SAE Aerospace An SAE International Group	AEROSPACE STANDARD	AS4373	REV. C
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(R) Test Methods for Insulated Electric Wire

RATIONALE

Addition/modification of aerospace test methods used by industry to harmonize with European methods.

FOREWORD

This document contains a series of test methods for aerospace wire which were designed for both process/quality control tests and to assist electrical design personnel in the selection of a wire for use in an individual aerospace vehicle. No one method can predict all the variables to which a wire can be exposed.

These test methods were collected from a number of aircraft manufacturers. Not all of these are needed for all applications in all vehicles. Some will be applicable for one vehicle, some for another.

It is intended that the test results from this document will be helpful to the electrical designer in making a selection based on the demonstrated performance of a wire under a variety of conditions. The designer may choose to develop additional tests for any unusual requirements of a new vehicle which are not covered in this document. As such this document should be viewed as a check list of baseline criteria for evaluation purposes. It should be supplemented to reflect requirements not contained herein.

A number of the tests contained herein are not short term procedures. As such these tests should be considered for evaluation purposes only, and not as a check on the quality conformance of a wire. This document also contains some new tests that have not been rigorously confirmed as reproducible. Such new tests are identified under the precision and bias statements in the individual test methods.

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TABLE OF CONTENTS

1. SCOPE

This standard describes test methods for insulated, single conductor, electric wire intended for aerospace applications. Particular requirements for the wire being tested need to be specified in a procurement document or other detail specification. Suggested minimum requirements are included in the notes at the end of some of the test methods. SAE Performance Standard AS4372 uses some of the tests in this document for evaluating comparative performance of aerospace wires.

1.1 Contents

This document is comprised of the following Sections:

1. Scope including Contents and Numbering System
2. Applicable Documents
3. Index of Sections and Test Methods
4. Test Methods and Test Procedures

1.2 Test Method Numbering

The test methods are assigned numbers, such as 101, 102, etc., from the applicable group as follows:

a. Group 100: Assembly, Handling, and Repair Tests

b. Group 200: Chemical, Biological, Radiological (CBR) Tests

c. Group 300: Physical Damage Tests

d. Group 400: Conductor Tests

e. Group 500: Electrical Tests

f. Group 600: Environmental Tests

g. Group 700: Mechanical Tests

h. Group 800: Thermal Tests

i. Group 900: Weight and Dimensional Tests

j. Group 1000: Wire Identification Marking and Evaluation

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 724-776-4970 (outside USA), www.sae.org.

AMS1424 Anti-Icing and Deicing-Defrosting Fluid

AS1241 Fire Resistant Phosphate Ester Hydraulic Fluid for Aircraft

AS3320 Stud - Straight, Ring Locked, CRES AMS 5731, .250-20UNJC X .250-28UNJF

AS4372 Performance Requirements for Wire, Electric, Insulated Copper or Copper Alloy

AS4851 Relative Thermal Life and Temperature Index for Insulated Electric Wire

AS5649 Wire and Cable Marking Process, UV Laser

AS22759/35 Wire, Electrical, Fluoropolymer-Insulated, Crosslinked Modified ETFE, Normal Weight, Silver-Coated, High-Strength Copper Alloy, 200°C, 600 Volt

AS25244 Circuit Breaker, Trip-Free, Push-Pull, 5 Thru 50 Amp, Type I

AS25281 Clamp, Loop, Plastic, Wire Support

AS58091 Circuit Breaker, Trip Free, Aircraft, General Specification for

AS50881 Wiring, Aerospace Vehicle

J1966 Lubricating Oils, Aircraft Piston Engines (Non-Dispersant Mineral Oil)

2.2 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 D 412 Rubber Properties in Tension, Standard Test Method for

ASTM D 471 Standard Test Fluids

ASTM D 638 Tensile Properties of Plastics, Test Method for

ASTM D 910 Aviation Gasoline, Standard Specification for

ASTM D 1153 Methyl Isobutyl Ketone, Standard Specification for

ASTM D 1868 Detection and Measurement of Partial Discharge (Corona) Pulse in Evaluation of Insulation Systems, Standard Test Method for

ASTM D 3032 Hookup Wire Insulation, Standard Test Method for

ASTM D 4814 Gasoline, Automotive, Combat

ASTM F 814 Specific Optical Density of Smoke Generated by Solid Materials for Aerospace Applications Standard Test Method for

ASTM G 53 Operating Light- and Water-Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of Non-metallic Materials, Standard Practice for

2.3 ANSI Publications

Available from American National Standards Institute, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

TT-I-735 Isopropyl Alcohol

2.4 U.S. Government Publications

Available from the Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, http://assist.daps.dla.mil/quicksearch/.

MIL-C-43616 Cleaning Compound, Aircraft Surface

MIL-DTL-5624 Turbine Fuel, Aviation Grades JP-4, JP-5 and JP-5/JP-8 ST

MIL-DTL-83133 Turbine Fuels, Aviation, Kerosene Types, NATO F-34(JP-8) and NATO F-35

MIL-PRF-5606 (Inactive for New Design) Hydraulic Fluid, Petroleum Base, Aircraft, Missile and Ordnance Hydrocarbon Base, Aircraft, Metric, NATO Code Number H-537

MIL-PRF-7808 Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, NATO Code Number 0-148

MIL-PRF-23699 Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, NATO Code Number 0-156

MIL-PRF-87252 Coolant Fluid, Hydrolytically Stable, Dielectric

MIL-PRF-87937 Cleaning Compounds, Aircraft Exterior Surfaces, Water Dilutable

MIL-STD-202 Test Methods for Electronic and Electrical Component Parts

MIL-STD-704 Aircraft Electric Power Characteristics

3. INDEX OF SECTIONS AND TEST METHODS

3.1 Test Methods Group 100 - Assembly, Handling, and Repair Tests

TABLE 1

Method No.	Title
101	Concentricity and Wall Thickness
102	Insulation Bonding to Potting Compounds
103	Insulation Pull-off Force
104	Insulation Shrinkage/Expansion
105	Solderability
106	Thermal/Mechanical Resistance - Single Wire
107	Thermal/Mechanical Resistance - Bundle
108	Solder Pot Test for Insulation Shrinkage
109	Percent Overlap of Insulating Tapes

3.2 Test Methods Group 200 - Chemical, Biological, Radiological/Nuclear, Biological, Chemical (CBR/NBC)

No test methods have been adopted for Group 200 - CBR/NBC. The United States military have done extensive testing on materials in a CBR/NBC environment. This information remains classified but is available to prime contractors. This section is reserved for industry CBR/NBC tests that may be developed or instituted in the future.

3.3 Test Methods Group 300 - Physical Damage Tests

No test methods have been adopted for Group 300 – Physical Damage Tests. This section is reserved for physical and/or in-service damage tests that may be developed or instituted in the future.

3.4 Test Methods Group 400 - Conductor Tests

TABLE 2

Method No.	Title
401	Conductor Diameter
402	Conductor Elongation and Tensile Breaking Strength
403	Conductor Resistance
404	Conductor Strand Blocking

3.5 Test Methods Group 500 - Electrical Tests

TABLE 3

Method No.	Title
501	Dielectric Constant
502	Corona Inception and Extinction Voltages
503	Impulse Dielectric
504	Insulation Resistance
505	Spark Test of Finished Wire Insulation
506	Surface Resistance
507	Time/Current to Smoke
508	Dry Arc Propagation Resistance
509	Wet Arc Propagation Resistance
510	Voltage Withstand (Wet Dielectric)
511	Wire Fusing Time
512	Voltage Rating

3.6 Test Methods Group 600 - Environmental Tests

TABLE 4

Method No.	Title
601	Fluid Immersion
602	Forced Hydrolysis
603	Humidity Resistance
604	Weight Loss Under Temperature and Vacuum
605	Propellant Resistance
606	Weathering Resistance
607	Wicking

3.7 Test Methods Group 700 - Mechanical Tests

TABLE 5

Method No.	Title
701	Abrasion
702	Cold Bend
703	Dynamic Cut Through
704	Flex Life
705	Insulation Tensile Strength and Elongation
706	Notch Propagation
707	Stiffness and Springback
708	Mandrel and Wrapback Test
709	Wrinkle Test
710	Durability of Wire Manufacturer's Color/Identification
711	Durability of Wire Installer's Identification
712	Bend Test

3.8 Test Method Group 800 - Thermal Tests

TABLE 6

Method No.	Title
801	Flammability
802	High Pressure/High Temperature Air Impingement (Burst Duct)
803	Smoke Quantity
804	Relative Thermal Life and Temperature Index
805	Thermal Shock Resistance
806	Property Retention After Thermal Aging
807	Multi-day Heat Aging Test (Life Cycle)
808	Blocking
809	Lamination Sealing
810	Topcoat Cure
811	Cross-link Proof Test
812	Flame Resistance
813	Insulation State of Sinter

3.9 Test Methods Group 900 - Weight and Dimensional Tests

TABLE 7

Method No.	Title
901	Finished Wire Diameter
902	Finished Wire Weight

3.10 Test Methods Group 1000 - Wire Identification Marking and Evaluation

TABLE 8

Method No.	Title
1001	Wire Marking Contrast

4. TEST METHODS AND TEST PROCEDURES

4.1 Test Methods Group 100 - Assembly, Handling and Repair Tests

4.1.1 Method 101, Concentricity and Wall Thickness

4.1.1.1 Scope

This test is to be used to determine the wall thickness and concentricity of an insulated wire.

4.1.1.2 Specimen

A wire specimen of not less than 6 in (152 mm) shall be tested.

4.1.1.3 Test Equipment

4.1.1.3.1 Magnifying Device

A microscope or optical comparator equipped with devices capable of making measurements reproducible to at least 0.0005 in (0.013 mm) shall be used.

4.1.1.4 Test Procedure

4.1.1.4.1 Wholly Tape Wrapped Constructions

Measurements of wall thickness shall be by measuring the finished wire insulation at its thinnest point. The wall thickness measurement shall be the shortest distance between the outermost rim of the finished wire and the outer rim of the outermost strand of the conductor.

4.1.1.4.2 Other Constructions

All other constructions shall have wall thickness measurements performed in accordance with section 16 of ASTM D 3032.

4.1.1.4.2.1 Concentricity

Of other than wholly tape wrapped constructions shall be calculated from the wall thickness as shown below:

a. Size 30 through 10:

$$\% \text{ Concentricity} = \frac{\text{Minimum wall thickness} \times 100}{\text{Maximum wall thickness}} \quad \text{(Eq. 1)}$$

b. Size 8 through 0000:

$$\% \text{ Concentricity} = \frac{\text{Minimum wall thickness} \times 100}{\text{Average wall thickness of 4 measurements taken } 90^\circ \text{ apart}} \quad \text{(Eq. 2)}$$

4.1.1.5 Results

Report wall thickness measurements for all constructions. Report concentricity for those constructions that are not wholly tape wrapped.

4.1.1.6 Information Required in Detail Specification

Number and wire size of specimens to be tested and number of measurements.

4.1.1.7 Precision Bias

A minimum concentricity of 70% is usually desirable.

4.1.2 Method 102, Insulation Bonding to Potting Compounds

4.1.2.1 Scope

This test is to be used to measure the bonding between potting compounds and wire insulation.

4.1.2.2 Specimen

See section 19.3 of ASTM D 3032 for specimen preparation.

4.1.2.3 Test Equipment

See section 19.2 of ASTM D 3032 for test apparatus.

4.1.2.4 Test Procedure

See section 19.4 of ASTM D 3032 for the test procedure and section 19.5 of ASTM D 3032 for the calculation of the pull-out strength.

4.1.2.5 Results

Report the average pull-out strength, specific identification of the potting compound, and surface preparation of the wire insulation.

4.1.2.6 Information Required in the Detail Specification

Description of the potting compound, primer (if applicable), surface preparation, and number of specimens to be tested.

4.1.2.7 Precision Bias

See section 19.7 of ASTM D 3032 for precision bias. Potting compounds can vary in property between manufacturer's and location of testing facilities. Care should be taken in drawing conclusion from single test results

4.1.3 Method 103, Insulation Pull-Off Force

4.1.3.1 Scope

This test method is to be used to determine the force required to remove the insulation material from the conductor of a finished wire.

4.1.3.2 Specimen

See section 27.4 of ASTM D 3032.

4.1.3.3 Test Equipment

See ASTM D 638 and section 27.3 of ASTM D 3032.

4.1.3.4 Test Procedure

4.1.3.4.1 Perform sections 27.5.1 through 27.5.5 of ASTM D 3032.

4.1.3.5 Results

Report results of pull test in pounds-force (Newton).

4.1.3.6 Information Required in Detail Specification

Number of specimens to be tested.

4.1.3.7 Precision Bias

This test method of ASTM D 3032 has not had the benefit of round-robin testing to determine precision.

4.1.4 Method 104, Insulation Shrinkage/Expansion

4.1.4.1 Scope

This test is to determine the longitudinal shrinkage or expansion experienced by a wire insulation after brief heat aging.

4.1.4.2 Specimen

The specimen shall be a 13 in (330 mm) length of wire cut flush on both ends.

4.1.4.3 Test Equipment

4.1.4.3.1 A razor blade or equivalent device to remove an insulation slug from conductor.

4.1.4.3.2 A device capable of measurement to 0.001 in (0.025 mm).

4.1.4.3.3 An air oven capable of maintaining the specified temperatures and tolerances.

4.1.4.4 Test Procedure

Strip 1/2 in (12.7 mm) of insulation shall be from each end of the finished wire specimen. Use a razor blade (or equivalent) held perpendicular to the axis of the wire to remove the insulation. The length of the exposed conductor at each end of the specimen shall be measured to the nearest 0.005 in (0.13 mm). The specimen shall be exposed for 6 h to a minimum temperature of 30 °C ± 3 °C (86 °F ± 5 °F) above the rated temperature of the specimen. An air circulating oven shall be used for this exposure. At the end of 6 h, remove the specimen from the oven and allow it to return to room temperature. Each end of the specimen shall be measured to the nearest 0.005 in (0.13 mm). The longitudinal shrinkage or expansion of the insulation shall be the greatest distance any layer of insulation has moved on either end of the specimen.

4.1.4.5 Results

Report oven temperature and greatest shrinkage or expansion of insulation.

4.1.4.6 Information Required in Detail Specification

Number and wire size of specimens to be tested, temperature rating of the insulated wire and limit of allowable shrinkage or expansion.

4.1.4.7 Precision Bias

A maximum longitudinal shrinkage or expansion of 0.125 in (3.13 mm) is usually desirable for sizes 12 and smaller. A maximum shrinkage or expansion requirement of 0.250 in (6.25 mm) is usually desirable for sizes 10 and larger.

4.1.5 Method 105, Solderability

4.1.5.1 Scope

This test is to be used to determine the solderability of tin coated copper conductor. At present, the solderability of wires with other coatings has not been validated to this or other test methods.

4.1.5.2 Specimen

A wire specimen of not less than 10 in (254 mm) shall be used.

4.1.5.3 Test Equipment

See Sections 2 and 3 of Method 208, MIL-STD-202.

4.1.5.4 Test Procedure

See Section 4 of Method 208, MIL-STD-202. One of the three test conditions listed in Table 9 shall be used.

TABLE 9

Condition	Hours of Steam Aging	Flux
A	8	R
B	1	R
C	0	R

4.1.5.5 Results

Report the actual and average results of the solderability test and the condition used.

4.1.5.6 Information Required in Detail Specification

Number and wire size of specimens to be tested, test condition required, and soldering pot or soldering iron method.

4.1.5.7 Precision Bias

This is a new method that has not had the benefit of any round-robin testing to determine precision.

4.1.6 Method 106, Thermal/Mechanical Resistance - Single Wire

4.1.6.1 Scope

This test is to be used to determine the combined thermal/mechanical cut-through resistance of an individual insulated wire and to simulate possible wire damage during removal of overbraids from wire bundles.

4.1.6.2 Specimen

A wire specimen of not less than 12 in (305 mm) shall be tested.

4.1.6.3 Test Equipment

4.1.6.3.1 A solder iron or system capable of controlling tip temperatures to 398 °C ± 3 °C (750 °F ± 5 °F), 343 °C ± 3 °C (650 °F ± 5 °F), and 288 °C ± 3 °C (550 °F ± 5 °F). The solder iron is to be equipped with a screwdriver tip approximately 0.105 in (2.67 mm) wide by 0.05 in (1.27 mm) thick.

4.1.6.3.2 A temperature-measuring device capable of providing an accurate measurement of the solder iron tip described in 4.1.6.3.1.

4.1.6.3.3 A scale capable of measuring a 5 lb (2.27 kg) ±3%, weight.

4.1.6.3.4 Moment external limit switch.

4.1.6.3.5 60 min standard timer.

4.1.6.3.6 Continuity detector box.

4.1.6.3.7 Test setup, fixture, and procedure.

4.1.6.4 Test Procedure

4.1.6.4.1 Test Setup

A recommended test setup is shown in Figure 1 and described in the following paragraphs. Use of equivalent, alternate fixtures to hold the soldering iron or boxes to detect continuity are acceptable.

4.1.6.4.1.1 Build a test fixture to hold the soldering iron in a vertical position. Figure 1 shows a clamp attached to a lever arm with no friction. The solder iron shall be weighted via the lever arm to provide a 5 lb (2.27 kg) load to the soldering iron tip. A 1 in (25.4 mm) minimum thickness PTFE sheet will provide a non-heat-conducting surface for the wire to rest on and a small groove in the PTFE sheet will help to keep the wire specimen in place during test. The limit switch used to start the timer shall be placed in either of the two locations shown in Figure 2. The first location is attached to the vertical stand so that the limit switch is activated by the lever arm as it is lowered onto the wire. The second location is beneath the PTFE sheet so that the force associated with the soldering iron resting on the wire activates the switch.

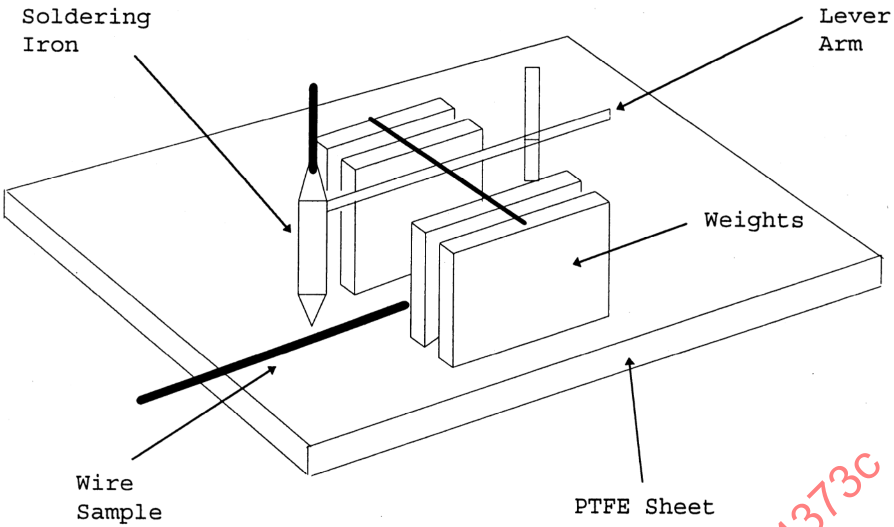


FIGURE 1 - THERMAL/MECHANICAL RESISTANCE TEST SETUP

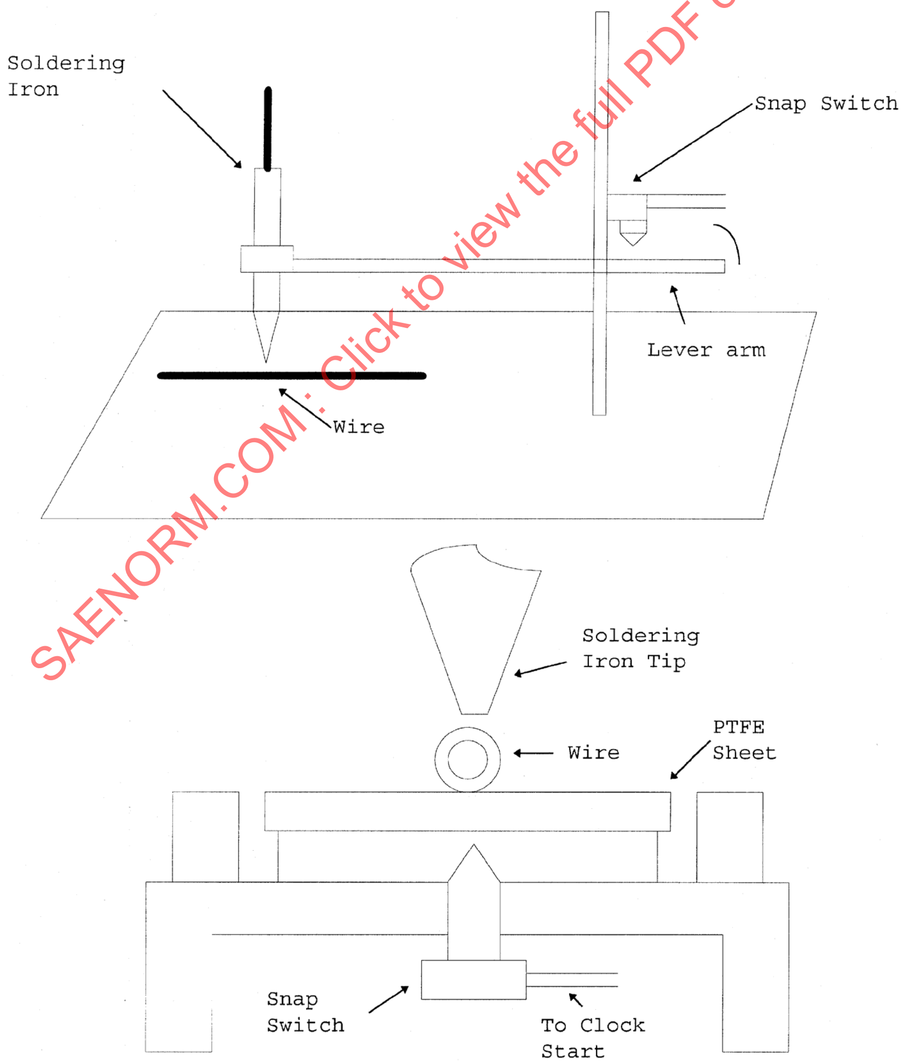


FIGURE 2 - TWO SUGGESTED PLACEMENTS FOR SNAP SWITCH TO START TIMER

4.1.6.4.1.2 The schematic for a suggested continuity tester box with a timer circuit is shown in Figure 3.

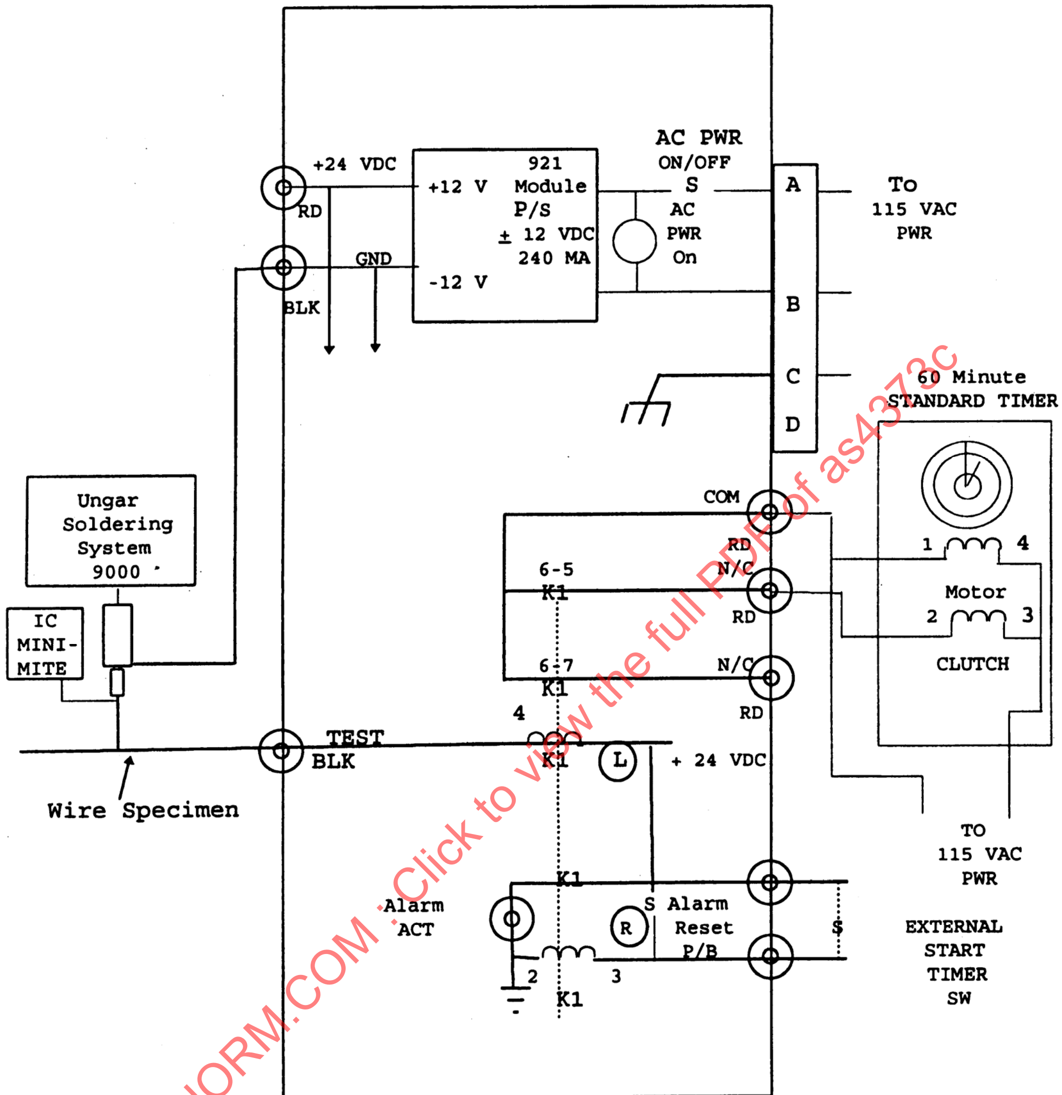


FIGURE 3 - CONTINUITY DETECTION CIRCUIT FOR SOLDER IRON RESISTANCE TEST

4.1.6.4.1.3 Check for the 5 lb (2.27 kg) load at solder iron tip by lowering the solder iron tip onto the scale and adding weights to the control arm until scale registers 5 lb (2.27 kg).

4.1.6.4.2 Test Procedure

4.1.6.4.2.1 Place wire specimen in groove of 1 in (25.4 mm) PTFE sheet and secure with tape.

4.1.6.4.2.2 Connect iron-constantan thermocouple to solder iron tip, and temperature measuring device described in 4.1.6.3.2. Measure the exact temperature of the solder iron tip and adjust solder iron to obtain required initial temperature of 398 °C ± 3 °C (750 °F ± 5 °F).

4.1.6.4.2.3 Connect continuity detector circuit using size 20 lead wire with alligator clips to solder iron and to the end of the wire specimen.

4.1.6.4.2.4 Lower the solder iron onto the wire specimen. Record the time it takes the solder iron to penetrate through the wire insulation as measured by the timer. Repeat test four times on each wire specimen. Rotate the specimen 90 degrees and index 0.5 in (12.7 mm) along specimen length for each repeat test. If penetration does not occur within 1 min, stop the test. Continue with next specimen.

4.1.6.4.2.5 Clean solder iron tip by lightly buffing with emery paper to remove residues after each test.

4.1.6.4.2.6 If failure occurs at 398 °C (750 °F), repeat same test at 343 °C (650 °F) on same wire specimen. If failure occurs at 343 °C (650 °F), repeat same test at 288 °C (550 °F) on same wire specimen.

4.1.6.5 Results

The time recorded as the time required for penetration of the solder iron to the inner conductor shall be the average time of the measurements taken.

4.1.6.6 Information Required in Detail Specification

Number and wire size of specimens to be tested.

4.1.6.7 Precision Bias

This is a new method that has not had the benefit of any round-robin testing to determine precision.

4.1.7 Method 107, Thermal/Mechanical Resistance - Bundle

4.1.7.1 Scope

This test is to be used to determine the ability of a bundle of insulated wire specimens to withstand the heat of a soldering iron when the iron rests on the bundle.

4.1.7.2 Specimen

Ten 12 in (305 mm) insulated wire specimens of the same size shall be used for each bundle to be tested. The bundle shall be formed by string-tying the grouped wires every 3 in (76 mm) from either end.

4.1.7.3 Test Equipment

The test equipment used, including monitoring/timing circuitry and excluding the test fixture, shall be as described in Method 106 of this document.

4.1.7.4 Test Procedure

Connect the stripped end of all wires to a common lead and use this lead to detect continuity between the iron and any conductor. See Figure 3 of Method 106 for a continuity detection circuit. Limit switch location similar to the second location of the limit switch shown in Figure 2 of Method 106 may be used. Lay the barrel of the soldering iron perpendicularly across the bundle so that it does not touch any string tie. If necessary, elevate the bundle to achieve contact. Measure the time for the iron to make contact with any conductor in the bundle. The test may be terminated if no penetration occurs within 5 min. Test with the soldering iron at 398 °C (750 °F), 343 °C (650 °F), and 288 °C (550 °F). Test three locations for each temperature, making sure that each point of contact is at least 0.5 in (13 mm) from any previous contact. It is not necessary to test at lower temperatures if no penetration occurs at 398 °C (750 °F).

4.1.7.5 Results

Report the time to penetration at all test temperatures.

4.1.7.6 Information Required in Detail Specification

Number and wire size of specimens to be tested.

4.1.7.7 Precision Bias

This is a new method that has not had the benefit of any round-robin testing to determine precision.

4.1.8 Method 108, Solder Pot Test for Insulation Shrinkage

4.1.8.1 Scope

This test is to be used to assess the insulation shrinkage of a wire after exposure to hot solder.

4.1.8.2 Specimen

The specimen shall be a length of insulated wire not less than 6 in (152 mm).

4.1.8.3 Test Equipment

4.1.8.3.1 A suitable container of molten (63/37 tin/lead) solder maintained at a temperature of approximately 320 °C (608 °F).

4.1.8.3.2 Mandrels of the sizes needed in 4.1.8.4.

4.1.8.4 Test Procedure

The specimen shall be taken from a point at least 6 in from the end of an inspection unit and shall be prepared for testing by removing 0.5 in of insulation from one end. At a point 0.5 in from the end of the insulation on the stripped end, the specimen shall be given a 90 degree bend over a mandrel of its own diameter. This end shall then be immersed in the solder for 5 s, to within 1/8 in of the insulation. There shall be no flux used in preparing the specimen. The insulation shall not flare away from the conductor nor open up over the bent portion. The shrinkage shall be measured as the greatest distance any layer of insulation has moved.

4.1.8.5 Results

Record the amount of shrinkage to the nearest 1 mm (1/32 in).

4.1.8.6 Information Required in Detail Specification

Number and wire size of specimens to be tested and limit of allowable shrinkage.

4.1.8.7 Precision Bias

This is a process control test.

4.1.9 Method 109, Percent Overlap of Insulating Tapes

4.1.9.1 Scope

This test determines the percent overlap of the insulating tape or tapes used in a finished wire.

4.1.9.2 Specimen

The specimen shall be not less than a 6 in (152 mm) length of wire cut flush on both ends.

4.1.9.3 Test Equipment

4.1.9.3.1 Insulation stripping tool with precision blades.

4.1.9.3.2 A single edged razor blade or equivalent cutting tool.

4.1.9.3.3 A microscope or equivalent optical device providing a magnification of 15 diameters minimum (preferably one with an eyepeice of similar means to measure angles).

4.1.9.4 Test Procedure

The test sample shall consist of at least three specimens. Specimens shall be prepared by stripping an insulation slug approximately 0.50 inch in length using the precision stripping tool. With the razor blade or cutting tool, cut the edge of each insulation slug to be examined. The cut faces of the specimen must be smooth, perpendicular to the slug axis, and perpendicular to each other. The cut edge of the insulation slug to be examined shall be positioned under the microscope or suitable optical device. Inspect the cut cross section under the microscope or suitable device at a magnification of 15 diameters, minimum. Measure, in degrees of rotation, the total length of the spiral edge displayed by the innermost insulation tape (wrap 1) in the cross section. Using the formula noted in Figure 4, convert the degrees of rotation to percent overlap of the tape in the insulation. Repeat the determination for any additional tape (wrap 2, etc.) in the cross section.

$$\%\ \text{overlap} = \left(\frac{(N + (x / 360)) - 1}{(N + (x / 360))} \right) \times 100$$

N = number of complete 360° overlaps

x = additional degrees of overlap past 360°

FIGURE 4 - FORMULA FOR CALCULATING PERCENT OVERLAP

4.1.9.5 Results

Report the degrees of rotation observed and the percent tape overlap of each tape in the insulation of each specimen

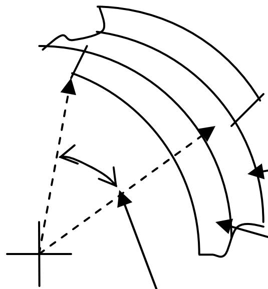
4.1.9.6 Information Required in Detail Specification

Specifications for wires with tape wrapped insulation shall list the minimum tape overlap of each insulating tape used in the finished wire.

4.1.9.7 Precision Bias

This test is only applicable to tape wrapped wire to provide verification of insulation overlap and is typically performed as an in-process test.

EXAMPLE:



Example: If x = 25 degree in the above picture the results would be:

$$\% \text{ overlap } = \left(\frac{(2 + (25 / 360)) - 1}{(2 + (25 / 360))} \right) \times 100 =$$

$$\% \text{ overlap } = \frac{1.069}{2.069} \times 100 = 51.7\%$$

4.2 Test Methods Group 200 - Chemical, Biological and Radiological Tests/Nuclear, Biological and Chemical (CBR/NBC)

4.2.1 When required by a user, specimens of insulation material shall be tested to the CBR/NBC requirements. Note that the Air Force has established an extensive data base on the chemical compatibility of materials for use in aerospace vehicles. While this database as a whole is classified information, it has been made available to prime aerospace contractors. Current contact for this database is at WL-MLSA, Wright Patterson AFB, Ohio. In addition, the Army has done extensive testing of a number of materials and should be consulted before testing to determine if a candidate insulation material has already been tested. Contact for this is NBC Survivability Office, Army CR&D, Edgewood, MD.

The intent of this material testing is to assure inertness of a material to the CBR/NBC exposure. The Air Force and the Army has established over a dozen qualified laboratories to do this type of CBR/NBC testing. However, these laboratories are not empowered to determine the suitability of an item, such as a wire, after exposure, but only to determine if there is an effect on the materials used for insulation. It is not recommended that handling of items after exposure be done outside of these qualified labs due to personnel safety considerations.

4.3 Test Methods Group 300 - Physical Damage Tests

This section is reserved for physical and/or in-service damage tests that may be developed or instituted in the future.

4.4 Test Methods Group 400 - Conductor Tests

4.4.1 Method 401, Conductor Diameter

4.4.1.1 Scope

This test is to be used to determine the diameter of conductors.

4.4.1.2 Specimen

An insulated wire of not less than 24 in (610 mm) shall be used.

4.4.1.3 Test Equipment

4.4.1.3.1 Micrometer

A micrometer or equivalent device capable of measuring to the nearest 0.0001 in (0.0025 mm).

4.4.1.4 Test Procedure

Remove the insulation without damaging or distorting the conductor. Determine the conductor diameter by measuring the outer diameter in at least three locations, approximately equally spaced along the length of the specimen. Each measurement shall consist of the average of two micrometer readings at the same location along the conductor, but taken 90 degrees from each other.

4.4.1.5 Results

Report measured conductor diameters and the average diameter for each specimen tested.

4.4.1.6 Information Required in Detail Specification

Number and wire size of specimens to be tested and number of measurement locations, if greater than three.

4.4.1.7 Precision Bias

This is a process control test.

4.4.2 Method 402, Conductor Elongation and Tensile Breaking Strength

4.4.2.1 Scope

This test is to be used to determine the tensile breaking strength and elongation of soft (annealed) copper strand or conductor, or copper alloy conductor.

4.4.2.2 Specimen

4.4.2.2.1 The specimen shall be a conductor or a wire strand from a multi-strand conductor removed from an insulated wire and shall be at least 12 in long.

4.4.2.2.2 For copper wire sizes 22 AWG and smaller, the specimen shall be the whole stranded conductor removed from the finished wire. For all wire sizes of high strength copper alloys, the specimen shall be the whole stranded conductor removed from the finished wire.

4.4.2.3 Test Equipment

4.4.2.3.1 A testing machine that meets the following requirements:

The machine shall be power-driven.

A dial, scale, or automatic recorder capable of indicating the applied tension to within ±1% when properly calibrated.

The indicator shall remain at the point of maximum force after rupture of the specimen. A spring-balanced type of machine is satisfactory if equipped to prevent recoil of the spring.

The machine, when used for a given specimen, should be of such capacity that the maximum load required to break the specimen is not greater than 85% nor less than 15% of the rated capacity.

The machine shall accommodate specimens of 10-in bench length.

The grips of the machine shall be designed to produce as nearly as possible uniformly distributed pure axial tension in the specimen. Older testing machines may have spool-type grips for specimens less than 0.208 in and wedge-type grips for specimens 0.208 in and larger. Newer testing machines will have power-actuated or mechanical vise grips.

4.4.2.3.2 A strip chart recorder or digital indicator that can be used in conjunction with the testing machine to measure the applied load and travel distance of the specimen grip.

4.4.2.3.3 Steel scale graduated to 1/32 in or finer or its decimal equivalent.

4.4.2.4 Test Procedure

Two parallel bench marks 10 in ± 1/32 in apart shall be placed on the specimen without damage to the copper. The specimen shall be placed in the testing machine so that the bench marks are between the spools but not in contact with the surface of the spools when spool grips are used. When using the usual wedge-type grip there shall be a distance of at least 1 in between each bench mark and the adjacent grip. The speed of the power-actuated grip shall be 10 in ± 2 in per minute under no load for a copper wire specimen and 2 in ± 0.5 in for a copper alloy wire specimen. If the jaw separation is more than 10 in, adjust the jaw speed for constant strain force. The tensile breaking strength shall be measured as the total tensile force indicated by the testing machine at break of the individual strand or first strand of the stranded conductor. If the specimen breaks outside the bench marks or within 1 in of either bench mark, the results shall be discarded and additional specimens tested until breaks are obtained within the prescribed portion. The elongation shall be calculated from the increased distance of the bench marks. The elongation shall be measured when the first strand of the stranded conductor or individual strand breaks as indicated on the recording device.

4.4.2.5 Results

Report the tensile breaking strength and elongation, as required by the Detail Specification, for each specimen of strand or conductor.

4.4.2.6 Information Required in Detail Specification

Number and wire size of specimens to be tested.

4.4.2.7 Precision Bias

This is a process control test.

4.4.3 Method 403, Conductor Resistance

4.4.3.1 Scope

This test is to be used to measure or calculate the DC resistance per unit length of a conductor at 20 °C (68 °F). A correction formula is provided to allow for when resistance measurements are taken at other than 20 °C (68 °F).

4.4.3.2 Specimen

A wire specimen of at least 36 in (914 mm) shall be used.

4.4.3.3 Test Equipment

4.4.3.3.1 A suitable DC current source for the resistance measurements.

4.4.3.3.2 A suitable bridge or potentiometer with the accessory equipment necessary for the measurement of resistance with an accuracy of 0.2%.

4.4.3.3.3 Temperature measuring equipment that will measure the temperature of the conductor to within 0.5 °C (1 °F).

4.4.3.3.4 A steel tape graduated to 1/64 in or finer or its decimal equivalent or other apparatus which will measure the length of the specimen to an accuracy of 0.2%.

4.4.3.4 Test Procedure

4.4.3.4.1 If a Kelvin double bridge is used, both current and potential leads shall be used. The current leads shall be attached in such a manner as to give assured contact with all the wires of the conductor. The potential leads should be attached by encircling clamps on the bared conductor or to a binding of fine copper wire wrapped tightly for several turns about the bare conductor.

4.4.3.4.2 The test shall be made by a method using both current and potential leads if the resistance of the specimen is less than 1 Ω. Where potential leads are used, the distance between each lead and the corresponding current lead shall be at least 3 times the diameter of the conductor.

4.4.3.4.3 The length of the specimen between potential leads shall be measured to an accuracy of 0.2% and the value recorded as L. In order to avoid raising the temperature of the specimen, the magnitude of the current shall be kept low and the time of its flow through the conductor shall be kept short to minimize the change in resistance due to rise in temperature of the specimen.

4.4.3.4.4 The resistance of the specimen shall be measured and the value recorded in ohms as R after indications have been steady for not less than 1 min. The ambient temperature shall be measured to an accuracy of 0.5 °C and the value recorded as T.

4.4.3.4.5 The resistance of the conductor per 1000 ft shall be calculated as follows:

$$\text{Resistance, ohms per 1000 ft} = \frac{R}{L} \times 1000 \quad \text{(Eq. 3)}$$

where:

R = Resistance of the specimen or the length of specimen between potential conductors, ohms

L = Length of the specimen or the length of specimen between potential conductors, feet

4.4.3.5 Results

Report measured resistance of specimen, measured length of specimen, calculated resistance per 1000 ft (305 m), and test temperature.

4.4.3.6 Information Required in Detail Specification

Number and wire size of specimens to be tested and acceptable resistance values.

4.4.3.7 Temperature Correction

See ASTM B 193 to normalize the resistance to 20 °C when the actual measurement is taken at a temperature other than 20 °C. In addition to the temperature coefficients listed therein, the temperature coefficient of copper alloy PD135 is 0.00342 and that of copper alloy CS95 is 0.00198.

4.4.3.8 Precision Bias

This is a process control test.

4.4.4 Method 404, Conductor Strand Blocking

4.4.4.1 Scope

This test provides a method to determine if conductor strands of 7 and 19 strand conductors will block (adhere) to each other in the finished wire. This test was developed as a process control test for silver coated copper conductors of MIL-DTL-81381 polyimide insulated wires, but it may be applied to other conductors and insulation types when strand blocking is a potential problem.

4.4.4.2 Specimen

The specimen shall be a 6 in (152 mm) length of finished wire.

4.4.4.3 Test Equipment

4.4.4.3.1 Wire insulation stripping tool.

4.4.4.3.2 Fine needle or thin blade.

4.4.4.3.3 Device to sever conductor strands.

4.4.4.4 Test Procedure

4.4.4.4.1 Preparation of Specimen

With the insulation stripping tool, initiate a stripping action 2 in (51 mm) from one end of the specimen and, without kinking or otherwise damaging the conductor, move the insulation slug endwise until approximately 3/4 in (19 mm) of the conductor is exposed. Remove the specimen from the stripping tool and proceed.

4.4.4.4.2 Procedure

4.4.4.4.2.1 For 19 Strand Unidirectional Lay and All 7 Strand

a. Grip the insulation with the fingers at both ends of the exposed portion of the conductor and rotate one end of the specimen so as to untwist the exposed strands and make them parallel with the conductor axis. The use of rubber pads or similar holding aids is permitted.

b. Retain the grip position used to untwist the strands and carefully push the ends of the exposed portion of the conductor toward each other in the conductor axis, causing the strands to spread apart in a "bird cage" effect. See Figure 5.

c. Gently probe non-separated strands with a fine needle or thin blade to determine whether they are fused together by metallic bonding or simply lying side by side. Metallic-bonded pairs or groups of strands which cannot be separated along the whole "bird cage" length, without forcing the needle or blade between the strands, shall each be counted as one in step d.

d. Count the number of unbonded single strands plus the number of metallic-bonded pairs or groups of strands in the conductor.

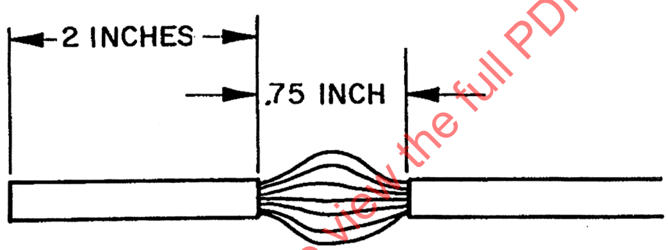


FIGURE 5 - TYPICAL 7-STRAND CONDUCTOR AFTER BIRDCAGING (NO STRANDS BLOCKED)

4.4.4.4.2.2 For 19 Strand "True Concentric" Lay

a. Perform step a as for unidirectional lay, but use only the rotation needed to untwist the 12-strand outer layer.

b. Perform step b as for unidirectional lay, using pressure needed to "bird cage" the outer layer. See Figure 5.

c., d. On the "bird cage" outer layer, perform steps c and d as for unidirectional lay.

e. Using a suitable tool, snip through each unbonded single strand and each bonded pair or group of strands of the outer layer approximately in the center of the "bird cage" and fold the snipped ends back toward the respective ends of the specimen. Do not cut the 7-strand core of the conductor.

f. Repeat steps a, b, c, and d with the 7-strand core.

g. Add the count of unbonded single strands and bonded pairs or groups of strands in the core to the count previously derived from the outer layer. This total is the count applicable to the entire 19 strand conductor.

4.4.4.5 Results

Report the count of unbonded single strands and metallic bonded pairs or groups in the conductor.

4.4.4.6 Information Required in Detail Specification

Number of specimens, conductor size of specimens, and the minimum number of unbonded strands.

4.4.4.7 Precision Bias

This is a new method that has not had the benefit of any round-robin testing to determine precision.

4.5 Test Methods Group 500 - Electrical Tests

4.5.1 Method 501, Dielectric Constant

4.5.1.1 Scope

This test is to be used to determine the dielectric constant of an insulation.

4.5.1.2 Specimen

A specimen of at least 15 ft (4.6 m) of size 22 wire shall be used.

4.5.1.3 Test Equipment

4.5.1.3.1 A suitable capacitance bridge that shall be capable of measuring the capacitance within a limit of error of 1 picofarad. It shall be capable of measuring the capacitance of a specimen, one side of which is grounded. Provisions shall be made for connecting and disconnecting the specimen at the specimen end of the leads connecting the specimen to the bridge.

4.5.1.3.2 A water bath in which the specimen can be immersed.

4.5.1.4 Test Procedure

4.5.1.4.1 The conductor diameter (d) shall be measured using Method 401 of AS4373.

4.5.1.4.2 The insulation diameter (D) shall be measured using Method 901 of AS4373.

4.5.1.4.3 The middle 10 ft (3.05 m) of the specimen shall be immersed in distilled water for the required period of time. A 2.5 ft (0.76 m) portion of each end of the specimen shall be kept well above the surface of the water as leakage insulation. The capacitance of the insulation shall be determined at a frequency of either 1000 or 60 cycles, using a suitable capacitance bridge. The voltage impressed upon the conductor shall be sufficient to give the required sensitivity of measurement, except that the impressed voltage on the conductor shall not be greater than 40 V per mil of insulation thickness. The specimen shall be immersed to the same depth, and the temperature of the water bath shall be the same, at the time readings are taken after each immersion period.

4.5.1.4.4 The dielectric constant (e) of the insulation shall be calculated after each immersion period as follows:

$$e = 13{,}600\ C\ \mathrm{Log}_{10}\ D / d \quad \text{(Eq. 4)}$$

where:

C = Capacitance in microfarads of the immersed 10 ft (3.05 m) of the specimen

D = Diameter over the insulation, inch(es)

d = Diameter over the conductor, inch(es)

4.5.1.5 Results

Record capacitance (C), conductor diameter (d), and insulation diameter (D). Report dielectric constant.

4.5.1.6 Information Required in the Detail Specification

Report the dielectric constant.

4.5.1.7 Precision Bias

This is a material dependent test.

4.5.2 Method 502, Corona Inception and Extinction Voltages

4.5.2.1 Scope

This test is to be used to determine the corona inception and extinction voltages (CIV and CEV) for an insulated wire specimen.

4.5.2.2 Specimen

Specimens shall be selected in accordance with Section 25.3.2.1 of ASTM D 3032 and shall be prepared as described in Section 25.3.2.2.

4.5.2.3 Test Equipment

The test equipment required for this test is described in Section 7 of ASTM D 1868.

4.5.2.4 Test Procedure

See Section 25.4 of ASTM D 3032.

4.5.2.5 Results

Report dimensions of specimen, type of ground electrode used, CIV, CEV, and test conditions, if other than ambient.

4.5.2.6 Information Required in Detail Specification

Number of specimens to be tested, wire size of specimens, and test conditions other than ambient.

4.5.2.7 Precision Bias

See ASTM D 3032.

4.5.3 Method 503, Impulse Dielectric

4.5.3.1 Scope

This test describes a method for detecting defects in finished wire insulation with an impulse dielectric test.

4.5.3.2 Specimen

See Section 13.5 of ASTM D 3032.

4.5.3.3 Test Equipment

See Sections 13.3 and 13.4 of ASTM D 3032.

4.5.3.4 Test Procedure

See Section 13.6 of ASTM D 3032.

4.5.3.5 Results

Report impulse voltage used.

4.5.3.6 Information Required in Detail Specification

Peak impulse voltage for test.

4.5.3.7 Precision Bias

A minimum peak impulse voltage of 6.5 kV is recommended.

4.5.4 Method 504, Insulation Resistance

4.5.4.1 Scope

This test is to be used to determine the insulation resistance of a finished wire specimen. Insulation resistance is of interest in high impedance circuits and as a measure of quality control. Changes in insulation resistance may indicate deterioration of other properties.

4.5.4.2 Specimen

See Section 6.3 of ASTM D 3032.

4.5.4.3 Test Equipment

See Section 6.2 of ASTM D 3032. A measuring apparatus that can measure at least 40,000 MΩ or as little as 12.5 pA (for current measurements) is needed to measure the desirable minimum insulation resistance as stated in the prevision bias.

4.5.4.4 Test Procedure

See Section 6.4 of ASTM D 3032. The last sentence of Section 6.4.1, "Discard any specimen with a gross defect...", shall not be applicable. Calculation of insulation resistance shall be as described in Section 6.5 of ASTM D 3032.

4.5.4.5 Results

Report the measured resistance, the immersed length, and the calculated insulation resistance.

4.5.4.6 Information Required in Detail Specification

Number and wire size of specimens.

4.5.4.7 Precision Bias

A minimum insulation resistance of 1000 MΩ - 1000 ft, is usually desirable.

4.5.5 Method 505, Spark Test of Finished Wire Insulation

4.5.5.1 Scope

This test describes a method for detecting defects in finished wire insulation with a spark test.

4.5.5.2 Specimen

See Section 13.10 of ASTM D 3032.

4.5.5.3 Test Equipment

See Sections 13.8 and 13.9 of ASTM D 3032. A 60 Hz waveform may be used instead of a 3 kHz, if desired.

4.5.5.4 Test Procedure

See Section 13.11 of ASTM D 3032.

4.5.5.5 Results

Report frequency and amplitude of test signal.

4.5.5.6 Information Required in Detail Specification

Test signal frequency and amplitude.

4.5.5.7 Precision Bias

A minimum test voltage of 1500 V rms is recommended.

4.5.6 Method 506, Surface Resistance

4.5.6.1 Scope

This test is to be used to determine the surface resistance of a finished wire specimen. This test was initially developed for wires with outer braid as part of the insulation system.

4.5.6.2 Specimen

See Section 7.3 of ASTM D 3032.

4.5.6.3 Test Equipment

See Section 7.2 of ASTM D 3032.

4.5.6.4 Test Procedure

Section 7.5 of ASTM D 3032 shall be followed. The specimen shall be positioned in the test chamber so that the ends are at least 1 in (25.4 mm) from any wall of the chamber.

4.5.6.5 Results

Report the DC potential and surface resistance values.

4.5.6.6 Information Required in Detail Specification

Number and wire size of specimens to be tested.

4.5.6.7 Precision Bias

A minimum surface resistance value of 5 MΩ - inch is usually desirable.

4.5.7 Method 507, Time/Current to Smoke

4.5.7.1 Scope

This test is to be used to determine the time and current at which a finished wire specimen produces smoke.

4.5.7.2 Specimen

A 12 in (304.8 mm) length of size 16 or smaller wire specimen shall be tested.

4.5.7.3 Test Equipment

4.5.7.3.1 Isopropyl alcohol

4.5.7.3.2 DC constant current source

4.5.7.3.3 Black background

4.5.7.3.4 Timer

4.5.7.3.5 Current meter

4.5.7.4 Test Procedure

The wire specimen shall be pre-cleaned using a cloth dampened with isopropyl alcohol and then stripped of 0.5 in (13 mm) insulation at each end. A DC constant current source shall be used to supply the required current and a suitable measuring device shall be used to verify current application. The wire specimen shall be suspended horizontally in air against a black background adequately illuminated to see the smoke. Apply 10 A for 30 s, then 15 A for 30 s and continue to increase current in 5 A steps every 30 s until there is evidence of smoke.

4.5.7.5 Results

Report current and time when smoke first appears and any pertinent unusual observation of the insulation condition at the end of the test.

4.5.7.6 Information Required in Detail Specification

Number and wire size of specimens.

4.5.7.7 Precision Bias

This is a new method which has not had the benefit of any round-robin testing to determine precision.

4.5.8 Method 508, Dry Arc Propagation Resistance

4.5.8.1 Scope

The dry arc propagation resistance test for wire provides an assessment of the ability of an insulation to prevent damage in an electrical arc environment. In service, electrical arcs may originate from a variety of factors, including insulation deterioration, faulty installation and chafing. It has been documented that results of an arc-propagation test may vary due to the method of arc initiation; therefore, this test method was selected as the standard test method to evaluate the general arc-propagation resistance characteristics of an insulation.

This test method initiates an arc with an oscillating blade. The arc-propagation resistance is defined as the length of arc-propagation damage along the wires in contact with the blade and by the extent of damage to all adjacent wires undamaged by the blade. This test also evaluates the ability of the insulation to prevent further arc-propagation when the electrical arc is re-energized. The power supply, test current, circuit resistances and other variables are optimized for testing 20 AWG wires. The use of other AWG wires may require modification to the test variables.

4.5.8.2 Specimen

A test specimen shall be a bundle of seven wires and shall be of sufficient length, 14 in (35.6 cm) minimum, to allow the bundle to be installed in the test fixture. Fifteen bundles shall be required for a full test. A minimum of 122.5 ft (37.3 m) of wire is required. It is recommended that 20 AWG wire be used for this test.

4.5.8.3 Test Equipment

4.5.8.3.1 An abrader blade made from 6061-T6 aluminum material. Use a grit size 60 grinding wheel or 60 grit sanding belt to sharpen the blade. A typical abrader blade is shown in Figure 5. Use the blade-sharpening fixture shown in Figure 7.

4.5.8.3.2 A transparent screen to protect laboratory personnel from molten metal, UV radiation, and other debris that may be ejected from the test specimen.

4.5.8.3.3 An oscillating mechanism to which the abrader blade is connected. The oscillating mechanism shall provide a stroke of 1.5 in ± 0.12 in (3.81 cm ± 0.3 cm) at a frequency of 0.5 cps ± 0.05 cps.

4.5.8.3.4 A test fixture that includes a test block to hold the wire at right angles to the abrading blade. The block shall be made from 6061-T6 aluminum (see Figure 10).

4.5.8.3.5 A three phase wye connect power supply, grounded at wye, derived from a rotary machine rated at least 20 KVA and meets the voltage and frequency requirements of MIL-STD-704 Table I (108 to 118 volts rms phase-to-neutral at 400 Hz ± 7 Hz).

4.5.8.3.6 A mechanical stop constructed of stainless steel.

4.5.8.3.7 SAE AS3320 - 7.5 (7.5 Amp) and appropriate protective circuit breakers (30 Amp typical).

4.5.8.3.8 Variable load and fixed load resistors.

4.5.8.3.9 Commercial Item Description (CID) from A-A-52080 through A-A-52084 (Type I, IV, or V) lacing tape or equivalent.

4.5.8.3.10 AS25281 plastic clamps, or equivalent.

4.5.8.4 Test Procedure

4.5.8.4.1 Preparation of a Bundle

Conduct a 2500 V Wet Dielectric test (or pass the wire through an impulse spark test set at 8KV) on 100% of the wire in accordance with the Wet Dielectric test procedure described in Test Method 510 before the arc propagation resistance test is performed. Discard any failed sections of wire. Cut seven wire segments at least 14 in (35.6 cm) in length for each of the 15 bundles. Clean the cut wires using a cloth saturated with isopropyl alcohol. Strip both ends of five of the seven wire segments. Use these stripped ends for making electrical connections. These five wire segments are the “Active Wires.” The two unstripped wire segments are the “Passive Wires.” Form the bundle by laying the seven segments straight and geometrically parallel. Assemble the wires to form the six-around-one configuration shown in Figure 8, with D1 and D2 being the passive wires. Use lacing tapes defined in 4.5.8.3.9 to hold the test bundle together as shown in Figure 9. Clean the assembled bundle using a cloth saturated with isopropyl alcohol.

4.5.8.4.2 Bundle Installation

A test fixture shall be used to hold the wire bundle in place perpendicular to the abrader blade. Details of a suggested test fixture are shown in Figure 10. The wire bundle is clamped with SAE AS25281 plastic clamps, or equivalent, at two points on the fixture at a minimum distance of 6 in (15.24 cm). The clamp points are equidistant from the point of application of the abrader. The slide bolt allows the adjusting screw to move the holding plates snugly against the bundle. Ensure that the active wires A1 and B1 are parallel with the top plane of the test fixture, and that the passive wires D1 and D2 are in complete contact with the base of the test fixture. The bundle must be restricted from moving while the abrader blade is cutting wires A1 and B1. The test fixture shall contain an adjustable mechanical stop, which may be set to allow for various penetration depths of the oscillating blade.

4.5.8.4.3 Electrical Connection

Connect the bundle to the power supply and circuit resistance using the schematic circuit shown in Figure 11. Connect one end of each active wire to the appropriate phase of the power supply as shown in Table 10. Use an SAE AS3320 - 7.5 (7.5 Amp) circuit breaker and a circuit resistance (Rf) in series with each of the active wires. Use the circuit resistance (Rf) values (±10%) shown in Table 11. Connect the other end of the five active wires under test to variable resistive (Ri) loads. Adjust the resistance (Ri) to limit the current flowing through each wire to 1.0 Amp ± 0.2 Amp. Protect the test circuits with appropriate circuit breakers connected on the supply side of the test set up. Connect the abrader blade to the neutral of the generator. Connect the generator neutral to ground. The generator load resistors (Rg) shall be set so that the generator is delivering 10 to 15% of its rated load at a voltage of 108 to 118 Volts rms phase to neutral.

TABLE10 - ELECTRICAL CONNECTION

Wire Identification	Power Supply	Layer
A1	Phase A	Top
B1	Phase B	Top
C1	Phase C	Middle
A2	Phase A	Middle
B2	Phase B	Middle
D1	None	Lowest
D2	None	Lowest

TABLE 11 - CIRCUIT RESISTANCE

Test Number	Circuit Resistance (ohm) ±10%
1	0.0
2	0.5
3	1.0
4	1.5
5	2.0

4.5.8.4.4 Initiation of Test

[Test three bundles for each of the five circuit resistances]. Install the oscillating mechanism, which may use a reciprocating arm, or vertical and horizontal precision linear ball slides (a suggested ball slide apparatus is shown in Figure 12). When installing the blade, make sure that the angled side of the blade faces the power side of the circuit. Adjust the mechanical stop to ensure that the abrader blade penetrates into the A1 and B1 wires a distance of 0.87 ± 0.08 times the radius of the wire. Close all circuit breakers. Apply a load of 0.55 lb ± 0.055 lb (250 g ± 25 g) to the abrader at the point of contact with one wire. Adjust the blade to ensure that the major plane of the blade lies perpendicular to the longitudinal axis of the bundle. Apply the abrader blade on the test bundle. Position the protective screen to shield the operator from ejecting objects and UV radiation. Apply three phase 400 Hz power. Actuate the abrader. Allow the abrader blade movement to continue.

4.5.8.4.5 Use one of the following conditions to conduct and complete the test.

4.5.8.4.5.1 If the abrader cuts through A1 and B1 wires without tripping phase A1 or phase B1 circuit breakers, stop the abrader movement. Disconnect the power.

4.5.8.4.5.2 Conduct the 1000 V Wet Dielectric test on wires A2, B2, C1, D1, and D2 in accordance with the Wet Dielectric procedure of Test Method 510. Record the number of wires that fail. Measure and record the total length of physical damage to each wire (including phase A1 and B1 wires) in inches.

4.5.8.4.5.3 If a circuit breaker in any of the phases A2, B2, or C1 trips at any time during the test, stop the abrader and disconnect the power. Perform tests as listed in 4.5.8.4.5.2.

4.5.8.4.5.4 If either phase A1 or phase B1 circuit breaker trips at any time during the test, stop the abrader. Disconnect the power and determine if the conductor of wires A1 or B1 are open. If both wires are open, conclude the test by performing tests as listed in 4.5.8.4.5.2. If wire A1 or B1 is not open, wait 3 to 4 min, reset the circuit breaker and restart the abrader and then immediately re-apply the power. Continue the test until either phase A1 or phase B1 circuit breaker has tripped a second time, phase A1 and B1 are open, or the blade movement is stopped by the mechanical stop. CAUTION: DO NOT RESET A CIRCUIT BREAKER THAT TRIPS TWICE. Perform the tests as listed in 4.5.8.4.5.2. Use a new abrader blade edge for each test bundle.

4.5.8.4.5.5 Circuit breakers should be periodically tested to assure they still meet the overload requirements of the applicable military specification (MS) sheet. Circuit breakers outside their overload trip requirements should be replaced.

4.5.8.5 Results

Report the number of wires that pass the dielectric test and the length of physical damage to each individual wire in the bundle.

4.5.8.6 Information Required in the Detailed Specification

Wire type and number of bundles tested.

4.5.8.7 Precision Bias

While this is a new test, numerous round-robin tests have been run to confirm the validity of this procedure. However, industry wide minimum requirements have not as yet been established.

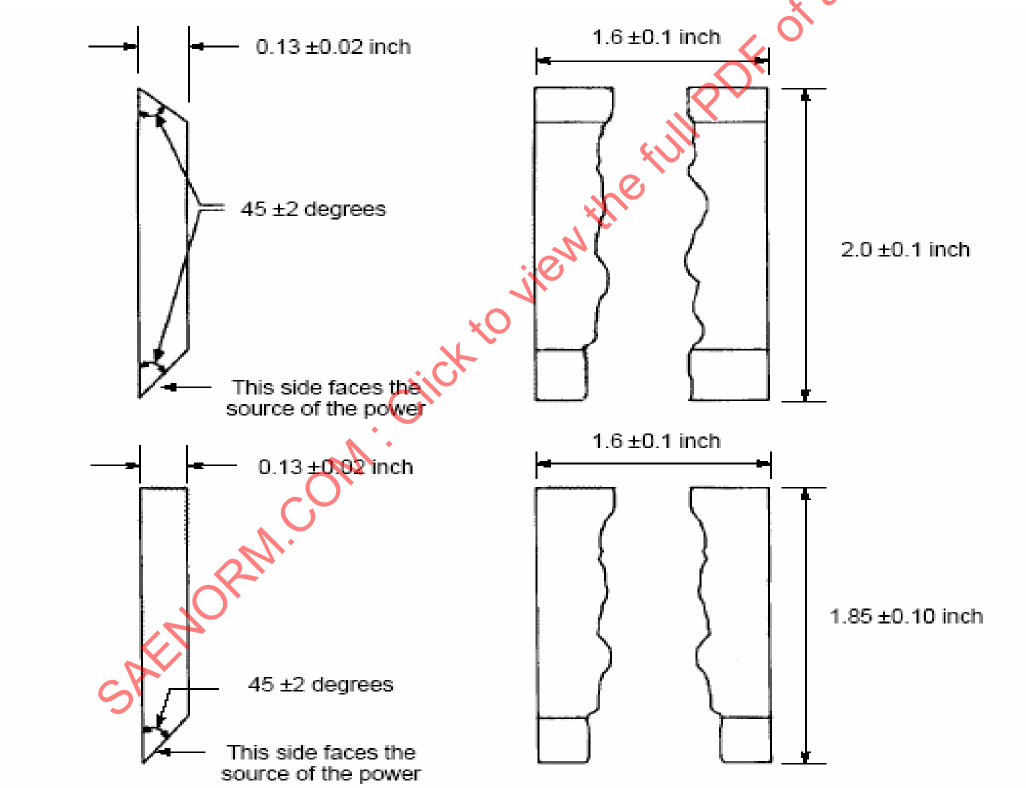


FIGURE 6 - BLADE

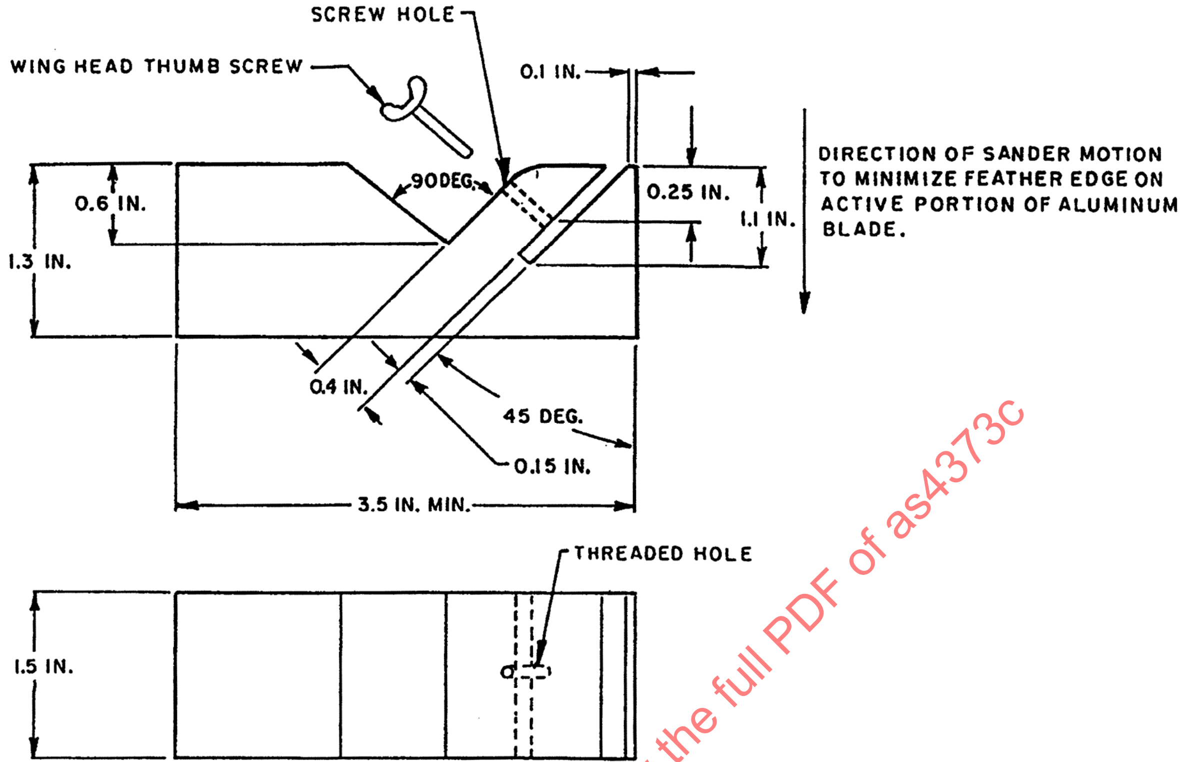


FIGURE 7 - ALUMINUM BLADE SHARPENING FIXTURE

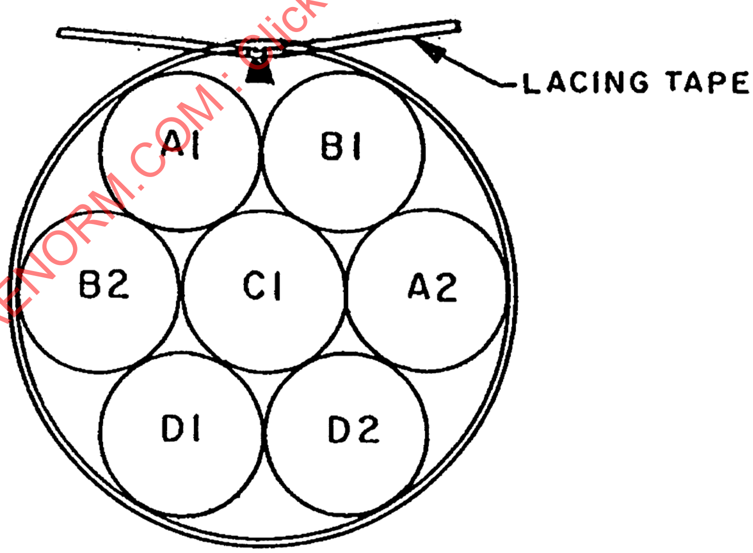


FIGURE 8 - BUNDLE CONFIGURATION

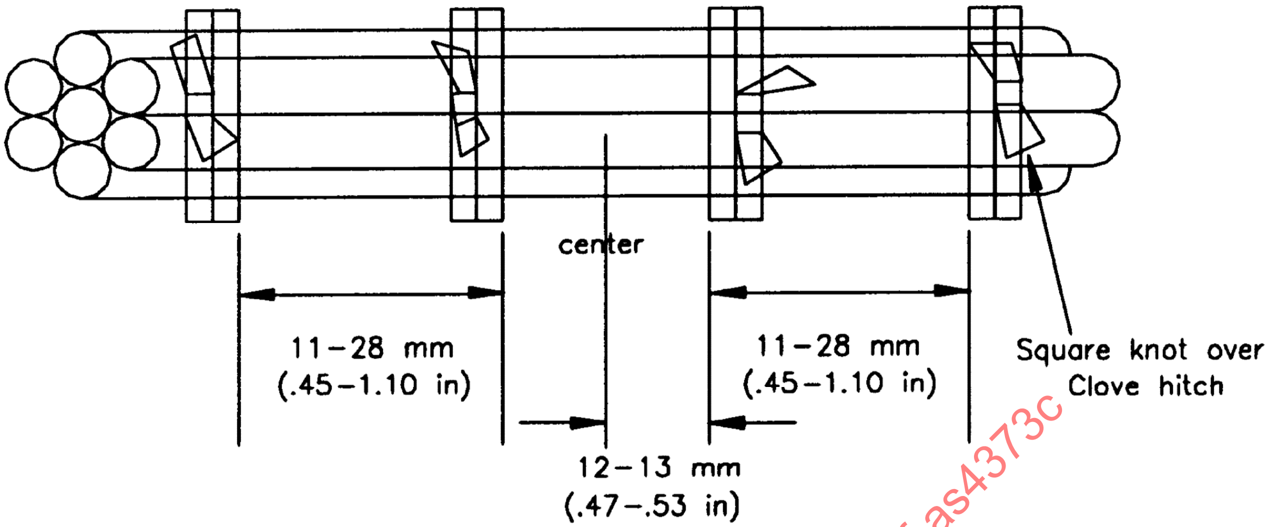


FIGURE 9 - BUNDLE TYING

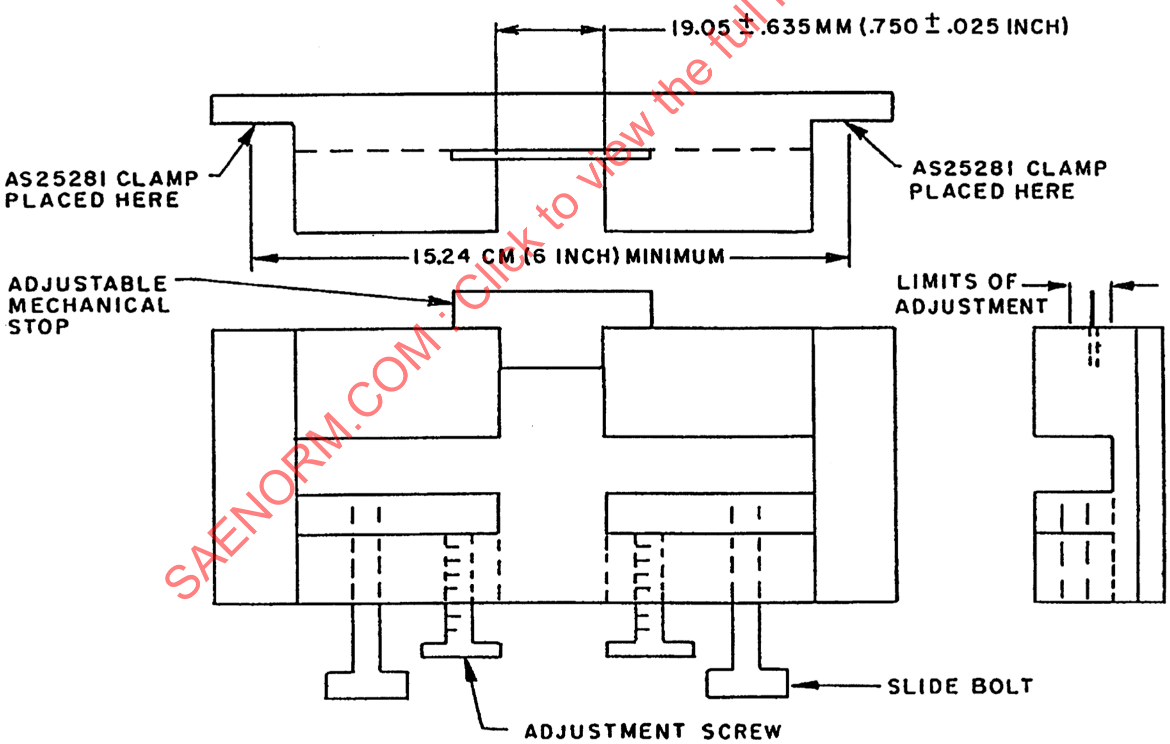


FIGURE 10 - TEST FIXTURE

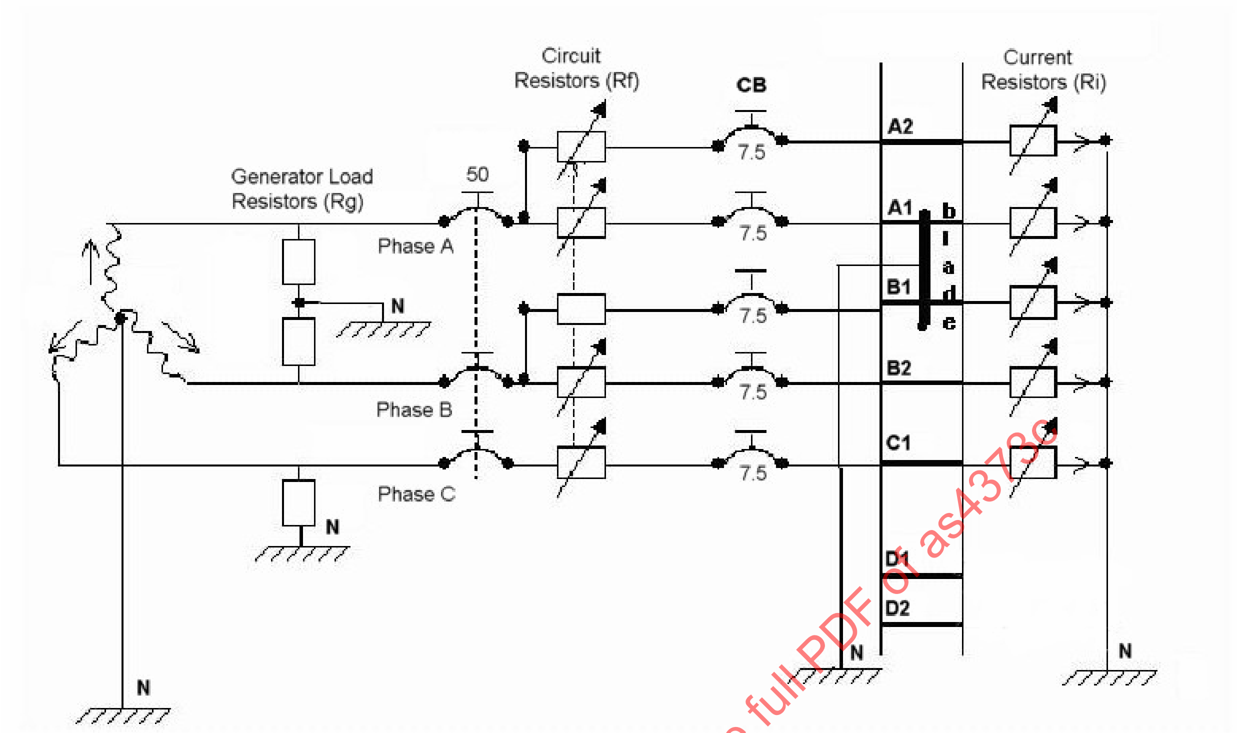


FIGURE 11 - ELECTRICAL CONNECTION

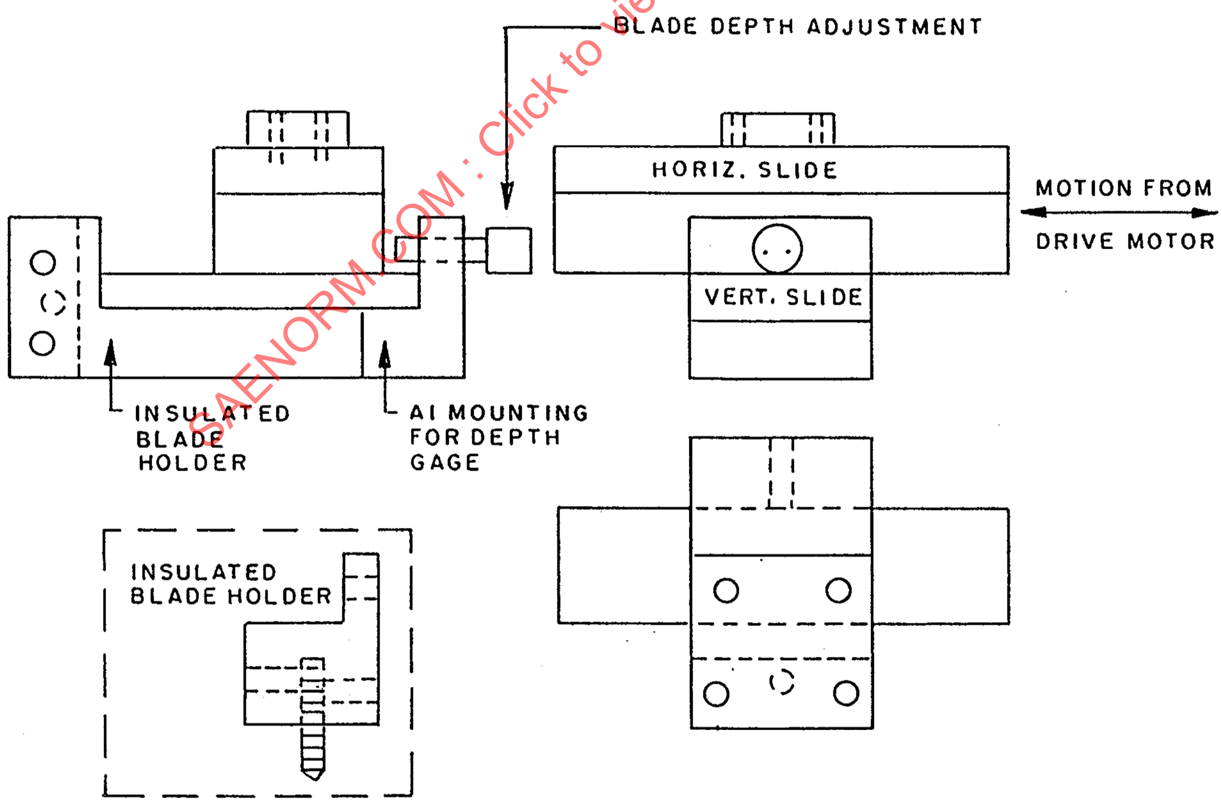


FIGURE 12 - BALL SLIDE BLADE FIXTURE

4.5.9 Method 509, Wet Arc Propagation Resistance

4.5.9.1 Scope

The wet arc propagation resistance test for wire insulation provides an assessment of the ability of an insulation to prevent damage in an electrical arc environment. In service, electrical arcs may originate from a variety of factors, including insulation deterioration, faulty installation and chafing, and may be further induced by water and other fluids which create conductive paths. It has been documented that results of an arc-propagation test may vary due to the method of arc initiation; therefore, this test method was selected as the standard test method to evaluate the general arc-propagation resistance characteristics of an insulation.

This test method initiates an arc by dripping salt water over pre-damaged wires which creates a conductive path between the wires. The arc-propagation resistance is defined as the length of arc-propagation damage along the wires after the wet arc test is completed and by the extent of damage to all adjacent wires undamaged by the wet arc test. This test also evaluates the ability of the insulation to prevent further arc-propagation when the electrical arc is re-energized. The power supply, test current, circuit resistances and other variables are optimized for testing 20 AWG wires. The use of other AWG wires may require modification to the test variables.

4.5.9.2 Specimen

A specimen shall be a bundle of seven wires approximately 8 to 16 in (20.3 to 40.6 cm) in length. Fifteen bundles are required for a full test. A minimum of 70 ft (21.3 m) of wire is required. It is recommended that 20 AWG wire be used.

4.5.9.3 Test Equipment

4.5.9.3.1 A transparent screen to protect laboratory personnel from molten metals, UV radiation, and other debris that may be ejected from the test specimen.

4.5.9.3.2 A variable speed, peristaltic pump or suitable other device and hypodermic needle or burette. The apparatus should be able to deliver the electrolyte solution at a rate of 100 mg ± 10 mg (0.0035 oz ± 0.00035 oz) per minute (8 to 10 drops of 3% sodium chloride solution) to the test specimen. An alternative means of delivery is acceptable.

4.5.9.3.3 A mechanical device for supporting the test bundle in free air in a horizontal position.

4.5.9.3.4 An electrolyte solution made by dissolving 3% ± 0.5% by weight of sodium chloride in distilled water.

4.5.9.3.5 A three phase wye connector power supply, grounded at wye, derived from a rotary machine of at least 20 KVA and that meets the voltage and frequency requirements of MIL-STD-704.

4.5.9.3.6 SAE AS3320 - 7.5 (7.5 Amp) and appropriate protective circuit breakers (30 Amp typical).

4.5.9.3.7 Variable load and fixed load resistors.

4.5.9.3.8 Commercial Item Description (CID) from A-A-52080 through A-A-52084 (Type I, IV, or V) lacing tape or equivalent.

4.5.9.4 Test Procedure

4.5.9.4.1 Preparation of a Bundle

Conduct a 2500 V Wet Dielectric test (or pass the wire through an impulse spark tester set at 8KV) on 100% of the wire in accordance with the Wet Dielectric test procedure described in Test Method 510 before the arc-propagation resistance test is performed. Discard any failed sections of wire. Cut seven wire segments 8 to 16 in (20.3 to 40.6 cm) in length for each of the 15 bundles. Clean the cut wires using a cloth saturated with isopropyl alcohol. Strip both ends of five of the seven wire segments. Use these stripped ends for making electrical connections. These five wire segments will be called “Active Wires.” The two non-stripped wire segments will be called “Passive Wires.” Using a sharp blade, cut a square groove completely around (360 degrees) the insulation of two of the active wires at their midpoints to expose the conductor taking care to not cut into the conductor strands. The width of the exposed conductor should be between 0.5 mm and 1.0 mm (0.0197 in and 0.03941 in). Form the bundle by laying the seven wire segments straight and geometrically parallel. Assemble the wires to form the six-around-one configuration shown in Figure 13, with D1 and D2 being the passive wires. The two pre-damaged wires should be placed in the A1 and B1 positions and care should be taken to ensure that there is a longitudinal distance of 6.0 to 6.5 mm (0.2362 to 0.2560 in) as measured between the stripped window and the two exposed conductors. Use lacing tapes defined in 4.5.9.3.8 to hold the test bundle together as shown in Figure 14. Clean the assembled bundle using a cloth saturated with isopropyl alcohol.

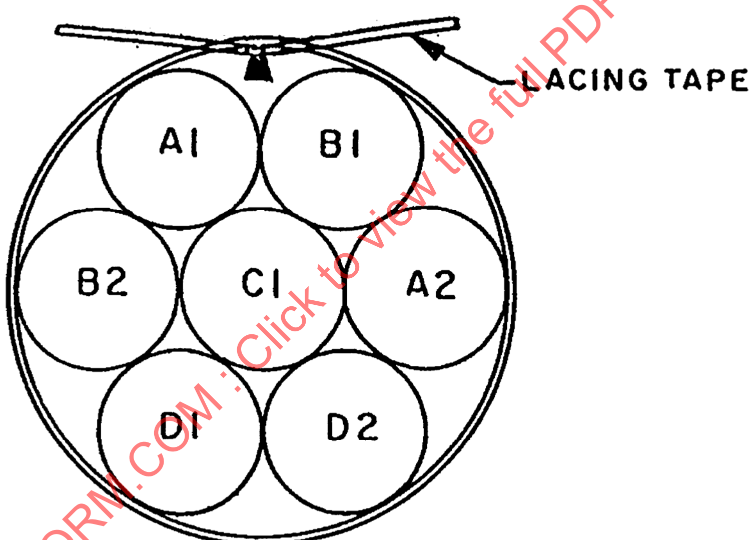


FIGURE 13 - BUNDLE CONFIGURATION

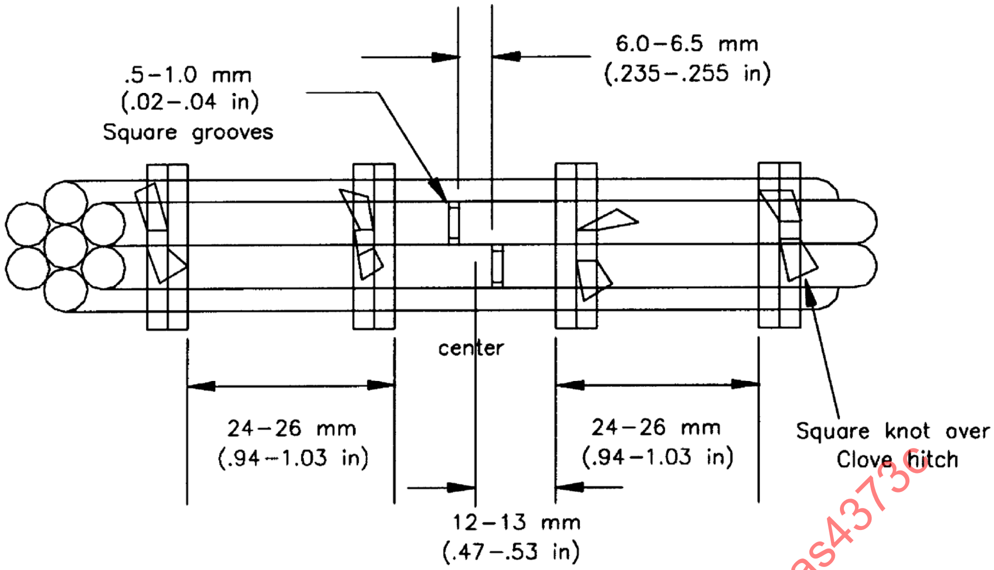


FIGURE 14 - BUNDLE TYING

4.5.9.4.2 Electrical Connection

Connect the test bundle to the power supply and circuit resistance using the schematic circuit shown in Figure 15. Connect one end of each active wire to the appropriate phase of the power supply as shown in Table 12. Use an SAE AS3320 - 7.5 (7.5 Amp) circuit breaker and a circuit resistance (Rf) in series with each of the active wires. Use the circuit resistance (Rf) values (±10%) shown in Table 13. Connect the other end of the five active wires under test to variable resistive (Ri) loads. Adjust the resistance (Ri) to limit the current flowing through each wire to 1 Amp ± 0.2 Amp. Protect the test circuits with appropriate circuit breakers connected on the supply side of the test set up. The generator load resistors (Rg) shall be set so that the generator is delivering 10 to15% of its rated load at a voltage of 108 to 118 Volts rms phase to neutral.

TABLE 12 - ELECTRICAL CONNECTION

Wire Identification	Power Supply	Layer
A1	Phase A	Top
B1	Phase B	Top
C1	Phase C	Middle
A2	Phase A	Middle
B2	Phase B	Middle
D1	None	Lowest
D2	None	Lowest

TABLE 13 - CIRCUIT RESISTANCE

Test Number	Circuit Resistance (ohm) ±10%
1	0.0
2	0.5
3	1.0
4	1.5
5	2.0

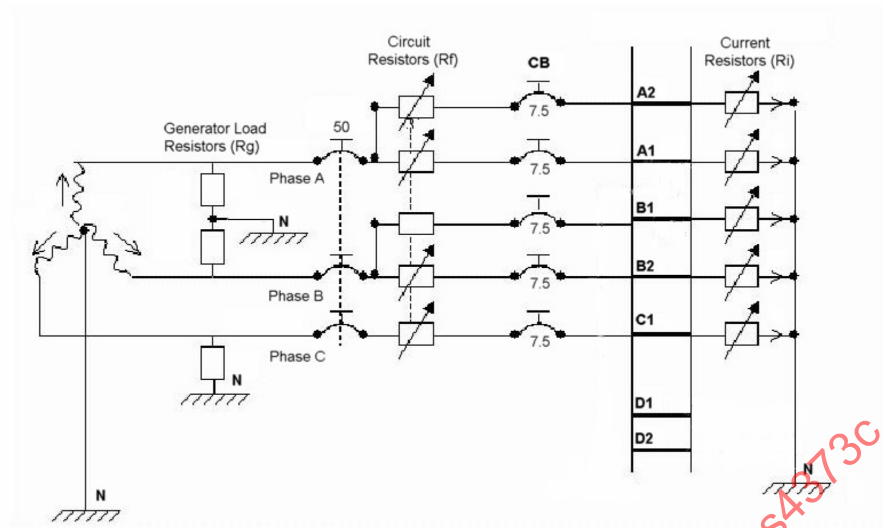


FIGURE 15 - ELECTRICAL CONNECTION

4.5.9.4.3 Initiation of Test

[Test three bundles for each of the five circuit resistances.] Using the mechanical supports, mount the test bundle in a draft-free location so that the wires with the exposed conductors are facing up. Adjust the flow of the electrolyte to 8 to 10 drops per minute. Position the hypodermic needle to drop the electrolyte into the groove between the wires with the exposed conductor. Position the tip of the needle so that the vertical distance of the tip is between 2.0 and 3.0 in (51 and 76 mm) above the specimen. Position the protective screen to shield the operator from ejecting objects or UV radiation. Close all circuit breakers. Allow the electrolyte to flow. Apply the three phase 400 Hz power.

4.5.9.4.4 Use one of the following conditions to conduct and complete the test:

4.5.9.4.4.1 If circuit breakers in any of the phases A2, B2, or C1 trip at any time during the test, wait 3 min and disconnect power. Conduct a 1000 V Wet Dielectric test on wires A2, B2, C1, D1, and D2 in accordance with the Wet Dielectric procedure of Test Method 510. Record the number of wires that fail. Measure and record the total length of physical damage to each wire (including phase A1 and B1 wires) in inches.

4.5.9.4.4.2 If either phase A1 or phase B1 circuit breaker trips at any time during the test, disconnect the power and identify the phase of the tripped circuit breaker. Wait 3 min. Reset the circuit breaker, apply power and continue the test. Continue the test for 8 h or until either phase A1 or phase B1 circuit breaker has tripped twice. CAUTION: DO NOT RESET CIRCUIT BREAKER THAT TRIPS TWICE. Conduct a 1000 V Wet Dielectric test of Test Method 510. Record the number of wires that fail. Measure and record the total length of physical damage to each wire (including phase A1 and B1 wires) in inches.

4.5.9.4.4.3 If the conductor(s) of phases A1 and B1 wires erode without tripping phase A1 or phase B1 circuit breakers (as may be indicated by an open circuit indicator), continue the test for a total of 8 h or until the conditions noted in 4.5.9.4.4.1 or 4.5.9.4.4.2 occur. Conduct a 1000 V Wet Dielectric test on wires A2, B2, C1, D1, and D2 in accordance with the Wet Dielectric procedure of Test Method 510. Record the number of wires that fail. Measure and record the total length of physical damage to each wire (including phase A1 and B1 wires) in inches.

4.5.9.4.4.4 Circuit breakers should be periodically tested to assure they still meet the overload trip requirements of the applicable military specification (MS) sheet. Circuit breakers outside their overload trip limits should be replaced.

4.5.9.5 Results

Report the number of wires that pass the dielectric test and the length of physical damage to each wire in the bundle.

4.5.9.6 Information Required in Detail Specification

Wire type and number of specimen bundles.

4.5.9.7 Precision Bias

This is a new method and round-robin testing to determine precision is in progress.

4.5.10 Method 510, Voltage Withstand (Wet Dielectric)

4.5.10.1 Scope

This test provides a method to determine insulation integrity following any type of performance test.

4.5.10.2 Specimen

See Section 8.3 of ASTM D 3032.

4.5.10.3 Test Equipment

See Section 8.2 of ASTM D 3032.

4.5.10.4 Test Procedure

See Section 8.4 of ASTM D 3032.

4.5.10.5 Results

Report electrification time, voltage, and time of failure if failure occurs.

4.5.10.6 Information Required in Detail Specification

Performance testing preceding Voltage Withstand and maximum voltage applied.

4.5.10.7 Precision Bias

A test voltage of at least 2.5 kV is recommended for 600 V or higher rated wire.

4.5.11 Method 511, Wire Fusing Time

4.5.11.1 Scope

This test is to be used to determine the time for an insulated wire to interrupt current in overcurrent conditions.

4.5.11.2 Specimen

Each specimen shall be a 12 in (305 mm) length of wire with the insulation stripped 0.5 in (13 mm) at both ends.

4.5.11.3 Test Equipment

4.5.11.3.1 DC constant current supply.

4.5.11.3.2 Timer.

4.5.11.4 Test Procedure

The specimen shall be mounted so that its length is horizontally suspended in free air and not resting on any surface. Using a DC constant current supply, apply 2.5 times the free air rated current. See Figure 3 of AS50881 for the free air rated current. Measure the time to interrupt current (open circuit). The test shall be terminated after 5 min if no current interruption occurs.

4.5.11.5 Results

Report test current and time to interrupt current.

4.5.11.6 Information Required in Detail Specification

Number and wire size of specimens.

4.5.11.7 Precision Bias

This method has not had the benefit of any round-robin testing to determine precision.

4.5.12 Method 512, Voltage Rating: TO BE DETERMINED

There is not currently an approved test under ASTM D 3032 that covers this requirement, but drafts are being worked on and the Task Group has decided to await the issuance of the ASTM test.

4.6 Test Methods Group 600 - Environmental Tests

4.6.1 Method 601, Fluid Immersion

4.6.1.1 Scope

This test is to be used to determine the effects of various fluids to the insulation on the wire specimen.

4.6.1.2 Specimen

Three 24 in (610 mm) wire specimens shall be used for each test fluid.

4.6.1.3 Test Equipment

4.6.1.3.1 Containers large enough to immerse to within 6 in (152 mm) of each end of the wire specimen, for each fluid in the fluid table below.

4.6.1.3.2 Quantities of each of the fluids selected from Table 14.

4.6.1.3.3 A micrometer or other device capable of measurement to 0.001 in (0.025 mm).

4.6.1.3.4 A device to remove the insulation off each end of the wire specimen.

4.6.1.3.5 A thermometer.

4.6.1.4 Test Procedure

4.6.1.4.1 Each 24 in (610 mm) specimen, for each test fluid in Table 14, shall have its diameter measured and shall then be immersed to within 6 in (152 mm) of each end for the time and temperature specified. During immersion, the radius of bend of the wire shall be not less than 14 nor more than 35 times the specified maximum diameter of the wire under test. Upon removal from the test fluid, the specimen shall be wiped dry and then remain for 1 h in free air at room temperature. The diameter shall be measured and compared to the initial diameter. The insulation shall be removed for a distance of 0.5 in (13 mm) from each end of the specimen. The specimen shall then be subjected to the Bend Test Method 713 and Voltage Withstand (Wet Dielectric) Method 510.

4.6.1.5 Results

Report the initial diameter and the diameter after immersion; the time and temperature of immersion and the results of the Bend Test Method 712 and of the Voltage Withstand (Wet Dielectric) Test Method 510.

4.6.1.6 Information Required in Detail Specification

The wire size and the fluids to be used for immersion.

4.6.1.7 Precision Bias

This is a fluid and material dependent test.

TABLE 14 - FLUID TABLE

	Test Fluid	Test Temp °C	Test Temp °F	Immersion Time (h)
a	MIL-L-23699, Lubricating Oil, Aircraft Turbine Engine, Synthetic Base	48-50	118-122	20
b	MIL-H-5606 (Inactive for New Design), Hydraulic Fluid, Petroleum Base, Aircraft Missile, and Ordnance	48-50	118-122	20
c	TT-I-735, Isopropyl Alcohol	20-25	68-77	168
d	MIL-DTL-5624, Turbine Fuel, Aviation, Grade JP-4 either or MIL-T-83133, JP-8	20-25	68-77	168
e	MIL-A-8243, Anti-Icing and Deicing-Defrosting Fluid, undiluted	48-50	118-122	20
f	MIL-A-8243, Anti-Icing and Deicing-Defrosting Fluid, diluted 60/40 (fluid/water) ratio	48-50	118-122	20
g	MIL-C-43616, Cleaning Compound, Aircraft Surface	48-50	118-122	20
h	ASTM D 1153, Methyl Isobutyl Ketone (For use in organic coatings)	20-25	68-77	168
i	SAE AS1241, Fire Resistant Hydraulic Fluid for Aircraft	48-50	118-122	20
j	MIL-L-7808, Lubricating Oil, Aircraft Turbine Engine, Synthetic Base	118-121	244-250	30
k	MIL-C-87936, Cleaning Compound, Aircraft Surface, Alkaline Waterbase, undiluted	63-68	145-154	20
l	MIL-C-87936, Cleaning Compound, Aircraft Surface, Alkaline Waterbase, diluted 25/75 (fluid/water) ratio	63-68	145-154	20
m	TT-S-735, Standard Test Fluids; Hydrocarbon, Type I	20-25	68-77	168
n	TT-S-735, Standard Test Fluids; Hydrocarbon, Type II	20-25	68-77	168
o	TT-S-735, Standard Test Fluids; Hydrocarbon, Type III	20-25	68-77	168
p	TT-S-735, Standard Test Fluids; Hydrocarbon, Type VII	20-25	68-77	168
q	Dielectric-coolant fluid, synthetic silicate ester base, Monsanto Coolanol 25 or equivalent	20-25	68-77	168
r	MIL-G-3056, Gasoline, Automotive, Combat	20-25	68-77	168
s	MIL-PRF-87252, Coolant Fluid, Hydrolytically Stable, Dielectric	20-25	68-77	168

4.6.2 Method 602, Forced Hydrolysis

4.6.2.1 Scope

This test was developed for tape wrapped polyimide insulated wires and results may not indicate the hydrolytic stability of other constructions.

4.6.2.2 Specimen

A 30 in (762 mm) specimen shall be used to run this test.

4.6.2.3 Test Equipment

4.6.2.3.1 PTFE or PTFE coated mandrels that are 6 times the diameter of the wire.

4.6.2.3.2 0.5 lb (0.227 kg) weights capable of being attached to the wire insulation.

4.6.2.3.3 An air oven capable of maintaining the rated temperature of the finished wire specimens.

4.6.2.4 Test Procedure

4.6.2.4.1 Heat Conditioned Wire

4.6.2.4.1.1 Specimen Preparation

Specimens shall be wrapped 10 times around a 6X mandrel and secured so that the specimen maintains continuous contact with the the mandrel. After wrapping tightly, hang a 0.5 lb (0.227 kg) weight to keep the wire against the mandrel during oven aging.

4.6.2.4.1.2 Procedure

Place the prepared specimens and mandrels into an oven pre-heated to the finished wire's rated temperature. The specimens shall remain in the oven for 8 h. Upon completion of the thermal conditioning, remove the specimens and allow to cool to room temperature. Immerse the specimens and mandrels into a 5% Saline solution at 70 °C (158 °F) with at least 2 in (5 cm) of each end out of the solution, for 672 h. Upon conclusion of the soak, remove the specimens and allow to cool to room temperature. Perform a final Voltage Withstand (Wet Dielectric) test, Method 510, at 2500 V AC.

4.6.2.4.2 Unconditioned Wire

4.6.2.4.2.1 Specimen Preparation

Specimens shall be wrapped 10 times around a 6X mandrel and secured so that the specimen maintains continuous contact with the mandrel.

4.6.2.4.2.2 Procedure

Immerse the specimens and mandrels into a 5% Saline solution at 70 °C (158 °C) with at least 2 in (5 cm) of each end out of the solution for 672 h. Upon conclusion of the soak, remove the specimens and allow to cool to room temperature. Perform a final Voltage Withstand (Wet Dielectric) test, Method 510, at 2500 VAC.

4.6.2.5 Results

For the heat conditioned wire, report the time and temperature for heat conditioning. For both heat conditioned and unconditioned wire report dielectric failure of the wire if any failure occurs.

4.6.2.6 Information Required in Detail Specification

Number of specimens and wire size to be tested.

4.6.2.7 Precision Bias

This test method has not had the benefit of any round-robin testing to determine precision.

4.6.3 Method 603, Humidity Resistance

4.6.3.1 Scope

This test is to be used to determine the effects of humidity and temperature cycling on the wire specimen's insulation.

4.6.3.2 Specimen

A 52 ft (16 m) length of size 12 or smaller specimen of wire shall be tested.

4.6.3.3 Test Equipment

4.6.3.3.1 A test chamber capable of maintaining an internal temperature of 70 °C ± 3 °C (158 °F ± 5 °F) and an internal relative humidity of 95% ± 5%. The test chamber shall be capable of being sealed to retain the total moisture content in the test space. The heat loss from the chamber shall be sufficient to reduce the internal temperature from the above specified operating temperature to 38 °C (100 °F) or lower within a period of 16 h from the time of removal of the source of heat.

4.6.3.3.2 Distilled or demineralized water shall be used to obtain the required humidity.

4.6.3.4 Test Procedure

The specimen shall be placed in the test chamber and the temperature and relative humidity raised over a 2 h period to the values specified in 4.6.3.3.1 and maintained at such for a period of 6 h. At the end of the 6 h period the heat shall be shut off. During the following 16 h period, the temperature shall drop to 38 °C ± 3 °C (100 °F ± 5 °F) or lower. At the end of the 16 h period, heat shall be again supplied for a 2 h period to stabilize to 70 °C ± 3 °C (158 °F ± 5 °F). This cycle (2 h heating, 6 h at high temperature, 16 h cooling) shall be repeated 15 times to extend the total time of the test to 360 h. At the end of the fifteenth cycle, the 50 ft (16.4 m) center section of the specimen shall be removed from the chamber and tested within 2 h for insulation resistance in accordance with Method 504.

4.6.3.5 Results

Report the insulation resistance in M - 1000 ft.

4.6.3.6 Information Required in the Detail Specification

Number and wire size of specimens to be tested.

4.6.3.7 Precision Bias

Lengths of less than 50 ft (16.4 m) will not produce reliable results.

4.6.4 Method 604, Weight Loss Under Temperature and Vacuum

4.6.4.1 Scope

This test is used to determine the weight loss from a wire specimen when subjected to vacuum and temperature. Some preconditioning may be required.

4.6.4.2 Specimen

A 24 in (610 mm) wire specimen shall be used for this test.

4.6.4.3 Test Equipment

4.6.4.3.1 A chamber capable of 33 mm Hg and the temperature rating of the wire specimen for 384 h operation.

4.6.4.3.2 A device to measure the weight of the specimens.

4.6.4.4 Test Procedure

4.6.4.4.1 Each specimen shall be weighed.

4.6.4.4.2 If preconditioning is specified in the detail specification, then such preconditioning shall be performed.

4.6.4.4.3 When preconditioning is required, the specimens shall be weighed again after completion of the preconditioning. The specimens shall be transferred to the chamber preset at the wire's rated temperature. As soon as practical, the chamber pressure shall be reduced to 33 mm Hg. The specimens shall remain in this pressure and temperature condition in the chamber for 384 h.

4.6.4.4.4 At the completion of this 384 h test, the specimens shall be removed from the chamber and weighed again within 30 min.

4.6.4.5 Results

The initial weight, the weight after preconditioning (if applicable), and the final weight shall be reported. The applicable weight loss value may be calculated. The preconditioning conditions (if applicable) and the temperature and pressure of the chamber shall be reported.

4.6.4.6 Information Required in the Detail Specification

The number and wire size of the specimens, the preconditioning parameters, and the chamber temperature and pressure.

4.6.4.7 Precision Bias

This test method has not had the benefit of any round-robin testing to determine precision.

4.6.5 Method 605, Propellant Resistance

With ever-increasing local and federal regulations for handling corrosive, toxic, and/or explosive materials such as propellants, it is impractical for non- government laboratories to perform this type of test. The manufacturers of missile systems who use these propellants have their own propellant tests, and they report that they also routinely route wires and cables away from areas in their missiles where even accidental spillage may have had come in contact with installed wires and cables. As a result, a test method for propellant resistance is not included in AS4373.

4.6.6 Method 606, Weathering Resistance

4.6.6.1 Scope

This test is to be used to determine the effects of UV light and condensation exposure to the insulation on the wire specimens.

4.6.6.2 Specimen

A 36 in (914 mm) wire specimen shall be used for this test.

4.6.6.3 Test Equipment

4.6.6.3.1 A UV light chamber per ASTM G 53 requirements.

4.6.6.3.2 Chamber capable of condensation exposure per ASTM G 53 requirements.

4.6.6.4 Test Procedures

This test shall be conducted by following ASTM G 53 for operating ultra violet (UV) light and water exposure apparatus. Use the following parameters for UV and condensation cycling:

a. 8 h UV at 70 °C ± 3 °C (158 °F ± 5 °F) = 1 cycle

b. 4 h Condensation at 40 °C ± 3 °C (104 °F ± 5 °F)

Perform 120 cycles of UV and condensation exposure. Remove the specimens after 120 cycles and subject them to the Bend Test Method 712 and the Voltage Withstand (Wet Dielectric) Test Method 510. Insure wire portion exposed to UV is in flex area.

4.6.6.5 Results

Report any cracking or splitting and any visible changes to the insulation or markings and the results of the Bend and Voltage Withstand Tests.

4.6.6.6 Information Required in the Detail Specification

Number and wire size of the specimens to be tested.

4.6.6.7 Precision Bias

This test method has not had the benefit of any round-robin testing to determine precision.

4.6.7 Method 607, Wicking

4.6.7.1 Scope

This test is applicable only for multi-layered or overbraided wires. This test is to be used to determine the length of dye travel within or between layers of insulation and to determine dye travel in overbraided wire. It is not applicable for determining wicking of fluids in the conductor.

4.6.7.2 Specimen

The specimens to be tested shall be 4 in ± 1/16 in (102 mm ± 1.6 mm) in length with square-cut ends.

4.6.7.3 Test Equipment

4.6.7.3.1 A container to hang the specimens into a depth of 2 in (51 mm).

4.6.7.3.2 A quantity of standard dye solution sufficient to meet the requirements of 4.6.7.4. The dye solution shall be prepared as follows:

a. Ethyl Alcohol: 30 ml

b. Rhodamine B dye: 0.02 g

c. Aerosol OT: 3 ml

d. Distilled water to make 2 L

The dye shall be dissolved in the ethyl alcohol before adding to the water. The solution shall be kept stoppered and a fresh solution shall be prepared every 30 days. A new portion of the solution shall be used for each test conducted.

4.6.7.3.3 A sharp blade to remove the wire insulation.

4.6.7.3.4 A clean dry lint free cloth.

4.6.7.3.5 A UV light source.

4.6.7.3.6 A scale capable of measurement to 1/16 in.

4.6.7.4 Test Procedures

Wicking of the dye shall be determined as follows:

4.6.7.4.1 Multi-layer Wire

The specimen shall be placed upright with the lower 2 in (51 mm) of its length immersed in the dye solution (4.6.7.3.2) in an open container and shall be left for 24 h at room temperature in a draft free area. It shall then be removed from the dye solution and the surface of the insulation shall be wiped with a clean, dry, lint free cloth. Within 5 min after removal from the solution, the specimen shall be observed under ultraviolet light to determine, to the nearest 1/16 of an inch, the distance the dye solution has traveled in any part of the insulation by wicking action. The layers of insulation may be dissected away with a sharp blade, working from the upper end of the specimen to facilitate observation.

4.6.7.4.2 Overbraided Wire

Repeat immersion and UV observation but determine the wicking action, if any, to the nearest 1/16 of an inch in the overbraid only.

4.6.7.5 Results

Report the distance traveled by the dye solution by either 4.6.7.4.1 or 4.6.7.4.2 depending upon the type of wire being tested.

4.6.7.6 Information Required in the Detail Specification

Number and wire size of the specimens to be tested and which procedure to use.

4.6.7.7 Precision Bias

This test can be used for design evaluation or process control.

4.7 Test Methods Group 700 - Mechanical Tests

4.7.1 Method 701, Abrasion

A test method for the abrasion resistance of wire has not been included in this standard. It has been shown that no one test can reproduce the various conditions of abrasion that can occur in an aerospace vehicle. The various tests that have been tried over many years have shown poor reproducibility.

4.7.2 Method 702, Cold Bend

4.7.2.1 Scope

This test is to be used to evaluate a wire specimen's resistance to cracking at low temperatures while being wrapped around a mandrel.

4.7.2.2 Specimen

A 36 in ± 1/2 in (914 mm ± 13 mm) specimen shall be used in this test.

4.7.2.3 Test Equipment

4.7.2.3.1 A chamber capable of maintaining -65 °C ± 3 °C (-85 °F ± 5 °F) and allows mechanical access for wrapping the specimen around a mandrel.

4.7.2.3.2 A rotatable mandrel for installation into the above chamber.

4.7.2.3.3 A sharp blade to remove the specimen insulation.

4.7.2.3.4 A test weight sufficient to hold the specimen taut on the mandrel.

4.7.2.4 Test Procedure

One end of the specimen shall be secured to the rotatable mandrel in the cold chamber and the other end to the test weight sufficient to hold the specimen taut on the mandrel. Provisions shall be made for rotating the mandrel by means of a handle or control located outside the chamber. The specimen of wire and the mandrel shall be conditioned at -65 °C ± 3 °C (-85 °F ± 5 °F) for 4 h. At the end of this period and while both mandrel and specimen are still at this low temperature, the specimen shall be wrapped helically, for its entire length or for 20 turns, whichever is the lesser number of turns, around the mandrel without opening the chamber. The bending shall be accomplished at a uniform rate of 2 rpm ± 1 rpm. At the completion of this test the specimen shall be removed from the cold box and from the mandrel without straightening. Allow the specimen to return to room temperature. The specimen shall be examined for cracks in the insulation. Allow specimen to return to room temperature and then remove the insulation for a distance of 1 in ± 1/8 in (25.4 mm ± 3.2 mm) from each end of the specimen and subject the specimen to Method 510 - Voltage Withstand Test with the bent portion submerged.

4.7.2.5 Results

Report any cracking or the results of Method 510 - Voltage Withstand as required.

4.7.2.6 Information Required in the Detail Specification

Number and wire size of specimens to be tested and mandrel size and weight required for each wire size and type.

4.7.2.7 Precision Bias

This test can be used for design evaluation or for process control. Mandrel sizes and weights will differ for each.

4.7.3 Method 703, Dynamic Cut-Through

4.7.3.1 Scope

This test is to be used to evaluate the resistance of the insulation of a wire specimen to the penetration of a cutting surface.

4.7.3.2 Specimen

The specimen shall be 18 in (450 mm) in length for this test.

4.7.3.3 Test Equipment

See Section 22.2 of ASTM D 3032 for the necessary equipment to perform this test. For the elevated temperature test, the cut through apparatus must be fixed inside the test chamber so that the test can be performed without disturbing the thermal environment. The standard cutting edge shall be a 20 ml diameter sewing needle.

4.7.3.4 Test Procedure

See Sections 22.4 through 22.5 of ASTM D 3032 for the test procedure.

4.7.3.5 Results

Report the force to cut-through each specimen and the temperature of the test.

4.7.3.6 Information Required in the Detail Specification

Number and wire size of the specimens to be tested and test temperature.

4.7.3.7 Precision Bias

This method has not had the benefit of any round-robin testing to determine precision.

NOTE: ASTM D 3032 states that precision for this test is not yet known and that optional cutting edges may be considered for different sizes of wires. If other cutting edges are used they should be covered in the detail specification sheet.

4.7.4 Method 704, Flex Life

4.7.4.1 Scope

This test is used to determine the ability of insulated wire to withstand repeated mechanical flexing. Step 1 procedure is to determine the number of flex cycles to catastrophic failure, which will be used for the baseline value for step 2. Step 2 is to more accurately predict the number of cycles when conductor strand breakage can begin.

4.7.4.2 Specimen

The specimens shall be size 22 wires prepared in accordance with 4.7.4.2.1 and 4.7.4.2.2.

NOTE: Prior to testing, check the dielectric strength of the insulation on each specimen. Use test method 510 of AS4373, eliminating the 4 h soak. Discard and replace all specimens that fail.

4.7.4.2.1 Step 1, Flex to Failure

Six 18 in specimens are required. Attach a Number 10 ring tongue terminal to one end of each specimen, be sure the terminal is attached to the conductor only. The terminal is used to attach weights to the specimens under test.

4.7.4.2.2 Step 2, Predetermined Number of Cycles

Twelve 18 in specimens are required. Specimens are to be prepared as described in 4.7.4.2.1.

4.7.4.3 Test Equipment

Construct the test fixture as shown in Figure 16. The PTFE coated mandrels shall have a diameter approximately six times the outer diameter of the wire specimen. The flex arm shall rotate +90 degrees from vertical; a total of 360 degrees of motion constitutes 1 cycle. Flex rate shall be 25 to 30 cpm. Weights having a total minimum value of 4.0 lb shall be attached to the conductor of the specimen and placed between the guide rods which are used to eliminate weight swing.

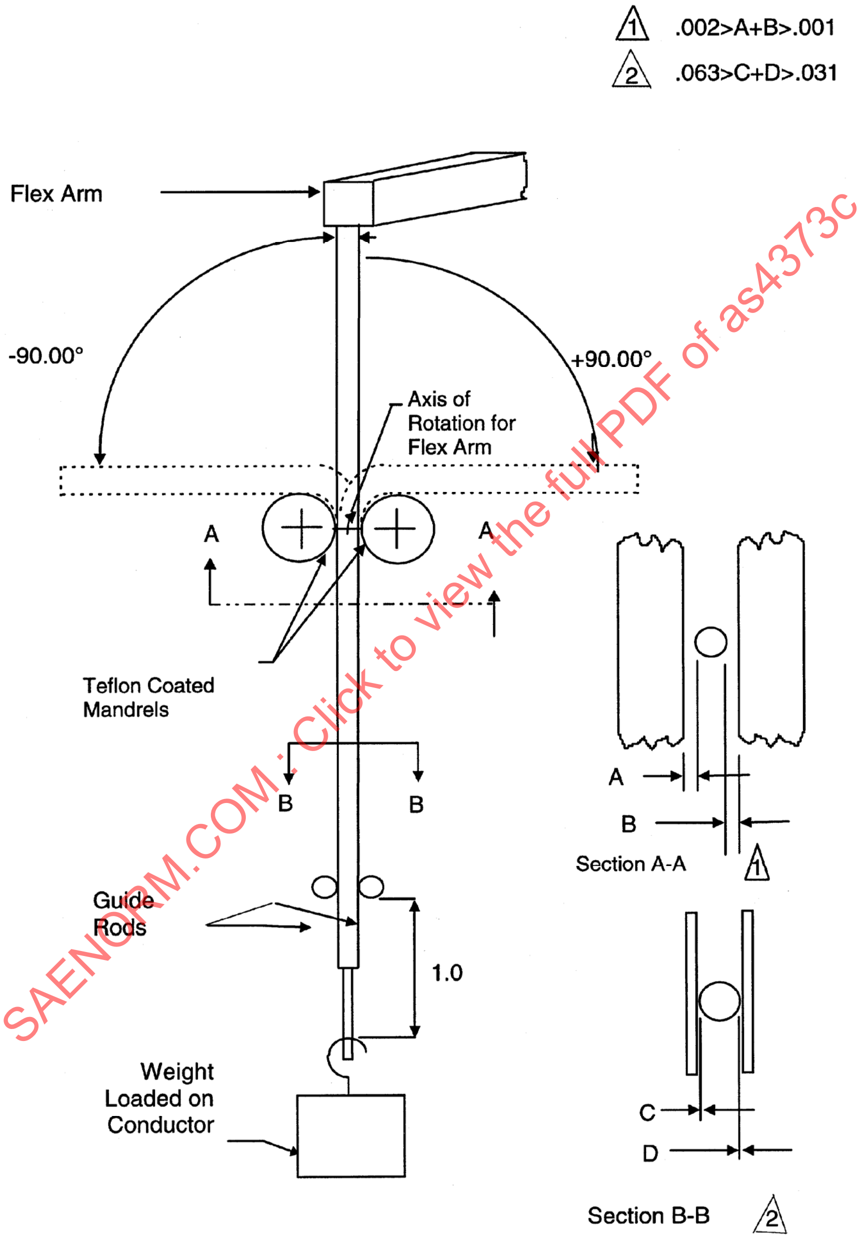


FIGURE 16 - FLEX LIFE TEST SETUP

4.7.4.4 Test Procedure

4.7.4.4.1 Step 1, Flex to Failure

Install the specimen in the fixture, attach the weight and flex at 25 to 30 cpm. Flex until complete separation of insulated wire occurs and the weight drops (catastrophic failure).

4.7.4.4.2 Step 2, Predetermined Number of Cycles

Using the baseline established from Step 1, Step 2 specimens shall be tested in sets of two with increasing number of flex cycles. Perform the cycle testing on the twelve specimens by installing the specimens in the fixture, attach the weights and flex at 25 to 30 cpm. Flex for the specified number of cycles unless catastrophic failure occurs first.

The first 2 specimens shall be cycled to 50% of the baseline established by Step 1. Stop the test, remove the specimens from the fixture and examine each specimen by removing the insulation in the area of flexure, count and record the number of broken strands

Continue this process increasing the cycles by 10% on two each of the remaining specimens (e.g., 60% 70% 80% 90%) of the baseline value. More than two specimens may be tested at one time provided the cycling can be halted periodically to remove the next specimens for examination.

4.7.4.5 Results

4.7.4.5.1 Step 1, Flex Until Failure

Record the number of cycles to failure for each specimen. Establish the baseline for Step 2 testing by determining the average number of cycles to failure of the specimens tested.

4.7.4.5.2 Step 2, Predetermined Number of Cycles

Describe and/or photograph the condition of each specimen at the point of flexure. Note the condition of the insulation and record the number of broken strands of the conductor for each specimen. Note any catastrophic failures and the number of cycles when occurred.

4.7.4.6 Information Required in the Detailed Specification

The value of the weight (recommend 20% of the breaking strength) to be used for each gauge size tested, shall be provided, if other than wire size 22 is to be tested.

4.7.4.7 Precision Bias

This procedure does not have the benefit of round-robin testing.

NOTE: This test method was developed to better define when flexing causes strand breakage in the conductor as catastrophic failure alone can be misleading.

4.7.5 Method 705, Insulation Tensile Strength and Elongation

4.7.5.1 Scope

This test is to be used to produce tensile property data for process control purposes of extruded electrical insulation.

4.7.5.2 Specimen

See Section 17.3 of ASTM D 3032 for specimen preparation.

As a suggestion for insulated wire constructions whose conductor is smaller than 12 mm^2 (6 AWG), the test specimen shall consist of a length of the entire section of the insulation with the conductor removed. A method for removing the conductor from the finished wire specimen is to circumferentially sever a 4 in segment of insulation from the center of a 24 in specimen. Then slowly elongate the conductor beyond its point of elasticity. Cut the conductor and remove the unstressed segment of insulation.

4.7.5.3 Test Equipment

See Section 17.2 of ASTM D 3032 for test apparatus.

4.7.5.4 Test Procedure

See Sections 17.4 through 17.5 of ASTM D 3032 for the test procedure. The jaw separation shall be 1 in ± 0.1 in and the jaw separation speed shall be 2 in ± 0.2 in per minute. If the jaw separation must be adjusted to allow for extensometers, the jaw separation speed shall be adjusted to maintain the same strain rate.

4.7.5.5 Results

Report rate of jaw separation, tensile strength, and elongation.

4.7.5.6 Information Required in the Detail Specification

Rate of jaw separation, minimum allowable tensile strength and elongation, temperature of the test, any special conditioning requirements, number and wire size of specimens to be tested.

4.7.5.7 Precision Bias

Reference ASTM D 412 for the precision of this test. It should be noted that a variance of ±10 to 20% from the average value is typical for this test, and that different materials will typically have higher or lower variances that cannot be predicted in advance of the test.

4.7.6 Method 706, Notch Propagation

4.7.6.1 Scope

This test is to be used to determine the susceptibility of finished wire to withstand notching or nicking without propagating the notch completely through the insulation to the conductor.

4.7.6.2 Specimen

A 6 in (150 mm) specimen shall be used for this test.

4.7.6.3 Test Equipment

4.7.6.3.1 A notching tool as described in Figure 17.

4.7.6.3.2 A 6X mandrel for wrapping of the specimen.

4.7.6.4 Test Procedure

A notching tool shall be built for each of the notch depths required. Use the tool to notch a 6 in (150 mm) specimen. Wrap and reverse wrap the entire specimen around a 6X mandrel. Visually examine the specimen at the end of each 10 cycles to detect when the notch penetrates to the conductor. The wrap and unwrap cycle shall continue until the conductor has been exposed (failure) or until 100 cycles have been completed. The number of cycles to failure shall be recorded.

4.7.6.5 Results

Report the number of cycles to failure and the notch depth for each failure.

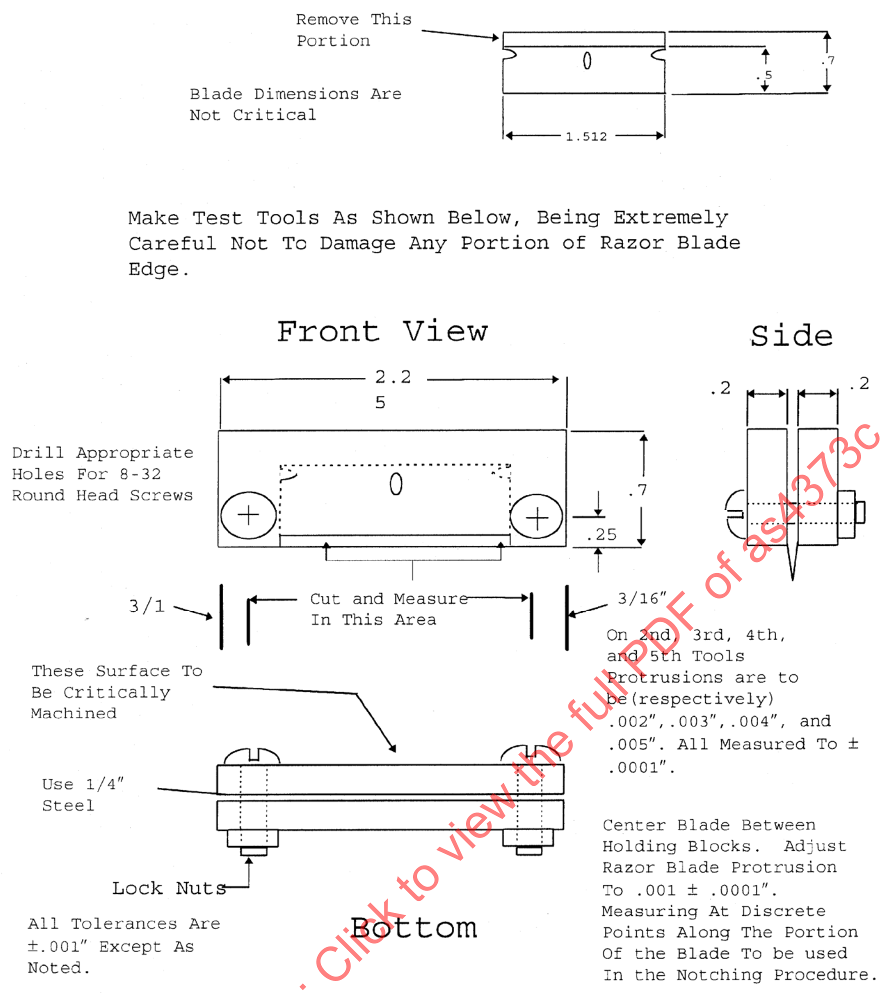


FIGURE 17 - NOTCHING TOOL

4.7.6.6 Information Required in the Detail Specification

Number and wire size of the specimens to be tested and notch depth(s).

4.7.6.7 Precision Bias

This test method has not had the benefit of any round-robin testing to determine precision.

NOTE: With some constructions it may be difficult to visually detect the conductor, 10X visual magnification may be used.

4.7.7 Method 707, Stiffness and Springback

4.7.7.1 Scope

This test is used to generate data for comparison between specimens using the same stiffness and springback apparatus. Stiffness and springback affect harness manufacturing, harness and cable installation, and maintenance operations.

4.7.7.2 Specimen

An 8 in (203 mm) finished wire specimen shall be used for this test. The specimen shall be straightened prior to testing to remove the majority of curvature from storage on the supply reels.

4.7.7.3 Test Equipment

4.7.7.3.1 An apparatus consisting of a pivoting arm mounted in the center of a scaled plate shall be fabricated according to Figures 18 and 19.

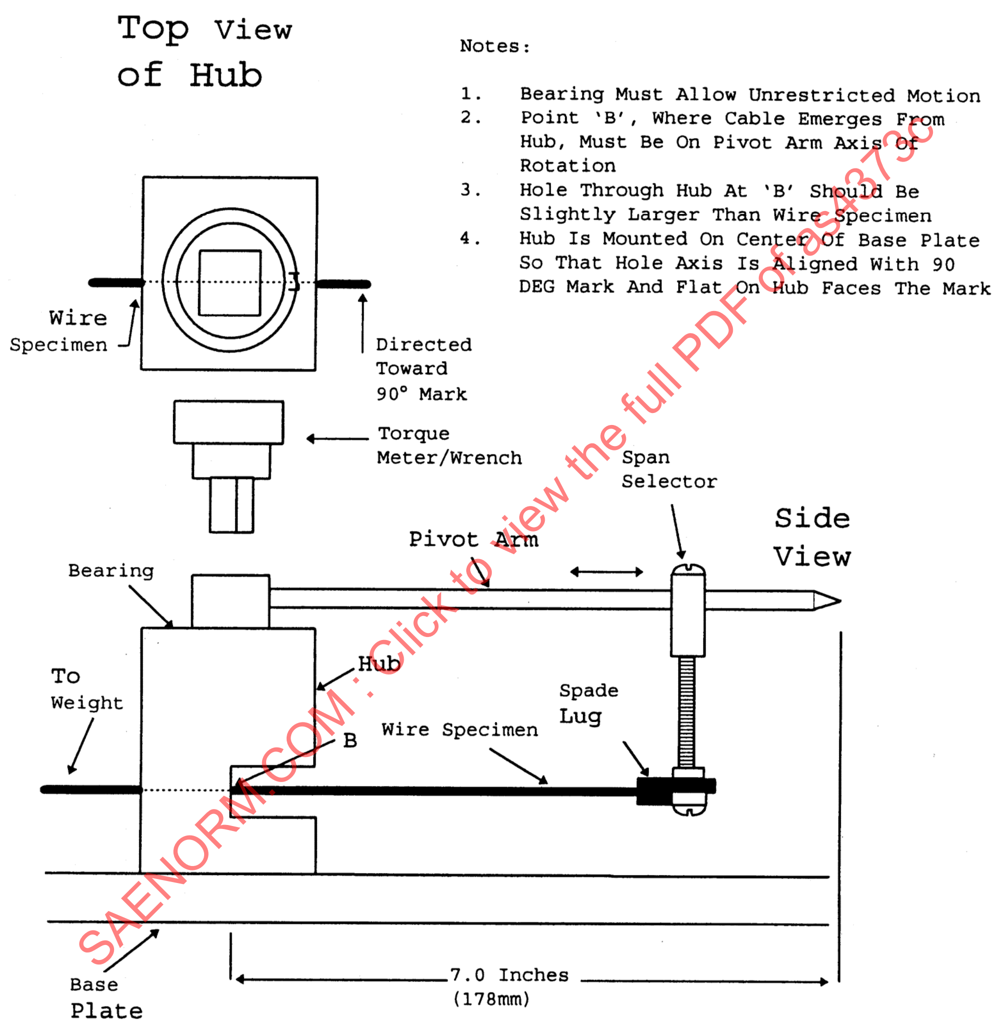


FIGURE 18 - TEST FIXTURE FOR STIFFNESS AND SPRINGBACK TEST

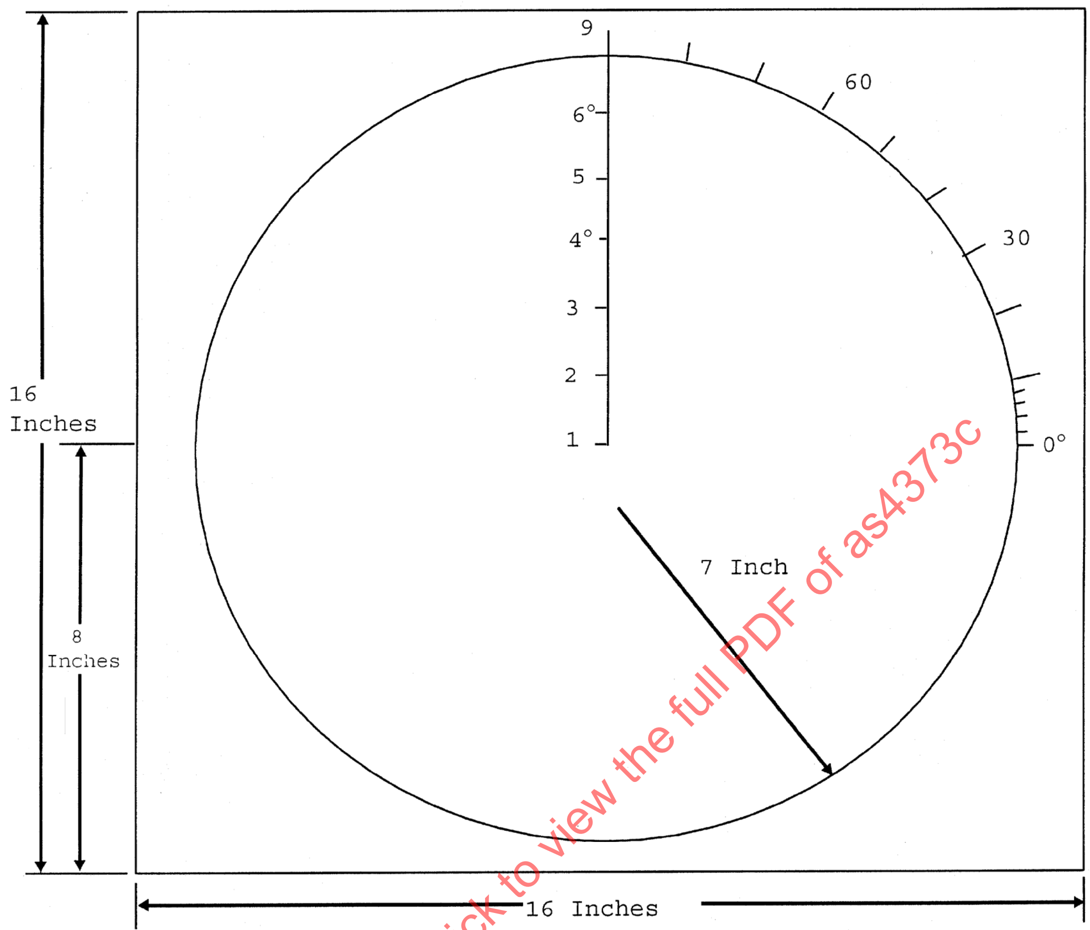


FIGURE 19 - STIFFNESS AND SPRINGBACK TEST FIXTURE BASE PLATE

4.7.7.3.2 A torque meter/wrench.

4.7.7.3.3 Alligator clip and string or equivalent.

4.7.7.4 Test Procedure

The test fixture shall be placed on a flat surface with the edge of the plate on the side of the wire specimen exit point from the hub located next to a clear vertical drop. The span selector shall be adjusted for the desired length of bend. The pivot arm shall be rotated to the 90 degree position (at rest location). One end of the wire specimen shall be terminated with a spade lug. The non-terminated end of the wire specimen shall be routed through the hole in the test fixture hub. The spade lug shall be attached at the base of the span selector. A weight as listed in Table 15 shall be attached to the non-terminated end of the wire specimen using an alligator clip and string. The weight shall be hung over the edge of the plate such that the wire specimen and string are directed along the same radial line as the hole in the hub.

TABLE 15

Wire Size	Weight (lb)	Weight (kg)
22	1.0	0.45
26	0.5	0.23

Using the torque meter, slowly rotate the pivot arm to the 0 degree position. The maximum torque value observed during the bending is the stiffness. The pivot arm shall be held at the 0 degree position for about 10 s. While holding the arm, the torque meter shall be removed. While maintaining finger contact with the arm, the arm shall be allowed to slowly rotate back toward the 90 degree position due to any tension in the wire specimen. Allow 10 s after springback action stops. The indicated angle is the springback.

4.7.7.5 Results

Report the torque needed to pull the specimen through the 90 degree bend and the degrees of springback.

4.7.7.6 Information Required in the Detail Specification

Number and wire size of the specimens to test and span selector length.

4.7.7.7 Precision Bias

This is a new method that has not had the benefit of any round-robin testing to determine precision. Limited testing indicates the following will bias comparison test results:

a. Different conductor constructions (unilay, concentric), materials (copper, aluminum, alloy, plating), sizes (i.e., 22 AWG versus 24 AWG), and different conductor stranding.

b. Different wall thickness of insulating material.

c. Different span selector settings (the shorter the span the more pronounced the performance difference between constructions).

4.7.8 Method 708, Mandrel and Wrapback Test

4.7.8.1 Scope

This test is to be used to determine whether a specimen will crack when wrapped upon itself or around a mandrel. The wrapback test has been used for process control purposes with wires insulated with PTFE to determine the degree of sintering of the insulation.

4.7.8.2 Specimen

Use a 12 in (305 mm) finished wire specimen for the wrapback test and a 12 in (305 mm) plus the additional length required for winding on the mandrel for the mandrel test.

4.7.8.3 Test Equipment

4.7.8.3.1 An air oven capable of maintaining the specified temperatures and tolerances.

4.7.8.3.2 Test mandrels as called out in the Detail Specification.

4.7.8.4 Test Procedure

4.7.8.4.1 Wrap Back Test

This test applies to wire sizes 10 through 30. The 12 in (305 mm) specimen shall be bent back on itself at the mid-portion on a radius not less than the radius of the wire. One end of the specimen shall be wound tightly around the other end as a mandrel for a total of four close turns and placed in an elevated temperature oven for a time period as specified in the Detail Specification (see Figure 20). After removal from the oven, the specimen shall be examined visually, without the aid of magnification, for cracks.

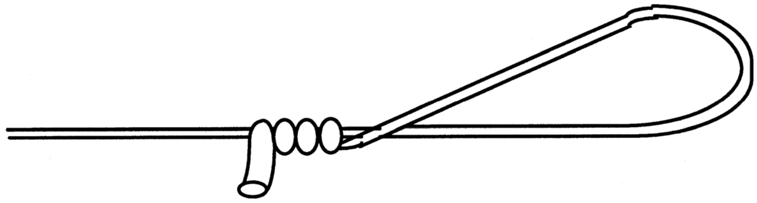


FIGURE 20 - WRAP BACK TEST

4.7.8.4.2 Mandrel Test

This test applies to wire sizes 0000 through 8. The specimen, with a length of 12 in (305 mm), plus the additional length required for winding on the mandrel, shall be wound tightly for two close turns around a mandrel diameter and temperature as specified in the Detail Specification. The winding shall be accomplished manually and shall be in the middle portion of the specimen so that 6 in (152 mm) of each end shall remain straight. The specimen shall then be removed from the mandrel without unwinding, examined visually for cracks, and subjected to the Voltage Withstand Test Method No. 510.

4.7.8.5 Results

Report any cracking of the insulation. Report the Voltage Withstand Test results for the Mandrel test of Procedure 4.7.8.4.2.

4.7.8.6 Information Required in the Detail Specification

Number and wire size of specimens to be tested, temperature and time at temperature for the Wrapback Test, and mandrel diameter and test temperature for the Mandrel Test.

4.7.8.7 Precision Bias

The wrapback test has not had the benefit of round-robin testing to determine its suitability for insulating materials other than PTFE.

4.7.9 Method 709, Wrinkle Test

4.7.9.1 Scope

This test is to be used to evaluate the quality of insulation application and the ability of the insulation to resist wrinkling. It is applicable only to wire sizes 10 and smaller.

4.7.9.2 Specimen

The test specimen shall be a 12 in (305 mm) length of finished wire.

4.7.9.3 Test Equipment

4.7.9.3.1 A device to provide 3X magnification.

4.7.9.3.2 Steel mandrels sized appropriately for the specimens tested.

4.7.9.4 Test Procedure

Bend the wire specimen one full turn around the mandrel as specified in Table 16.

TABLE 16

Wire Size	Mandrel Size inch	Mandrel Size mm
24-30	1/8	3.2
22	3/16	4.76
20	1/4	6.4
18	5/16	7.9
16	3/8	9.5
14	1/2	12.7
12	3/4	19.0
10	1.0	25.4

The wire specimen shall then be examined at 3X magnification for wrinkles. It may be examined on the mandrel or after removal from the mandrel leaving the coil intact.

4.7.9.5 Results

Report wrinkling for each specimen tested.

4.7.9.6 Information Required in the Detail Specification

Number and wire size of specimens to be tested.

4.7.9.7 Precision Bias

This is a process control test.

4.7.10 Method 710, Durability of Wire Manufacturer's Color and/or Identification

4.7.10.1 Scope

This test shall be used to evaluate the durability of color/markings applied to the wire for coding. This test is not applicable for braided wire constructions.

4.7.10.2 Specimen

A 6 in (152 mm) finished wire specimen shall be used.

4.7.10.3 Test Requirement

4.7.10.3.1 The marking durability test fixture shall be designed to hold a 6 in (152 mm) specimen of finished wire firmly clamped in a horizontal position with the upper longitudinal surface of the specimen fully exposed. The durability apparatus, such as the GE Scrape Abrader Apparatus or equivalent, shall be capable of rubbing a small cylindrical sewing needle, 0.025 in ± 0.002 in (0.63 mm ± 0.05 mm) in diameter, repeatedly over the upper surface of the wire. The longitudinal axis of the needle and the specimen must be at right angles to each other. A weight affixed to a jig above the sewing needle shall control the weight normal to the surface of the insulation. A motor-driven, reciprocating cam mechanism and counter shall be used to deliver an accurate number of abrading strokes in a direction parallel to the axis of the specimen. The length of the stroke shall be 3/8 in (9.5 mm) and the frequency of the stroke shall be 120 strokes (60 stroking cycles) per minute.

4.7.10.3.2 After each test the sewing needle should be examined for wear and replaced if worn.

4.7.10.4 Test Procedure

NOTE: The 0.5 lb (0.227 kg) weight and the 250 strokes (125 cycles) stated in this procedure are default values if none are provided in the Detail Specification.

In performing the test, the specimen shall be mounted in the specimen clamp and a 0.5 lb (0.227 kg) weight shall be applied through the abrading sewing needle to the colored or marked surface. The counter shall be set at zero and the drive motor started. The specimen shall be subjected to 250 strokes (125 cycles) and shall then be examined. If a continuous line of solid color insulation coating or of the stripe, band, or printed marking, as applicable, has been removed or obliterated by the needle, the specimen shall be considered failed. Three specimens shall be tested from each specimen unit and failure of any specimen shall constitute failure of the specimens unit.

4.7.10.5 Results

Report any specimen that fails.

4.7.10.6 Information Required in the Detail Specification

Number and wire size of specimens to be tested.

4.7.10.7 Precision Bias

This is a process control test. The surface finish on the sewing needle may affect the results of this test.

4.7.11 Method 711, Durability and Legibility of Wire Installer's Identification

4.7.11.1 Scope

This test is used to determine the capability of finished insulated wire to be legibly and permanently marked by the installer. The test will also determine if the marking process can chemically or physically degrade the insulation. The Aerospace Vehicle Wiring Specification, AS50881, imposes the following requirements upon identification marking on wires: "the characters shall be legible and permanent and the method of identification shall not impair the characteristics of the wire."

4.7.11.2 Specimen

Specimens shall be long enough to be properly processed by the marking machines of choice. Allow, as a minimum, 3 ft (92 cm) of specimen per fluid in the immersion test (1 set). Four specimen sets are required.

4.7.11.3 Test Equipment

4.7.11.3.1 Wire Marking Machines designed for marking wire insulation

4.7.11.3.2 Test Fluids

4.7.11.3.3 Test-Fluid Heating Apparatus

4.7.11.3.4 Ultraviolet/Condensation Chamber

4.7.11.3.5 Heat Aging Oven

4.7.11.3.6 Abrasion Tester (General Electric #51204061, Wellman #31581238G1 or Equivalent)

4.7.11.3.7 Wet Dielectric Test Apparatus

4.7.11.4 Test Procedure

4.7.11.4.1 Wire Marking

Mark all specimens with repeated groupings of an alphanumeric character string using the marking system according to the governing process standard, or according to the equipment manufacturer's operating instructions if there is not a process standard. The print string must include a minimum of six different alphanumeric characters. Special marks such as bar codes may also be made. Gaps between groups of marks shall be no longer than 3 in (7.6 cm). Any necessary curing shall be performed as part of the marking process.

4.7.11.4.2 Visual Examination of Marking

A marked test specimen shall be wiped with a soft, lint-free cloth, placed flat on a work surface and visually examined from a distance of 15 in ± 2 in (38 cm ± 5 cm) without additional magnification (other than what is normally used for the aided eye). A light source shall be used which can provide an ambient nominal illumination of 30 ft candles. For initial examination only, a magnification of between 6 and 10 times shall be used to inspect for any mechanical damage to the insulation or conductor.

4.7.11.4.3 Abrasion Durability

All specimens shall be mounted in the specimen clamp of the scrape abrasion tester so that the abrading needle of the fixture (Figure 21) will make contact with the mark. A weight of 500 g, including the weight of the fixture shall be applied through the needle to the identification marking. The abrading needle shall be 0.025 in ± 0.002 in (0.064 cm ± 0.005 cm). The specimen shall be subjected to 125 cycles (250 strokes). Perform a visual examination in accordance with 4.7.11.4.2. The specimens shall then be divided into three groups or four groups if the weathering resistance test is specified. Each test specified in 4.7.11.4.4 through 4.7.11.4.7 requires one group of specimens.

4.7.11.4.4 Thermal Aging

Specimens shall be thermally aged for 166 h at rated temperature. Perform a visual examination test in accordance with 4.7.11.4.2 and, if required in the detail specification, a marking contrast examination in accordance with 4.7.11.4.8.

4.7.11.4.5 Fluid Immersion

One 3-ft (1 m) specimen of each type of mark shall be immersed in the first fluid. A second 3-ft specimen of each type of mark shall be immersed in the second fluid, and so on. Perform a visual examination in accordance with 4.7.11.4.2 and, if required in the detail specification, a marking contrast examination in accordance with AS4373 Method 1001 and an abrasion durability test in accordance with 4.7.11.4.3.

4.7.11.4.6 Weathering Resistance

When required by the detail specification, specimens shall be subjected to weathering resistance tests per ASTM G 53. Specimens shall be subjected to 14 cycles of exposure to ultraviolet light and condensation. Each cycle consists of 8 h of UV exposure at 63 °C followed by 4 h of condensation at 400 °C. Perform a visual examination in accordance with 4.7.11.4.2 and, if required in the detail specification, a marking contrast examination in accordance with AS4373 Method 1001.

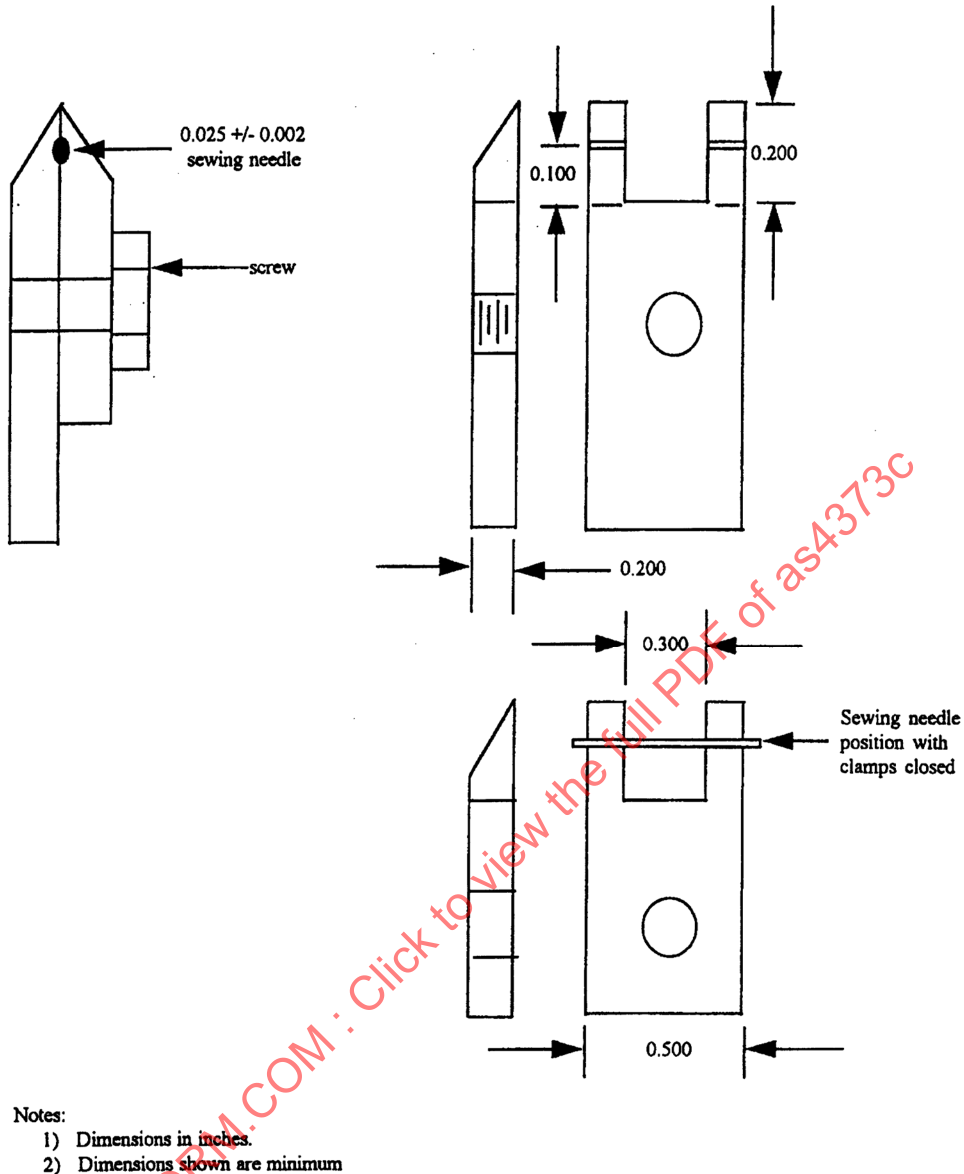


FIGURE 21 - CLAMP DEVICE FOR PRINT DURABILITY TEST

4.7.11.4.7 Wet Dielectric

Perform the wet dielectric test per ASTM D 3032 Section 5, except that a minimum voltage of 2.5 KV, 60 Hz, shall be applied for 1 min. Voltage shall be ramped up and down at a 500 V/s rate.

4.7.11.5 Results

Determine if the characters remain legible after the abrasion durability test. There shall be no continuous line of erasure or obliteration through the marking. Record results. Note if any visible degradation has occurred, if the mark is still readable, if the mark is totally obliterated, etc.; if the bar code is used, report whether the bar code remains machine readable. Note that on small gauge wire, even fresh alphanumeric characters may be difficult to read. Report the results of each specimen on the wet dielectric test (pass or fail).

4.7.11.6 Information Required in the Detail Specification

4.7.11.6.1 Wire type and size to be marked.

4.7.11.6.2 Marking process to be tested. If special marks such as bar codes are to be tested, this must also be specified.

4.7.11.6.3 Fluids to be used in immersion test. Fluid temperature and duration of immersion must also be specified for each fluid.

4.7.11.6.4 Weathering Resistance test is optional. Its inclusion must be specified in the detail specification.

4.7.11.6.5 Specify weight and number of cycles used for the abrasion durability test on tape construction wire and cable.

4.7.11.6.6 Test to be performed and sequence of testing, if different then as specified herein.

4.7.11.7 Precision Bias

This is a process control test, but may be used as a component performance test. The surface finish on the sewing needle may affect the results of this test. The number of cycles and weight used for the abrasion durability test should, where applicable, comply with the requirement for durability of wire manufacturer's identification for that insulation construction.

4.7.12 Method 712, Bend Test

4.7.12.1 Scope

This test provides a method to determine the sensitivity of the insulation to cracking.

4.7.12.2 Specimen

A 24 in (610 mm) wire specimen shall be used. (Longer lengths may have to be used on some of the large size specimens.)

4.7.12.3 Test Equipment

Mandrels and weights as specified in Table 17.

4.7.12.4 Test Procedure

In a 20 to 25 °C (68 to 77 °F) environment, one end of the specimen shall be secured to the mandrel and the other end to the load weight given above. The mandrel shall be rotated until the full length of the specimen is wrapped around the mandrel and is under tension with adjoining coils in contact. The mandrel shall then be rotated in reverse direction until the full length of the wire, which was outside during the first wrapping, is now next to the mandrel. This procedure shall be repeated until two bends in each direction have been formed in the same section of the wire. The outer surface of the wire shall then be observed for cracking of the insulation.

4.7.12.5 Results

Report the mandrel size and weight used and any observation on insulation cracking.

4.7.12.6 Information Required in the Detail Specification

None.

TABLE 17

Wire Size	Nominal Diameter of Mandrel	Load Weight lb +3%	Load Weight kg +3%
30	50X	0.50	0.227
28	50X	0.50	0.227
26	50X	0.50	0.227
24	50X	0.50	0.227
22	50X	1.00	0.454
20	50X	1.00	0.454
18	50X	1.00	0.454
16	50X	1.00	0.454
14	50X	3.00	1.36
12	40X	3.00	1.36
10	40X	3.00	1.36
8	30X	4.00	1.81
6	30X	4.00	1.81
4	30X	4.00	1.81
2	30X	6.00	2.72
1	30X	6.00	2.72
0	20X	6.00	2.72
00	20X	8.00	3.63
000	20X	8.00	3.63
0000	20X	12.00	5.44

4.7.12.7 Precision Bias

This is an established test.

4.8 Test Methods Group 800 - Thermal Tests

4.8.1 Method 801, Flammability

4.8.1.1 Scope

This test evaluates a finished wire specimen's burning characteristics.

4.8.1.2 Specimen

A 24 in (610 mm) finished wire specimen shall be used for this test.

4.8.1.3 Test Equipment

4.8.1.3.1 A Bunsen-type gas burner with a 1/4 in (6.35 mm) inlet, a needle valve in the base for gas adjustment, a bore of 3/8 in (9.53 mm) nominal, and a barrel length of approximately 4 in (10.16 cm) above the air inlets.

4.8.1.3.2 A thermocouple pyrometer.

4.8.1.3.3 CP methane or equivalent.

4.8.1.3.4 A specimen holder designed so that the lower end of a 24 in (60.96 cm) wire specimen is held by a clamp, while the upper end of the specimen passes over a pulley and can be suitably weighted to hold the specimen taut at an angle of 60 degrees with the horizontal, in a plane parallel to and approximately 6 in (15.24 cm) from the back of the chamber (see 4.8.1.3.5).

4.8.1.3.5 A test chamber approximately 1 ft (30.48 cm) square by 2 ft (60.96 cm) in height, open at the top and front to provide adequate ventilation for combustion but to prevent drafts.

4.8.1.3.6 Facial tissue conforming to A-A-1 505 or equivalent.

4.8.1.4 Test Procedure

The specimen shall be marked at a distance of 8 in (20.32 cm) from its lower end to indicate the point for flame application and shall be placed in the specified 60 degree position in the test chamber. The lower end of the specimen shall be clamped in position in the specimen holder and the upper end shall be passed over the pulley of the holder and weighted with the weight sufficient to keep the wire taut. If specified in the detailed specification, a sheet of the facial tissue shall be suspended taut and horizontal 9.50 in below the point of application of the flame to the wire specimen, so that any material dripping from the wire specimen shall fall upon the tissue. The flame shall be 3 in with a 1 in inner cone. The flame temperature shall be at least 954 °C at its hottest point. With the burner held perpendicular to the specimen and at an angle of 30 degrees from the vertical plane of the specimen, the hottest portion of the flame shall be applied to the lower side of the wire at the test mark. The period of test flame application shall be 30 s for all sizes of wire and the test flame shall be withdrawn immediately at the end of that period.

4.8.1.5 Results

Report the distance of flame travel, the time of burning after removal from the test flame and the presence of any incendiary drips from the wire during testing. Breaking of the wire specimen for size 24 and smaller shall not be considered as failure provided the requirements for flame travel limits, duration of flame, and absence of incendiary dripping are met.

4.8.1.6 Information Required in the Detail Specification

Number and wire size of specimens to be tested.

4.8.1.7 Precision Bias

This is an established test.

4.8.2 Method 802, High Pressure/High Temperature Air Impingement (Burst Duct)

4.8.2.1 Scope

This test is to be used to evaluate the effects of a burst hot air duct on the insulation of a finished wire specimen.

4.8.2.2 Specimen

A seven-wire harness shall be used in this test.

4.8.2.3 Test Equipment

4.8.2.3.1 A cylindrical tube of 1 in (25 mm) inner diameter, capable of carrying 315 °C ± 3 °C (600 °F ± 5 °F) air at 70 to 80 psi shall be used. A 0.015 in ± 0.0015 in (0.38 mm ± 0.038 mm) wide slit should be cut along the length of the tube for 1.00 in ± 0.010 in (25 mm ± 0.25 mm) to enable the air to impinge upon a wire harness.

4.8.2.3.2 A SAE AS3320 - 7.5 A circuit breaker.

4.8.2.3.3 A power supply.

4.8.2.4 Test Procedure

The seven-wire harness shall be constructed as shown in Figure 22. The wire harness shall be firmly mounted above and perpendicular to the slot in the tube with a distance of 1.0 in ± 0.125 in (25 mm ± 3.2 mm) between them. Apply power to the harness and then initiate air flow through the tube. Air temperatures shall be maintained at 315 °C ± 3 °C (600 °F ± 5 °F) and air pressure shall be maintained at 70 to 80 psi. After 2 h, remove power, interrupt air flow, and determine if any of the following conditions exist or existed during the test.

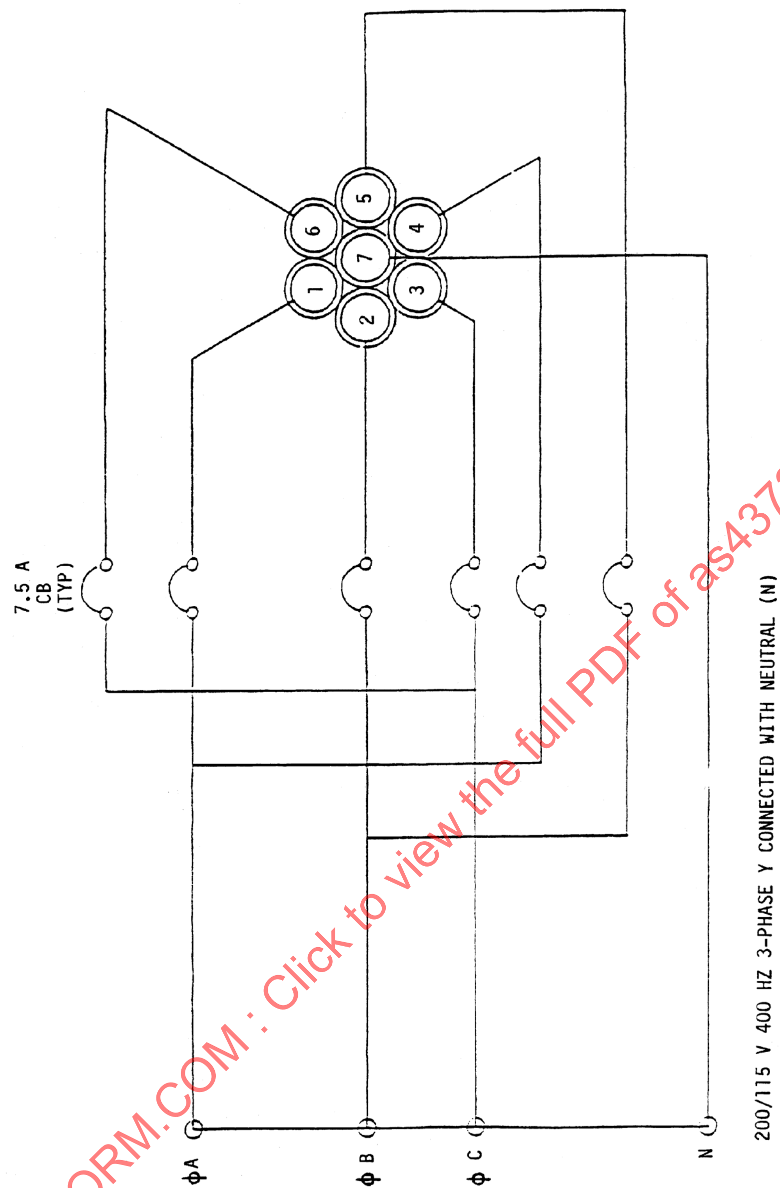


FIGURE 22 - ELECTRICAL CONNECTIONS FOR TEST METHOD 802

a. Circuit breaker open (interrupted)

b. Bare conductor visible

c. Conductor broken

d. Continuous flaming for more than 3 s

Existence of one or more of these conditions constitutes failure of the test and shall be recorded.

4.8.2.5 Results

Report any of the aforementioned conditions in 4.8.2.4.

4.8.2.6 Information Required in the Detail Specification

Number and wire size of specimens to be tested.

4.8.2.7 Precision Bias

4.8.2.7.1 Due to differences in vehicle performance, changes in pressure and temperatures for different vehicles should be considered for this test, and the test adjusted to reflect these conditions.

4.8.2.7.2 This method has not had the benefit of any round-robin testing to determine precision.

4.8.3 Method 803, Smoke Quantity

4.8.3.1 Scope

This method provides a test for determining the smoke generated from an insulated wire when exposed to radiant heat and to flame for 20 min.

4.8.3.2 Specimen

See Section 7.3.2.5 of ASTM F 814.

4.8.3.3 Test Equipment

See Section 6 of ASTM F 814.

4.8.3.4 Test Procedure

See Section 10 of ASTM F 814.

4.8.3.5 Results

See Section 12 of ASTM F 814.

4.8.3.6 Information Required in the Detail Specification

Number and wire size of specimens to be tested.

4.8.3.7 Precision Bias

See Section 13 of ASTM F 814 and the X3 Commentary (pages 890-894) of ASTM F 814.

4.8.4 Method 804, Relative Thermal Life and Temperature Index

4.8.4.1 Scope

This method provides a means for developing time versus temperature curves and temperature indices for flexible electrical insulating material systems used as primary insulation or jackets on wire. The procedure of AS4851 shall be used in conjunction with ASTM D 3032 as described in AS4851 and below.

NOTE: This test requires at least 10 months to complete.

4.8.4.2 Specimen

The specimens shall be 16 in (406 mm) in length for this test. (See Section 14.6 of ASTM D 3032.)

4.8.4.3 Test Equipment

See Section 14.4 of ASTM D 3032 for the equipment necessary to perform this test.

4.8.4.4 Test Procedure

See Section 14.7 of ASTM D 3032 for the procedures necessary to perform this test.

4.8.4.5 Results

The results shall be reported in accordance with Section 14.10 of ASTM D 3032.

4.8.4.6 Information Required in the Detail Specification

Number and wire size of specimens to be tested as given in Section 14.5 of ASTM D 3032.

4.8.4.7 Precision Bias

The Precision Bias shall be as stated in Section 14.11 of ASTM D 3032.

4.8.5 Method 805, Thermal Shock Resistance

4.8.5.1 Scope

This test is to be used to evaluate short-term shrinkage or expansion of the finished wire insulation after thermal shock.

4.8.5.2 Specimen

A 5 ft (1.52 m) length of finished wire shall be used for this test, with a minimum coil diameter of 1 ft (0.305 m). See Section 21.4 of ASTM D 3032.

4.8.5.3 Test Equipment

See Section 21.3 of ASTM D 3032 for the equipment necessary to perform this test.

4.8.5.4 Test Procedures

This test shall be performed in accordance with Section 21.5 of ASTM D 3032 except that the oven temperature shall be the rated temperature of the insulated wire specimen and the low temperature shall be -55 °C ± 3 °C (-67 °F ± 5 °F). Also, the exposure time at each temperature shall be 30 min.

4.8.5.5 Results

See Section 21.6 of ASTM D 3032 for the data to be reported. Also, the specimens shall have no flaring of the insulation layers.

4.8.5.6 Information Required in the Detail Specification

Number and wire size of specimens to be tested and temperature rating of the insulated wire.

4.8.5.7 Precision Bias

See Section 21.7 of ASTM D 3032. Also see the recommended values in Table 18.

TABLE 18 - MAXIMUM RECOMMENDED VALUES

Wire Size	Inches	mm
30 - 12	0.0625	1.6
10 - 8	0.1	2.5
6 - 0000	0.125	3.2

4.8.6 Method 806, Property Retention After Thermal Aging

4.8.6.1 Scope

This test evaluates the mechanical properties of the same specimens of insulated, finished wire before and after 1000 h of thermal aging.

4.8.6.2 Specimen

A wire specimen of sufficient length to conduct the tests listed below shall be arranged in a 12 in (305 mm) coil.

4.8.6.3 Test Equipment

4.8.6.3.1 An air oven capable of maintaining the specified temperatures and tolerances.

4.8.6.3.2 See the Test Methods listed below for the necessary equipment required to perform this test.

4.8.6.4 Aged Test Procedure

The coiled wire specimen shall be placed on a flat surface in a temperature chamber and conditioned at the rated temperature for 1000 h. The specimen shall then be removed from the chamber, placed on a flat surface, and allowed to cool to ambient temperature. Once cooled, the coil shall be cut to appropriate lengths to conduct the tests listed in Table 19. Use separate specimens for each test.

TABLE 19

Test	Method	Length Required
Dynamic cut-thru	703	18 ft (5.49 m)
Flex life	704	18 in (45.7 cm)
Notch propagation	706	6.0 ft (1.83 m)

4.8.6.5 Results

Report the unaged and aged data required in the Test Methods listed above.

4.8.6.6 Information Required in the Detail Specification

Number and wire size of specimens to be tested, temperature rating of the insulated wire and specific cutting edge to be used in Test Method 703.

4.8.6.7 Precision Bias

This is a new method that has not had the benefit of any round-robin testing to determine precision.