UL 83B

STANDARD FOR SAFETY

Switchboard and Switchgear Wires and Cables

UL Standard for Safety for Switchboard and Switchgear Wires and Cables, UL 83B

First Edition, Dated October 15, 2020

Summary of Topics

This First Edition of ANSI/UL 83B covers requirements for 14 – 4/0 AWG sizes of 600-V, single-conductor, switchboard and switchgear wires and cables, Type TBS, for use in accordance with the National Electrical Code.

The new requirements are substantially in accordance with Proposal(s) on this subject dated July 17, 2020.

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Standard for Switchboard and Switchgear Wires and Cables

First Edition

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This ANSI/UL Standard for Safety consists of the First Edition.

The most recent designation of ANSI/UL 83B as an American National Standard (ANSI) occurred on October 15, 2020. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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1 Scope

1.1 These requirements cover 14 – 4/0 AWG sizes of 600-V, single-conductor, switchboard and switchgear wires and cables for use in accordance with the National Electrical Code.

2 General

2.1 Units of measure

Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information. This applies to all values with the exception of conductor size.

2.2 Reference publications

Where reference is made to any Standards, such reference shall be considered to refer to the latest editions and revisions thereto available at the time of printing, unless otherwise specified.

NFPA (National Fire Protection Association) Publication

NFPA 70-2014, *National Electrical Code*

3 Definitions

3.1 The following definitions apply in this Standard:

PVC – a thermoplastic compound whose characteristic constituent is polyvinyl chloride or a copolymer of vinyl chloride and vinyl acetate.

Thermoplastic – a polymeric material that can repeatedly be softened by heating and hardened by cooling and that in the softened state can be shaped through the application of force.

4 Construction

4.1 Conductors

4.1.1 General

Circuit and equipment-grounding conductors shall be of either copper, copper-clad aluminum, or aluminum.

4.1.2 Aluminum conductors

4.1.2.1 Aluminum conductors shall be of aluminum conductor material (ACM), AA 8000 series alloy.

4.1.2.2 Annex A provides the chemical composition of recognized aluminum alloy conductor materials.

4.1.2.3 Solid aluminum conductors in size 12 – 8 AWG shall comply with the requirements for aluminum-wire stock (aluminum-alloy conductor material). All other aluminum conductors shall comply with the requirements for semi-annealed 8000 series aluminum conductors in Requirements for Aluminum Conductors of an 8000 Series Alloy, Section 10 of UL 1581.

4.1.3 Copper-clad aluminum conductors

4.1.3.1 The requirements of Annex B shall apply to solid conductors or the individual wires of stranded conductors prior to stranding.

4.1.3.2 Copper-clad aluminum conductors shall comply with the requirements in Requirements for Copper-Clad Aluminum Conductors, Section 11 of UL 1581.

4.1.4 Copper conductors

4.1.4.1 General

The requirements of Clauses 4.1.4.2 or 4.1.4.3 shall apply to solid conductors or the individual wires of stranded conductors prior to stranding.

4.1.4.2 Bare copper conductors

Each wire in a bare copper conductor shall comply with the requirements of ASTM B3.

4.1.4.3 Tin-coated copper conductors

Each wire in a tin-coated conductor shall comply with the requirements of ASTM B33.

4.1.5 Sizes and stranding

4.1.5.1 Sizes

Conductor sizes and stranding shall be as shown in Table 1.

4.1.5.2 Stranding

4.1.5.2.1 General

4.1.5.2.1.1 The minimum number of wires (strands) in a conductor shall be in accordance with Table 2.

4.1.5.2.1.2 Copper strands smaller than 0.0127 mm^2 (36 AWG) and aluminum strands smaller than 0.324 mm^2 (22 AWG) shall not be used. A compact-stranded conductor shall not be segmented.

4.1.5.2.2 Concentric

A concentric conductor shall be a round conductor consisting of a round central core surrounded by one or more layers of helically laid round wires all having the same diameter.

4.1.5.2.3 Compact

A compact-stranded conductor shall be a round conductor consisting of a central core surrounded by one or more layers of helically laid wires, and formed into a smooth outermost layer by rolling, drawing, or other means. The lay length of every layer shall be not less than 8 times nor more than 16 times the outside diameter of the completed conductor, except that for sizes 33.6 mm^2 (2 AWG) and smaller, the maximum lay length shall be 17.5 times the outside diameter. The direction of lay of the outermost layer shall be left-hand, and it shall be reversed or unidirectional/unilay in successive layers.

4.1.5.2.4 Compressed

A compressed-stranded conductor shall be a round conductor consisting of a central core surrounded by one or more layers of helically laid wires with either the direction of lay reversed in successive layers or unilay or unidirectional lay. The direction of lay of the outer layer shall be left-hand in all cases. The strands of one or more layers shall be slightly compressed by rolling, drawing, or other means to change the originally round strands to various shapes that achieve filling of some of the spaces originally present between the strands.

4.1.5.2.5 Assembly of strands

A 19-wire combination round-wire unilay stranded conductor shall be round and shall consist of a straight central wire, an inner layer of six wires of the same diameter as the central wire, and an outer layer consisting of six wires with the same diameter as the central wire alternated with six wires with a diameter of 0.732 times the diameter of the central wire. No particular assembly of the individual wires of any other stranded conductor shall be required. However, simple bunching (untwisted strands) shall not be used. The length of lay of the strands in a bunch-stranded conductor twisted as a single bunch shall not be greater than as indicated in Table 3. The direction of lay of the strands in a bunch-stranded conductor shall be left-hand.

4.1.5.2.6 Length and direction of lay

Every stranded conductor other than a compact-stranded conductor or a bunch-stranded conductor twisted as a single bunch shall comply with the following:

a) The direction of lay of the strands, members, or ropes in a 13.3 – 107 mm^2 (6 AWG – 4/0) conductor, other than a compressed unilay single input wire, combination unilay or a compressed unilay or compressed unidirectional lay conductor, shall be reversed in successive layers. Rope-lay conductors with bunch-stranded or concentric-stranded members shall be either unidirectional or reversed. All unidirectional lays and the outer layer of reversed lays shall be in the left-hand direction.

b) For a bunch-stranded member of a rope-lay-stranded conductor in which the members are formed into rope-stranded components that are then cabled into the final conductor, the length of lay of the individual members within each component shall not be more than 30 times the outside diameter of one of those members.

c) For a concentric-stranded member of a rope-lay-stranded conductor, the length of lay of the individual strands in a member shall be 8 – 16 times the outside diameter of the member. The direction of lay of the strands in each member shall be reversed in successive layers of the member.

d) The length of lay of the strands in both layers of a 19-wire combination round-wire unilay-stranded copper or aluminum conductor shall be 8 – 16 times the outside diameter of the completed conductor. Otherwise, the length of lay of the strands in every layer of a concentric-lay-stranded conductor consisting of fewer than 37 strands shall be 8 – 16 times the outside diameter of the conductor.

e) The length of lay of the strands in the outer two layers of a concentric-lay-stranded conductor consisting of 37 or more strands shall be 8 – 16 times the outside diameter of the conductor.

f) The length of lay of the members or ropes in the outer layer of a rope-lay-stranded conductor shall be 8 – 16 times the outside diameter of that layer.

The length of lay shall be determined in accordance with the test, Length of lay, in UL 2556.

4.1.6 Diameter and cross-sectional area

4.1.6.1 The nominal diameters of solid and stranded conductors are shown in Table 4 – Table 9. There are no diameter requirements for conductor classes not referenced in Table 4 – Table 9. See Clause 5.2 for conductor resistance requirements. The minimum diameter for stranded conductors is 98 percent of the nominal. The maximum diameter is 101 percent of the nominal. The diameter shall be determined in accordance with the test, Conductor diameter, in UL 2556.

4.1.6.2 Conductor sizes in mm^2 (AWG/kcmil) covered by this Standard are shown in Table 4. The nominal cross-sectional area of a conductor identified in Table 4 is not a requirement.

4.1.7 Joints

4.1.7.1 A joint (butt splice) where allowed shall be made before or after insulating and prior to further processing. Where joints (butt splices) are made after insulating, the insulation applied over the joint shall be of the same insulation material used throughout the length of the conductor, or of another insulating material that meets or exceeds the electrical, physical, and mechanical requirements of this Standard for the original insulating material.

4.1.7.2 A joint in a solid conductor or in one of the individual wires of a stranded conductor shall neither increase the diameter nor materially decrease the strength of the conductor or the individual wire. Not more than one of the wires in a stranded conductor of 19 wires or less, nor more than one of the wires in any given layer in a stranded conductor of more than 19 wires, shall be joined in any 0.3 m (1 ft) of conductor.

4.1.7.3 In a rope-lay-stranded conductor, which consists of a central core surrounded by one or more layers of stranded members (primary groups), each member shall be considered equivalent to a solid wire, and as such, shall be spliced as a unit. These joints shall not be any closer together than 2 lay lengths.

4.1.7.4 A joint shall be allowed in a Class B stranded 2.08 mm^2 (14 AWG), 3.31 mm^2 (12 AWG), 5.26 mm^2 (10 AWG), or 8.37 mm^2 (8 AWG) insulated copper conductor intended to be used in a multiple-conductor cable, with an overall covering. The joint (butt splice) shall be made by machine brazing or welding the entire conductor such that the resulting solid section of the stranded conductor is no longer than 13 mm (0.50 inch). In addition, the joint shall not increase the diameter of the conductor, there shall be no sharp points, and the distance between joints in a single conductor shall not average less than 1000 m (3280 ft) in any finished length of that single insulated conductor. Insulated conductors with a joint (butt splice) shall not be surface marked with a type designation.

4.1.8 Separator

A separator of suitable material between the conductor and the insulation shall be optional. The separator shall be of contrasting color to the conductor color, except that clear or green shall not be used. White-colored separator over aluminum conductors shall be optional. The separator and the other wire or cable components shall not have any deleterious effect on each other.

4.2 Insulation

4.2.1 General

4.2.1.1 Conductors shall be insulated for their entire length with PVC or other thermoplastic material meeting all the requirements of this Standard. The insulation shall be applied directly over the conductor, or over the separator if provided, and shall fit tightly thereto. The insulation shall be free from pores, splinters, and other inhomogeneities visible without magnification to normal or corrected-to-normal vision.

4.2.1.2 If the insulation is applied in more than one layer, the interface between the layers shall be free of voids visible without magnification to normal or corrected-to-normal vision, and all layers shall be taken together for all measurements and tests.

4.2.2 Repairs

4.2.2.1 Where a repair is made in the insulation, the insulation applied to the repaired section shall be equivalent to that removed.

4.2.2.2 The repaired section of the finished conductor shall comply with the same electrical and thickness requirements specified in this Standard.

4.2.3 Colored insulation

When colored insulation is required, either the insulation shall be colored throughout its thickness or a thin colored coating of suitable material shall be applied to the surface of the insulation. The coating material shall not have an adverse effect on the properties of the insulation. If the coating is of an extruded type, it shall be considered as part of the insulation and shall comply with all requirements.

4.2.4 Thickness and centering

4.2.4.1 The minimum average thickness and the minimum thickness at any point of the insulation shall be as shown in Table 10. Compliance shall be determined in accordance with the test, Thickness, in UL 2556.

4.2.4.2 The insulation shall have a circular cross-section, with the insulation applied concentrically about the conductor and fitting tightly on the conductor or over any separator.

4.2.5 Physical properties of insulation

4.2.5.1 General

4.2.5.1.1 The tensile strength and ultimate elongation of PVC insulation, before and after aging, shall be as specified in Table 11.

4.2.5.2 Test requirement

Compliance with Clause 4.2.5.1 shall be determined in accordance with the test, Physical properties (ultimate elongation and tensile strength), in UL 2556.

4.2.5.3 Evaluation of alternative insulation materials for use in this Standard (see Annex C)

4.2.5.3.1 Alternative insulation materials for products shall be evaluated in accordance with the test, Dry temperature rating of new materials (long-term aging test), in UL 2556.

4.2.5.3.2 Materials having characteristics different from those specified in Table 11 shall be evaluated for the requested temperature rating in accordance with Clause 5.16. To be evaluated, materials shall have an initial absolute minimum tensile strength of not less than 6.8 MPa (1000 lbf/in^2), and an absolute minimum elongation of 100 percent before aging.

4.2.5.3.3 The temperature rating and thickness of those materials having characteristics different from those specified in Table 11 shall be as required for the specific thermoplastic-insulated wire or cable type.

The electrical, mechanical, and physical characteristics of the wire or cable using these materials shall be such that the materials meet the specified requirements for PVC for the temperature rating.

4.2.5.3.4 Insulation material complying with Clause 4.2.5.3.2 shall then be evaluated to establish requirements for its specific physical properties, unaged and after aging for 7 days at 121°C in accordance with Annex A of UL 2556.

5 Test requirements

5.1 General

Every length of finished insulated conductor shall be capable of meeting the test requirements set out in Clauses 5.2 – 5.19, as applicable.

5.2 Conductor resistance

5.2.1 The direct-current resistance of the conductor shall not be greater than as specified in Table 12 – Table 21 inclusive. For conductors for which the maximum resistance is not tabulated in Table 12 – Table 21, the maximum resistance for a given size of the solid or stranded construction shall be determined by multiplying the maximum resistance tabulated in the tables for uncoated copper of the same size and construction by the ratio of 100 percent IACS (International Annealed Copper Standard) to the percent conductivity as shown in the applicable conductor standard.

5.2.2 Compliance shall be determined in accordance with the test, DC resistance, in UL 2556.

5.2.3 Compliance shall be determined in accordance with the test, DC resistance, in UL 2556.

5.3 Tests on aluminum conductors

5.3.1 Physical properties

5.3.1.1 All aluminum conductors shall have a minimum elongation at break of 10 percent. Wires (strands) removed from a finished stranded conductor shall have a tensile strength of 98 – 159 MPa (14,250 – 23,100 lbf/in^2). The tensile strength of all other conductors shall be 103 – 152 MPa (15,000 – 22,000 lbf/in^2). Compliance shall be determined in accordance with the test, Physical properties of conductors – Maximum tensile strength and elongation at break, in UL 2556.

5.3.1.2 Compliance with the requirements in 5.3.1.1 for stranded conductors shall be determined either on wires taken prior to stranding into conductors, any strand(s) taken from a stranded conductor, or the stranded conductor as a whole, at the option of the manufacturer. In case of non-compliance, the results from specimens taken from a center strand only shall be considered for referee purposes.

5.3.2 High-current heat cycling [3.31 – 8.37 mm^2 (12 – 8 AWG) conductors only]

5.3.2.1 A minimum of 24 thermocouples (26 thermocouples if one test jig is rejected before 51 cycles are completed) shall measure less than 175°C, with each temperature profile exhibiting thermal stability.

5.3.2.2 Compliance shall be determined in accordance with the test, High-current heat cycling for aluminum conductors, in UL 2556.

5.4 Flexibility at room temperature after aging

The insulation shall not show any cracks, either on the surface or internally, when wound around a mandrel of the diameter specified in Table 22, Column B, at room temperature, in accordance with the test, Flexibility at room temperature after aging, in UL 2556, before aging and after aging in an air oven as specified in Table 11.

5.5 Heat shock

5.5.1 The insulation shall not show any cracks, on the surface or internally, after a specimen of finished wire is wound around a mandrel after conditioning in an air-circulating oven for 1 hour to a temperature of 121 ±1° C. For single conductors the mandrel diameter shall be as specified in Column A of Table 22. Compliance shall be determined in accordance with the test, Heat Shock, in UL 2556.

5.5.2 For 42.4 mm^2 (1 AWG) and smaller, the specimen shall be tightly wound for four adjacent turns around the mandrel, and both ends of the specimen shall be securely held in place. For 53.5 mm^2 (1/0 AWG) and larger, a U-bend shall be made between the specimen in contact with the mandrel for not less than 180 degrees.

5.6 Cold bend

5.6.1 Cold bend

5.6.1.1 After conditioning at a temperature of −25 ±1° C for 4 h, the insulation shall not show any cracks when tested in accordance with the test, Cold bend, in UL 2556 modified as indicated in Clause 5.6.1.2. The mandrel diameter shall be as specified in Column B of Table 22.

5.6.1.2 In the case of 85.0 mm^2 (3/0 AWG) or smaller conductors, the specimen shall be tightly wound for four adjacent turns around the mandrel, and the winding shall be done at a uniform rate of approximately 4 s per turn. For size 107 mm^2 (4/0 AWG) a 180 degree U-bend shall be performed.

5.7 Deformation

5.7.1 The thickness of the insulation shall not decrease by more than 50 percent, when subjected to the load specified in Table 23 and tested in accordance with the test, Deformation, in UL 2556 when maintained at 121 ±1°C during the test.

5.8 Flame and smoke

5.8.1 Vertical flame (required)

When tested in accordance with the test, FV-1/Vertical Flame, in UL 2556, a specimen of a wire shall not flame longer than 60 s following five 15 s applications of the test flame, the period between applications being 15 s. If 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 area shall be ignored) after any of the five applications of flame, the wire or cable shall be judged capable of conveying flame along its length. If any specimen emits flaming or glowing particles or flaming drops at any time that ignite the cotton on the burner, wedge, or floor of the enclosure (flameless charring of the cotton shall be ignored), the wire or cable shall be judged capable of conveying flame to combustible materials in its vicinity.

5.8.2 FV-2/VW-1 (optional)

5.8.2.1 Vertical specimen

5.8.2.1.1 For a given size of a finished wire or cable to be marked VW-1, that size and 2.08 mm^2 (14 AWG) copper or 3.31 mm^2 (12 AWG) aluminum shall comply with the requirements of the horizontal flame test described in Clause 5.8.2.2, and with the requirements of Clause 5.8.2.1.2 when tested in accordance with the test FV-2/VW-1, in UL 2556.

5.8.2.1.2 Each specimen shall be judged not capable of conveying flame along its length or in its vicinity if the following conditions apply:

a) The specimen does not show 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 area shall be ignored) after any of the five applications of flame;

b) The specimen does not emit flaming or glowing particles or flaming drops at any time that ignite the cotton on the burner, wedge, or floor of the enclosure (flameless charring of the cotton shall be ignored); and

c) The specimen does not continue to flame longer than 60 seconds after any application of the gas flame.

5.8.2.2 Horizontal specimen

Each size of a given construction of a finished wire that is marked VW-1, in addition to complying with Clause 5.8.2.1, shall be capable of not conveying flame along its length or in its vicinity when a specimen is subjected to the test in FT2/FH/Horizontal flame, in UL 2556. The total length of the char in the specimen shall not exceed 100 mm (4 inches), and the dripping particles emitted by the specimen during or after the application of the flame shall not ignite the cotton on the floor of the enclosure, on the base of the burner, or on the wedge.

5.9 Oil resistance (optional)

5.9.1 Oil resistance at 60°C

5.9.1.1 To be marked PR I, tensile strength and elongation of the insulation shall not be less than 50 percent of the unconditioned value after immersion of the finished wire in IRM 902 oil for 96 hours at 100° C. Compliance shall be determined in accordance with the applicable clauses of the test, Oil resistance, in UL 2556.

5.9.1.2 After immersion, each specimen shall be cut in half at the center of the U bend to provide two specimens for physical tests from each length immersed.

5.9.2 Oil resistance at 75°C

5.9.2.1 To be marked PR II, in addition to complying with the requirements of Clause 5.9.1, the retention of tensile strength and elongation of the insulation shall be not less than 65 percent of the unconditioned value after immersion of the finished wire or cable in IRM 902 oil for 60 d at 75° C. Compliance shall be determined in accordance with the applicable clauses of the test, Oil resistance, in UL 2556

5.9.2.2 Specimens of wire shall be immersed without removal of the nylon jacket, if present. After immersion, each specimen shall be cut in half at the center of the U bend to provide two specimens for physical tests from each length immersed. The nylon jacket shall be removed prior to the physical tests.

5.10 Gasoline and oil resistance (optional)

5.10.1 To be marked GR I or GR II, the retention of tensile strength and elongation of wet rated insulated conductors found to be in compliance with the requirements of Clause 5.9.1 or 5.9.1, respectively, shall not be less than 65 percent after 30 d immersion in water saturated with equal volumes of iso-octane and toluene (ASTM Reference Fuel C) maintained at 23 ±1°C. Compliance shall be determined in accordance with the applicable clauses of the test, Gasoline resistance, in UL 2556.

5.10.2 After immersion for the specified length of time, each specimen shall be cut in half at the center of the U bend to provide two specimens for physical tests from each length immersed.

5.11 Abrasion resistance (insulations other than PVC)

The insulation on solid 2.08 mm^2 (14 AWG) conductors shall not wear through to expose the conductor on any of 6 specimens subjected to 800 cycles of abrasion by means of a weight that exerts a force of 3.3 ±0.1 N or 340 ±13 gf (12.0 ±0.5 ozf), in accordance with the procedure described in the test, Abrasion resistance, in UL 2556.

5.12 Crush resistance (insulations other than PVC)

An average of not less than 1000 N (225 lbf) shall be necessary to crush solid 2.08 mm^2 (14 AWG) insulated conductors until contact is established between the conductor of the specimen and the earth-grounded flat steel plate or steel rod when a specimen of the finished wire is subjected to the crushing procedure described in the test, Crush resistance – Method 2, in UL 2556.

5.13 Impact resistance (insulations other than PVC)

A free-falling steel weight that impacts with an energy of 2.7 J (2 ft-lbs) upon the insulation and nylon jacket (if present) of a solid 2.08 mm^2 (14 AWG) specimen shall not expose the conductor or cause triggering of the indicator in more than two out of ten specimens when tested in accordance with the test, Impact resistance, in UL 2556.

5.14 Durability of ink printing

5.14.1 The printing on the finished wire shall remain legible after being subjected to the test, Durability of ink printing, in UL 2556.

5.14.2 One of two specimens shall be conditioned in a forced air oven at 90°C for 24 h; the other shall be left at room temperature for 24 h.

5.15 Color coating

5.15.1 Surface (ink or paint) coated thermoplastic-insulated wire shall comply with the requirements in Clauses 5.15.2 – 5.15.4, when tested in accordance with the test, Color coating, in UL 2556.

5.15.2 The surface-coated thermoplastic-insulated conductor shall comply with the tensile strength and ultimate elongation requirements before and after the air-oven aging applicable to the insulation.

5.15.3 The coating shall not flake off of the surface of the insulation when samples of the wire are flexed at room temperature in the manner described in the test, Color coating, in UL 2556 both before and after the air-oven aging applicable to the insulation.

5.15.4 The surface coating shall not migrate when tested in accordance with the test, Color coating, in UL 2556.

5.16 Long-term aging of insulation

5.16.1 The absolute elongation of insulation material referenced in Clause 4.2.5.3 shall be not less than 50 percent after being subjected to long-term aging in an air oven in accordance with the test, Dry temperature rating of new materials (long-term aging test), in UL 2556.

5.16.2 The minimum unaged and aged tensile and ultimate elongation values for the compound shall be established at 85 percent of the average measured value of the six specimens.

5.17 A-C spark test

Every finished production length of single-conductor cable shall be subjected to the a-c spark test in accordance with the test, Spark, in UL 2556. The test potential shall be as shown in Table 24.

5.18 Electrical continuity

Each conductor shall be continuous when tested in accordance with either Method 1 or Method 2 described in the test, Continuity, in UL 2556,

5.19 Leakage Resistance

The surface leakage resistance of finished Type TBS wire, after exposure for 18 h to a saturated moist atmosphere at a temperature of 23.0 ±1.0° C (73.4 ±1.8° F), shall not be less than 1.0 megohm as determined in accordance with Test of Type TBS for Surface Leakage Resistance, Section 1300 of UL 1581.

6 Marking

6.1 Marking on product

6.1.1 General

6.1.1.1 All markings on the finished product shall legible. The use of a marker tape, surface printing, indent, or embossed marking shall meet the intent of this requirement. The process shall not result in a thickness less than the minimum specified.

6.1.1.2 The marking legend shall be repeated at intervals not exceeding 1.0 m (40 inches), except for conductor size, which shall be repeated at intervals not exceeding 610 mm (24 inches) and the marking for identification of copper-clad aluminum shall be repeated at intervals that are not longer than 6 inches or 150 mm.

6.1.1.3 Required markings are described in Clauses 6.1.2 – 6.1.6. Optional markings are described in Clauses 6.1.7 – 6.1.9.

6.1.2 Manufacturer's identification

A finished wire or cable shall have a durable distinctive marking throughout its entire length by which the organization responsible for the product is readily identified.

6.1.3 Type designation

6.1.3.1 The type designation shall be marked as indicated in Clause 6.1.1. The use of the word "Type" shall be optional. Marking of the maximum operating dry temperature rating of insulation as applicable shall be optional.

6.1.4 Conductor size

6.1.4.1 The size of conductors shall be marked on the product, expressed in one or more of the following forms:

a) mm^2 (AWG);

b) AWG (mm^2); or

c) AWG

6.1.4.2 The use of either a comma or a period signifies a decimal. For printing on products, the use of mm^2 in place of mm^2 shall be allowed.

6.1.4.3 The mm^2 marked shall be the nominal cross-sectional area in square millimeters shown in Table 4.

6.1.5 Aluminum conductors

Aluminum conductors shall be marked "AL". The additional marking "ACM" shall be optional.

6.1.6 Compact copper conductors

Compact-stranded copper conductors shall be marked "Compact Copper", or "Compact Cu", or "Cmpct Cu" after the conductor size.

6.1.7 Flame test marking (optional)

Insulated conductors with the markings "VW-1" or "FV-2" shall meet the requirements of Clause 5.8.2.

6.1.8 Oil resistance (optional)

Wires or cables marked "PR I" shall meet the requirements of Clause 5.9.1. Wires or cables marked "PR II" shall meet the requirements of Clause 5.9.2.

6.1.9 Gasoline and oil resistance (optional)

6.1.9.1 Wires or cables marked "GR I" shall meet the requirements of Clauses 5.9.1 and 5.10.1.

6.1.9.2 Wires or cables marked "GR II" shall meet the requirements of Clauses 5.9.2 and 5.10.1.

6.2 Marking on package

Each package of wire shall be tagged or marked to indicate legibly the following:

a) Manufacturer's identification;

b) Type designation;

c) Conductor size, in accordance with Clause 6.1.4;

d) "AL" after the conductor size (item c), when aluminum conductor is used. The additional marking "ACM" shall be optional;

e) If compact stranding is used, the word "COMPACT" or "CMPCT";

f) If stranded copper conductors are compacted, the words "Compact Copper" or "Compact Cu" or "Cmpct Cu" shall be included adjacent to the conductor size (item c). The following statement shall also appear on the package: "Terminate with connectors identified for use with compact-stranded copper conductors";

g) Voltage rating;

h) Maximum operating dry temperature ratings of insulation shall be optional.

6.3 Month and year of manufacture

The month and year of manufacture shall be included among the package markings described in Clause 6.2 or shall be included among the product markings described in Clause 6.1. The use of a code shall be allowed.

Tables

Table 1
Conductor sizes and stranding

Metal	Conductor size range		Type of stranding
	mm^2	AWG or kcmil	
Copper	2.08 – 107	14 – 4/0	Solid, compact, concentric, compressed, and rope lay
Copper	2.08 – 13.3	14 – 6	Bunched
Aluminum	3.31 – 107	12 - 4/0	Solid, compact, concentric and compressed
Aluminum	13.3 – 107	6 – 4/0	Combination unilay

Table 2
Conductor stranding

Sizes of wire		Minimum number of strands[b]		
mm^2	AWG or kcmil	Combination unilay	Compact stranded	All others
2.08 – 8.37	14 – 8	19[a]	7	7
13.3 – 33.6	6 – 2	19	7	7
42.4 – 107	1 – 4/0	19	19	19

[a] Copper only.

[b] Single input strands shall be in accordance with ASTM B801, ASTM B835, ASTM B836, ASTM B901, and ASTM B902.

Table 3
Length of lay of strands in a bunch-stranded conductor twisted as a single bunch[a]

Size of conductor		Maximum acceptable length of lay	
mm²	AWG	mm	in
2.08	14	44	1-3/4
3.31	12	51	2
5.26	10	64	2-1/2
8.37	8	70	2-3/4
13.3	6	86	3-3/8
larger than 13.3	larger than 6	16 times the conductor diameter	

[a] Includes the following bunch-stranded constructions twisted as a single bunch under Classes I, K, and M:

Conductor size		Number of strands in single bunch		
mm²	AWG	Class I	Class K	Class M
2.08	14	–	41	104
3.31	12	–	65	–
5.26	10	26	104	–
8.37	8	41	–	–
13.3	6	65	–	–

Note: Nominal strand configuration and number of wires are found in ASTM B174 or NMX-J-297-ANCE.

Table 4
Diameters over solid conductors and cross-sectional area for all solid and stranded conductors

Size of conductor		Nominal diameter of solid conductor		Nominal cross-sectional area of conductor	
mm²	AWG or kcmil	mm	mils	mm²	cmil or kcmil
2.08	14 AWG	1.63	64.1	2.08	4110 cmil
3.31	12	2.05	80.8	3.31	6530
5.26	10	2.588	101.9	5.261	10380
8.37	8	3.264	128.5	8.37	16510
13.3	6	4.115	162.0	13.3	26240
21.2	4	5.189	204.3	21.2	41740
26.7	3	5.827	229.4	26.67	52620
33.6	2	6.543	257.6	33.6	66360
42.4	1	7.348	289.3	42.4	83690
53.5	1/0	8.252	324.9	53.5	105600
67.4	2/0	9.266	364.8	67.4	133100
85.0	3/0	10.40	409.6	85.0	167800
107	4/0	11.68	460.0	107	211600

Table 5
Diameters over round compact-stranded conductors

Conductor size		Nominal diameter	
mm²	AWG or kcmil	mm	inches
3.31	12	2.16	0.085
5.26	10	2.72	0.107

Table 5 Continued on Next Page

Table 5 Continued

Conductor size		Nominal diameter	
mm^2	AWG or kcmil	mm	inches
8.37	8	3.40	0.134
13.3	6	4.29	0.169
21.2	4	5.41	0.213
26.7	3	6.02	0.238
33.6	2	6.81	0.2.68
42.4	1	7.59	0.299
53.5	1/0	8.53	0.336
67.4	2/0	9.55	0.376
85.0	3/0	10.74	0.423
107	4/0	12.07	0.475

Table 6
Diameters over round compressed concentric-lay-stranded conductors for Classes B, C, and D

Conductor size		Nominal diameter	
mm^2	AWG or kcmil	mm	inches
2.08	14 AWG	1.80	0.071
3.31	12	2.26	0.089
5.26	10	2.87	0.113
8.37	8	3.61	0.142
13.3	6	4.52	0.178
21.2	4	5.72	0.225
26.7	3	6.40	0.252
33.6	2	7.19	0.283
42.4	1	8.18	0.322
53.5	1/0	9.19	0.362
67.4	2/0	10.3	0.405
85.0	3/0	11.6	0.456
107	4/0	13.0	0.512

Table 7
Diameters over round compressed single input wire and unidirectional or unilay-stranded conductors for Class B

Conductor size		Nominal diameter	
mm^2	AWG	mm	inches
3.31	12[a]	2.26	0.089
5.26	10[a]	2.87	0.113
8.37	8[a]	3.61	0.142
13.3	6[a]	4.52	0.178
21.2	4[a]	5.72	0.225
26.7	3[a]	6.40	0.252
33.6	2[a]	7.19	0.283
42.4	1 AWG	7.95	0.313

Table 7 Continued on Next Page

Table 7 Continued

Conductor size		Nominal diameter	
mm²	AWG	mm	inches
53.5	1/0	8.94	0.352
67.4	2/0	10.03	0.395
85.0	3/0	11.25	0.443
107	4/0	12.65	0.498

[a] Applies to single input wire only.

Table 8
Diameter over round concentric-lay-stranded conductors for Classes B, C, and D

Conductor size		Nominal diameter	
mm²	AWG or kcmil	mm	inches
2.08	14 AWG	1.85	0.0727
3.31	12	2.32	0.0915
5.26	10	2.95	0.116
8.37	8	3.71	0.146
13.3	6	4.67	0.184
21.2	4	5.89	0.232
26.7	3	6.60	0.260
33.6	2	7.42	0.292
42.4	1	8.43	0.332
53.5	1/0	9.45	0.372
67.4	2/0	10.62	0.418
85.0	3/0	11.94	0.470
107	4/0	13.41	0.528

Table 9
Strand and conductor dimensions for 19-wire combination round-wire unilay-stranded conductors

Conductor size		Nominal strand dimensions								Nominal conductor diameter E = 3A + 2C	
		Large strand				Small strand					
		Diameter (A)		Cross-sectional area		Diameter (C)		Cross-sectional area			
mm²	AWG	mm	inch	mm²	cmil	mm	inch	mm²	cmil	mm	inch
2.08	14	0.4	0.0159	0.128	253	0.3	0.0117	0.069	137	1.80	0.071
3.31	12	0.5	0.0201	0.205	404	0.4	0.0147	0.109	216	2.29	0.090
5.26	10	0.6	0.0253	0.324	640	0.5	0.0185	0.173	342	2.87	0.113
8.37	8	0.8	0.0319	0.515	1018	0.6	0.0234	0.277	548	3.63	0.143
13.3	6	1.0	0.0402	0.818	1616	0.7	0.0294	0.437	864	4.55	0.179
21.2	4	1.3	0.0507	1.301	2570	0.9	0.0371	0.696	1376	5.74	0.226
26.7	3	1.4	0.0570	1.644	3249	1.1	0.0417	0.880	1739	6.45	0.254
33.6	2	1.6	0.0640	2.073	4096	1.2	0.0468	1.108	2190	7.26	0.286
42.4	1	1.8	0.0718	2.609	5155	1.3	0.0526	1.400	2767	8.15	0.321
53.5	1/0	2.1	0.0807	3.296	6512	1.5	0.0591	1.768	3493	9.14	0.360
67.4	2/0	2.3	0.0906	4.154	8208	1.7	0.0663	2.225	4396	10.26	0.404
85.0	3/0	2.6	0.1017	5.234	10343	1.9	0.0745	2.809	5550	11.53	0.454
107	4/0	2.9	0.1142	6.600	13042	2.1	0.0836	3.537	6989	12.95	0.510

Table 10
Insulation thickness, minimum average and minimum at any point

Conductor size	Minimum thicknesses			
	Average		At any point	
	mils	mm	mils	mm
14 – 10	30	0.76	27	0.69
9, 8	45	1.14	40	1.02
7 – 2	60	1.52	54	1.37
1 – 4/0	80	2.03	72	1.83

Table 11
Physical properties of PVC insulation

Minimum properties	
Before aging:	
Tensile strength, MPa (lbf/in^2)	10.3 (1500)
Elongation, percent, minimum increase in distance between 25 mm (1 inch) gauge marks	100
After aging:	
at 121°C, 7d	
Retention of tensile strength, percent	70
Retention of elongation, percent	65/45[a]
[a] The 45 percent applies only to samples aged in die-cut form.	

Table 12
Maximum direct-current resistance at 20°C of solid conductors of aluminum and bare copper

Size of conductor		Aluminum		Bare copper	
mm^2	AWG	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft
2.08	14	–	–	8.45	2.57
3.31	12	8.71	2.65	5.31	1.62
5.26	10	5.48	1.67	3.34	1.02
8.37	8	3.45	1.05	2.10	0.641
13.3	6	2.17	0.661	1.32	0.403
21.2	4	1.36	0.416	0.832	0.254
26.7	3	1.08	0.330	0.660	0.201
33.6	2	0.857	0.261	0.523	0.159
42.4	1	0.680	0.207	0.415	0.126
53.5	1/0	0.539	0.164	0.329	0.100
67.4	2/0	0.428	0.130	0.261	0.0795
85.0	3/0	0.339	0.103	0.207	0.0631
107	4/0	0.269	0.0820	0.16	0.0500

Table 13
Maximum direct-current resistance at 20°C of aluminum and bare copper conductors – concentric-stranded Classes B, C, and D; compact-stranded; and compressed-stranded

Size of conductor		Aluminum		Bare copper	
mm^2	AWG or kcmil	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft
2.08	14 AWG	–	–	8.62	2.62
3.31	12	8.88	2.71	5.43	1.65
5.26	10	5.59	1.70	3.41	1.04
8.37	8	3.52	1.07	2.14	0.653
13.3	6	2.21	0.674	1.35	0.411
21.2	4	1.39	0.424	0.848	0.259
26.7	3	1.10	0.336	0.673	0.205
33.6	2	0.875	0.267	0.534	0.163
42.4	1	0.693	0.211	0.423	0.130
53.5	1/0	0.550	0.168	0.335	0.102
67.4	2/0	0.436	0.133	0.266	0.0811
85.0	3/0	0.346	0.106	0.211	0.0643
107	4/0	0.274	0.0836	0.167	0.0510

Note: Nominal strand configuration and number of wires are found in ASTM B8 or NMX-J-012-ANCE for copper conductors, and NMX-J-032-ANCE for aluminum conductors.

Table 14
Maximum direct-current resistance at 20°C of copper conductors, concentric-stranded Class B with each strand coated with tin or a tin alloy and compressed-stranded Class B with each strand coated

Size of conductor			
mm^2	AWG or kcmil	Ohms per km	Ohms per 1000 ft
2.08	14 AWG	8.96	2.73
3.31	12	5.64	1.72
5.26	10	3.55	1.08
8.37	8	2.23	0.680
13.3	6	1.40	0.428
21.2	4	0.882	0.269
26.7	3	0.700	0.213
33.6	2	0.555	0.169
42.4	1	0.440	0.134
53.5	1/0	0.349	0.106
67.4	2/0	0.277	0.0843
85.0	3/0	0.219	0.0669
107	4/0	0.172	0.0525

Note: Nominal strand configuration and number of wires are found in ASTM B8.

Table 15
Maximum direct-current resistance at 20°C of copper conductors concentric-stranded Classes C and D with each strand coated with tin or a tin alloy and compressed-stranded Classes C and D with each strand coated

Size of conductor		Class C		Class D	
mm^2	AWG	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft
2.08	14 AWG	9.15	2.78	9.25	2.82
3.31	12	5.75	1.75	5.75	1.75
5.26	10	3.55	1.08	3.62	1.10
8.37	8	2.23	0.679	2.23	0.679
13.3	6	1.41	0.427	1.41	0.427
21.2	4	0.882	0.269	0.882	0.269
26.7	3	0.700	0.213	0.700	0.213
33.6	2	0.555	0.169	0.555	0.169
42.4	1	0.440	0.134	0.440	0.134
53.5	1/0	0.349	0.106	0.349	0.106
67.4	2/0	0.276	0.0844	0.276	0.0844
85.0	3/0	0.219	0.0669	0.219	0.0669
107	4/0	0.174	0.0530	0.174	0.0530
Note: Nominal strand configuration and number of wires are found in ASTM B8 or NMX-J-012-ANCE.					

Table 16
Maximum direct-current resistance at 20°C of 19-wire combination round-wire unilay-stranded copper conductors

Size of conductor		Each strand coated		Each strand uncoated	
mm^2	AWG	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft
2.08	14	9.15	2.78	8.62	2.62
3.31	12	5.75	1.75	5.43	1.65
5.26	10	3.55	1.08	3.41	1.04
8.37	8	2.23	0.679	2.14	0.654
13.3	6	1.41	0.427	1.35	0.412
21.2	4	0.882	0.269	0.848	0.259
26.7	3	0.700	0.213	0.673	0.205
33.6	2	0.555	0.169	0.534	0.163
42.4	1	0.440	0.134	0.423	0.129
53.5	1/0	0.349	0.106	0.335	0.102
67.4	2/0	0.277	0.0844	0.266	0.0811
85.0	3/0	0.219	0.0669	0.211	0.0643
107	4/0	0.172	0.05230	0.167	0.0510

Table 17
Maximum direct-current resistance at 20°C of 19-wire combination round-wire unilay-stranded aluminum conductors

Conductor size			
mm^2	AWG	Ohms per km	Ohms per 1000 ft
13.3	6	2.21	0.674
21.2	4	1.39	0.424
26.7	3	1.10	0.336
33.6	2	0.875	0.267
42.4	1	0.693	0.211
53.5	1/0	0.550	0.168
67.4	2/0	0.436	0.133
85.0	3/0	0.346	0.106
107	4/0	0.274	0.0836

Table 18
Maximum direct-current resistance at 20°C of solid copper conductors coated with tin or a tin alloy

Conductor size			
mm^2	AWG	Ohms per km	Ohms per 1000 ft
2.08	14	8.78	2.68
3.31	12	5.53	1.68
5.26	10	3.48	1.06
8.37	8	2.16	0.659
13.3	6	1.36	0.415
21.2	4	0.856	0.261
26.7	3	0.679	0.207
33.6	2	0.538	0.164
42.4	1	0.427	0.130
53.5	1/0	0.337	0.103
67.4	2/0	0.267	0.0814
85.0	3/0	0.212	0.0655
107	4/0	0.168	0.0512