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AEROSPACE STANDARD

SAE AS4373 REV. A

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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 an individual aerospace vehicle. No one method can predict all the variables to which a wire can be exposed.

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

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

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

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1. SCOPE:

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

1.1 Contents:

This document is comprised of the following Sections:

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

1.2 Test Method Numbering:

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

a. Group 100: Assembly, Handling, and Repair Tests
b. Group 200: Chemical, Biological, Radiological (CBR) Tests
c. Group 300: Combat Damage Tests
d. Group 400: Conductor Tests
e. Group 500: Electrical Tests
f. Group 600: Environmental Tests
g. Group 700: Mechanical Tests
h. Group 800: Thermal Tests
i. Group 900: Weight and Dimensional Tests

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 publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AS1241	Fire Resistant Phosphate Ester Hydraulic Fluid for Aircraft
AS4372	Performance requirements for Wire, Electric, Insulated Copper or Copper Alloy
AS4851	Relative Thermal Life and Temperature Index

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor, West Conshohocken, PA 19428-2959.

ASTM D 910	Aviation Gasoline, Standard Specification for
ASTM D 1153	Methyl Isobutyl Ketone, Standard Specification for
ASTM D 1868	Detection and Measurement of Partial Discharge (Corona) Pulse in Evaluation of Insulation Systems, Standard Test Method for
ASTM D 3032	Hookup Wire Insulation, Standard Test Method for
ASTM F 814	Specific Optical Density of Smoke Generated by Solid Materials for Aerospace Applications Standard Test Method for
ASTM G 53	Operating Light- and Water-Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of Non-metallic Materials, Standard Practice for
ASTM D 412	Rubber Properties in Tension, Standard Test Method for

2.3 ANSI Publications:

Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

A-A-1505	Tissue
TT-I-735	Isopropyl Alcohol
TT-S-735	Standard Test Fluids, Hydrocarbon

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

2.4 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-A-8243	Anti-Icing and Deicing-Defrosting Fluid
MIL-C-5809	Circuit Breaker, Trip Free, Aircraft, General Specification for
MIL-C-87252	Coolant Fluid, Hydrolytically Stable, Dielectric
MIL-C-87936	Cleaning Compounds, Aircraft Exterior Surfaces, Water Dilutable
MIL-C-43616	Cleaning Compound, Aircraft Surface
MIL-G-3056	Gasoline, Automotive, Combat
MIL-H-5606	Hydraulic Fluid, Petroleum Base, Aircraft, Missile and Ordnance Hydrocarbon Base, Aircraft, Metric, NATO Code Number H-537
MIL-L-6082	Lubricating Oil, Aircraft Piston Engine (Non Dispersent Mineral Oil)
MIL-L-7808	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, NATO Code Number 0-148
MIL-L-23699	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, NATO code number 0-156
MIL-P-26536	Propellant, Hydrazine
MIL-P-26539	Propellant, Nitrogen Tetroxide
MIL-P-27402	Propellant, Hydrazine-Uns-Dimethylhydrazine (50 percent N2H4 -50 percent UDMH)
MIL-T-5624	Turbine Fuel, Aviation Grades JP-4, JP-5 and JP-5/JP-8 ST
MIL-T-43435	Tape, Lacing and Tying
MIL-T-83133	Turbine Fuels, Aviation, Kerosene Types, NATO F-34(JP-8) and NATO F-35
MIL-W-5088	Wiring, Aerospace, Vehicle
MIL-W-22759/35	Wire, Electrical, Fluoropolymer Insulated Copper or Copper Alloy
MS3320	Circuit Breaker-Aircraft, Trip-free, Push Pull, 1 through 20 Amps, Type 1, -55 to +121 Degrees C
MIL-STD-202	Test Methods for Electronic and Electrical Component Parts
MIL-STD-2223	Test Methods for Insulated Electric Wire

3. INDEX OF SECTIONS AND TEST METHODS:

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

TABLE 1

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

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

3.3 Test Methods Group 300 - Physical Damage Tests:

TABLE 2

Method No.	Title
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3.4 Test Methods Group 400 - Conductor Tests:

TABLE 3

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

3.5 Test Methods Group 500 - Electrical Tests:

TABLE 4

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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
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510	Voltage Withstand (Wet Dielectric)
511	Wire Fusing Time

3.6 Test Methods Group 600 - Environmental Tests:

TABLE 5

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606	Weathering Resistance
607	Wicking

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708	Mandrel and Wrap Back Test
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710	Durability of Wire Manufacturer's Color/Identification
711	Durability of Wire Installer's Identification (TBD)
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TABLE 7

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803	Smoke Quantity
804	Relative Thermal Life and Temperature Index
805	Thermal Shock Resistance
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807	Multiday Heat Aging Test
808	Blocking
809	Lamination Sealing
810	Topcoat Cure
811	Crosslink Proof Test
812	Flame Resistance

3.9 Test Methods Group 900 - Wire Diameter and Weight:

TABLE 8

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

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 0.0005 in (0.013 mm) shall be used.

4.1.1.4 Test Procedure:

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

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

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

a. Size 30 through 10:

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

b. Size 8 through 0000:

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

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

4.1.1.6 Information Required in Detail Specification: Number of samples, wire size of samples, number of measurements.

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

4.1.2 Method 102, Insulation Bonding to Potting Compounds:

4.1.2.1 Scope: This test is to be used to measure the bonding between potting compounds and wire insulations.

4.1.2.2 Samples: See section 19.3 of ASTM D 3032 for sample preparation.

4.1.2.3 Test Equipment: See section 19.2 of ASTM D 3032 for test apparatus.

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

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

4.1.2.6 Information Required in the Detail Specification: Description of the potting compound, primer if applicable, surface preparation, and number of samples to be tested.

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

4.1.3 Method 103, Insulation Pull-Off Force:

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

4.1.3.2 Samples: See section 27.4 of ASTM D 3032.

4.1.3.3 Test Equipment: See ASTM D 638 and section 27.3 of ASTM D 3032.

4.1.3.4 Test Procedure:

4.1.3.4.1 Perform sections 27.5.1 through 27.5.5 of ASTM D 3032.

4.1.3.5 Results: Report results of pull test in pounds-force (Newton's).

4.1.3.6 Information Required in Detail Specification: Number of samples to be tested.

4.1.3.7 Precision Bias: This test method of ASTM D 3032 has not had the benefit of round robin testing to determine precision.

4.1.4 Method 104, Insulation Shrinkage/Expansion:

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

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

4.1.4.3 Test Equipment:

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

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

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

4.1.4.4 Test Procedure: Strip 1/2 in (12.7 mm) of insulation shall be from each end of the finished wire specimen. Use a razor blade (or equivalent) held perpendicular to the axis of the wire to remove the insulation. The length of the exposed conductor at each end of the specimen shall be measured to the nearest 0.005 in (0.13 mm). The specimen shall be exposed for 6 h to a minimum temperature of 30 °C ± 3 °C (86 °F ± 5 °C) 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.

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

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

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

4.1.5 Method 105, Solderability:

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

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

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

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

TABLE 9

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

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

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

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

4.1.6 Method 106, Thermal/Mechanical Resistance - Single Wire:

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

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

4.1.6.3 Test Equipment:

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

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

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

4.1.6.3.4 Moment external limit switch.

4.1.6.3.5 60 min standard timer.

4.1.6.3.6 Continuity detector box.

4.1.6.3.7 Test setup, fixture, and procedure.

4.1.6.4 Test Procedure:

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

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

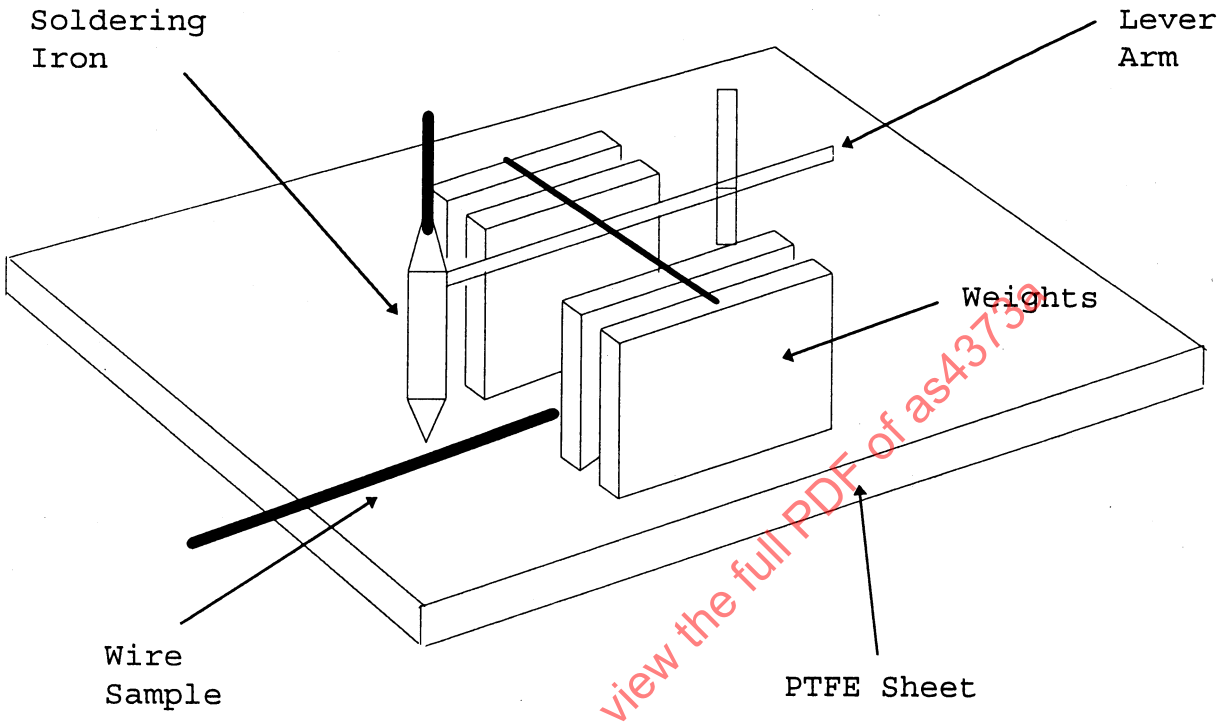

FIGURE 1 - Thermal/Mechanical Resistance Test Setup

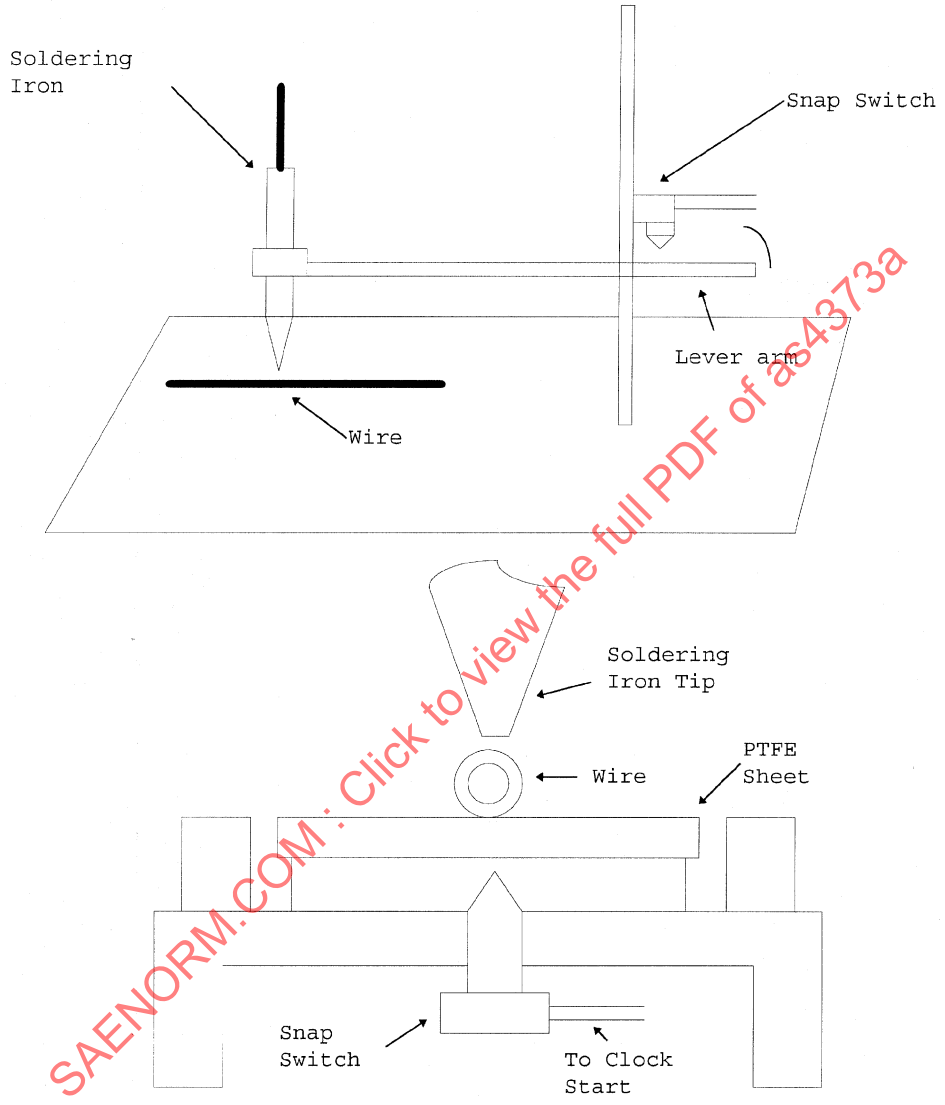

FIGURE 2 - Two Suggested Placements for Snap Switch to Start Timer

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

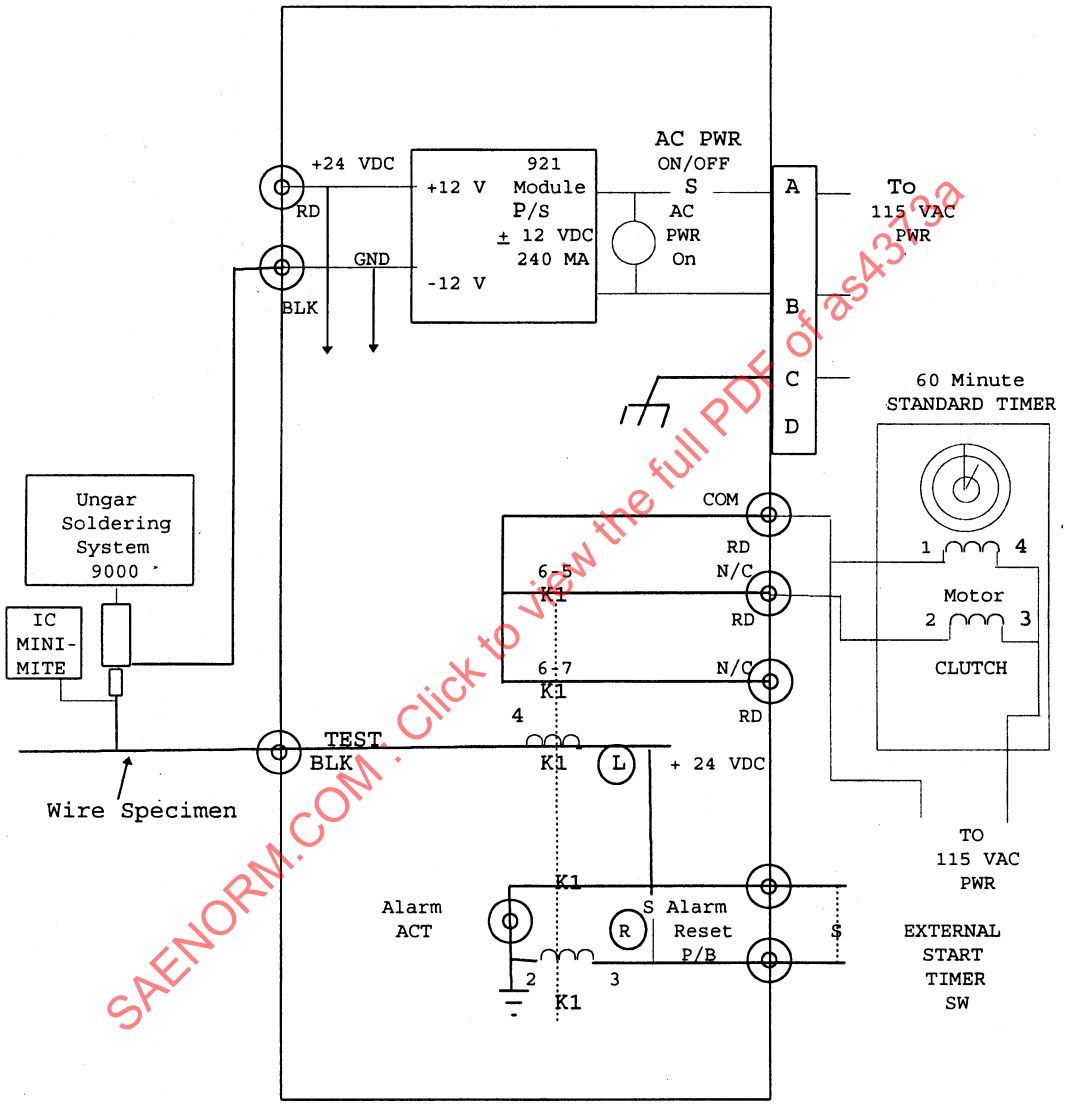

FIGURE 3 - Continuity Detection Circuit for Solder Iron Resistance Test

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

4.1.6.4.2 Test Procedure:

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

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

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

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

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

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

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

4.1.6.6 Information Required in Detail Specification: Number of samples and wire size of samples.

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

4.1.7 Method 107, Thermal/Mechanical Resistance - Bundle:

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

4.1.7.2 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.

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

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

4.1.7.5 Results: Report the time to penetration at all test temperatures.

4.1.7.6 Information Required in Detail Specification: Number and wire size of samples to be tested.

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

4.1.8 Method 108, Solder Pot Test for Insulation Shrinkage:

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

4.1.8.2 Samples: The sample shall be a length of insulation not less than 6 in (152 mm).

4.1.8.3 Test Equipment: The equipment shall be as specified in Section 3.1 of Fed. Test Method Std. No. 228, Method 8231.

4.1.8.4 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.

4.1.8.5 Results: Record the amount of shrinkage to the nearest 1/32 in or 1 mm for each sample tested.

4.1.8.6 Information Required in Detail Specification: Number and wire size of samples to be tested.

4.1.8.7 Precision Bias: The results of this test should be expressed in 1/32 in or 1 mm 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. 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 WL-MLSA, Wright Patterson AFB, Ohio. In addition, the Army has done extensive testing of a number of materials and should be consulted before testing to determine if a candidate insulation material has already been tested. Contact for this is NBC Survivability Office, Army CR&D, Edgewood, MD.

The intent of this material testing is to assure inertness of a material to the CBR/NBC exposure. The Air Force and the Army has established over a dozen qualified laboratories to do this type of CBR/NBC testing, 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.

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: See MIL-STD-2223 Method 3007.

4.3.3 Test Equipment: See MIL-STD-2223 Method 3007.

4.3.4 Test Procedure: See MIL-STD-2223 Method 3007.

4.3.5 Results: Report the number of wires which pass the dielectric test after the bundle has been energized, and the length of physical damage to the individual wires in the bundle.

4.3.6 Information Required in the Detailed Specification: Wire type and number of bundles tested.

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

been established.

4.4 Test Methods Group 400 - Conductor Tests:

4.4.1 Method 401, Conductor Diameter:

4.4.1.1 Scope: This test is to be used to determine the diameter of 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: A circumferential measuring tape calibrated to measure conductor diameter to the nearest 0.01 in (0.25 mm).

4.4.1.4 Test Procedure: Remove the insulation without damaging or distorting the conductor. Determine the conductor diameter by measuring the outer diameter in at least three locations 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.

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: This is a process control test.

NOTE: This test is primarily used to inspect uninsulated conductor. It is difficult to prepare the uninsulated sample once the conductor has been insulated.

4.4.2 Method 402, 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, except that for sizes 22 AWG and smaller, the test sample shall consist of the whole stranded conductor removed from the finished wire. For high strength copper alloys the test sample shall consist of the whole stranded conductor removed from the finished wire for all sizes.

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, except that power actuated or mechanical vise grips may be used. In addition, a strip chart recorder or digital indicator shall be used in conjunction with the testing machine to measure the applied load and travel distance of the specimen 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 the travel distance of the grip rather than by measuring the specimen after the break. The elongation shall be measured when the first strand of the stranded conductor breaks as indicated on the recording devise. 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 conductor 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: This is a process control test.

NOTE: This test is primarily used to inspect uninsulated conductor. It is difficult to prepare the uninsulated sample once the conductor has been insulated.

4.4.3 Method 403, Conductor Resistance Per Unit Length:

4.4.3.1 Scope: This test is to be used to measure or calculate the DC resistance per unit length of a conductor at 20 °C (68 °F). Correction values are given to allow for resistance measurements taken at other than 20 °C (68 °F).

4.4.3.2 Samples: See Section 2 of Method 6021, Fed. Test Method Std. No. 228.

4.4.3.3 Test Equipment: See Section 3 of Method 6021, Fed. Test Method Std. No. 228.

4.4.3.4 Test Procedure: See Section 4 of Method 6021, Fed. Test Method Std. No. 228.

4.4.3.5 Results: Report measured resistance of sample, measured length of sample, calculated resistance per 1000 ft (305 m), and test temperatures.

4.4.3.6 Information Required in Detail Specification: Number of samples, conductor size of samples, acceptable resistance values.

4.4.3.7 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 (alpha t) = 0.0034 for high strength copper alloys (PD 135)).

4.4.4 Method 404, Conductor Strand Blocking:

4.4.4.1 Scope: This test provides a method for examination of 7 and 19 strand conductors for conductor strand blocking (adhesion).

4.4.4.2 Samples: The sample shall be a 6 in (152 mm) length of finished wire.

4.4.4.3 Test Equipment:

4.4.4.3.1 Wire insulation stripping tool.

4.4.4.3.2 Fine needle or thin blade.

4.4.4.3.3 Device to sever conductor strands.

4.4.4.4 Test Procedure:

4.4.4.4.1 Preparation of 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.

4.4.4.4.2 Procedure:

4.4.4.4.2.1 For 19 Strand Unidirectional Lay and all 7 Strand:

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

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

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.

4.4.4.4.2.2 For 19 Strand "True Concentric" Lay:

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

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

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

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

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

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

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

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

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

4.5 Test Methods Group 500 - Electrical Tests:

4.5.1 Method 501, Dielectric Constant:

4.5.1.1 Scope: This test is to be used to determine the dielectric constant (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: This is a material dependent test.

4.5.2 Method 502, Corona Inception and Extinction Voltages:

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

4.5.2.2 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: See ASTM D 3032.

4.5.3 Method 503, Impulse Dielectric:

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

4.5.3.2 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.

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 MΩ - 1000 ft , is usually desirable.

4.5.5 Method 505, Spark Test of Finished Wire Insulation:

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

4.5.5.2 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 7.3 of ASTM 3032.

4.5.6.3 Test Equipment: See Section 7.2 of ASTM 3032.

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

4.5.6.5 Results: Report the DC potential and surface resistance values.

4.5.6.6 Information Required in Detail Specification: Number and wire size of samples to be tested.

4.5.6.7 Precision Bias: A minimum surface resistance value of 5 MΩ - inch is usually desirable.

4.5.7 Method 507, Time/Current to Smoke:

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

4.5.7.2 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 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 against a black background adequately illuminated to see the smoke. Apply 10 A for 30 s, then 15 A for 30 s and continue to increase current in 5 A steps every 30 s until there is evidence of smoke.

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

4.5.7.6 Information Required in Detail Specification: Number and wire size of 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 DETERMINED

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

4.5.9 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.

4.5.9.2 Samples: See MIL-STD-2223 Method 3006.

4.5.9.3 Test Equipment: See MIL-STD-2223 Method 3006.

4.5.9.4 Test Procedure: See MIL-STD-2223 Method 3006.

4.5.9.5 Results: Report number of wires which pass the dielectric test and the length of physical damage to the wire in the bundle.

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 for 600 V or higher rated wire.

4.5.11 Method 511, Wire Fusing Time:

4.5.11.1 Scope: This test is to be used to determine the time for an insulated wire to interrupt current 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.

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 method 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 10.

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

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

4.6.1.4 Test Procedure:

4.6.1.4.1 Each 24 in (610 mm) specimen, for each test fluid in Table 10, shall have its diameter measured and shall then be immersed to within 6 in (152 mm) of each end for the time and temperature specified. During immersion, the radius of bend of the wire shall be not less than 14 nor more than 35 times the specified maximum diameter of the wire under test. Upon removal from the test fluid, the specimen shall be wiped dry and then remain for 1 h in free air at room temperature. The diameter shall be measured and compared to the initial diameter. The insulation shall be removed for a distance of 0.5 in (13 mm) from each end of the specimen. The specimen shall then be subjected to the Bend Test Method 713 and Voltage Withstand (Wet Dielectric) Method 510.

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

4.6.1.6 Information Required in Detail Specification: The wire size and the fluids to be used for immersion.

4.6.1.7 Precision Bias: This is a fluid and material dependent test.

TABLE 10 - Fluid Table

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

4.6.2 Method 602, Forced Hydrolysis:

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

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

4.6.2.4 Test Procedure:

4.6.2.4.1 Heat Conditioned Wire:

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

4.6.2.4.2 Unconditioned Wire: 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 test method has not had the benefit of any round-robin testing to determine precision.

4.6.3 Method 603, Humidity Resistance:

4.6.3.1 Scope: This test is to be used to determine the effects of humidity and temperature cycling on the wire 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 °C ± 3 °C (158 °F ± 5 °F) and an internal relative humidity of 95% ± 5%. The test chamber shall be capable of being sealed to retain the total moisture content in the test space. The heat loss from the chamber shall be sufficient to reduce the internal temperature from the above specified operating temperature to 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.

4.6.3.4 Test Procedure: The specimen shall be placed in the test chamber and the temperature and relative humidity raised over a 2 h period to the values specified in 4.6.3.3.1 and maintained at such for a period of 6 h. At the end of the 6 h period the heat shall be shut off. During the following 16 h period, the temperature shall drop to 38 °C ± 3 °C (100 °F ± 5 °F) or lower. At the end of the 16 h period, heat shall be again supplied for a 2 h period to stabilize to 70 °C ± 3 °C (158 °F ± 5 °F). This cycle (2 h heating, 6 h at high temperature, 16 h cooling) shall be repeated 15 times to extend the total time of the test to 360 h. At the end of the fifteenth cycle, the 50 ft (16.4 m) center section of the specimen shall be removed from the chamber and tested within 1 h for insulation resistance in accordance with Method 504.

4.6.3.5 Results: Report the insulation resistance in M - 1000 ft.

4.6.3.6 Information Required in the Detail Specification: The number and wire size of samples.

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

4.6.4 Method 604, Weight Loss Under Temperature and Vacuum:

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

4.6.4.2 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.

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 test method 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 of 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 1.5 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 following list.

4.6.5.3.3 A device to remove the insulation off each end of the wire sample.

TABLE 11

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_2H_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 1 in 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.

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: This is a fluid and material dependent test.

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:

a. 8 h UV at 70 °C ± 3 °C (158 °F ± 5 °F) = 1 cycle
b. 4 h Condensation at 40 °C ± 3 °C (104 °F ± 5 °F)

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

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

4.6.6.6 Information Required in the Detail Specification: The number and wire size of the samples.

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

4.6.7 Method 607, Wicking:

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

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

4.6.7.3 Test Equipment:

4.6.7.3.1 A container to hang the specimens 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. The dye solution shall be prepared as follows:

a. Ethyl Alcohol: 30 ml
b. Rhodamine B dye: 0.02 g
c. Aerosol OT: 3 ml
d. Distilled water to make 2 L

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

4.6.7.3.3 A sharp blade to remove the wire insulation.

4.6.7.3.4 A clean dry lint free cloth.

4.6.7.3.5 A UV light source.

4.6.7.3.6 A scale capable of 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 Multi-layer Wire: The specimen shall be placed upright with the lower 2 in (51 mm) of its length immersed in the dye solution (4.6.7.3.2) in an open container and shall be left for 24 h at room temperature in a draft free area. It shall then be removed from the dye solution, 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 of an inch, the distance the dye solution has traveled in any part of the insulation by wicking action. The layers of insulation may be dissected away with a sharp blade, working from the upper end of the specimen to facilitate observation.

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

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

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

4.6.7.7 Precision Bias: This test can be used for design evaluation or process control.

4.7 Test Methods Group 700 - Mechanical Tests:

4.7.1 Method 701, Abrasion: TO BE DETERMINED

There 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.

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 °C ± 3 °C (-85 °F ± 5 °F) and allows mechanical access for wrapping the specimen around a mandrel.

4.7.2.3.2 A rotatable mandrel for installation into the above chamber.

4.7.2.3.3 A sharp blade to remove the specimen insulation.

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

4.7.2.4 Test Procedure: One end of the specimen shall be secured to the rotatable mandrel in the cold chamber and the other end to the test weight sufficient to hold the specimen taut on the mandrel. Provisions shall be made for rotating the mandrel by means of a handle or control located outside the chamber. The specimen of wire and the mandrel shall be conditioned at -65 °C ± 3 °C (-85 °F ± 5 °F) for 4 h. At the end of this period and while both mandrel and specimen are still at this low temperature, the specimen shall be wrapped helically, for its entire length or for 20 turns, whichever is the lesser number of turns, around the mandrel without opening the chamber. The bending shall be accomplished at a uniform rate of 2 rpm ± 1 rpm. At the completion of this test the specimen shall be removed from the cold box and from the mandrel without straightening. 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.

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 design evaluation or for process control. Mandrel sizes and weights will differ for each.

4.7.3 Method 703, Dynamic Cut-Through:

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

4.7.3.2 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. The standard cutting edge shall be a 20 ml diameter sewing needle.

4.7.3.4 Test Procedure: See Sections 22.4 through 22.5 of ASTM D 3032 for the test procedure.

4.7.3.5 Results: Report the force to cut-through each 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 method has not had the benefit of any round-robin testing to determine precision.

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

4.7.4 Method 704, Flex Life:

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

4.7.4.2 Samples: Each sample shall be size 22 wire prepared in accordance with 4.7.4.2.1 and 4.7.4.2.2.

NOTE: Prior to testing, check the dielectric strength of the insulation on each specimen. Use test method 510 of AS4733, eliminating the 4 h soak. Discard and replace all specimens that fail.

4.7.4.2.1 Step 1, Flex to Failure: Six 18 in specimens are required. Attach a Number 10 ring tongue terminal to one end of each specimen, be sure the terminal is attached to the conductor only. The terminal is used to attach weights to the specimens under test.

4.7.4.2.2 Step 2, Predetermined Number of Cycles: Twelve 18 in specimens are required. Specimens are to be prepared as described in 4.7.4.2.1.

4.7.4.3 Test Equipment: Construct the test fixture as shown in Figure 4. The PTFE coated mandrels shall have a diameter approximately six times the outer diameter of the wire specimen. The flex arm shall rotate +90° from vertical; a total of 360° of motion constitutes 1 cycle. Flex rate shall be 25 to 30 cpm. Weights having a total minimum value of 4.0 lb shall be attached to the conductor of the specimen and placed between the guide rods which are used to eliminate weight swing.

4.7.4.4 Test Procedure:

4.7.4.4.1 Step 1, Flex to Failure: Install the specimen in the fixture, attach the weight and flex at 25 to 30 cpm. Flex until complete separation of insulated wire occurs and the weight drops (catastrophic failure).

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

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

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

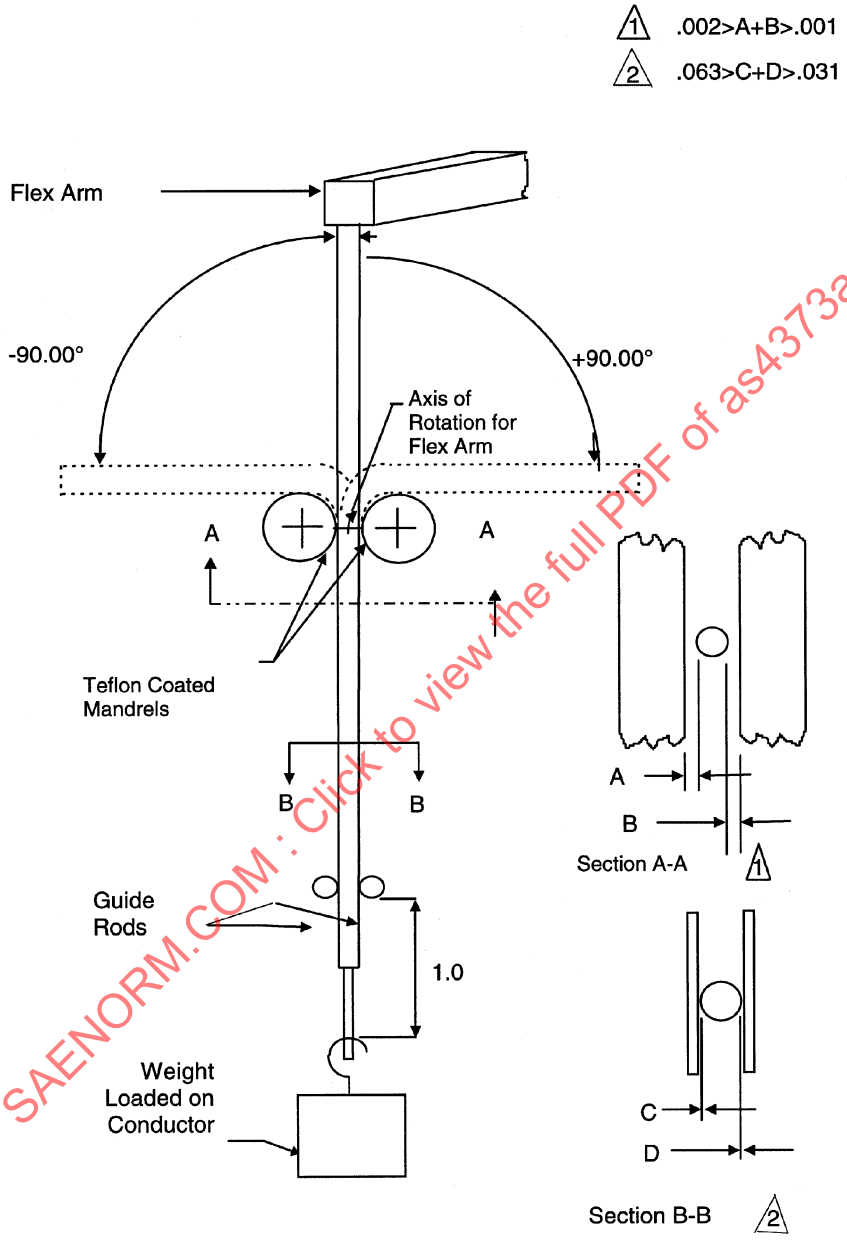

FIGURE 4 - Flex Life Test Setup

4.7.4.5 Results:

4.7.4.5.1 Step 1, Flex Until Failure: Record the number of cycles to failure for each specimen. Establish the baseline for Step 2 testing by determining the average number of cycles to failure of the samples tested.

4.7.4.5.2 Step 2, Predetermined Number of Cycles: Describe and/or photograph the condition of each specimen at the point of flexure. Note the condition of the insulation and record the number of broken strands of the conductor for each specimen. Note any catastrophic failures and the number of cycles when occurred.

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

4.7.4.7 Precision Bias: This procedure does not have the benefit of round robin testing.

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

4.7.5 Method 705, Insulation Tensile Strength and Elongation:

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

4.7.5.2 Samples: See Section 17.3 of ASTM D 3032 for sample preparation.

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

4.7.5.3 Test Equipment: See Section 17.2 of ASTM D 3032 for test apparatus.

4.7.5.4 Test Procedure: See Sections 17.4 through 17.5 of ASTM D 3032 for the test procedure.

4.7.5.5 Results: Report the rate of jaw separation, the tensile strength and elongation.

4.7.5.6 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.

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

4.7.6 Method 706, Notch Propagation:

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

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

4.7.6.3 Test Equipment:

4.7.6.3.1 A notching tool as described in Figure 5.

4.7.6.3.2 A 6X mandrel for wrapping of the specimen.

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

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

4.7.6.6 Information Required in the Detail Specification: The number and wire size of the samples and the notch depth(s).

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

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

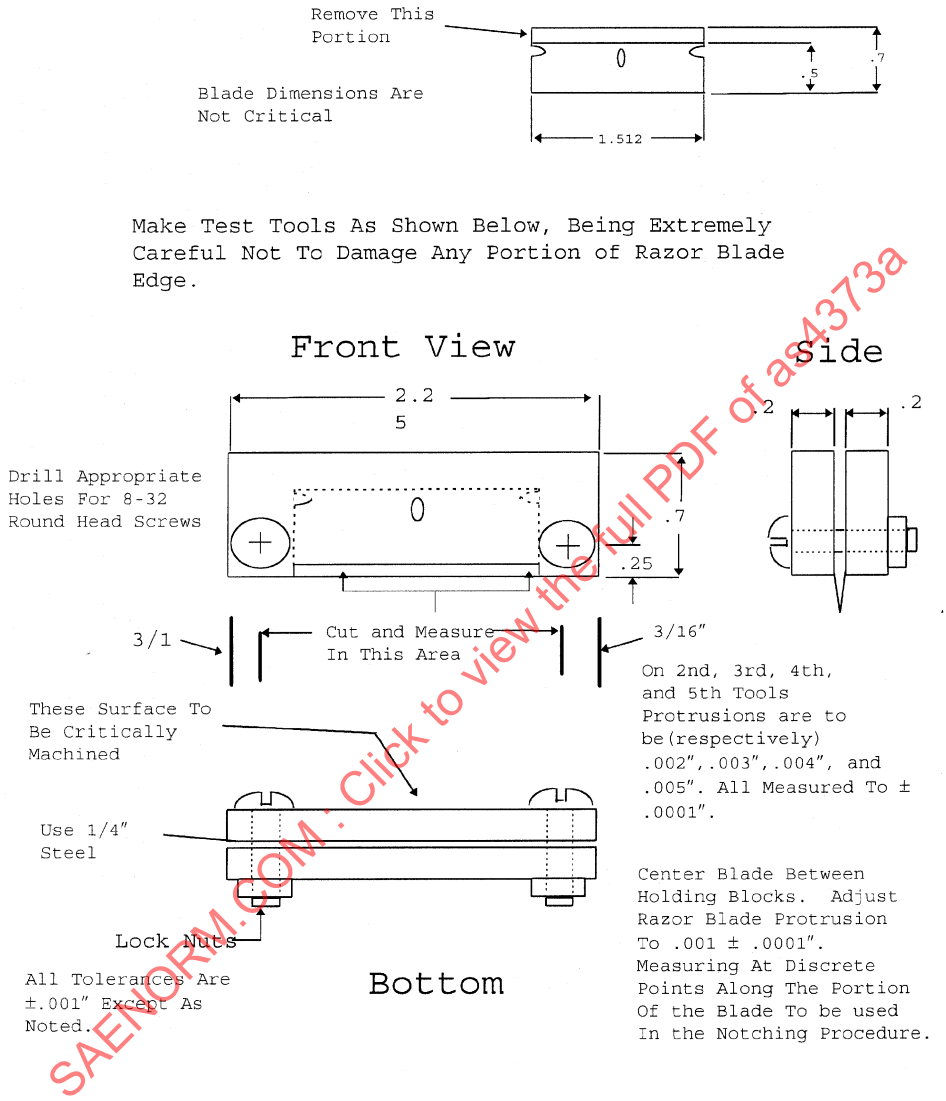

FIGURE 5 - Notching Tool

4.7.7 Method 707, Stiffness and Springback:

4.7.7.1 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.

4.7.7.2 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.

4.7.7.3 Test Equipment:

4.7.7.3.1 An apparatus consisting of a pivoting arm mounted in the center of a scaled plate shall be fabricated according to Figures 6 and 7.

4.7.7.3.2 A torque meter/wrench.

4.7.7.3.3 Alligator clip and string or equivalent.

4.7.7.4 Test Procedure: The test fixture shall be placed on a flat surface with the edge of the plate on the side of the wire specimen exit point from the hub located next to a clear vertical drop. The span selector shall be adjusted for the desired length of bend. The pivot arm shall be rotated to the 90° 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 12 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.

TABLE 12

Wire Size	Weight in lb	Weight in kg
22	1.0	0.45
26	0.5	0.23

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.

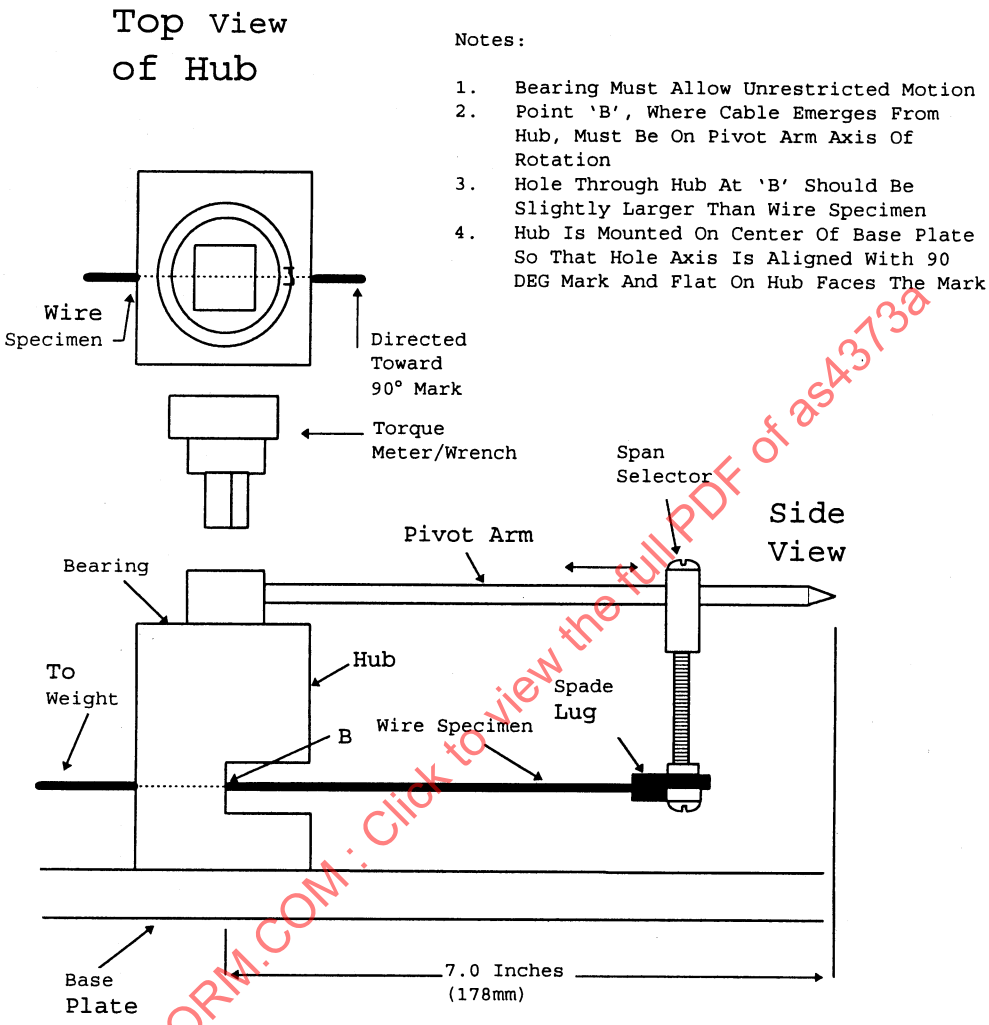

FIGURE 6 - Test Fixture Stiffness and Springback

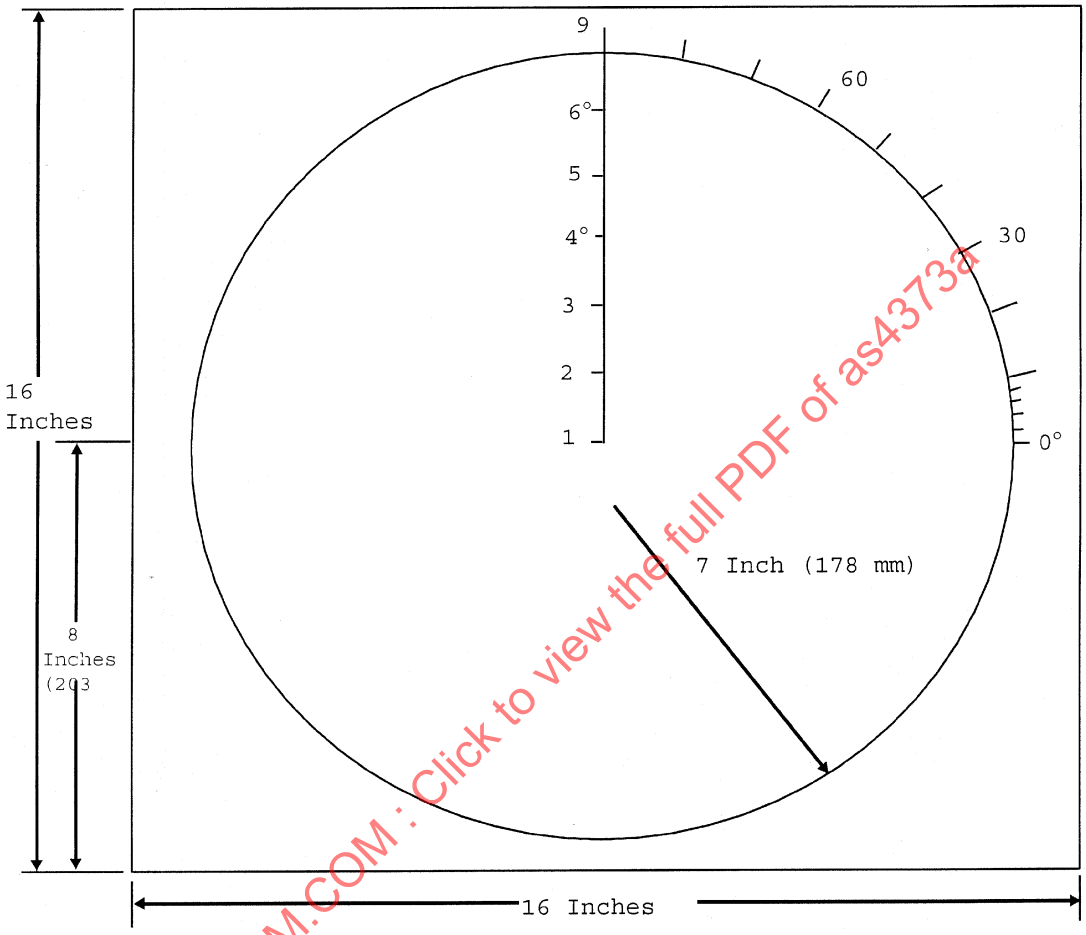

FIGURE 7 - Stiffness and Springback Fixture Base Plate

4.7.7.5 Results: Report the torque needed to pull the specimen through the 90° bend and the degrees of springback.

4.7.7.6 Information Required in the Detail Specification: The number and wire size of the samples to test and the span selector length for testing.

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

a. 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).

4.7.8 Method 708, Mandrel and Wrapback Test:

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

4.7.8.2 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.

4.7.8.3 Test Equipment:

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

4.7.8.3.2 Test mandrels as called out in the Detail Specification.

4.7.8.4 Test Procedure:

4.7.8.4.1 Wrap Back Test: This test applies to sizes 10-30 finished wire for all insulation's. 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 8). After removal from the oven, the specimen shall be examined visually, without the aid of magnification for cracks.

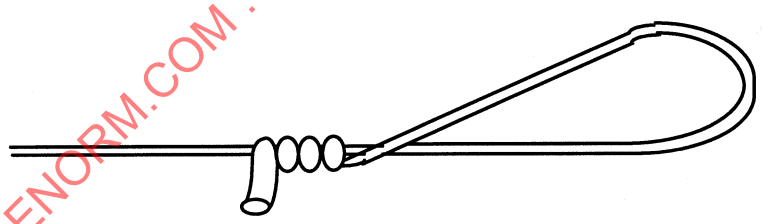

FIGURE 8 - Wrap Back Test

4.7.8.4.2 Mandrel Test: This test applies to sizes 0000-8 finished wire for all insulation's. 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.

4.7.8.5 Results: Report any cracking of the insulation. Report the Voltage Withstand Test results for the Mandrel test of Procedure 4.7.10.4.2.

4.7.8.6 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.

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

4.7.9 Method 709, Wrinkle Test:

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

4.7.9.2 Sample: The test sample shall be a 12 in (305 mm) length of finished wire.

4.7.9.3 Test Equipment:

4.7.9.3.1 A device to provide 3X magnification.

4.7.9.3.2 Steel mandrels sized appropriately for the samples tested.

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

TABLE 13

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

The wire 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.

4.7.9.5 Results: Report wrinkling for each sample tested.

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

4.7.9.7 Precision Bias: This is a process control test.

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

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

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

4.7.10.3 Test Requirement:

4.7.10.3.1 The marking durability test fixture shall be designed to hold a 6 in (152 mm) specimen of finished wire firmly clamped in a horizontal position with the upper longitudinal surface of the specimen fully exposed. The durability apparatus, such as the GE Scrape Abrader Apparatus or equivalent, shall be capable of rubbing a small cylindrical sewing needle, 0.025 in ± 0.002 in (0.63 mm ± 0.05 mm) in diameter, repeatedly over the upper surface of the wire 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.

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

4.7.10.4 Test Procedure: 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.

4.7.10.5 Results: Report any specimen that fails.

4.7.10.6 Information Required in the Detail Specification: The number and wire size of the specimens.

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

4.7.11 Method 711, Durability of Wire Installer's Identification: A test procedure for this method is currently being developed. Upon it's completion the procedure will be included in future revisions.

4.7.12 Method 712, Bend Test:

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

4.7.12.2 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.)

4.7.12.3 Test Equipment: Mandrels and weights as specified in Table 14.

TABLE 14

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

4.7.12.4 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.

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

4.7.12.6 Information Required in the Detail Specification: None.

4.7.12.7 Precision Bias: This is an established test.

4.8 Test Methods Group 800 - Thermal Tests:

4.8.1 Method 801, Flammability:

4.8.1.1 Scope: This test evaluates a finished wire sample's burning characteristics.

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

4.8.1.3 Test Equipment:

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

4.8.1.3.2 A thermocouple pyrometer.

4.8.1.3.3 A sheet of facial tissue conforming to A-A-1505.

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

4.8.1.4 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: This is an established test.

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

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

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

4.8.2.3.2 A 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 constructed as shown in Figure 11. The wire harness shall be firmly mounted above and perpendicular to the slot in the tube with a distance of 1.0 in ± 0.125 in (25 mm ± 3.2 mm) between them. Apply power to the harness and then initiate air flow through the tube. Air temperatures shall be maintained at 315 °C ± 3 °C (600 °F ± 5 °F) and air pressure shall be maintained at 70 to 80 psi. After 2 h, remove power, interrupt air flow, and determine if any of the following conditions exist or existed during the test.

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

4.8.3 Method 803, Smoke Quantity:

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

4.8.3.2 Samples: See Section 7.3.2.5 of ASTM F 814.

4.8.3.3 Test Equipment: See Section 6 of ASTM F 814.

4.8.3.4 Test Procedure: See Section 10 of ASTM F 814.

4.8.3.5 Results: See Section 12 of ASTM F 814.

4.8.3.6 Information Required in the Detail Specification: The wire size of the samples to be tested.

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

4.8.4 Method 804, Thermal Index:

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

NOTE: This test has a duration of 10 to 15 months as a minimum.

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

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

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

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

4.8.4.6 Information Required in the Detail Specification: The wire size and number of samples to be tested as given in Section 14.5 of ASTM D 3032.

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