UL 183

STANDARD FOR SAFETY

Manufactured Wiring Systems

UL Standard for Safety for Manufactured Wiring Systems, UL 183

Fourth Edition, Dated September 22, 2009

Summary of Topics

This revision to ANSI/UL 183 dated October 26, 2020 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made.

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin.

The requirements are substantially in accordance with Proposal(s) on this subject dated August 7, 2020.

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UL 183

Standard for Manufactured Wiring Systems

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September 22, 2009

This ANSI/UL Standard for Safety consists of the Fourth Edition including revisions through October 26, 2020.

The most recent designation of ANSI/UL 183 as a Reaffirmed American National Standard (ANS) occurred on October 14, 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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INTRODUCTION

1 Scope

1.1 These requirements cover wiring systems for use in outdoor locations, field-installed wiring assemblies using off-site manufactured subassemblies for branch circuits, remote-control circuits, signaling circuits, and communication circuits in accessible areas. The products covered under this standard are to be installed in accordance with Article 604 of the National Electrical Code, ANSI/NFPA 70.

2 Glossary

2.1 For the purposes of this standard the following definitions apply.

2.2 ACCESSIBLE PART – A part that is:

a) Located so that it can be contacted by a person; or

b) Not recessed the required distance behind an opening.

2.3 BRANCH CIRCUIT– The circuit conductors between the final over-current device protecting the circuit and the outlet(s).

2.4 BRANCH CIRCUIT, MULTIWIRE– A branch circuit that consists of two or more ungrounded conductors that have a voltage between them, and a grounded conductor that has equal voltage between it and each ungrounded conductor of the circuit, and that is connected to the neutral or grounded conductor of the system.

2.5 CLASS 2 CIRCUIT– An isolated secondary circuit involving a potential of not more than 30-volt rms maximum 42.4 volts peak open circuit secondary potential under any condition of loading or open circuit by:

a) An inherently-limited Class 2 transformer;

b) A combination of an isolated transformer secondary winding and a fixed impedance or regulating network that together comply with the performance requirements for an inherently-limited Class 2 transformer;

c) A dry-cell battery having output characteristics not greater than those of an inherently-limited Class 2 transformer;

d) Any combination of (a), (b), and (c) that together comply with the performance requirements for an inherently-limited Class 2 transformer; or

e) One or more combinations of a Class 2 transformer and an overcurrent protective device that together comply with the performance requirements for a noninherently-limited Class 2 transformer.

A circuit derived from a line-connected circuit by connecting impedance in series with the supply circuit as a means of limiting the voltage and current is not considered to be a Class 2 circuit.

2.6 CONTINUOUS PLUG-IN BUSWAY – A continuous plug-in busway is rated at 600V, 40 Amperes or less, has no exposed bus bars, and is intended for general use, including installation within the reach of persons.

2.7 ENCLOSURE – A housing which provides a degree of protection against contacting live parts (i.e., connector, conductors, and contacts). The enclosures are constructed of metal, polymeric material, or hybrid (combination of metal and polymer).

2.8 ENCLOSURE, ENVIRONMENTAL – The portion or portions of a device intended to provide a degree of protection to the contacts, blades, terminals, conductors, and other live parts of the device and of any adjoining devices or components comprising a complete protective system against outdoor conditions, both when the device is unmated and when it is fully connected to its intended mating device.

2.9 FITTING – A means of securing conduit, cable, or raceway to an enclosure or box.

2.10 INSULATION, BASIC – The insulation necessary for the intended functioning of the product and for basic protection against the risk of electric shock.

2.11 INSULATION, SUPPLEMENTARY – An independent insulation provided in addition to the basic insulation to reduce the risk of electric shock in case of breakdown of the basic insulation.

2.12 LIMITED POWER SOURCE (LPS)– A limited power source is as specified in the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1, and shall comply with the requirements of UL 60950-1.

2.13 LOW-VOLTAGE CIRCUIT – A circuit involving a potential of not more than 30 volts dc or ac rms (42.4 volts ac peak).

2.14 MANUFACTURED WIRING SYSTEM CONNECTOR – A device consisting of an electrical and mechanical enclosure, multi-pole electrical contacts and provided in either a male or female locking configuration for connection to a like configured connector.

2.15 MULTI-POLE SPLICING WIRE CONNECTOR – An insulated multi-pole mating or non-mating connector intended for factory wiring or field wiring contained in an outlet box, junction box, or within an equipment enclosure. Used to connect two or more branch-circuit conductors.

2.16 RACEWAY – A completely enclosed channel intended specifically for holding and routing wiring and providing separation of:

a) Power and lighting circuits; and

b) Power-limited or communication circuits.

2.17 RISK OF ELECTRIC SHOCK – A risk of electric shock is considered to exist in any accessible connective part of a system if a potential greater than 42.4 volts peak (30 volts rms) exists, and the available current is more than 5 milliamperes (7.07 mA peak) through a 1500-ohm resistor connected between:

a) The part and other accessible connective parts; or

b) Between the part and ground.

2.18 RISK OF FIRE – A risk of fire is considered to exist in any branch-circuit-connected component part or assembly. In addition, risk of a fire is considered to exist in a component part or assembly if the power supply for such a part or assembly is capable of delivering more than 15 watts into an external resistor connected between the point in question and any return to the supply. A power supply not capable of delivering more than 15 watts as previously mentioned, is considered to be energy limited.

2.19 SECONDARY CIRCUIT– A circuit that is supplied by an induced voltage from a primary, where a primary circuit is that supplied by a branch circuit.

2.20 SUPPLEMENTARY PROTECTOR – A manually resettable device designed to open the circuit automatically on a predetermined value of time versus current or voltage.

3 Components

3.1 A component of a product covered by this standard shall comply with the requirements for that component, and shall be used in accordance with its recognized rating and other limitations of use. See Appendix A for a list of standards covering components used in the products covered by this standard.

3.2 Component receptacles shall be used with conductors or leads in accordance with their recognized rating and other limitations of use in accordance with the Standard for Attachment Plugs and Receptacles, UL 498.

3.3 A component is not required to comply with a specific requirement that:

a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or

b) Is superseded by a requirement in this standard.

3.4 A component shall be used in accordance with its rating established for the intended conditions of use.

3.5 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

3.6 Prefabricated floor boxes shall comply with the Standard for Metallic Outlet Boxes, UL 514A, when used as a component of a manufactured wiring system.

3.7 Receptacle configurations constructed in accordance with Wiring Devices – Dimensional Specifications, ANSI/NEMA WD6 shall comply with the Standard for Attachment Plugs and Receptacles, UL 498.

3.7.1 Hospital grade convenience receptacles shall comply with the requirements for Hospital Grade Receptacles in the Standard for Attachment Plugs and Receptacles, UL 498.

3.7.2 When hospital grade convenience receptacles are utilized in a manufactured wiring system that has not been evaluated for use in patient care areas in accordance with Supplement SA, the manufactured wiring system shall be provided with installation instructions and a marking that specify that the manufactured wiring system is not intended for installation in patient care areas. Refer to 45.20 and 46.7.

3.8 Insulated multi-pole splicing wire connectors shall comply with the Standard for Insulated Multi-Pole Splicing Wire Connectors, UL 2459.

4 Units of Measurement

4.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

5 Undated References

5.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

CONSTRUCTION

6 General

6.1 A manufactured wiring system shall be formed and assembled so that it has the strength and secureness of connections necessary to resist the abuses to which it is subjected without introducing a risk of fire, electric shock, or injury to persons due to the total or partial separation and resulting reduction of spacings, loosening or displacement of parts, or other serious defects.

6.2 Manufactured wiring systems intended for outdoor locations shall comply with the outdoor use construction and performance requirements specified in Section 40, Outdoor Use Performance, and 45.17.

7 Connecting Cable and Flexible Metal Conduit

7.1 Cable shall be one of the following constructions:

a) Type AC or Type MC, having 8 AWG (8.4 mm^2), 10 AWG (5.3 mm^2), or 12 AWG (3.3 mm^2) insulated copper ungrounded circuit conductors nominally rated 600 volts. A bare or insulated copper grounding conductor equivalent in size to the ungrounded circuit conductor shall also be provided; or

b) Cable Type MC, having 8 AWG (8.4 mm^2), 10 AWG (5.3 mm^2), or 12 AWG (3.3 mm^2) insulated copper ungrounded circuit conductors nominally rated 600 volts and marked "armor is grounding path component" on or in the cable.

Exception No. 1: A fixture tap not longer than 6 feet (1.83 m) and intended for connection to a single fixture may contain conductors smaller than 12 AWG but not smaller than 18 AWG.

Exception No. 2: Conductors for use in remote control, signaling, or communications circuits may be smaller than 12 AWG. Class 2 or 3 powered conductors may be run in MC-PCS cables with non Class 2 or 3 powered conductors.

Exception No. 3: The grounded circuit conductor of type MC or type AC cable may be larger in size than the other conductors provided the grounded circuit conductor does not exceed 8 AWG (8.4 mm^2).

7.2 Type AC or Type MC shall comply with the Standard for Armored Cable, UL 4, or the Standard for Metal Clad Cables, UL 1569.

7.3 Flexible metal conduit or liquid-tight flexible conduit shall be 3/8 inch (9.5 mm) or larger trade size provided with 8 AWG (8.4 mm^2), 10 AWG (5.3 mm^2), or 12 AWG (3.3 mm^2) insulated copper conductors and an insulated or uninsulated copper-grounding conductor equivalent in size to the ungrounded circuit conductor.

Exception No. 1: Conductors shall not be smaller than 12 AWG unless they comply with Exception No. 1 or Exception No. 2 of 7.1.

Exception No. 2: The grounded circuit conductor shall not be larger in size than the other conductors unless the grounded circuit conductor does not exceed size 8 AWG (8.4 mm^2).

7.4 Flexible metal conduit, liquid-tight flexible metal conduit, or liquid-tight flexible nonmetallic conduit shall comply with the Standard for Flexible Metal Conduit, UL 1, the Standard for Liquid-Tight Flexible Steel Conduit, UL 360, or the Standard for Liquid-Tight Flexible Nonmetallic Conduit, UL 1660.

Exception: Flexible metal conduit is not required to comply with all specified construction dimensions under the following conditions:

a) Trade sizes of 9/16-inch and 5/8-inch oval shaped and flexible metal conduit shall comply with the 1/2-inch trade size performance requirements in UL 1, and trade size of 3/8-inch reduced wall flexible conduit shall be provided with internal and external diameters as specified in Table 7.1. All other construction and performance requirements shall be in accordance with UL 1;

b) All mating fittings and connector assemblies used with conduit specified in (a) shall be factory installed;

c) The field installation end of a fitting or connector intended for field assembly to the building electrical system shall comply with the construction requirements of the Standard for Conduit, Tubing, and Cable Fittings, UL 514B;

d) All conduit specified in (a) shall be provided with factory installed conductors;

e) The flexible metal conduit in (a) shall be subjected to follow up evaluation on performance testing in accordance with UL 1 on the indicated trade sizes.

Table 7.1
Conduit dimensions

Trade size of conduit (inches)	External diameters		Internal diameters	
	Minimum	Maximum	Minimum	Maximum
3/8	0.560	0.690	0.375	0.520

7.5 Liquid-tight flexible nonmetallic conduit shall not be used in lengths exceeding 6 feet (1.8 m) between mating connectors or enclosures.

Exception: This requirement does not apply to liquid-tight flexible nonmetallic conduit with a smooth inner surface with integral reinforcement within the conduit wall identified as type "B" or " FNMC-B."

7.6 Electrical components marked in accordance with 45.5(a), shall comply with the following conduit restrictions:

a) Type MC cable employing a smooth or corrugated impervious metal sheath without an overall nonmetallic covering has no length restrictions; and

b) Flexible metal conduit is suitable for use in lengths up to 4 ft (1.2 m).

Exception: Installation instructions that include a statement about maximum allowed length of conduit that may be installed in the duct or plenum meet the intent of this requirement.

7.7 Electrical components marked in accordance with 45.5 (b) shall incorporate one of the following conduit types without length restrictions:

a) Type MC cable, without an overall nonmetallic cover;

b) Type AC Cable; or

c) Flexible Metallic Conduit.

7.8 Insulated conductors shall have a minimum temperature rating of 75°C (167°F).

7.9 The connectors used with cable or conduit shall effectively close any openings in the connection.

8 Continuous Plug-in Busway

8.1 Continuous plug-in busway and busway fittings shall comply with the Standard for Busways, UL 857.

8.2 Continous plug-in busway shall have provision for installation and support in accordance with the National Electrical Code, NFPA 70.

8.3 A continous plug-in busway shall contain factory mounted, bare, or insulated conductors which shall be copper or aluminum bars, rods, or tubes. The busway shall be grounded and provided with an equipment ground busbar equivalent in size to the ungrounded busbar. The busway shall be rated a nominal 600 volts, 20, 30, or 40 amperes.

9 Knockouts

9.1 A knockout provided in a raceway for a 1/2 inch or larger trade size conduit shall comply with the knockout requirements in Connections for Wiring Systems in the Standard for Metallic Outlet Boxes, UL 514A.

10 Connecting Flexible Cord

10.1 Components of a manufactured wiring system which are intended to serve as a transition between a manufactured wiring system and utilization equipment which is not permanently secured to the building structure may utilize flexible cord in lieu of the flexible metal conduit, liquid-tight flexible metal conduit, or Type AC or MC cable specified in Section 7, Connecting Cable and Flexible Metal Conduit. The flexible cord shall be classified for hard usage, shall utilize minimum 12 AWG conductors, and shall not exceed 6 feet (1.83 m) in length. The cord shall be provided with a strain relief means as specified in Section 24, Flexible Cord Strain Relief.

11 Mechanical Assembly and Enclosure

11.1 A fitting or other component shall be prevented from turning, loosening, or otherwise becoming disengaged from its mounting means.

11.2 The means by which the turning or loosening is prevented is to include more than friction between surfaces.

11.3 A manufactured wiring system may be shipped from the factory unassembled or disassembled to the degree necessary to facilitate shipment, if the following conditions are met:

a) The manufactured wiring system is constructed so that field assembly can be accomplished without drilling, cutting, crimping, or performing other operations requiring the use of tools for other than field-wiring connections.

b) The relationship between the current-carrying parts is established at the time of manufacture, and is not dependent upon installation personnel.

11.4 A junction box or similar device made of sheet metal shall have a thickness not less than the value specified in Table 11.1, unless investigated and found acceptable for the application.

Table 11.1
Thickness of sheet metal for enclosures

Maximum area of any surface		Maximum dimension		Minimum thickness, inch (mm)					
				Steel				Copper, brass, or aluminum	
				Without supporting frame		With supporting frame or equivalent reinforcing			
square-inches	(cm^2)	inches	(mm)	Zinc-coated	Uncoated[a]	Zinc-coated	Uncoated[a]	Without supporting frame	With supporting frame or equivalent reinforcing
6[b]	(38.7)	3	(76.2)	0.023 (0.54)	0.020 (0.51)	0.023 (0.54)	0.020 (0.51)	0.023 (0.54)	0.023 (0.54)
36	(232.2)	8	(203.2)	0.029 (0.74)	0.026 (0.66)	0.023 (0.54)	0.020 (0.51)	0.036 (0.91)	0.029 (0.74)
90	(580.5)	12	(304.8)	0.034 (0.85)	0.032 (0.81)	0.023 (0.54)	0.020 (0.51)	0.045 (1.10)	0.029 (0.74)
135	(870.7)	18	(457.2)	0.045 (1.10)	0.042 (1.07)	0.034 (0.85)	0.032 (0.81)	0.058 (1.48)	0.045 (1.10)
360	(2322)	24	(609.6)	0.056 (1.40)	0.053 (1.35)	0.045 (1.10)	0.042 (1.07)	0.075 (1.88)	0.058 (1.48)
1200	(7740)	48	(1219.2)	0.070 (1.78)	0.067 (1.71)	0.056 (1.40)	0.053 (1.35)	0.095 (2.40)	0.075 (1.88)
1500	(9675)	60	(1524.0)	0.097 (2.44)	0.093 (2.37)	0.056 (1.40)	0.053 (1.35)	0.122 (3.10)	0.075 (1.88)
Over 1500	(9675)	–	–	0.126 (3.10)	0.123 (3.09)	0.056 (1.40)	0.053 (1.35)	0.153 (3.88)	0.075 (1.88)

[a] Including stainless steel.

[b] Volume of enclosure not more than 12 cubic inches (196.64 cm^3)

11.5 For an unreinforced flat surface, cast metal shall not be less than 1/8 inch (3.2 mm) thick, malleable iron shall not be less than 3/32 inch (2.4 mm) thick, and die-cast metal shall not be less than 5/64 inch (2.0 mm) thick.

Exception: Metal of lesser thickness but not less than 3/32 inch, 1/16 inch (1.6 mm), and 3/64 inch (1.2 mm), respectively, shall comply with the Compression and Deflection Tests in the Standard for Office Furnishings, UL 1286.

11.6 An enclosure shall be constructed as follows:

a) If intended for use in ducts used for environmental air-handling, there shall be no openings. An enclosure shall be constructed of metal.

b) If intended for use in environmental air-handling spaces (plenums), other than ducts, openings in the enclosure that are not closed during the assembly shall comply with the following:

1) The largest dimension of an opening shall not be more than 1/4 inch (6.4 mm) and the smallest dimension shall not be more than 1/16 inch (1.6 mm);

2) There shall be a maximum of five openings in any one side or end of the enclosure and the total area of all openings shall not be more than 0.2 square inch (1.3 cm^2); and

3) There shall be a maximum of 15 openings in the enclosure and the total area of all openings shall not be more than 0.5 square inch (3.2 cm^2); and

4) Enclosures molded of polymeric materials shall comply with the Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces, UL 2043.

5) In addition to the requirements of Section 22A, Mating Connectors, mating connectors molded of polymeric materials shall also comply with the Standard for Fire Test for Heat and

Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces, UL 2043.

c) An enclosure not intended for use in environmental air-handling spaces shall comply with the following:

1) The largest dimension of an opening shall not be more than 1/4 inch (6.4 mm) and the smallest dimension shall not be more than 1/16 inch (1.6 mm);

2) There shall be a maximum of five openings in any one side or end of the enclosure and the total area of all openings shall not be more than 0.2 square inch (1.3 cm^2);

3) There shall be a maximum of 15 openings in the enclosure and the total area of all openings shall not be more than 0.5 square inch (3.2 cm^2).

11.7 An interconnecting cable or other component shall be constructed so that the wire terminations will not be stressed when the complete device is extended to its maximum length.

11.8 Each manufactured wiring system shall be provided with a means for capping any unused connector opening in the field. The cap for each connector shall be secured by screws, bolts and nuts, or other positive means; or a snap-fit method that complies with the Cap Separation Test, Section 42. Caps shall be provided with each assembly, or may be provided as an accessory kit when specified in the installation and operating instructions in accordance with 46.5.

Exception: A manufactured wiring system connector that complies with Section 26, Accessibility to Uninsulated Live Parts, need not be provided with a means to cap unused connector openings. The installation instructions shall contain a statement to inform the user that caps are not required in accordance with 46.6.

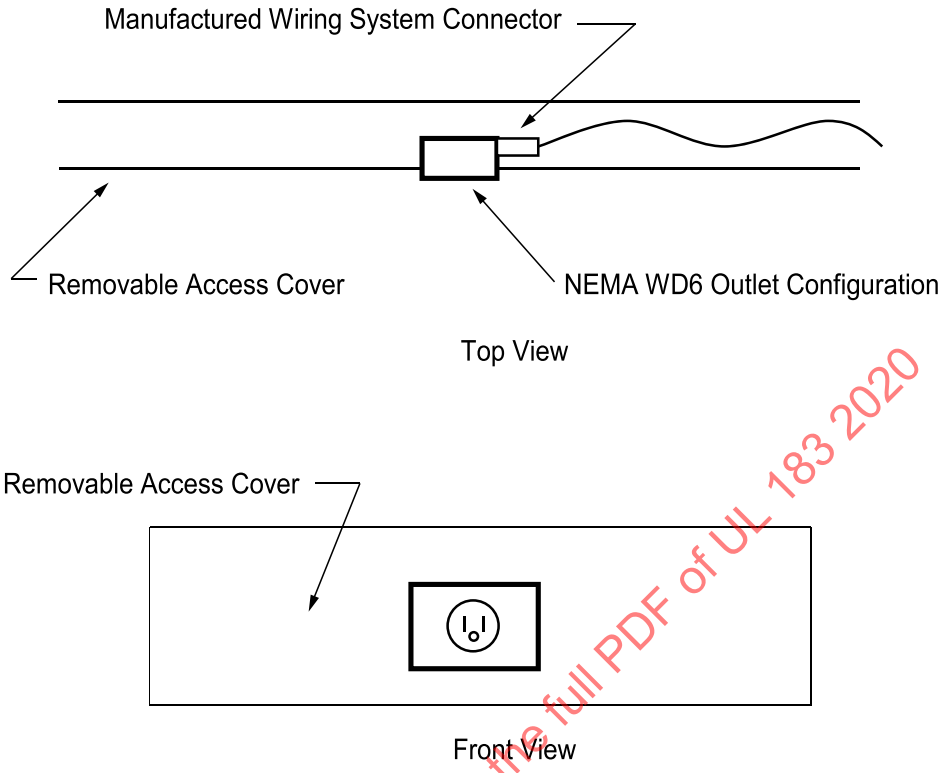
11.9 A cap made of sheet metal shall have a thickness not less than the values specified in Table 11.1. A polymeric cap that does not contact live parts shall have the strength to resist the mechanical stresses to which it is subjected during intended use of the product and have a minimum HB rating. Polymeric caps that contact live parts shall comply with the requirements for direct support and enclosure of live parts in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, as specified in the table for material property considerations.

11.10 Receptacles mounted to and supported by a cover shall be provided with more than one securement point for the receptacle.

11.11 A receptacle outlet of the type specified in 3.7 installed so that access to the manufactured wiring assembly connector(s), is not accessible without first removing an access cover shall be subjected to either the Overload or Current Cycling Test. The installation instructions shall be used to determine the recommended installation configuration. See Figure 11.1.

Exception: A receptacle outlet of the feed through type when installed as described above shall be subjected to Temperature and Overload Tests.

Figure 11.1



11.12 A receptacle as installed and as described in 11.11 shall be marked as shown in 45.22 and instructions shall be provided as specified in 46.8.

12 Enclosures of Polymeric Material

12.1 The material thickness of a polymeric enclosure, including a cap or cover, is not specified. A polymeric enclosure provided as the sole means of protecting electrical components against mechanical abuse shall have the strength to resist the mechanical stresses to which it is subjected during intended use of the product. A polymeric enclosure or part shall comply with the enclosure requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

13 Protection Against Corrosion

13.1 Enclosures and fittings for use in a manufactured wiring system shall be protected against corrosion on all inside and outside surfaces, unless the metal is inherently resistant to ordinary dry location indoor atmosphere corrosion. The acceptability of corrosion protection shall be determined as described in the applicable requirements for protection against corrosion in the Standard for Metallic Outlet Boxes, UL 514A, and Conduit, Tubing and Cable Fittings, UL 514B.

Exception: This requirement does not apply to cut edges.

13.2 Iron and steel parts other than those described in 13.1 shall be provided with corrosion protection, such as enameling, galvanizing, plating, or other equivalent means, if the malfunction of unprotected parts introduces a risk of fire, electric shock, or injury to persons.

13.3 Enclosures for outdoor locations of a metallic construction shall comply with the applicable requirements in the Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50, and the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E.

13.4 Enclosures for outdoor locations of a nonmetallic construction shall comply with the applicable requirements in the Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50, the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E, and the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

14 Field Wiring

14.1 A field-wiring terminal is any terminal to which a supply conductor or other wire is intended to be connected in the field by an installing electrician.

14.2 A terminal for connection of an equipment-grounding conductor shall be capable of securing a conductor suitable for the intended wire size.

14.3 A wiring terminal shall be prevented from turning.

14.4 A wiring terminal shall not employ a wire-binding screw having a head less than 0.275 inch (6.4 mm) in diameter. If a pretapped hole is not provided, a self tapping screw having not less than 32 threads per inch (1.26 threads per mm) shall be used.

14.5 A terminal plate tapped for a wire-binding screw shall be of a metal not less than 0.050 inch (1.27 mm) thick, except that a plate not less than 0.030 inch (0.76 mm) thick is acceptable if the tapped threads have the necessary mechanical strength. There shall be two or more full threads in the metal, which may be extruded if necessary to provide the threads.

14.6 Means shall be provided to retain all strands of the conductors. If used, an upturned lug or cupped washer shall be capable of retaining a supply conductor of the size intended.

14.7 A terminal (for example, a plate and screw) intended for the connection of a grounded supply conductor shall be made of, or plated with, metal that is substantially white in color and shall be readily distinguishable from other terminals; or the terminal may be identified in some other manner, such as on the wiring diagram attached to the component containing the terminal for the grounded-supply conductor.

14.8 An insulated conductor intended for the connection of a grounded supply conductor shall be finished to show a white or gray color and shall be readily distinguishable from other insulated conductors.

14.9 The surface of an insulated conductor intended solely for connection of an equipment-grounding conductor shall be substantially green with or without one or more yellow stripes, and no other insulated conductor visible to the installer shall be so identified.

14.10 A field-wiring wire-binding screw intended for connection of an equipment-grounding conductor shall be located so that it will not require removal during normal servicing of the product and shall have one of the following constructions:

a) A green terminal screw with a hexagonal head;

b) A green hexagonal terminal nut;

c) A green pressure wire connector; or

d) When the terminal of the grounding conductor is not visible, the conductor entrance hole shall be marked with one of the following:

1) The color Green;

2) The word "green" or "ground";

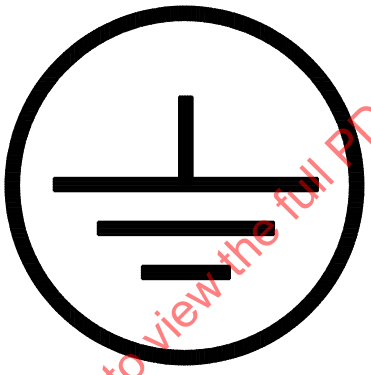
3) The letters "G" or "GR"; or

4) The grounding symbol illustrated in Figure 14.1.

14.11 The free length of a lead inside an outlet box, wiring compartment or at the end of a length of conduit shall be a minimum of 6 in (150 mm) long if the lead is intended for field connection.

Figure 14.1

Grounding Symbol



IEC417, Symbol 5019

15 Internal Wiring

15.1 Wires shall be routed away from sharp edges, screw threads, burrs, fins, and other areas that abrade the wires.

15.2 Conductor insulation shall have a voltage rating of 600 volts. The insulation shall be rated for the maximum anticipated temperature, but not less than 75°C (167°F).

15.3 Copper conductors used for wiring in a wire conductor raceway, cable, or through branch circuit shall be 12 AWG (3.3 mm^2) for a 20 Amp circuit, 10 AWG (5.3 mm^2) for a 30 Amp circuit, or 8 AWG (8.4 mm^2) for a 40 Amp circuit. Alternatively, 10 AWG copper conductors may be used for 20 Amp circuits, and 8 AWG copper conductors may be used for 20 and 30 Amp circuits.

Exception: Insulated conductors for a fixture tap intended for direct connection to a single fixture may be less than 12 AWG but not less than 18 AWG (1.82 mm^2) if the fixture tap does not have manufactured wiring system plug-in connectors on both ends.

15.4 Conductors used for internal wiring within a component assembly enclosure may be smaller than the branch circuit conductor if tested as specified in 27.3; Section 35, Fault Current Test; Section 36, Internal Conductor Overcurrent Test; and found suitable for the maximum intended load permitted by the intended branch circuit over current rating.

15.5 Grounded conductors installed in the same raceway or enclosure shall be uniquely identified. Identification that distinguishes each grounded conductor shall be one of the following:

a) An outer covering of white, gray, white or gray with a colored stripe, or by three continuous white stripes on other than green insulation along its entire length; or

b) Other and different means of identification that distinguishes each grounded conductor.

Exception: Grounded conductors are not required to be color coded where they are not accessible during intended use and maintenance of the system.

15.6 Class 2 or 3 powered conductors shall not be run in AC, MC cables, flexible metal conduit or cords with non Class 2 or 3 powered conductors. Class 2 or 3 powered conductors may be run in MC-PCS cables with non Class 2 or 3 powered conductors.

15A Low Voltage Charging Circuits

15A.1 An outlet with one or more Class 2 power outputs shall also comply with the following requirements:

a) The Standard for Class 2 Power Units, UL 1310; or

b) the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1, and the requirements for Class 2 transformers in the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3.

16 Receptacle Wiring

16.1 Convenience receptacles shall be connected to the manufactured wiring system branch circuit conductors in accordance with Table 16.1.

Table 16.1
Smallest acceptable sizes of receptacle leads

Current rating of receptacle	Copper supply leads		Copper equipment grounding leads	
Amperes	AWG	(mm^2)	AWG	(mm^2)
15	14	(2.1)	14	(2.1)
20	12	(3.3)	12	(3.3)
30	10	(5.3)	10	(5.3)
40	8	(8.4)	10	(5.3)

16.2 A receptacle connected to a 20 or 30 Amp branch circuit conductor shall be connected by a minimum 14 AWG (2.1 mm^2) copper conductor or equivalent.

16.3 A receptacle connected to a 40 Amp branch circuit conductor shall be connected by a minimum 12 AWG (3.3 mm^2) copper conductor or equivalent.

16.4 A receptacle connected to a 20 Amp branch circuit conductor shall be rated 15 or 20 Amps.

16.5 A receptacle connected to a 30 Amp branch circuit conductor shall be rated 30 Amps.

16.6 A receptacle connected to a 40 Amp branch circuit conductor shall be rated 40 Amps.

16.7 When more than one branch circuit supplies receptacles within a single enclosure, each circuit shall be subjected to the test specified in 27.3 simultaneously.

16A Conductor Fill Requirements

16A.1 Electrical junction boxes and conduit bodies used as outlet, device and junction boxes shall be of sufficient size to provide free space for all enclosed conductors. Conductor fill requirements and the corresponding volume required are to be determined in accordance with the National Electrical Code (NEC), NFPA 70, Article 314.

Exception: Electrical junction boxes, conduit bodies used as outlet, device and junction boxes having a fill exceeding, or a volume less than, that specified in the NEC meets the intent of the requirement when the enclosure with the provided conductor fill and volume, complies with Temperature Test, Section 27, and has no provision for field installed conductors.

17 Control Circuits

17.1 Each control circuit shall comply with the requirements for line-voltage circuits.

Exception: A secondary control circuit is not required to comply with the requirements for line-voltage circuits when all of the following conditions are met:

a) The circuit complies with the requirements for a Class 2 circuit or a limited power source circuit; and

b) A secondary circuit shall comply with the Standard for Solid-State Controls for Appliances, UL 244A. Compliance with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills these requirements.

17.2 A switch having an identified "off" function shall be either:

a) An air gap switching device having, in the "off" mode, an air gap between the line and load terminals; or

b) A solid-state switching device having a maximum let-through current of 0.5 mA.

17.3 A switch as mentioned in 17.2(b) shall not be used to provide a disconnect function and shall be marked as indicated in 45.19.

17A Supplementary Protectors

17A.1 Supplementary protectors are optional. When supplementary protection is provided the protection shall comply with the requirements in the Standard for Supplementary Protectors for Use in Electrical Equipment, UL 1077. The supplementary protection device shall comply with the following:

a) Be suitable for General Industrial use;

b) Be rated for the maximum voltage of the Manufactured Wiring System or the specific receptacle (s), device(s) or circuit(s) protected by the supplementary protector;

c) The trip current shall be minimum 125 percent of the current rating of the maximum rated receptacle(s), device(s) or circuit(s) protected;

d) The overload rating shall be 6 times the current rating of the receptacle(s), device(s) or circuit(s) protected;

e) The supplementary overcurrent protection device shall be suitably rated for a fault current of not less than that indicated in Table 17A.1.

f) Be of the automatic-trip-free, manual-reset type.

Table 17A.1
Circuit capacity of supply source

Input rating (VA)	Available fault current (A)
1875 or less	1000
More than 1875 to 3750	2000
More than 3750 to 5000	3500
More than 5000	5000

17A.2 A supplementary overcurrent protection device shall open all ungrounded conductors within the circuit it is protecting.

17A.3 A supplementary overcurrent protection device shall not be connected to the equipment grounding conductor.

17A.4 The ampere rating of the supplementary protector shall not be greater than the ampacity of the receptacle(s), device(s) or circuit(s) protected.

17A.5 When a supplementary protector does not protect all receptacle(s), device(s) or circuit(s) within the Manufactured Wiring System the receptacle(s), device(s) or circuit(s) shall be identified to indicate which receptacle(s), device(s) or circuit(s) is protected. See 45.21.

18 Laser Devices

18.1 Laser products shall comply with the Code of Federal Regulations (CFR), 21 CFR Part 1040.

18.2 With reference to 18.1, compliance of laser products with the Code of Federal Regulations (CFR), Title 21 Part 1040, shall be determined by:

a) Determining the Class of the laser product and the Class of the radiation emitted by the laser product (as defined in the CFR) from the manufacturer's Center for Devices and Radiological Health (CDRH) product report;

b) Verifying that the manufacturer's markings and labels having the information specified in the CFR are affixed on the laser product (as defined in the CFR);

c) Determining that the corresponding construction features, such as protective housing, interlocks, and similar features, are provided in accordance with the CFR;

d) Determining that the resulting construction complies with the construction requirements of this Standard; and

e) Verifying that the manufacture's safety instructions required by the CFR are provided with the laser product (as defined in the CFR).

19 Splices and Connections

19.1 All splices and connections shall be mechanically secure and provide electrical continuity as determined by the Temperature Test, Section 27, and the Vibration Test, Section 30. A soldered connection shall be made mechanically secure before being soldered if loosening of the connection results in a condition that introduces a risk of fire or electric shock.

19.2 A splice shall be provided with insulation equivalent to that of the conductors involved.

19.3 In determining if splice insulation consisting of fabric, thermoplastic, or other type of tubing is acceptable, consideration is to be given to such factors as its dielectric properties, heat- and moisture-resistant characteristics, and the like. Thermoplastic tape wrapped over a sharp edge is not acceptable.

19.4 Where stranded internal wiring is connected to a wire-binding screw, the construction shall be such that loose strands of wire will not contact:

a) Other uninsulated live parts not always of the same polarity; or

b) Dead metal parts.

This can be accomplished by use of pressure terminal connectors, soldering lugs, crimped eyelets, or by any other equivalent means that comply with the requirement in 14.6.

20 Grounding

20.1 All connections to a metal raceway system shall provide a continuous electrical grounding connection. Components in the raceway system shall be mechanically secured and comply with testing specified in Section 38, Grounding Impedance Test.

20.2 The grounding means shall have an ampacity at least equivalent to the supply conductors as specified in 7.1 and 7.2.

20.3 The intended raceway system that is connected to a device, fitting, module head junction or outlet box shall comply with the requirements in Section 38, Grounding Impedance Test.

20.4 Sheet metal screws shall not be used to connect grounding conductors to terminals, dead metal enclosures, or to bond dead metal enclosures to conductors or other dead metal parts.

20.5 Standardized NEMA configuration convenience receptacles incorporating self grounding devices or yokes shall comply with the requirements in the Standard for Attachment Plugs and Receptacles, UL 498, and may be installed without a bonding strap or bonding jumper when mounted to a metallic junction box bonded to the grounding conductor.

20.6 A manufactured wiring system assembly that has a grounding path through conductor traces on a printed-wiring board shall comply with the Fault Current Test, Section 35.

21 Bonding

21.1 A conductor, including a strap, jumper, or similar part, that is used only for bonding shall comply with the following:

a) Be of copper, copper alloy, aluminum, or other material that has been investigated and found acceptable for use as an electrical conductor;

b) Be protected from mechanical damage;

c) Not be secured by a removable fastener used for any purpose other than bonding unless the bonding conductor is not likely to be omitted after removal and replacement of the fastener;

d) The arrangement of the bonding conductor shall be such that the disconnection or removal of a receptacle or other device does not interrupt the grounding path; and

e) Have the flexibility needed to withstand mechanical stress due to vibration or flexing during use.

21.2 Bonding shall be by a positive means, such as by a clamp, rivet, bolt, screw, or welded joint.

21.3 A bonding screw shall engage at least two full threads and shall be used in conjunction with upturned lugs, a cupped washer, or an equivalent method that is capable of retaining a 10 AWG conductor under the head of the screw.

21.4 A bonding connection means shall penetrate nonconductive coatings, such as paint, vitreous enamel, or powder coatings.

21.5 A metal-to-metal hinge-bearing member of a door or cover used as a means for bonding the door or cover shall be of the multiple-bearing-pin (piano) type.

21.6 Bonding around a resilient mounting shall not depend on the clamping action of rubber, thermoplastic polymeric material, or similar material.

21.7 If the continuity of a bonding system relies on the integrity of a nonmetallic material, the dimensional stability of the material shall be considered in addition to any other material characteristics that could affect the bond. These material characteristics include the material's mechanical strength, thermal aging characteristics, moisture-absorption properties, combustibility, resistance to impact, distortion, creep, arcing, and ignition. The bonding system, together with the nonmetallic material, shall comply with 38.2.

21.8 A bonding member shall be enclosed, located, or otherwise protected so that it will be unlikely to be damaged during handling or installation.

21.9 A metal part of a resilient mounting that also serves as a bonding path shall be inherently resistant to corrosion or shall be plated or finished as protection against corrosion.

21.10 A bonding member shall have the flexibility necessary to withstand normal mechanical stress due to vibration. Compliance with the performance requirements within this Standard shall be used to determine compliance with this requirement.

22 Mating Connectors

22.1 *Deleted*

22.2 *Deleted*

22.3 *Revised and relocated as 22A.5.1*

22.4 *Revised and relocated as 22A.6.1*

22.5 *Revised and relocated as 22A.5.2*

22A Mating Connectors

22A.1 General

22A.1.1 All parts that provide electrical insulation or an enclosure of a connector shall comply with the requirements in 22A.2.1 – 22A.4.1. Hard rubber shall not be employed.

22A.1.2 A polymeric material used for electrical insulation or an enclosure shall be fabricated in accordance with the Standard for Polymeric Materials – Fabricated Parts, UL 746D.

Exception: A polymeric material that is fabricated in the same location where final assembly takes place and where no blending or compounding operations are involved is not required to comply with this requirement.

22A.2 Flammability

22A.2.1 A polymeric material used for electrical insulation or an enclosure shall have a flame class rating of HB, V-2, V-1, V-0, VTM-2, VTM-1, or VTM-0 in accordance with the requirements of the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94. The flame class rating of the material shall be judged at the minimum thickness employed at the walls and barriers in the device which are critical to the functioning of the insulation of the device.

22A.3 Electrical properties

22A.3.1 A polymeric material used for electrical insulation or an enclosure shall have a Comparative Tracking Index (CTI) rating of 175 V or greater or a performance level class of at least 3.

22A.3.2 A polymeric material used for electrical insulation or an enclosure of live parts shall have Hot Wire Ignition (HWI) and High-Current Arc Resistance to Ignition (HAI) ratings or performance level classes of at least those shown in Table 22A.1 for the flame class rating determined in accordance with 22A.2.1. For materials with other than VTM flammability classifications, the HWI and HAI ratings of the material shall be evaluated using the specimen thickness employed in the end product or nominal 1/8 inch (3.2 mm) thickness, whichever is greater.

Table 22A.1
Hot wire ignition (HWI) and high-current arc resistance to ignition (HAI) ratings of insulating materials

Flammability classification[a]	HWI[b,d]		HAI[c,d]	
	Mean ignition time (sec)	PLC	Mean no. of arcs	PLC
V-0, VTM-0	7 and up to 15	4	15 and up to 30	3
V-1, VTM-1	15 and up to 30	3	15 and up to 30	3
V-2, VTM-2	15 and up to 30	3	15 and up to 30	3
HB	30 or more	2	60 or more	1

[a] Flammability classification – Described in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

[b] Hot Wire Resistance to Ignition – Described in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

[c] High-Current Arc Resistance to Ignition – Described in UL 746A.

[d] Mean ignition time and mean no. of arcs to be used to evaluate Filament Wound Tubing, Industrial Laminates, Vulcanized Fiber, and similar polymeric materials only. All other materials are to be judged using the performance level class values.

22A.4 Thermal properties

22A.4.1 A polymeric material used for electrical insulation or an enclosure of live parts shall have the relative thermal index ratings shown in Table 22A.2 for the specific application of the insulating material. For materials with other than VTM flammability classifications, the material shall be evaluated using the specimen thickness employed in the end product or nominal 1/8 inch (3.2 mm) thickness, whichever is greater.

Table 22A.2
Minimum relative thermal indices of insulating materials used in insulation

Application	Minimum relative thermal index[a], Degrees C		
	Electrical	Mechanical with impact[b]	Mechanical without impact
Connectors	80	60	80

[a] Relative Thermal Index – Described in the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B.

[b] For industrial laminates, vulcanized fiber, and similar polymeric materials, the material's minimum RTI for Mechanical shall be evaluated using the values specified for Mechanical Without Impact.

22A.5 Mating connector physical requirements

22A.5.1 Mating connectors shall:

a) Be of the locking type;

b) Be reliably keyed by a physical or mechanical means to maintain correct polarity consistent with the wiring diagram on the power-feed of connected parts and proper interconnection of parts;

Exception: Mating connectors for the lighting industry shall be reliably keyed by a physical or mechanical means to maintain correct polarity between the following groups:

a) Group I – 120 V;

b) Group II – 277 V; and

c) Group III – 120 V IG (Isolated Ground), 208 V, 240 V, 250 V, 347 V, or 480 V.

The terminals shall be marked identifying the terminal positions and identifying the hot, neutral, and ground terminals.

c) Be reliably keyed so that a system with a lower ampere rating cannot interconnect to a system with a higher ampere rating;

d) Have the grounding-conductor terminals connect before or at the same time mating supply-conductor terminals connect when two or more connectors are mated as intended. During disconnection of mating connectors, the supply-conductor terminals shall disconnect before or at the same time the grounding-conductor terminal disconnects.

e) Be rated 20, 30 or 40 amperes in accordance with 15.3.

Exception: In a limited-energy circuit, the mating connector may be rated for maximum current available.

22A.5.2 A bushing shall be provided to protect internal wiring from abrasive surfaces. The bushing shall be at least 0.015 inch (0.38 mm) thick and secured in place so that any motion likely to occur does not

result in the bushing being displaced. A bushing material, if not known to be acceptable for the application, shall be subjected to the Aging/Penetration Test, Section 29.

22A.6 Mating connectors for use in environmental air handling spaces (plenums)

22A.6.1 Mating connectors for products used in environmental air handling spaces (plenums), as described in 11.6(b), shall also comply with the Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces, UL 2043.

23 Strain Relief

23.1 Strain relief shall be provided so that mechanical stress placed on the raceway or cable, such as a pull or a twist, is not transmitted to terminals, splices, or internal wiring.

23.2 Means shall be provided to prevent the cable or conduit from being pushed into the enclosure of a manufactured wiring system through the entry hole when such displacement results in:

a) Subjecting the cable or conduit to mechanical damage;

b) Exposing the cable or conduit to a temperature higher than that for which it is rated;

c) Reducing spacings (such as from a live part to a metal strain-relief clamp) below the minimum required values; or

d) Damaging internal connections or components.

To determine compliance, the cable or conduit shall be tested in accordance with Section 31, Push-Back Relief Test.

23.3 The strain relief means provided as specified in 23.1 shall be subjected to the Pull-Out Test, Section 32.

24 Flexible Cord Strain Relief

24.1 Strain relief shall be provided to restrict a mechanical stress on a flexible cord from being transmitted to terminals, splices, or interior wiring, as determined in the Strain Relief Test, Section 33.

24.2 Means shall be provided to restrict the flexible cord from being pushed into the unit through the cord entry hole when such displacement subjects the cord to mechanical damage or to exposure to a temperature higher than that for which the cord is rated, or reduces spacings below the minimum required values.

24.3 A knot in the supply cord shall not be used to provide strain relief.

25 Spacings

25.1 *Deleted*

25.2 *Deleted*

25A Spacings

25A.1 Unless provided with insulation rated for the highest voltage involved, insulated conductors of different circuits - internal wiring - shall be separated by barriers or shall be segregated and shall, in any case, be separated or segregated from uninsulated live parts connected to different circuits. Also see 15.6.

25A.2 Segregation of insulated conductors may be accomplished by clamping, routing, or equivalent means that provides permanent separation from an insulated or uninsulated live part of a different circuit.

25A.3 A barrier used to separate or segregate internal wiring shall have mechanical strength and be held in place to provide permanent separation, and it shall be acceptable for the temperatures involved.

25A.4 A barrier intended to separate or segregate low-voltage field wiring from line-voltage parts shall be of material of sufficient thickness to serve its intended purpose. It shall be supported so that its deformation cannot be readily accomplished to defeat its purpose.

25A.5 For factory-installed components and wiring, spacings through air and over surface of insulation between uninsulated live parts of opposite polarity, between uninsulated live parts of Class 2 circuits and Class 2 conductors, and dead metal parts shall be:

a) Not less than 1/16 inch (1.60 mm) where adjacent parts may be subjected to a difference in potential of 250 volts or less; and

b) Not less than 1/8 inch (3.17 mm) where adjacent parts may be subjected to a difference in potential of more than 250 volts.

Exception: The inherent spacings of a component, such as a snap switch, are judged on the basis of the requirements for the component in question.

25A.6 At a field-wiring terminal, spacings of at least 1/4 inch (6.35 mm) shall be maintained.

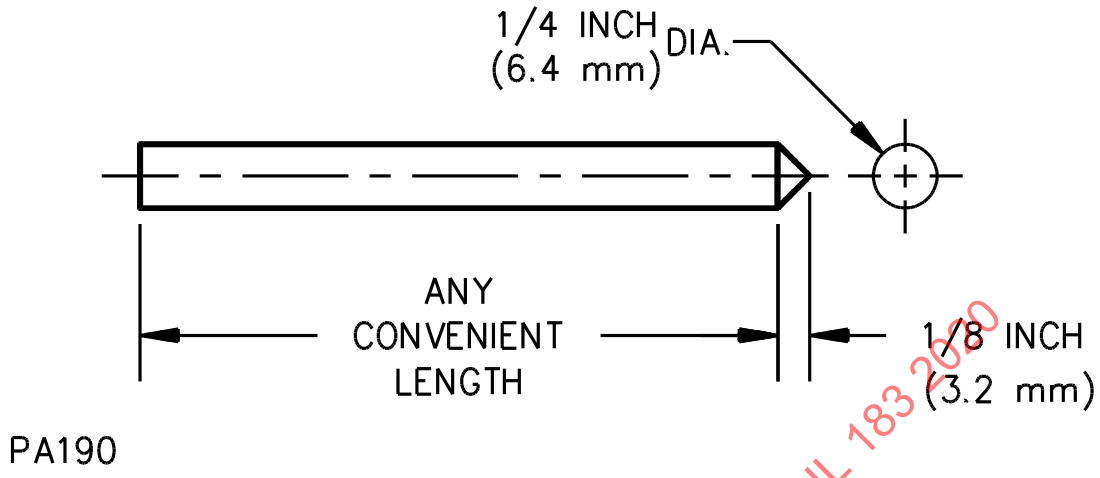
26 Accessibility to Uninsulated Live Parts

26.1 A manufactured wiring system connector that is not supplied with caps in accordance with 11.8 shall comply with 26.2.

26.2 Contacts and associated live parts in the contact opening of a male or female device shall not be able to be contacted by the probe illustrated in Figure 26.1. The probe in Figure 26.1 is to be inserted point first as far as possible into the opening without distorting the perimeter of the opening.

Figure 26.1

Probe



PERFORMANCE

27 Temperature Test

27.1 Assemblies used in a manufactured wiring system shall not attain a temperature that exceeds:

a) The material's capability, as determined in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, for a plastic enclosure; and

b) The temperatures specified in Table 27.1 when corrected to a 40° C (104° F) ambient temperature.

The temperature measurement shall be made on wiring terminals in connectors, fittings, and other assemblies that are likely to produce temperature rises due to resistive connections in the live part.

Table 27.1
Maximum acceptable temperature rises[g]

	Materials and components	°C	°F
A.	Components		
	1. Fuses	50	90
	2. Wood and other cellulosic material[a]	50	90
	3. Sealing compounds	b	b
	4. Insulated wires and cord	c	c
	5. Thermoplastic material	d	d
	6. Enclosure of an automatic starter for a fluorescent ballast	50	90
	7. (UL 498) NEMA style receptacle contacts[e]	30[e]	54[e]
	8. Printed-wiring boards	f	f
B.	Electrical insulation – general		
	1. Fiber employed as electrical insulation	50	90
	2. Varnished-cloth insulation	45	81

Table 27.1 Continued on Next Page

Table 27.1 Continued

Materials and components	°C	°F
[a] These limitations do not apply to a compound or component that is rated for a higher temperature.		
[b] The maximum thermoplastic sealing compound temperature is 15°C (27°F) less than the softening point of the compound as determined by the Ring-and-Ball Apparatus, ASTM E28-14. Thermoset compounds which have been investigated for particular temperature ratings, the maximum temperature of the compound shall not exceed the temperature rating of the compound when adjusted to a 40°C (104°F) ambient as specified in 27.7.		
[c] For insulated conductors the maximum temperature shall not exceed the maximum operating temperature specified for the wire when adjusted to a 40°C (104°F) ambient as specified in 27.7.		
[d] For compounds which have been investigated for particular temperature ratings, the maximum temperature shall not exceed the temperature rating of the compound when adjusted to a 40°C (104°F) ambient as specified in 27.7.		
[e] The maximum temperature when corrected to 25°C (77°F) is 55°C (131°F).		
[f] The maximum temperature rise of the printed-wiring board is the operating temperature of the board minus an assumed ambient of 40°C (104°F).		
[g] The maximum temperature rise of any component shall not exceed the temperature limit of the component minus an assumed ambient temperature of 40°C (104°F).		
NOTE – Temperature rises in this table are based on a 40°C (104°F) ambient except for UL 498 NEMA receptacles are certified based on 25°C (77°F) and a correction factor for a higher ambient is not applied. .		

27.2 The circuit is to be loaded so that the rated current flows through each grounded and ungrounded supply conductor. A grounded supply conductor intended for connection to a multi-wire branch circuit is to carry 100 percent of rated current. The current flowing through the grounded supply conductor is to be not less than rated current of the system. Unless specifically requested otherwise, the test is to be conducted at low-voltage.

27.3 The receptacle (s) provided with the longest length conductors from the manufactured wiring systems branch circuit wiring is to be loaded to its maximum current rating, and then the next closest receptacle to the field wiring connection on the same branch circuit shall be loaded to its maximum current rating or the balance of the rating of the manufactured wiring system assembly. If necessary, additional receptacles shall be loaded to their maximum current rating until the manufactured wiring system component assembly is carrying its maximum rated current for each factory installed branch circuit or all available convenience outlets in the assembly are carrying their maximum rated current. The test may be repeated in other load configurations to determine the maximum temperature on each component within the assembly. Consideration should be made to load adjacent receptacles supplied by separate branch circuits. Immediately following the temperature test, the dielectric voltage withstand test shall be conducted.

27.4 Temperatures are to be measured using thermocouples consisting of 28 – 32 AWG (0.08 – 0.03 mm^2) iron and constantan wires. It is a common practice to employ thermocouples consisting of 30 AWG (0.05 mm^2) iron and constantan wires with a potentiometer-type indicating instrument. This equipment is to be used if a referee measurement of temperature is necessary.

27.5 The temperature test is to be conducted following the first 50 cycles of the overload test on the device and is to continue for 4 hours even though stabilized temperatures may be attained in a shorter time.

27.6 The temperature test is to be conducted in an ambient of 40° C (104° F). At the manufacturer's request, the test may be conducted at a lower ambient, but not lower than 25°C (77°F).

27.7 When temperatures on the device have stabilized, they are to be recorded and corrected to a nominal 40°C test compartment temperature by use of the formula:

$$T = Tm + (40 - Tc)$$

in which:

Tc is the test compartment air temperature in degrees C;

Tm is the temperature measured on the device in degrees C; and

T is the corrected temperature in degrees C on the device.

27A Temperature Cycling Test

27A.1 The Temperature Cycling Test shall be conducted when the construction is as specified in 11.11. The Temperature Cycling Test shall be conducted as specified for the Temperature Test, Section 27, except the connectors under test shall be subjected to the heat cycling as specified in Table 27A.1 instead of the Overload Test specified in 27.5.

Table 27A.1
Temperature test – typical time schedule

Hour	Action taken
0	Power supply on
16	Temperature measurement
17	Power supply off
24	Power supply on
40	Temperature measurement
41	Power supply off
48	Power supply on
71	Temperature measurement
72	Power supply off

27A.2 The Temperature Cycling Test is to be performed for 72 h. During the test, the supply source is to be disconnected from the circuit two times and the system is to return to ambient temperature. The disconnection is to last not less than 4 h and not more than 7 h. Temperature readings are to be taken after at least 6 h have elapsed after each start-up and during the final hour of the test. See Table 27A.1.

28 Aging/Creep Test

28.1 Six samples of a fitting, consisting in whole or in part of molded components, shall be conditioned for 168 hours in an air-circulating oven at 100 ±1°C (212 ±2°F). The samples shall not crack, warp, deform, or show other visible signs of deterioration.

Exception: This test does not apply to manufactured wiring systems composed of components previously tested and certified.

29 Aging/Penetration Test

29.1 Unless previously investigated, a bushing material shall be subjected to:

a) An oven conditioning test consisting of 7 hours in an air-circulating oven at a temperature 10 ±1° C (18 ±2° F) higher than the maximum temperature observed during the Temperature Test, Section 27, but not less than 100 ±1°C (212 ±2°F); and

b) A penetration test (see 29.2) as-received and after the oven conditioning.

The bushing shall not show cracks or other signs of deterioration after the oven conditioning and shall not crack or melt so as to expose metal during the penetration test.

29.2 This test requires 6 samples of armored cable or flexible metal conduit. Each sample is to be 6 to 8 inches (15 – 20 cm) in length. The bushing is to be mounted on armored cable or flexible metal conduit as intended. The armored cable or flexible metal conduit is to be mounted horizontally in an air-circulating oven at a temperature 10 ±1° C (18 ±2° F) higher than the maximum temperature observed on the conductor or fitting during the Temperature Test, Section 27. A loop of 12 AWG (3.3 mm^2) bare, solid copper conductor is to be brought through the open end of each section of armored cable or flexible metal conduit. A 10-pound (4.54-kg) weight is to be suspended from each loop of the conductor. The support means shall be located so that the plane of the cable or conduit opening remains in the vertical orientation when the weight is applied. The test is to be continued for 72 hours.

30 Vibration Test

30.1 A manufactured wiring system assembly shall not be adversely affected so as to present a risk of fire or electric shock when tested in accordance with 30.2.

Exception: This test does not apply to manufactured wiring systems composed of components previously tested and certified.

30.2 Six samples of an entire manufactured wiring system assembly or representative components are to be placed on a vibration testing machine. The samples to be used are to employ the fittings subjected to the Aging/Creep Test, Section 28. The cable or conduit is to be supported, but not clamped, at points 1 foot (0.31 m) and 5-1/2 feet (1.68 m) from the fitting. At a point on the conduit or cable 10 feet (3.05 m) from the clamp, the conduit or cable is to be secured after being rotated axially for 180 degrees in a direction that permits the conduit or cable to loosen in the fitting or clamp. The test machine is to be set to vibrate at a frequency of 2000 cycles per minute. The amplitude is to be set at 1/32 inch (0.78 mm) peak-to-peak. The test is to be continued for 24 hours. The vibrating force is to be applied in a direction along the longitudinal axis of the fitting.

31 Push-Back Relief Test

31.1 To determine compliance with 23.2, a product shall be tested in accordance with 31.2 without occurrence of any of the conditions specified in 23.2 (a) – (d).

31.2 The conduit or cable is to be held 1 inch (25.4 mm) from the point where the conduit or cable emerges from the product and is then to be pushed back into the product. When a removable bushing which extends further than 1 inch is present, it is to be removed prior to the test. When the bushing is an integral part of the cord, then the test is to be carried out by holding the bushing. The conduit or cable is to be pushed back into the product in 1 inch (25.4 mm) increments until the conduit or cable buckles or the force to push the conduit or cable into the product exceed 6 pounds-force (26.7 N). The conduit or cable within the product is to be manipulated to determine compliance with 23.2.

32 Pull-Out Test

32.1 The connectors, fittings, and other assemblies shall be subjected to the force specified in 32.2 and 32.3. There shall be no:

a) Displacement of parts;

b) Damage to the cable or flexible metal conduit; or

c) Stress transmitted to the conductors.

Exception: This test does not apply to manufactured wiring systems composed of components previously tested and certified.

32.2 The six samples of the assembly subjected to the vibration test in 30.1 are to be secured in place, and a weight as specified in Table 32.1 is to be suspended from the cable for 5 minutes. The weight is to be attached at a point on the assembly 3 feet (0.91 m) from the lower end of the fitting.

32.3 Six additional as-received assemblies (with fittings on each end) not more than a total of 4 feet (1.21 m) long are also to be tested. One fitting on each sample is to be secured in place. A weight as specified in Table 32.1 is then to be attached to the lower fitting and suspended for 5 minutes.

Table 32.1
Pull force

Trade size of fitting	Metric designator	Force	
		N	(lbf)
1/2	16	333	75
3/4	21	444	100
1	27	556	125
1-1/4 to 4	35 to 103	667	150

33 Strain Relief Test

33.1 When tested in accordance with 33.2, the strain relief means provided on a flexible cord is to withstand for 1 minute, without displacement of the cord, a direct force of 35 pounds (156 N) applied to the cord with the connections within the unit disconnected.

33.2 A 35-pound (15.9 kg) weight is to be suspended on the cord and supported by the unit so that the strain-relief means is stressed from any angle that the construction of the unit permits. There shall be no movement of the cord that results in stress to the connections.

34 Overload Test

34.1 Current-carrying mating components shall be subjected to the overload test described in 34.2 – 34.11. Each mating component shall function as intended without undue burning or pitting of the contacts.

34.2 The device is to be tested by inserting and withdrawing the mating component that is to be connected to the load. The grounding contact is to be grounded through:

a) A 15-ampere fuse for a device rated 30 amperes or less; or

b) Through a 30-ampere fuse for a device that is rated more than 30 amperes.

The device is to make and break 150 percent of rated current at rated voltage for 250 cycles of operation at a rate no faster than 10 cycles per minute. The contacts are to mate for not more than 1 second during each cycle. The temperature test is to be conducted immediately after the first 50 cycles (see 27.4).

34.3 Alternatively, one set of devices are to be subjected to the 50 cycles of operation in the overload test as described in 34.2, followed by the temperature test (see 27.4) on the devices and then, to determine resistance to arcing, a second previously untested set of devices are to be subjected to 250 cycles of operation under the overload test conditions.

34.4 Alternatively, one set of devices are to be subjected to the 250 cycles of operation in the overload test as described in 34.2 with the temperature test (see 27.4) conducted immediately after the completion of the entire 250 cycles.

34.5 The fuse in the test circuit is to have the next higher standard fuse rating than the value of the test current. If either the line fuse or the grounding fuse opens during the test specified in 34.2, the results are not acceptable.

34.6 The test is to be conducted with a load the power factor of which is from 0.75 to 0.80 unless the device has a horsepower rating. In that case, the value of the current shall be as specified in the Standard for General-Use Snap Switches, UL 20, for 2 horsepower or less, and as specified in the Standard for Enclosed and Dead-Front Switches, UL 98, for alternating-current rating of more than 2 horsepower. The load for horsepower rating shall have a power factor from 0.40 to 0.50.

34.7 The test is to be conducted by a machine if the device is rated 20 amperes or less. The machine is to withdraw and insert an unrestricted mating component with an average velocity of 30 ±3 inches per second in each direction using a 2-1/2 inch (63.5 mm) stroke measured from the fully inserted position. The velocity is to be determined without the outlet device installed on the machine to eliminate restrictions on the motion.

34.8 The potential of the test circuit is to be from 95 to 105 percent of the rating of the device in volts.

34.9 A test on alternating current may be waived if acceptable results have been obtained in a direct-potential test that was conducted at a volt-ampere value equal to or greater than the alternating-potential rating.

34.10 The contacts are not to be adjusted, lubricated, or otherwise conditioned before or during the test.

34.11 Each sample is to be mounted and wired to represent conditions of its intended use. If the device is intended for use with a faceplate or the like, it is to be mounted with a metal plate as in service.

34.12 A locking mechanism is to be defeated for this test.

35 Fault Current Test

35.1 When required by 15.4, three samples of previously untested component receptacle assemblies shall be subjected to the Fault Current Test as described in 35.2. The receptacle component assembly shall comply with the requirements in 35.3. Each receptacle component assembly shall be tested once.

35.2 Each component receptacle assembly is to be tested on a circuit calibrated in accordance with 35.4. The available current capacity of the circuit is to be minimum 5000 Amps. The frequency of the test circuit is to be 60 ±12 Hz. The grounding or bonding circuit is to be connected in series with a circuit breaker or time-delay non-current limiting fuse that is rated for the maximum ampacity of the circuit in which the receptacle component assembly is intended to be installed, suitable for branch circuit protection, and connected directly to the test circuit. The circuit breaker or fuse shall open when the test circuit is closed

35.3 A component receptacle assembly shall have a grounding-path resistance of 0.1 ohm or less after the test described in 35.2 as determined by 35.2. During and following the Fault Current Test, the following conditions shall not occur:

a) Emission of flame, molten metal, or glowing or flaming particles through any openings (pre-existing or created as a result of the test) in the product;

b) Charring, glowing, or flaming of the supporting surface;

c) Ignition of the enclosure;

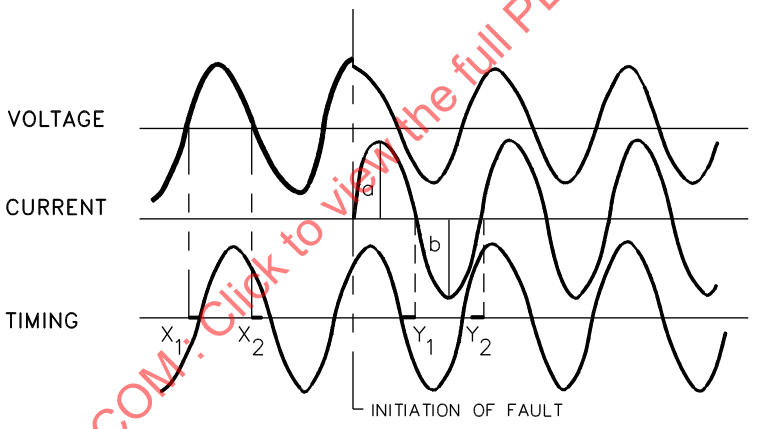
d) Creation of any openings in the enclosure that result in accessibility of live parts, when evaluated in accordance with 6.1; and

e) There shall not be evidence of degradation or separation of a trace from a printed-wiring board.

35.4 To calibrate the test circuits, the current is to be the rms value of the first complete cycle (see Figure 35.1) when the circuit is closed to produce a symmetrical current waveform. The direct-current component is not to be added to the value obtained when measured as illustrated. In order to obtain the required symmetrical waveform of a single-phase test circuit, controlled closing is recommended although random closing methods may be used. The power factor is to be determined by referring the open-circuit voltage wave to the two adjacent zero points at the end half of the first complete current cycle by transposition through a required timing wave. The power factor is to be computed as an average of the values obtained by using the two current zero points.

Figure 35.1

Determination of current and power factor



$$Current = \frac{a+b}{2} \text{ rms calibration of instrument element}$$

$$Power\ Factor = \frac{Cos\left[(Y_1+X_1) \times 180°\right]}{2} + \frac{Cos\left[(Y_2+X_2) \times 180°\right]}{2}$$

Where X and Y values are fractions of the 1/2–cycle distance in which they occur.

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36 Internal Conductor Overcurrent Test

36.1 Three previously untested receptacle assemblies are to be subjected to the Internal Conductor Overcurrent Test. The assembly shall comply with the requirements in 36.4 and 36.5. Each receptacle component assembly shall be tested once.

36.2 The resistance of each circuit conductor path is to be determined by measuring the voltage drop when a current of 25 A, derived from a 60 Hz source with a no-load voltage not exceeding 6 V, is passed between the input port and output port connectors of each conductor path.

36.3 The overload current is to be 200 percent (40 Amps, 60 Amps, or 80 Amps) of the current rating of the maximum size branch circuit (20 Amps, 30 Amps, or 40 Amps) to which the receptacle component assembly is intended to be connected. The overcurrent test current is to be applied for 2 minutes.

36.4 During and following this test, the following conditions shall not occur:

a) Emission of flame, molten metal, or glowing or flaming particles through any openings (pre-existing or created as a result of the test) in the product;

b) Charring, glowing, or flaming of the supporting surface;

c) Ignition of the enclosure;

d) Creation of any openings in the enclosure that result in accessibility of live parts, when evaluated in accordance with 6.1; and

e) There shall not be evidence of degradation or separation of a trace from a printed-wiring board.

36.5 After the sample has cooled to room temperature, the resistance of each circuit conductor path is to be determined as specified in 36.2. The resistance of each conductor path shall not increase by more than 10 percent. The resistance of the grounding circuit shall not exceed 0.1 ohm.

37 Conductor-Secureness Test

37.1 The connection of a 8 – 16 AWG (8.4 – 1.3 mm^2) conductor to a terminal of a wiring device shall not break when subjected for 1 minute to a pull of 30 pounds (133 N) applied between the terminal and the conductor. A 18 AWG (0.82 mm^2) conductor shall not break when subjected for 1 minute to a pull of 20 pounds (89 N) applied between the terminal and the conductor.

37.2 If a conductor is connected to a terminal before the terminal has been assembled to the wiring device, the test shall be conducted on the unassembled terminal and conductor.

Exception: An insulation-displacement-type wiring device, or other such device that relies on the enclosure to maintain integrity, may be tested as an assembled terminal and conductor in the housing.

37.3 If the construction is such that the enclosure also provides a retaining force on a conductor, the test shall be conducted on an assembly consisting of the terminal, conductor, and enclosure.

37.4 While the test is being performed, the angle between the terminal and the conductor is to be the same as in the completely assembled wiring device. The force is to be applied gradually.

38 Grounding Impedance Test

38.1 General

38.1.1 The impedance of two electrically and mechanically interconnected wiring components, between the point of connection of the conductor cable and other metal parts (such as a module head or fitting), shall not be more than 0.1 ohm when measured in accordance with 38.1.2.

38.1.2 An alternating current of 25 amperes from a source of supply is to be passed from the point of connection of the grounding conductor, through the module head or fitting and the connected cable or conduit. The voltage drop is to be measured between a point on the cable or conduit and a point on the module head or fitting. The point on the cable or conduit is to be 1/16 inch (1.6 mm) from the point of connection. The point on the module head is to be 1/16 inch (1.6 mm) from the point of connection.

38.2 Grounding or bonding fittings

38.2.1 A grounding or bonding fitting shall carry the current specified in Table 38.1 for the time specified in that table. The current shall be based on either:

a) The conduit or cable size involved; or

b) The largest size of wire for which the fitting is marked, whichever is lower.

The fitting shall not crack, break, or melt. Arcing and burning of a throat insulator is acceptable.

38.2.2 A grounding or bonding fitting intended for use with a grounding conductor is to be mounted on a length of maximum size conduit or cable for which it is intended to be used, or on an enclosure or outlet box in the intended manner. A grounding conductor of the maximum intended size, not less than 2 feet (0.61 m) long, is to be installed. A pressure terminal connector employed to hold the conductor is to be tightened using the torque specified in the Standard for Wire Connectors, UL 486A-486B. The test current is to be passed through the equipment and the grounding wire in series.

38.2.3 A bonding device intended to bond conduit or cable to an enclosure is to be tested by assembling the device, with the maximum intended size conduit or cable, to a typical enclosure, such as a 4-inch (101.6-mm) square outlet box, and causing the test current to flow from the conduit or cable through the joint to the enclosure. The test current is to be as specified in Table 38.1 for the conduit or cable size used.

38.2.4 After having carried the current specified in 38.2.1, continuity shall exist on the test sample assembly when measured between a point on the conduit, or cable, enclosure, or outlet box 1/4 inch (6.4 mm) from the connection of a grounding or bonding fitting and a similar point on the wire.

38.2.5 Any indicating device such as an ohmmeter, battery-and-buzzer combination, or the like may be used to determine whether continuity exists.

Table 38.1
Short-time test currents

Conduit or cable trade size, inch	Equipment grounding and bonding conductor		Time, seconds	Current, amperes
	size-copper	(mm^2)		
–	14 AWG	(2.1)	4	300
–	12	(3.3)	4	470
–	10	(5.3)	4	750
1/2	8	(8.4)	4	1180
3/4, 1	6	(13.3)	6	1530
1-1/4, 1-1/2	4	(21.2)	6	2450
–	3	(26.7)	6	3100
2	2	(33.6)	6	3900

Table 38.1 Continued on Next Page

Table 38.1 Continued

Conduit or cable trade size, inch	Equipment grounding and bonding conductor		Time, seconds	Current, amperes
	size-copper	(mm^2)		
2-1/2	1	(42.4)	6	4900
3, 3-1/2, 4	1/0	(53.5)	9	5050
4-1/2	2/0	(67.4)	9	6400
5, 6	3/0	(85.0)	9	8030
–	4/0	(107.2)	9	10100
–	250 MCM	(127.0)	9	12000

39 Dielectric Voltage-Withstand Test

39.1 The insulation and spacings of a manufactured wiring system shall withstand for 1 minute without breakdown the test potential specified in 39.3.

39.2 Breakdown will usually be indicated by the tripping of an overload protector in the test equipment; however, an abrupt decrease or retarded advance of the voltmeter reading may also be indicative of insulation breakdown.

39.3 A 60-hertz essentially sinusoidal potential is to be applied between live parts conductively connected to the supply circuit, ungrounded supply conductor(s), grounded supply conductor(s), and dead metal parts. The applied potential is to be 1240 volts, or 1000 volts plus two times the supply voltage, whichever is higher. The supply source is to have sufficient capacity to maintain the potential specified, except in case of breakdown. The voltage is to be increased gradually from zero until the prescribed test potential is reached or until breakdown occurs. The potential shall be applied between:

a) The supply wiring and dead metal parts; and

b) Any two conductors. This test is to be continued until each conductor has been tested with respect to every other conductor.

39.4 A direct-current test potential may be employed. The applied potential is to be 1740 volts or a value of 1.4 times the appropriate ac test potential, whichever is greater.

39.5 Load connected across the line components or components which employ transient voltage surge suppressors are not required to have the suppression element connected for this test.

40 Outdoor Use Performance

40.1 Assemblies of components such as liquid-tight flexible conduit, fitting for liquid-tight conduit, and enclosures which have been previously evaluated for outdoor use are not required to be retested.

40.2 Assembled manufactured wiring systems intended to be marked "Outdoor" shall comply with the Rain Test specified in the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E.

40.3 Portions of a manufactured wiring system intended to connect to an enclosure marked with a type designation as specified in the Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50, indicating the external conditions for which the enclosure is intended shall comply with the performance requirements specified in UL 50, the Standard for Enclosures for Electrical