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AEROSPACE STANDARD

SAE AS4373

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Submitted for recognition as an American National Standard

TEST METHODS FOR INSULATED ELECTRIC WIRE

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 a 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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SAE reviews each technical report at least every five years at which time it may be reaffirmed, revised, or cancelled. SAE invites your written comments and suggestions.

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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:

Group:

- | | |
|-----|--|
| 100 | Assembly, Handling, and Repair Tests |
| 200 | Chemical, Biological, Radiological (CBR) Tests |
| 300 | Combat Damage Tests |
| 400 | Conductor Tests |
| 500 | Electrical Tests |
| 600 | Environmental Tests |
| 700 | Mechanical Tests |
| 800 | Thermal Tests |
| 900 | Weight and Dimensional Tests |

When a test method revision incorporates a technical change, a decimal number shall be added or consecutively increased, such as 101.1 for the first revision of method 101. Alternately, a test method that incorporates a technical change may be assigned an entirely new test method number.

2. APPLICABLE DOCUMENTS:

The following documents of the issue listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) specified in the solicitation form a part of this standard to the extent specified herein.

2.1 Federal Specifications:

- | | |
|----------|---|
| TT-I-735 | Isopropyl Alcohol |
| TT-M-268 | Methyl Isobutyl Ketone (For Use in Organic Coating) |
| TT-S-735 | Standard Test Fluids, Hydrocarbon |
| UU-T-450 | Tissue |

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2.2 Military Specifications:

MIL-A-8243	Anti-Icing and Deicing-Defrosting Fluid
MIL-C-5809	Circuit Breaker
MIL-C-87936	Cleaning Compounds, Aircraft Exterior Surfaces, Water Dilutable
MIL-C-43616	Cleaning Compound, Aircraft Surface
MIL-G-3056	Gasoline, Automotive, Combat
MIL-G-5572	Gasoline, Aviation, Grades 80/87, 100/130, 115/145
MIL-H-5606	Hydraulic Fluid, Petroleum Base, Aircraft, Missile and Ordnance
MIL-H-33282	Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Aircraft, Metric, NATO Code Number H-537
MIL-L-6082	Lubricating Oil, Aircraft Reciprocating Engine (Piston)
MIL-L-7808	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, NATO Code Number O-148
MIL-L-23699	Lubricating Oil, Aircraft Turbine Engines, Synthetic Base
MIL-P-26536	Propellant, Hydrazine
MIL-P-26539	Propellant, Nitrogen Tetroxide
MIL-P-27402	Propellant, Hydrazine-Uns-Dimethylhydrazine (50 percent N ₂ H ₄ -50 percent UDMH)
MIL-T-5624	Turbine Fuel, Aviation Grades JP-4 and JP-5
MIL-T-43435	Tape, Lacing and Tying
MIL-T-81533	Trichloroethane, 1,1,1, (Methyl Chloroform) Inhibited, Vapor Degreasing
MIL-W-5088	Wiring, Aerospace, Vehicle
MIL-W-22759/32-35,41-46	Wire, Electrical, Fluoropolymer Insulated Copper or Copper Alloy
MS3320	Circuit Breaker-Aircraft, Trip-free, Push Pull, 1 Thru 20 Amps, Type 1, -55 to +121 Degrees C

2.3 Federal Standards:

FED-STD-228 Cable and Wire, Insulated, Methods of Testing

2.4 Military Standards:

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

The following documents form a part of this standard to the extent specified herein. The issues of the documents which are Department of Defense (DoD) adopted shall be those listed in the issue of the DODISS specified in the solicitation. The issue of the documents that have not been adopted shall be those in effect on the date of the cited DODISS.

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2.4 American Society for Testing and Materials:

ASTM D 256	Impact Resistance of Plastics and Electrical Insulation Materials
ASTM D 1868	Detection and Measurement of Partial Discharge (Corona) Pulses in Evaluation of Insulation Systems
ASTM D 3032	Hookup Wire Insulation
ASTM F 814	Specific Optical Density of Smoke Generated by Solid Materials for Aerospace Applications
ASTM G 53	Operating Light- and Water-Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of Non-metallic Materials
ASTM D 412	-----

2.5 Society of Automotive Engineers:

SAE AS1241	Hydraulic Fluid
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3. INDEX OF SECTIONS AND TEST METHODS:

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

Method No.	Title
100	Concentricity and Wall Thickness
102	Insulation Bonding to Potting Compounds (TBD) ¹
103	Insulation Pull-off Force (TBD)
104	Insulation Removability (TBD)
105	Insulation Shrinkage/Expansion
106	Solderability
107	Thermal/Mechanical Resistance - Single Wire
108	Thermal/Mechanical Resistance - Bundle
109	Solder Pot Test for Insulation Shrinkage

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

Method No.	Title
TBD ¹	

3.3 Test Methods Group 300 - Combat Damage Tests

Method No.	Title
301	Dry Arc Resistance and Fault Propagation

¹TBD = To be determined.

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3.4 Test Methods Group 400 - Conductor Tests:

Method No.	Title
401	Conductor Diameter
402	Soft/Annealed Copper Elongation and Tensile Breaking Strength
403	High Strength Copper Alloy Elongation and Tensile Breaking Strength
404	Conductor Resistance
405	Conductor Strand Blocking

3.5 Test Methods Group 500 - Electrical Tests:

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	Voltage Rating (TBD)
509	Wet Arc Tracking
510	Voltage Withstand (Wet Dielectric)
511	Wire Fusing Time

3.6 Test Methods Group 600 - Environmental Tests

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

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3.7 Test Methods Group 700 - Mechanical Tests:

Method No.	Title
701	Abrasion (TBD)
702	Cold Bend
703	Dynamic Cut Through
704	Flex Life (TBD)
705	Insulation Impact Resistance (TBD)
706	Insulation Tensile Strength and Elongation
707	Notch Propagation
708	Stiffness and Springback
709	Vibration (TBD)
710	Mandrel and Wrap Back Test
711	Wrinkle Test
712	Durability of Color/Identification
713	Wire Surface Markability (TBD)
714	Bend Test

3.8 Test Method Group 800 - Thermal Tests:

Method No.	Title
801	Flammability
802	High Pressure/High Temperature Air Impingement (Burst Duct)
803	Smoke Quantity
804	Thermal Index
805	Thermal Shock Resistance
806	Toxicity (TBD)
807	Property Retention After Thermal Aging
808	Multiday Heat Aging Test
809	Blocking
810	Lamination Sealing
811	Topcoat Cure
812	Crosslink Proof Test
813	Flame Resistance

3.9 Test Methods Group 900 - Wire Diameter and Weight:

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

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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 sample.

4.1.1.2 Samples: Unless otherwise specified by the detail specifications, a wire sample of not less than 6 in (152.4 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 0.013 mm or 0.0005 in 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 ASTM D 3032.

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

1. Size 30 through 10
% Concentricity = $\frac{\text{Minimum wall thickness} \times 100}{\text{Maximum wall thickness}}$
2. Size 8 through 0000
% Concentricity = $\frac{\text{Minimum wall thickness} \times 100}{\text{Average wall thickness of 4 measurements taken } 90^\circ \text{ apart}}$

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 of samples, wire size of samples, number of measurements.

4.1.1.7 Precision Bias: A minimum concentricity of 70% is usually desirable.

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4.1.2 Method 102, Insulation Bonding to Potting Compounds: TO BE DETERMINED²

4.1.3 Method 103, Insulation Pull-Off Force: TO BE DETERMINED³

4.1.4 Method 104, Insulation Removability: TO BE DETERMINED⁴

4.1.5 Method 105, Insulation Shrinkage/Expansion:

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

4.1.5.2 Samples: The sample shall be a 13 in (330 mm) length of wire cut flush on both ends.

4.1.5.3 Test Equipment:

4.1.5.3.1 A razor blade or equivalent device to remove a insulation slug from conductor.

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

4.1.5.3.3 A circulating air oven with temperature capability up to 300°C (572°F).

4.1.5.4 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 (86°F ± 5) 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. The longitudinal shrinkage or expansion of the insulation shall then be calculated as the greatest distance any layer of insulation has moved on either end.

4.1.5.5 Results: Report oven temperature and maximum shrinkage or expansion of insulation in inches or mm.

4.1.5.6 Information Required in Detail Specification: Number of samples, wire size of samples, and rated temperature of samples.

²There is no standard test for this requirement. A test method has been requested from another subcommittee of AE-8.

³A new test method - Strip Force Test - has recently been released as Section 27 of ASTM D 3032. The Task Group will use this as a basis for Method 103 in the next revision of this standard.

⁴There is no standard test for this requirement to determine the limits on splaying of conductor strands. A new test method is being drafted for a future revision of this standard.

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4.1.5.7 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.

4.1.6 Method 106, Solderability:

4.1.6.1 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 have not been validated to this or other test methods.

4.1.6.2 Samples: Unless otherwise specified by the detail specification, a wire sample of not less than 10 in (254 mm) shall be used.

4.1.6.3 Test Equipment: See Sections 2 and 3 of Method 208, MIL-STD-202.

4.1.6.4 Test Procedure: See Section 4 of Method 208, MIL-STD-202. One of the three test conditions listed below shall be used.

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

4.1.6.5 Results: Report the actual and average result of the solderability test and the condition used.

4.1.6.6 Information Required in Detail Specification: Number of samples to be tested, wire size of sample, test condition required.

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 - Single Wire:

4.1.7.1 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.

4.1.7.2 Samples: Unless otherwise specified by the detail specification, a wire sample of not less than 12 in (305 mm) shall be tested.

4.1.7.3 Test Equipment:

4.1.7.3.1 Ungar Electronic Soldering System 9000 or equivalent with screwdriver tip #9016 (tip measures approximately 0.105 in (2.67 mm) width by 0.05 in (1.27 mm) thick or equivalent).

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4.1.7.3.2 IC Thermo Electric MiniMite Temperature Indicator or equivalent.

4.1.7.3.3 Fairbanks Morse Company Scale [75 lbs (34.1 kg)] or equivalent.

4.1.7.3.4 Moment external limit switch.

4.1.7.3.5 60 min standard timer.

4.1.7.3.6 Continuity detector box.

4.1.7.3.7 Test fixture.

4.1.7.4 Test Procedure:

4.1.7.4.1 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.

4.1.7.4.1.1 Built 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 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 sample in place during test. The limit switch used to start the timer could 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 and the second location is beneath the PTFE sheet so that the force associated with the soldering iron resting on the wire activates the switch.

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

4.1.7.4.1.3 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).

4.1.7.4.2 Test Procedure:

4.1.7.4.2.1 Place wire specimen in groove of 1 in (25.4 mm) on PTFE sheet and secure wire using tape.

4.1.7.4.2.2 Connect iron-constantan thermocouple to solder iron tip. Connect to IC MiniMite or equivalent to measure the exact temperature of the solder iron tip. Adjust solder iron to obtain required temperature.

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

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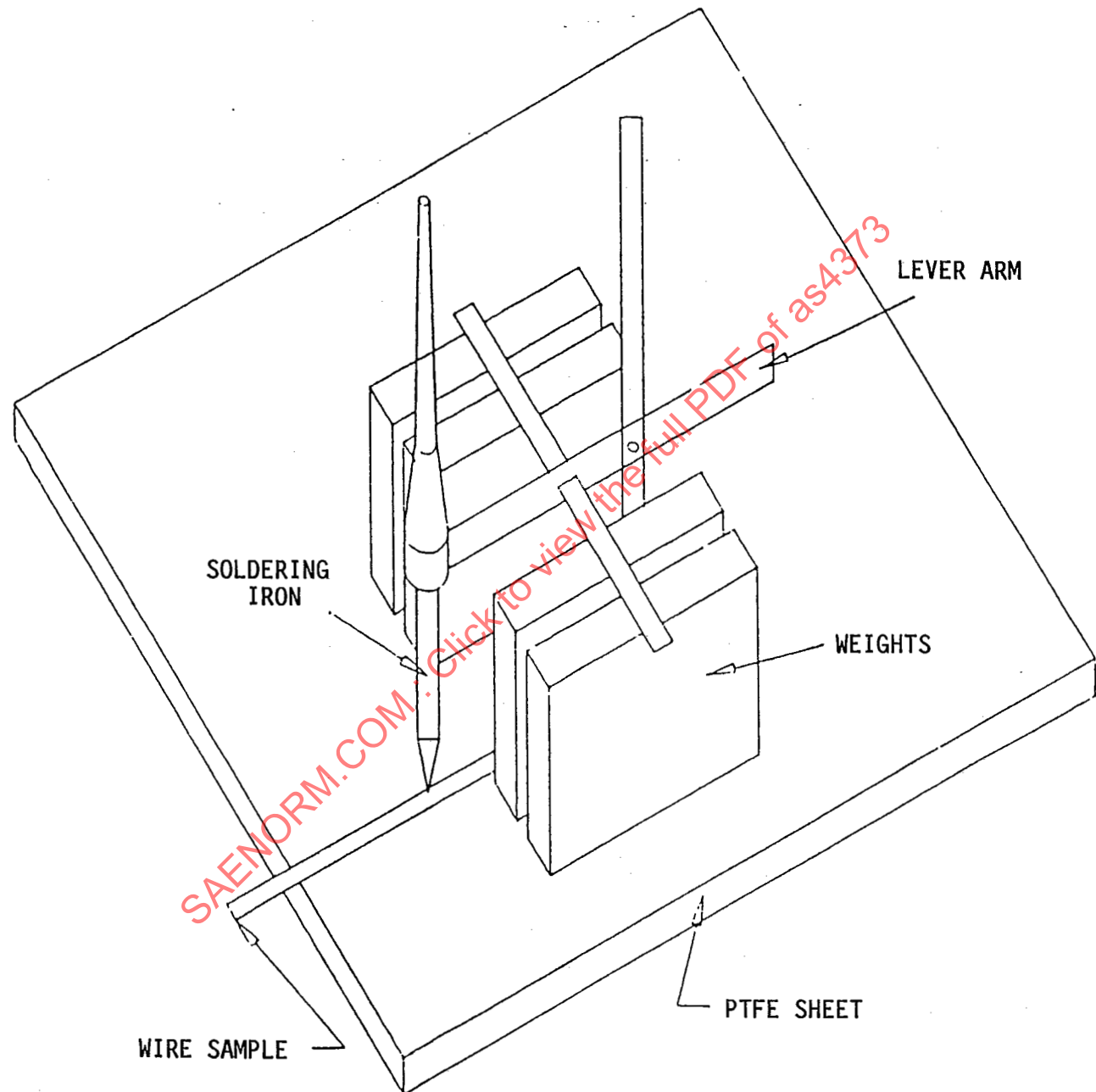


FIGURE 1 - Thermal/Mechanical Resistance Test Setup

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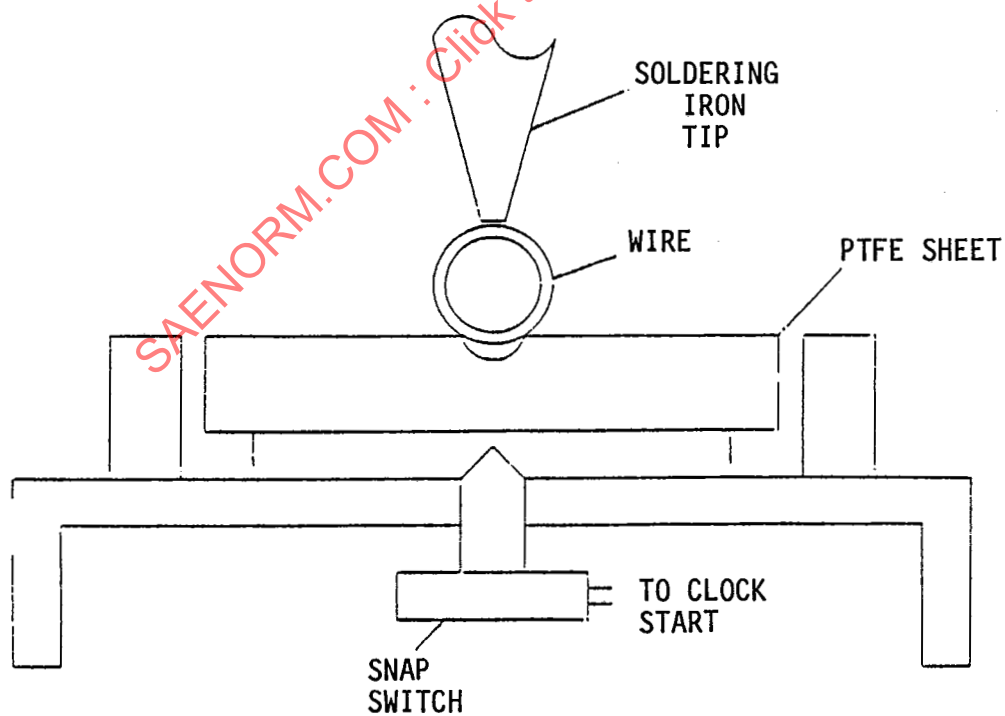
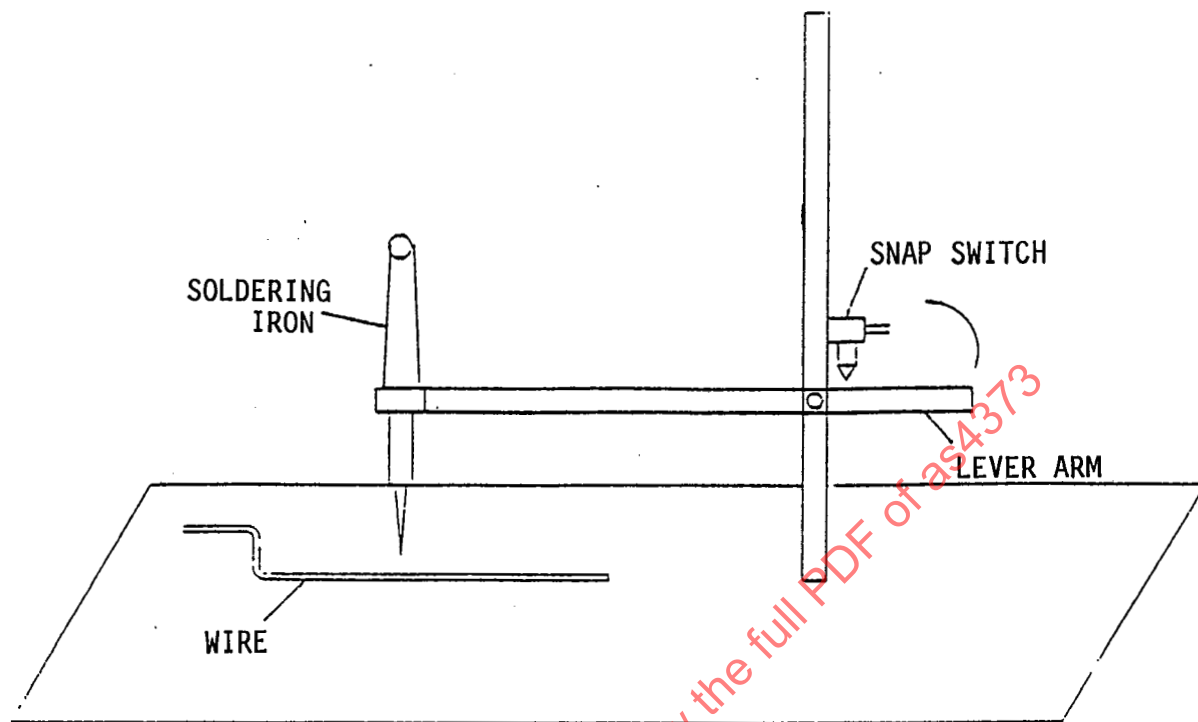


FIGURE 2 - Two Suggested Placements for Snap Switch to Start Timer

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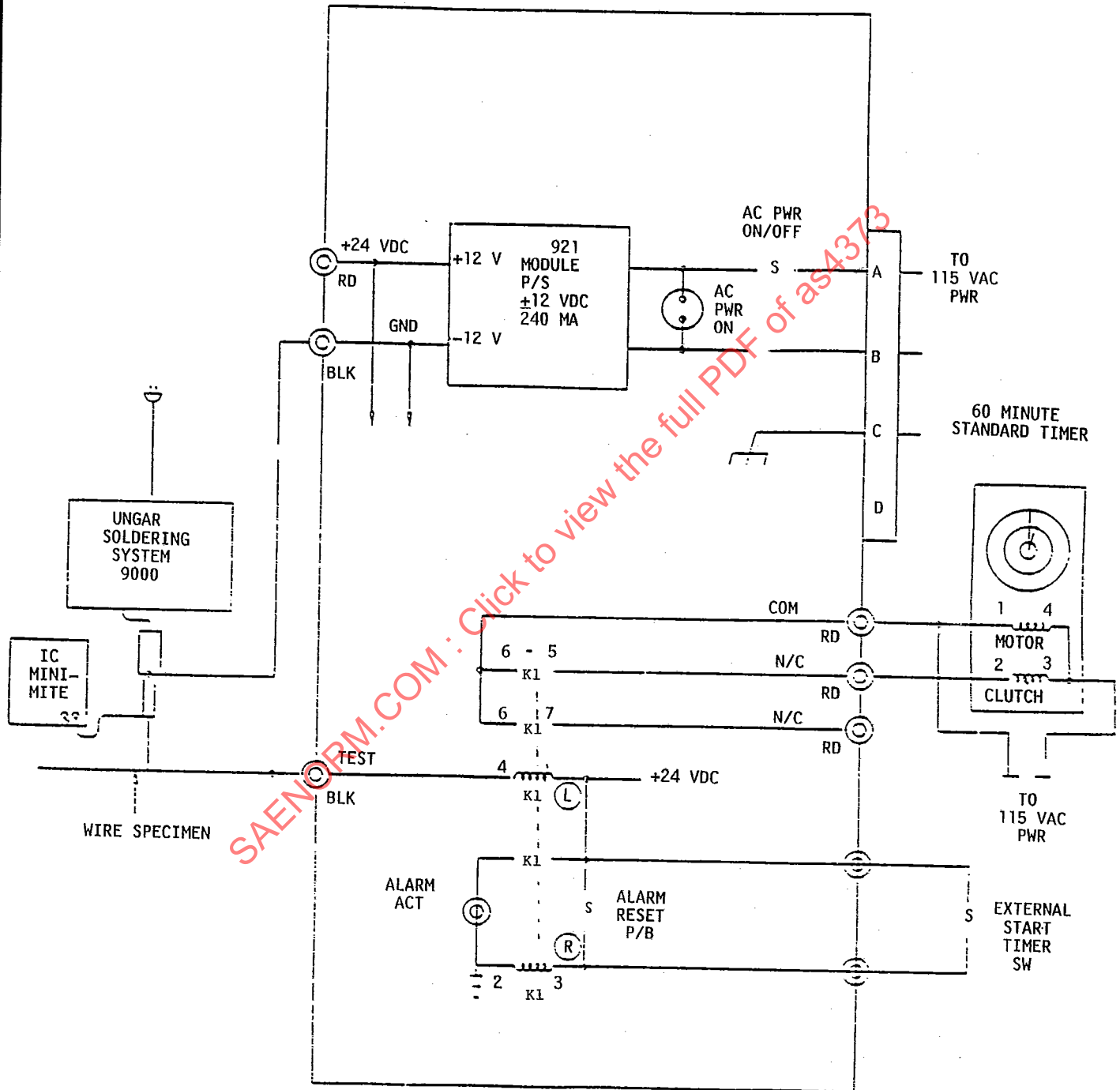


FIGURE 3 - Continuity Detection Circuit for Solder Iron Resistance Test

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- 4.1.7.4.2.4 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 different times on each wire specimen, 0.5 in (12.7 mm) apart from each other. If penetration does not occur within 1 min, stop the test. Continue with next sample.
- 4.1.7.4.2.5 Clean solder iron tip by lightly buffing with emery paper to remove residues after each test.
- 4.1.7.4.2.6 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.
- 4.1.7.5 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.
- 4.1.7.6 Information Required in Detail Specification: Number of samples and wire size of samples.
- 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, Thermal/Mechanical Resistance - Bundle:
- 4.1.8.1 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.
- 4.1.8.2 Samples: 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.
- 4.1.8.3 Test Equipment: The test equipment used, including monitoring/timing circuitry and excluding the test fixture, shall be as described in Method 107 of this document.
- 4.1.8.4 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 107 for a continuity detection circuit. Limit switch location similar to the second location of the limit switch shown in Figure 2 of Method 107 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 at three locations for each temperature, making sure that each point of contact is at least 0.5 in (13 mm) from any previous point of contact. It is not necessary to test at lower temperatures if no penetration occurs at 398°C (750°F).

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- 4.1.8.5 Results: Report the time to penetration at all test temperatures.
- 4.1.8.6 Information Required in Detail Specification: Number and wire size of samples to be tested.
- 4.1.8.7 Precision Bias: This is a new method that has not had the benefit of any round-robin testing to determine precision.
- 4.1.9 Method 109, Solder Pot Test for Insulation Shrinkage:
- 4.1.9.1 Scope: This test is to be used to assess the insulation shrinkage of a wire after exposure to hot solder.
- 4.1.9.2 Samples: The sample shall be a length of insulation not less than 6 in (152 mm).
- 4.1.9.3 Test Equipment: The equipment shall be as specified in Section 3.1 of FED. TEST METHOD STD. NO. 228, Method 8231.
- 4.1.9.4 Test Procedure: The test procedure shall be as specified in Section 4.1 of FED. TEST METHOD STD. NO. 228, Method 8231. The shrinkage shall be measured as the greatest distance any layer of insulation has moved.
- 4.1.9.5 Results: Record the amount of shrinkage to the nearest 1/32 in for each sample tested.
- 4.1.9.6 Information Required in Detail Specification: Number and wire size of samples to be tested.
- 4.1.9.7 Precision Bias: The results of this test should be expressed in 1/32 in increments.
- 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 as stated in Army Regulation 70-71. Note that the Air Force has established an extensive data base on the chemical compatibility of materials for use in aerospace vehicles. While this data base as a whole is classified information, it has been made available to prime aerospace contractors. Current contact for this data base is at WRDC-MLSA, Wright Patterson AFB, Ohio, phone 513-255-5117. 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, phone 301-671-3410.

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, but 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; nor is it recommended that handling of items after exposure be done outside of these qualified labs due to personnel safety considerations.

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4.3 Test Methods Group 300 - Combat Damage Tests:

4.3.1 Method 301, Dry Arc Resistance and Fault Propagation:

4.3.1.1 Scope: This test is to be used to measure the resistance to arcing and propagation of faults in a bundle. This test also examines the damage to adjacent wires in a bundle which are not directly involved in the arc.

4.3.2 Samples:

4.3.2.1 Wire Specimens: Each bundle shall be comprised of insulated wire specimens in the quantities and lengths listed below.

Wire Size	Number of Segments	Length of Segments (± 1 in) (± 2.54 cm)
26 twst pr	2	48 (122)
26	2	48 (122)
26	1	100 (254)
22 twst pr	2	48 (122)
22	3	48 (122)
22	1	100 (254)
20	2	48 (122)
20	1	100 (254)
16	3	48 (122)

Size 24 may be used if 26 is not available.

4.3.2.2 Bundle Fabrication: Each of the fourteen 48-in (122 cm) segments shall have one end terminated with a #10 ring tongue terminal and the other end stripped of 1/4 in (6.3 mm) of insulation. The wire specimens shall then be grouped in a bundle with a cross section that approximates the one shown in Figure 4. The three 100-in (254 cm) segments are common integrity circuits. Both ends of each segment shall float and shall be at the same end of the bundle as the ring tongue terminations. At the opposite end the common integrity wires shall be bent from the bundle exit position to the entry position with a loop not extending more than 2 in from the stripped ends of the other wires in the bundle. The bundle shall then be string tied at 2 in (50.8 mm) intervals for a total of 36 in (91.4 cm). The string the closest to the stripped wire ends shall be approximately 1/2 in (12.7 mm) from the insulation end. See Figure 4 for illustration.

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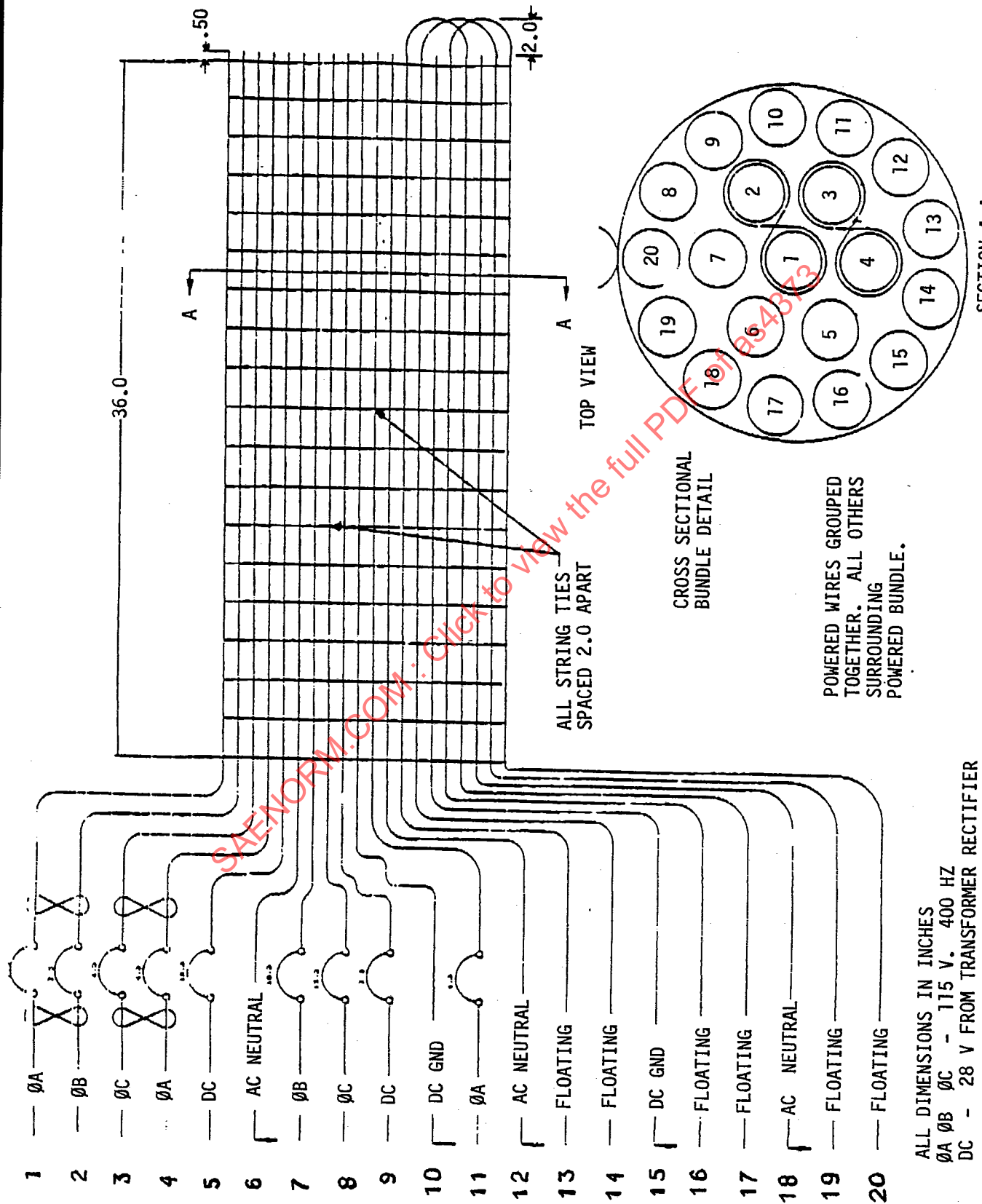


FIGURE 4 - Arc Resistance and Fault Propagation Test Setup

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4.3.2.3 Equipment:

- 4.3.2.3.1 Circuit Breaker Panel or Box: A panel or box that provides termination points for the ring tongue terminals on the test bundle, circuit breaker protection for powered circuits, and input terminals for the power source leads is required. The circuit breakers shall be as follows:

Wire Size	Circuit Breaker
26	MS3320-4
24 (if used)	MS3320-5
22	MS3320-7.5
20	MS3320-10
16	MS3320-15

- 4.3.2.3.2 Generator: An aircraft generator rated at 40 kVA minimum shall be used to supply three-phase, 115 V, 400 Hz power.

- 4.3.2.3.3 Transformer Rectifier: A representative aircraft transformer rectifier rated at 75 amps minimum shall be used to supply 28 VDC.

- 4.3.2.3.4 Video Camera: A video camera shall be used to document the test and provide a record to time the duration of arcing and/or flaming.

- 4.3.2.4 Test Procedure: A single 32 AWG or smaller strand shall be wrapped and tied around the bundle periphery at the stripped end to compress the conductors together and establish contact. Horizontally mount the harness as shown in Figure 4 and attach the ring tongue terminals to the circuit breaker box. Use size 12 wire with a maximum length of 15 ft (457 cm) to apply the signals below and on Figure 4.

Location	Power
1	A
2	B
3	C
4	A
5	DC
6	AC Neutral
7	B
8	C
9	C
10	DC GND
11	A
12	AC Neutral
13/17	Common Integrity
14/19	Common Integrity
15	DC GND
16/20	Common Integrity
18	AC Neutral

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4.3.2.4 (Continued):

Start the video tape shortly before applying power simultaneously to the 14 circuits that are to be powered. Note and record the number and type of circuit breakers interrupted, any physical evidence of carbonized insulation, and the length of the insulation consumed during the arc. The three common integrity circuits shall then be removed from the bundle and checked with the Voltage Withstand (wet dielectric) Test Method 510. Immerse all but 6 in (15.0 cm) of each end of the specimens and apply power to the two conductor ends tied together.

4.3.2.5 Results: Report the circuit breakers that were interrupted, the approximate arc and/or flame duration as determined from the video tape, and the wet dielectric test results for each of the three common integrity circuits.

4.3.2.6 Information Required in Detail Specification: Number of bundles to be tested and whether size 26 or 24 is to be used in the bundle.

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

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 determint the diameter of stranded conductors.

4.4.1.2 Samples: Unless otherwise specified in the detail specification, an insulated wire of not less than 24 in (610 mm) shall be tested.

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).

4.4.1.3.2 Measuring Tape: Lufkin Tape Rule #W606PD or equivalent.

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 along the length of the sample. Each measurement shall consist of two micrometer readings taken 90° from each other. For size 8 and larger, a circumferential measuring tape calibrated for diameter may be used (such as Lufkin Tape Rule #W606 PD or equivalent).

4.4.1.5 Results: Report measured conductor diameters and the average diameter for each sample tested:

4.4.1.6 Information Required in Detail Specification: Number of samples, conductor size of samples, and number of measurement locations.

4.4.1.7 Precision Bias:

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4.4.2 Method 402, Soft/Annealed Copper 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 or annealed copper strand or conductors.

4.4.2.2 Samples: The test sample shall be as described in Section 2.1 of FED. TEST METHOD STD. NO. 228, METHOD 3211.

4.4.2.3 Test Equipment: The test equipment shall be as described in Section 3.1 of FED. TEST METHOD STD. NO. 228, METHOD 3211. In addition, a chart recorder shall be used in conjunction with the testing machine to record the travel distance of the power-actuated grip.

4.4.2.4 Test Procedure: The test shall be conducted as described in Sections 4.1-5 of FED. TEST METHOD STD. NO. 228, Method 3211, except that the elongation shall be determined by means of a recording chart that measures the travel of the power-actuated grip rather than by measuring the specimen after the break. For wire sizes 20 and larger, the tests shall be performed on individual strands taken from the conductor of the finished wire. For sizes 22 and smaller, the tests shall be performed on the whole conductor removed from the finished wire and the elongation shall be measured when the first strand of the conductor breaks as indicated on the recording chart. Instead of tensile strength, the tensile breaking strength shall be measured as the total tensile force indicated by the testing machine at break of the first strand.

4.4.2.5 Results: Report the tensile breaking strength and elongation for each sample of strand or conductor.

4.4.2.6 Information Required in Detail Specification: The conductor size and number of samples to be tested.

4.4.2.7 Precision Bias:

4.4.3 Method 403, High Strength Copper Alloy Elongation and Tensile Breaking Strength:

4.4.3.1 Scope: This test is to be used to determine the tensile breaking strength and elongation of high strength copper alloy conductors.

4.4.3.2 Samples: The test sample shall be as described in Section 2.1 of FED. TEST METHOD STD. NO. 228, METHOD 3211, except that test samples shall be the whole conductor for all sizes.

4.4.3.3 Test Equipment: The test equipment shall be as described in Section 3.1 of FED. TEST METHOD STD. NO. 228, METHOD 3211. In addition, a chart recorder shall be used in conjunction with the testing machine to record the travel distance of the power-actuated grip.

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- 4.4.3.4 Test Procedure: The test shall be conducted as described in Sections 4.1-5 of FED. TEST METHOD STD. NO. 228, METHOD 3211, except that the elongation shall be determined by means of a recording chart that measures the travel of the power actuated grip rather than by measuring the specimen after the break. In addition, the rate of travel of the power-actuated grip shall be $2.0 \text{ in} \pm 0.5$ ($51 \text{ mm} \pm 13$)/min. Instead of tensile strength, the tensile breaking strength shall be measured as the total tensile force indicated by the testing machine at break of the first strand.
- 4.4.3.5 Results: Report the tensile breaking strength and elongation for each sample of each size tested.
- 4.4.3.6 Information Required in Detail Specification: The conductor size and number of samples to be tested.
- 4.4.3.7 Precision Bias:
- 4.4.4 Method 404, Conductor Resistance:
- 4.4.4.1 Scope: This test is to be used to measure or calculate the DC resistance of a conductor at 20°C (68°F). Correction values are given to allow for resistance measurements taken at other than 20°C (68°F).
- 4.4.4.2 Samples: See Section 2 of Method 6021, FED. TEST METHOD STD. NO. 228.
- 4.4.4.3 Test Equipment: See Section 3 of Method 6021, FED. TEST METHOD STD. NO. 228.
- 4.4.4.4 Test Procedure: See Section 4 of Method 6021, FED. TEST METHOD STD. NO. 228.
- 4.4.4.5 Results: Report measured resistance of sample, measured length of sample, calculated resistance per 1000 feet (305 M), and test temperatures.
- 4.4.4.6 Information Required in Detail Specification: Number of samples, conductor size of samples, acceptable resistance values.
- 4.4.4.7 Precision Bias: Correction method for resistance values measured at other than 20°C (68°F) shall be as described in Section 5.1.2 of Method 6021, FED. TEST METHOD STD. NO. 228 (temperature coefficient of resistance (α_t) = .0034 for high strength copper alloys (PD 135)).
- 4.4.5 Method 405, Conductor Strand Blocking:
- 4.4.5.1 Scope: This test provides a method for examination of 7 and 19 strand conductors for conductor strand blocking (adhesion).
- 4.4.5.2 Samples: The sample shall be a 6 in (152 mm) length of finished wire.

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4.4.5.3 Test Equipment:

4.4.5.3.1 Wire insulation stripping tool.

4.4.5.3.2 Fine needle or thin blade.

4.4.5.3.3 Device to sever conductor strands.

4.4.5.4 Test Procedure:

4.4.5.4.1 Preparation of Sample: With the insulation stripping tool, initiate a stripping action 2 in (51 mm) from one end of the sample 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.

4.4.5.4.2 Procedure:

4.4.5.4.2.1 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.
- c. Gently probe unseparated 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.

4.4.5.4.2.2 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.
- c., d. On the "bird cage" outer layer, perform steps c and d as for unidirectional lay.

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4.4.5.4.2.2 (Continued):

- 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 stes 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.

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

4.4.5.6 Information Required in Detail Specification: Number of samples, conductor size of samples, and the minimum number of unbonded strands.

4.4.5.7 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 (K) of the insulation.

4.5.1.2 Sample: A 15 ft (4.6 m) length of size 22 wire shall be used.

4.5.1.3 Test Equipment: The test equipment shall be selected in accordance with Section 3, Method 6271 of FED. TEST METHOD STD. NO. 228.

4.5.1.4 Test Procedure: See section 4.3, Method 6271 of FED. TEST METHOD STD. NO. 228 to measure the conductor diameter (d) and the capacitance. The Insulation Diameter (D) shall be measured using Method 901 of AS4373. The dielectric constant shall be calculated using section 5.1 of Method 6271 of FED. TEST METHOD STD. NO. 228.

4.5.1.5 Results: Record the dielectric constant (K), capacitance (C), conductor diameter (d) and insulation diameter (D).

4.5.1.6 Information Required in the Detail Specification: Report the dielectric constant.

4.5.1.7 Precision Bias:

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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 Samples: Samples 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 samples to be tested, wire size of samples, and test conditions other than ambient.
- 4.5.2.7 Precision Bias:

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 Samples: 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 sample. 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 Samples: See Section 6.3 of ASTM D 3032.
- 4.5.4.3 Test Equipment: See Section 6.2 of ASTM D 3032.
- 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.

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- 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 samples.
- 4.5.4.7 Precision Bias: A minimum insulation resistance of 1000 M Ω - 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 Samples: 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 sample. This test was initially developed for wires with outer braid as part of the insulation system.
- 4.5.6.2 Samples: See Section 2 of Method 6041, FED. TEST METHOD STD. NO. 228.
- 4.5.6.3 Test Equipment: See Section 3 of Method 6041, FED. TEST METHOD STD. NO. 228.
- 4.5.6.4 Test Procedure: Section 4 of Method 6041 shall be followed except all specimens, after being prepared with electrodes but prior to testing, shall be cleaned by the procedure described in Section 2.1 of Method 6041. In addition, 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 samples to be tested.
- 4.5.6.7 Precision Bias: A minimum surface resistance value of 5 M Ω /in is usually desirable.

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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 Sample: 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 construction paper or equivalent for background
 - 4.5.7.3.4 Timer
 - 4.5.7.3.5 Current meter
- 4.5.7.4 Test Procedure: The wire sample shall be precleaned 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 sample shall be suspended horizontally in air and the background shall be a vertical sheet of black construction paper or equivalent 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 samples.
- 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, Voltage Rating: TO BE DETERMINED⁵

⁵There 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.

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4.5.9 Method 509, Wet Arc Tracking:

- 4.5.9.1 Scope: This test is to be used to evaluate the performance of insulated wire under wet arc tracking conditions. Note that this test is a BSI standard as of March 1989.
- 4.5.9.2 Samples: Each sample shall be a bundle of seven size 20 wires, 16 in (400 mm) long.
- 4.5.9.3 Test Equipment:
- 4.5.9.3.1 PROPAN-2-OL fluid.
- 4.5.9.3.2 MIL-T-43435-B type IV ties or equivalent.
- 4.5.9.3.3 Three-phase power supply (200/115 V, 400 Hz).
- 4.5.9.3.4 200/240 V 15 W lamps.
- 4.5.9.3.5 MIL-C-5809 or equivalent 7.5 A circuit breakers.
- 4.5.9.3.6 Electrolyte solution of 2% by mass of ammonium chloride and $0.1 \pm 0.01\%$ by mass of Iso-octylphenoxypolyethoxyethanol, the polyethoxy chain to contain approximately 10 ethoxy units.
- 4.5.9.3.7 A pipette with an internal exit orifice diameter of $1.0 \text{ mm} \pm 0.1$, capable of delivering a $100 \text{ mg/min} \pm 10$, at approximately 2 drops per min.
- 4.5.9.4 Test Procedure:

CAUTION

This test can produce severe electrical arcing and associated ejection of molten metal. Appropriate precaution should be taken, including the provision of a transparent screen to protect personnel.

- 4.5.9.4.1 Sample Preparation: Seven 16-in (400 mm) lengths shall be cut consecutively from 1 length of size 20 wire and shall then be cleaned with PROPAN-2-OL fluid. Damage two of the pieces by cutting around the entire circumference at the midpoint of each piece. Ensure that the cut penetrates to the conductor and is $0.5 \text{ mm} \pm 0.1$ wide. Form the bundle by laying the wires parallel, six around one. String tie the bundle at 30 mm intervals, ensuring that the cut areas are equidistant between ties. The two cut wires must be adjacent to each other and the cuts longitudinally separated by $10 \text{ mm} \pm 0.5$. All wires must be in continuous close contact during the test and the bundle shall be positioned so that the two cut wires are uppermost.

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4.5.9.4.2 Electrical Connections: The seven wires shall be connected to the power supply as shown in Figure 5. Use indicating lamps connected line to neutral to show when a sample becomes an open circuit, so that the potential fault current is not affected. Use 7.5 A circuit breakers and a three phase power supply derived from a rotary machine giving 200 V line to line, 400 Hz and having continuous rating of not less than 5 kVA. Include a noninductive 1.0Ω resistance of appropriate power rating to withstand the short circuit current, in each of the three line feeders connecting the generator to the test circuit but not in the neutral connection. The supply shall be connected to the upper end of the bundle (see Figure 6) and the lamps shall be connected to the other end.

4.5.9.4.3 Procedure: Perform the test at an ambient temperature of $23^{\circ}\text{C} \pm 5$. Support the bundle in free air at a 10° angle to horizontal. Position the pipette so that the electrolyte contacts the bundle from a height of $10 \text{ mm} \pm 2$ above the uppermost wires at a point 1 to 2 mm from the nearest cut area on the higher end of the bundle. See Figure 6. Energize the bundle and start the electrolyte flow at $100 \text{ mg/min} \pm 10$. Care should be taken to ensure the electrolyte flows between the damage sites as evidenced by steaming of the electrolyte and/or scintillation. The test shall be run (continuously if possible) until an active or passive failure occurs, subject to the limitations below.

An active failure is one that produces a disruptive arc such that an open circuit of the conductor and/or the tripping of a circuit breaker and/or fire propagation results.

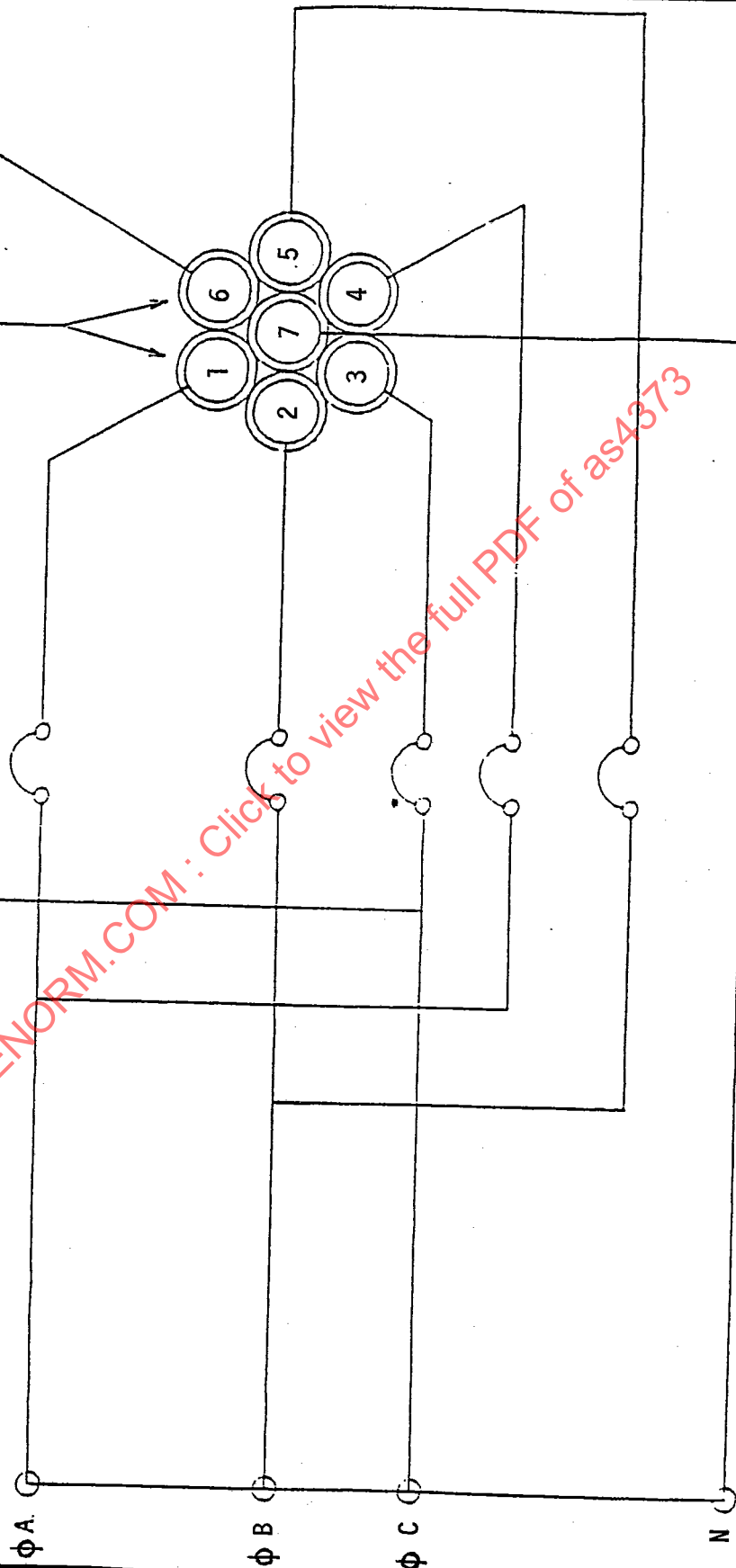
Following an active failure as defined here, the electrolyte flow shall be stopped and the electrical power shall be switched off. The tripped circuit breaker(s) shall be reset. Electrical power shall then be reapplied for the time necessary for any fault condition to fully develop but thermal circuit breakers shall not be reset.

A passive failure will not trip circuit breakers but will usually involve the progressive erosion of conductors without a disruptive arc until an open circuit occurs on one or both of the initially damaged wires. A total test duration of 24 h from the onset of electrolytic action shall be completed for this failure mode.

NOTE: It is recognized that the nature of some insulating materials and/or the surface finish of some wire constructions may resist this failure mode when the wires are new, clean, and in the particular configuration defined for this test. While this resistance to failure is a characteristic that is worthy of note for assessment, it is not justification for discontinuing what is essentially a destructive test. Should a test continue beyond a normal working day, the electrolyte and power may be shut off overnight and the test continued the next day. A total of five test specimens shall be tested with a new specimen employed for each test.

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FAULTED WIRES

7.5 A
CB
(TYP)

200/115 V 400 HZ 3-PHASE Y CONNECTED WITH NEUTRAL (N)

FIGURE 5 - Electrical Connections for Wet Arc Tracking Test

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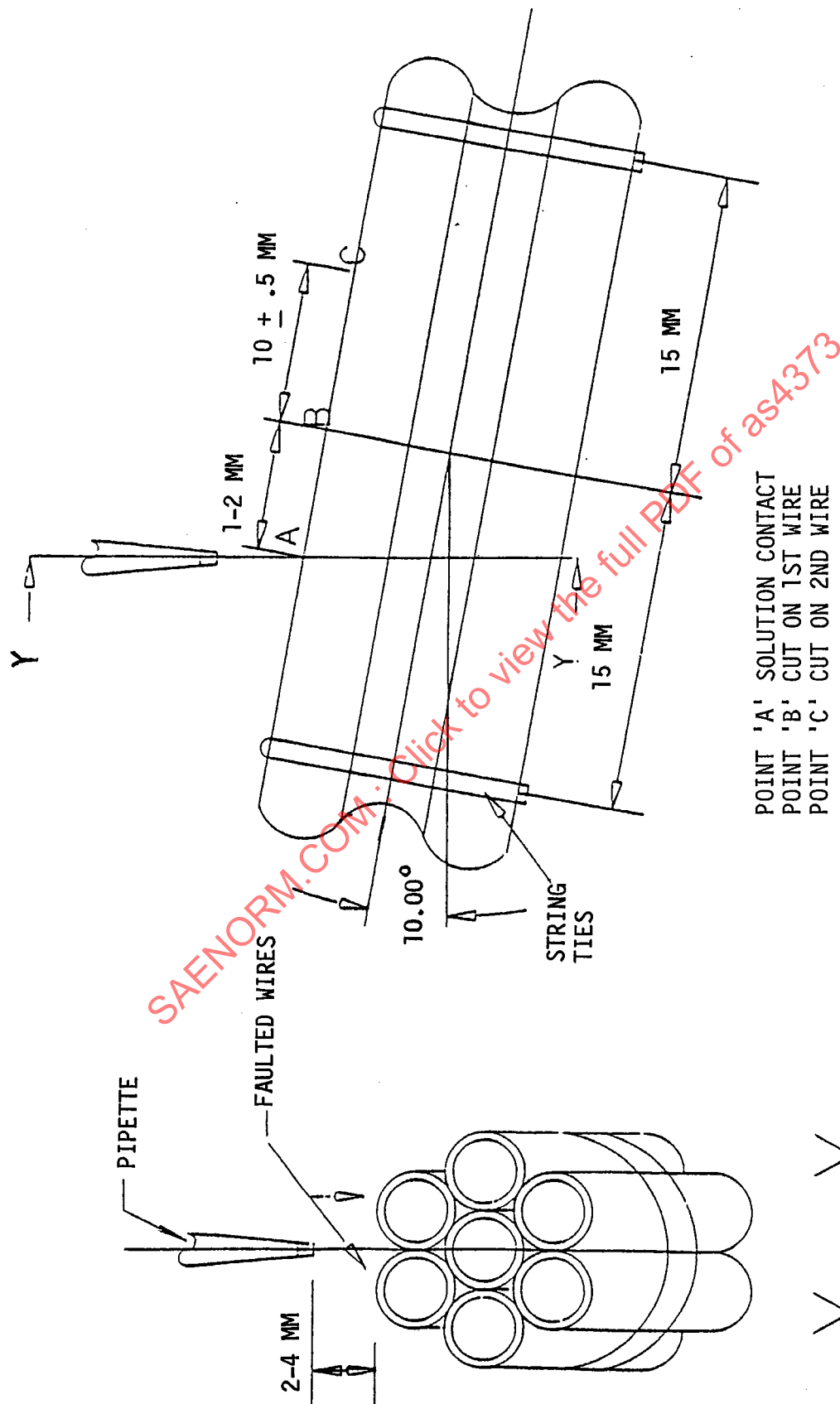


FIGURE 6 - Test Setup for Wet Arc Tracking Test

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- 4.5.9.5 Results: Report details of observations made during the test including time to and type of failure, circuit breaker activity, and damage to insulation including length of char. Photo document damage areas on any wires.
- 4.5.9.6 Information Required in Detail Specification: Wire type and number of sample 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 Samples: 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.
- 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 under overcurrent conditions.
- 4.5.11.2 Samples: Each sample 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 MIL-W-5088 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.

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- 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 samples.
- 4.5.11.7 Precision Bias: This is a new method that has not had the benefit of any round-robin testing to determine precision.
- 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 sample.
- 4.6.1.2 Samples: 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 sample, for each fluid in the fluid table below.
- 4.6.1.3.2 Quantities of each of the fluids selected from Table 1.
- 4.6.1.3.3 A micrometer or other device capable of measurement to 0.001 in (0.25 mm).
- 4.6.1.3.4 A device to remove the insulation off each end of the wire sample.
- 4.6.1.4 Test Procedure:
- 4.6.1.4.1 Each 24-in (610 mm) specimen, for each test fluid in Table 1, 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 714 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 714 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:

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TABLE 1 - Fluid Table

	Test fluid	Test temperature [°C (°F)]	Immersion time (h)
a	MIL-L-23699, Lubricating Oil, Aircraft Turbine Engine, Synthetic Base	48-50 (118-122)	20
b	MIL-H-5606, 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-T-5624, Turbine Fuel, Aviation, Grade JP-4	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	TT-M- , Methyl Isobutyl Ketone (For Use in Organic Coatings)	20-25 (68-77)	168
i	SAE-AS-1241, 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 ¹	MIL-C-25769, Cleaning Compound, Aircraft Surface, Alkaline Waterbase, undiluted	63-68 (145-154)	20
l ¹	MIL-C-25769, 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

¹The specification for this has been cancelled and superceded in MIL-C-87936.

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TABLE 1 (Continued)

	Test fluid	Test temperature [°C (°F)]	Immersion time (h)
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-T-81533, 1,1,1 Trichloroethane (Methyl Chloroform) Inhibited, Vapor Degreasing	20-25 (68-77)	168
s	Azeotrope of trichlorotrifluoroethane and methylene chloride, Dupont Freon TMC or equivalent	20-25 (68-77)	168
t	MIL-G-3056, Gasoline, Automotive, Combat	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 Samples: 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 coated steel 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 A temperature measuring device capable of measurements to within $\pm 5^{\circ}\text{C}$ of the wire's rated temperature.

4.6.2.3.4 A variable current source capable of applying the rated free air current for each wire.

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4.6.2.4 Test Procedure:

4.6.2.4.1 Heat Conditioned Wire:

4.6.2.4.1.1 Sample Preparation: A 30-in (762 mm) specimen shall be wrapped 10 times around a 6X PTFE coated steel mandrel. After wrapping tightly attach a 0.5 lb (0.227 kg) weight to the insulation on each end.

4.6.2.4.1.2 Procedure: Apply the appropriate single wire in free air current for the sample's rated temperature obtained from MIL-W-5088, Figure 2, for 8 h. Measure the stabilized insulation temperature with a thermocouple attachment. Remove current and weights and immerse in 5% saline solution at 70°C (158°F) with at least 2 in (5 cm) of each end out of the water for 672 h. Remove specimen from solution, return to room temperature and perform Test Method 510 at 2500 V AC.

4.6.2.4.2 Unconditioned Wire: Repeat 4.1.2 omitting the requirement to raise the wire to its rated temperature for 8 h.

4.6.2.5 Results: For the heat conditioned wire report the current applied for the sample's rated temperature and the stabilized insulation temperature. 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 samples and wire size to be tested.

4.6.2.7 Precision Bias: This is a new method that 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 sample's insulation.

4.6.3.2 Samples: 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 $70^{\circ} \pm 3$ (158°F ± 5) and an internal relative humidity of $95\% \pm 5$. 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 not more than 38°C (100°F) 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.

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- 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 3.1 and maintained at such for a period of 6 h. At the end of the hour period the heat shall be shut off. During the following 16 h period, the temperature shall drop to $38^{\circ}\text{C} \pm 3$ ($100^{\circ}\text{F} \pm 5$) or lower. At the end of the 16 h period, heat shall be again supplied for a 2 h period to stabilize to $70^{\circ}\text{C} \pm 3$ ($158^{\circ}\text{F} \pm 5$). 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 (15.25 m) center section of the specimen shall be tested for insulation resistance in accordance with Method 504 - Insulation Resistance.
- 4.6.3.5 Results: Report the insulation resistance in $\text{M}\Omega$ -1000 ft.
- 4.6.3.6 Information Required in the Detail Specification: The number and wire size of samples.
- 4.6.3.7 Precision Bias:
- 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 Samples: 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 sample for 384 h operation.
- 4.6.4.3.2 A device to measure the weight of the samples.
- 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 samples shall be removed from the chamber and weighed again within 30 min.

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- 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 samples, the preconditioning parameters, and the chamber temperature and pressure.
- 4.6.4.7 Precision Bias: This is a new method that has not had the benefit of any round-robin testing to determine precision.
- 4.6.5 Method 605, Propellant Resistance:
- 4.6.5.1 Scope: This test is to be used to determine the effects of various propellants on the insulation on the wire sample.
- 4.6.5.2 Samples: Three 24-in (610 mm) wire samples shall be used for each propellant.
- 4.6.5.3 Test Equipment:
- 4.6.5.3.1 Containers large enough to immerse to within 1-1/2 in (38 mm) of each end of the wire sample for each propellant listed below.
- 4.6.5.3.2 Quantities of each of the propellants selected from the list below.
- 4.6.5.3.3 A device to remove the insulation off each end of the wire sample.

PROPELLANT	IMMERSION TIME (min)
MIL-P-26536, Propellant, Hydrazine	30
MIL-P-26539, Propellant, Nitrogen Tetroxide	1
MIL-P-27402, Propellant, Hydrazine-Unsymmetrical Dimethylhydrazine (50% N ₂ H ₄ - 50% UDMH)	30

- 4.6.5.4 Test Procedure: Each 24-in (610 mm) specimen of finished wire shall be immersed to within 1.5 in (38 mm) of each end in each of the above propellants for the specified time at normal room temperature, using a separate specimen for each propellant. During the 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 propellants, the specimens shall remain for no more than 48 h in free air at room temperature. The insulation shall be removed for a distance of one inch from each end of the specimens and the specimens shall be subjected to the Voltage Withstand (Wet Dielectric) Test Method 510. Examine the specimen for surface cracks or crazing prior to voltage withstand.

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- 4.6.5.5 Results: Cracks or crazing shall be reported. Results of the Voltage Withstand (Wet Dielectric) Test Method 510 shall be reported.
- 4.6.5.6 Information Required in the Detail Specification: The number and wire size of the samples and the propellants to be used for testing.
- 4.6.5.7 Precision Bias:
- 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 samples.
- 4.6.6.2 Samples: A 36-in (914 mm) wire sample 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 A 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:
- 8 h UV at $70^{\circ}\text{C} \pm 3$ ($158^{\circ}\text{F} \pm 5$) = 1 cycle
 4 h Condensation at $40^{\circ}\text{C} \pm 3$ ($104^{\circ}\text{F} \pm 5$)
- Perform 120 cycles of UV and condensation exposure. Remove the specimens after 120 cycles and subject them to the Bend Test Method 714 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: The number and wire size of the samples.
- 4.6.6.7 Precision Bias: This is a new method that 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 multilayered 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.

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4.6.7.2 Samples: The wires to be tested shall be 4 in $\pm 1/16$ (102 mm ± 1.6) in length with square-cut ends.

4.6.7.3 Test Equipment:

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

4.6.7.3.2 A quantity of standard dye solution sufficient to meet the requirements of 3.1 above. The dye solution shall be prepared as follows:

Ethyl Alcohol	30 mL
Rhodamine B dye	0.02 gm
Aerosol OT	3 mL
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 lintfree cloth.

4.6.7.3.5 A UV light source.

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

4.6.7.4 Test Procedures: Wicking of the dye shall be determined as follows:

4.6.7.4.1 Multilayer Wire: The specimen shall be placed upright with the lower 2 in (51 mm) of its length immersed in the dye solution (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, the surface of the insulation shall be wiped with a clean, dry, lint free cloth and within 5 min after removal from the solution, the specimen shall be observed under ultraviolet light to determine to the nearest 1/16 in 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 in in the overbraid only.

4.6.7.5 Results: Report the distance traveled by the dye solution by either 4.1 or 4.2 depending upon the type of wire being tested.

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4.6.7.6 Information Required in the Detail Specification: The number and size of the samples and which procedure to use with or without the dye solution.

4.6.7.7 Precision Bias:

4.7 Test Methods Group 700 - Mechanical Tests:

4.7.1 Method 701, Abrasion: TO BE DETERMINED⁶

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 Samples: A 36-in (914 mm) specimen shall be used in this test.

4.7.2.3 Test Equipment:

4.7.2.3.1 A chamber capable of maintaining $-65^{\circ}\text{C} \pm 3$ ($-85^{\circ}\text{F} \pm 5$) 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 $-65^{\circ}\text{C} \pm 3$ ($-85^{\circ}\text{F} \pm 5$) 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 ± 1 rpm. At the completion of this test the specimen shall be removed from the cold box and from the mandrel without straightening. 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 (25.4 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.

⁶There is not currently an approved test under ASTM D 3032 which covers this requirement, but drafts are being worked on and the Task Group has decided to await the issuance of the ASTM test.

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4.7.2.6 Information Required in the Detail Specification: The number and wire size of the samples and mandrel size and weight.

4.7.2.7 Precision Bias: This test can be used for two purposes, design evaluation or for process control. Mandrel sizes and weights will differ for each purpose.

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 Samples: 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. Also, the standard cutting edge shall be a 20 mil 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 sample and the temperature of the test.

4.7.3.6 Information Required in the Detail Specification: The number and wire size of the samples and the test temperature.

4.7.3.7 Precision Bias: This is a new method that has not had the benefit of any round-robin testing to determine precision. Note that 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: TO BE DETERMINED⁷

4.7.5 Method 705, Insulation Impact Resistance: TO BE DETERMINED⁸

4.7.6 Method 706, Insulation Tensile Strength and Elongation:

4.7.6.1 Scope: This test is to be used to produce tensile property data for control and specification of extruded electrical insulation.

⁷There is not a current standard test to adequately distinguish between conductor life and insulation life under flexing of insulated wire. The Task Group has requested that the user members of AE-8D develop such a new test.

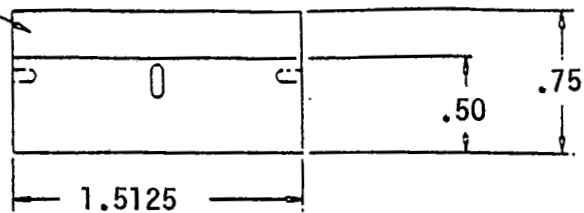
⁸The previously considered test method has shown to have poor reproducibility and will be considered for redrafting by NAC.

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- 4.7.6.2 Samples: See Section 17.3 of ASTM D 3032 for sample preparation.
- 4.7.6.3 Test Equipment: See Section 17.2 of ASTM D 3032 for test apparatus.
- 4.7.6.4 Test Procedure: See Sections 17.4 through 17.5 of ASTM D 3032 for the test procedure.
- 4.7.6.5 Results: Report the rate of jaw separation, the tensile strength and elongation.
- 4.7.6.6 Information Required in the Detail Specification: The rate of jaw separation the minimum allowable tensile strength and elongation, the temperature of the test, any special conditioning requirements, the wire size, and number of samples to be tested.
- 4.7.6.7 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.
- 4.7.7 Method 707, Notch Propagation:
- 4.7.7.1 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.
- 4.7.7.2 Samples: A 6-in (150 mm) specimen shall be used for this test.
- 4.7.7.3 Test Equipment:
- 4.7.7.3.1 A notching tool as described in Figure 7.
- 4.7.7.3.2 A 6X mandrel for wrapping of the specimen.
- 4.7.7.4 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.
- 4.7.7.5 Results: Report the number of cycles to failure and the notch depth for each failure.
- 4.7.7.6 Information Required in the Detail Specification: The number and wire size of the samples and the notch depth(s).
- 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.

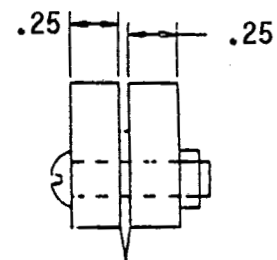
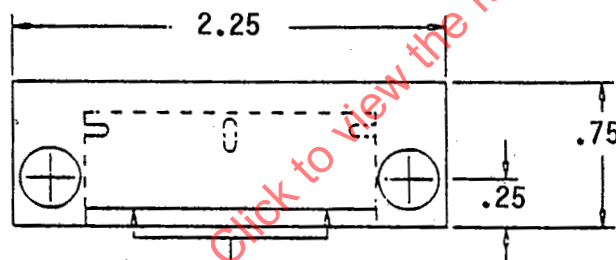
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REMOVE THIS PORTION

BLADE DIMENSIONS ARE
NOT CRITICALMAKE TEST TOOLS AS SHOWN BELOW, BEING EXTREMELY CAREFUL
NOT TO DAMAGE ANY PORTION OF RAZOR BLADE EDGE.

FRONT VIEW

SIDE

DRILL APPROPRIATE
HOLES FOR 8-32
ROUND HEAD SCREWS

3/16"

CUT AND MEASURE
IN THIS AREA

3/16"

THESE SURFACES TO BE
CRITICALLY MACHINEDON 2ND, 3RD, 4TH,
AND 5TH TOOLS
PROTRUSIONS ARE TO BE (RESPECTIVELY)
.002", .003", .004"
and .005". ALL MEASURED TO
 $\pm .0001$ ".

USE 1/4" STEEL

LOCK NUTS

ALL TOLERANCES ARE
 $\pm .001$ " EXCEPT AS
NOTED.

BOTTOM

CENTER BLADE BETWEEN
HOLDING BLOCKS. ADJUST
RAZOR BLADE PROTRUSION
TO $.001 \pm .0001$ ".
MEASURING AT DISCRETE
POINTS ALONG THE PORTION
OF THE BLADE TO BE USED
IN THE NOTCHING PROCEDURE.

FIGURE 7 - Notching Tool

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4.7.8 Method 708, Stiffness and Springback:

- 4.7.8.1 Scope: This test is used to generate data for comparison between samples using the same stiffness and springback apparatus. Stiffness and springback affect harness manufacturing, harness and cable installation, and maintenance operations.
- 4.7.8.2 Samples: 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.
- 4.7.8.3 Test Equipment:
- 4.7.8.3.1 An apparatus consisting of a pivoting arm mounted in the center of a scaled plate shall be fabricated according to Figures 8 and 9.
- 4.7.8.3.2 A torque meter/wrench.
- 4.7.8.3.3 Alligator clip and string or equivalent.
- 4.7.8.4 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° position (at rest location). One end of the wire specimen shall be terminated with a spade lug. The unterminated 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 2 shall be attached to the unterminated 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.

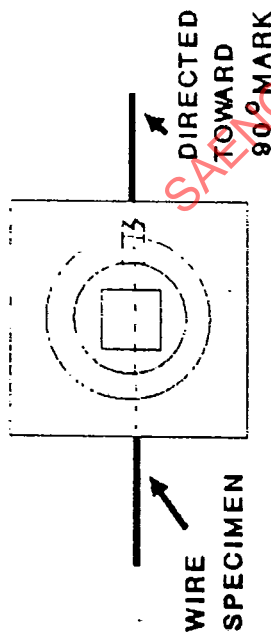
Using the torque meter, slowly rotate the pivot arm to the 0° position. The maximum torque value observed during the bending is the stiffness. The pivot arm shall be held at the 0° position for about 10 s. While holding the arm, the torque meter shall be removed. While maintaining finger contact with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

TABLE 2

WIRE SIZE	WEIGHT IN lb (kg)
22	1.0 (0.45)
26	0.5 (0.23)

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TOP VIEW OF HUB



NOTES:

1. BEARING MUST ALLOW UNRESTRICTED MOTION
2. POINT 'B', WHERE CABLE EMERGES FROM HUB, MUST BE ON PIVOT ARM AXIS OF ROTATION
3. HOLE THROUGH HUB AT 'B' SHOULD BE SLIGHTLY LARGER THAN WIRE SPECIMEN
4. HUB IS MOUNTED ON CENTER OF BASE PLATE SO THAT HOLE AXIS IS ALIGNED WITH 90 DEG MARK AND FLAT ON HUB FACES THE MARK

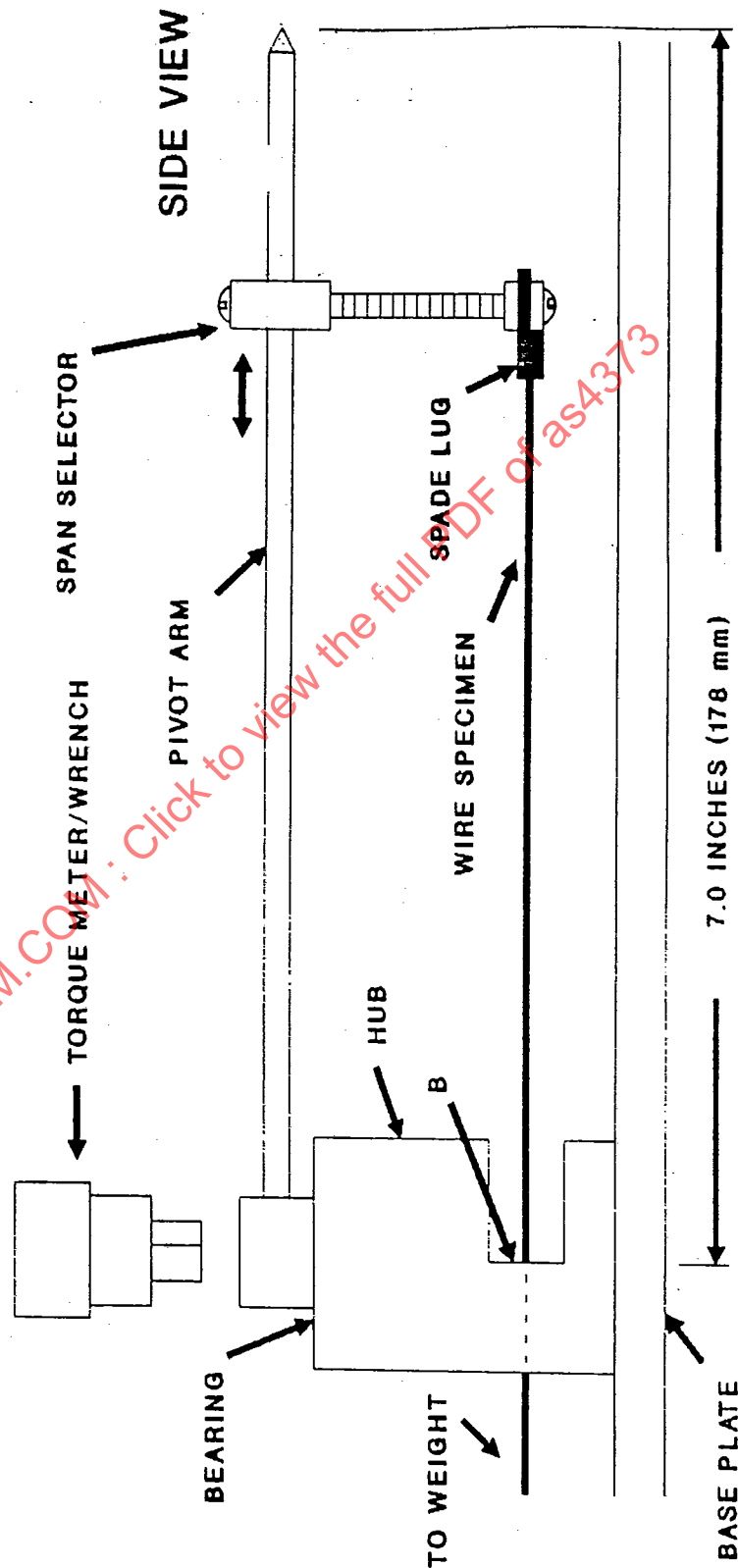


FIGURE 8 - Test Fixture

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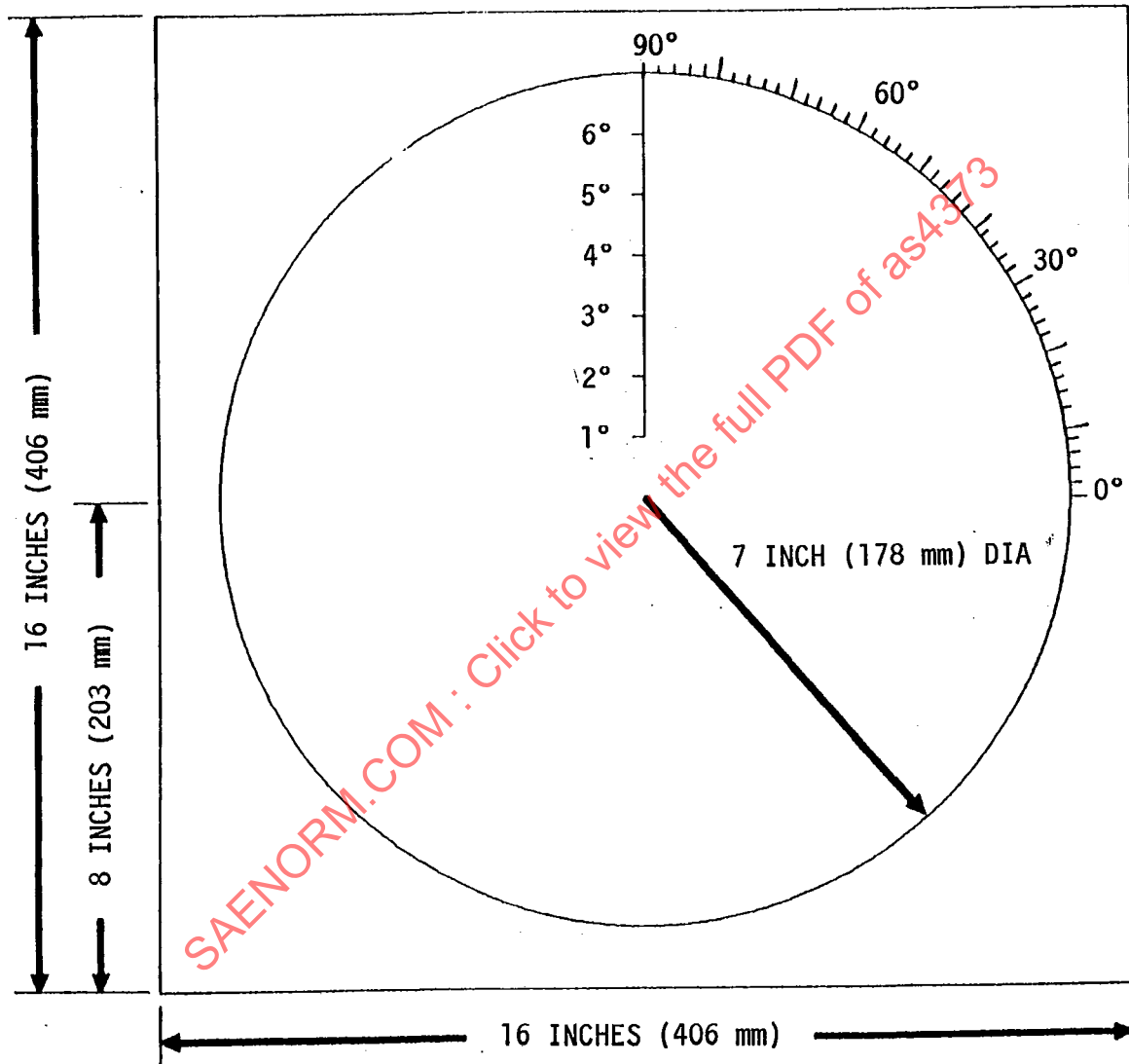


FIGURE 9 - Test Fixture Base Plate

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- 4.7.8.5 Results: Report the torque needed to pull the specimen through the 90° bend and the degrees of springback.
- 4.7.8.6 Information Required in the Detail Specification: The number and wire size of the samples to test and the span selector length for testing.
- 4.7.8.7 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. Use of different conductor constructions (unilay, concentric), materials (copper, aluminum, alloy, plating), sizes (22 AWG versus 24 AWG), and different conductor stranding.
 - b. use of different wall thickness of insulating material.
 - c. Use of different span selector settings (the shorter the span the more pronounced the performance difference between constructions).
- 4.7.9 Method 709, Vibration: TO BE DETERMINED⁹
- 4.7.10 Method 710, Mandrel and Wrapback Test:
- 4.7.10.1 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.
- 4.7.10.2 Samples: Use 12-in (305 mm) finished wire samples for the wrapback test and 12 in (305 mm) plus the additional length required for winding on the mandrel for the mandrel test.
- 4.7.10.3 Test Equipment:
- 4.7.10.3.1 An oven capable of sustained temperatures as set forth by the Detail Specification.
- 4.7.10.3.2 Test mandrels as called out in the Detail Specification.
- 4.7.10.4 Test Procedure:
- 4.7.10.4.1 Wrap Back Test: This test applies to sizes 10-30 finished wire for all insulations. 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, and 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 10). After removal from the oven, the specimen shall be examined visually, without the aid of magnification for cracks.

⁹There currently is no acceptable procedure or vibration level that can be tested that will predict an acceptable performance level for this property. It appears that this property is more of a system test than a wire test. The Task Group does not have a solution to this dilemma and has requested help from AE-8D for this problem.

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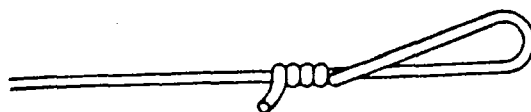


FIGURE 10 - Wrap Back Test

- 4.7.10.4.2 Mandrel Test: This test applies to sizes 0000-8 finished wire for all insulations. 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 Procurement Document. 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.
- 4.7.10.5 Results: Report any cracking of the insulation. Report the Voltage Withstand Test results for the Mandrel test of Procedure 4.7.10.4.2.
- 4.7.10.6 Information Required in the Detail Specification: The wire size and the number of samples for either test, the temperature and the time at temperature for the Wrapback Test and the mandrel diameter and the test temperature for the Mandrel Test.
- 4.7.10.7 Precision Bias: The wrapback test has not had the benefit of round-robin testing to determine its suitability for insulating materials other than PTFE.
- 4.7.11 Method 711, Wrinkle Test:
- 4.7.11.1 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.
- 4.7.11.2 Sample: The test sample shall be a 12-in (305 mm) length of finished wire.
- 4.7.11.3 Test Equipment:
- 4.7.11.3.1 A device to provide 3X magnification.
- 4.7.11.3.2 Steel mandrels sized appropriately for the samples tested.

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- 4.7.11.4 Test Procedure: Bend the wire sample one full turn around the mandrel as specified below.

WIRE SIZE	MANDREL SIZE in (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 (25.4)

The wire sample 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.

- 4.7.11.5 Results: Report wrinkling for each sample tested.

- 4.7.11.6 Information Required in the Detail Specification: Numbers and wire size of samples to be tested.

- 4.7.11.7 Precision Bias:

- 4.7.12 Method 712, Durability of Color/Identification:

- 4.7.12.1 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.

- 4.7.12.2 Samples: For this test, 6-in (152 mm) finished wire specimens shall be used.

- 4.7.12.3 Test Requirement:

- 4.7.12.3.1 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 $\pm$ 0.002 (0.63 mm $\pm$ 0.05) in diameter, repeatedly over the upper surface of the wire so that the longitudinal axis of the needle and the specimen are 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.

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- 4.7.12.3.2 A sewing needle that is $0.025 \text{ in} \pm 0.002$ ($0.63 \text{ mm} \pm 0.05$) in diameter. After each test, the abrading surface of the needle should be examined for wear and replaced if worn.
- 4.7.12.4 Test Procedure: In performing the test, a specimen of wire 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 sample unit and failure of any specimen shall constitute failure of the sample unit.
- 4.7.12.5 Results: Report any specimen that fails.
- 4.7.12.6 Information Required in the Detail Specification: The number and wire size of the specimens.
- 4.7.12.7 Precision Bias:
- 4.7.13 Method 713, Wire Surface Markability: TO BE DETERMINED¹⁰
- 4.7.14 Method 714, Bend Test:
- 4.7.14.1 Scope: This test provides a method to determine the sensitivity of the insulation to cracking.
- 4.7.14.2 Samples: A 24-in (610 mm) wire sample shall be used for this test. (Longer lengths may have to be used on some of the large size samples.)

¹⁰Wire surface markability by high speed methods such as laser, ink jet, and contact printing is still under investigation by users. The method for generating the mark needs to be more clearly defined in order to achieve a performance requirement. In view of this, the requirement for markability for laser, ink jet and contact printing is waived until such a method can be developed. This requirement is not to be confused with a wire durability test.

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4.7.14.3 Test Equipment: Mandrels and weights as specified in the following:

Wire Size	Nominal Diameter of Mandrel	Winding Tension (lb)
30	50X	0.50
28	50X	0.50
26	50X	0.50
24	50X	0.50
22	50X	1.00
20	50X	1.00
18	50X	1.00
16	50X	1.00
14	50X	3.00
12	40X	3.00
10	40X	3.00
8	30X	4.00
6	30X	4.00
4	30X	4.00
2	30X	6.00
1	30X	6.00
0	20X	6.00
00	20X	8.00
000	20X	8.00
0000	20X	12.00

4.7.14.4 Test Procedure: In a 20 to 25°C (68 to 77°F) environment, one end of the sample 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.

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

4.7.14.6 Information Required in the Detail Specification: None.

4.7.14.7 Precision Bias:

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 sample's burning characteristics.

4.8.1.2 Samples: A 24-in (610 mm) finished wire sample shall be used for this test.

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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 A sheet of facial tissue conforming to UU-T-450.

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° 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 ft² (30.48 cm²) 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.

4.8.1.4 Test Procedure: The 24-in (60.96 cm) specimen of wire 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° 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. With the burner held perpendicular to the specimen and at an angle of 30° 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 or absence of flame in the facial tissue due to incendiary drip from the specimen. Charred holes or charred spots in the tissue shall be ignored in the absence of actual flame. Breaking of the wire specimens in sizes 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: The wire size and number of samples.

4.8.1.7 Precision Bias:

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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 Samples: 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 $315^{\circ}\text{C} \pm 3$ ($600^{\circ}\text{F} \pm 5$) air at 70 to 80 psi shall be used. A $0.015 \text{ in} \pm 0.0015$ ($0.38 \text{ mm} \pm 0.038 \text{ mm}$) wide slit should be cut along the length of the tube for $1.00 \text{ in} \pm 0.010$ ($25 \text{ mm} \pm 0.25$) to enable the air to impinge upon a wire harness.

4.8.2.3.2 A MS3320 - 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 identical to the one shown in Figure 11 except the center wire shall be protected with a MS3320 - 7.5 circuit breaker. The wire bundle shall be firmly mounted above and perpendicular to the slot in the tube with a distance of $1.0 \text{ in} \pm 0.125$ ($25 \text{ mm} \pm 3.2$) between them. Apply power to the bundle and then initiate air flow through the tube. Air temperatures shall be maintained at $315^{\circ}\text{C} \pm 3$ ($600^{\circ}\text{F} \pm 5$) 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.

- 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: The wire size and number of samples 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 is a new method that has not had the benefit of any round-robin testing to determine precision.