700.3 While the specimens of wire, the apparatus, and the surrounding air are in thermal equilibrium with one another at a temperature of 24.0 ±8.0°C (75.2 ±14.4°F), the cylinder is to be released, is to fall freely in the guide tube and strike the wire once, and is then immediately to be raised back up to and be secured at the 18-inch or 460-mm height. This process is to be repeated for each of the five remaining specimens of wire.

700.4 Each of the impacted specimens is to have its impacted area immersed in tap water that is at a temperature of 24.0 ±8.0°C (75.2 ±14.4°F). The water is to be in an earth-grounded metal container whose inside metal surface is directly and entirely in contact with the water (not painted, enameled, or otherwise insulated). The insulation in the impacted area of each specimen is to be stressed electrically to breakdown by means of a 48 – 62 Hz sinusoidal or nearly sinusoidal rms potential applied between the conductor in the specimen and the earth-grounded water container. The test potential is to be supplied by an isolation transformer complying with 820.1.

700.5 The applied potential is to be increased from near zero at a uniform or nearly uniform rate that is not less than 100 percent of the voltage rating for the product in 60 s, and is not more than 100 percent in 10 s (the rate of increase is not to exceed 500 V/s in any case). The increase is to continue in this manner until breakdown occurs. The breakdown potential for each of the six impacted specimens is to be recorded, and the average of these potentials is to be calculated and recorded. It is appropriate to discard one individual breakdown value that differs widely from most of the other individual values. Where one is discarded, none of the remaining values shall be less than 10 percent of the breakdown voltage of the unimpacted wire.

700.6 Each of six 15-inch or 380-mm or longer wire specimens not subjected to the impact is to be subjected to the dielectric-breakdown procedures with the center portion of its length immersed in water as described in 700.4 and 700.5. The breakdown potential is to be recorded for each of these specimens, and the average of these potentials is to be calculated and recorded.

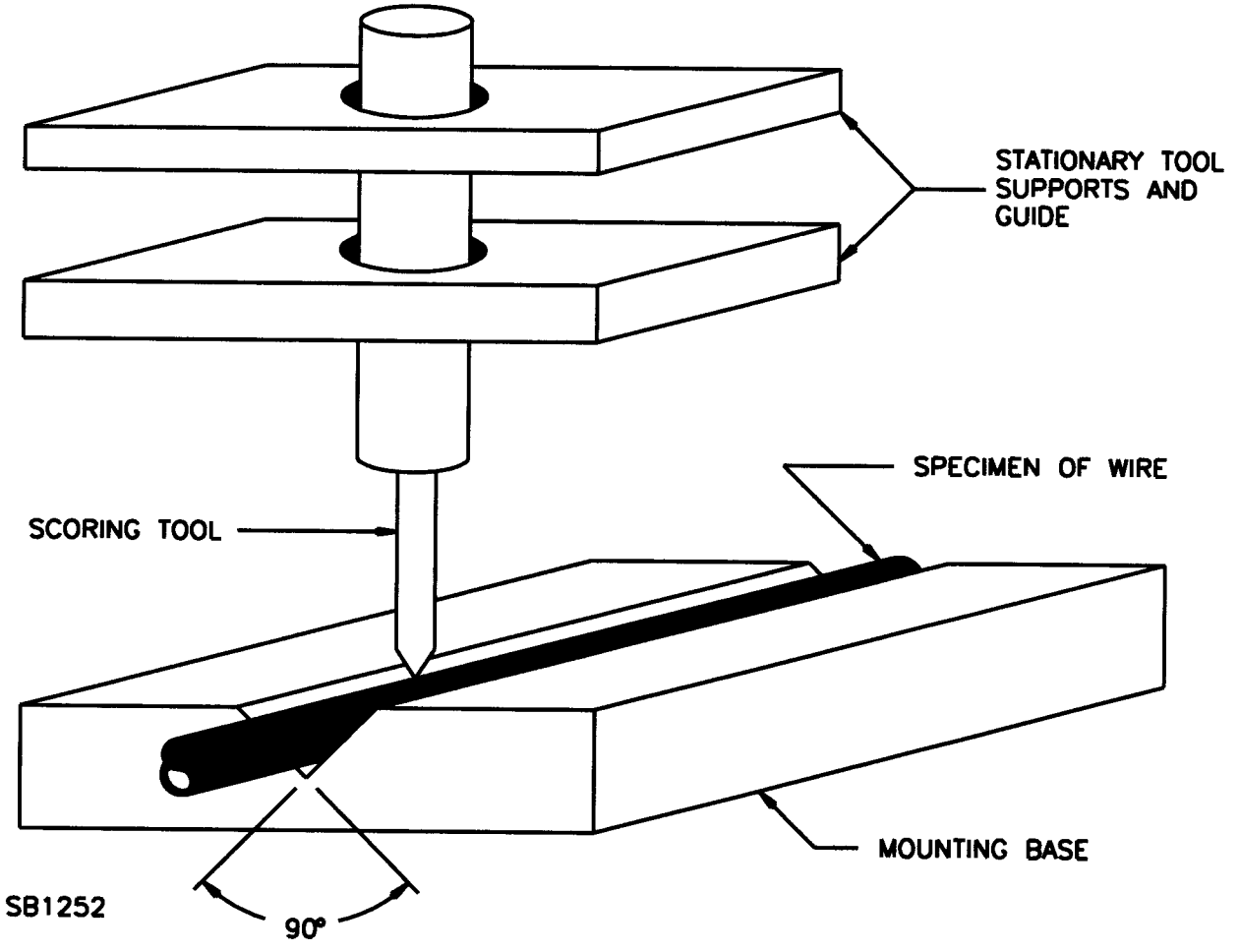
701 – 719 *Reserved for Future Use*

720 Dielectric Breakdown Test of Types XHHW-2, XHHW, and XHH after Scoring

720.1 The test is to be made using the apparatus illustrated in Figure 720.1 or such apparatus in multiple. The apparatus and the specimens are to be in thermal equilibrium with the surrounding air at a temperature of 24.0 ±8.0°C (75.2 ±14.4°F) throughout the test. Six straight, untwisted 15-inch or 380 mm specimens are to be cut from a sample length of finished solid 14 AWG Type XHHW-2, XHHW, or XHH wire. Each specimen is to be placed in a 90° V-shaped slot in the mounting base as shown in Figure 720.1 and is to have its ends secured to keep the specimen from moving in the slot. The longitudinal axes of the specimens are to be parallel to one another. The mounting base is to be secured to a flat, horizontal table that moves in a horizontal plane in a direction parallel to the longitudinal axes of the specimens. The longitudinal axes of the specimens are to be horizontal.

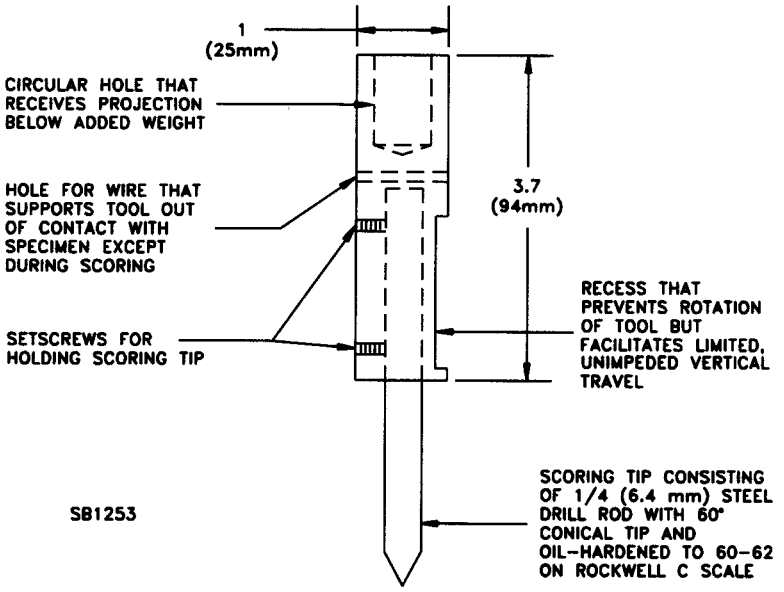
720.2 Identical scoring tools, the essentials of which are detailed in Figure 720.2, are to be placed in the stationary tool supports and guide (see Figure 720.1) above each specimen, with each tool supported (by means of a wire) so that its scoring point is above and out of contact with the specimen. The longitudinal axis of each tool is to be vertical and in the same plane as the longitudinal axis of the specimen under the tool.

Figure 720.1
Scoring Apparatus



See Figure 720.2 for details of scoring tool

Figure 720.2
Scoring tool



Dimensions are shown in inches (millimeters)

720.3 While the table is at one end of its travel, the wire supporting each tool is to be removed and the tool is to be lowered gently to bring its point to bear on the specimen. The point is to bear on a specimen with 14.0 ±0.1 ozf or 3.89 ±0.03 N or 397 ±3 gf. The table is then to be started in horizontal reciprocating motion (simple harmonic motion) at the rate of 28 cycles per minute parallel to the longitudinal axes of the specimens, each cycle consisting of one complete back-and-forth motion with a 6-inch or 150-mm stroke. Each stroke is to be centered on the longitudinal axis of the tool. The table is to be stopped after seven complete, continuous cycles, and each tool is then immediately to be raised away from its specimen and is to be supported (by means of the wire) out of contact with the specimen.

720.4 Each of the scored specimens is to have its scored area immersed in tap water that is at a temperature of 24.0 ±8.0°C (75.2 ±14.4°F). The water is to be in an earth-grounded metal container whose inside metal surface is directly and entirely in contact with the water (not painted, enameled, or otherwise insulated). The insulation in the scored area of each specimen is to be stressed electrically to breakdown by means of a 48 – 62 Hz sinusoidal or nearly sinusoidal rms potential applied between the conductor in the specimen and the earth-grounded water container. The test potential is to be supplied by an isolation transformer complying with 820.1.

720.5 The applied potential is to be increased from zero at a uniform or nearly uniform rate that is not less than 100 percent of the voltage rating for the product in 60 s, and is not more than 100 percent in 10 s (the rate of increase is not to exceed 500 V/s in any case). The increase is to continue in this manner until breakdown occurs. The breakdown potential for each of the six scored specimens is to be recorded, and the average of these potentials is to be calculated and recorded. It is appropriate to discard one individual breakdown value that differs widely from most of the other individual values. Where one is discarded, none of the remaining values shall be less than 10 percent of the breakdown voltage of the unscored wire.

720.6 Each of six 15-inch or 300-mm or longer wire specimens not subjected to the scoring is to be subjected to the dielectric-breakdown procedure with the center portion of its length immersed in water as described in 720.4 and 720.5. The breakdown potential is to be recorded for each of these specimens and the average of these potentials is to be calculated and recorded.

721 – 759 *Reserved for Future Use*

760 Dielectric Voltage-Withstand Test of Straight Foil-Wrapped Specimens

760.1 The test specimen is to be a 60-inch or 1500-mm straight length of finished wire with its center 36-inch or 915-mm section wrapped tightly with metal foil. The potential is to be applied between the conductor and the foil.

760.2 The wire is to be stressed by means of an isolation transformer that complies with 820.1.

760.3 The applied potential is to be increased from near zero at a uniform or nearly uniform rate that is not less than 100 percent of the voltage rating of the wire or cable in 60 s, and is not more than 100 percent in 10 s (the rate of increase is not to exceed 500 V/s in any case). The increase is to continue in this manner until the voltage reaches the specified rms test potential. Where this level is reached without breakdown, the voltage is to be held constant at the specified level for 5 min and is then to be reduced to near zero at the rate mentioned above. The wire or cable does not comply where breakdown occurs at less than the potential specified in the wire standard while the applied potential is being increased or decreased or in less than 5 min at the potential specified in the wire standard.

761 – 779 *Reserved for Future Use*

780 Dielectric Voltage-Withstand Test of Foil-Wrapped U-Bend Specimens

780.1 A 15-inch or 380-mm specimen is to be bent 90° around a mandrel having the same diameter as the specimen. Two bends in the same plane are to be made 2 inches or 50 mm apart near the center of the specimen, and pressure is to be applied to keep the specimen from slipping. Metal foil is then to be wrapped tightly around a 5-inch or 125-mm section of the U-bend specimen, including both bends.

780.2 The specimen is then to be tested as indicated in 760.2 and 760.3. The test time is to be 60 s. The wire does not comply where there is a dielectric breakdown or where the overall braid ruptures because of the bending.

781 – 799 *Reserved for Future Use*

800 Dielectric Voltage-Withstand Test for Cord Conductors

800.1 The test potential shall be applied between each circuit conductor and every other circuit conductor and each grounding conductor. In a multiple-layer cable, the potential shall be applied between each circuit conductor and every adjacent circuit conductor and, where there are one or more grounding conductors, the potential shall be applied between each grounding conductor and every circuit conductor adjacent to it. In the case of a construction that includes a metal shield, the test shall be repeated with the test potential applied between the shield and all of the insulated (circuit and grounding) conductors connected together.

800.2 In a multiple-layer cable, it is appropriate to conduct the test by interconnecting the alternate conductors in each layer and applying the test potential between the two groups and then interconnecting all of the conductors of each layer and applying the test potential between successive layers.

800.3 The test potential is to be supplied by an isolation transformer complying with 820.1. The test potential is to be applied as indicated in 820.4.

801 – 819 *Reserved for Future Use*

820 Dielectric Voltage-Withstand Test of Coils and Reels in Water

820.1 The apparatus is to consist of a tank in which the test coil is to be immersed in water; an earth-grounding electrode or its equivalent (an earth-grounded metal tank whose inside metal surface is directly and entirely in contact with the water – not painted, enameled, or otherwise insulated); a circuit breaker, lamp bank, or other means for indicating the flow of breakdown current in the test circuit; and a testing transformer that complies with the following. The test potential is to be supplied by a 48 – 62 Hz isolation transformer whose output potential is continuously variable from near zero to at least the specified rms test potential at a rate not exceeding 500 V/s. With a specimen in the circuit, the output potential is to have a crest factor (peak voltage divided by rms voltage) equal to 95 – 105 percent of the crest factor of a pure sine wave over the upper half of the output range. The output voltage is to be monitored continuously by a voltmeter that, where of the analog rather than digital type, shall have a response time that does not introduce a lagging error greater than 1 percent of full scale at the specified rate of increase in voltage, and that has an overall accuracy that does not introduce an error exceeding 5 percent. The maximum current output of which the transformer is capable shall enable routine testing of full reels of the wire or cable without tripping of the circuit breaker by the charging current. The water is to be at any convenient temperature and no correction factor is to be used.

820.2 In preparing the coil or reel for the test, each end of the wire or cable is to be brought out well above the water level in the tank. Any fibrous covering and separator are to be removed from the surface of the insulation for about 6 inches or 150 mm at each end to assist in reducing surface leakage and the likelihood of surface breakdown. It is appropriate to dip the insulation at the ends in melted paraffin to keep moisture from forming a conductive path from the conductor metal across the surface of the insulation to the water. The coil or reel is then to remain immersed in water for not less than 6 h before the test potential is applied.

820.3 One side of the test circuit is to be connected to the conductor of the wire and the other side to an electrode that is earth-grounded and is in contact with the water in which the coil is immersed.

820.4 The applied potential is to be increased from near zero at an uniform or nearly uniform rate that is not less than 100 percent of the potential rating of the wire or cable in 60 s, and is not more than 100 percent in 10 s (the rate of increase is not to exceed 500 V/s in any case). The increase is to continue in this manner until the voltage reaches the level of the rms test potential specified. Where this level is reached without breakdown, the voltage is to be held constant at the specified level for 60 s and is then to be reduced to near zero at the rate mentioned above. The wire or cable does not comply where breakdown occurs at less than the potential specified in the wire standard while the applied potential is being increasing or decreased, or in less than 60 s at the potential specified in the wire standard.

820.5 Breakdown usually is revealed by a current rush resulting from the decreased resistance of the circuit and is indicated by the tripping of a circuit breaker, the illumination of a bank of lamps connected in series with the test coil, or other means. Where the current output of which the transformer is capable is large, breakdown often is observed by a flash at the point on the cable at which the breakdown takes place. Where other means do not do so, the insulation resistance determined at room temperature as described in Insulation-Resistance Test in Water, Section 920, indicates a breakdown. It is partly to provide this positive check that the voltage test is made first.

821 – 829 *Reserved for Future Use*

830 Dielectric Voltage-Withstand Tests for Power-Limited Circuit Cable and for Cable for Power-Limited Fire-Alarm Circuits

830.1 The equipment is to consist of either a d-c power supply complying with 830.2 or an a-c power supply complying with 830.3, and also a circuit breaker, current meter, or other means for indicating a heavy flow of current in the test circuit. The maximum current output of which the d-c or a-c supply is capable shall enable routine testing of full reels of the cable without tripping of the circuit breaker by the charging current.

830.2 For a d-c test, the power supply is to have an output potential of the voltage specified for a d-c test of the cable type. Any ripple shall not exceed 1 percent. After a fault, the test potential shall recover to the specified voltage before testing another conductor.

830.3 For an a-c test, the test potential is to be supplied by a 48 – 62 Hz isolation transformer whose output is continuously variable from near zero to an rms potential of at least the specified voltage. With a specimen in the circuit, the output potential is to have a crest factor (peak voltage divided by rms voltage) equal to 95 – 105 percent of the crest factor of a pure sine wave over the upper half of the output range. The output voltage is to be monitored continuously by a voltmeter that, where of the analog rather than digital type, shall have a response time that does not introduce a lagging error greater than 1 percent of full scale at 50 V/s, and that has an overall accuracy that does not introduce an error exceeding 5 percent.

830.4 The full test potential is to be applied for the specified number of seconds between each conductor and the earth-grounded cable elements (all other conductors and any shield(s) and/or metal covering connected together and to earth ground). During each application, observation is to be made to determine whether there is any current leakage or rupture of the insulation as indicated by such means as the tripping of the circuit breaker or a deflection of the needle of the current meter. At least once every 24 h, the test leads are to be connected together and the circuit is to be closed to make certain that the current-indicating means is functioning as intended and that the circuit is complete. Where multiple test leads are used, each shall be tested.

831 – 899 *Reserved for Future Use*

SPARK TEST

900 Method

900.1 A spark tester shall include a voltage source, electrode, voltmeter, fault-signal device or system, and the appropriate electrical connections. The ability of the equipment to comply with the requirements in 900.2 – 900.17 shall be certified at least annually by an accredited independent calibration service or its equivalent such as checking the test potential with a voltmeter whose calibration is traceable. Calibration shall be traceable to a National Institute of Standards and Technology (USA) standard or to other national physical measures recognized as equivalent by NIST.

900.2 The voltage source of a spark tester shall maintain the test voltage specified in the wire Standard under all normal conditions of leakage current. The core of a transformer and one end of its secondary winding shall be solidly connected to earth ground. A voltage source shall not be connected to more than one electrode.

900.3 The electrode shall be of the link- or bead-chain type and shall make intimate contact throughout its entire length with the surface of the wire being tested.

900.4 The bottom of the metal electrode enclosure shall be U- or V-shaped, the chains shall have a length appreciably greater than the depth of the enclosure, and the width of the trough shall be (typically 1-1/2 inches or 40 mm) greater than the diameter of the largest size of wire that is tested.

900.5 For a bead-chain electrode, the longitudinal and transverse spacings of the chains and the diameter of each bead shall comply with Table 900.1. The vertical spacing between beads in each chain shall not exceed the diameter of a bead.

900.6 The electrode shall have an earth-grounded metal screen or an equivalent guard that protects operating personnel against electric shock from the electrode and associated live parts.

900.7 The voltmeter shall be connected in the circuit to indicate the actual test potential at all times.

900.8 The equipment shall include a light, counter, or other device or system that gives a signal in the event of a fault. When a fault is detected, the signal shall be maintained until the indicator is reset manually.

Table 900.1
Maximum center-to-center spacings of bead chains

Diameter of a bead[a]		Longitudinal spacing within each row[a]		Transverse spacing between rows[a]			
				Chains staggered		Chains not staggered	
inch	mm	inch	mm	inch	mm	inch	mm
3/16	5.0	1/2	13	1/2	13	3/8	10
3/32	2.5	The chains shall be staggered and shall touch one another in the longitudinal and transverse directions.					

[a] A diameter and spacings other than indicated comply where investigation shows that the chains contact an equal or greater area of the outer surface of the wire.

900.9 The spark test shall be conducted as the wire is being cut just prior to storage in or shipping from the factory in which the wire is made. The insulation at points of repair shall be resparked.

900.10 Wire that has been spark-tested in compliance with 900.9 need not be resparked after any of the following further-processing operations at the wire factory:

a) Cutting into lengths shorter than 200 ft or 60 m.

b) Striping that does not require heat curing.

c) Color coating that does not require heat curing.

900.11 The length of the electrode is not specified; however, the rate of speed at which the wire travels through the electrode shall keep any point on the wire in contact with the electrode for not less than a total of 18 positive and negative crests of the supply voltage (the equivalent of 9 full cycles of the supply voltage). The maximum speed of the wire is to be determined by means of whichever of the following formulas is applicable

$$\text{feet per minute} = (5/9) \times (\text{frequency in hertz}) \times (\text{electrode length in inches})$$

or

$$\text{meters per minute} = (1/150) \times (\text{frequency in hertz}) \times (\text{electrode length in millimeters})$$

For convenience, Table 900.2 shows the formulas for several frequencies.

900.12 The conductor of the wire shall be earth-grounded during the spark test. Where the conductor coming from the pay-off reel is bare, the conductor shall be earth-grounded at the pay-off reel or at another point at which continuous contact with the bare conductor, prior to the insulating process, is maintained and the conductor is not required to be tested for continuity or earth-grounded at the take-up reel. Where the conductor coming from the pay-off reel is insulated, an earth-ground connection shall be made at either the pay-off or take-up reel. However, for the 10 and smaller AWG sizes, an earth-ground connection shall be made at both the pay-off and the take-up reels where the 10 and smaller AWG sizes are not tested for continuity and found to be of one integral length. In any case, each earth-ground connection shall be bonded directly to the earth ground in the spark tester.

900.13 To determine whether or not a wire is continuous, the conductor is to be connected in series with a lamp, buzzer, bell, or other indicator and a power supply. The conductor is continuous from end-to-end of the finished wire where the lamp lights, the bell or buzzer sounds, or another indicator signal is given.

Table 900.2
Formula for maximum speed of wire in terms of electrode length L

Nominal supply frequency in Hertz	Feet per minute (L in inches)	Meters per minute (L in millimeters)
50	$27.8L_{in}$	$0.333L_{mm}$
60	$33.3L_{in}$	$0.400L_{mm}$
100	$55.6L_{in}$	$0.667L_{mm}$
400	$222L_{in}$	$2.67L_{mm}$
1000	$556L_{in}$	$6.67L_{mm}$
3000	$1667L_{in}$	$20.0L_{mm}$
4000	$2222L_{in}$	$26.7L_{mm}$

900.14 For the factory production continuity testing of a wire, it is the manufacturer's choice whether to substitute either of the following for the test in 900.13: a continuous eddy-current procedure complying with 900.15 and 900.16, or a continuous differential capacitive-current procedure complying with 900.17.

900.15 The eddy-current test arrangement shall include equipment that complies with each of the following:

a) The equipment is to apply current at one or several frequencies in the range of 1 – 125 kHz to a test coil for the purpose of inducing eddy currents in the conductor moving through the coil at production speed.

b) The equipment is to detect the variation in impedance of the test coil caused by each break in the conductor.

c) The equipment is to provide a visual indication to the operator.

900.16 The longitudinal axis of the conductor is to be coincident with the electrical center of the test coil. The wire is to have little or no vibration as it passes through the test coil and is to clear the coil by a distance that is not greater than 1/2 inch or 13 mm. Variations in the speed of the wire through the test coil are to be limited to plus 50 percent and minus whatever percentage (50 percent maximum) keeps the signal amplitude from falling below the level at which a break can be detected. Separate calibration, balance, and adjustments for sensitivity, maximum signal-to-noise ratio, and maximum rejection of signals indicating gradual variations in diameter and other slow changes are to be made for each size, type of stranding, and conductor material. Calibration without any wire in the test coil is to be made at least daily to check whether the equipment is functioning. The temperature along the length of the wire being tested is not to vary from the temperature at which the equipment was calibrated, balanced, and so forth for the size, type of stranding, and conductor material unless the variations are gradual and are without hot or cold spots that cause false signals.

900.17 The differential capacitive-current procedure shall include equipment that complies with each of the following:

a) The equipment is to be used in conjunction with a 1 – 3 kHz or higher-frequency spark tester.

b) Two pickup electrodes are to be located in tandem either along the portion of the conductor being tested that is moving from the grounded pay-off reel toward the spark electrode, or along the portion of the conductor being tested that is moving toward the grounded take-up reel from the spark electrode.

c) As each break in the conductor is passing from the first pickup electrode toward the second, the equipment is to detect the difference between the voltage capacitively coupled from the conductor under test to the pickup electrode nearest the spark electrode and the lower voltage coupled to the pickup electrode nearest the grounded reel.

d) The equipment is to show a visual indication to the operator.

901 – 909 *Reserved for Future Use*

910 Spark Tests for Power-Limited Circuit Cable and for Cable for Power-Limited Fire-Alarm Circuits

910.1 A d-c or a-c spark tester for power-limited circuit cable and for cable for power-limited fire-alarm circuits shall include a voltage source, an electrode, a voltmeter, a system for detecting and counting signaling faults, and the appropriate electrical connections. The ability of the equipment to comply with the requirements in 910.2 – 910.15 shall be certified at least annually by an accredited independent calibration service or its equivalent such as by checking the test potential with an applicable voltmeter whose calibration is traceable. Calibration shall be traceable to a National Institute of Standards and Technology (USA) standard or to other national physical measures recognized as equivalent by NIST.

910.2 The voltage source of a d-c or a-c spark tester for power-limited circuit cable and for cable for power-limited fire-alarm circuits shall maintain the following test voltage under all normal conditions of leakage current:

a) A sinusoidal or nearly sinusoidal rms potential of the voltage specified for an a-c test of the cable type.

b) The voltage specified for a d-c test of the cable type. The current output of which the d-c power supply is capable shall not exceed 5 mA. Any ripple shall not exceed 1 percent. After a fault, the d-c test voltage shall recover to the specified level in 5 milliseconds or less time unless 2 ft or less of the product or 610 mm or less of the product travels through the electrode in the time it takes for the full voltage recovery.

910.3 One terminal of the d-c power supply, and the core of a transformer and one end of its secondary winding in an a-c power supply, shall be solidly connected to earth ground. A voltage source shall not be connected to more than one electrode.

910.4 The electrode of a d-c or a-c spark tester for power-limited circuit cable and for cable for power-limited fire-alarm circuits shall be of the link- or bead-chain type or shall be of another type, which shall be evaluated. A link- or bead-chain electrode shall make intimate contact throughout its entire length with the surface of the insulated conductor or pair of conductors being tested.

910.5 The bottom of a metal link- or bead-chain electrode enclosure shall be U- or V-shaped, the chains shall have a length appreciably greater than the depth of the enclosure, and the width of the trough shall be greater (typically 1-1/2 inches or 40 mm) than the diameter of the largest product being tested.

910.6 For a bead-chain electrode, the longitudinal and transverse spacings of the chains and the diameter of each bead shall comply with Table 910.1. The vertical spacing between beads in each chain shall not exceed the diameter of a bead.

Table 910.1
Maximum center-to-center spacings of bead chains

Diameter of a bead[a]		Longitudinal spacing within each row[a]		Transverse spacing between rows[a]			
				Chains staggered		Chains not staggered	
inch	mm	inch	mm	inch	mm	inch	mm
3/16	5.0	1/2	13	1/2	13	3/8	10
3/32	2.5	The chains shall be staggered and shall touch one another in the longitudinal and transverse directions.					
[a] A diameter and spacings other than as indicated comply where investigation shows that the chains contact an equal or greater area of the outer surface of the insulated conductor or initial assembly of conductors.							

910.7 The electrode shall have an earth-grounded metal screen or an equivalent guard that protects operating personnel against electric shock from the electrode and associated live parts.

910.8 The voltmeter shall be connected in the circuit to indicate the actual test potential at all times.

910.9 The equipment shall include a fault detector, fault counter, and a means of signaling each fault that occurs. When a fault is detected, the signal shall be maintained until the indicator is reset manually.

910.10 The fault detector shall detect a voltage breakdown of the insulation. A breakdown is characterized by arcing between the electrode and the earth-grounded conductor(s) under test. A breakdown is defined as a decrease of 25 percent or more from the test voltage applied between the electrode and the earth-grounded conductor(s).

910.11 The fault detector shall consist of a trigger circuit that converts an input pulse of short time duration to an output pulse of a magnitude and duration that reliably operates the fault-indicating circuit.

910.12 The fault counter shall accommodate the faults as a numerically increasing sequence and shall display the accumulated total. The response time of the fault counter shall result in the counter registering faults spaced no farther than 24.0 inches or 610 mm apart for any combination of product speed and counter response time. This distance is to be calculated as follows:

Distance between faults	=	Product speed expressed as inches per second or 0.2 x feet per minute or 0.656 x meters per minute	x	Counter response time in seconds

910.13 For a d-c test using a link- or bead-chain electrode, the surface of the insulated conductor(s) shall be in intimate contact with the link or bead chains for a distance of 5.0 ±1.0 inches or 125 ±25 mm.

910.14 The length of a link- or bead-chain electrode is not specified for an a-c test; however, the rate of speed at which the insulated conductor(s) travel through the electrode shall keep any point on the product in contact with the electrode for not less than a total of 18 positive and negative crests of the a-c supply voltage (the equivalent of a full 9 cycles of the a-c supply voltage). The maximum speed of the product is to be determined for an a-c test by means of whichever of the following formulas is applicable:

feet per minute = (5/9)× (frequency in hertz) × (electrode length in inches)

or

meters per minute = (1/150)× (frequency in hertz) × (electrode length in millimeters)

For convenience, Table 910.2 shows the formulas for seven frequencies.

Table 910.2
Formula for maximum speed of wire in terms of electrode length L of link- or bead-chain electrode

	Formula	
Nominal supply frequency in Hertz	Feet per minute (L in inches)	Meters per minute (L in millimeters)
50	$27.8L_{in}$	$0.333L_{mm}$
60	$33.3L_{in}$	$0.400L_{mm}$
100	$55.6L_{in}$	$0.667L_{mm}$
400	$222L_{in}$	$2.67L_{mm}$
1000	$556L_{in}$	$6.67L_{mm}$
3000	$1667L_{in}$	$20.9L_{mm}$
4000	$2222L_{in}$	$26.7L_{mm}$

910.15 The conductor(s) being tested shall be earth-grounded during the spark test. Where the conductor(s) coming from the pay-off reel(s) are bare, the conductor(s) shall be earth-grounded at the pay-off reel or at another point at which continuous contact with the bare conductor, prior to the insulating process, is maintained and the conductor is not required to be tested for continuity or earth-grounded at the take-up reel. Where the conductor coming from a pay-off reel is insulated, an earth-ground connection shall be made at each pay-off reel and at the take-up reel unless each conductor is tested for continuity as described in the wire Standard before the spark test is made and is found to be of one integral length. In any case, each earth-ground connection shall be bonded directly to the earth ground in the spark tester.

911 – 918 *Reserved for Future Use*

INSULATION RESISTANCE

919 Test Procedure for Determining the Multiplying-Factor Column for Adjusting Insulation Resistance

919.1 Two specimens, conveniently of a 18 or 16 AWG solid conductor with a wall of insulation whose average thickness is 10 – 15 mils or 0.25 – 0.38 mm, are to be selected as representative of the insulation of interest. The specimens are to be of a length (at least 200 ft or 60 m) that yields insulation-resistance values that are stable within the calibrated range of the measuring equipment at the lowest water-bath temperature.

919.2 The two specimens are to be immersed in a water bath equipped with heating, cooling, and circulating facilities. The ends of the specimens are to extend at least 24 inches or 600 mm above the surface of the water to reduce electrical leakage. The specimens are to be in the water at room temperature for 16 h before adjusting the bath temperature to 50.0°F (10.0°C) or before transferring the specimens to a 50.0°F (10.0°C) bath.

919.3 The d-c resistance of the metal conductor is to be measured at applicable intervals of time until the temperature remains unchanged for at least 5 min. The insulation is then to be taken as being at the temperature of the bath indicated on the bath thermometer.

919.4 Each of the two specimens is to be exposed (919.3 applies) to successive water temperatures of 50.0, 61.0, 72.0, 82.0, and 95.0°F (10.0, 16.1, 22.2, 27.8, and 35.0°C) and, returning, 82.0, 72.0, 61.0, and 50.0°F (27.8, 22.2, 16.1, and 10.0°C). Insulation-resistance readings are to be taken at each temperature after equilibrium is established.

919.5 The two sets of readings (four readings in all) taken at the same temperature are to be averaged for the two specimens. These four average values and the average of the single readings at 95.0°F (35.0°C) are to be plotted on semilog paper. A continuous curve (usually a straight line) is to be drawn through the five points. The value of insulation resistance at 60.0°F (15.6°C) is then to be read from the graph.

919.6 The resistivity coefficient C for a 1.0°F (0.55°C) change in temperature is to be calculated to two decimal places by dividing the insulation resistance at 60.0°F (15.6°C) read from the graph by the insulation resistance at 61.0°F (16.1°C). In Table 919.1, C heads the column of multiplying factors M that applies to the particular insulation.

Table 919.1
Multiplying factor M[a] for adjusting insulation resistance to 60.0°F (15.6°C)

Temperature		Resistivity Coefficient C for 1.0°F (0.55°C)									
°F	°C	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	1.12
40	4.4	0.55	0.46	0.38	0.31	0.26	0.22	0.18	0.15	0.12	0.10
41	5.0	0.48	0.40	0.33	0.28	0.28	0.23	0.19	0.16	0.14	0.12
42	5.6	0.59	0.49	0.42	0.35	0.30	0.25	0.21	0.18	0.15	0.13
43	6.1	0.60	0.51	0.44	0.37	0.32	0.27	0.23	0.20	0.17	0.15
44	6.7	0.62	0.53	0.46	0.39	0.34	0.29	0.25	0.22	0.19	0.16
45	7.2	0.64	0.56	0.48	0.42	0.36	0.32	0.28	0.24	0.21	0.18
46	7.8	0.66	0.58	0.50	0.44	0.39	0.34	0.30	0.26	0.23	0.20
47	8.3	0.68	0.60	0.53	0.47	0.42	0.37	0.33	0.29	0.26	0.23
48	8.9	0.70	0.56	0.56	0.50	0.44	0.40	0.36	0.32	0.29	0.26
49	9.4	0.72	0.65	0.59	0.53	0.48	0.42	0.39	0.35	0.32	0.29
50	10.0	0.74	0.68	0.61	0.56	0.51	0.46	0.42	0.39	0.35	0.32
51	10.6	0.77	0.70	0.64	0.59	0.54	0.50	0.46	0.42	0.39	0.36
52	11.1	0.79	0.73	0.68	0.63	0.58	0.54	0.50	0.47	0.43	0.40
53	11.7	0.81	0.76	0.71	0.67	0.62	0.58	0.55	0.51	0.48	0.45
54	12.2	0.84	0.79	0.75	0.70	0.67	0.63	0.60	0.56	0.54	0.51
55	12.8	0.86	0.82	0.78	0.75	0.71	0.68	0.65	0.62	0.59	0.57
56	13.3	0.89	0.86	0.82	0.79	0.76	0.74	0.71	0.68	0.66	0.64
57	13.9	0.92	0.89	0.86	0.84	0.82	0.79	0.77	0.75	0.73	0.71
58	14.4	0.94	0.93	0.91	0.89	0.87	0.86	0.84	0.83	0.81	0.80
59	15.0	0.97	0.95	0.94	0.95	0.94	0.93	0.92	0.91	0.90	0.89
60	15.6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
61	16.1	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	1.12
62	16.7	1.06	1.08	1.10	1.12	1.17	1.17	1.19	1.21	1.23	1.25
63	17.2	1.09	1.12	1.16	1.19	1.23	1.26	1.30	1.33	1.37	1.40
64	17.8	1.13	1.17	1.22	1.26	1.31	1.36	1.41	1.46	1.52	1.57
65	18.3	1.16	1.22	1.28	1.34	1.40	1.47	1.54	1.61	1.69	1.76
66	18.9	1.19	1.27	1.34	1.42	1.50	1.59	1.68	1.77	1.87	1.97
67	19.4	1.23	1.32	1.41	1.50	1.61	1.71	1.83	1.95	2.08	2.21
68	20.0	1.27	1.37	1.48	1.59	1.72	1.85	1.99	2.14	2.20	2.48
69	20.6	1.30	1.42	1.55	1.69	1.84	2.00	2.17	2.36	2.56	2.77
70	21.1	1.34	1.48	1.63	1.79	1.97	2.16	2.37	2.59	2.84	3.11
71	21.7	1.38	1.54	1.71	1.90	2.10	2.33	2.58	2.85	3.15	3.48
72	22.2	1.43	1.60	1.80	2.01	2.25	2.52	2.81	3.14	3.50	3.90
73	22.8	1.47	1.67	1.89	2.13	2.41	2.72	3.07	3.45	3.88	4.36
74	23.8	1.51	1.73	1.98	2.26	2.58	2.94	3.34	3.80	4.31	4.89

Table 919.1 Continued on Next Page

Table 919.1 Continued

Temperature		Resistivity Coefficient C for 1.0°F (0.55°C)									
°F	°C	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	1.12
75	23.9	1.56	1.80	2.08	2.40	2.76	3.17	3.64	4.18	4.78	5.47
76	24.4	1.60	1.87	2.18	2.54	2.95	3.43	3.97	4.59	5.31	6.13
77	25.0	1.65	1.95	2.29	2.69	3.16	3.70	4.33	5.05	5.90	6.87
78	25.6	1.70	2.03	2.41	2.85	3.38	4.00	4.72	5.56	6.54	7.69
79	26.1	1.75	2.11	2.53	3.03	3.62	4.32	5.14	6.12	7.26	8.61
80	26.7	1.81	2.19	2.65	3.21	3.87	4.66	5.60	6.73	8.06	9.65
81	27.2	1.86	2.28	2.79	3.40	4.14	5.03	6.11	7.40	8.95	10.8
82	27.8	1.92	2.37	2.93	3.60	4.43	5.44	6.66	8.14	9.93	12.1
83	28.3	1.97	2.46	3.07	3.82	4.74	5.87	7.26	8.95	11.0	13.6
84	28.9	2.03	2.56	3.23	4.05	5.07	6.34	7.91	9.85	12.2	15.2
85	29.4	2.09	2.67	3.39	4.29	5.43	6.85	8.62	10.8	13.6	17.0

[a] Calculated from the formula $M = C^{(t - 60)}$ in which C is determined as described in 919.1 – 919.6 and t is the temperature of the cable in degrees F.

920 Insulation-Resistance Test in Water

920.1 The insulation-resistance test equipment and procedures shall be applicable. Otherwise they are not specified. A megohm bridge used for this purpose shall be of applicable range and calibration and shall present readings that are accurate to 10 percent or less of the value indicated by the meter. A d-c potential of 100 – 500 V shall be applied to the insulation for 60 s prior to each reading. Each galvanometer indication shall be given 60 s to stabilize before the reading is recorded. The duration of each reading shall be 60 s in the case of range switching or for metering equipment requiring time to achieve a null. Delay is not required for instant-reading equipment that has been demonstrated to produce correct readings without a 60-s delay.

920.1 revised May 6, 2003

920.2 The center 50-ft or 20-m sections of 55-ft or 22-m coils of the samples of a thermoplastic- or thermoset-insulated wire or cable are to be prepared as described in 820.2, and the water temperature is to be maintained within 1.0°C (1.8°F) of being constant at any temperature in the range of 10.0 – 29.4°C (50.0 – 85.0°F) for the entire 6-h or longer immersion previous to the measurement of resistance. The ends of the samples used in the tests at 60°C (140°F) or 75°C (167°F) are to be brought well away from the tank.

920.3 The specimen for the determination of insulation resistance of a flexible-cord conductor or a fixture wire is to be a coil or reel of the finished insulated conductor (or a coil of finished cord in the case of a parallel cord) neither less than 50 ft nor more than 5000 ft in length or neither less than 15 m nor more than 1500 m in length.

920.4 Each end of the fixture wire or the flexible cord is to be brought out well above the water level in the tank. The conductors of a parallel cord are to be joined together. The ends are to be dipped in melted paraffin, or a guard circuit is to be employed, to keep moisture from forming a conducting path between the surface of the insulation and the conductor. The coil is then to remain immersed in water for not less than 12 h, except that it is appropriate to immerse a coil no longer than 250 ft or 75 m for less than 12 h but not less than 4 h. The temperature of the water is to be maintained within 1.0°C (1.8°F) of being constant at any temperature in the range of 10.0 – 26.7°C (50.0 – 80.0°F) for the entire immersion time previous to the measurement of resistance.

920.5 A retest at 15 ±1°C (59 ±2°F) is to be made for a coil that does not show complying test results when the water temperature is at a different temperature.

920.6 Where coils are connected together for the insulation-resistance test and complying results are not obtained, the individual coils are to be retested to determine which ones have insulation resistance that complies.

921 – 999 *Reserved for Future Use*

STABILITY FACTOR

1000 Test

1000.1 Tests are to be made using three 15-ft or 5-m specimens of insulated conductor. Specimens of insulated cord conductors are to be without any polyester-tape or similarly non-absorbent separator, and are to be selected before assembly into finished cord. Specimens of a Type XHHW-2, RHW-2, XHHW, or RHW wire or cable are to be selected after cross-linking and before any covering is applied. Not less than 48 h after cross-linking of the conductor insulation, each specimen is to be dried for 24 h in air at 70.0 ±2.0°C (158.0 ±2.6°F) and is then to be cooled in air to 50°C (122°F) before being immersed in water.

1000.2 The middle 120-inch or 3048-mm section of each specimen is to be immersed continuously in tap water at a temperature of 50.0 ±1.0°C (122.0 ±1.8°F) for 14 d for cord conductors and in tap water at a temperature of 75.0 ±1.0°C (167.0 ±1.8°F) for 14 d for a Type XHHW or RHW wire or cable and in tap water at a temperature of 90.0 ±1.0°C (194.0 ±1.8°F) for 14 d for a Type XHHW-2 or RHW-2 wire or cable. The 30-inch or 762-mm end portions of each specimen are to be kept dry above the water as leakage insulation. A tight-fitting cover for the tank is to be placed directly above the surface of the water, the level of which is to be kept constant.

1000.3 The percentage power factor of each specimen is to be measured with 60 Hz current at average stresses of 80 and 40 volts per mil or 3150 and 1575 volts per millimeter after 1 d and 14 d total immersion, and each result is to be expressed to the nearest 0.1. The stability factor of each specimen is then to be computed and expressed to the nearest 0.1.

1000.4 The stability-factor difference is then to be computed for each specimen by subtracting the stability factor determined after 1 d from the stability factor determined after 14 d. The stability-factor difference is to be expressed to the nearest 0.1.

1001 – 1019 *Reserved for Future Use*

CAPACITANCE AND RELATIVE PERMITTIVITY

1020 Test

1020.1 The capacitance of the insulation is to be measured with bridge apparatus as the average from three specimens after immersion of the specimens for 24 h, 7 d, and 14 d, respectively, in tap water at 30.0 ±1.0°C (86.0 ±1.8°F) for 60°C (140°F) insulation, at 75.0 ±1.0°C (167.0 ±1.8°F) for 75°C (167°F) insulation, and at 90.0 ±1.0°C (194.0 ±1.8°F) for 90°C (194°F) insulation. Each result is to be expressed to the nearest picofarad. The increases in capacitance from 1 d to 14 d and from 7 d to 14 d are to be expressed as percentages of the 1-d and 7-d values, respectively.

1020.2 The capacitance of the insulation is to be determined, using a sinusoidal or nearly sinusoidal current at a frequency of 1000 Hz or 60 Hz, by means of a capacitance bridge. Where measured at 1000 Hz, the potential impressed upon the insulation is not to exceed 10 V. Where measured at 60 Hz, the potential impressed upon the insulation is to result in an average stress of 80 volts per mil of insulation or 3150 volts per millimeter of insulation.

1020.3 The test is to be made on a 15-ft or 5-m specimen of finished wire, from which any covering(s) over the insulation have been removed, including any flame-retardant coating. It is appropriate in the case of a Type XHHW-2, RHW-2, XHHW, or RHW wire or cable or of a cord conductor to select the specimen from production after cross-linking and before any covering is applied (including any flame-retardant coating). The nylon jacket is to be removed from Type THWN-2 or THWN wire and from a nylon-jacketed insulated conductor from a service cord.

1020.4 The center 120-inch or 3048-mm section of the specimen is to be immersed in tap water for 14 d, with a 30-inch or 976-mm portion at each end kept dry above the water as leakage insulation. The water temperature and the depth of immersion of the specimen are to be the same whenever readings are taken. The relative permittivity (dielectric constant) of the insulation is to be determined after 1 d by means of the formula

$$\epsilon_r = 13{,}600 \times C \times \log_{10} \frac{DIA}{dia}$$

in which:

ε_r *is the relative permittivity (formerly SIC),*

C is the capacitance in microfarads of the immersed 120-inch or 3048-mm portion of the sample,

DIA is the measured diameter over the insulation in inches or millimeters, and

dia is the measured diameter under the insulation in inches or millimeters.

1021 – 1039 *Reserved for Future Use*

MECHANICAL WATER ABSORPTION

1040 Test

1040.1 The absorption of water is to be expressed as milligrams mass per square inch of exposed surface or as milligrams mass per square centimeter of exposed surface and is to be determined after a 168-h immersion of the specimen in tap water at 70.0 ±1.0°C (158.0 ±1.8°F) for insulation having a temperature rating of 60°C (140°F), and at 82.0 ±1.0°C (179.6 ±1.8°F) for insulation having a temperature rating of 75°C (167°F).

1040.2 Where the conductor size is 1 AWG or smaller, the specimens to be used are to be 11-inch or 280-mm lengths of the wire or cable or cord conductor. Where the conductor size is 1/0 AWG or larger, the specimens are to be cut from the insulation in segments 4 inches long by 1 inch wide and 0.04 inch thick or 100 mm by 25 mm by 1 mm. The test procedure for a No. 1 AWG or smaller conductor is described in 1040.3 – 1040.8 and, for a No. 1/0 AWG or larger conductor, is described in 1040.9.

1040.3 Any jacket or other covering(s), including a coating to improve the resistance of the insulated conductor to flame, outside of the insulation is (are) to be removed or specimens are to be selected before application of any jacket or other covering (including a coating to improve the resistance of the insulated conductor to flame), leaving the insulation completely exposed. The surface of the finished insulated conductor is to be cleaned of all fibers and particles of foreign material by means of a cloth wet with ethyl alcohol. The specimens are to be dried in a vacuum over calcium chloride for 48 h at 70.0 ±1.0°C (158.0 ±1.8°F) and subsequently cooled to room temperature in a desiccator. Each specimen is to be weighed to the nearest milligram promptly after removal from the desiccator, and this weight is to be designated as W_1. Each specimen is then to be bent into the form of a U around a mandrel having a diameter four times the measured diameter of the specimen.

1040.4 The water bath is to consist of a vitreous-enameled-steel or glass vessel containing tap water, and is to be automatically controlled so that the water temperature is maintained at the specified temperature. The vessel is to have a close-fitting sheet-metal cover plate of brass or other nonferrous metal and is to have holes that just accommodate the specimens.

1040.5 The ends of each specimen are to be inserted through two holes in the cover plate so that 10 inches or 250 mm of the specimen are exposed below the plate. Rubber stoppers having holes bored to fit the specimens tightly, or accurately drilled, close-fitting washers of the same nonferrous metal as the cover plate described in 1040.4, are to be used to complete the closure of the hole in the cover plate and to assist in holding the specimens in place. The water level is to be maintained flush with the underside of the cover plate. Water is not to touch the ends of the specimens.

1040.6 The specimens are to remain in the water for 168 h, after which the cover plate with the specimens is to be removed from the vessel and transferred to a similar vessel filled with tap water at room temperature. The rubber stoppers or the metal washers are then to be taken off of one specimen at a time, each specimen is to be removed and shaken to dispose of loose water, and any remaining surface moisture is to be blotted off lightly with a clean, lintless, absorbent cloth. Each specimen is to be weighed again to the nearest milligram within 3 min after removal from the water, and this weight is to be designated as W_2.

1040.7 The specimens are then to be dried in a vacuum over calcium chloride for 48 h at 70.0 ±1.0°C (158.0±1.8°F), cooled to room temperature in a desiccator, and weighed to the nearest milligram promptly after removal from the desiccator. This weight is to be designated as W_3.

1040.8 Moisture absorption (MWA) in milligrams per square inch or in milligrams per square centimeter is to be determined by one or the other of the following formulas depending on whether W_3 is less or greater than W_1

$$MWA = \frac{W_2 - W_3}{S} \quad \textit{if } W_3 \textit{ is less than } W_1$$

or

$$MWA = \frac{W_2 - W_1}{S} \quad \textit{if } W_3 \textit{ is greater than } W_1$$

in which:

W_1 is original weight of the sample in milligrams,

W_2 is the weight of the sample in milligrams after immersion,

W_3 is the weight of the sample in milligrams after final drying, and

S is the area of the immersed surface of the sample in square inches or square centimeters (circumference times length immersed).

1040.9 Where segments of insulation are used as specified in 1040.2, the specimens are to be buffed, split, or skived to remove all corrugations and are then to be cleaned, dried, cooled, and weighed as described in 1040.3, after which they are to be placed in a water bath at the specified temperature for 168 h. They are then to be transferred to tap water at room temperature, removed one at a time, shaken, blotted, and reweighed as described in 1040.6. The specimens are then to be dried, cooled, and weighed again as outlined in 1040.7. The formulas in 1040.8 also apply to segment specimens, except that the immersed surface in square inches or square centimeters is to be determined by means of the following formula, in which all dimensions are expressed in inches or all dimensions are expressed in centimeters. T in the formula is the thickness of the buffed, split, or skived specimen.

$$S = 2(\textit{length} \times \textit{width}) + 2T \times (\textit{length} + \textit{width})$$

1041 and 1042 *Reserved for Future Use*

SWELLING AND BLISTERING IN WATER

1043 Test

1043.1 Finished cord that has a circular cross section is to be used for this test. Dye or another means that is durable in hot water and does not damage the cord is to be used to mark five test points along either a 32-ft or 10-m length of the cord. On a 32-ft specimen, the marks are to be 7 ft apart at points measuring 2, 9, 16, 23, and 30 ft from one end. On a 10-m specimen, the marks are to be 2 m apart at points measuring 1, 3, 5, 7, and 9 m from one end. The maximum and minimum diameters of the cord are to be measured to the nearest 0.001 inch or 0.01 mm at each of the five marked points. Each measurement is to be made by means of a machinist's micrometer caliper calibrated to read directly to at least 0.001 inch or 0.01 mm and having flat surfaces on both the anvil and the end of the spindle. The sum of the ten measurements is to be divided by 10 and recorded as d, the average diameter of the cord before immersion.

1043.2 The specimen is to be coiled, with the coil being relaxed and circular and at least 24 inches or 600 mm in overall diameter. The coil is to be immersed in tap water that is maintained at a temperature of 50.0 ±1.0°C (122.0 ±1.8°F), with a length of 12 inches or 300 mm that is kept dry and extending above the water at each end. The water bath is to have a width or diameter that accommodates the coil laid horizontal in the bath without any turn of the coil touching a vertical surface of the tank. The cord is to remain immersed continuously for 336 h (14 d) and is then to be removed from the water, uncoiled, and laid straight on a surface that is dry, flat, horizontal, and at room temperature. Without delay, all surface moisture is to be blotted from the surface of the cord by means of a clean, absorbent cloth that is free of lint.

1043.3 The cord does not comply where there is any evidence of blistering. Where there is no blistering, the maximum and minimum diameters of the cord are to be measured immediately at each of the five marked points. The sum of these ten measurements is to be divided by 10 and recorded as D, the average diameter of the cord after immersion. The cord does not comply where the increase I in average diameter (swelling) calculated as follows exceeds 20.0 percent.

$$I = 100(D - d)/d$$

1044 – 1059 *Reserved for Future Use*

FLAME TESTS

1060 Vertical Flame and FT1 Tests

1060.1 A vertical specimen of the finished wire, cable, or cord:

a) Shall not convey flame along its length, and

b) Shall not convey flame to combustible materials in its vicinity

during, between, or after five 15-s applications of a standard test flame. The standard test flame is to be nominally 125 mm high and is to produce heat at the nominal rate of 500 W (1700 Btu/h). The period between applications is to be 15 s regardless of whether flaming of the specimen ceases of its own accord within 15 s of the previous application. ***Except that cotton is not to be used, for an FT1 test***, this test is to be conducted as described in 1080.2 – 1080.11 and 1060.2 using one of the fuels described in 1080.3 and the standard laboratory burner and calibration as specified in 1080.1. The results of this test are to be judged as indicated in 1060.3.

1060.2 The burner is to be tilted forward into position to apply the gas flame to the specimen, kept there for 15 s, quickly tilted back to the stop to remove the flame from the specimen for 15 s, and so forth for a total of five 15-s applications of the gas flame to the specimen with 15 s between applications. The gas flame is to be reapplied to the specimen 15 s after the previous application regardless of whether flaming of the specimen ceases of its own accord within 15 s of the previous application.

1060.3 Where any specimen shows more than 25 percent of the indicator flag burned away or charred (soot that can be removed with a cloth or the fingers, and brown scorching, are to be ignored) after any of the five applications of flame, the wire, cable, or cord is to be judged capable of conveying flame along its length. Where any specimen emits flaming or glowing particles or flaming drops at any time that ignite the cotton (***does not apply to an FT1 test***) (flameless charring of the cotton is to be ignored), the wire, cable, or cord is to be judged capable of conveying flame to combustible materials in its vicinity. Where any specimen continues to flame longer than 60 s after the five applications of the gas flame, the wire, cable, or cord is to be judged capable of conveying flame to combustible materials in its vicinity.

1060.3 revised May 6, 2003

1061 Cable Flame Test

1061.1 A vertical specimen of the finished cable:

a) Shall not convey flame along its length, and

b) Shall not convey flame to combustible materials in its vicinity

during, between, or after three 60-s applications of a standard test flame. The standard test flame is to be nominally 125 mm high and is to produce heat at the nominal rate of 500 W (1700 Btu/h). The period between applications is to be 30 s regardless of whether flaming of the specimen ceases of its own accord within 30 s of the previous application. This test is to be conducted as described in 1080.2– 1080.11 and 1061.2 using one of the fuels described in 1080.3 and the standard laboratory burner and calibration as specified in 1080.1. The results of this test are to be judged as indicated in 1061.3.

1061.2 The burner is to be tilted forward into position to apply the gas flame to the specimen, kept there for 60 s, quickly tilted back to the stop to remove the flame from the specimen for 30 s, and so forth for a total of three 60-s applications of the gas flame to the specimen with 30 s between applications. The gas flame is to be reapplied to the specimen 30 s after the previous application regardless of whether flaming of the specimen ceases of its own accord within 30 s of the previous application.

1061.3 Where any specimen shows more than 25 percent of the indicator flag burned away or charred (soot that can be removed with a cloth or the fingers, and brown scorching, are to be ignored) following three applications of flame, the cable is to be judged capable of conveying flame along its length. Where any specimen emits flaming or glowing particles or flaming drops at any time that ignite the cotton (flameless charring of the cotton is to be ignored), or continues to flame longer than 60 s after three applications of the gas flame, the cable is to be judged capable of conveying flame to combustible materials in its vicinity.

1061.3 revised May 6, 2003

1062 – 1079 *Reserved for Future Use*

1080 VW-1 (Vertical-Specimen) Flame Test

1080.1 A vertical specimen:

a) Shall not convey flame along its length, and

b) Shall not convey flame to combustible materials in its vicinity

during, between, or after any of five 15-s applications of a standard test flame. The standard test flame is to be nominally 125 mm high and is to produce heat at the nominal rate of 500 W (1700 Btu/h). The period between applications is to be 15 s where the specimen flaming ceases within 15 s or less time, or the duration of the specimen flaming where the specimen flame persists longer than 15 s. This test is to be conducted as described in 1080.2 – 1080.13 using one of the fuels described in 1080.3 and the standard laboratory burner[a] described in ASTM D 5025-99. The gas flame produced by the burner is to be calibrated as described in ANSI/ASTM D 5207-98. The results of this test are to be judged as indicated in 1080.14.

[a]Sources of burners that comply with ASTM D 5025-99:

a supplier
Catalog No. 13–1927–000
Atlas Electric Devices Company
4114 North Ravenswood Avenue
Chicago, IL 60613

a manufacturer
UL flame test Tirrill burner with
ASTM D 5025 orifice:
0.90 ±0.03 mm orifice diameter
1.60 ±0.05 mm orifice length
Humboldt Manufacturing Company
7302 West Agatite Avenue
Norridge, IL 60656

1080.2 This test is to be conducted in a draft-free chamber having an air-tight, windowed sash, door, or other means for access and viewing. Each linear interior dimension of the chamber is to be at least 24 inches or 610 mm. The actual dimensions are to result in an interior volume of the chamber of at least 140 ft^3 or 4 m^3, including the volume of the exhaust transition. The size of the exhaust transition, if any, is not specified. At least 70 ft^3 or 2 m^3 of this volume is to be above the area of the gas and specimen flames as space for the heat and smoke to accumulate and not influence the flames. The chamber volume at or below the level of the flames is not to contain obstructions to the natural flow of chamber air supplying oxygen to the flames. The chamber is to have an air-tight glove box for arm-and-hand access to the apparatus or other means for adjusting the apparatus while the access is completely closed. The interior of the chamber is to be visible without obstruction while the access is closed. The chamber is to be fitted with an exhaust blower for pulling smoke and fumes out of the test area after the test. A tight-sealing damper is to be located between the chamber and the blower to prevent drafts while the blower is not operating. The exhaust blower is not to be operated during the test or during calibration. Immediately after each calibration and each test, the damper is to be opened and the blower is to be operated to purge the chamber of all smoke and fumes.

1080.3 For referee purposes, the fuel for this test is to be technical-grade methane (at least 98.0 percent pure) having a nominal heating value of 1000 Btu (thermochemical) per cubic foot or 37.3 MJ/m^3 or 8.9 kilocalories (thermochemical) per cubic meter. Otherwise, it is appropriate to use methane of a different grade, natural gas from a cylinder or a gas main, or propane. In each such case, the gas is to be of a grade that enables the test flame to be calibrated.

1080.4 The burner flame is to be calibrated at least every 30 days and each time that a cylinder of gas is changed (see 1080.7) or any of the equipment is changed. Where the gas used is other than the grade of methane specified for referee purposes, the burner flame is to be calibrated each day immediately before testing is begun.

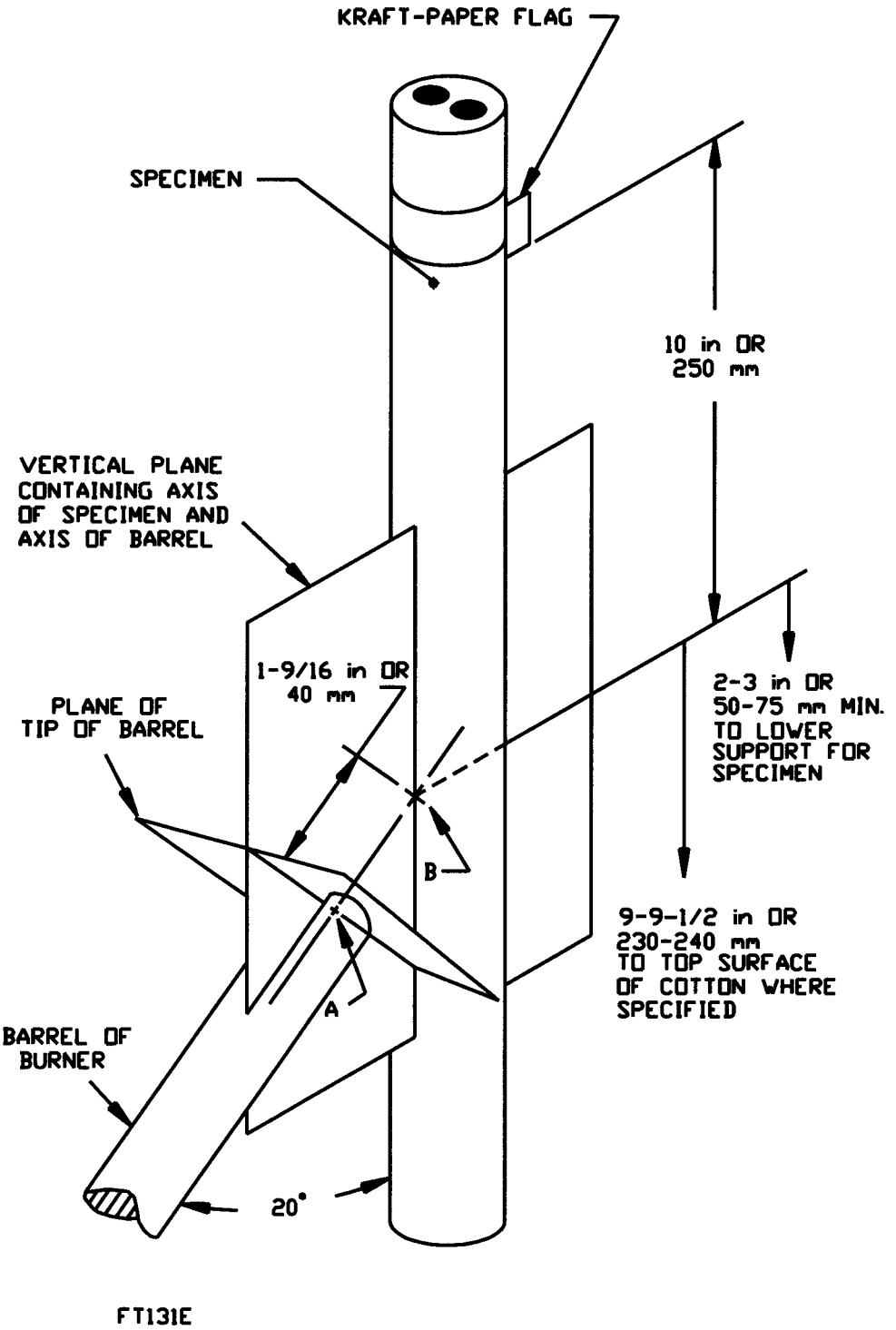
1080.5 This test is to be performed on unaged specimens. The specimens, the apparatus, and the surrounding air are to be in thermal equilibrium with one another at a temperature of 25.0 ±10°C or 77 ±18°F throughout the test.

1080.6 The test is to be conducted in the draft-free chamber described in 1080.2. The burner mounted on the wedge is to be placed directly on the floor of the chamber or, for ease of testing, on a bench within the chamber. The testing surface (chamber floor or bench top) is to be placed 4 ft or 1200 mm below the top of the chamber walls (at the transition to the exhaust). The dimensions of the testing surface of the bench are to accommodate the rectangular layer of cotton described below. A specimen 18 inches or 455 mm long cut from a straight sample length of the finished cord, wire, cable, or cord conductor is to be secured with its longitudinal axis vertical. Where required, lab stands or other supports that do not create updrafts or impede the air supply to the flame, are to be used to hold the specimen in place. A flat, horizontal layer of dry (untreated), pure, surgical cotton not more than 1/4 inch or 6 mm thick is to cover an area of the testing surface centered on the vertical axis of the test specimen and consisting of a circle 6 – 8 inches or 150 – 200 mm in diameter. Cotton is not to be on the burner or on or under the wedge.

There are not to be any openings through the layer of cotton. The upper surface of the cotton is to be 9 – 9-1/2 inches or 230 – 240 mm below point B, which is the point at which the tip of the blue inner cone of the 500-W test flame touches the specimen (this is shown in Figure 1080.1).

1080.6 revised May 6, 2003

Figure 1080.1
Dimensions for VW-1 and other vertical-specimen flame tests



Proportions exaggerated for clarity of detail