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MIL-STD-2223
31 AUGUST 1992

MILITARY STANDARD

TEST METHODS
FOR
INSULATED ELECTRIC WIRE

AMSC N/A

FSC 6145

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FOREWORD

Test Methods for Insulated Electric Wire

1. This military standard is approved for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this standard should be addressed to: Commanding Officer, Naval Air Warfare Center Aircraft Division Lakehurst, Systems Requirements Department (Code SR3), Lakehurst, NJ 08733-5100, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this standard or by letter.

3. Background. The selection of insulated electric wire for use in the design and construction phase of weapons systems and equipment requires the evaluation and correlation of test data. The data received from prime contractors, wire manufacturers, private laboratories, and military laboratories has not been able to be correlated to past data. The chief reason for this is the absence of a unified standard prescribing test methods, procedures, apparatus, data analysis, and data presentation. The absence of a single coordinated standard encourages and often requires duplication of testing and reduces reliability of weapons systems and equipment, thereby impairing engineering control, design maintenance, quality assurance, standardization, and logistics.

To correct this situation, a unified set of test methods and procedures was required to be developed to serve as a basic engineering tool for obtaining and presenting engineering data. As a result, this standard was developed and prepared to satisfy this vital need. This standard delineates standard test methods, procedures, conditions, apparatus, and methods of recording, analyzing and presenting test data. The purpose of the resulting test data is to determine the capability of insulated electric wire to withstand the various environmental, electrical and mechanical conditions encountered when used in military weapons systems.

The test methods of this standard were drawn from existing coordinated commercial, military and federal specifications. Test method selection was based on ability of the method to be referenced in military acquisition specifications, correlation of the method to actual operating conditions, usage history of the method, and the ability of the method to provide repeatable results.

Test methods meeting the above criteria are yet to be determined for the following tests:

Abrasion
Dynamic Cut-Through
Flex Life
Dry Arc Resistance and Fault Propagation
Wet Arc Resistance
Insulation Removability/Pulloff Force

Test methods for these requirements are planned to be added to this standard when acceptable test methods are developed or identified.

CONTENTS

FIGURES (Continued) PAGE

TABLES PAGE

1. SCOPE

1.1 Applicability. This standard establishes test methods for insulated single conductor electric wires made with tin-coated, silver-coated or nickel-coated conductors of copper or copper alloy.

1.2 Numbering system. The test methods are designated by numbers assigned in accordance with the following system.

1.2.1 Class of tests. The tests are divided into classes as shown below:

1001 - 1999	-	Environmental tests
2001 - 2999	-	Mechanical tests
3001 - 3999	-	Electrical tests
4001 - 4999	-	Thermal tests
5001 - 5999	-	Visual and physical conductor tests
6001 - 6999	-	Visual and physical finished wire tests
7001 - 7999	-	Special tests

1.2.2 Revision of test methods. Revisions are identified by a decimal point and a number added to the basic method number. For example, if the wrap test is initially 2002, the first revision will be numbered 2002.1; 2002.2 will indicate the second revision issued. Subsequent revisions will be numbered consecutively.

1.3 Method of reference. When applicable, test methods herein shall be referenced in the individual specification by specifying this standard, the method number, and the details required in the summary paragraph of the applicable method. To avoid revising specifications that refer to this standard, the decimal number shall not be used when referencing test methods of this standard. For example, use 2002 not 2002.1.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

SPECIFICATIONS

FEDERAL

QQ-S-571	Solder, Tin Alloy: Tin-Lead Alloy; and Lead Alloy
TT-I-735	Isopropyl Alcohol

SPECIFICATIONS (Continued)

MILITARY

MIL-H-5606	Hydraulic Fluid, Petroleum Base; Aircraft, Missile and Ordnance
MIL-T-5624	Turbine Fuel, Aviation, Grades JP-4, JP-5, and JP-5/JP-8ST.
MIL-L-6082	Lubricating Oil, Aircraft Piston Engine (Non-Dispersant Mineral Oil)
MIL-P-7254	Propellants, Nitric Acid
MIL-F-14256	Flux, Soldering, Liquid (Rosin Base)
MIL-L-23699	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, NATO Code Number 0-156
MIL-P-26536	Propellant, Hydrazine
MIL-P-26539	Propellants, Nitrogen Tetroxide
MIL-P-27402	Propellant, Hydrazine-uns-Dimethylhydrazine (50% N_2H_4 - 50% UDMH)
MIL-W-81381	Wire, Electric, Polyimide-Insulated, Copper or Copper Alloy

STANDARDS

FEDERAL

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

MILITARY

MIL-STD-202	Test Methods for Electronic and Electrical Component Parts
MIL-STD-810	Environmental Test Methods and Engineering Guidelines

(Unless otherwise indicated, copies of federal and military specifications, standards and handbooks are available from the DODSSP Standardization Document Order Desk, 700 Robbins Avenue, Bldg. 4D, Philadelphia, PA 19111-5094.)

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM E 104	Standard Practice for Maintaining Constant Relative Humidity By Means of Aqueous Solutions
ASTM B 355	Nickel Coated Soft or Annealed Copper Wire, Standard Specification for
ASTM D 412	Rubber Properties in Tension, Standard Test Methods
ASTM D 910	Aviation Gasoline, Standard Specification for
ASTM D 3032	Wire Insulation, Hookup, Standard Methods of Testing

(Applications for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103-1187.)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE), INTERNATIONAL

SAE-ARP-1931	Glossary of Terms With Specific Reference to Electrical Wire and Cable
SAE-AS4373	Test Methods for Insulated Electric Wire

(Application for copies should be addressed to SAE, International, 400 Commonwealth Avenue, Warrendale, PA 15096-0001.)

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NBS-HDBK-100	Copper Wire Cable

(Application for copies should be addressed to National Institute of Standards and Technology, Administration Building 101 (Publications Office), Gaithersburg, MD 20879.)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 Terms and definitions. Unless otherwise defined in this document, the definitions applicable to this document are defined in publication SAE-ARP-1931.

4. GENERAL REQUIREMENTS

4.1 Test requirements. The requirements that must be met by the wires subjected to the test methods described herein are specified in the individual specifications. Whenever this document conflicts with the individual specification, the latter shall govern.

4.2 Standard test conditions. Unless otherwise specified herein, or in the individual specification, all measurements and tests shall be made at temperatures of 15° to 35°C (59° to 95°F) at air pressure of 650 to 800 millimeters of mercury, and a relative humidity of 45 to 75 percent. Whenever these conditions must be closely controlled in order to obtain more reproducible results; for referee purposes, temperature, relative humidity, and atmospheric pressure conditions of 25 + 0, -2°C (77 + 0, -3.6°F), 50 percent ±2 percent, and 650 to 800 millimeters of mercury shall be used.

4.3 Test materials. It shall be the responsibility of the user of this standard to locate the proper equipment, supplies, fluids, and other returned items of this standard. Sources for some of the items are listed on Qualified Products List for that specification. The preparing activity of this standard and the qualifying activity of the appropriate wire specifications may be contacted to assist in locating test materials. The government is prohibited from providing specific suggested sources on non-QPL items in Military Standards by paragraph 4.6 of MIL-STD-962. However, the qualifying activity of the particular specification can provide guidance to assist you in locating test materials in many instances.

5. DETAIL REQUIREMENTS

5.1 Index of test methods. Table I is the numerical index of the individual test methods described herein.

TABLE I. Numerical index of test methods.

Method Number	Title
	Environmental tests - Class 1000
1001	Fluid Immersion
1002	Nitric Acid Immersion (Acid Resistance)
1003	Propellant Immersion (Propellant Resistance)
1004	Humidity Resistance
1005	Wicking
1006	Flammability
1007	Flame Resistance (Fire Resistant Wire)
1008	Steam Aging of Topcoat (Cure)
	Mechanical tests - Class 2000
2001	Insulation Tensile Strength and Elongation
2002	Wrap
2003	Wrap Back

TABLE I. Numerical index of test methods - Continued.

Method Number	Title
2004	Cold Bend
2005	Circumferential Insulation Elongation
2006	Bend
2007	Wrinkle
	Electrical tests - Class 3000
3001	Spark Test of Primary Insulation
3002	Impulse Dielectric
3003	Insulation Resistance
3004	Surface Resistance
3005	Wet Dielectric
	Thermal tests - Class 4000
4001	Elevated Temperature Aging (Life Cycle)
4002	High Temperature Endurance (Fire Resistant Wire)
4003	Crosslink Proof (Accelerated Aging)
4004	Thermal Shock
4005	Insulation Shrinkage/Expansion
4006	Lamination Sealing
4007	Blocking
4008	Smoke
	Visual and Physical Conductor tests - Class 5000
5001	Conductor Diameter
5002	Conductor Elongation and Break Strength
5003	Conductor Resistance
5004	Conductor Solderability
5005	Conductor Strand Blocking
5006	Adhesion of Nickel Coating
	Visual and Physical Finished Wire tests - Class 6000
6001	Finished Wire Diameter
6002	Finished Wire Weight
6003	Insulation Wall Thickness and Concentricity
6004	Print Identification or Color Code Durability
6005	Percent Overlap of Insulating Tapes

5.2 Cross reference list for test methods. Table II provides a cross-reference to similar, but not identical, commercial or government wire test method standards. The list is provided to assist the user in comparing test data and methods. Environmental and general test methods for electronic equipment are provided in MIL-STD-810 and MIL-STD-202.

TABLE II. Cross-reference list for test methods.

Method Number	Test Method Title	FED-STD-228 (Method)	ASTM D 3032 (Section)	SAE AS 4373 (Method)
1001	Fluid Immersion	7021	23	601
1002	Nitric Acid Immersion	7011	--	--
1003	Propellant Immersion	--	--	605
1004	Humidity Resistance	--	--	603
1005	Wicking	--	--	607
1006	Flammability	5211 5221	18	801
1007	Flame Resistance	--	--	813
1008	Steam Aging of Topcoat	--	--	811
2001	Insulation Tensile Strength and Elongation	3021 3031	17	706
2002	Wrap	--	--	--
2003	Wrapback	--	--	710
2004	Cold Bend	2011	--	702
2005	Circumferential Insulation Elongation	--	--	--
2006	Bend	--	--	714
2007	Wrinkle	--	--	711
3001	Spark test of Primary Insulation	6211		505
3002	Impulse Dielectric	--	13	503
3003	Insulation Resistance	6031	6	504
3004	Surface Resistance	6041	7	506
3005	Wet Dielectric	6111	8	510
4001	Elevated Temperature Aging	--	--	808
4002	High Temperature Endurance	--	--	--
4003	Crosslink Proof	--	--	812
4004	Thermal Shock	--	24	805
4005	Insulation Shrinkage/Expansion	--	21	105
4006	Lamination Sealing	--	--	810
4007	Blocking	--	--	809
4008	Smoke	--	--	507
5001	Conductor Diameter	3211	--	401
5002	Conductor Elongation and Tensile Strength	3212	--	402/403
5003	Conductor Resistance	6021	--	404
5004	Conductor Solderability	--	--	106
5005	Conductor Strand Blocking	--	--	405
5006	Adhesion of Nickel Coating	--	--	--
6001	Finished Wire Diameter	--	15	901
6002	Finished Wire Weight	8311	--	902
6003	Insulation Wall Thickness and Concentricity	--	16	101
6004	Print Identification and Color Code Durability	--	--	712

6. NOTES

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

6.1 Intended use. This standard contains requirements for the development of test methods for insulated electric wire.

6.2 Subject term (key word) listing.

Circumferential
Insulation
Mandrels
Sample
Thermal
Typical
Wicking

6.3 Data requirements. The following Data Item Descriptions (DID's) must be listed, as applicable, on the Contract Data Requirements List (DD Form 1423) when this standard is applied on a contract, in order to obtain the data, except where DOD FAR Supplement 27.475-1 exempts the requirement for a DD Form 1423.

Reference Paragraph	DID Number	DID Title	Suggested Tailoring
5.1	DI-NDTI-80809A	Test/Inspection Reports	

The above DID's were those cleared as of the date of this standard. The current issue of DOD 5010.12-L, Acquisition Management Systems and Data Requirements Control List (AMSDL), must be researched to ensure that only current, cleared DID's are cited on the DD Form 1423.

CLASS 1000

ENVIRONMENTAL TESTS

METHOD 1001

FLUID IMMERSION

1. PURPOSE. This test determines the ability of a wire to resist degradation when exposed to common fluids the wire may come into contact with during its service life. Typical forms of degradation from this test include swelling or softening of insulation materials, delamination of tape wrapped insulations, and reduction in the electrical properties of the insulation. Immersion may also degrade the insulation color, stripes, bands, or identification markings which is generally not considered a failure criteria. The list of fluids for this test method may need to be supplemented with other fluids to determine if a wire is suitable for a specific application. The test temperature for any fluid shall be at least 10°C below the fluids' flash point.

2. TEST EQUIPMENT

a. One Pyrex, stainless steel, or similar inert vessel to contain each test fluid in a sufficient quantity to completely immerse the wire within six inches of each end.

b. An air circulating oven or other heating device capable of maintaining the fluid temperature within ±3°C of required setting.

c. Immersion thermometer covering the test temperature range of the fluid.

d. Sufficient quantities of each test fluid listed.

e. Micrometer or similar device to measure wire diameters within 0.0001 inch.

3. TEST SAMPLE

3.1 Sample. Test sample shall be a minimum of three specimens at least 24 inches in length for each fluid.

4. TEST PROCEDURE

4.1 Fluid preparation. Each fluid shall be heated to the temperature specified. Adequate ventilation shall be provided for all fluid fumes.

4.2 Pre-immersion tests. Each wire specimen shall have the diameter measured to the nearest 0.0001 inch within the center 12-inch portion according to method 6001.

4.3 Immersion. Each specimen, for each test fluid listed, shall be immersed to within 6 inches of each end for the time and temperature specified. During immersion the radius of bend of the wire shall not be 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 hour in free air at room temperature. The diameter shall be measured within the same 12-inch section as in 4.2 and compared to the initial diameter. The insulation shall be removed for a distance .5 inch from each end of the specimen. The specimen shall then be subjected to the bend test of method 2206 and the wet dielectric test of method 3005.

TABLE I. Test fluids and immersion time.

Test Fluid	Test Temperature	Immersion Time
MIL-L-23699, Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, NATO Code Number O-156	48° to 50°C (118° to 122°F)	20 hours
MIL-H-5606, Hydraulic Fluid, Petroleum Base; Aircraft, Missile and Ordinance	48° to 50°C (118° to 122°F)	20 hours
TT-I-735, Isopropyl Alcohol	20° to 25°C (68° to 77°F)	168 hours
MIL-T-5624, Turbine Fuel, Aviation, Grades JP-4, JP-5, and JP-5/JP-8ST.	20° to 25°C (68° to 77°F)	168 hours

5. RESULTS. Report the percentage diameter change and the results of the bend and wet dielectric test.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. Any additional test fluids and their immersion times and temperatures shall be specified.

METHOD 1002

NITRIC ACID IMMERSION (ACID RESISTANCE)

1. PURPOSE. This test determines the ability of a wire to resist degradation when exposed to a strong acid. This test utilizes red fuming nitric acid for this test. Failures are defined as dielectric breakdowns of the insulation.

2. TEST EQUIPMENT

   a. One Pyrex, stainless steel, or similar inert vessel to contain the acid in a sufficient quantity to completely immerse the wire within six inches of each end.

   b Sufficient quantity of red fuming nitric acid with a specific gravity of 1.52.

3. TEST SAMPLE

3.1 Sample. Test samples shall be a minimum of three specimens at least 24 inches in length.

4. TEST PROCEDURE. The test specimens shall be immersed to within 1.50 inches of each end in red fuming nitric acid (specific gravity 1.52) at room temperature for 8 hours. Adequate ventilation shall be provided for all fumes. Following this acid immersion, the specimens shall be removed and immersed, except for 1.50 inches at each end, for 1 hour in water at room temperature containing 0.5 percent of aerosol or equivalent wetting agent. The specimens in the water solution shall then be subjected to the wet dielectric test of method 3005.

5. RESULTS. Report the results of the wet dielectric test.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. List if this test is applicable for the wire type specified.

METHOD 1003

PROPELLANT IMMERSION (PROPELLANT RESISTANCE)

1. PURPOSE. This test determines the ability of a wire to resist degradation when exposed to common missile propellants. Failures are defined as dielectric breakdowns of the insulation.

2. TEST EQUIPMENT

a. One Pyrex, stainless steel, or similar inert vessel to contain each propellant in a sufficient quantity to completely immerse the wire within 1.50 inches of each end.

3. TEST SAMPLE

3.1 Sample. Test samples shall be a minimum of three specimens at least 24 inches in length for each propellant.

4. TEST PROCEDURE

4.1 Procedure. Separate specimens for each test propellant listed shall be immersed to within 1.50 inches of each end for the specified time at normal room temperature.

TABLE I. Test propellants and immersion time.

Propellant	Immersion Time
MIL-P-7254, Propellants, Nitric Acid	30 Minutes
MIL-P-26536, Propellant, Hydrazine	30 Minutes
MIL-P-26539, Propellants, Nitrogen Tetroxide	1 Minute
MIL-P-27402, Propellant, Hydrazine-uns-Dimethylhydrazine (50% N_2H_4 - 50% UDMH)	30 Minutes

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 2 hours 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 wet dielectric test of method 3005.

5. RESULTS. Report the results of the wet dielectric test on the specimens from each propellant.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. List if this test is applicable for the wire type specified.

METHOD 1004

HUMIDITY RESISTANCE

1. PURPOSE. The purpose of this test is to permit evaluation of the properties of materials used in wire as they are influenced or deteriorated by the effects of high humidity and heat. This is an accelerated environmental test, accomplished by the continuous exposure of the specimen to high relative humidity during temperature cycling. Failures are determined by a loss of insulation resistance of the sample.

2. TEST EQUIPMENT

a. A test chamber capable of maintaining an internal temperature of 70 $\pm$ 2°C and an internal relative humidity of 95 $\pm$ 5 percent shall be used. The test chamber shall be sealable 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 within a period of 16 hours from the time of removal of the source of heat. Distilled or demineralized water shall be used to obtain the required humidity.

3. TEST SAMPLE. A wire specimen 52 feet long shall be used to conduct this test.

4. TEST PROCEDURE. The specimen shall be placed in the test chamber and the temperature and relative humidity raised over a 2-hour period to 70° $\pm$ 2°C and 95% $\pm$ 5% and maintained at such for a period of 6 hours. At the end of the 6-hour period, the heat shall be shut off. During the following 16-hour period, the temperature shall drop to 38°C or lower. This shall constitute a cycle (2 hours heating, 6 hours at high temperature, 16 hours cooling). A total of 15 consecutive cycles shall be performed for total test time of 360 hours. No more than 2 hours after the end of the fifteenth cycle, the center 50 feet of the sample shall be subjected to the Insulation Resistance Test of Method 3003 with one foot at each end above the test solution.

5. RESULTS. Report the final insulation resistance measured and any other observations.

6. *INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. List any test* deviations.

METHOD 1005

WICKING

1. PURPOSE. This test is applicable for multi-layer or braided insulations only. Procedure A of this test is used to determine the length of dye travel within or between the layers of insulation and to determine dye travel in braided wire. Procedure B of this test is used to determine weight increase due to distilled water absorption in the braided wire. Procedure C of this test is used to determine wicking in wires for fire resistance applications only. Wicking of fluids in the conductor is not considered a failure in this test.

2. TEST EQUIPMENT

a. A test tube, beaker or similar container to hold the wicking fluid.

b. A sharp blade to remove the insulation.

c. A clean, dry, lint free cloth.

d. A quantity of standard dye solution prepared as follows:

TABLE I. Wicking solution, procedure A.

Reagent	Quantity
Ethyl alcohol	30 ml
Rhodamine B dye	0.02 gm
75% solution	3 ml
Distilled water to make	2 liters

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 (procedure A).

e. An ultra-violet (UV) light source (procedure A).

f. A length scale capable of measurement to the nearest 1/16 inch (.062) (procedure A).

g. A weight scale capable of measuring to the nearest 0.1 milligram (procedure B).

h. Esterline angus, medium dry, red instrument ink (procedure C).

3. TEST SAMPLE. Test samples shall consist of at least three wire specimens with square cut ends 4 ± 1/16 inches in length for procedures A and B and three specimens 6 ± 1/16 inch in length for procedure C.

4. TEST PROCEDURE

4.1 Procedure A (dye travel). The specimens shall be placed upright in the standard dye solution in an open container with the lower 2 inches of length immersed, but not touching the bottom of the container. The immersion shall be for 24 hours at room temperature in a draft-free area. Specimens shall then be removed from the dye solution, wiped dry with the clean, dry, lint free cloth, and within 5 minutes, examined under ultraviolet light to determine the length the dye solution has traveled by wicking action in any part of the insulation. Wicking of dye solution in the conductor is not considered a failure. The layers of insulation may be dissected away with a sharp blade, working from the upper end of the specimen, to facilitate observation.

4.2 Procedure B (weight increase). The specimens shall be weighed accurately to the nearest 0.1 milligram. The weighed specimen shall be placed upright in the distilled water in an open container with the lower 2 inches of length immersed, but not touching the bottom of the container. The immersion shall be for 24 hours at room temperature in a draft-free area. Specimens shall then be removed from the water, wiped free of excess moisture with a dry, clean, lint free cloth, and within 5 minutes after removal from the water, weighed again to the nearest 0.1 milligram. The percentage change in weight shall be calculated to determine weight gain.

4.3 Procedure C (ink travel). The specimens shall be vertically immersed for 2 inches of their length in esterline angus, medium dry, red instrument ink, which is contained in an open test tube, and conditioned for 24 hours at room temperature in a draft-free room. After this conditioning, the ink on the surface shall be removed immediately from the 2 inches immersed by wiping gently with a clean, dry, lint-free cloth. The specimen shall then be examined for wicking action in any part of the insulation. The distance that the ink has wicked above the 2-inch immersed portion of the specimen shall be recorded as the distance of wicking.

5. RESULTS. Report the distance traveled by the dye solution or ink in or between each layer of insulation or braid for procedures A and C. Report the percentage increase in weight for procedure B.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. List which test condition is required, the applicability of the test, and any exceptions.

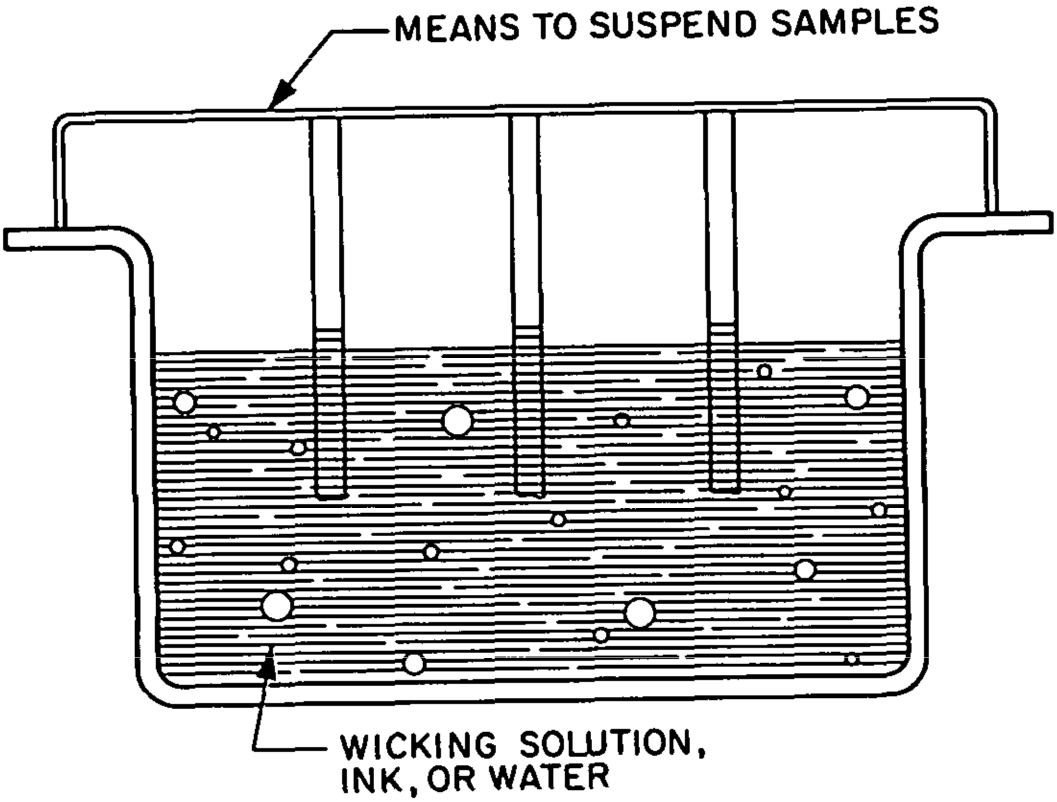


FIGURE 1. Typical wicking test.

Note - Procedure B is inactive for new design and procedure C is inactive for new design except for use with fire resistant wires.

METHOD 1006

FLAMMABILITY

1. PURPOSE. The test determines the resistance of a wire insulation to burning when exposed to a flame. Burning resistance is measured as the amount of time combustion continues or the distance the insulation burns during or after flame application. This test also evaluates secondary ignition due to burning droplets. This test provides a standard laboratory test for evaluating the burning resistance of a wire, but does not simulate most actual service applications. There are many other similar tests using different wire and flame orientations.

2. TEST EQUIPMENT. Test equipment shall be as follows:

a. A test chamber protected from drafts but provided with means for venting fumes at the top and admitting an adequate supply of fresh air at the bottom. A chemistry hood with the exhaust fan turned off, or a metal box about 2 feet wide by 3 feet high by 2 feet deep, with an open front or a viewing window and holes for air intake and venting of fumes may be used.

b. A Bunsen, Tirrill, or equivalent burner with a .250 inch inlet, a nominal bore of .375 inch, and a height (barrel length) of approximately 4 inches from the primary inlets to the top. The tube shall not be equipped with end attachments such as a stabilizer.

c. A supply of combustion gas with suitable regulator and meter for uniform gas flow (natural gas having a heat content of approximately 1000 BTU/Ft^3 has been found to provide adequate results).

d. Stopwatch or other suitable timing device.

e. A thermocouple pyrometer or equivalent device.

f. Facial tissue conforming to A-A-1505.

3. TEST SAMPLE. A test sample shall consist of a wire specimen 24 inches long.

4. TEST PROCEDURE

4.1 Procedure A (60 flame test). The 24 inch specimen of wire shall be marked at a distance of 8 inches from its lower end to indicate the point for flame application and shall be placed in the specified 60-degree position in the test chamber. The lower end of the specimen shall be clamped in position in the specimen holder and the upper end shall be passed over the pulley of the holder and loaded with sufficient weight 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 flame shall be adjusted to provide an all blue conical flame approximately 2 inches high with a temperature of 955° ± 30°C (1751° ± F) at its hottest point as measured by a thermocouple pyrometer or equivalent device. A sheet of the facial tissue shall be suspended taut and horizontal 9.50 inches below the point of application of the flame to the wire specimen and at least .50 inch from the chamber floor, so that any material dripping from the wire specimen shall fall upon the tissue. The flame shall be applied for 30 seconds and then withdrawn at the end of the 30 seconds.

4.2 Procedure B (60 flame test with dielectric test). Perform the same 60 degree flame test as procedure A, then subject the tested specimen to the wet dielectric test of method 3005, except the time of immersion shall be 5 minutes and the time of exposure to full voltage shall be only 1 minute.

4.3 Procedure C (vertical flame test). Perform the same as condition A, except the sample shall be 18 ± 1/2 inch and marked 14 ± 1/2 inch from one end to indicate the point of flame application, the wire shall be suspended vertically with the flame inclined 20 degrees from the vertical towards the wire, the duration of flame exposure shall be 15 seconds only, and the flame temperature shall be 1010 ± 56°C (1850 ± 100°F). Areas of the wire having the original insulation undamaged but covered with soot deposits removable by wiping or covered with material that has melted or flowed down the wire shall not be considered as part of the burn length.

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 wire 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.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. List the number of samples to be tested, the test condition (A, B, or C), and the limits for the maximum burning time and burn length.

Note - Procedures B and C are inactive for new design.

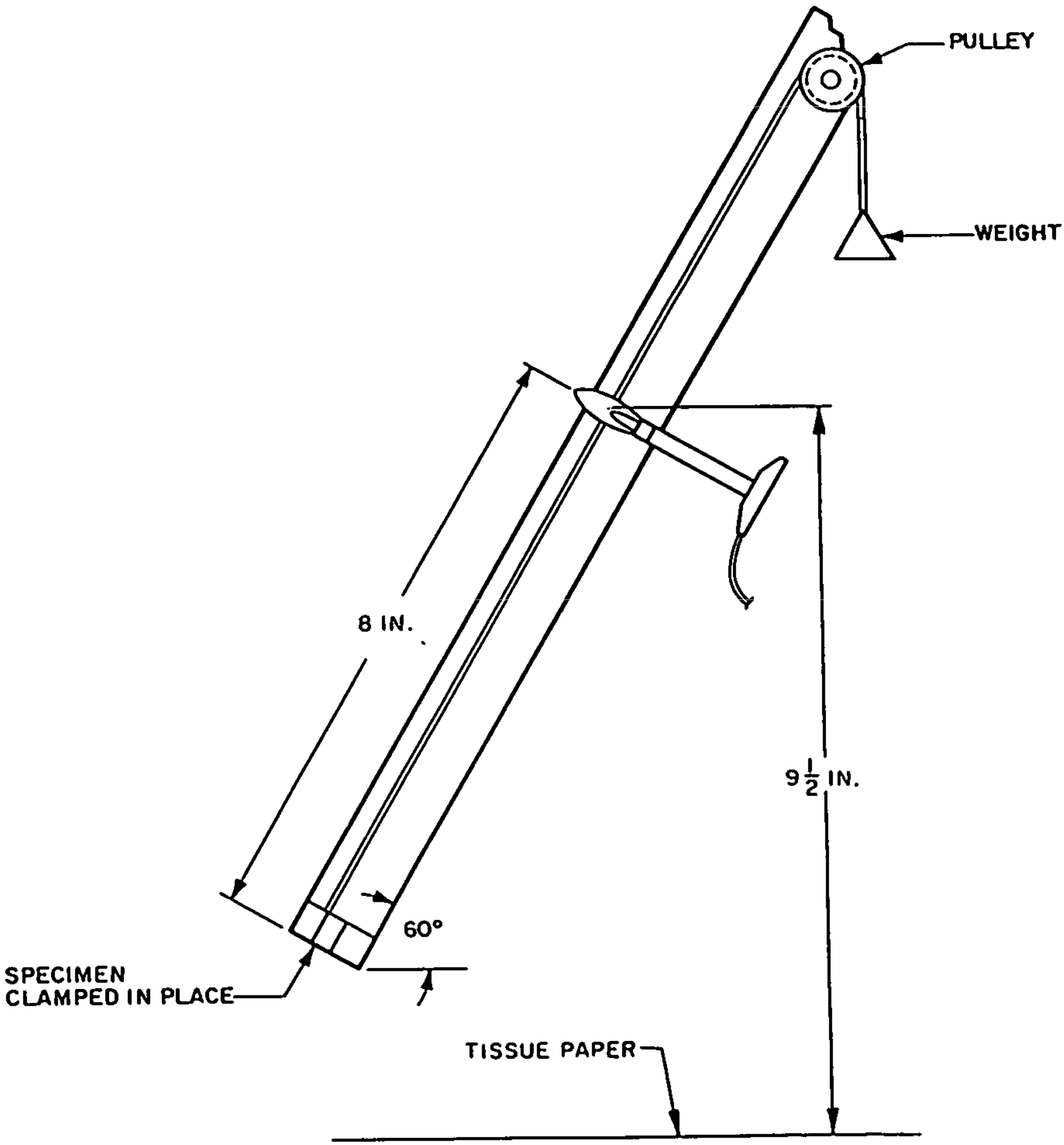


FIGURE 1. Procedure A, flammability test.

METHOD 1007

FLAME RESISTANCE (FIRE RESISTANT WIRE)

1. PURPOSE. The test determines the ability of the wire to maintain a minimum insulation resistance while being subjected to a direct flame and vibration.

2. TEST EQUIPMENT. Test equipment shall be as follows:

   a. ASTM D 910 grade 100 aviation gasoline.

   b. A solution of 50 percent turbine fuel conforming to MIL-T-5624, grade JP-4 and 50 percent aircraft lubricating oil conforming to MIL-L-6082, grade 1100.

   c. Lubricating oil conforming to MIL-L-6082, grade 1100.

   d. A mounting rack as shown in figure 1.

   e. A Shorting bar for use in the test circuit.

   f. Two nickel-chrome ribbons.

   g. A burner as described by figure 2.

   h An apparatus for applying the specified vibration to the specimen.

   i. Test circuit as shown in figure 1.

3. TEST SAMPLE. A test sample shall consist of three wire specimens 24 inches long.

4. TEST PROCEDURE

4.1 Preparation of specimens. A 24-inch specimen shall have its center 18-inch section immersed for 24 hours at room temperature in aviation gasoline conforming to ASTM D 910, grade 100 aviation gasoline. A second specimen shall be immersed in like manner for 24 hours at room temperature in a solution of 50 percent turbine fuel conforming to MIL-T-5624, grade JP-4, and 50 percent aircraft lubricating oil conforming to MIL-L-6082, grade 1100. A third specimen shall be suspended for 4 hours in the vapors of aircraft lubricating oil conforming to MIL-L-6082, grade 1100, which shall be maintained at a temperature of 250°F (121°C). Upon removal from the liquid and after wiping with a clean cloth, wire bands consisting of one turn of wire, no larger than size 30, shall be wrapped around each specimen, thus designating its 7-inch middle section, plus an additional outer band 4 inches outside each of these two bands. See figure 1 for details.

4.1.1 Specimen installation. Each specimen shall then be mounted in the rack with the center 7-inch section so located that it shall be centered 1 inch above the burner top plate as shown on figure 1. Each of the two nickel-chrome ribbons shall be wrapped once around the specimen with the edges butted together. The two ribbons shall be 1 inch apart at the midsection of the 7-inch section as illustrated on figure 1. The conductor of the specimen and the nickel-chrome ribbons shall be connected in the test circuit as shown on figure 1. A shorting bar shall be inserted between the nickel-chrome ribbons and the conductor, and the meter adjusted to read approximately zero ohm.

4.1.2 Burner adjustment. The thermocouple shall be located in a plane 1 inch above the burner top plate, near the center of the burner. The burner, figure 2, shall be ignited and the flow of gas, air and secondary air shall be adjusted to give a nonoxidizing, nonreducing (neutral) flame approximately 1 inch high with a flame temperature, as measured by the thermocouple of 2000° ± 50°F (1093° ± 27°C).

> CAUTION: The proper flame will be obtained by using a minimum amount of gas and secondary air. The flame shall be uniform over the top of the top plate area (this is achieved mainly by adjustment of secondary air), and the tip of the blue cone shall be approximately 1 inch above the burner top plate. The burner shall be run until a stable temperature and flame have been achieved before starting any test. The tip of each flame shall not be yellow; to achieve this, for each gas valve adjustment, the air valve shall be opened to the point just beyond that which gives a yellow-tipped flame.

4.1.3 Vibration. After the flame has stabilized, the specimen shall be vibrated at approximately 30 Hz with the rack having a maximum total excursion of approximately 0.06 inch. Vibration shall be parallel to the burner surface and perpendicular to the test specimens axis.

4.1.4 Flame application. After removing the thermocouple, the vibrating specimen shall be positioned in the stabilized flame so that the lower surface of the specimen is at the same position in the flame as that previously occupied by the hot junction of the thermocouple, and so that the 7 inch mid-section is centered over the burner top plate. The specimen shall remain in this position in the flame for a 5 minute test period. With the ohmmeter observed continuously during this period, the minimum reading shall be recorded. At the end of the 5 minute period, the burner shall be repositioned under the thermocouple and the flame temperature checked.

5. RESULTS. Report the minimum resistance observed on the ohm-meter and any instances of conductor breakage.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. List the minimum resistance across the insulation required during the test.

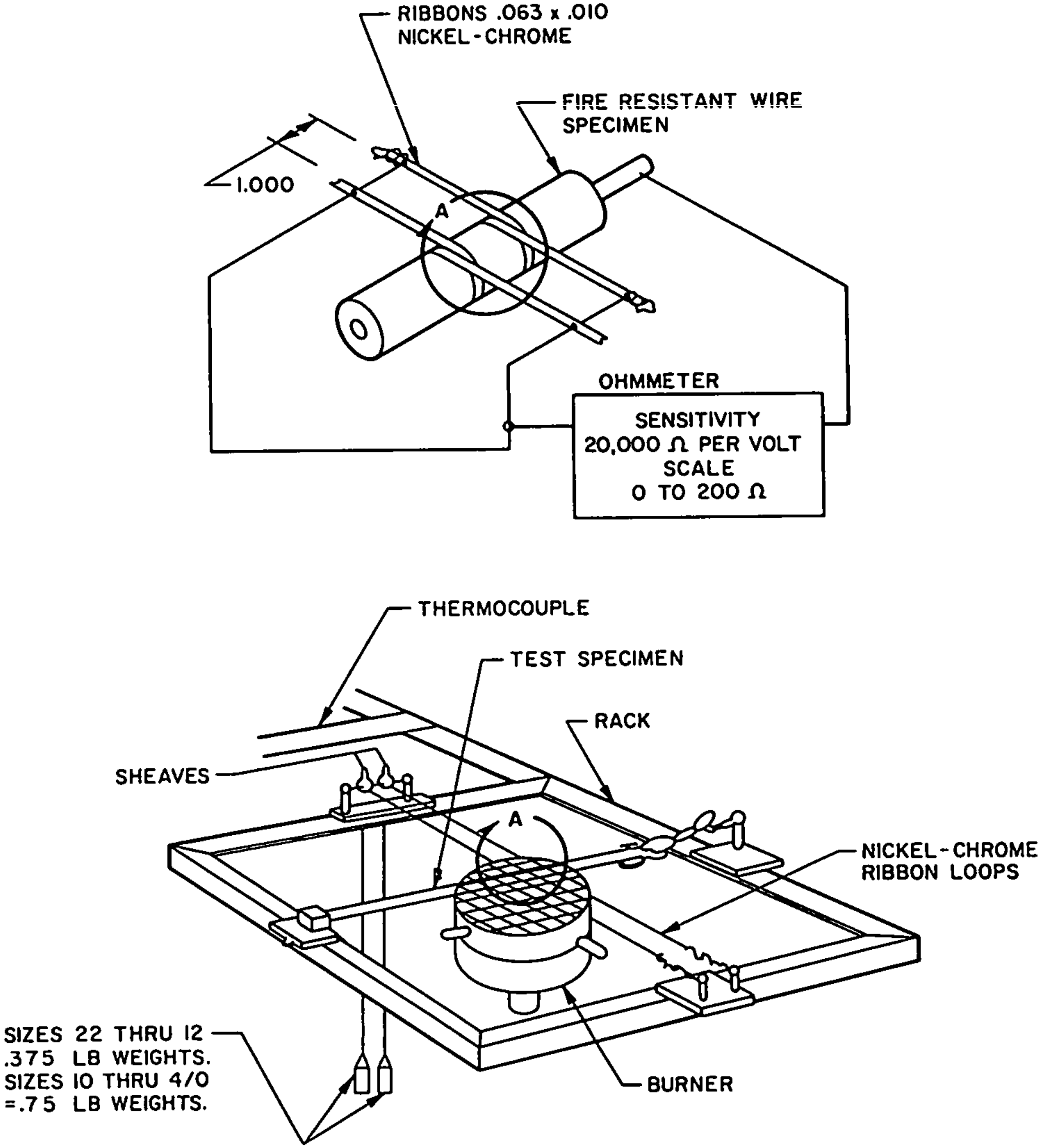


FIGURE 1. Flame test fixture.

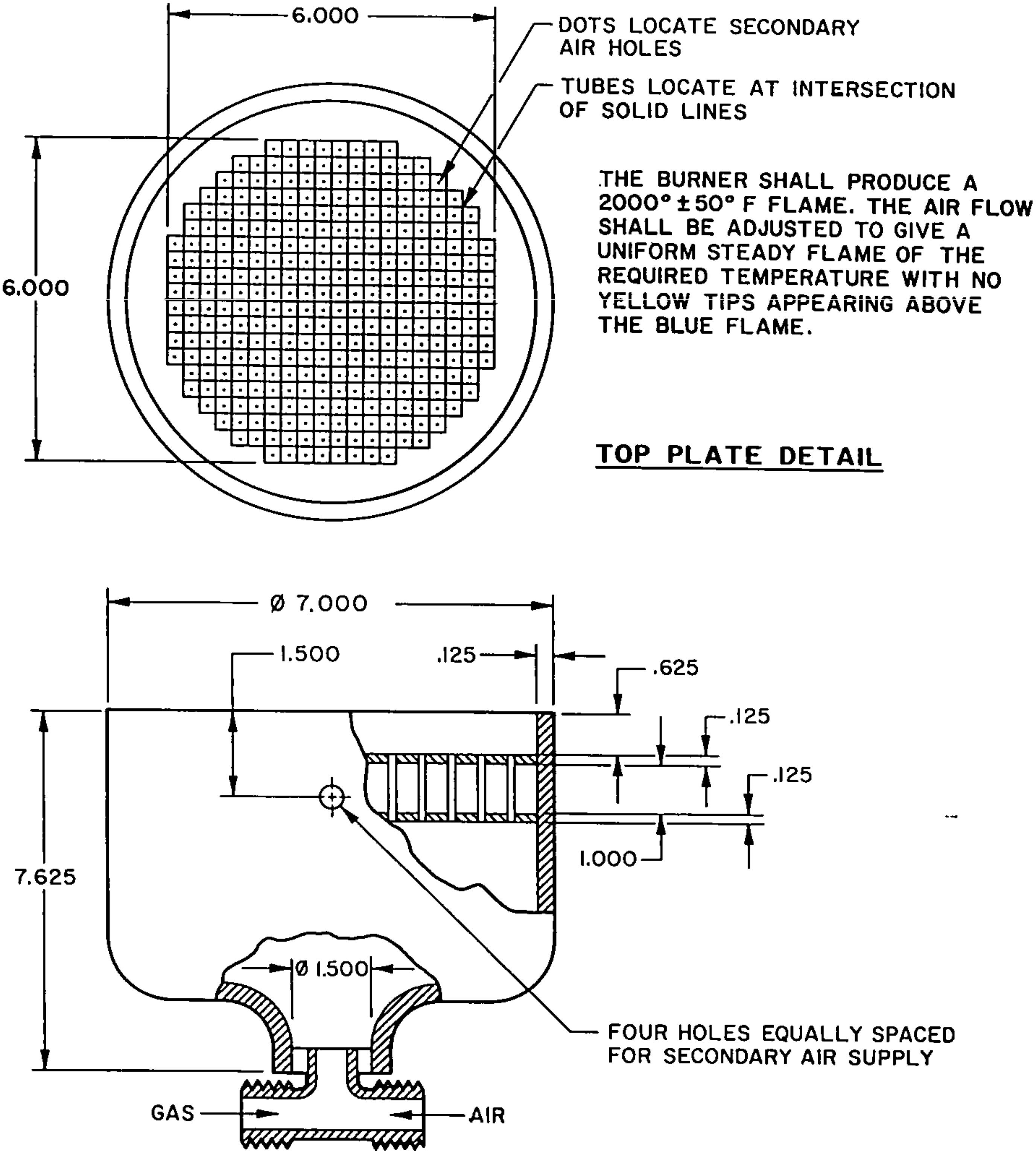
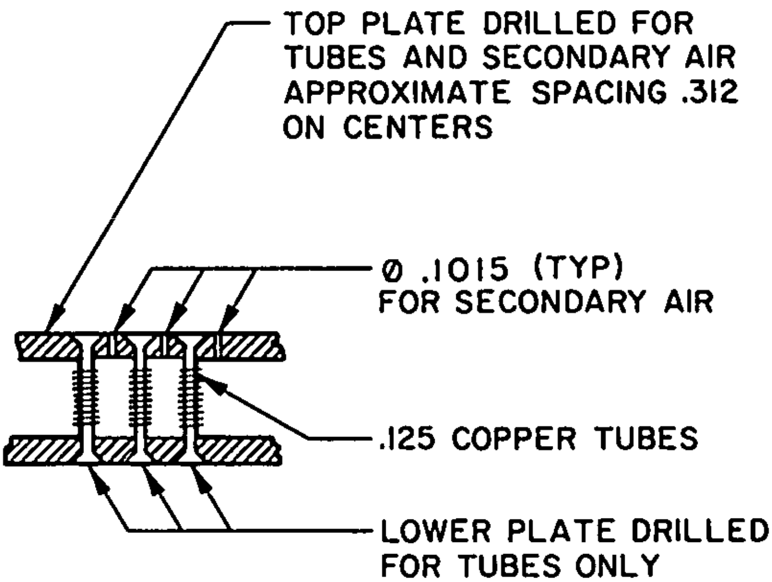


FIGURE 2. Burner details.



TUBING DETAIL

INCHES	mm
.1015	2.58
.125	3.18
.312	7.92
.625	15.88
1.000	25.40
1.500	38.10
6.000	152.40
7.000	177.80
7.625	193.68

NOTES:
1. Dimensions are in inches.
2. Metric equivalents are given for general information only and are based upon 1.00 inch = 25.4 mm.
3. Unless otherwise specified, tolerance is $\pm$.005 (.13 mm).

FIGURE 2. Burner details.

METHOD 1008

STEAM AGING OF TOPCOAT (CURE)

1. PURPOSE. This test determines if the topcoat of a wire has been properly processed and cured to be resistant to cracking. This is determined by exposure to boiling water, then subjecting the topcoat to mechanical stress. This test was developed for polyimide and modified polyimide topcoats.

2. TEST EQUIPMENT

   a. 200 ml of distilled water.

   b. A 2-liter Erlenmeyer flask with a rubber stopper and fitted with a water cooled reflux condenser.

   c. Hot plate for boiling the water in the flask.

   d. Test mandrels for wire sizes 16 and larger.

3. TEST SAMPLES. Test sample shall consist of three wire specimens approximately 12 inches in length.

4. TEST PROCEDURE. Two hundred milliliters of distilled water, together with a few boiling chips or beads, shall be placed in a 2-liter Erlenmeyer flask and the flask shall be closed by a rubber stopper fitted with a water-cooled reflux condenser. The flask shall be heated by hot plate or heating mantle until the water is boiling and condensate is returning from the reflux condenser. One end of an approximately 12-inch (30.5 cm) length of the wire to be tested shall be inserted into the flask by passing it between the rubber stopper and the side of the flask or through a snugly fitting hole in the stopper, so that 5 inches of the wire length extends into the vapor base inside the flask. The portion of the wire inside the flask shall be essentially straight and shall not be in contact with the glass sides of the flask or condenser, the layer of liquid water in the bottom of the flask, other test samples, or the liquid condensate returning from the condenser. Heating of the flask shall be resumed, with stopper and reflux condenser again in place. The portion of the wire inside the flask shall be exposed to the vapor phase above the boiling water for exactly one hour and then be removed from the flask. A 4-inch (102 mm) specimen shall be cut from the vapor-exposed portion of the wire, avoiding the one inch which was nearest the rubber stopper during vapor exposure. The 4-inch (102 mm) specimen shall be allowed to cool at room temperature for a minimum of fifteen minutes, after which it shall be wrapped in a tight spiral for six turns or the full length of the specimen, whichever is lesser, around a mandrel which for wire sizes 18 and smaller shall be the specified maximum diameter of the wire and for wire sizes 16 and larger shall be three times the specified maximum diameter of the wire. The specimen shall then be inspected visually for cracks without the aid of magnification.

5. RESULTS. Report any cracks observed in the topcoat of the wire.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. Specifications shall list the applicability of this test.

CLASS 2000

MECHANICAL TESTS

METHOD 2001

INSULATION TENSILE STRENGTH AND ELONGATION

1. PURPOSE. This test provides tensile property data on extruded electrical insulation removed from the wire and is used as a process control test for the extrusion test. Tensile properties are useful to determine the ability of the insulation to withstand mechanical stresses it may experience in use. Comparison of tensile properties before and after environmental or thermal exposure is useful to determine the extent of insulation degradation due to the exposure.

2. TEST EQUIPMENT

a. Power driven tensile test machine with sample grips attached to a force indicator. The machine sample grips shall be capable of separating to apply force to the specimen at a uniform speed controllable to within ± 1.0 inch per minute. The force indicator shall be accurate within ±1 percent of the actual force and shall be capable of indicating the maximum force obtained.

b. Extensometer, calipers, scale, or other device for accurately measuring the length of separation of the bench marks at break.

c. When necessary, dies for cutting dumbbell specimens in large wires.

d. Micrometer or equivalent device to determine the dimensions needed to calculate the sample cross-sectional area.

3. TEST SAMPLES. A minimum of at least three specimens at least three inches long shall be used. The samples shall be prepared by carefully separating the insulation from the conductor without damage to the insulation.

3.1 Straight tube specimens. Straight tube specimens shall be used whenever possible.

3.2 Dumbbell samples. When size or other considerations prohibit the use of straight tube specimens, dumbbell samples shall be prepared. The dumbbell samples shall be prepared in accordance with ASTM D 412 (die type C or D).

3.3 Bench marks. Two parallel bench marks shall be marked on each specimen equidistant from the center of the specimen and perpendicular to its long axis (length). The bench marks shall not be more than 0.010 inches wide and shall be approximately 1 inch apart. On dumbbell samples, the bench marks shall be marked on the reduced area section of the specimen.

4. TEST PROCEDURE

4.1 Pretest measurements. The length between the bench marks shall be measured to the nearest 0.01 inch. The inner and outer diameters of the straight tube samples or the width and thickness of the dumbbell samples at the reduced area section shall be measured. The cross-sectional area shall be calculated from these measurements.

4.1.1 Dumbbell samples. Cross-Sectional Area = Width x Thickness

4.1.2 Straight tube. Cross-Sectional Area = $\frac{(OD^2 - ID^2)}{4}$

OD = Outside diameter of the insulation
ID = Inside diameter of the insulation

As an alternate, the weight, length, and density method of method 3021 of FED-STD-228 can be used to calculate the cross-sectional area.

4.2 Determination. The specimen shall be placed in the grips of the calibrated tensile test machine and adjusted such that the tension will be distributed uniformly over the cross-section of the specimen. The force shall be applied at a uniform rate of 20 $\pm$ 1 inch per minute. After rupture of the specimen, the breaking force and the distance the bench marks were apart at the time of rupture shall be recorded. Repeat the procedure on the other specimens.

4.3 Calculations. The tensile strength of each specimen shall be calculated as follows:

$$\text{Tensile Strength(psi)} = \frac{F}{C}$$

Where:

F = Breaking Force(pounds)
C = Cross-sectional area of the unstretched specimen in square inches

The elongation of the specimen shall be calculated as follows:

$$\text{Elongation(percent)} = \frac{(D - G)}{G} \times 100$$

Where:

D = The distance between the bench marks at the moment of rupture(inches)
G = The distance between the bench marks on the unstretched specimens (inches)

5. RESULTS. Report the average tensile strength and elongation of the specimens tested.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. Specifications shall list any deviations in sample size, sample preparation, application of force speed, or other variations.

METHOD 2002

WRAP

1. PURPOSE. This test determines if a wire is susceptible to cracking when wrapped around a mandrel. This test has been applied to many wire types especially overbraided or tape wrapped wires. This test or the wrap back test is usually required in the individual wire specification.

2. TEST EQUIPMENT

a. Test mandrels of the size indicated.

b. Means to secure the wires to the test mandrels.

3. TEST SAMPLES. Test sample shall consist of three specimens of wire of sufficient length as required to conduct this test.

4. TEST PROCEDURE. Each specimen of finished wire, with a length of 12 inches plus the additional length required for winding on the mandrel, as specified in the table or in the individual specification, shall be wound tightly for two close turns around a mandrel of the diameter specified below.

TABLE I. Test mandrels and wire size.

WIRE SIZE	Mandrel Diameter (in.) (±3%)	WIRE SIZE	Mandrel Diameter (in.) (±3%)
30	.125	10	.375
28	.125	8	.75
26	.125	6	1.00
24	.125	4	1.25
22	.125	2	2.00
20	.125	1	2.50
18	.250	0	3.00
16	.250	00	4.00
14	.375	000	5.00
12	.375	0000	6.00

The winding may be accomplished manually or automatically and shall be in the middle portion of the specimen so that at least six inches of each end shall remain straight. The specimen shall then be removed from the mandrel, examined visually for cracks, and subjected to the wet dielectric test, method 3005.

5. RESULTS. Report any observed cracks and the results of the wet dielectric test.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. Specifications shall list the required mandrel size if different than the preferred sizes listed in the table of this test method. The recommended mandrel sizes and weights of table I are applicable to "light weight" wires.

METHOD 2003

WRAP BACK

1. PURPOSE. This test determines if a wire is susceptible to cracking when wrapped around its own diameter then exposed to a short time heat exposure. This test has been used for process control of wires insulated with Polytetrafluoroethylene (PTFE). This test or the wrap test is usually required in the individual wire specifications.

2. TEST EQUIPMENT

a. Air oven capable of maintaining the required test temperature.

3. TEST SAMPLES. Test sample shall consist of three specimens a minimum of twelve inches long.

4. TEST PROCEDURE. For wire sizes 10 and smaller, a 12-inch specimen of finished wire 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 (see figure 1). For sizes 8 and larger, the specimen shall be wound for four close turns around a mandrel of the diameter required by the specification sheet. In either case, the ends of the specimen shall be left unsecured to permit unhampered relaxation of the turns. The specimen shall then be placed in an air oven for 2 hours at the temperature required by the specification sheet. At the end of this period, the outside surface of the wire specimen shall be visually examined, without the aid of magnification, for cracks. There are no blocking or color retention requirements on samples subjected to the wrap back test.

Note - It is recommended the mandrel diameter required by the specification be 3 times the wire diameter under test for wire sizes 8 and larger. It is recommended that all acquisition specifications require all sizes of PTFE insulated wire be tested bent back on itself.

5. RESULTS. Report any observed cracks.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. Specifications shall list the wrap back test temperature, the mandrel sizes for wires size 8 and larger, and any test deviations.

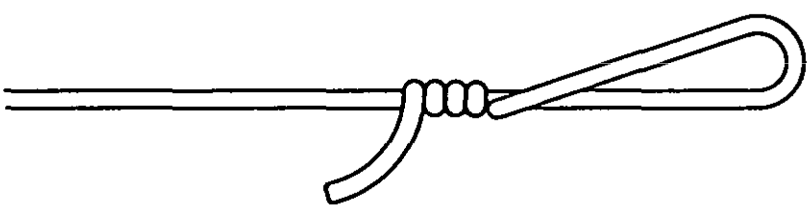


FIGURE 1. Wrap back test.

METHOD 2004

COLD BEND

1. PURPOSE. This test determines the resistance of a wire to cracking or dielectric breakdown at low temperature while being wrapped around a mandrel.

2. TEST EQUIPMENT

   a. A chamber capable of maintaining -65° ± 2°C (-85° ± 3.6°F) which allows the specimen to be wrapped around a mandrel without opening the chamber.

   b. A rotatable mandrel for installation inside the cold chamber.

   c. Means for attaching the specimens to the mandrel.

3. TEST SAMPLES. Test sample shall consist of at least three specimens at least 36 inches in length.

4. TEST PROCEDURE. One end of each specimen shall be secured to a rotatable mandrel in a cold chamber and the other end to the load weight. The test mandrel diameter and the load weight shall be as listed below unless otherwise specified. The specimens of wire and the mandrel shall be conditioned at -65° ± 2°C for 4 hours unless otherwise specified. After the 4-hour 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.

TABLE I. Test mandrels and loads.

WIRE SIZE	Mandrel Diameter (in.) (±3%)	Test Load (lbs) (±3%)
26	1.00	3.00
24	1.00	3.00
22	1.00	4.00
20	1.00	4.00
18	1.50	5.00
16	1.50	5.00
14	2.00	5.00
12	2.00	5.00
10	3.00	6.00
8	4.00	10.00
6	5.00	10.00
4	6.00	15.00
2	8.00	15.00
1	10.00	15.00
0	10.00	15.00
00	12.00	20.00

At the completion of this test the specimen shall be removed from the cold chamber and allowed to return to room temperature. The specimen shall be removed from the mandrel without straightening and shall be examined for cracks in the insulation. After the visual examination remove the insulation for a distance of 1 inch from each end of the specimen and subject the specimen to the wet dielectric test specified in method 3005 with the bent portion submerged.

5. RESULTS. Report any observed cracks and the results of the wet dielectric test.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. Specifications shall list the mandrel sizes, test loads, and test temperature if different than those specified in this method. The recommended mandrel sizes and weights of table I are applicable to "normal weight" wires.

METHOD 2005

CIRCUMFERENTIAL INSULATION ELONGATION

1. PURPOSE. This test determines the elongation of insulation of a wire in a circumferential (radial) direction. This test was developed to measure the resistance of polytetrafluoroethylene (PTFE) and mineral filled PTFE to rupture when under a radial stress.

2. TEST EQUIPMENT

a. Wire strippers to remove an undamaged insulation slug.

b. A sharp razor blade or cutting tool.

c. Power driven apparatus capable of driving test cone at 20 ± 2 inches/minute.

d. Test cone (see figure 2).

e. Specimen holding block (see figure 3).

f. Scale, strip chart, or other means to measure the length the cone travels at specimen rupture.

3. TEST SAMPLE. Three 1.0 to 1.5-inch slugs of insulation are needed for this test.

3.1 Specimen preparation. A 1 to 1.5-inch slug or insulation shall be removed from the conductor. Care shall be taken to prevent scratching, crimping, stretching or otherwise damaging the insulation. The diameter of the exposed conductor should be measured to the nearest 0.001 inch. Cut five cylindrical test specimens 0.125 inch ± .02 inch in length from the insulation slug using a sharp razor blade or an appropriate sample preparation fixture. Both ends of the cylindrical test specimens shall be cut square.

4. TEST PROCEDURE. Slide a specimen onto the cone until it just touches the edges of the cone. The cone should be attached to a movable crosshead as shown in figure 2. Position the specimen holding block perpendicular to the cone as shown in figure 3. The overall test apparatus is shown in figure 1. Align the cone tip and the appropriate sized hole of the specimen holding block for the wire size being tested. Move the cone through the stationary specimen at a uniform speed of 20 ± 2 inches/minute until the specimen ruptures. Determine the length of the cone that has passed through the specimen causing rupture. The percent circumferential elongation is calculated as follows:

$$\% \text{ CE} = \frac{(2 \text{ X L X Tan } \quad - \text{ CD})}{\text{CD}} \text{ X } 100$$

% CE = Percent circumferential elongation
L = Cone length required to rupture specimen (inches)
CD = Conductor Diameter (inches)
= Measured cone angle taper (degrees)
2 X L X Tan   Inner diameter of the test specimen at rupture (inches)

Five specimens shall be tested.

5. RESULTS. Report the average value of the 5 specimens tested.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. Specifications shall list the applicability of this test.

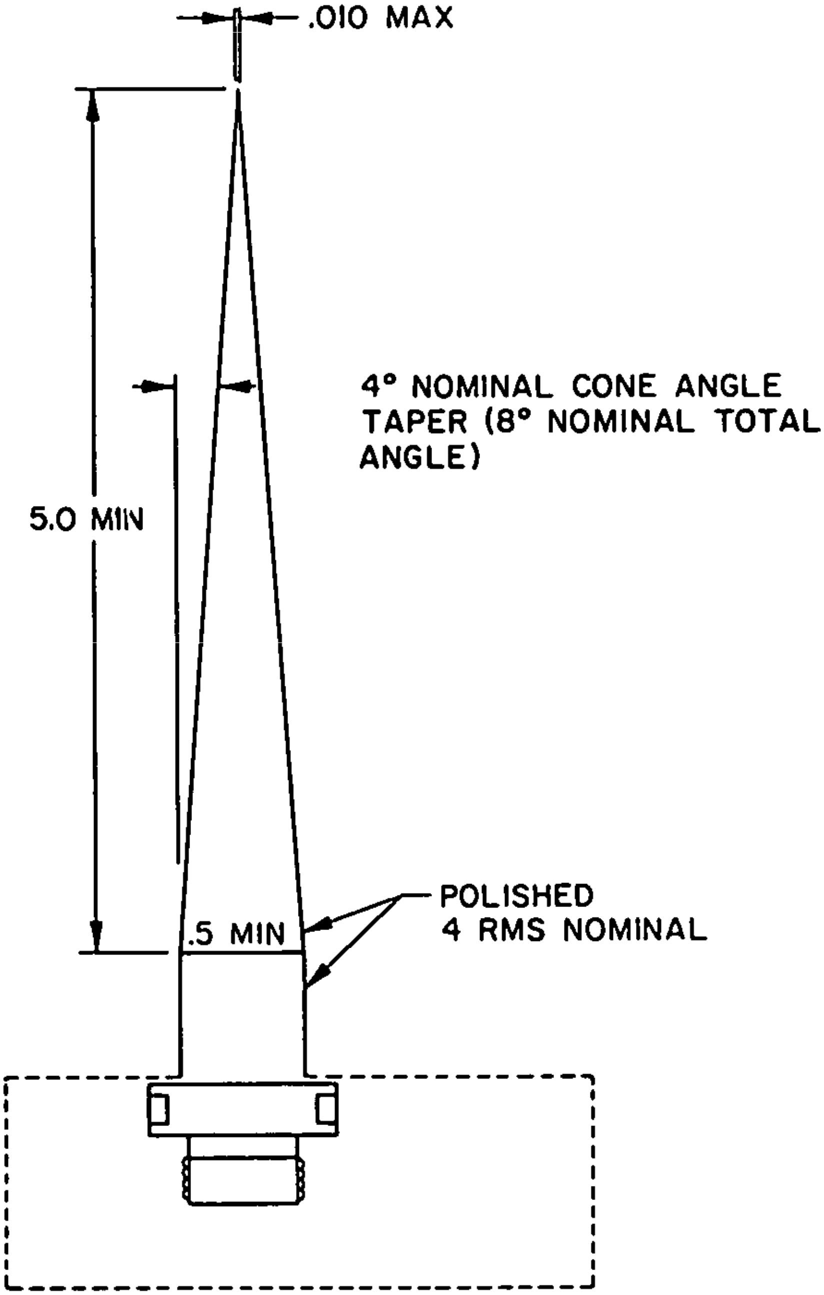


FIGURE 1. Circumferential elongation apparatus.

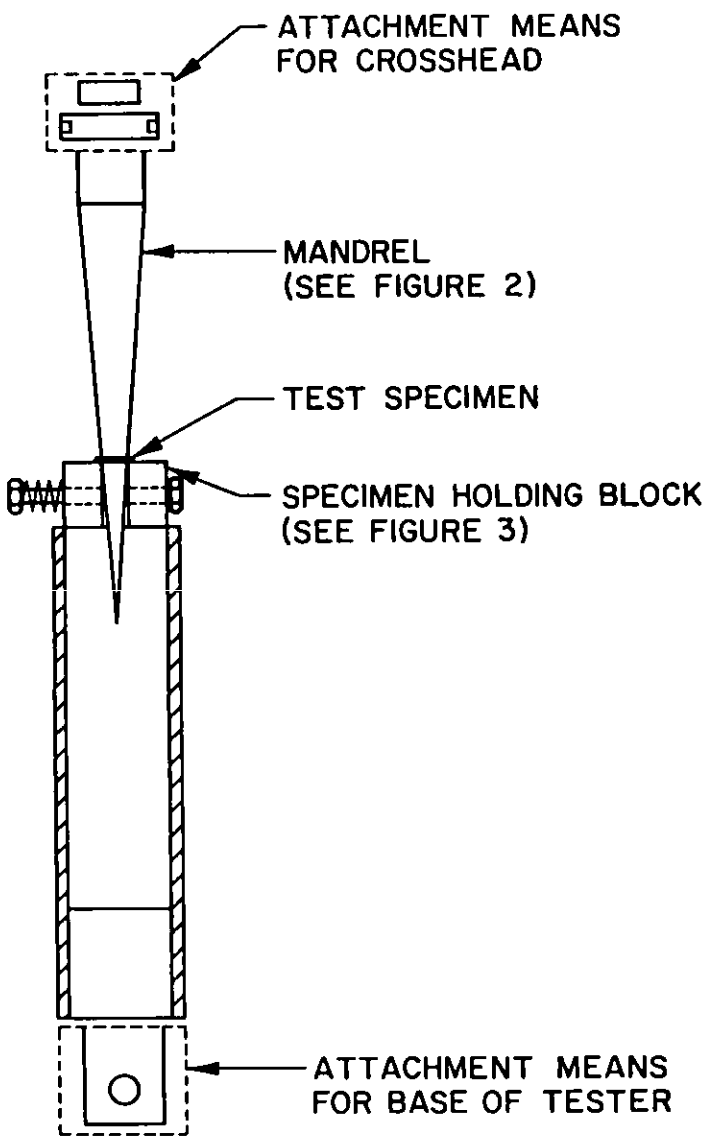


FIGURE 2. Test mandrel for circumferential elongation.

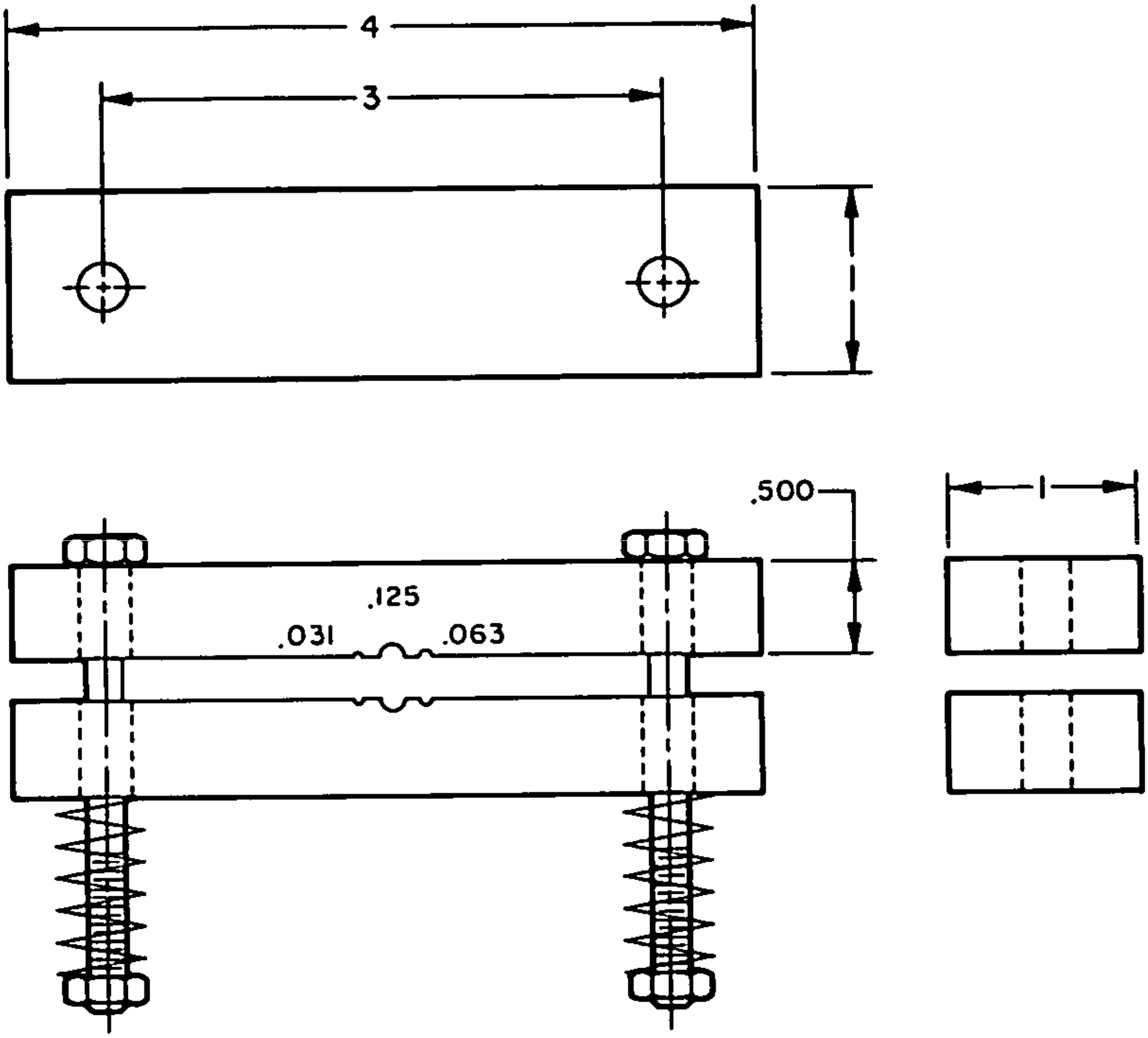


FIGURE 3. Circumferential elongation specimen holding block.

METHOD 2006

BEND

1. PURPOSE. This test is used as a post test to mechanically stress the insulation of a wire after an environmental or thermal exposure. This test usually precedes the wet dielectric test of method 3005. This test was developed as a post test of the elevated temperature aging (life cycle) and cross-link proof (accelerated aging) tests in many military wire specifications.

2. TEST EQUIPMENT

    a. Test mandrels of the size required.

    b. Means to secure the wires to the test mandrels.

3. TEST SAMPLE. Test samples shall consist of the specimens required by the applicable environmental or thermal test.

4. TEST PROCEDURE. At room ambient, one end of each specimen shall be secured to the mandrel and the other end to the load weight specified in the applicable specification. The mandrel shall be rotated until the full length of the specimen is wrapped around the mandrel and is under the specified tension with the adjoining coils in contact. The mandrel shall be rotated in the 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.

5. RESULTS. Report any observed cracks.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. Specifications shall list the required mandrel size and test load to be used.

Note - The test mandrel size and load weight from the elevated temperature aging (life cycle) or cross-link proof (accelerated aging) tests are generally used.

CLASS 3000

ELECTRICAL TESTS

METHOD 3001

SPARK TEST OF PRIMARY INSULATION

1. PURPOSE. This method is used as a process control test to determine and remove defects in the primary insulation of insulated wires. Presence of a weak spot in the insulation results in a breakdown at that spot. When breakdown occurs, the spark test equipment is designed to stop the wire spooling equipment allowing the operator to remove the defective area of the wire. This method is preferred to water immersion as it constitutes an instantaneous, continuous test. The spark test is a 100 percent in-process test that supplements, not replaces, the wet dielectric test and insulation resistance tests which should be done on a sampling basis. The impulse dielectric test of method 3002 is the preferred test for detecting faults in the insulation of a finished wire due to its higher sensitivity to detecting faults.

2. TEST EQUIPMENT

a. Spark tester capable of providing an essentially sinusoidal voltage with a transformer of sufficient capacity to maintain the test voltage specified in the individual specification. The spark tester shall have the core of the transformer and one end of the secondary winding connected to ground. The spark tester shall not be simultaneously connected to multiple electrodes and shall have a voltmeter that indicates the actual applied voltage at all times.

b. The electrode shall be a bead chain or fine wire mesh construction capable of providing contact with practically all of the wire insulation surface. The electrode shall be provided with a grounded metallic screen, or equivalent, as a guard against contact by operators. The length of the electrode shall be sufficient to meet the requirements in the procedures section. If a bead chain electrode is used, the beads shall have a diameter not greater than 3/16 inches. The longitudinal spacing of the chains shall be .500 inch or less and the transverse spacing of the chains shall be .375 inches or less, except the spacing may be as long as .500 inch if the transverse rows of the chain are staggered. The bottom of the metal enclosure shall be V-shaped. The chains shall have a length appreciably greater than the depth of the enclosure. The width of the trough shall be approximately 1.50 inches greater than the diameter of the largest wire to be tested.

c. A fault signaling device or system shall include a visible signal, a fault recording device, and/or an automatic stop device. The arrangement shall be such that when the fault signal is given, it will be maintained until manually reset.

3. TEST SAMPLES. Test sample shall consist of 100 percent of the wire after application of the primary insulation, but prior to application of the outer insulation, jacket or other material.

4. TEST PROCEDURE. The conductor shall be earth-grounded during the spark test. An earth-ground connection shall be made at both ends of the pay-off and take-up reels, except that, if the wire is tested for continuity and the conductor is one of integral length, the earth-ground connection need only be made at one end. In any case, the conductor on a reel at which a earth-ground connection is made shall be bonded directly to the earth-ground on the transformer of the spark tester. The entire length of the wire shall be passed through the electrode of the spark tester at the specified voltage and frequency. Electrode length and speed of wire movement shall be such that each length of the insulation is subjected to the test voltage for a minimum of 0.2 seconds. Any portion of the wire showing insulation breakdown shall be cut out of the wire including at least two inches on each side of the fault. The frequency and voltage of the spark shall be specified in the individual specification.

5. RESULTS. Report if 100 percent of the wire has been subjected to the in-process spark test and certify that all faults detected were removed as required before application of any outer insulation, jacket, or other material.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. Specifications shall list the test voltage and frequency to be used as well as the applicability of this test.

METHOD 3002

IMPULSE DIELECTRIC

1. PURPOSE. This method detects and removes insulation defects in finished wires. The test is primarily used as a 100 percent screening test at final packaging, but may be used as an in-process test or as an incoming inspection test by the user. Because of possible damage in handling, damage caused by repeated impulse testing, and variations in test parameters, comparisons between producer's and customer's test results are not significant. The impulse dielectric test is preferred to a 100 percent wet dielectric test since faults can be located and removed during final spooling without subjecting the wire to immersion in water which is potentially detrimental.

2. TEST EQUIPMENT. The electrode head through which the wire is passed in the impulse dielectric test shall be of a suitable bead chain construction such that the electrode will give intimate metallic contact with practically all of the wire insulation surface. The characteristics of the test impulse and of the equipment auxiliary to the electrode head shall be as follows:

a. Test impulse - The waveform of the voltage supplied to the electrode head shall consist of a negative pulse, the peak magnitude of which shall be as specified for the wire under test, followed by a damped oscillation. The peak impulse voltage for wire shall be as specified. The rise time of the negative impulse wave front from zero magnitude to 90 percent of the specified peak voltage shall be not more than 75 microseconds. The peak value of the first positive overshoot and each of the subsequent damped oscillations shall be smaller than the initial negative pulse. The time during which each pulse and accompanying damped oscillation (positive and negative) remains at an absolute potential of 80 percent or greater of the specified peak voltage shall be 20 to 100 microseconds. The pulse repetition rate shall be 200 to 250 pulses per second, inclusive. Except for the final peak voltage adjustment conformity to these test impulse parameters shall be determined with no capacitive load impressed upon the electrode.

b. Capacitive tolerance - The tolerance of the equipment to change in capacitive load shall be such that the peak output voltage shall not be reduced by more than 12 percent in the event of an increase of capacitive load, between electrode and ground, from an initial load of 12.5 picofarads per inch to 25 picofarads per inch of electrode length.

c. Instrument voltmeter - Connected to the electrode head, there shall be a peak reading voltmeter indicating continually the potential of the electrode. The voltmeter shall show full deflection at a potential not exceeding 15 kilovolts and shall have a minimum accuracy of ± 4 percent at the specified test impulse potential.

d. Failure detection circuit - There shall be a failure detection circuit to give a visible or audible indication of insulation failure, automatically deenergize the electrode head, and stop progress of the wire through the electrode. The detecting circuit shall be sufficiently sensitive to indicate a fault at 75 percent of the specified test voltage when the electrode is arced to ground through a 20 kilohm resistor and shall be capable of detecting a fault which lasts for the duration of only one impulse.

2.1 Calibration of equipment. The instrument voltmeter shall be calibrated by comparison with an external standard voltmeter capable of detecting the peak potential at the electrode head with or without auxiliary circuitry. In performing the calibration, the standard voltmeter shall be connected to one of the electrode beads directly or through a calibrated attenuator circuit. The impulse generator shall be energized and the voltage control of the impulse generator shall be adjusted until the reading on the standard voltmeter is the specified potential, at which point the reading on the instrument voltmeter shall be observed and recorded. This calibration shall be repeated for each peak potential at which it is intended to operate the equipment. An alternative procedure is by means of a calibrated oscilloscope connected to the electrode through a suitable attenuator. The peak magnitude of the negative pulse can then be read directly from the waveform display. An oscilloscope connected to the electrode head at suitable test points shall also be used to verify conformance to the other waveform parameters specified in 2a.

3. TEST SAMPLES. Test samples shall consist of 100 percent of the finished wire.

4. TEST PROCEDURE. The finished wire shall be threaded through the electrode head and the conductor shall be grounded at one or both ends. The electrode shall be energized to the specified peak potential and, after final adjustment of the voltage with wire in the electrode head, the wire shall be passed from the pay-off spool through the electrode and onto the take-up spool. The speed of passage of the wire through the electrode shall be such that the wire is subjected to not less than 3 nor more than 100 pulses at any given point. Any dielectric failures which occur shall be cut out or marked for later removal along with at least 2 inches of wire on each side of the failure. During all parts of the test, including string-up of new lengths, every effort shall be made to test the entire length, including ends of the wire, in accordance with this procedure. All ends or other portions of the wire not so tested shall be removed subsequent to the test. When specified, dielectric failures, untested portions of wire, or portions which have been exposed to fewer or more than the specified number of pulses may be marked by stripping the insulation or by other suitable method of marking as specified in the contract in lieu of being cut out of the wire.

5. RESULTS. Report if 100 percent of the wire has been subjected to the impulse dielectric test and certify that all faults detected were removed or marked as required.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. Specifications shall list the peak test voltage to be used.

METHOD 3003

INSULATION RESISTANCE

1. PURPOSE. This test determines the insulation resistance of a finished wire sample. Insulation resistance is of interest in high impedance circuits and as a measure of quality control of the insulation process. Changes in insulation resistance may indicate deterioration in other properties of the wire.

2. TEST EQUIPMENT

   a. Apparatus such as a megohm bridge, megohm meter, insulation resistance test set, or other suitable equipment.

   b. Voltage source capable of supplying a constant 500 volts ± 10 percent.

   c. Tub, jar, or other insulated vessel large enough to hold sufficient water to immerse the specimen length.

   d. Anionic wetting agent or quantity of 5 percent by weight sodium chloride in water.

3. TEST SAMPLES. Test sample shall consist of a wire at least 26 feet in length with the insulation removed for 1 inch at each end. The stripped ends shall be twisted together.

4. TEST PROCEDURE. The test specimen shall be immersed within approximately six inches of each end in a water bath containing 0.5 to 1.0 percent of an anionic wetting agent of 5 percent by weight sodium chloride at room temperature. After a 4-hour minimum immersion time, the specimen shall be subjected to a potential of 500 volts ± 10 percent applied between the conductors tied together and the water bath, which serves as the second electrode (see figure 1). The insulation resistance of the specimen shall be measured after one minute of electrification and shall be converted to megohms for 1000 feet as follows:

$$\text{Megohms for 1,000 feet} = \frac{\text{Measured resistance (megohm)} \times \text{Immersed Length (feet)}}{\text{1,000 feet}}$$

5. RESULTS. Report the calculated value for the insulation resistance in megohms for 1000 feet.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. Specifications shall list any preconditioning tests or any deviations.

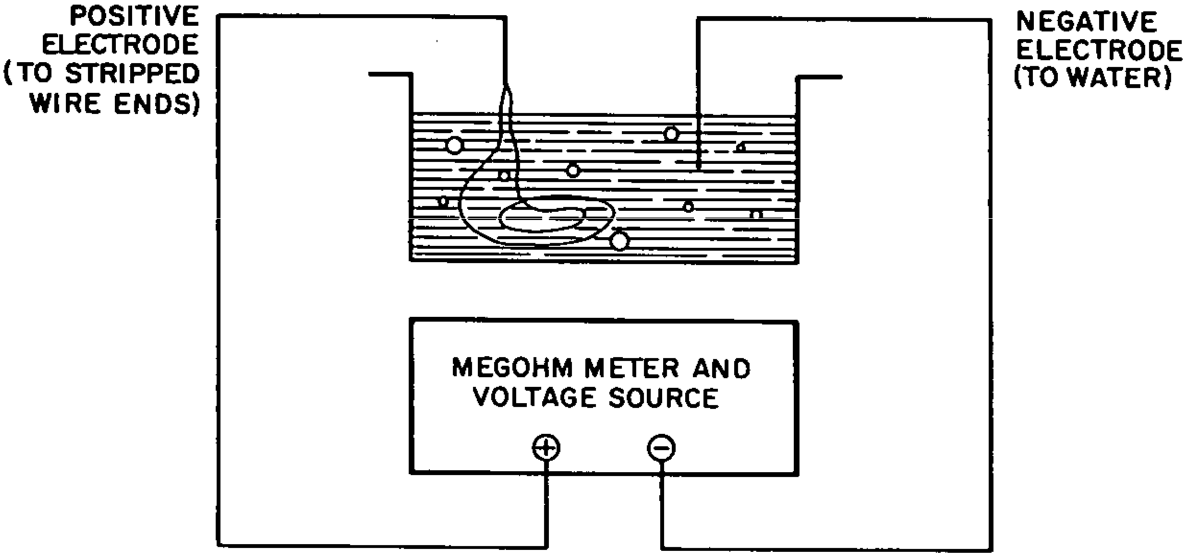


FIGURE 1. Typical insulation resistance test.

METHOD 3004

SURFACE RESISTANCE

1. PURPOSE. This method is intended for use in determining the surface resistance of the wire.

2. TEST EQUIPMENT

a. A test chamber capable of maintaining a temperature of 25° ± 1°C and an internal relative humidity of 95 ± 4 percent. A chamber may be formed from a tightly-covered rectangular glass vessel containing an ample reservoir of saturated aqueous solution of chemically pure potassium sulphate (see ASTM E 104). The chamber should be instrumented to measure the relative humidity within the chamber, with the humidity indication visible from outside the chamber. All instrumentation through-leads into the chamber should be suitably protected where they enter the chamber, to prevent introduction of any error in the specimen measurements. The electrical resistance of the chamber measured across each pair of lead wires with no specimens in place, shall be not less than 1 million megohms. This measurement should be made after the chamber has been closed and conditioned for 96 hours at 95 ± 4 percent relative humidity and a temperature of 25° ± 1°C.

b. Voltage source capable of supplying a constant 500 volts ± 10 percent.

c. Apparatus to measure resistance between the electrodes such as a megohm bridge, megohm meter, insulation resistance test set, or other suitable apparatus.

d. Dielectric tester to apply 2,500 volts at 60 Hz.

3. TEST SAMPLES. The specimen shall consist of a 6-inch length of finished wire. In the sampling operation and subsequently until completion of the test, this specimen shall be handled with maximum care to avoid even the slightest contamination, especially with regard to the surface area which will be under test. The specimen shall be cleaned by a distilled water wash, followed by an isopropyl alcohol wash and a second distilled water rinse, dried carefully in an air or air oven, and handled subsequently with maximum care as previously directed. Cleaning shall be after application of electrodes.

4. TEST PROCEDURE

4.1 The 6-inch specimen shall be provided, near its center, with two electrodes spaced 1-inch apart between their nearest edges. Each electrode shall be composed of several turns of fine (AWG 27 or finer) tin-coated copper wire, wrapped snugly around the circumference of the specimen, leaving a free end of the fine wire of sufficient length for soldering to electrical lead wires. The test specimens shall be at least one inch from each wall of the chamber. With the specimen and electrodes thus prepared, the electrodes shall be soldered to lead wires in the test chamber, the test chamber shall be closed, and the test assembly shall be conditioned for 96 hours at the specified relative humidity and temperature. The surface resistance between the electrodes shall be measured with a dc potential of 500 $\pm$ 10 percent volts while the specimen is still within the test chamber after 1 minute electrification. No temperature correction factor shall be applied. The surface resistance computed by multiplying the measured resistance between the electrodes by the measured overall diameter of the specimen in inches shall be not less than that specified in the specification. Following the initial resistance measurement, a 2500 volt (rms), 60 cycle potential shall be applied between electrodes for 1 minute. There shall be no evidence of distress such as arcing, smoking, burning, flashover, or dielectric failures. After a discharge interval of 15 to 20 minutes, following the potential test, the surface resistance shall be remeasured and shall be not less than that specified in the detail specification or specification sheet.

5. RESULTS. The initial surface resistance value and the post test surface-resistance value shall be recorded.

6. INFORMATION REQUIRED IN INDIVIDUAL SPECIFICATION. The number of specimens to test and test deviations shall be listed.

METHOD 3005

WET DIELECTRIC

1. PURPOSE. This test determines the dielectric integrity of the wire insulation following an environmental or other test. Dielectric integrity is determined by applying an AC potential across the insulation between the conductor and a water ground with the insulated wire immersed.

2. TEST EQUIPMENT

   a. Dielectric test apparatus to apply an essentially sinusoidal wave form of a nominal frequency of 60 Hz. The voltage source shall be capable of supplying a steady voltage as specified. The applied voltage shall be displayed by a voltmeter accurate to within 5 percent. The tester shall have a fault indicator to determine breakdown or excessive leakage current.

   b. Tub, jar, or other insulated vessel large enough to hold sufficient water to immerse the specimen length.

   c. Quantity of 5 percent by weight sodium chloride in water.

   d. Anionic wetting agent (optional).

3. TEST SAMPLES. Test samples shall be of the number and length as specified in the preconditioning test. The insulation shall be removed from approximately one inch on each end and the uninsulated ends twisted together.

4. TEST PROCEDURE. The uninsulated ends of each specimen shall be fastened to a metallic contact and attached to an electric lead of the dielectric tester. The specimens shall be immersed to within 3 inches of the stripped ends in the salt water solution (which may contain the anionic wetting solution) at room temperature. After a 5-hour minimum immersion time, a voltage as specified at 60 Hz shall be applied between the lead attached to the conductor and the lead immersed in the salt water solution. The voltage shall be gradually increased at a uniform rate from 0 to the specified voltage in 30 seconds, maintained at the specified voltage for 5 minutes, and then decreased to zero in 30 seconds.

5. RESULTS. Report the results and the mode of any observed failure.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. Specifications shall list the test voltage, the number of specimens, and any applicable preconditioning tests.

CLASS 4000

THERMAL TESTS

METHOD 4001

ELEVATED TEMPERATURE AGING (LIFE CYCLE)

1. PURPOSE. This test determines if the wire insulation can withstand a temperature aging test for a time period at a temperature greater than the temperature rating of the insulation. To pass this test, the wire must withstand the bend and wet dielectric tests after the thermal exposure.

2. TEST EQUIPMENT

   a. Air circulating test oven capable of maintaining the chamber at the temperature limits specified. The oven shall have a means to secure the test mandrels horizontally to assure the weighted specimens do not touch any part of the chamber. The chamber shall be designed so the mandrels may be secured to minimize mechanical movement or vibration from the chamber or external sources. The air velocity in the chamber shall be capable of being maintained at 100 to 200 feet per minute as determined at room temperature.

   b. Test mandrels which may be coated with PTFE to prevent sticking of the wire specimens.

   c. Thermocouple recorder or stripchart recorder to accurately and continuously monitor the chamber temperature.

   d. Test weights as required.

3. TEST SAMPLE. The test sample shall be at least three specimens 24 inches in length. One inch of insulation shall be removed from each end of each specimen.

4. TEST PROCEDURE. The test oven shall be set and thermally stabilized at the specified temperature of the individual specification. The test oven shall be shut off and allowed to return to room temperature. Each end of the conductor shall be loaded with the test weight required in the individual specification and the central portion of each weighted specimen shall then be bent in a "U" shape over a horizontally placed mandrel of the diameter required (see figure 1). The portion of the insulation between the conductor and the mandrel will be under compression and the conductor will be under tension. The mandrel with the weighted samples shall then be placed in the oven and the oven turned on again. The specimens shall be maintained for the time and at the temperature required. The start of the time period shall be determined as the point in time the test oven restabilizes at the specified test temperature. After completion of the air oven thermal exposure, the oven shall be shut off, the door opened, and the specimens allowed to cool to room temperature, in the oven, for at least 1 hour. When cooled, the wire shall be immediately freed from tension, removed from the mandrel and straightened. Each specimen shall then be subjected to the bend test of method 2006 followed by the wet dielectric test of method 3005.

5. RESULTS. Report the results and the bend and wet dielectric test.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. Specifications shall list the length of time of the test, the test temperature and tolerance, the wet dielectric test voltage, the test mandrel size, and the test weight required. The recommended mandrel sizes are applicable to "normal weight" wires.

Note - The test temperature is recommended to be 30°C greater than the rated insulation temperature and the exposure time is recommended to be 500 hours. The weights and mandrel sizes chosen are related to the insulation thickness. One standard set of test mandrels and weights is listed below:

TABLE I. Test mandrels and loads.

WIRE SIZE	Mandrel Diameter (In.) (±3%)	Test Load (Lbs) (±3%)
30	.375	.250
28	.375	.500
26	.375	.500
24	.500	.750
22	.500	1.00
20	.500	1.50
18	.750	2.00
16	1.00	2.00
14	1.00	3.00
12	1.50	3.00
10	2.00	3.00
8	3.00	4.00
6	4.00	4.00
4	5.00	4.00
2	6.00	6.00
1	8.00	6.00
0	8.00	6.00
00	10.00	8.00

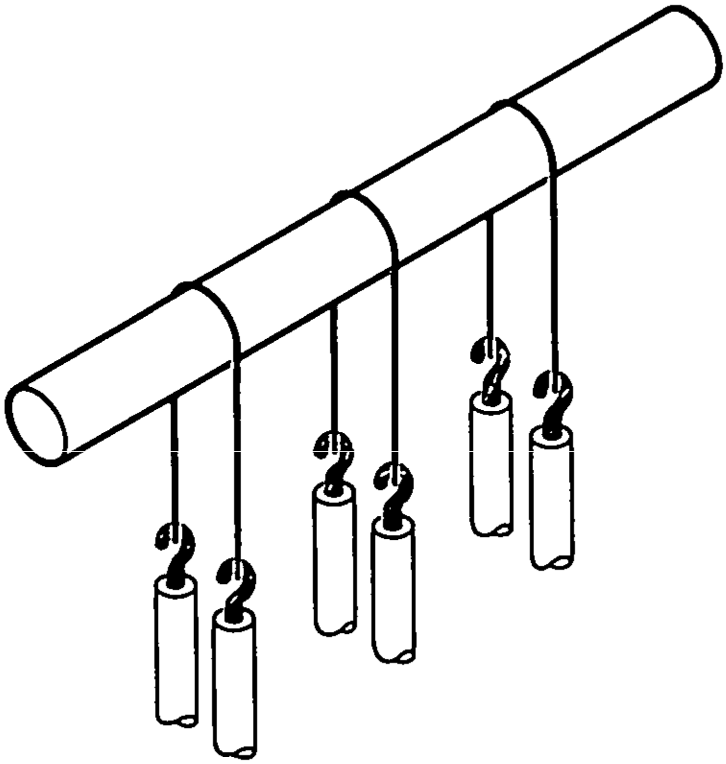


FIGURE 1. Typical sample arrangement.

METHOD 4002

HIGH TEMPERATURE ENDURANCE (FIRE-RESISTANT WIRE)

1. PURPOSE. This test determines the ability of the insulation of a firezone or similar wire to resist degradation due to exposure to a high temperature. Degradation is judged by change in conductor resistance, cracking during bending, insulation dielectric breakdown, or decreased resistance to fluids. The test is generally applied to fire resistant or similar wire types in lieu of the elevated temperature aging (life cycle) test.

2. TEST EQUIPMENT

a. Air oven capable of maintaining a temperature of 343°C ± 3°C (650°F ± 5°F). The oven shall have test ports to allow the sample leads to be connected to a power supply.

b. AC or DC constant current power supply to provide the currents listed in table I.

c. Voltmeter.

d. Ammeter.

e. Fluids as specified in the individual specification.

f. Test mandrels as required.

g. Load weights as required.

3. TEST SAMPLES. Test sample shall consist of one continuous length of at least 24 feet (for inside the oven) and an additional length to attach to the current source outside the test oven.

4. TEST PROCEDURE

4.1 High temperature endurance. The wire sample shall be placed in the oven which shall be maintained at 343° ± 3°C (650°F ± 5°F). The ends of the specimen shall be run through the ports of the oven and connected to the current source which may be either AC or DC. The current through the conductor shall be adjusted to stabilize at the value given in table I for the applicable wire size. When the stabilized oven test temperature and the stabilized conductor current are reached, the initial voltage and current measurements shall be recorded. The current loaded wire shall remain in the air oven at an oven temperature of 343° ± 3°C (650° ± 5°F) for a period of 100 +1, -0 hours. The current through the conductor shall be checked periodically and maintained at the required test value. At the end of the 100-hour period, while still at the stabilized temperature and conductor current, final voltage and current measurements shall be recorded. Change in resistance during the conditioning period shall be calculated from the voltage and current measurements. The wire shall then be cooled to room temperature and examined for visual defects. Change in color of the finished wire or printed identification shall not be considered a defect. The ends of the wire sample that were outside the oven during conditioning shall be discarded. From the wire which was inside the oven during conditioning, the following 3 foot specimens shall be cut for further testing:

a. Specimen no. 1 - bend test method 2006 followed by wet dielectric test method 3005.

b. Specimen nos. 2 through 7 - fluid immersion test method 1001 followed by bend test method 2006 and wet dielectric test method 3005.

The specific fluids to be used shall be specified in the individual specification. The bend test mandrels and weights are specified in table II.

TABLE I. Current for conditioning.

Size	Test Current
22	4.5
20	5.5
18	9.0
16	11.5
14	16.5
12	21.0
10	28.5
8	37.5
6	52.0
4	70.0
2	94.0
1	105
0	127
00	146
000	169
0000	202

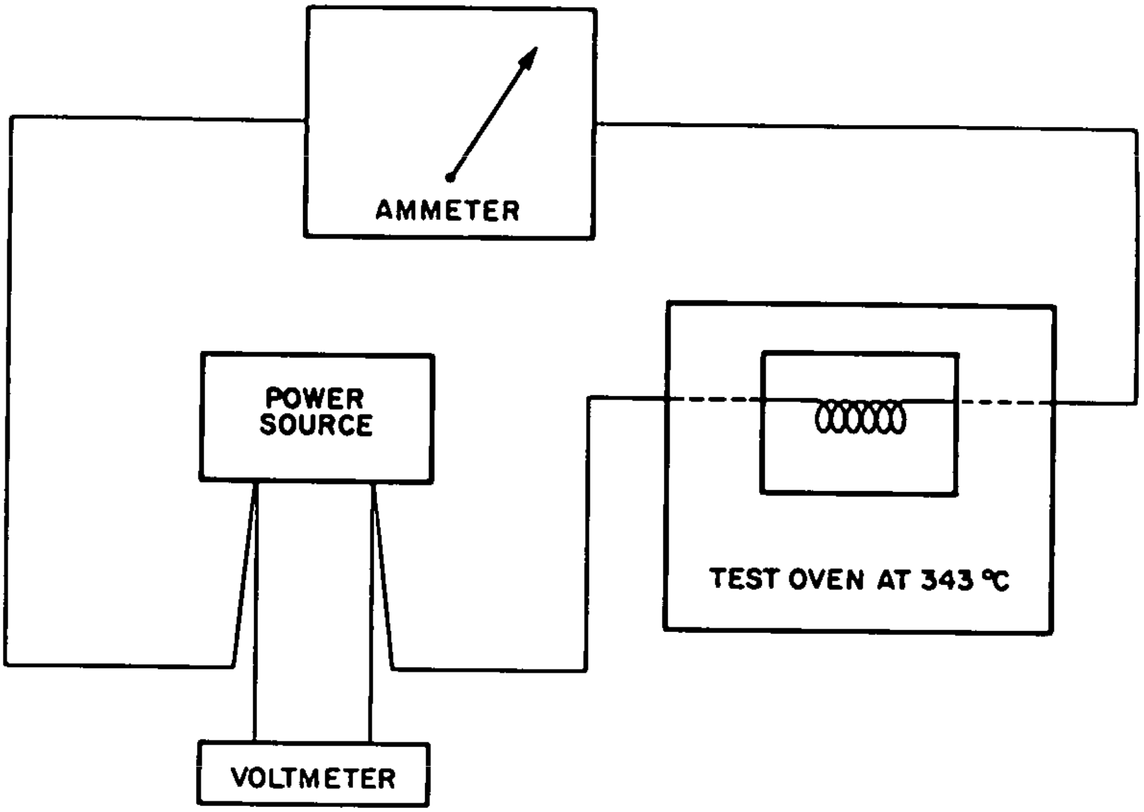


FIGURE 1. Typical high temperature endurance test.

TABLE II. Bend test.

WIRE SIZE	Mandrel Diameter in Inches	Test Load (Lb)
22	6	2
20	6	2
18	6	2
16	8	3
14	8	3
12	8	3
10	10	5
8	12	5
6	14	10
4	16	10
2	20	15
1	22	15
0	24	20
00	24	25
000	24	30
0000	24	30

The change in conductor resistance may be calculated as follows:

$$\% \text{ Change in Resistance} = \frac{\left[\frac{V_F}{I_F} - \frac{V_I}{I_I}\right]}{\left[\frac{V_I}{I_I}\right]}$$

Where: V_I = Initial Voltage I_I = Initial Current
V_F = Final Voltage I_F = Final Current

5. RESULTS. Report the percent change in conductor resistance, results of the bend and wet dielectric tests, the results of the fluid immersion tests, and any visual defects observed.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. Specifications shall list the wet dielectric test voltage, the maximum percent conductor resistance change allowed, and the fluids to be used.

METHOD 4003

CROSSLINK PROOF (ACCELERATED AGING)

1. PURPOSE. This test determines if the insulation of a wire has been converted to a thermoset material by polymer crosslinking. The test is performed for a short time period at a temperature much greater than the temperature rating of the insulation. To pass this test, the wire must withstand the bend and wet dielectric tests after the thermal exposure. This test has been named "accelerated aging" in some military specifications and has been applied to some insulation materials which are not crosslinked.

2. TEST EQUIPMENT

a. Air circulating test oven capable of maintaining the chamber at the temperature limits specified. The oven shall have a means to secure the test mandrels horizontally to assure the weighted specimens do not touch any part of the chamber. The chamber shall be designed so the mandrels may be secured to minimize mechanical movement or vibration from the chamber or external sources. The air velocity in the chamber shall be capable of being maintained at 100 to 200 feet per minute as determined at room temperature.

b. Test mandrels which may be coated with PTFE to prevent sticking of the wire specimens.

c. Thermocouple recorder or stripchart recorder to accurately and continuously monitor the chamber temperature.

d. Test weights as required.

3. TEST SAMPLE. The test sample shall be at least three specimens each 24 inches in length. One inch of insulation shall be removed from each end of each specimen.

4. TEST PROCEDURE. The test oven shall be set and thermally stabilized at the specified temperature of the individual specification. The test oven shall be shut off and allowed to return to room temperature. Each end of the conductor shall be loaded with the test weight required in the individual specification and the central portion of each weighted specimen shall then be bent in a "U" shape over a horizontally placed mandrel of the diameter required (see figure 1). The portion of the insulation between the conductor and the mandrel will be under compression and the conductor will be under tension. The mandrel with the weighted samples shall then be placed in the oven and the oven turned on again. The specimens shall be maintained for the time and at the temperature required. The start of the time period shall be determined at the point in time the test oven restabilizes at the specified test temperature. After completion of the air oven thermal exposure, the oven shall be shut off, the door opened, and the specimens allowed to cool to room temperature, in the oven, for at least 1 hour. When cooled, the wire shall be immediately freed from tension, removed from the mandrel and straightened. Each specimen shall then be subjected to the bend test of method 2006 followed by the wet dielectric test of method 3005.

5. RESULTS. Report the results and the bend and wet dielectric test.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. Specifications shall list the length of time of the test, the test temperature and tolerance, the wet dielectric test voltage, the test mandrel size, and the test weight required. The recommended test mandrels and weights are applicable to "normal weight" wires.

Note - The test recommended time of exposure is 6 hours. The temperature should be greater than the melting point of the uncrosslinked insulation material. The weights and mandrel sizes chosen are related to the insulation thickness. One standard set of test mandrels and weights is listed below:

TABLE I. Test mandrels and loads.

WIRE SIZE	Mandrel Diameter (In.) (±3%)	Test Load (Lbs) (±3%)
30	.375	.250
28	.375	.500
26	.375	.500
24	.500	.750
22	.500	1.00
20	.500	1.50
18	.750	2.00
16	1.00	2.00
14	1.00	3.00
12	1.50	3.00
10	2.00	3.00
8	3.00	4.00
6	4.00	4.00
4	5.00	4.00
2	6.00	6.00
1	8.00	6.00
0	8.00	6.00
00	10.00	8.00

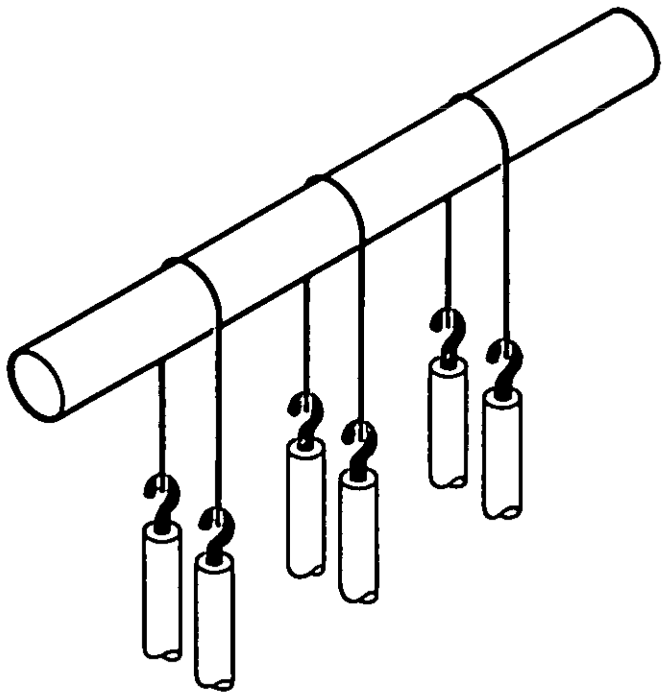


FIGURE 1. Typical sample arrangement.

METHOD 4004

THERMAL SHOCK

1. PURPOSE. This test determines the ability of wire insulation to resist shrinkage or expansion due to a brief exposure to temperature extremes. This test helps to measure inherent stresses in the insulation which affect longitudinal changes in the insulation.

2. TEST EQUIPMENT

   a. Suitable thermal shock chamber or combination of an air oven and cold chamber capable of maintaining the specified temperatures and tolerances.

   b. Timers to measure cycle times.

   c. Scale to measure shrinkage/expansion to the nearest 0.001 inch.

   d. Razor blade or equivalent sharp cutting tool.

3. TEST SAMPLES. Test samples shall consist of a specimen of wire five feet long prepared by carefully removing 1 inch of insulation from each end of the wire with the razor blade or other sharp cutting tool held perpendicular to the axis of the wire. The length of the exposed conductor on each end shall be measured to the nearest 0.001 inch. The specimen shall be formed into a loose coil not less than 1 foot in diameter and shall be laid on a wire screen for handling throughout the test.

4. TEST PROCEDURE. The specimen shall be placed in the oven or hot chamber preheated to the specified temperature for 30 minutes. The specimen shall be removed from the oven or hot chamber and within two minutes placed in the cold chamber precooled to -55° ± 2°C (-67°F ± 3.6°F) for 30 minutes unless otherwise specified. After 30 minutes the cycle (hot, room, then cold temperature) shall be repeated. A total of 4 full cycles shall be performed. At the conclusion of the 4th cycle, the distance from the end of each layer of the insulation to the end of the conductor shall be measured to the nearest 0.001 inch on each end of each specimen. The difference in the length of exposed conductor before and after the test shall be calculated. The insulation shall also be checked for flaring of any layer.

5. RESULTS. Report the change in length of exposed conductor on each end of each specimen and report flaring of any layer of the insulation.

6. *INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION.* Specifications shall list the maximum expansion/contraction of the insulation allowed, the high temperature and tolerance, and the cold temperature and tolerance to use (if other than -55°C).

> Note - The rated maximum temperature of the insulation is recommended as the high test temperature.

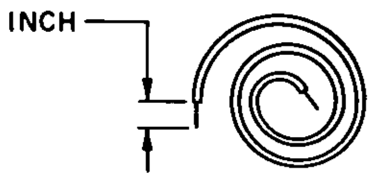


FIGURE 1. Typical thermal shock sample.

METHOD 4005

INSULATION SHRINKAGE/EXPANSION

1. PURPOSE. This test determines the ability of wire insulation to resist shrinkage or expansion due to a brief exposure to a high temperature. This test helps to measure inherent stresses in the insulation which affect longitudinal changes in the insulation.

2. TEST EQUIPMENT

   a. Suitable air oven capable of maintaining the specified temperatures and tolerance.

   b. Timer to measure exposure.

   c. Scale to measure shrinkage/expansion to the nearest 0.001 inch.

   d. Razor blade or equivalent sharp cutting tool.

3. TEST SAMPLES. Test sample shall consist of 3 wire specimens 13 inches long prepared by carefully removing .500 inch of insulation from each end of the wire with the razor blade or other sharp cutting tool held perpendicular to the axis of the wire (see figure 1). The length of the exposed conductor on each end shall be measured to the nearest 0.001 inch.

4. TEST PROCEDURE. The oven shall be thermally stabilized then the specimen shall be placed in the oven at the specified temperature for 6 hours. After 6 hours, remove the specimens from the oven and allow the specimens to return to room temperature. The distance from the end of each layer of the insulation to the end of the conductor shall be measured to the nearest 0.001 inch on each end of each specimen. The difference in the length of exposed conductor before and after the test shall be calculated.

5. RESULTS. Report the change in length of exposed conductor on each end of each specimen.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. Specifications shall list the maximum expansion/contraction of the insulation allowed, and the high temperature and tolerance.

Note - A test temperature 30°C greater than the rated temperature of the insulation is recommended.

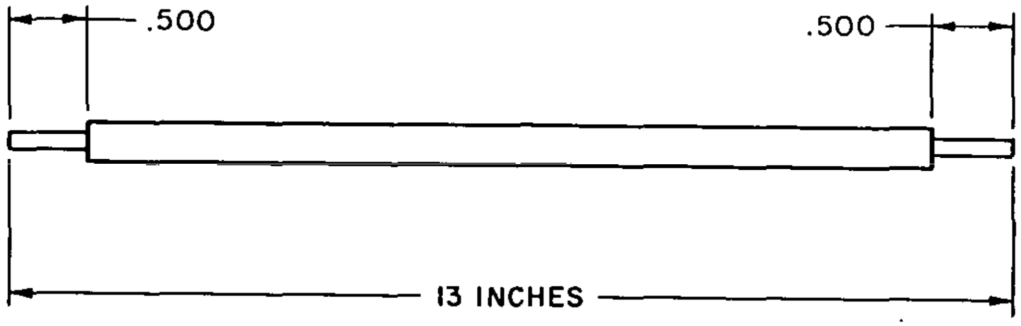


FIGURE 1. Insulation shrinkage/expansion sample.

METHOD 4006

LAMINATION SEALING

1. PURPOSE. This test determines if tape wrapped insulations have been properly processed. Failure of this test indicates the layers of tape are not properly sealed and have too little adhesion between their layers.

2. TEST EQUIPMENT

   a. Air circulating oven capable of maintaining the temperature and tolerance specified.

3. TEST SAMPLE. A test sample shall consist of 3 wire specimens 12 inches long cut flush at both ends.

4. TEST PROCEDURE. The specimens shall be maintained at the temperature specified for 48 hours in an air oven. At the end of this period, the specimen shall be removed from the oven and allowed to return to room temperature. The specimen shall then be visually examined for delamination. Delamination is defined as separation of layers or lifting of tapes along the insulation or at the ends.

5. RESULTS. Report any delamination.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. Specifications shall list the test temperature and tolerance.

Note - A test temperature 30°C greater than the rated temperature of the insulation is recommended.

METHOD 4007

BLOCKING

1. PURPOSE. This test determines if a wire will block (stick to itself) after exposure to a short time thermal exposure.

2. TEST EQUIPMENT

a. Metal spool or mandrel of the specified diameter.

b. Clamps or other means to secure the wire to the spool or mandrel.

c. Air oven to maintain the temperature and tolerances specified.

3. TEST SAMPLES. Test sample shall consist of a wire specimen of sufficient length to wind at least 9 times around the specified spool or mandrel and to be secured to the spool or mandrel.

4. TEST PROCEDURE. One end of the specimen shall be affixed to a metal spool or mandrel of the specified diameter. The wire shall then be wound helically at the tension shown for the wire size for at least three turns, with the succeeding turns in close contact with one another. The winding shall be continued until there are at least three closely-wound layers of such helical turns on the spool (see figure 1). The free end of the wire shall then be affixed to the spool or mandrel to prevent unwinding or loosening of the turns. The spool or mandrel with the attached wire specimen shall be placed for 24 hours in an air oven at the temperature specified. At the end of 24 hours, the spooled wire shall be removed from the oven and allowed to come to room temperature. The wire shall be unwound from the spool manually, and examined for adhesion (blocking) of adjacent turns.

TABLE I. Wire and barrel size, winding tension.

WIRE SIZE	Min Barrel Diameter of Spool or Mandrel	Winding Tension (Lbs) (±3%)
30	50X	.50
28	50X	.50
26	50X	.50
24	50X	.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

5. RESULTS. Report the results of the blocking test.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. Specifications shall list the blocking test temperature and the tolerance.

Note - The recommended test temperature is the rated temperature of the wire insulation.

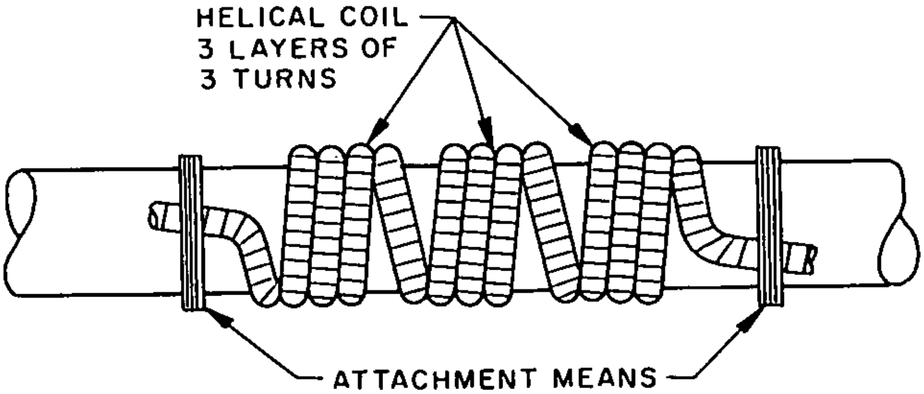


FIGURE 1. Typical blocking sample arrangement.

METHOD 4008

SMOKE

1. PURPOSE. This test determines if the insulation of a wire will produce smoke when the conductor is subjected to an overload current which raises the conductor temperature to the rated temperature of the insulation.

2. TEST EQUIPMENT

   a. A flat black viewing background at least 10 feet in length.

   b. A constant current power supply.

   c. Voltmeter.

   d. Ammeter.

   e. Thermometer.

3. TEST SAMPLES. Test sample shall consist of a wire specimen approximately 15 feet in length.

4. TEST PROCEDURE. This test shall be conducted at room ambient temperature in still air. The specimen shall be suspended so that at least the central 10-foot section is horizontal and unsupported. One end of the wire shall be suitably weighted so that no sagging will occur. The resistance of the central 10-foot section shall be measured in accordance with Method 5003 (Conductor Resistance). During the test, while passing direct current through the wire to raise its temperature, the voltage drop shall be measured over the 10-foot section. The voltage-to-current ratio (resistance) needed to provide the required smoke test temperature specified in the individual specification (based on conductor resistance change) shall then be determined by use of the following formula:

$$\frac{E_T}{I_T} = R_a \left[1 + \frac{T_T - T_a}{K + T_a} \right]$$

Where:

E_T = Voltage drop over the central 10-foot section at smoke test temperature
I_T = Test current (amps) to provide the required smoke test temperature
R_a = Measured conductor resistance at room ambient (ohms)
T_T = Smoke test temperature (°C) specified in the individual specification
T_a = Ambient temperature (°C)
K = Temperature coefficient of resistance (from NBS-HDBK-100) as follows:

K = 234.5 for standard annealed copper conductors
K = 279.0 for high strength copper alloy conductors

The current shall be increased slowly until the resistance of the conductor is stabilized at the value calculated above. The conductor temperature shall be maintained for 15 minutes during which time the finished wire under current load will be observed for any evidence of smoke against the flat black background.

5. RESULTS. Report any evidence of smoke from the wire insulation.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. Specifications shall list the smoke test temperature and the tolerance.

Note - The recommended test temperature is the rated temperature of the wire insulation.

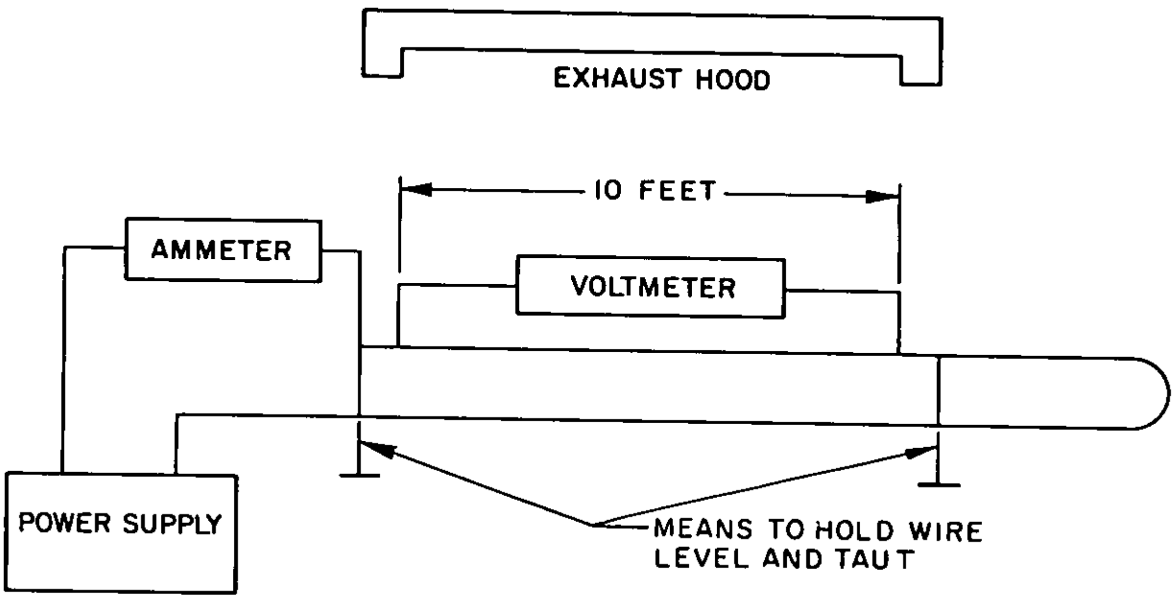


FIGURE 1. Typical smoke test arrangement.

CLASS 5000

VISUAL AND PHYSICAL CONDUCTOR TESTS

METHOD 5001

CONDUCTOR DIAMETER

1. PURPOSE. This test determines the diameter of the conductor after the insulation has been removed.

2. TEST EQUIPMENT

   a. Micrometer or equivalent device capable of measuring to the nearest 0.0001 inch.

3. TEST SAMPLES. Test samples shall consist of at least three 24-inch wire lengths.

4. TEST PROCEDURE. Remove the insulation from the specimens 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 stripped conductor. Each measurement shall consist of two micrometer readings taken 90 degrees from each other. For sizes 8 and larger, a circumferential measuring tape calibrated for diameter measurements may be used in lieu of the micrometer method.

5. RESULTS. Report each measured conductor diameter and the average conductor diameter for each specimen measured.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. Specifications shall list the number of specimens to test if other than specified here.

METHOD 5002

CONDUCTOR ELONGATION AND BREAK STRENGTH

1. PURPOSE. This test determines the percentage elongation at break for soft or annealed copper conductors and the break strength and the percent elongation for high strength copper alloy conductors. This test is used as process control test on the conductors either before application of insulation or after insulation with the insulation removed. The insulation process may affect the elongation and break strength of the conductor.

2. TEST EQUIPMENT

   a. Power driven tensile test machine with sample grips attached to a force indicator. The machine sample grips shall be capable of separating to apply force to the specimen at a uniform rate of speed controllable to within 2 inches per minute. The force indicator shall be accurate to within ± 1 percent of the actual force applied and shall indicate the maximum force applied to break the wire or first strand as applicable.

   b. Strip chart recorder or other device to accurately measure the length of separation of the bench marks at break.

   c. Tensile machine grips which shall produce as nearly as possible uniformly distributed pure axial tension in the specimen. Grips should be spool type for specimens less than 0.208 inch in diameter, and wedge type for specimens 0.208 inch and larger in diameter.

3. TEST SAMPLES. Test sample shall consist of at least 3 wire specimens 20 inches in length. For insulated conductors, the insulation shall be removed without nicking, scraping elongating, or otherwise damaging the conductor.

4. TEST PROCEDURE. Two parallel bench marks shall be marked at 10 ± 1/32 inches apart on each specimen without damage to the conductor. A specimen shall be placed in the grips of the calibrated testing machine and adjusted such that the bench marks are between the grips (for wedge-type grips there shall be at least 1 inch between each bench mark and the adjacent grip).

4.1 Soft or annealed copper. 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 upon the whole conductor removed from the finished wire and the elongation shall be measured when the first strand of the conductor breaks. The elongation at break of the individual strand or of the first strand of the whole conductor, as applicable, shall be determined by means of a recording device on the testing machine. The speed of the power actuated grips shall be 10 ± 2 inches/minute under no load.

4.2 High strength copper alloy. When testing insulated samples the test shall be performed on the whole conductor removed from the finished wire. Conductor elongation shall be measured when the first strand of the conductor breaks and the total tensile force indicated by the testing machine at break of the strand shall be regarded as the breaking strength of the conductor. The elongation at break of the first strand of the whole conductor shall be determined by means of a recording device on the testing machine. The speed of the power actuated grips shall be 10 ± 2 inches/minute under no load.

4.3 Calculations. The elongation of the specimen shall be calculated as follows:

$$\text{Percent elongation} = \frac{(L - 10)}{(10)} \times 100$$

Where:

L = The distance between the bench marks on the specimen immediately after rupture (inches).

5. RESULTS. Report the average measured percent elongation for annealed or soft copper conductors and the average percent elongation and average conductor breaking strength for high strength copper alloy conductors.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. Specifications shall list the number of specimens to test if other than specified here and any test deviations.

METHOD 5003

CONDUCTOR RESISTANCE

1. PURPOSE. This test determines the direct current (DC) resistance of the conductor of a wire at a specified reference temperature which is usually 20°C (68°F). A formula is provided to convert the resistance value measured at other temperatures to the specified reference temperature.

2. TEST EQUIPMENT

   a. Resistance measuring device. A Kelvin bridge or suitable 4 terminal method apparatus accurate to within 0.1 percent of the reading shall be used if the resistance reading is less than 1 ohm. A Wheatstone bridge or suitable alternate apparatus accurate to within 1 percent of the reading may be used if the resistance is greater than 1 ohm.

   b. Temperature measuring device that will determine the conductor temperature to within 0.5°C (0.9°F).

   c. A scale to measure the specimen length to within 0.2 percent.

3. TEST SAMPLES. Test sample shall be free of splices, surface cracks, or other visible defects and shall be at least 36 inches long.

4. TEST PROCEDURE

4.1 Kelvin bridge method. Separate current and potential leads shall be used. The current leads shall be attached in such a manner as to give assured contact with all the strands of the conductor. The potential lead clamps shall be such as to encircle all of the conductor and of small enough width so that the tested length can be assured within the $\pm$ 0.2 percent accuracy. The distance between the current and potential lead contact shall be greater than three times the diameter of the specimen.

4.2 Wheatstone bridge method. The resistance of the leads connecting the bridge to the specimen shall be obtained with the leads short-circuited on themselves and the result subtracted from the measured resistance of the specimen.

Note - In conductor resistance measurements the applied current raises the temperature of the conductor, so care should be taken to use a low current value and a short application time to minimize this effect.

4.3 Measurement. The test specimen should be allowed to come to the same temperature as the surrounding medium to assure a correct reading. To eliminate errors due to contact potential, two readings, one direct, and one with the current reversed, may be taken in direct succession and the results averaged. The resistance, the conductor length, and the conductor temperature shall be measured and recorded. The measured resistance shall be converted to ohms per 1,000 feet as follows:

$$\text{Conductor Resistance (ohms/1,000 feet)} = \frac{\text{Measured resistance (Ohms)} \times 1{,}000 \text{ feet}}{\text{Sample length (feet)}}$$

4.4 Temperature correction. When measurement is made at other than the reference temperature, the measured resistance may be corrected to the reference temperature as follows:

$$R_T = \frac{R_t}{1 + \alpha(t - T)}$$

Where:

R_T = Resistance at reference temperature T.
R_t = Resistance as measured at temperature t.
αT = Temperature coefficient of resistance of the specimen being measured at reference temperature T.
T = Reference temperature.
t = Temperature at which measurement is made.

Note: The parameter α_T varies with the material, the copper conductivity, and the temperature. The value for 100 percent conductivity copper at 20°C is 0.00393. The value for high strength copper alloy at 20°C is 0.00334. Values for temperature coefficients for other materials, conductivities, and temperatures can be found in table 2 of NBS-HDBK-100 of the National Bureau of Standards.

5. RESULTS. Report the average measured resistance, sample length used, test temperature, and the calculated resistance for 1,000 feet. Show any calculations to correct the measured resistance to the specified reference temperature.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. Specifications shall list the maximum conductor resistance per 1,000 feet and the reference temperature.

METHOD 5004

CONDUCTOR SOLDERABILITY

1. PURPOSE. This test determines the ability of the conductor of a wire to be adequately covered with solder. This provides information if the conductor of the wire is solderable at the point in time the solderability test occurs. This test was developed to determine the solderability of tin plated or tin-lead plated terminations for MIL-STD-202 method 208, and has been applied to other plating types and to wires.

2. TEST EQUIPMENT

a. Solder pot. A static solder pot of sufficient size to contain at least 2 pounds of solder shall be used. This apparatus shall be capable of maintaining the solder at 245°C ± 5°C (473° ± 9°F).

b. Dipping device. A mechanical dipping device capable of controlling the rates of immersion and emersion of the specimens and providing a dwell time (time of total immersion to the required depth) in the solder bath as specified shall be used. A suggested dipping device is shown in figure 208-2 of method 208 from MIL-STD-202.

c. Optical equipment. An optical system capable of providing magnification of 10X shall be used unless otherwise specified.

d. Flux. The flux shall conform to type R of MIL-F-14256, Flux, Soldering, Liquid (Rosin Base).

e. Solder. The solder shall conform to type S, composition Sn60 or Sn63, of QQ-S-571, Solder; Tin Alloy: Tin-Lead Alloy; and Lead Alloy.

3. TEST SAMPLES. Test sample shall consist of at least 3 specimens at least 10 inches long. The insulation shall be removed for a distance of 3 inches from one end of each specimen.

4. TEST PROCEDURE

4.1 Preparation of terminations. No wiping, cleaning, scraping, or abrasive cleaning of the terminations shall be performed. Any special preparation of the terminations, such as bending or reorientation prior to the test, shall be specified in the individual specification. The insulation on stranded wires shall be removed so as not to loosen the strands in the wire. During handling, special care shall be exercised to prevent the surfaces being tested from being abraded or contaminated by grease, perspirants, abnormal atmospheres, etc.

4.2 Application of flux. Specimens shall be immersed in type R or RMA flux which is at room ambient temperature. Unless otherwise specified in the individual specification, terminations shall be immersed to within 0.05 inch of the insulation. The surface to be tested shall be immersed in the flux for 5 to 10 seconds, and shall be removed and allowed to drain for 10 to 60 seconds.

4.3 Solder dip. The dross and burned flux shall be skimmed from the surface of the molten solder. The molten solder shall then be stirred with a clean, stainless-steel paddle to assure that it is at a uniform temperature of 245°C ± 5°C (473° ± 9°F). The surface of the molten solder shall be skimmed again just prior to immersing the specimens in the solder. The wire shall be attached to a dipping device and the flux-covered terminations immersed once in the molten solder to the depth specified. The immersion and emersion rates shall be 1 ± .25 inch per second and the dwell time in the solder bath shall be 5 ± .50 seconds. After the dipping process, the part shall be allowed to cool in air. Residue flux shall be removed from the terminations by dipping in isopropyl alcohol. If necessary, a soft cloth moistened with clean isopropyl alcohol shall be used to remove all remaining flux.

4.4 Examination of conductor. After each dip-coated termination has been thoroughly cleaned of flux, the 1-inch portion of the dipped lead nearest the component, or the whole lead if less than 1 inch, or the fillet area (whichever is applicable), shall be examined using a magnification of 10X unless otherwise specified.

5. RESULTS. Report the solder coverage of each specimen and any other observations. The appendix to method 208 of MIL-STD-202 may be used as a guide in making this determination.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. List the required percent of solder coverage required, any steam aging or other environmental preconditioning tests, any variation in flux type, and any other test deviations.

METHOD 5005

CONDUCTOR STRAND BLOCKING

1. PURPOSE. This test determines if the conductor strands will block (adhere) to each other in the finished wire. This test is a process control test of the insulating process. The test was first developed to examine the tin plated conductors of polyimide insulated wires in MIL-W-81381 but may be applied to other conductor and insulation types.

2. TEST EQUIPMENT

   a. Wire insulation stripping tool.

   b. Fine needle or thin blade.

   c. Device to sever conductor strands.

3. TEST SAMPLES. Test sample shall consist of at least 3 specimens of wire 6 inches long.

4. TEST PROCEDURE

4.1 Preparation of sample. With the insulation stripping tool, initiate a stripping action 2 inches from one end of the sample and without kinking or otherwise damaging the conductor, move the insulation slug endwise until approximately .750 inch of the conductor is exposed. Remove the specimen from the stripping tool.

4.2 Procedure.

4.2.1 For 19 strand unidirectional lay and all 7-strand.

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

   b. Retain the grip position used to untwist the strands and carefully push the ends of the exposed portion of the conductor toward each other in the conductor axis, causing the strands to spread apart in a "bird cage" effect (see figure 1).

   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.

4.2.2 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.

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

6. INFORMATION REQUIRED IN INDIVIDUAL SPECIFICATION. Specifications shall list the number of samples and the minimum number of unbonded strands required.

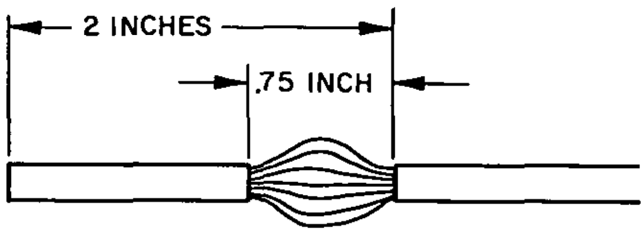


FIGURE 1. Typical 7-strand conductor after birdcaging (no strands blocked).

METHOD 5006

ADHESION OF NICKEL COATING

1. PURPOSE. This test determines the ability of nickel plating or coating to adhere properly to the underlying copper or high strength copper alloy material. This test is generally used as a process control test.

2. TEST EQUIPMENT

   a. Thermal shock chamber or air oven capable of maintaining 250° $\pm$ 3°C.

   b. Materials as required for continuity of coating test of ASTM B 355.

3. TEST SAMPLES. Test sample shall consist of two six inch specimens of uninsulated conductor strands.

4. TEST PROCEDURE. One strand specimen shall be wrapped over its own diameter for eight close turns. The second strand specimen shall remain in its straight form. Both specimens shall then be subjected to ten continuous cycles of temperature change. Each cycle shall consist of 4 hours at 250° $\pm$ 3°C followed by 4 hours at room temperature. Upon completion of the thermal cycling, the straight specimen shall be wrapped over its own diameter for eight close turns in a manner identical to that of the first specimen. Both wrapped specimens shall then be tested for continuity of plating in accordance with ASTM B 355.

5. RESULTS. Report the results of the continuity of coating test on each specimen.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. Specifications shall list the applicability of this test.

This test is inactive for new design - Adhesion of nickel coating requirements are covered by ASTM B 355 for new design.

CLASS 6000

VISUAL AND PHYSICAL FINISHED WIRE TESTS

METHOD 6001

FINISHED WIRE DIAMETER

1. PURPOSE. This test determines the diameter of the finished insulated wire.

2. TEST EQUIPMENT

   a. Micrometer or equivalent device capable of measuring to the nearest 0.0001 inch.

3. TEST SAMPLES. Test samples shall consist of at least three 24-inch wire lengths.

4. TEST PROCEDURE. Determine the wire diameter by measuring the outer diameter in at least three locations along the length of the insulated wire. Each measurement shall consist of two micrometer readings taken 90 degrees from each other. For sizes 8 and larger, a circumferential measuring tape calibrated for diameter measurements may be used in lieu of the micrometer method.

5. RESULTS. Report each measured insulated wire diameter and the average diameter for each specimen measured.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. Specifications shall list the number of specimens to test if other than specified here.

METHOD 6002

FINISHED WIRE WEIGHT

1. PURPOSE. This test determines the weight/1,000 feet of the finished wire. Procedure I determines the weight by measurement of a short length of wire and converting this to weight/1,000 feet. Procedure II measures the weight of wire on a spool and uses the known length of the wire on the spool to determine the weight/1,000 feet.

2. TEST EQUIPMENT

a. Weight scale of sufficient accuracy.

b. Length scale of sufficient accuracy.

3. TEST SAMPLES. Test sample for procedure I shall be a wire specimen a minimum of 10 feet in length. The sample of procedure II shall be the entire known length of wire on the spool or reel.

4. TEST PROCEDURE

4.1 Procedure I. The length and weight of a specimen a minimum of 10 ft (3 meters) in length shall be accurately determined and the measured length and weight converted to pounds/1,000 feet as follows:

$$\text{Pounds/1,000 feet} = \frac{\text{Measured Weight (lbs)}}{\text{Measured sample length (feet)}} \times 1{,}000 \text{ feet}$$

4.2 Procedure II. The net weight of the finished wire on the reel or spool shall be calculated by determining the tare weight of the empty reel or spool and the gross weight of the reel or spool with the wire and the following formula:

$$\text{Net Weight Wire} = (\text{Gross weight} - \text{Tare weight})$$

The net weight shall be divided by the accurately determined length of wire on the reel or spool and the result converted to pounds/1,000 feet as follows:

$$\text{Pounds/1,000 feet} = \frac{\text{Net Weight Wire (lbs)}}{\text{Finished Wire length (feet)}} \times 1{,}000 \text{ feet}$$

When wood or other moisture absorbent materials are used for the reel or spool, the determination of the tare weight and the net weight shall be made under substantially the same conditions of relative humidity.

5. RESULTS. Report the calculated weight per 1,000 feet as determined above. Report the gross, net, and tare weight for procedure II.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. Specifications shall list the number of specimens to test and the procedure to use.

METHOD 6003

INSULATION WALL THICKNESS AND CONCENTRICITY

1. PURPOSE. This test determines the wall thickness and insulation concentricity of a finished wire. Concentricity of the insulation is defined as the ratio of the maximum wall thickness (thickest point) to the minimum wall thickness (thinnest point). Concentricity measurements are generally only applied to the insulation of extruded wires.

2. TEST EQUIPMENT

   a. Optical measuring device capable of reading to the nearest 0.0005 inch.

   b. Single-edged razor blade or equivalent cutting tool.

   c. Insulation stripping tool with precision-sized blades (if needed).

3. TEST SAMPLES. The sample shall consist of at least three specimens. Specimens shall be prepared by making a circumferential cut around the perimeter of the wire through the insulation to the conductor using the cutting tool. The cut shall be made approximately .50 inch from the end of the wire specimen. The wire shall be flexed on either side of the circumferential cut to break the adhesion of the insulation slug and the conductor. The slug should be stripped from the conductor using fingers or the stripping tool if needed. Care should be taken not to distort the razor cut surface on the slug which will be used for the wall thickness measurements.

4. TEST PROCEDURE

4.1 Wall thickness. All wall thickness measurements shall be made on cross-sections of the wire specimens using the optical measuring device set at a suitable magnification. A wall thickness shall be the shortest distance between the outer rim of the primary insulation or the finished wire, as applicable, and the outer rim of the outermost strand of the conductor.

4.2 Concentricity.

4.2.1 Concentric lay wires (usually size 30-10). The concentricity of the primary insulation or the finished wire, as applicable, shall be determined by first locating and recording the minimum and the maximum wall thickness (see figure 1) of a wire specimen at the same cross-section per paragraph 4.1. Calculate the concentricity of the wire insulation as follows:

$$\text{\% Concentricity} = \frac{\text{Minimum wall thickness}}{\text{Maximum wall thickness}} \times 100$$

4.2.2 Concentricity of rope-lay wires (usually size 8 and larger). The concentricity of the primary insulation or the finished wire, as applicable, shall be determined by first locating and recording the the minimum wall thickness of a wire specimen. At the same cross-section, on the outer rim of the primary insulation or the finished wire, as applicable, three more wall thickness measurements shall be taken each one being 90 degrees apart (see figure 2) around the circumference of the wire (determined by moving clockwise from the point of the minimum wall thickness). The average of these four readings shall be considered to be the average wall thickness. The percent concentricity shall be determined as follows:

$$\%\ \text{Concentricity} = \frac{\text{Minimum wall thickness}}{\text{Average wall thickness of 4 measurements}} \times 100$$

5. RESULTS. Report the measured wall thickness for all constructions. Report concentricity for those constructions that require it in the individual specification.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. Specifications shall list the applicability of the concentricity test and the requirements for wall thickness.

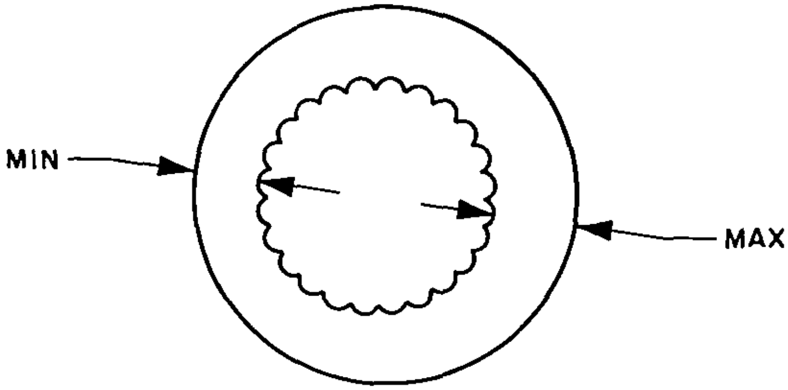


FIGURE 1. Example of minimum and maximum wall thickness.

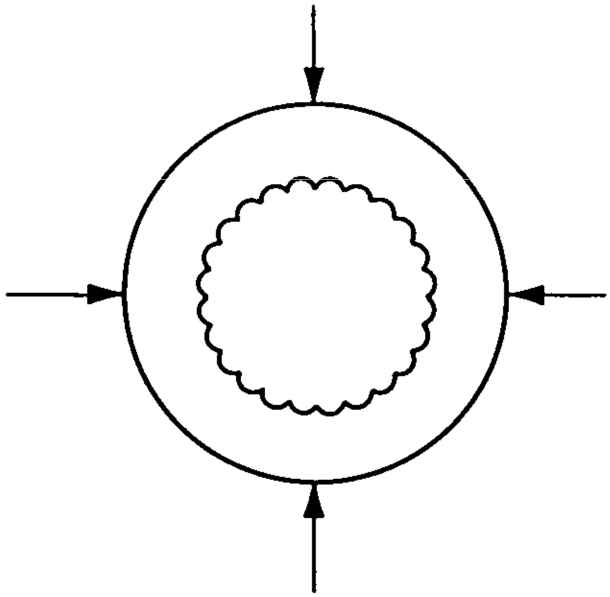


FIGURE 2. Example of 4 points, each 90 degrees apart around circumference.

METHOD 6004

PRINT IDENTIFICATION OR COLOR CODE DURABILITY

1. PURPOSE. This test determines the durability of printed identification markings or color code markings such as stripes, bands, or insulation colors. This test evaluates the markings for permanency.

2. TEST EQUIPMENT

a. Apparatus designed to hold a 6-inch specimen of finished wire firmly clamped horizontally with the upper longitudinal surface of the specimen fully exposed. The apparatus shall be capable of rubbing a small cylindrical sewing needle 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 force normal to the surface of the insulation. A motor-driven, reciprocating cam mechanism and counter shall be used to deliver the specified number of abrading strokes in a direction parallel to the axis of the specimen.

b. A steel sewing needle 0.025 $\pm$ .002 inches in diameter.

3. TEST SAMPLES. Test samples shall consist of 3 wire specimens 6 inches in length. Each specimen shall contain the full product identification marking or the color coding as applicable.

4. TEST PROCEDURE. A specimen of wire shall be mounted in the specimen clamp and the weight specified in the individual specification shall be applied through the abrading sewing needle to the surface of the wire marked with the product identification or the color code. The counter shall be set and the drive motor started. The specimen shall be subjected to the specified number of strokes. The length of the stroke shall be .375 inch and the frequency of the stroke shall be 120 strokes (60 stroking cycles) per minute. The test shall be repeated on the other specimens. The tested specimens shall then be examined visually.

5. RESULTS. Report the results of the durability test on each specimen. Report any qualitative observations as well as pass/fail information.

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. Specifications shall list the number of abrading cycles (strokes), the test load, and which markings this test shall be applied to.

Note - Most wire specifications require 125 cycles (250 strokes) or 250 cycles (500 strokes) and 500 grams of weight. These number of cycles and the weight used are usually lower for braided insulations.

METHOD 6005

PERCENT OVERLAP OF INSULATING TAPES

1. PURPOSE. This test determines the percent overlap of the insulating tape or tapes used in a finished wire. The percent overlap is determined by measuring the degrees of rotation of the tape around the conductor and converting this number to percent overlap by use of the graph in figure 1. Adequate percent overlap helps to insure the wire possesses correct wall thickness, dielectric properties and mechanical properties. This test is only applicable to tape-wrapped wire.

2. TEST EQUIPMENT

   a. Insulation stripping tool with precision sized blades.

   b. Single edged razor blade or equivalent cutting tool.

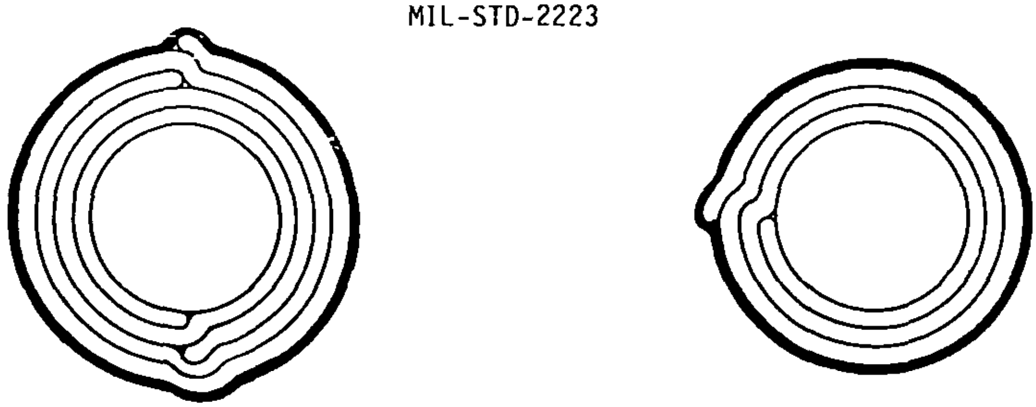
   c. Microscope or equivalent optical device providing a magnification of 15 diameters minimum (preferably one with an eyepiece or similar means to measure angles).

3. TEST SAMPLES. The test sample shall consist of at least three specimens. Specimens shall be prepared by stripping an insulation slug approximately .50 inch in length using the precision stripping tool. With the razor blade or cutting tool, cut the edge of each insulation slug to be examined. The cut faces of the specimen must be smooth, perpendicular to the slug axis, and perpendicular to each other.

4. TEST PROCEDURE. The cut edge of the insulation slug to be examined shall be positioned under the microscope or suitable optical device. Inspect the cut cross-section under the microscope or suitable device at a magnification of 15 diameters, minimum. Measure, in degrees of rotation, the total length of the spiral edge displayed by the innermost insulation tape (wrap 1) in the cross-section. By reference to part B of figure 1, convert the degrees of rotation to percent overlap of the tape in the insulation. Repeat the determination for any additional tape (wrap 2, etc.) in the cross-section.

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

6. INFORMATION REQUIRED IN THE INDIVIDUAL SPECIFICATION. Specifications for wires with tape wrapped insulation shall list the minimum tape overlap of each insulating tape used in the finished wire.

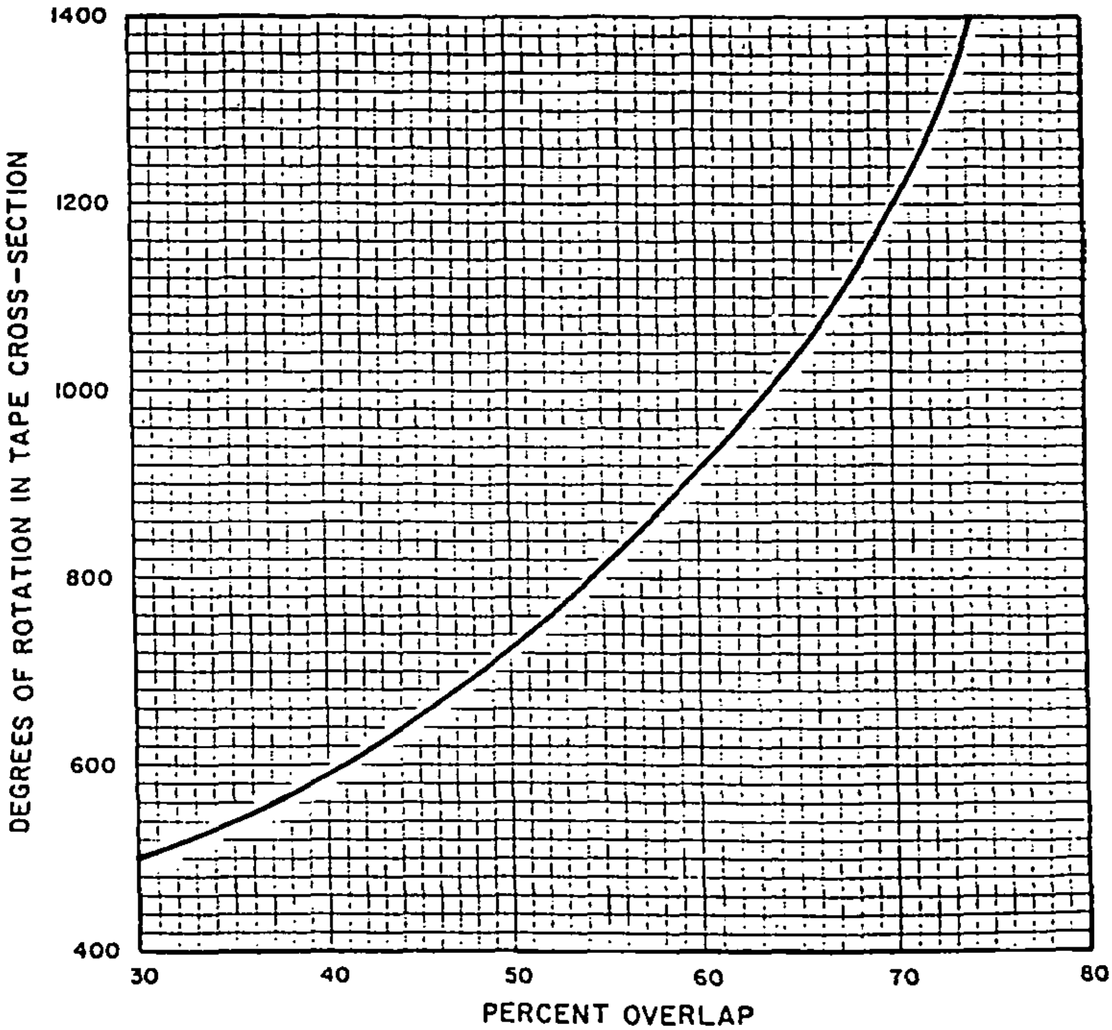


50 PERCENT OVERLAP, TWO TAPE CONSTRUCTION (720 DEGREES OF ROTATION, EACH TAPE)

67 PERCENT OVERLAP, SINGLE TAPE CONSTRUCTION (1080 DEGREES OF ROTATION)

WITH INSULATION TOP COATING, BOTH CONSTRUCTIONS.

A. TYPICAL INSULATION CROSS-SECTIONS (X80)



B. CONVERSION OF DEGREES OF ROTATION TO PERCENT OVERLAP.

FIGURE 1. Percent overlap of tapes in tape insulation.

Custodians:
Navy - AS
Army - CR
Air Force - 85
DLA -

Review activities:
Navy -
Army - AR
Air Force -

User activities:
Navy -
Army -
Air Force -

Preparing activity:
Navy - AS

(Project 6145-1173)

Commanding Officer
Naval Air Warfare Center Aircraft Division Lakehurst
Systems Requirements Department (Code SR3)
Lakehurst, NJ 08733-5100

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I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER MIL-STD-2223	2. DOCUMENT DATE (YYMMDD) 31 AUGUST 1992

3. DOCUMENT TITLE
TEST METHODS FOR INSULATED ELECTRIC WIRE

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)*

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME *(Last, First, Middle Initial)*	b. ORGANIZATION	
c. ADDRESS *(Include Zip Code)*	d. TELEPHONE *(Include Area Code)* (1) Commercial (2) AUTOVON *(if applicable)*	7. DATE SUBMITTED *(YYMMDD)*

8. PREPARING ACTIVITY

a. NAME COMMANDING OFFICER, NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION LAKEHURST SYSTEMS REQUIREMENTS DEPARTMENT	b. TELEPHONE *(Include Area Code)* (1) Commercial (908) 323-7488 (2) AUTOVON 624-7488
c. ADDRESS *(Include Zip Code)* CODE SR3 LAKEHURST, NJ 08733-5100	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466 Telephone (703) 756-2340 AUTOVON 289-2340

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