

UL 2251

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Plugs, Receptacles and Couplers for Electric Vehicles

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Underwriters Laboratories Inc. (UL)
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UL Standard for Safety for Plugs, Receptacles and Couplers for Electric Vehicles, UL 2251

First Edition, Dated February 28, 2002

Revisions: This Standard contains revisions through and including February 23, 2007.

Summary of Topics

This revision to UL 2251 include the elimination of the term "pigtail" when describing leads.

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Text that has been changed in any manner is marked with a vertical line in the margin. Changes in requirements are marked with a vertical line in the margin and are followed by an effective date note indicating the date of publication or the date on which the changed requirement becomes effective.

The revised requirements are substantially in accordance with UL's Proposal(s) on this subject dated January 9, 2007.

The revisions dated February 23, 2007 include a reprinted title page (page1) for this Standard.

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The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the note following the affected item. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a "SUPERSEDED REQUIREMENTS" notice.

New product submittals made prior to a specified future effective date will be judged under all of the requirements in this Standard including those requirements with a specified future effective date, unless the applicant specifically requests that the product be judged under the current requirements. However, if the applicant elects this option, it should be noted that compliance with all the requirements in this Standard will be required as a condition of continued Recognition and Follow-Up Services after the effective date, and understanding of this should be signified in writing.

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FEBRUARY 28, 2002

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UL 2251

Standard for Plugs, Receptacles and Couplers for Electric Vehicles

First Edition

February 28, 2002

An effective date included as a note immediately following certain requirements is one established by Underwriters Laboratories Inc.

Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements. 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 <http://csds.ul.com>.

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INTRODUCTION

1 Scope

1.1 These requirements cover plugs, receptacles, vehicle inlets, and connectors, rated up to 800 amperes and up to 600 volts ac or dc, intended for conductive connection systems, for use with electric vehicles in accordance with National Electrical Code (NEC), ANSI/NFPA-70 for either indoor or outdoor nonhazardous locations.

1.2 This standard does not directly apply to the following but is able to supplement other applicable standards:

- a) Devices produced integrally with flexible cord or cable that are covered by the Standard for Cord Sets and Power-Supply Cords, UL 817;
- b) Devices solely intended for direct connection to the branch circuit in accordance with Articles 300, 400 and 410 of the NEC such as attachment plugs, cord connectors and receptacles, which can include 3 or more pilot contacts, that are covered by the Standard for Attachment Plugs and Receptacles, UL 498;
- c) Single and multi-pole connectors, intended for connection to copper conductors, for use in data, signal, control and power applications within and between electrical equipment, where exposed, for use in accordance with the National Electrical Code, that are covered by the Standard for Attachment Plugs and Receptacles, UL 498;
- d) Devices of the pin and sleeve type construction, intended to provide power from branch circuits to utilization equipment, or for direct connection of utilization equipment to the branch circuit, that are covered by the Standard for Plugs, Receptacles, and Cable Connectors of the Pin and Sleeve Type, UL 1682;
- e) Devices intended for use in hazardous locations that are covered by the Standard for Receptacle-Plug Combinations for Use in Hazardous (Classified) Locations, UL 1010;
- f) Devices consisting of wiring terminals and supporting blocks intended for the connection of wiring that are covered by the Standard for Terminal Blocks, UL 1059;
- g) Devices such as modular jacks and plugs that are intended for use with telecommunications networks, that are covered by the Standard for Telephone Equipment, UL 1459, and the Standard for Communications Circuit Accessories, UL 1863;
- h)) Devices such as wire connectors and soldering lugs, that are covered by the Standards for Wire Connectors and Soldering Lugs for Use with Copper Conductors, UL 486A; Splicing Wire Connectors, UL 486C; or Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E;
- i) Devices such as quick-connect terminals that are covered by the Standard for Electrical Quick-Connect Terminals, UL 310;
- j) Products such as power outlet assemblies that are covered by the Standard for Power Outlets, UL 231;
- k) Products such as switched interlocks that are covered by the Standard for Industrial Control Equipment, UL 508.

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1.3 In the text of this standard, the term "device" refers to any product covered by this standard. The letters "EV" refer to an electric vehicle.

2 Glossary

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

2.2 CONTACT – A conductive element in a component that mates with a corresponding element to provide an electrical path.

2.3 CONTROL CONTACT – A conductive element intended to carry an indicating or controlling signal.

2.4 CONTROL PILOT – The primary control conductor that is connected to the equipment earth through the control circuitry on the vehicle. It performs several functions, including assurance that the vehicle is present and connected, start/stop control, charging area ventilation requirements, supply equipment current rating, and provides for the continuous monitoring of the presence of the equipment earth.

2.5 DELAYED ACTION – An arrangement that delays the separation of device housings to reduce the likelihood of exposure of arcing contacts during the breaking of the circuit when the plug is withdrawn.

2.6 ENCLOSURE – The case or housing into which the insulator and contacts are assembled.

2.7 FIELD WIRING TERMINAL – A terminal to which power supply, control, or equipment grounding connections will be made in the field when the device is installed.

2.8 INSULATOR – That portion of a device that provides for separation and support of contacts.

2.9 INTERLOCKED RECEPTACLE – An outlet having a device, either electrical or mechanical, that is intended to reduce the likelihood of energizing the contacts before proper engagement with a plug, and that either is intended to reduce the likelihood of the plug being withdrawn while its contacts are energized or de-energizes the line contacts before separation.

2.10 LOCKING RETAINING DEVICE – A mechanical arrangement that holds a plug or connector in position when it is in proper engagement and is intended to reduce the likelihood of its unintentional withdrawal. It could also facilitate environmental sealing.

2.11 MEASUREMENT INDICATION UNIT (MIU) – The output voltage across the meter, in millivolts RMS, in the measurement instrument in Figure 30.2, divided by 500 ohms. [The instrument indication is equal to the RMS value in milliamperes when the frequency is 60 Hz (sinusoidal current)]. The reading may not be a direct indication of the RMS or other common amplitude quantifier of leakage current when the leakage current is of complex waveform or frequency other than 50 or 60 Hz.

2.12 PLUG – A device intended to receive power when inserted in a receptacle, which establishes connection between conductors of the attached flexible cord or cable and the conductors connected to the receptacle or connector.

2.13 RECEPTACLE – A device that is intended to provide power to an inserted plug, and that is usually installed as a fixed outlet or on equipment.

2.14 TERMINAL – A conductive part provided on a contact for connecting a conductor.

2.15 VEHICLE CONNECTOR – A portable receptacle that by insertion into an vehicle inlet, establishes an electrical connection to the electric vehicle for the purpose of providing power and information exchange, with means for attachment of flexible cord or cable. This device is a part of the coupler.

2.16 VEHICLE COUPLER – A means enabling the connection, at will, of a flexible supply cord to the equipment. It consists of a connector and a vehicle inlet.

2.17 VEHICLE INLET – The part incorporated in, or fixed to the vehicle or intended to be fixed to it, which receives power from a connector.

3 Components

3.1 Except as indicated in 3.2, a component of a product covered by this standard shall comply with the requirements for that component.

3.2 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.

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

3.4 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.

4 Units of Measurement

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

5 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.

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CONSTRUCTION

6 General

6.1 The ratings mentioned throughout this standard, including those mentioned in 59.2, represent maximum ampacity and voltage for a device. A device is considered to be for use on either alternating or direct current unless the rating includes a marking to restrict the use to alternating current. See 60.6.

7 Configurations

7.1 Configurations of various plug and receptacle and connector and vehicle inlet combinations are located in General, Section 62. Other combinations of plugs and receptacles that are investigated accordingly are not precluded by this requirement.

8 Insulating Materials

8.1 Flammability

8.1.1 All parts that act as the electrical insulation or enclosure of a device shall be of ceramic, or another insulating material permitted for the particular application. Hard rubber is not permitted.

8.1.2 Vulcanized fiber can be used for insulating washers, separators, and barriers, but not as the sole support for live parts. The material shall be moisture resistant in accordance with 29.1 and 29.2.

8.1.3 A polymeric material used for electrical insulation, an internal barrier necessary to maintain electrical spacings, or enclosure of live parts shall have a flame class rating of V-0, V-1, V-2, VTM-0, VTM-1, VTM-2, or HB in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception No. 1: The internal insulating systems of components where component requirements exist need not have a flame class rating.

Exception No. 2: A small part meeting all the following criteria need not have a flame class rating:

- a) Its volume does not exceed 2 cm³ (0.122³ inch), and*
- b) Its maximum dimension does not exceed 3 cm (1.18 inches), and*
- c) Its location is such that it cannot propagate flame from one area to another or act as a bridge between a possible source of ignition and other ignitable parts.*

Exception No. 3: Fiber and similar material that is equal to or less than 0.25 mm (0.010 inch) thick need not have a flame class rating.

8.2 Electrical properties

8.2.1 A polymeric material used for electrical insulation, an internal barrier necessary to maintain electrical spacings, or enclosure of live parts shall comply with the requirements in Sections 25 – 27.

Exception No. 1: A polymeric material having a maximum Comparative Tracking Index (CTI) performance level class of 3 need not comply with the Comparative Tracking Index Test, Section 25.

Exception No. 2: A polymeric material having Hot Wire Ignition (HWI) performance level class values not greater than those shown in Table 8.1 for the applicable flammability classification need not comply with the Glow Wire Test, Section 26. For materials with other than VTM flammability classifications, the material shall be evaluated using the specimen thickness employed in the end product or minimum 3.0 mm (0.118 inch) thickness, whichever thickness is greater.

Exception No. 3: A polymeric material having High-Current Arc Resistance to Ignition (HAI) performance level class values not greater than those shown in Table 8.1 for the applicable flammability classification need not comply with the High-Current Arc Resistance to Ignition Test, Section 27. For materials with other than VTM flammability classifications, the material shall be evaluated using the specimen thickness employed in the end product or minimum 3.0 mm (0.118 inch) thickness, whichever thickness is greater.

Exception No. 4: The internal insulating systems of components where component requirements exist need not comply with the requirement in Sections 25 – 27.

Exception No. 5: A small part meeting all the following criteria need not comply with the requirements in Sections 27 – 29.

- a) Its volume does not exceed 2 cm³ (0.122 inch³), and*
- b) Its maximum dimension does not exceed 3 cm (1.18 inches), and*
- c) Its location is such that it cannot propagate flame from one area to another or act as a bridge between a possible source of ignition and other ignitable parts.*

Exception No. 6: Fiber and similar material that is equal to or less than 0.25 mm (0.010 inch) thick need not comply with the requirements in Sections 25 – 27.

Exception No. 7: A polymeric material used in an enclosure of a plug or connector which does not enclose live parts, or which encloses insulated live parts where the insulation thickness is greater than 0.071 mm (0.028 inch), need not comply with the requirements in the Glow Wire Test, Section 26.

Exception No. 8: A polymeric material used in an enclosure that is separated through air by more than 0.8 mm (1/32 inch) from uninsulated live parts and more than 12.7 mm (1/2 inch) from arcing parts need not comply with the requirements in Sections 25 – 27.

Table 8.1
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	30 and up to 60	2
V-2, VTM-2	30 and up to 60	2	30 and up to 60	2
HB	30 and up to 60	2	60 and up to 120	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 the Standard for Polymeric Materials – Short Term Property Evaluations, 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.

8.3 Thermal properties

8.3.1 A polymeric material used for electrical insulation or enclosure of live parts shall have the relative thermal index ratings shown in Table 8.2 for the specific application of the insulating material.

Table 8.2
Minimum relative thermal indices of insulating materials used in insulation and enclosure applications

Application	Minimum relative thermal index ^a – Degrees C		
	Electrical ^c	Mechanical ^{b,c} with impact	Mechanical ^{b,c} without impact
Permanently wired devices (including equipment or vehicle inlets and receptacles)	100	100	100
Cord connected devices (including attachment plugs, connectors and adapters)	100	100	100

^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 minimum RTI for Mechanical shall be the values specified for Mechanical Without Impact.
^c For devices containing fuses, the minimum thermal indices shall be the values shown above or the temperature measured on the insulating material during the fuseholder temperature test, whichever is greater. See Fuseholder Temperature Test, Section 50.

9 Protection Against Corrosion

9.1 Parts of iron or steel other than stainless steel parts shall be protected against corrosion, in accordance with the Resistance to Corrosion Test, Section 54.

10 Enclosures

10.1 General

10.1.1 An enclosure shall be constructed so as to reduce the risk of unintentional contact with uninsulated live parts, see 13.1, and to provide internal parts with protection from specified external conditions.

10.2 Mechanical strength

10.2.1 An enclosure shall have adequate strength and rigidity for its intended use. It shall not permit any increase in shock or fire hazard due to total or partial collapse with resulting reduction in spacings, loosening, or displacement of parts, or other serious defects.

10.3 Nonmetallic enclosures

10.3.1 An enclosure can be made of a polymeric material if the material and design have been investigated and found suitable for the purpose.

10.3.2 A nonmetallic enclosure or a nonmetallic part of an enclosure shall comply with the applicable requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, and except as modified by this standard.

10.3.3 Among the factors taken into consideration when an enclosure is being judged are:

- a) Mechanical strength,
- b) Resistance to impact,
- c) Moisture-absorptive properties,
- d) Combustibility,
- e) Resistance to distortion or physical damage at temperatures to which the material can be subjected under conditions of normal or abnormal usage, and
- f) Resistance to atmospheric effects - rain and sunlight in the case of a device intended for outdoor use.

For a nonmetallic enclosure all of these factors are to be considered with respect to thermal aging.

10.3.4 If a nonmetallic enclosure or a nonmetallic part of an enclosure is used on a device intended for use outdoors, the performance of the enclosure material shall not be adversely affected by water, exposure to UV and other atmospheric effects. The enclosure shall comply with the requirements in the Standard for Polymeric Materials — Use in Electrical Equipment Evaluations, UL 746C.

10.3.5 If a nonmetallic enclosure is identified as being intended to be exposed to specific chemicals, oils, acids, solvents, cleaning agents, and the like, the performance of the enclosure material shall not be adversely affected by such substances as determined by applicable tests as described in the Standard for Polymeric Materials – Short Term Property Evaluation, UL 746A.

10.3.6 Pliable, molded natural or synthetic rubber, or a combination thereof, or a pliable composition of which the basic constituent is vinyl chloride or a copolymer of vinyl chloride and vinyl acetate, in the finished device that complies with the Accelerated Aging Tests, Section 24, can be employed as an insulating material for the body of a plug, or a connector.

10.4 Metallic enclosures

10.4.1 An enclosure can be constructed of iron, steel, copper, brass, bronze, zinc, or aluminum alloys containing not less than 80 percent aluminum. Magnesium, or its alloys shall not be used.

Exception: Zinc or a zinc-based alloy shall not be used for an enclosure or parts of an enclosure which are in the primary grounding path.

10.5 Attachment plugs

10.5.1 An attachment plug shall not be provided with more than one cord-outlet hole, unless the additional holes are capable of being closed or do not expose live parts.

10.6 Specific enclosures

10.6.1 An enclosure marked with one or more enclosure type designations indicating the environmental conditions for which it is intended shall comply with the requirements applicable to the enclosure type number or numbers. See Enclosure Tests for Environmental Protection, Section 58, and 60.13.1 – 60.13.5.

11 Current-Carrying Parts

11.1 A current-carrying part shall be of silver, copper, or a copper alloy, or other material acceptable for the application. Plated iron or steel shall not be used for parts that are depended upon to carry current. Wire binding screws shall not be of iron or steel.

Exception No. 1: Stainless steel can be employed for a part not subject to arcing.

Exception No. 2: Pressure wire terminal screws can be made of plated iron or steel.

11.2 Iron or steel, if protected against corrosion by zinc, tin, or equivalent plating, can be used for screws, plates, yokes or other parts that are employed as a means of clamping the conductor providing such parts are not the primary current-carrying members.

11.3 Suitable means shall be provided for retaining live parts within such limits of alignment as to ensure that plugs will enter receptacles, connectors, and the like, in the intended manner.

11.4 Uninsulated live parts shall be secured in place so that a reduction in the clearances and creepage distances below those required in 12.1 and 12.2 is not likely.

11.5 A current-carrying part shall be prevented from turning relative to the surface on which it is mounted if such turning would adversely affect the performance of the device.

12 Clearances and Creepage Distances

12.1 The clearances and creepage distances between field wiring terminals of opposite polarity and the clearances and creepage distances between a field wiring terminal and any other uninsulated metal part, dead or live, not of the same polarity shall not be less than 6.4 mm (1/4 inch).

Exception: If the field wiring terminals are intended for solder connections only, using solid or tinned stranded wire, the clearances and creepage distances between the terminals are as specified in Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840. See 60.11.2.

12.2 In all circuits other than at field wiring terminals, the acceptability of the clearances and creepage distances between an uninsulated live part and any other uninsulated metal part, dead or live, not of the same polarity shall be as specified in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840.

12.3 The dead metal mentioned in 12.2 includes a metal surface (a metal face plate in the case of a flush receptacle) on which the device is mounted in the intended manner. A dead-metal screw head, rivet, or the like is not considered to be exposed to contact by persons after the device is installed in the intended manner, if it is located in a hole so that the dead metal cannot be contacted by the probe illustrated in Figure 13.1.

12.4 Clearances and creepage distances shall be measured in accordance with the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840. In determining the pollution degree and overvoltage category, the end-use application is to be considered and could modify those characteristics given in 12.7 and 12.8.

12.5 Clearances and creepage distances are to be measured in all conditions of use, both with and without mating devices of the intended configuration installed and any movable parts displaced to the position of a minimum spacing.

12.6 The clearances and creepage distances required in 12.1 shall be measured through air and over insulating and conductive surfaces with the device wired as intended with the maximum anticipated conductor size. They shall be measured from any point on the terminal that is able to contact the clamped conductor as in the case of a wire-binding-screw terminal, or from any point on the perimeter of an opening to receive a conductor in the case of an enclosed terminal.

12.7 The level of pollution expected or controlled for indoor use equipment shall be pollution degree 3. For outdoor use equipment, pollution degree 4 is expected, unless protection is afforded by a suitable enclosure appropriate for the installation in which case a lower pollution degree is capable of being achieved. The interior of equipment with enclosure types 3, 3S, 4, 4X, 6 and 6P or Marine type is to be considered pollution degree 3. Hermetically sealed or encapsulated enclosures are considered pollution degree 1.

12.8 Plugs, connectors, inlets and other cord connected devices shall be rated overvoltage Category II and receptacles and other devices connected to fixed wiring will be rated overvoltage Category III as defined in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840.

13 Accessibility of Live Parts

13.1 To reduce the likelihood of unintentional contact that could involve a risk of electric shock from uninsulated live parts, a live part shall not be contacted by the probe illustrated in Figure 13.1. See 13.6.

13.2 The probe illustrated in Figure 13.1 is to be applied to any depth that the recessing will permit; and is to be rotated, changed in configuration or angled before, during and after application to any position that is necessary to examine the device.

13.3 The probe mentioned in 13.1 is to be used as a measuring instrument to judge the accessibility provided by the recessing and not as an instrument to judge the strength of a material; it is to be applied with a 13.3 N (3 lbf) to determine accessibility.

13.4 During the examination of a product to determine whether it complies with the requirements in 13.1, the device is to be wired and assembled in accordance with the manufacturer's instructions. Any other part that is able to be opened or removed by the user without using a tool is to be opened or removed.

13.5 Plug and receptacle combinations shall be examined to determine that the plug shroud (sleeve) enters the receptacle before the plug contacts become energized.

13.6 Mating devices shall not have exposed live contacts when fully mated or during engagement or withdrawal.

13.7 Compliance with 13.6 is to be determined with the use of the probe shown in Figure 13.1 in every possible position. See 13.2.

14 Grounding and Dead Metal Parts

14.1 A receptacle, plug, connector, or vehicle inlet shall be of a grounding type and shall have a separate contact for interconnection of the equipment grounding conductor.

14.2 The equipment grounding terminal or lead and its corresponding pin or contact of a male inlet or equipment outlet intended for permanent installation shall be conductively connected to the mounting means, housing, hood, shell, or other dead metal parts of a device that can come into contact with the equipment or vehicle enclosure.

Exception No. 1: The conductive connection need not be provided if the mounting means, housing, hood, or shell is constructed of an insulating material and the lack of ground continuity to the equipment enclosure is readily apparent.

Exception No. 2: The conductive connection need not be provided if the device is marked in accordance with 60.3.1.

14.3 A metal shell of a device that is used as the grounding contact member shall be as follows:

- a) The surface of the shell that is depended upon for grounding continuity shall not be painted or otherwise subjected to conditions that could result in loss of grounding continuity;
- b) One or more separate spring type components are incorporated to provide grounding path continuity;
- c) The components are protected against damage; and
- d) The shell complies with the requirements of the Grounding Path Current Test, Section 41.

14.4 The grounding contact shall be located and formed so that the path of electrical continuity to the grounding contact of the plug or connector and its mating device, is completed before continuity is established between any other contact and its respective contact on the plug or inlet.

14.5 The grounding contact path, except for the metal housing or mounting, shall be of copper or a copper alloy or equivalent material. If a metal housing is a part of the primary equipment grounding path, it shall not be of zinc or a zinc based alloy.

14.6 A copper-based alloy rivet, which is used to hold parts together in the grounding-contact path or forms a part of the grounding path, shall contain not less than 80 percent copper.

14.7 A connection in the grounding-contact path shall be secured by riveting, bolting, welding or by an equivalent mechanical means of securement, capable of complying with the requirements of the Grounding Path Current Test, Section 41.

14.8 In mating devices provided with an equipment-grounding contact, the grounding contact shall not be capable of touching a line-side phase contact, independent of any polarization feature of the enclosure. Such devices shall comply with the requirements of the Polarization Integrity Test, Section 53.

14.9 All exposed non-current-carrying metal parts of a device that are likely to become energized, shall be conductively connected to the equipment ground.

14.10 Grounding and other dead metal parts shall be secured in place so that a reduction in spacings below those required in 12.1 is not likely.

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15 Grounding Connections

15.1 The grounding conductors of a device shall not be smaller in size than indicated in Table 15.1.

Table 15.1
Minimum acceptable sizes of grounding conductors

Device rating, amperes (Not exceeding)	Copper grounding conductors AWG (mm ²)
20	12 (3.3)
30	10 (5.3)
40	10 (5.3)
60	10 (5.3)
100	8 (8.4)
200	6 (13.3)
300	4 (21.2)
400	3 (26.7)
500	2 (33.6)
600	1 (42.4)
800	1/0 (53.5)

15.2 An integral grounding lead shall not be shorter than 152 mm (6 inches).

15.2 revised February 23, 2007

15.3 A terminal provided for the field connection of a grounding conductor shall:

- Employ a mechanical clamping means that does not depend upon solder for the connection of the wire, and
- Be capable of securing a conductor of the minimum size indicated in Table 15.1.

16 Terminal Parts

16.1 Devices shall be provided with suitable terminals or leads for the connection of conductors having an ampacity not less than the current rating for which they are intended. See 60.1.2 – 60.1.4, Table 16.1, and Table 16.2.

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Table 16.1
Minimum acceptable size of wire leads

Wire size		Ampacity ^{a,d} of insulated conductors		Ampacity ^{b,d} of flexible cord	
AWG	mm ²	60°C (140°F)	75°C (167°F)	A	B
18	0.88	—	—	7	10
16	1.3	—	—	10	13
14	2.1	15	15	15	18
12	3.3	20	20	20	25
10	5.3	30	30	25	30
8	8.4	40	50	35	40
6	13.3	55	65	45	55
4	21.2	70	85	60	70
3	36.7	85	100	—	—
2	33.6	95	115	80	95
1	42.4	110	130	—	—
1/0 ^{c,e}	53.5	125	150	—	—
2/0 ^{c,e}	67.4	145	175	—	—
3/0 ^{c,e}	85.0	165	200	—	—
4/0 ^{c,e}	107.2	195	230	—	—
kcmil					
250 ^{c,e}	127	215	255	—	—
300 ^{c,e}	152	240	285	—	—
350 ^{c,e}	177	260	310	—	—
400 ^{c,e}	203	280	335	—	—
500 ^{c,e}	253	320	380	—	—
600 ^{c,e}	304	355	420	—	—
700 ^{c,e}	355	385	460	—	—
750 ^{c,e}	380	400	475	—	—
800 ^{c,e}	405	410	490	—	—
900 ^{c,e}	456	435	520	—	—
1000 ^{c,e}	506	455	545	—	—
1250 ^{c,e}	633	495	590	—	—
1500 ^{c,e}	760	520	625	—	—
1750 ^{c,e}	887	545	650	—	—
2000 ^{c,e}	1013	560	665	—	—

^a These values of ampacity apply only if not more than three current carrying conductors are employed in a raceway or in a cable. Where the number of current carrying conductors intended to be installed in a raceway or in a cable exceeds three, the ampacities shall be reduced in accordance with Article 310-15 (b)(2)(a) of the National Electrical Code, ANSI/NFPA 70. Where the number of current carrying conductors in a flexible cord exceeds three, the ampacities shall be reduced in accordance with Article 400 of the National Electrical Code, ANSI/NFPA 70.

^b The ampacities under subheading A apply to 3-conductor cords and other multiconductor cords connected to utilization equipment so that only 3 conductors are current carrying. The ampacities under subheading B apply to 2-conductor cords and other multiconductor cords connected to utilization equipment so that only 2 conductors are current carrying.

^c For wire sizes 1/0 AWG and larger, it is assumed that wire with at least 75°C (167°F) temperature rating will be used at full 75°C (167°F) ampacity, unless marked with a minimum conductor size. See 60.1.2 and 60.1.4.

^d The ampacity of 90°C (194°F) wire shall be considered to be the same as:

1) 60°C (140°F) for wire ratings 100 amperes or less, unless the device is identified for use with 75°C (167°F) conductors, and

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Table 16.1 Continued

Wire size		Ampacity ^{a,d} of insulated conductors		Ampacity ^{b,d} of flexible cord	
AWG	mm ²	60°C (140°F)	75°C (167°F)	A	B
2) 75°C (167°F) wire for devices rated over 100 amperes. See 60.1.2 and 60.1.4. ^e For a multiple conductor (parallel) connector at a terminal, the ampacity value is to be multiplied by the number of conductors that the terminal will accommodate [1/0 AWG (53.5 mm ²) and larger conductors only].					

16.2 Pressure wire and set screw terminals used with single or multipole conductors shall comply with the applicable requirements in the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E.

16.3 A terminal plate that has a tapped hole for a soldering lug or pressure-wire connector shall be at least 1.27 mm (0.050 inch) thick and shall not have fewer than two full threads in the metal for a terminal screw.

16.4 Wiring terminals of a receptacle shall be located or protected so they are not likely to be forced against the wiring in the terminal box or compartment during installation.

Table 16.2
Ampacity of cable types W and G^{b,c}

AWG	Size mm ²	60°C (140°F)			75°C (167°F)		
		D ^a	E	F	D ^a	E	F
8	8.4	60	55	48	70	65	57
6	13.3	80	72	63	95	88	77
4	21.2	105	96	84	125	115	101
3	26.7	120	113	99	145	135	118
2	33.6	140	128	112	170	152	133
1	42.4	165	150	131	195	178	156
1/0 ^d	53.5	195	173	151	230	207	181
2/0 ^d	67.4	225	199	174	265	238	208
3/0 ^d	85.0	260	230	201	310	275	241
4/0 ^d	107.2	300	265	232	360	317	277
kcmil							
250 ^d	127	340	296	259	405	354	310
300 ^d	152	375	330	289	445	395	346
350 ^d	177	420	363	318	505	435	381
400 ^d	203	455	392	343	545	469	410
500 ^d	253	515	448	392	620	537	470

^a The ampacities under subheading D are the allowable ampacity for single-conductor Types W cable only where the individual conductors are not installed in raceways and are not in physical contact with each other except in lengths not to exceed 610 mm (24 inches) where passing through the wall of an enclosure. The ampacities under subheading E apply to 2-conductor cables and other multiconductor cables connected to equipment so that only 2 conductors are current-carrying. The ampacities under subheading F apply to 3-conductor cables and other multiconductor cables connected to equipment so that only 3 conductors are current-carrying.

^b For wire sizes 1/0 AWG and larger, it is assumed that wire with at least a 75°C (167°F) temperature rating will be used at full 75°C (167°F) ampacity, unless marked with a minimum conductor size. See 60.1.2 – 60.1.4.

^c The ampacity of 90°C (194°F) wire shall be considered to be the same as:

Table 16.2 Continued

AWG	Size mm ²	60°C (140°F)			75°C (167°F)		
		D ^a	E	F	D ^a	E	F
1) 60°C (140°F) wire for ratings 100 amperes or less, unless the device is identified for use with 75°C (167°F) conductors, and							
2) 75°C (167°F) wire for devices rated over 100 amperes.							
See 60.1.2 – 60.1.4.							
^d For a multiple conductor (parallel) connector at a terminal, the ampacity value is to be multiplied by the number of conductors that the terminal will accommodate [1/0 AWG (53.5 mm ²) and larger conductors only].							

16.5 Crimp type terminals can be provided with an inspection hole at the end of the crimp well to assure the full insertion of the conductor. Devices with crimp terminals shall be installed in accordance with the manufacturer's recommendations and be used with stranded conductors only.

16.6 Wire binding screws used in making electrical connections shall not be smaller than indicated in Table 16.1. Wiring terminal screws shall have no fewer than two threads of engagement into metal.

Table 16.3
Minimum sizes of wire binding screws

Contact rating, amperes	Minimum size of screw	Minimum head diameter ^a	Maximum number of threads per inch (per 25.4 mm)
15 or 20	6	7.0 mm (0.276 inch)	36 ^b
up to 35	8	8.3 mm (0.327 inch)	32 ^b
^a A No. 6 (M3) terminal screw, minimum head diameter 6.3 mm (1/4 inch), may be used on devices not intended for permanent installation and rated at 15 A. ^b No. 8 or larger screws having more than the number of threads per inch (per 25.4 mm) indicated may be used for terminals if the assembly is capable of withstanding a tightening torque of 1.8 N·m (16 lbf-in) applied to the wire-binding screw without stripping either the screw threads or the terminal plate threads, or damaging the slot in the heads of the screw. See 16.7.			

16.7 A binding screw that has 32 or more threads per inch (per 25.4 mm) with a terminal plate formed from stock 0.76 mm (0.030 inch) thick, can have the metal extruded at the tapped hole to provide two full threads for the binding screw.

16.8 The terminals of a device intended to accommodate No. 8 AWG or larger wire shall comply with the applicable requirements in the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E.

16.9 The tightening torque for the field wiring terminals of the devices mentioned in 16.3 and 16.8 shall be specified by the device manufacturer and shall be marked as described in 60.11.1. The specified tightening torque shall not be less than 90 percent of the value employed in the static heating test in the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E, for the maximum wire size corresponding to the ampere rating of the device.

Exception: A lesser torque value is able to be assigned if the connector is investigated in accordance with the Standard for Wire Connectors and Soldering Lugs for Use with Copper Conductors, UL 486A, or the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E using the lesser assigned torque value.