TIR		
Ref. Plane to Outer Conductor (mating surface)	0.001		⊥
Thread P.D. to Outer Conductor (mating surface)	0.005 TIR		
Center Contact to Dielectric Tip	Flush to 0.003 Depressed		

Table 19 - Interface gauging - Type 2 male primary interface (4.8.2.4.3)

Reference to Type 2 - Male Primary Interface (Figure 11)			
	Max.	Min.	Notes
Coupling Ring			
Thread Size 0.6875-24 UNEF-2B			
Thread Length	0.255	0.245	
Thread Relief		0.690	
Relief Depth	0.223	0.213	
Outer Conductor			After forming
O.D. (slotted)	0.421	0.418	
O.D. (solid)	0.411	0.407	
I.D.		0.384	
Radius	0.008	0.005	
Ref. Plane Finish	32 √		
Center Pin			
Length (shoulder to tip)	0.192	0.182	
Length (contact surface)	0.045	0.035	
O.D. (contact surface)	0.198	0.196	-A-
Finish	32 √		
Dielectric			
I.D. (at center pin shoulder)	0.198	0.196	
I.D.	0.280	0.278	
Depth from Ref. Plane	0.312	0.309	
Recessed Below Ref. Plane	0.010	0.007	
Locating Dimensions			
Ref. Plane to Center Pin Shoulder	0.310	0.306	
Outer Conductor to Center Pin Contact Surface	0.005 TIR		
Ref. Plane to Center Pin Contact Surface	0.001		⊥

Table 20 - Interface gauging - Type 2 female primary interface (4.8.2.4.3)

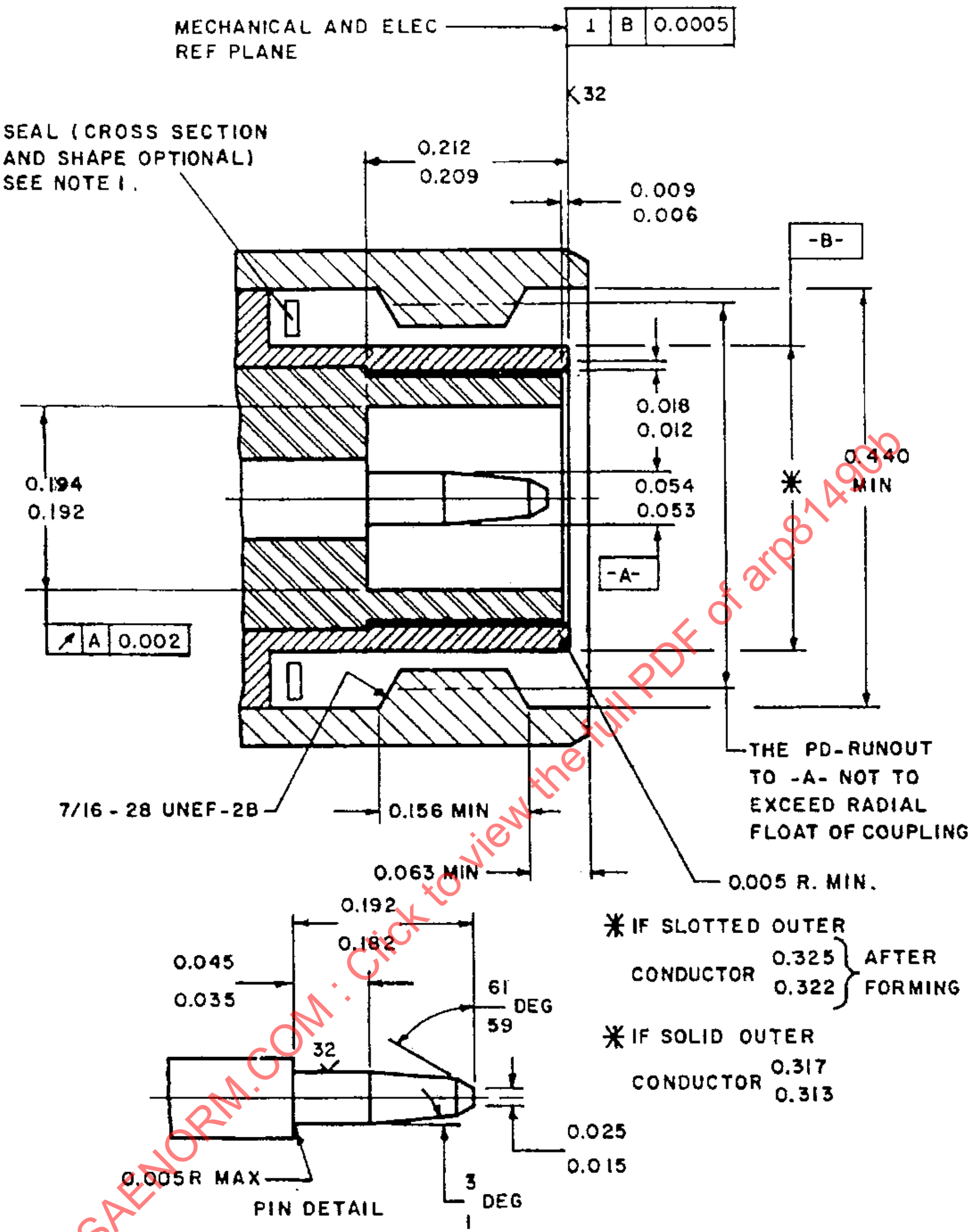
Reference to Type 2 - Female Primary Interface (Figure 12)			
	Max.	Min.	Notes
Outer Conductor			
O.D.	0.630		
Thread Size 0.6875-24 UNEF-2A			
Thread Length		0.250	
Thread Relief	0.077	0.044	
I.D. Length (ref. plane to front)	0.495	0.491	
I.D. (mating surface at ref. plane)	0.415	0.411	-A-
I.D. (at front)	0.498	0.482	
Mating Surface (at ref. plane)	0.040	0.020	
Radius (at ref. plane)	0.004		
Ref. Plane Finish	32√		
Dielectric			
Length (ref. plane to shoulder)	0.007	0.004	
Length (ref. plane to tip)	0.308	0.304	
Diameter (at ref. plane)	0.383	0.381	
Diameter (after shoulder)	0.270	0.268	
Diameter (at tip)	0.189	0.188	
I.D. (at tip)	0.129	0.127	
Center Contact			
O.D. (with pin gauge inserted)	0.1225	0.1215	
Finish (mating surface)	32√		
I.D. Depth		0.300	
Locating Dimensions			
Ref. Plane to Tip of Center Contact	0.305	0.301	
Outer Conductor (mating surface) to Ref. Plane	0.0005		⊥
Thread P.D. to Outer Conductor (mating surface)	0.005 TIR		

Table 21 - Interface gauging - Type 3 male primary interface (4.8.2.4.3)

Reference to Type 3 - Male Primary Interface (Figure 13)			
	Max.	Min.	Notes
Coupling Ring			
Thread Size 0.625-24 UNEF-2B			
Thread Length	0.197	0.177	
Thread Relief		0.630	
Relief Depth	0.168	0.158	
Outer Conductor			
O.D. (slotted)	0.327	0.321	After forming
O.D. (solid)	0.3165	0.3150	
I.D.		0.275	-A-
Radius	0.008	0.005	
Ref. Plane Finish	32		
Center Pin			
Length (shoulder to tip)	0.190	0.180	
Length (contact surface)	0.080	0.070	
O.D. (contact surface)	0.0655	0.0645	-B-
O.D. (shoulder)	0.1202	0.1192	
Finish	32		
Locating Dimensions			
Ref. Plane to Center Pin Shoulder	0.211	0.208	
Ref. Plane to Outer Conductor Shoulder	0.412	0.398	
I.D. Outer Conductor to O.D. Outer Conductor	0.002 TIR		
I.D. Outer Conductor to Center Pin Contact Surface	0.006 TIR		
I.D. Outer Conductor to Ref. Plane	0.0005		⊥
Center Pin (shoulder) to Center Pin Contact Surface	0.002 TIR		

Table 22 - Interface gauging - Type 3 female primary interface (4.8.2.4.3)

Reference to Type 3 - Female Primary Interface (Figure 14)			
	Max.	Min.	Notes
Outer Conductor			
Thread Size 0.625-24 UNEF-2A			
Thread Length	0.202	0.172	
Thread Relief (front)	0.077	0.047	
Thread Relief (front to rear)		0.490	
I.D. Length (ref. plane to front)	0.361	0.357	
I.D. (mating surface at ref. plane)	0.319	0.317	-A-
I.D. (at front)	0.344	0.336	
Mating Surface (at ref. plane)	0.025	0.015	
Radius (at ref. plane)	0.004		
Ref. Plane Finish	32		
Center Contact			
I.D. (mating surface)	0.063		After forming
Finish (mating surface)	32		
I.D. Depth		0.350	
O.D.	0.1215	0.1205	
Locating Dimensions			
Ref. Plane to Center Contact Tip	0.207	0.204	
Outer Conductor (mating surface) to Ref. Plane	0.0005		⊥
Thread P.D. to Outer Conductor (mating surface)	0.005 TIR		
Center Contact (mating surface) to Outer Conductor (mating surface)	0.006 TIR		



NOTE 1. SEAL AND ITS LOCATING DIMENSIONS TO BE DETERMINED TO INSURE CONNECTOR MATES ELECTRICALLY AND MECHANICALLY AND SEALS TO TYPE 1- FEMALE HAVING DIMENSIONS SPECIFIED IN FIGURE 2.

Figure 9 - Type 1 - male, E-W precision primary interface (3.3.1.1)

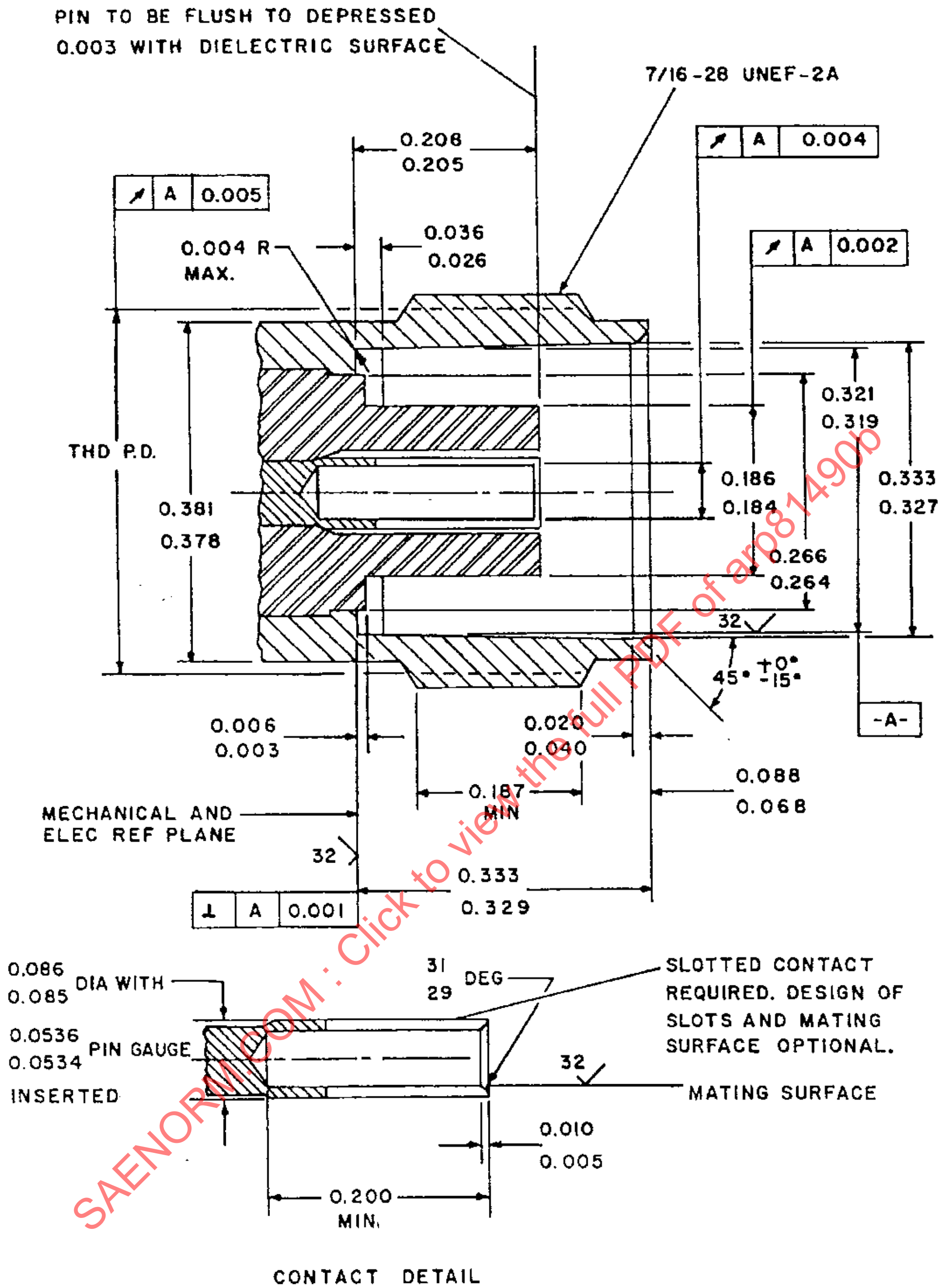
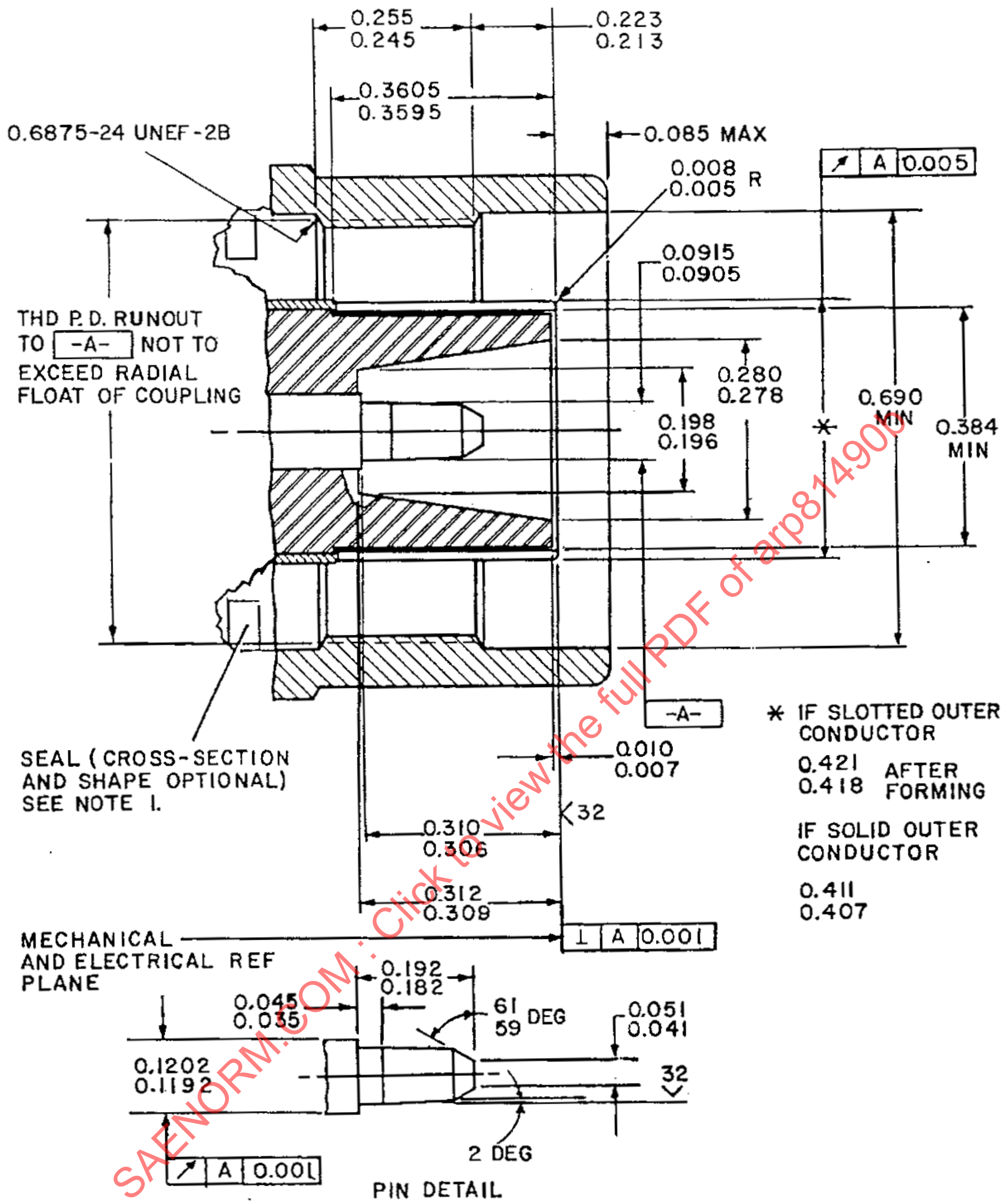


Figure 10 - Type 1 - female, E-W precision primary interface (3.3.1.1)



NOTE 1.

SEAL AND ITS LOCATING DIMENSIONS TO BE DETERMINED TO INSURE CONNECTOR MATES ELECTRICALLY AND MECHANICALLY AND SEALS TO TYPE 2-FEMALE HAVING DIMENSIONS SPECIFIED IN FIGURE 4.

Figure 11 - Type 2 - male, E-W precision primary interface (3.3.1.1)

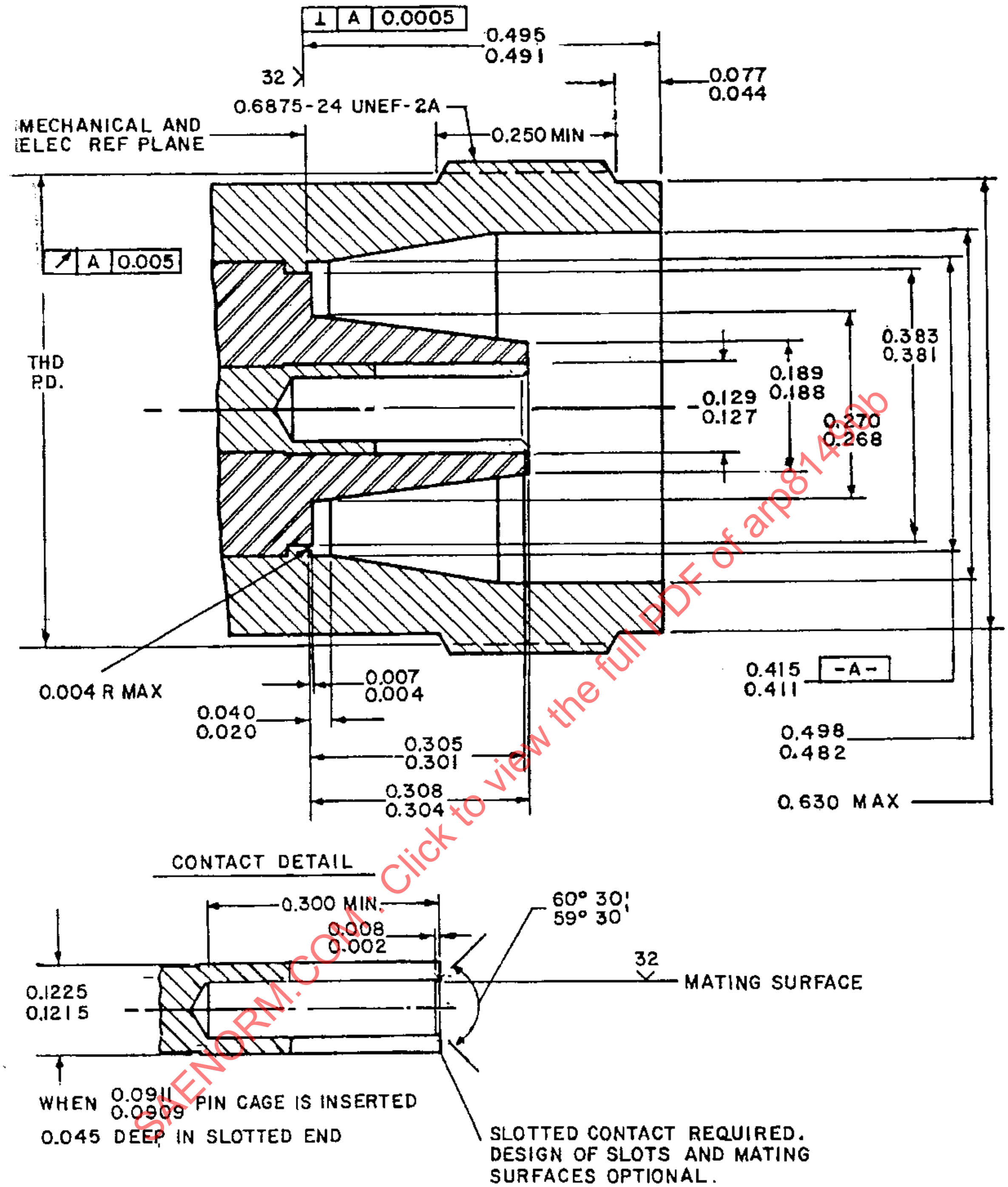


Figure 12 - Type 2 - female, E-W precision primary interface (3.3.1.1)

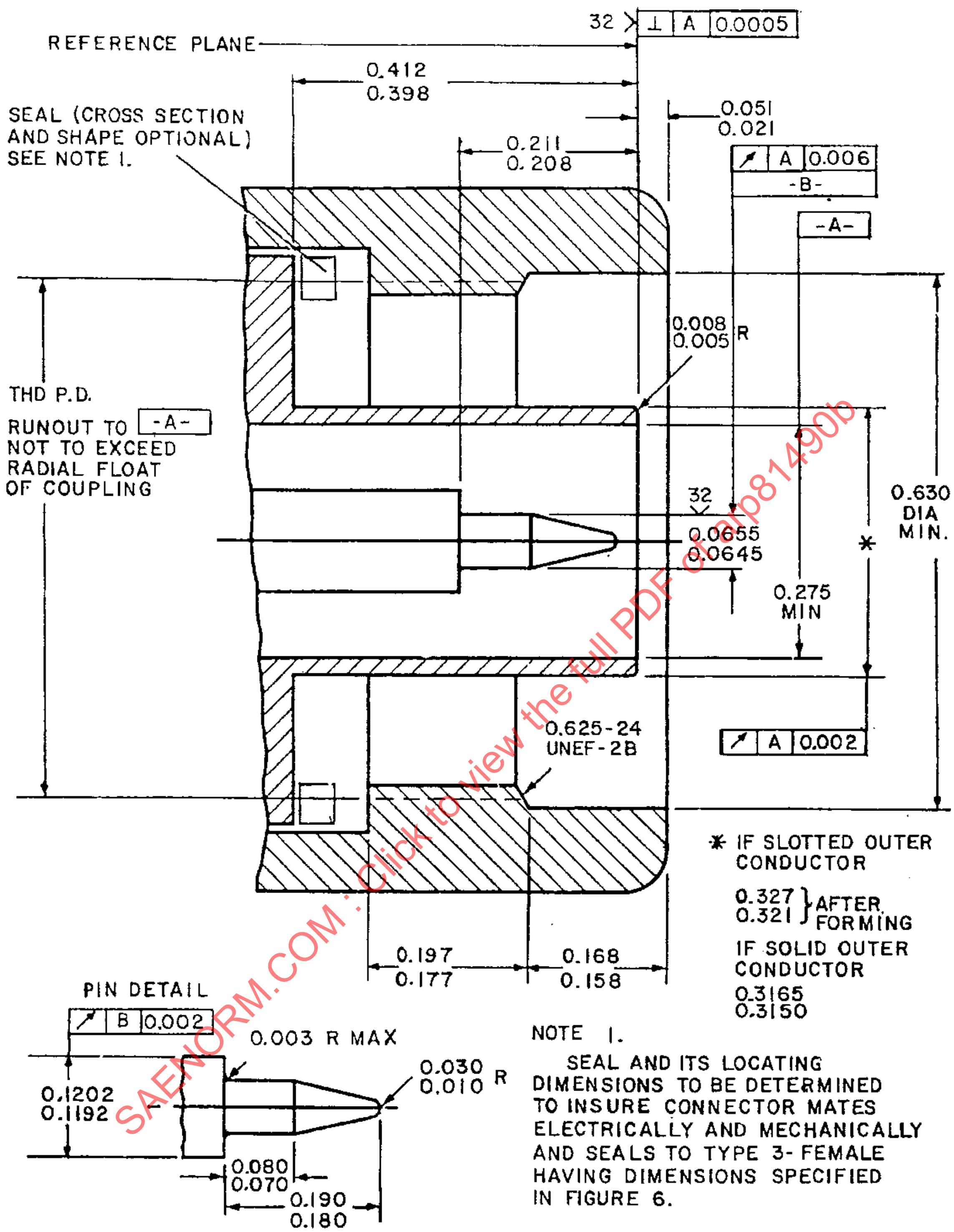


Figure 13 - Type 3 - male, E-W precision primary interface (3.3.1.1)

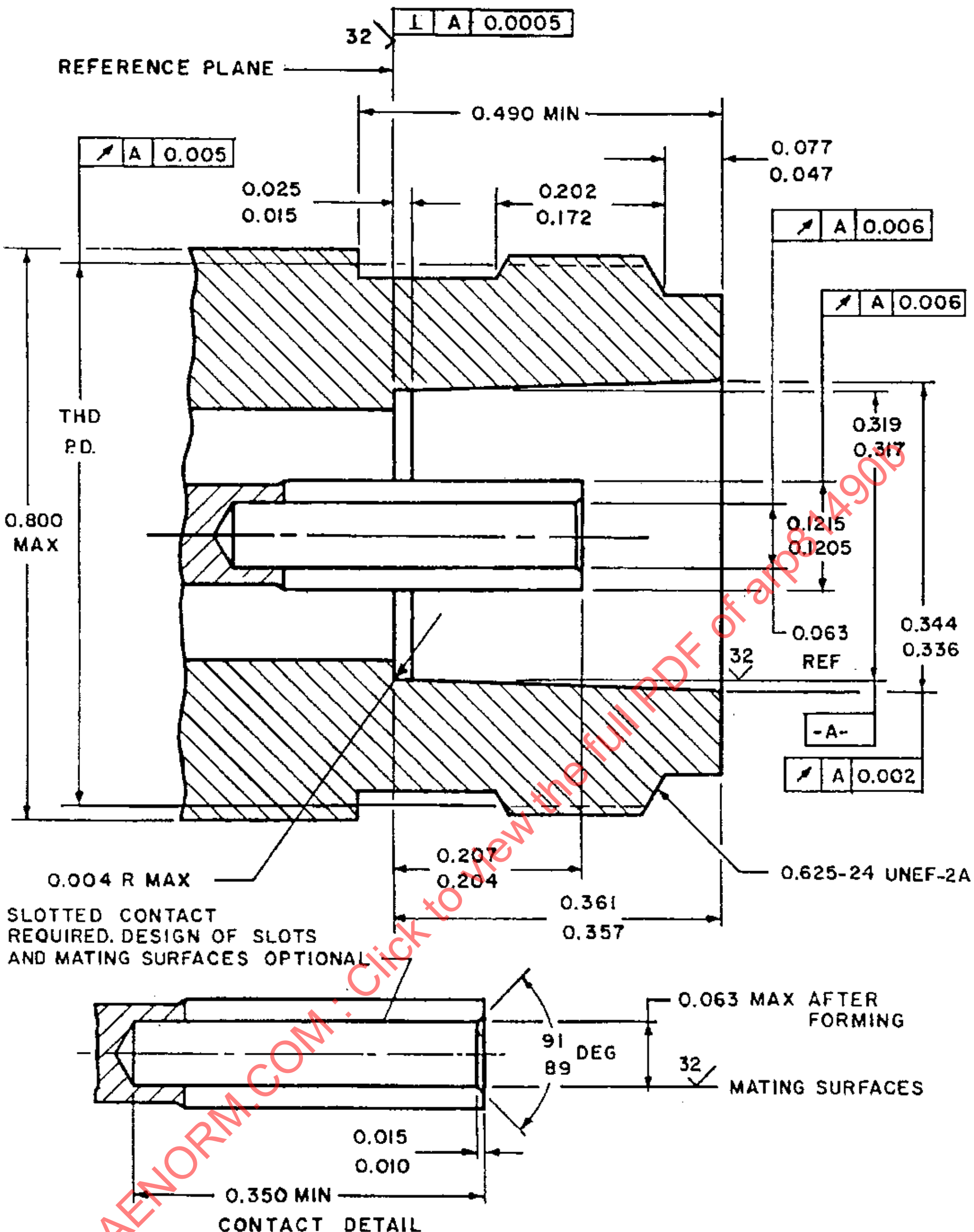


Figure 14 - Type 3 - female, E-W precision primary interface (3.3.1.1)

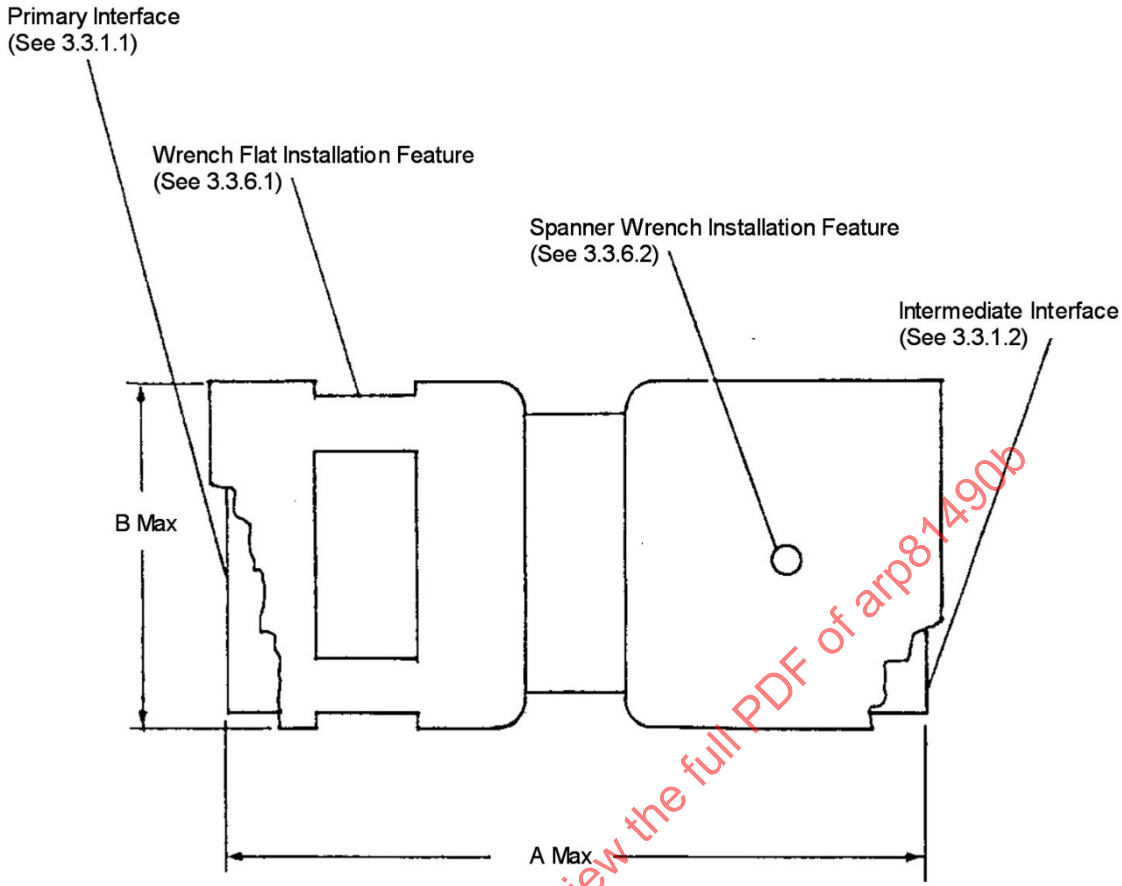


Figure 15 - Style A, straight replaceable interface component (3.3.1.3)

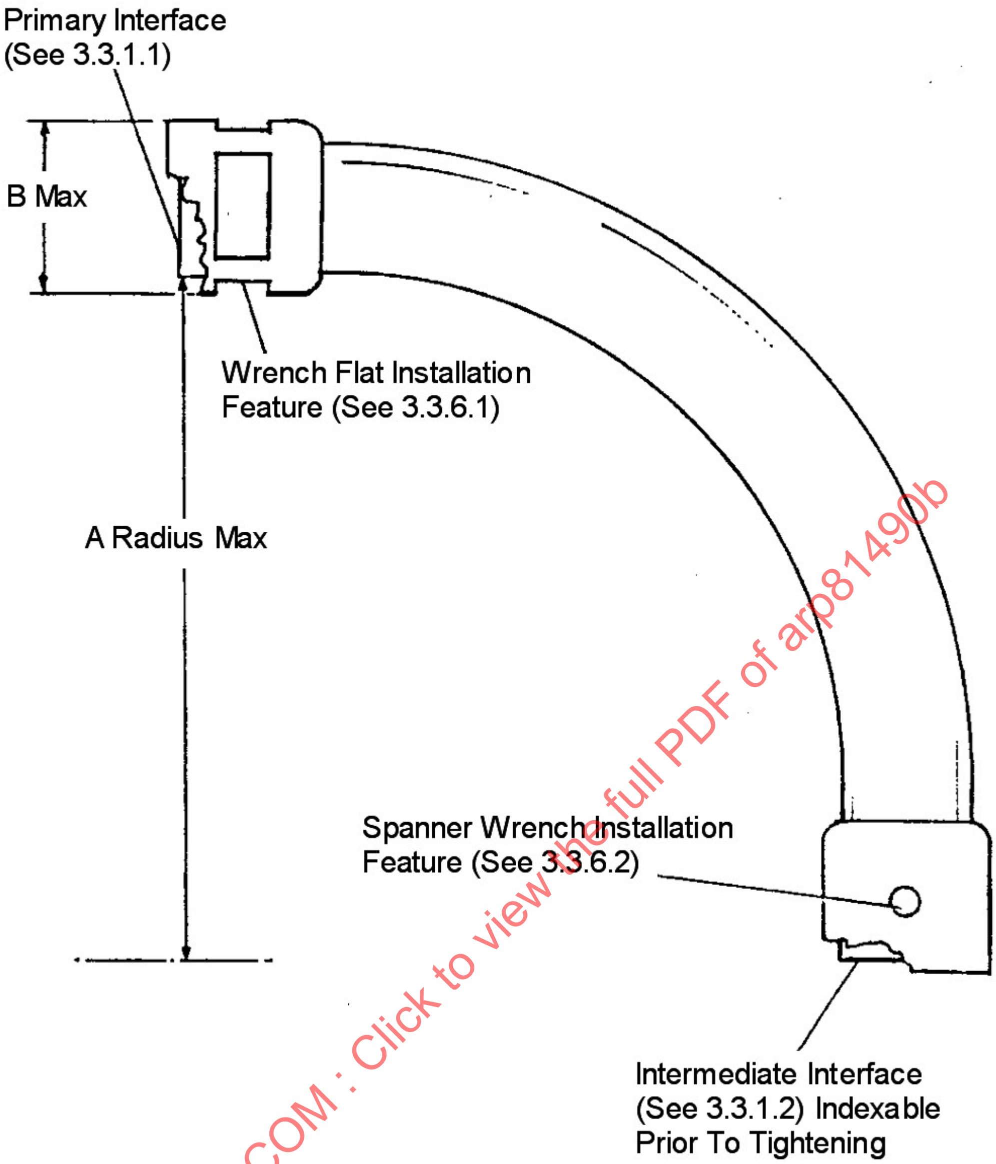


Figure 16 - Style B, 90 degree elbow replaceable interface component (3.3.1.3)

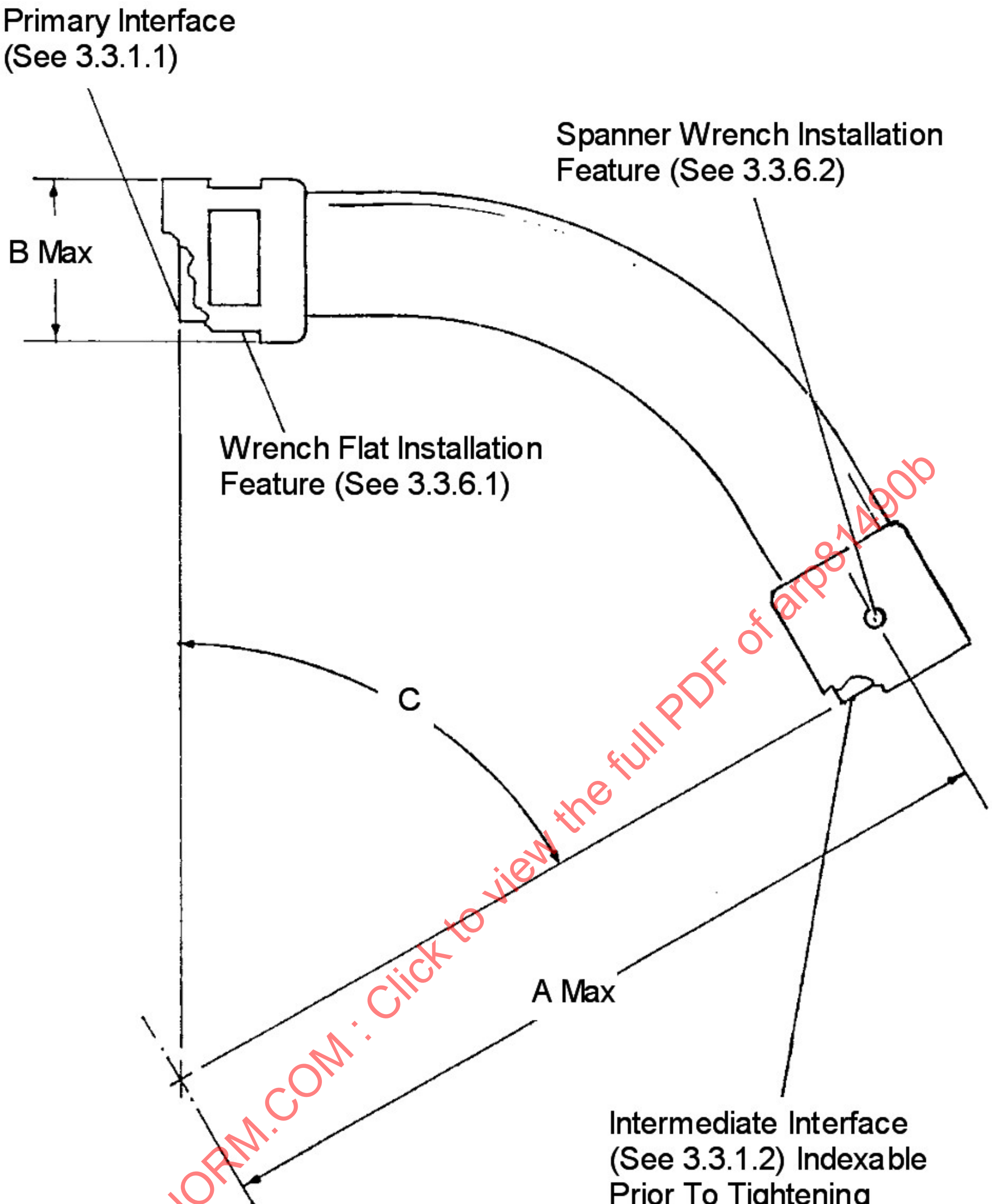
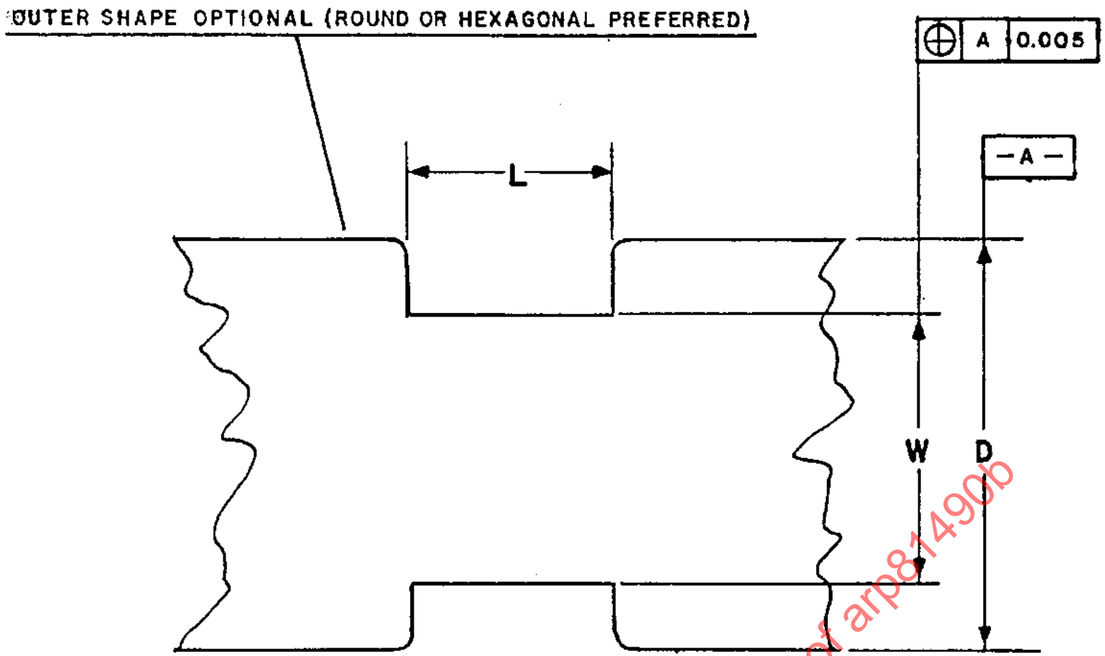
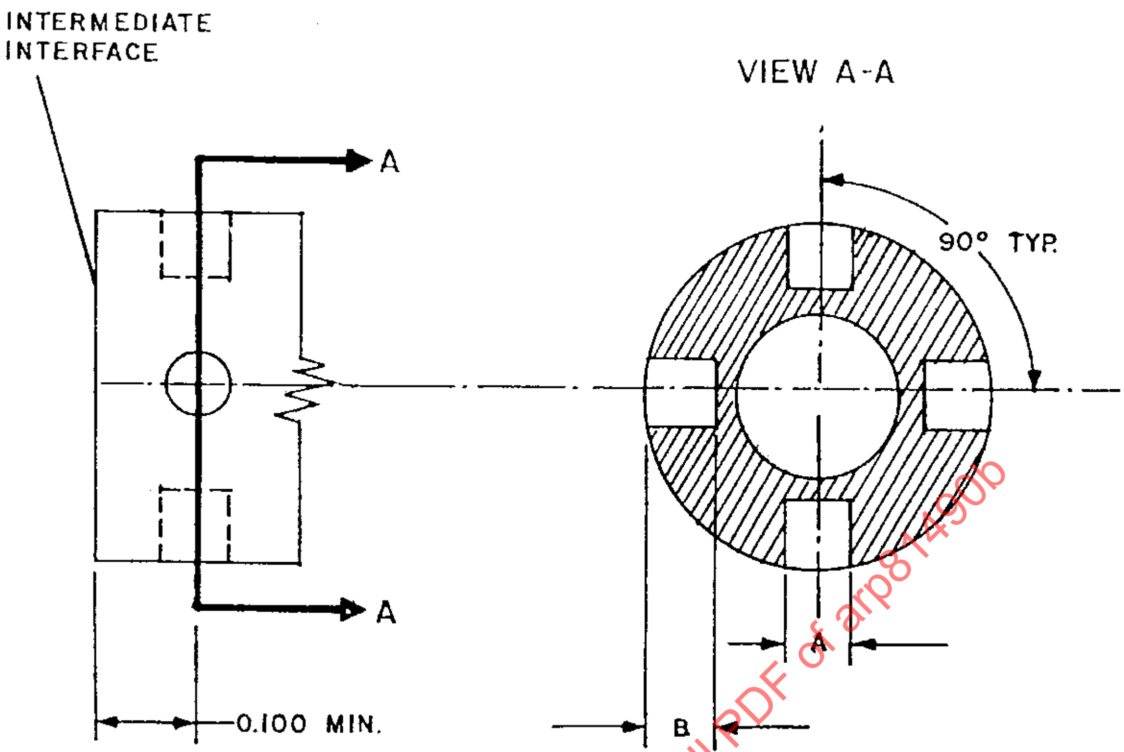


Figure 17 - Style C, angular replaceable interface component (3.3.1.3)



PRIMARY INTERFACE TYPE	W (ACROSS FLATS)		L (FLAT LENGTH)	D (OUTER DIA.)	NOTES
	MAX.	MIN.	MIN.	MAX.	
1	0.625	0.606	0.300	0.800	EITHER SIZE ACCEPTABLE
	0.562	0.547	0.300	0.800	
2	0.781	0.759	0.500	0.800	
3	0.781	0.759	0.500	0.800	

Figure 18 - Wrench flat sizes for primary interfaces (3.3.6.1)



TEM TRANSMISSION LINE TYPE	A (DIA)		B (MAX)
	MIN	MAX	
I	0.094	0.098	0.070
II	0.094	0.098	0.050

Figure 19 - Intermediate interface spanner wrench holes (3.3.6.2)

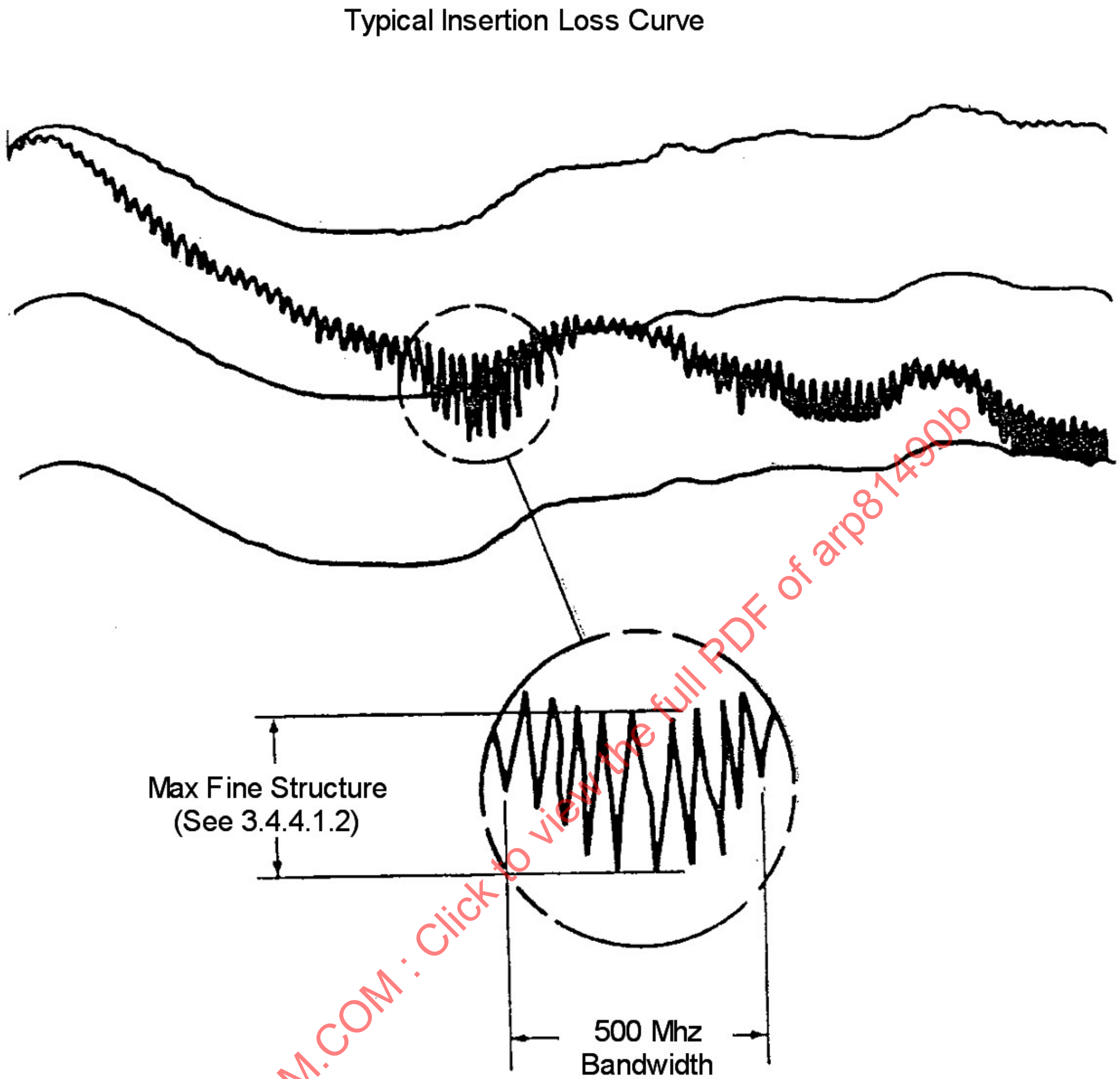


Figure 20 - Typical fine structure variation (4.8.3.6.1)

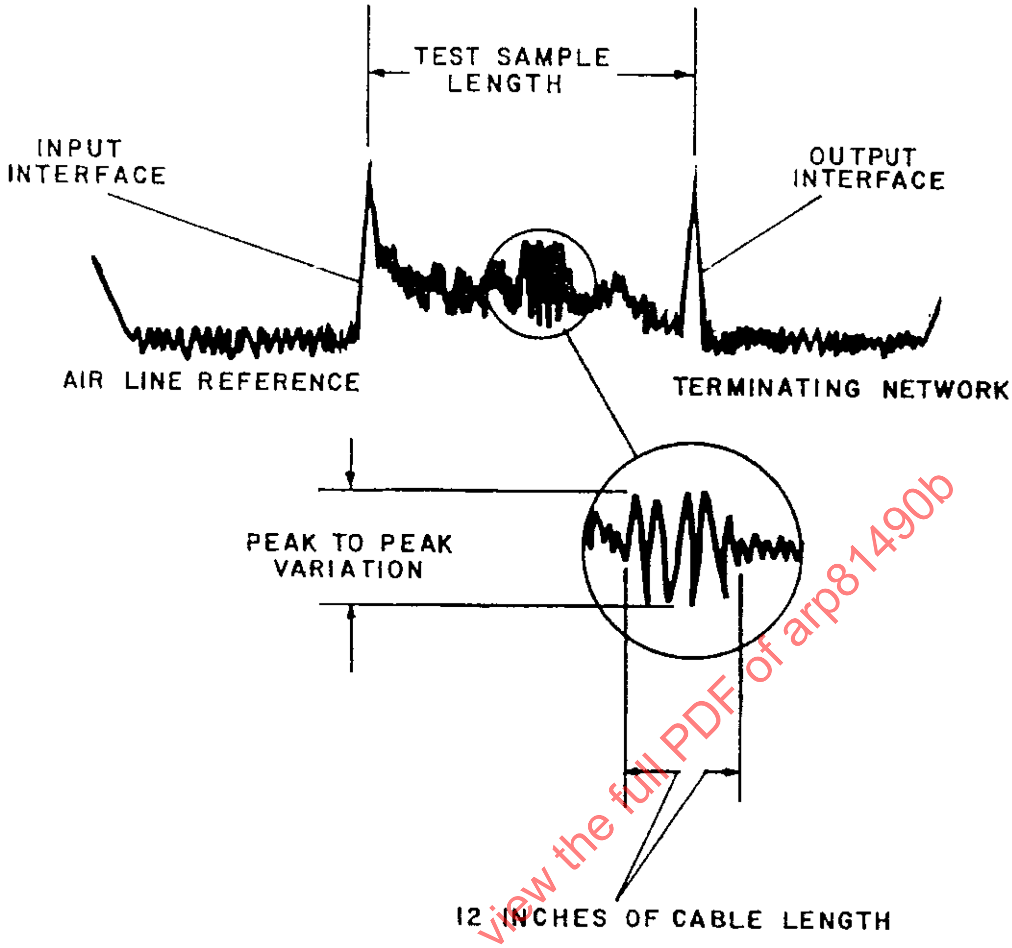


Figure 21 - Typical impedance plot (4.8.5.4.4)

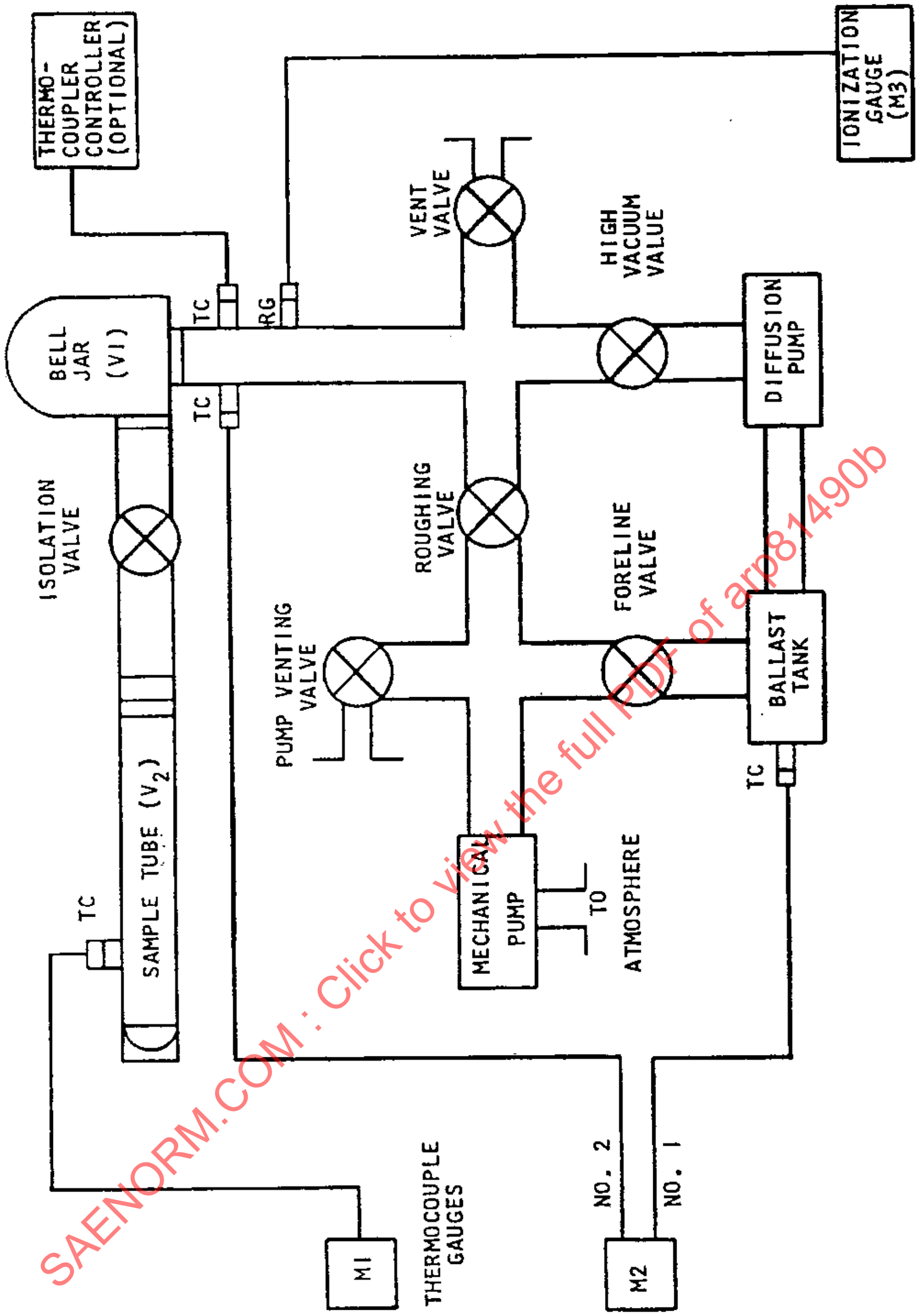


Figure 22 - Vapor leakage test fixtures (4.8.6.2)

EQUIPMENT ITEM	EQUIPMENT NOMENCLATURE	REQUIRED PERFORMANCE PARAMETERS
1	Microwave Sweep Oscillator	Leveled output variable 0 to 100 mw minimum
2	Directional Coupler	20 dB
3	Variable Attenuator	Variable 0 to 50 dB
4	Isolator	20 dB isolation minimum
5	Direction Coupler	10 dB
6	Harmonic Frequency Converter	--
7	Network Analyzer with Gain Indicator Plug-In	--
8	X-Y Recorder	--
9	Fixed Attenuator	20 dB
10	Test Cavity	(See sheet 5 of 10)
11	DC Oscilloscope	--
12	Frequency Meter	--
13	Detector Mount	--
*	Short Circuit Assy	(See sheet 6 of 10)

Figure 23 - RF leakage test equipment and setup (sheet 1 of 10) (4.8.8.2)

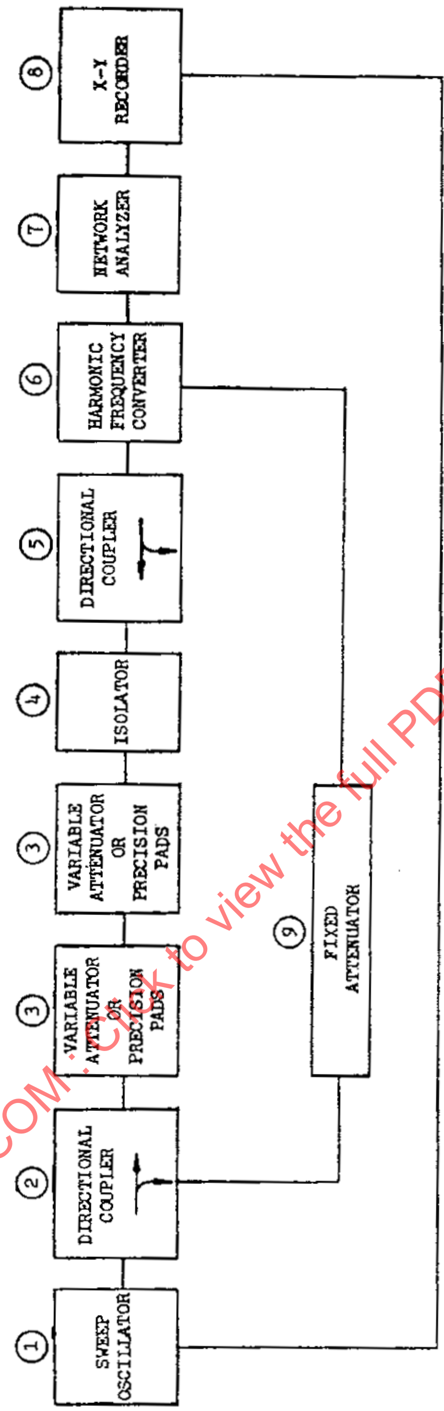


Figure 23 - RF leakage test equipment and setup (sheet 2 of 10) (continued)

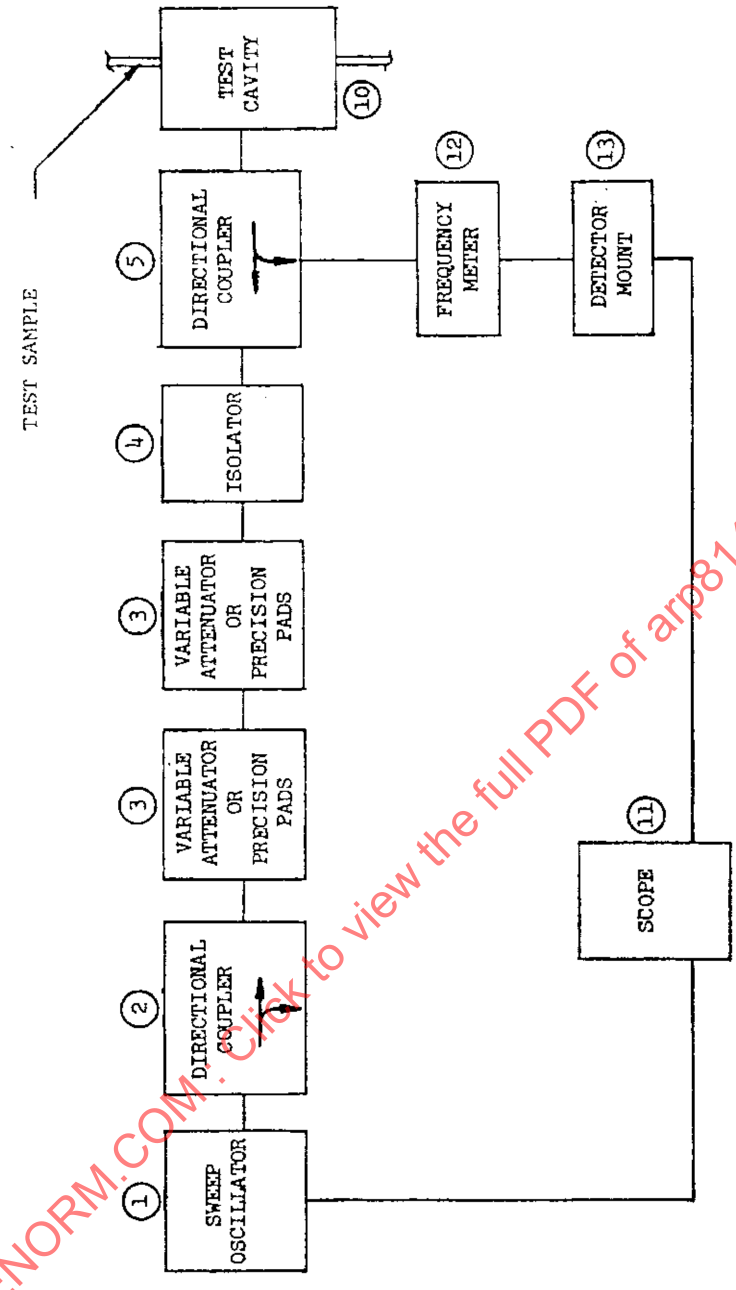


Figure 23 - RF leakage test equipment and setup (sheet 3 of 10) (continued)

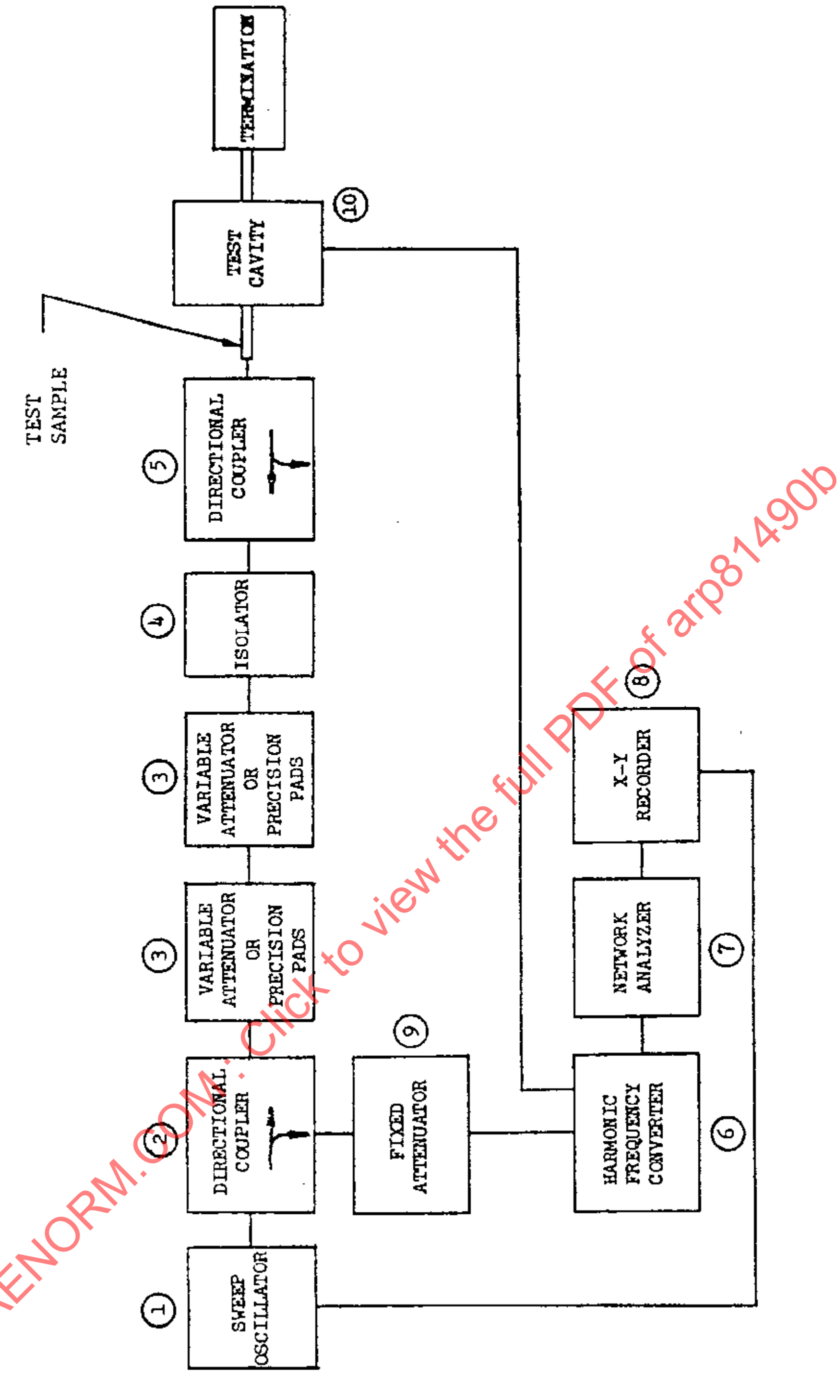


Figure 23 - RF leakage test equipment and setup (sheet 4 of 10) (continued)

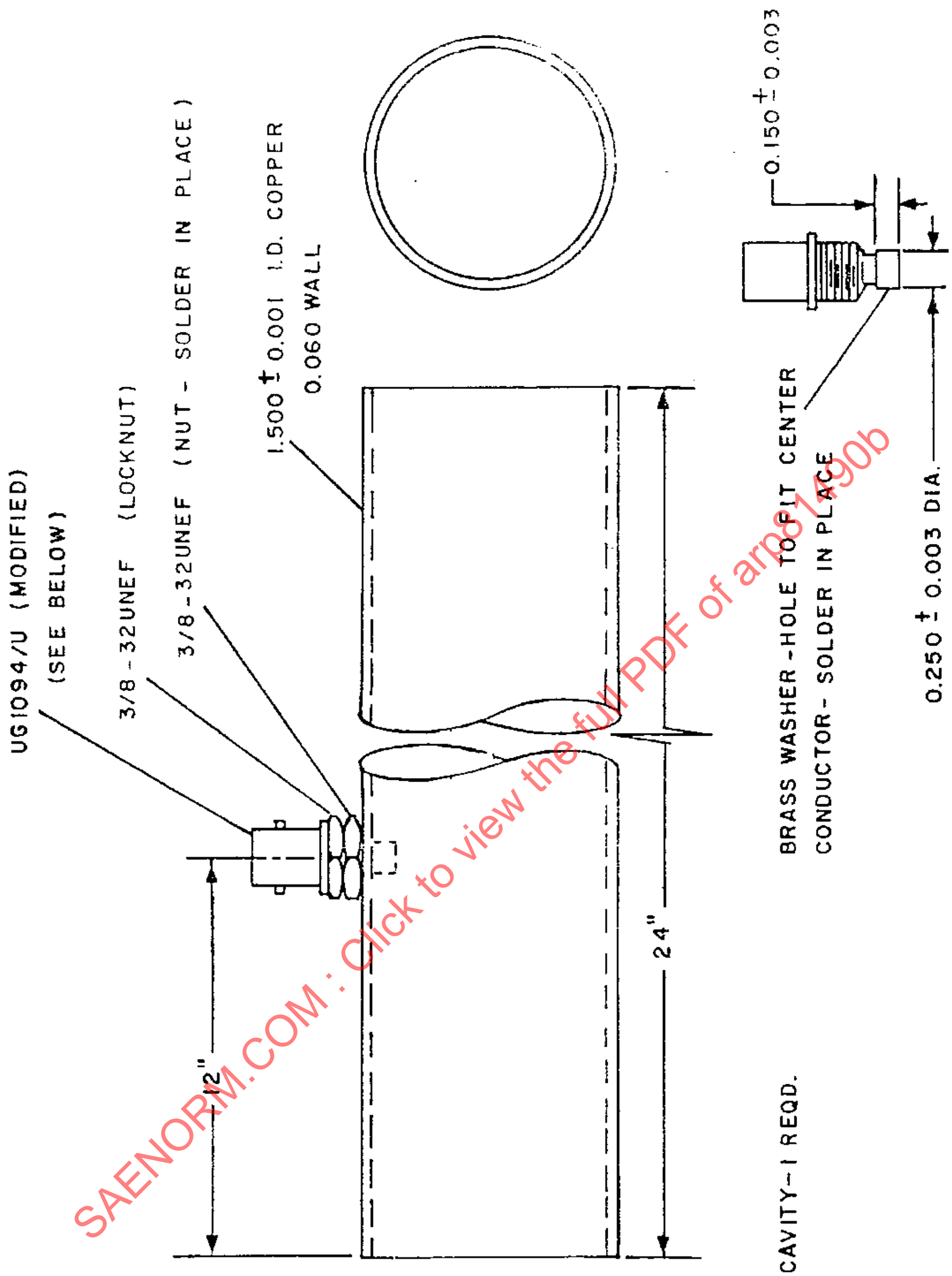


Figure 23 - RF leakage test equipment and setup (sheet 5 of 10) (continued)

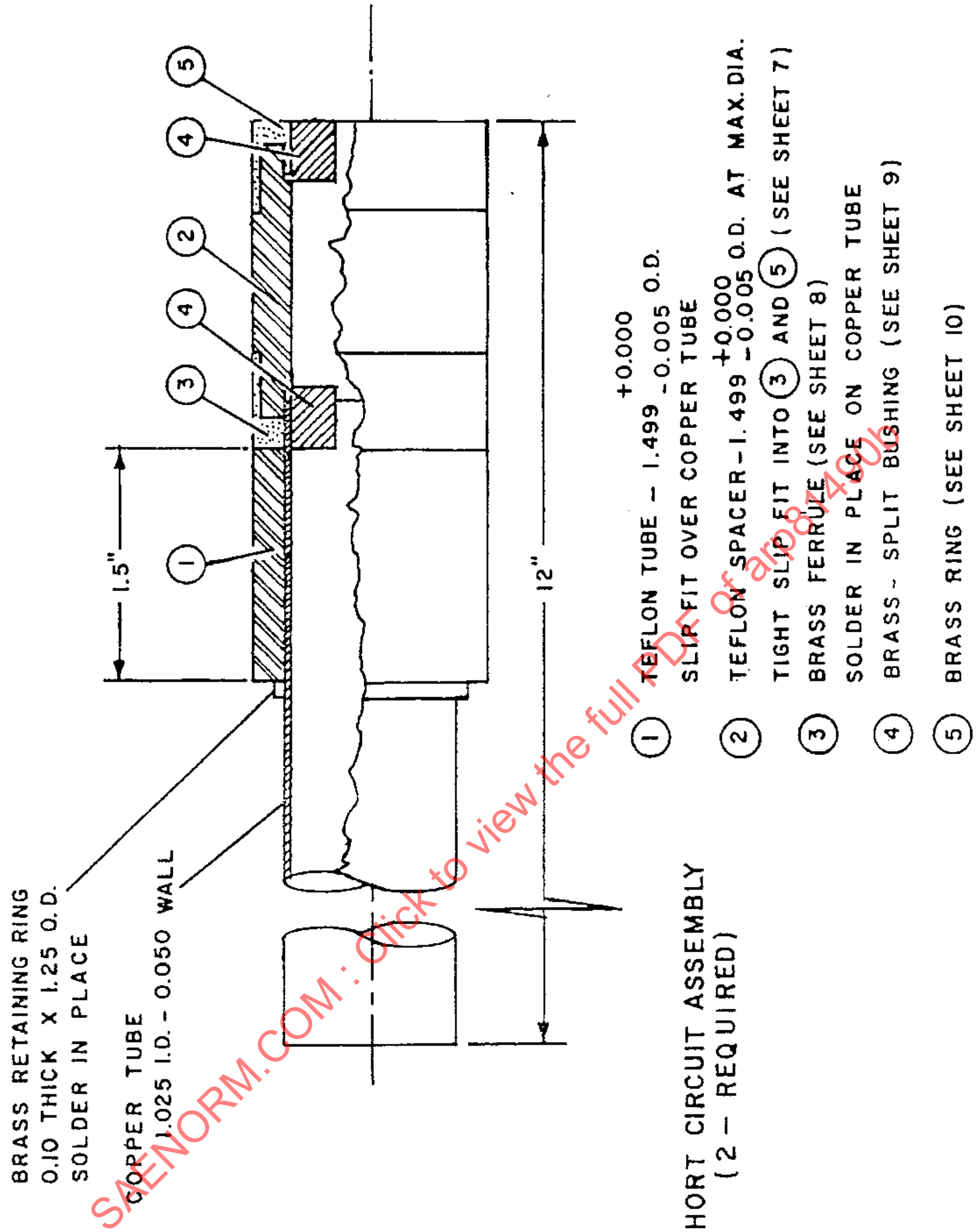
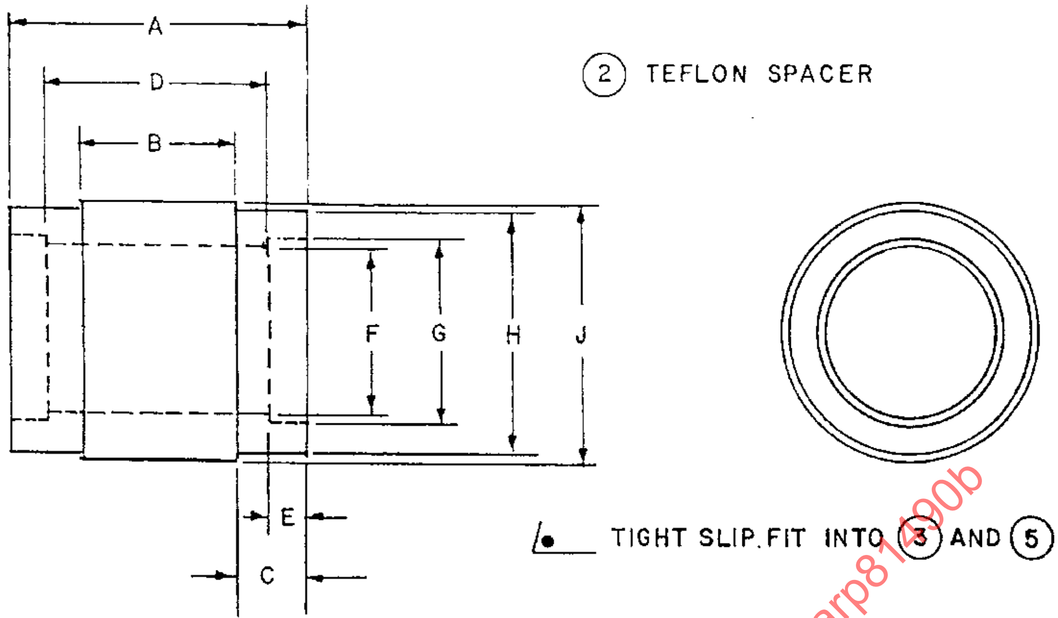
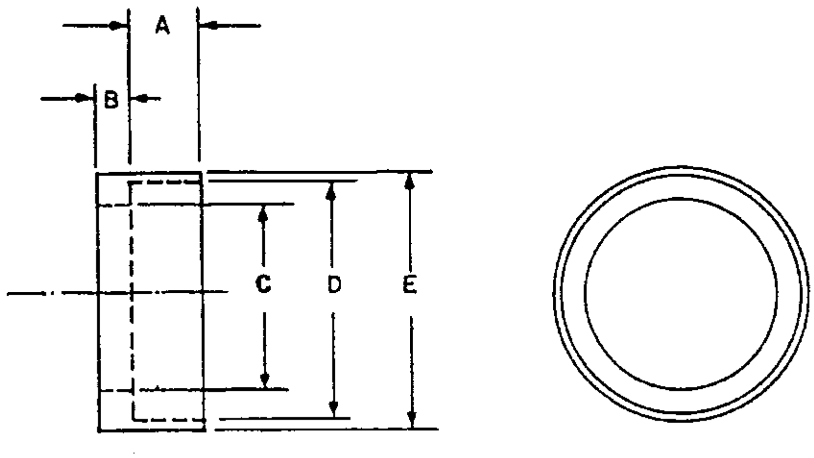


Figure 23 - RF leakage test equipment and setup (sheet 6 of 10) (continued)



	2 GHz TO 8 GHz	8 GHz TO 16 GHz
A	1.740 ± 0.005	0.700 ± 0.005
B	0.900 ± 0.005	0.350 ± 0.005
C	0.420 + 0.000 − 0.005	0.175 + 0.000 − 0.005
D	1.300 ± 0.005	0.450 ± 0.005
E	0.220 ± 0.005	0.125 ± 0.005
F	1.000 + 0.000 − 0.005 DIA	1.000 + 0.000 − 0.005 DIA
G	1.125 DIA (tight slip fit)	1.125 DIA (tight slip fit)
H	1.410 DIA (tight slip fit)	1.410 DIA (tight slip fit)
J	1.499 + 0.000 − 0.005 DIA	1.499 + 0.000 − 0.005 DIA

Figure 23 - RF leakage test equipment and setup (sheet 7 of 10) (continued)

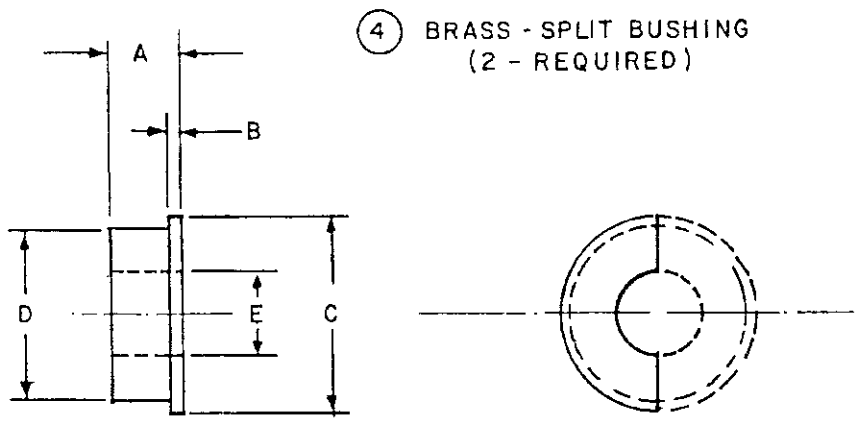


(3) BRASS FERRULE

	2 GHz TO 8 GHz	8 GHz TO 16 GHz
A	0.420 +0.005 -0.000	0.175 +0.005 -0.000
B	0.180 ±0.002	0.075 ±0.002
C	/●	/●
D	1.410 ± 0.002 DIA	1.410 ± 0.002 DIA
E	1.470 + 0.005 - 0.000	1.470 + 0.005 - 0.000

/● DIA TO SLIP OVER AND SWEAT SOLDER TO 1.125 DIA COPPER TUBE.

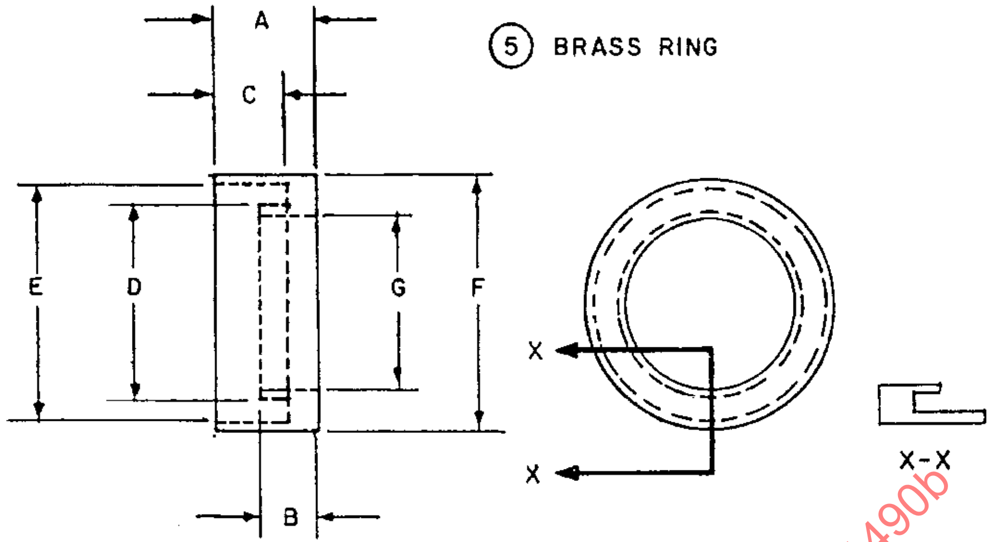
Figure 23 - RF leakage test equipment and setup (sheet 8 of 10) (continued)



	2 GHz TO 8 GHz	8 GHz TO 16 GHz
A	0.400 ± 0.005	0.145 ± 0.003
B	0.060 ± 0.001	0.020 ± 0.001
C	1.125 ± 0.001 DIA	1.125 ± 0.001 DIA
D	1.025 + 0.000 − 0.003 DIA	1.025 + 0.000 − 0.003 DIA
E	⦿	⦿

⦿ DIA TO SLIP EASILY OVER TEST CABLE

Figure 23 - RF leakage test equipment and setup (sheet 9 of 10) (continued)



	2 GHz TO 8 GHz	8 GHz TO 16 GHz
A	0.600 ± 0.003	0.350 ± 0.002
B	0.340 + 0.002 − 0.000	0.125 + 0.002 − 0.000
C	0.420 + 0.005 − 0.000	0.175 + 0.005 − 0.000
D	1.125 ± 0.001 DIA	1.125 ± 0.001 DIA
E	1.410 ± 0.001 DIA	1.410 ± 0.001 DIA
F	1.470 + 0.005 − 0.000	1.470 + 0.005 − 0.000
G	1.025 + 0.000 − 0.004 DIA	1.025 + 0.000 − 0.004 DIA

Figure 23 - RF leakage test equipment and setup (sheet 10 of 10) (continued)