the comparison cable (control) resisted rupture in a separate test. That level of force is to be held constant for 60 s and is then to be reduced to zero by removing the dead weight(s) or, in the compression machine, by raising the upper steel plate at the rate of 0.50 ±0.05 in/min or 10 ±1 mm/min until the test cable is free.

1600.4 The test cable is to be advanced and crushed at each of the successive marks for a total of three crushes. The overall jacket or metal covering and the insulation on each conductor are to be examined at each of the three points at which the test cable was crushed. The test cable is not eligible for the 200 lbf or 890 N or 91 kgf reduced limit stated in the wire Standard for crushing the insulation on its conductors where the overall covering or any of the insulation is split, torn, cracked, or otherwise ruptured at any of the three points. Flattening of the jacket or the insulation, or both of these, without rupture is to be disregarded.

1600.5 IMPACT TEST – A solid rectangular block of steel 4-3/4 inches or 212 mm long by 3 inches or 76 mm wide by 5 inches or 127 mm high, with its upper face (4-3/4 inches by 3 inches or 212 mm by 76 mm) horizontal, is to be secured to a concrete floor, the building framework, or another solid support.

1600.6 An impact weight of 3 lb or 1.36 kgf is to be used. The impact weight is to consist of a solid steel cylinder having a diameter of 1-1/4 inches or 31.8 mm, with the edges of its lower face (the face that strikes the cable) rounded to a radius of 1/16 inch or 1.5 mm.

1600.7 The impact weight is to be supported with its lower face horizontal. A vertical line through the centers of gravity of the impact weight and the stationary block is to be coincident with a vertical line through the dimensional center of the lower face of the impact weight and the dimensional center of the upper face of the stationary block. A set of rails or other vertical guides is to constrain the impact weight and keep its lower face horizontal while the weight is falling and after it has struck the cable. The rails or other guides are not to interfere with the free fall of the impact weight. A means is to be at the top of the guides for releasing the impact weight to fall freely from any chosen height and strike the cable. The weight is to be kept from striking the cable more than once during each drop.

1600.8 The specimens, the apparatus, and the surrounding air are to be in thermal equilibrium with one another at a temperature of 24.0 ±8.0°C (75.2 ±14.4°F) throughout the test.

1600.9 The cable with the metal sheath under evaluation is to be tested in a continuous length of at least 11 ft or 3.35 m, with ten strikes being made on that length of this cable (test cable). The points at which the test cable is to be struck are to be measured and marked with chalk or by another innocuous means on the test length before the test is begun. The first mark is to be placed 12 inches or 305 mm from one end of the test length and the nine remaining marks are to be made at succeeding intervals of 12 inches or 305 mm down the length of cable.

1600.10 Each of the insulated circuit conductors in the test cable is to be connected in series with a 3-W 120-V neon lamp to the energized conductor of a 2-wire 120-V 48 – 62 Hz grounded a-c supply circuit. The metal sheath in the test cable is to be connected to all parts of the impact apparatus, to earth ground, and to the grounded supply wire.

1600.11 The impact weight is to be secured several cable diameters above the stationary steel block, and the test cable at the first mark is to be placed and held on the steel block, with the longitudinal axis of the cable horizontal and in the vertical plane containing the coincident vertical lines mentioned in 1600.7. The position of the impact weight is to be adjusted to place the lower face of the weight the same distance above the upper surface of the test cable as it was released from and resulted in contact in a separate test on the comparison cable (control). The impact weight is to be released from this height, is to fall freely in the guides, is to strike the test cable once, and is then immediately to be raised up to and secured at

the initial height. Note is to be taken and recorded of whether any or all of the neon lamps light during the impact indicating a momentary or other contact between the circuit conductors or between one or more of the circuit conductors and the metal sheath.

1600.12 The test cable is to be advanced to and impacted at each of the successive marks for a total of ten strikes. The test cable is not eligible for the 200 lbf or 890 N or 91 kgf reduced limit stated in the wire standard for crushing the insulation on its conductors where any lamp lights at more than two of the ten impact points.

1601 – 1609 *Reserved for Future Use*

MOISTURE ABSORPTION BY FIBROUS COVERINGS OTHER THAN TAPE

1610 Test

1610.1 The apparatus for this test is to consist of a desiccator containing anhydrous calcium chloride, a set of mandrels having diameters as indicated in Table 1610.1, a quick-damping balance accurate to 10 mg, and an agitated constant-temperature bath of tap water maintained at a temperature of 21.0 ±1.0°C (69.8±1.8°F). The bath is either to be fitted with a cover to keep out dust or is to be placed within a tight enclosure during the test. Where at any time the water becomes dirty or shows the presence of a surface film of dust or wax, it is to be replaced with fresh water.

1610.2 Before cutting a test specimen to size, the coil or other sample of the wire, cable, or assembly that is to be tested is to attain a room temperature of 21.0 ±1.0°C (69.8 ±1.8°F). Handling and flexing of samples to be tested are to be reduced to the absolute minimum required for conducting the test.

1610.3 A specimen 24 ±1/4 inches or 610 ±6 mm long is to be cut from the coil or other sample of wire, cable, or assembly and is to be bent around a mandrel of the diameter indicated in Table 1610.1 (single conductor) or in Table 1610.2 (multiple-conductor cable or assembly). For a 2 AWG or smaller wire and for a multiple-conductor cable or assembly for which the factor F in Table 1610.2 is 2 or 3, the maximum number of complete turns that fit on the mandrel are to be made around the mandrel with the wire tight on the mandrel, adjacent turns 1/8 – 1/4 inch or 3 – 6 mm apart, and with a 2– 2-1/2-inch or 50 – 60-mm straight length at each end of the specimen extending away from the mandrel. For wire sizes larger than 2 AWG and for a multiple-conductor cable or assembly for which the factor F in Table 1610.2 is 4.5, 6, 9, or 10, a half turn is to be made around the mandrel.

Table 1610.1
Mandrel diameters for moisture and cold-bend tests on single conductors

Size of conductor	Diameter of mandrel	
	inches	mm
14 AWG	0.313	8
13	0.350	9
12	0.375	9
11	0.415	11
10	0.563	14
9	0.585	15
8	0.688	17
7	0.740	19
6	1.250	32
5	1.305	33
4	1.375	35
3	1.458	37
2	1.563	40
1	2.688	68
1/0	2.875	73
2/0	3.000	76
3/0	3.250	83
4/0	3.500	89
250 kcmil	5.188	132
300	5.500	140
350	5.875	149
400	6.250	159
450	6.625	168
500	6.750	171
550	10.500	267
600	11.000	279
650	11.250	286
700	11.500	292
750	12.000	305
800	12.250	311
900	12.875	327
1000	13.500	343
1100	17.000	432
1200	17.250	438
1250	17.500	445

Table 1610.1 Continued on Next Page

Table 1610.1 Continued

Size of conductor	Diameter of mandrel	
	inches	mm
1300	17.750	451
1400	18.125	460
1500	18.500	470
1600	18.875	479
1700	19.375	492
1750	19.750	502
1800	19.875	505
1900	20.125	511
2000	20.500	521

Table 1610.2
Mandrel-diameter factor F for moisture and cold-bend tests on multiple-conductor cables and assemblies

Calculated diameter over the finished cable or assembly		Factor F by which the calculated diameter over the finished cable or assembly is to be multiplied to obtain the mandrel diameter
inches	mm	
0 – 0.375	0 – 9.52	2
0.376 – 0.500	9.53 – 12.70	3
0.501 – 0.750	12.71 – 19.05	4.5
0.751 – 1.125	19.06 – 28.58	6
1.126 – 1.500	28.59 – 38.10	9
over 1.500	over 38.10	10

1610.4 The specimen is to be removed from the mandrel without disturbing its form and is to be placed in the desiccator over anhydrous calcium chloride at a temperature of 21.0 ±1.0°C (69.8 ±1.8°F) for at least 18 h. It is then to be removed from the desiccator and weighed to the nearest 10 mg. The weight is to be recorded as W.

1610.5 The specimen is then to be immersed in the tap-water bath, with 1 ±1/8 inch or 25 ±3 mm of each end of the coil or 180° bend projecting above the surface of the water. After 24 h of immersion, the specimen is to be removed from the bath, shaken vigorously for 5 s to remove adherent moisture and weighed again 2 min after removal from the bath. This weight is to be recorded as W_1. All fibrous coverings other than tape are then to be removed from the full length of the specimen. The conductor(s), insulation, and any tape are then to be weighed. In the case of an assembly for use in armored cable, any overall fibrous covering and any fibrous covering on the individual wires are to be taken together in one test and a second test is to be made on only the fibrous covering on the individual wires. This weight is to be recorded as W_2.

1610.6 The moisture absorbed by the specimen is not to be adjusted for the portion of the specimen projecting above the water. The percentage of absorption is to be calculated (to 0.1 percent) by means of the expression

$$\frac{100(W_1 - W)}{W - W_2}$$

1611 – 1629 *Reserved for Future Use*

FALLING PARTICLES AND DRIPPING FROM FIBROUS-COVERED WIRE AND CABLE

1630 Test

1630.1 A 7-inch or 180-mm specimen of the finished fibrous-covered wire or cable is to be secured in a horizontal position above the floor of a full-draft circulating-air oven for 7 h at the rated temperature of the wire or cable ±1.0°C (±1.8°F). The saturant, finish, and any lubricant comply where, with a clean sheet of aluminum foil or white paper covering the entire floor of the oven for the 7 h, drippings or particles or drippings and particles do not fall from the wire or cable onto the paper or foil.

1631 – 1669 *Reserved for Future Use*

ARCING OF TYPE HPN CORD

1670 Flame Test

1670.1 One end of a sample length of finished Type HPN cord having two circuit conductors with or without one grounding conductor is to be cut off, with the face of the cut end flat and perpendicular to the longitudinal axis of the cord. The cord is to be laid out straight and flat on a horizontal, electrically nonconductive, noncombustible surface, with 4 inches or 100 mm of the cord at the cut end extending beyond the edge of the supporting surface. The circuit conductors at the end of the cord opposite the cut end are to be connected to a 120 V 48 – 62 Hz sinusoidal or nearly sinusoidal rms branch-circuit supply that has a 15-A fuse or circuit breaker, and has a capacity that enables short circuiting of the circuit to cause the fuse or circuit breaker to open. Any grounding conductor is not to be connected.

1670.2 A Tirrill, Bunsen, or similar appropriate gas burner having a vertical barrel that has an inside diameter of 3/8 inch or 9.5 mm and extends 4 inches or 102 mm above the air inlets is to be lit and adjusted for a steady flame with an overall height of 1-1/2 inches or 38 mm with the temperature at its tip 816°C (1500°F) or higher as measured using a chromel-alumel (nickel-chromium and nickel-manganese-aluminum) thermocouple. With its barrel vertical, the burner is to be placed under the free end of the cord with the tip of the blue inner cone touching the flat underside of the cord at a point that is midway between the conductors and 1/2 inch or 13 mm from the cut end. The flame is to be applied for 120 s and then removed. The cord does not comply where arcing occurs between the conductors during application of the flame or where the fuse or circuit breaker opens.

1671 – 1679 *Reserved for Future Use*

1680 Broken-Strands Test

1680.1 For each test, the specimen is to be 40 inches or 1 m long and is to be taken from a length of the finished cord containing two circuit conductors with or without a grounding conductor. Both ends of each circuit conductor are to be bared for electrical connection. Any grounding conductor is to be present and disregarded. A commercially available strain-relief bushing for the type and size of cord being tested is to be assembled to the cord as intended at a point 24 inches or 610 mm from one end of the specimen.

1680.2 By means of the bushing, the specimen is to be secured in a flexing machine with the 24-inch or 610-mm end of the cord hanging vertically below the bushing. The circuit conductors are to be connected in series with one another, a lamp or other device to signal breakage of a circuit conductor, and a 48 – 62 Hz, 24-V rms supply circuit that operates at a current not exceeding 200 mA. A weight exerting the force indicated in Table 1680.1 is to be secured to the cord at a point 8-1/2 inches or 215 mm below the bushing.

Table 1680.1
Weight for strand-breaking flexing

AWG size of circuit conductors	Weight		
	lbf	N	gf
18	2	8.9	907
17	2.5	11.1	1134
16	3	13.3	1361
14	4	17.8	1814
12	5	22.2	2268

1680.3 The machine is to flex the cord edgewise at the point of exit of the cord from the bushing. The flexing is to be by simple harmonic motion at a rate at or near 12 cycles per minute. Each cycle is to consist of flexing the cord from its original vertical position to a horizontal position 90° to one side, back through 180° from that position to a similar horizontal position to the other side, and then back to the original vertical position. The circuit conductors in the cord are to remain in the same vertical plane throughout the flexing. The flexing is to continue until all of the strands of one circuit conductor break as indicated by the lamp or other signal device. Breakage of a circuit conductor is to stop the flexing machine.

1680.4 The strain-relief bushing is to be removed and the specimen is to be examined for damage to the insulation. Where there is any splitting, cracking, or other visible damage to the insulation or where any strand(s) extend through the insulation, the specimen is to be discarded and a new specimen is to be prepared, flexed until one circuit conductor breaks, and examined for damage to the insulation. For this flexing procedure, the weight attached to the cord is to be reduced (steps of 4 ozf, 1.1 N, or 113 gf typically are convenient) to result in the flexing breaking a circuit conductor without any visible damage to the insulation.

1680.5 The undamaged specimen is to be wrapped with four single layers of bleached cheesecloth that is 2 inches or 50 mm wide, runs 14 – 15 yd/lb or 26 – 28 m^2/kg, and has what is known in the trade as a count of 32 by 28 (a square 1 inch on a side has 32 threads in one direction and 28 threads in the other direction or a square 1 cm on a side has 13 threads in one direction and 11 threads in the other direction). The cheesecloth is to be tight on the specimen, centered over the break in the circuit conductor, and held

in place by a strain-relief bushing that is larger than the one indicated in 1680.1 (see Table 1680.2 for some appropriate cord/bushing combinations). The bushing is to be assembled to the cheesecloth-wrapped cord at a point 1/4 inch or 5 mm from the break in the circuit conductor.

Table 1680.2
Combinations of cord and bushing

Cord construction	Typical bushing[a]
18/2, 18/3, 16/2	SR-4K-1
16/3	SR-5W-1
14/2, 14/3 smaller dimensions	SR-33-1
14/2, 14/3 larger dimensions	SR-34-2

[a] The specific bushings shown are not required. These particular bushings are mentioned as a guide because the selection of bushings is difficult and these have been used successfully in a number of tests. Different bushings are to be used where required by the dimensions of the cord being tested and the layering of cheesecloth over the cord. The designations shown are for Heyco bushings made by the Heyman Manufacturing Company of Kenilworth, New Jersey 07033.

1680.6 By means of the bushing, the specimen is to be secured in a vertical sheet-metal bracket. As shown in Figure 1680.1, the longitudinal axis of the specimen is to be horizontal at the point at which the bushing passes through the vertical surface of the bracket. The cheesecloth-wrapped break in the circuit conductor is to be in front of the bracket.

1680.7 The bared ends of the broken circuit conductor are to be connected in series with a variable resistor, an a-c ammeter of applicable range, overcurrent protection, and a 48 – 62 Hz supply circuit of 120 ±2 V as shown in Figure 1680.1. A 120-V neon lamp is to be connected either in parallel with the broken circuit conductor, or in parallel with the variable resistor. The lamp acts as an indicator of the circuit being opened (lamp lit where in parallel with the broken conductor, lamp dark where in parallel with the resistor) and closed (lamp dark where in parallel with the broken conductor, lamp lit where in parallel with the resistor) in the specimen as the specimen is flexed. The unbroken circuit conductor and any grounding conductor are to be present and are not to be in the circuit.

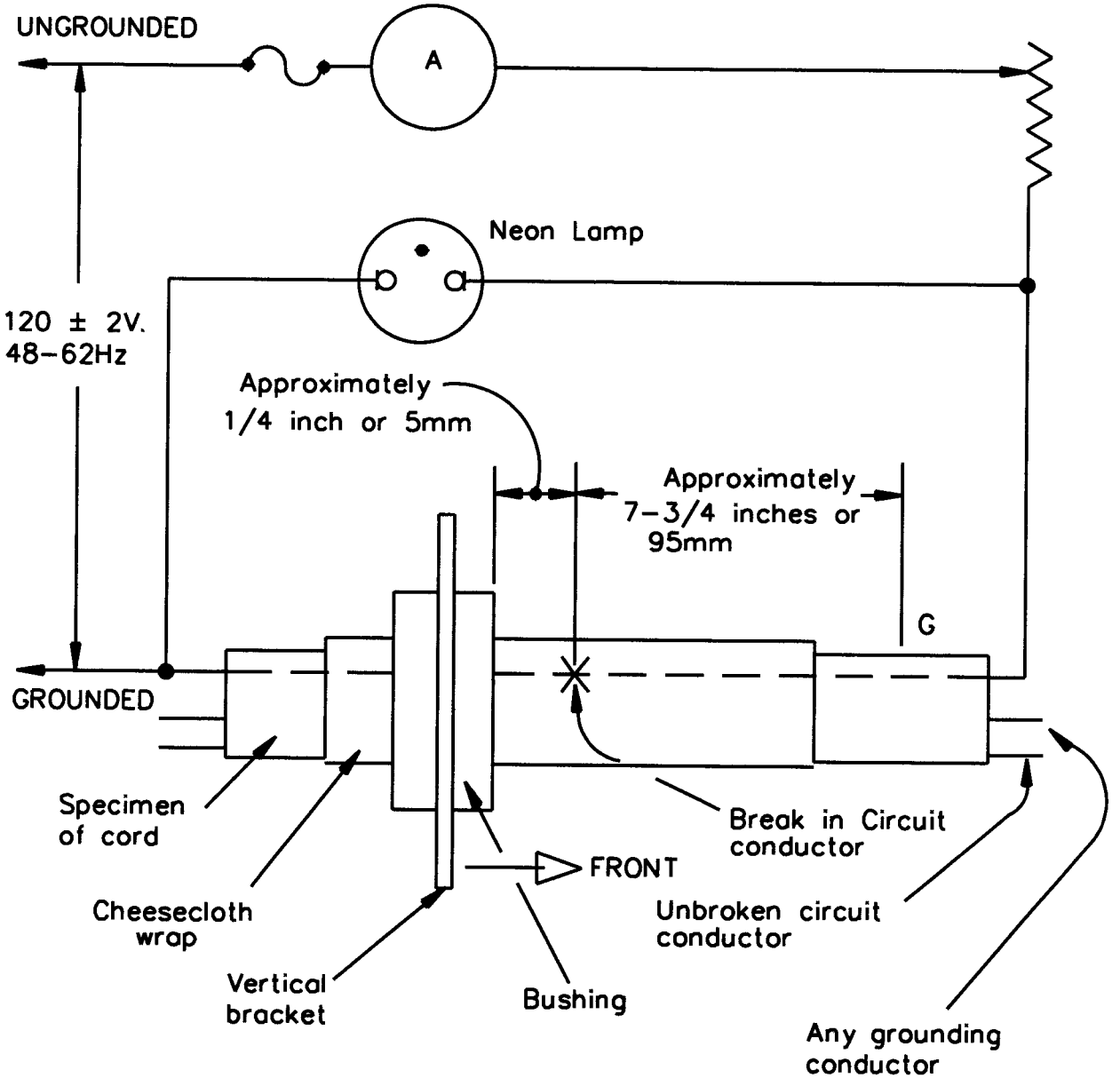
1680.8 The variable resistor is to be adjusted to result in the current indicated in Table 1680.3 flowing in the broken circuit conductor.

Table 1680.3
Current in the broken circuit conductor

AWG size of circuit conductors in cord	RMS current in amperes
18	10.0 ±0.5
16	15.0 ±0.5
14	20.0 ±0.5
12	30.0 ±0.5

1680.9 While the current is flowing, the specimen is to be grasped 7-3/4 inches or 197 mm from the break in the circuit conductor (point G in Figure 1680.1). Without physically straining the insulation, the cord is to be moved back and forth to result in the circuit being opened and closed at the break in the circuit conductor as indicated by the neon lamp lighting and going dark. Each cycle of make and break is to take 3 – 4 s. The test is to be discontinued after 20 cycles of opening and closing the circuit.

Figure 1680.1
Arcing circuit



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1680.10 Where the insulation is perforated as evidenced by flaming, glowing, or charring of the cheesecloth, the test is to be stopped. Perforation in 20 or fewer cycles constitutes noncompliance.

1680.11 Where 20 cycles is not completed on an unperforated specimen because contact is no longer made between the broken ends of the circuit conductor, that specimen is to be discarded and the test is to be repeated with a new specimen.

1681 – 1689 *Reserved for Future Use*

DURABILITY OF INDELIBLE-INK PRINTING

1690 Test

1690.1 Two straight 300-mm or 12-inch specimens of the single- or multiple-conductor construction are to be cut from a sample length of any convenient size of the finished wire or cable on which the ink printing is being evaluated. The specimens are to be handled minimally and are not to be wiped, scraped, or otherwise cleaned in any way.

1690.2 One of the specimens is to be aged in a circulating-air oven that complies with 420.8 and 420.9, including 100 – 200 fresh-air changes per hour, operating for the time and at the temperature specified for the insulation or jacketing material whose outer surface is printed, and is then to be removed from the oven and kept in still air to cool to room temperature for 60 min before being tested. The one remaining specimen is to rest for at least 24 h in still air at 23.0 ±5.0°C (73.4 ±9.0°F) before being tested.

1690.3 The test is to be made using a weight whose lower face is machined to a flat, rectangular surface measuring 25 mm by 50 mm or 1 inch by 2 inches. The height of the weight is to be uniform to ensure even distribution of the weight throughout the area of the lower face. Clamps or other means are to be provided for securing to the lower face of the weight a layer of craft felt (composition not specified) that is 1.2 mm or 0.047 inch thick. Without the felt in place, the weight and the means for securing the felt to the weight are to exert 450 ±5 g or 1 lbf ±0.2 ozf or 4.45 ±0.06 N on a specimen. It is appropriate to use the felt for several tests; however, the felt is to be replaced as soon as the fibers flatten or become soiled. While not in use, the weight is to be stored resting on one of its surfaces that is not covered with felt. The apparatus and the specimens are to be in thermal equilibrium with the surrounding air at a temperature of 23.0 ±5.0°C (73.4 ±9.0°F) throughout the test. Each specimen is to be placed on a solid, flat, horizontal surface with the printing up and at the center of the length of the specimen. The ends of each specimen are to be bent around supports or otherwise secured to keep the printed area of the insulation or jacket from rotating out from under the weight.

1690.4 The felted surface of the weight is to be placed on the printed area of a specimen with the felted surface horizontal and with the 50-mm or 2-inch dimension of the felted surface parallel to the length of the specimen. With the weight so resting on the specimen, the felt is to be slid lengthwise by hand along the printed area of the specimen for a total of three cycles. Each cycle is to consist of one complete back-and-forth motion covering the entire length of the specimen. The three cycles of rubbing are to be completed at an even pace, taking a total time of 5 – 10 s. The procedure is to be repeated on the second specimen. Where the printing is illegible on either of the two specimens, the ink printing on the wire or cable does not comply.