

UL 2231–2

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Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: Particular Requirements for Protection Devices for Use in Charging Systems

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UL Standard for Safety for Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits:
Particular Requirements for Protection Devices for Use in Charging Systems, UL 2231-2

First Edition, Dated May 1, 2002

The new requirements are substantially in accordance with UL's Bulletin(s) on this subject dated January 20, 1999 and August 26, 1996. The bulletin(s) is now obsolete and may be discarded.

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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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MAY 1, 2002

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Supply Circuits: Particular Requirements for Protection Devices for Use in
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May 1, 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.

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FOREWORD

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involves a risk of fire or of electric shock or injury to persons shall be evaluated using appropriate additional component and end-product requirements to maintain the level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this standard does not comply with this standard. Revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

INTRODUCTION

1 Scope

1.1 This standard is intended to be read together with the Standard for Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: General Requirements, UL 2231-1. The requirements of UL 2231-1 apply unless modified by this standard.

2 General

2.1 This Part contains the construction and performance requirements that are applied to a device that is intended to become an integral part of an overall device or charging system.

2.2 The Standard for Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: General Requirements, UL 2231-1 contains an outline of the features required to provide protection based on voltage and grounding or isolation of the system or part of the system under consideration.

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. See Appendix A for a list of standards covering components used in the products covered by this standard.

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.

CONSTRUCTION

6 General

6.1 The design, workmanship, and degree of production uniformity shall be such that the reliability of the device to perform the functions evaluated by the requirements is high.

7 Grounding

7.1 A grounding circuit shall comply with Part F of Article 250 of the National Electrical Code (NEC) with respect to the size of the grounding conductors.

7.2 All accessible parts of a device that are likely to become energized when arc-over, insulation failure, or the similar conditions occur, shall be connected together and to the terminals intended for an equipment grounding conductor.

7.3 Except as described in 7.4 the equipment grounding conductor shall be sized in accordance with Article 250 of the National Electrical Code (NEC).

7.4 When a charging circuit interrupting device is intended for use in a circuit where the voltage to ground is greater than 300 Vrms, the impedance of the grounding circuit shall not be higher than that value which limits the voltage to 150 Vrms on accessible parts with respect to earth at the site of the fault during a low impedance fault.

7.5 The accessible parts of a device intended for use on an isolated supply with not more than 150 Vrms between conductors are not required to be grounded.

7.6 Accessible parts that are double insulated from energized parts shall not be grounded unless the grounding path is monitored by use of a ground/monitor interrupter.

7.7 A portable device shall be provided with an equipment grounding conductor that extends to the vehicle connector. On the supply side of the interrupting contacts of the CCID, the equipment grounding conductor shall not be connected to accessible conductive parts. On the load side of the CCID interrupting contacts, the equipment grounding conductor shall be connected to the vehicle connector and shall not be connected to accessible metal unless permitted by the construction and potentials involved. See Table 6.1 of the Standard for Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: General Requirements, UL 2231-1.

8 Insulation and Protective Features

8.1 An interrupting device such as a charging circuit interrupting device, a grounding monitor/interrupter or an isolation monitor/interrupter, shall have insulation and features or accessories that are required for the voltage rating and type of system where use is intended. See Protective Systems, Section 6, of UL 2231-1 for insulation requirements and features.

8.2 Double insulation or reinforced insulation shall be provided in that part of a grounded circuit between the connections to the supply and the interrupting contacts of the charging circuit interrupting device.

8.3 A device that is required to be double insulated and is rated 120 or 120/240 Vrms or less shall comply with the requirements of the Standard for Double Insulation Systems for Use in Electrical Equipment, UL 1097.

8.4 A device that is required to be double insulated and is rated more than 120 or 120/240 Vrms shall comply with the intent of UL 1097.

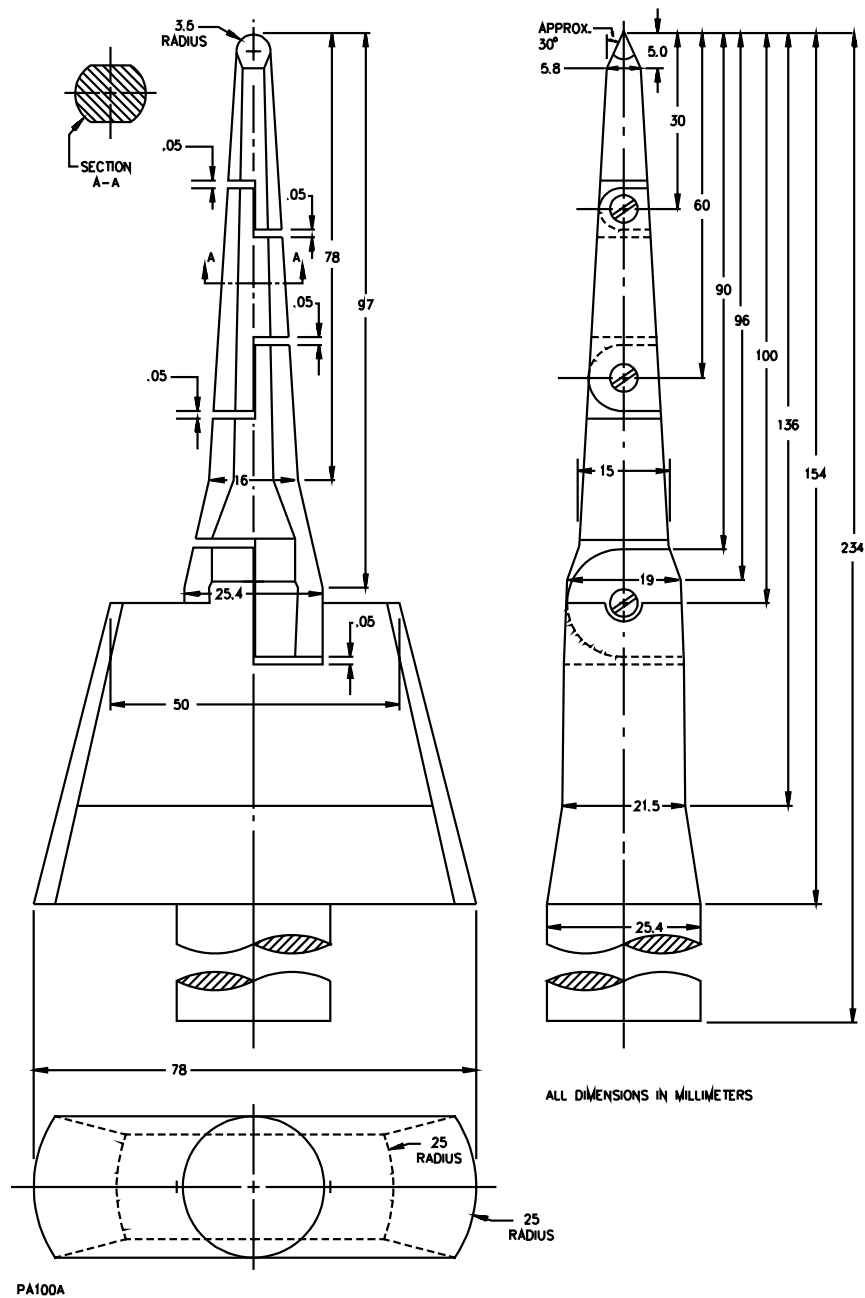
9 Accessibility of Energized Parts

9.1 Parts of a device that are capable of being energized during normal operation shall not be accessible.

9.2 In determining compliance with the provisions of 9.1:

- a) A part is determined to be accessible when it is capable of being touched by any part of the articulated probe, see Figure 9.1, under normal conditions,
- b) A permanently connected device is to be mounted as intended,
- c) A door or cover that is capable of being opened or removed without the use of a separate tool is to be open or removed,
- d) A door or cover that must be opened or removed in order to use a device is to be opened or removed, and
- e) Material that is not accepted as insulation is evaluated as conductive.

Figure 9.1
Articulated probe



^a The probe is to be used only as a gauge and inserted with minimal force. The probe shall be rotated with the moveable sections straight or in any possible position resulting from bending one or more sections in the same direction.

10 Internal Wiring

10.1 The gauge and insulation of wires shall withstand the mechanical and electrical stresses of service. Particular consideration should be given to the effect of vibration and user servicing where wire smaller than No. 24 AWG (0.21 mm²) is employed.

10.2 In a double-insulated device, there shall be at least one independent means provided at a wire termination or splice, which alone prevents the conductor from becoming free to bridge supplementary or reinforced insulation in the event that the wire breaks at the termination or splice. A wire-binding screw or nut, such as one with a spring-type lockwasher or equivalent, shall be suitably prevented from loosening under conditions where such loosening allows the attached conductor to become free to bridge supplementary or reinforced insulation.

10.3 Electrical splices and terminations shall provide effective, continuous conductivity.

10.4 In determining compliance of a clamped splice or termination with the provisions of 10.3, consideration is to be given to the risk of permanent deformation under mechanical load (creep).

11 Spacings

11.1 The spacings of a device are to be evaluated in accordance with:

- a) Spacings, Section 11, and Table 11.1, or
- b) Clearances and Creepage Distances, Section 12.

Exception: When a device is an integral part of a charging system, the spacings of the device are to be evaluated in accordance with the requirements in Spacings, Section 21, of the Standard for Safety for Electric Vehicle (EV) Charging System Equipment, UL 2202.

11.2 Except at field-wiring terminals, the through-air and over-surface spacings between conductive parts shall not be less than the values shown in Table 11.1.

11.3 Spacings at field wiring terminals shall not be less than the values shown in Table 11.2.

Table 11.1
Through-air and over-surface spacings

Parts separated by	Operating potential between parts									
	70 V peak or less			71 – 200 V peak			201 – 400 V peak			
	Through air		Over surface	Through air		Over surface	Through air		Over surface	
	Open ^a inch (mm)	Closed-in ^b inch (mm)	Open ^a inch (mm) Closed-in ^b inch (mm)	Open ^a inch (mm)	Closed-in ^b inch (mm)	Open ^a inch (mm) Closed-in ^b inch (mm)	Open ^a inch (mm)	Closed-in ^b inch (mm)	Open ^a inch (mm)	Closed-in ^b inch (mm)
Functional insulation ^c	1/16 ^d (1.6)	1/16 ^d (1.6)	1/16 ^d (1.6)	1/8 (3.2)	1/16 ^d (1.6)	1/4 (6.4)	1/4 (6.4)	1/16 (1.6)	1/4 (6.4)	1/8 (3.2)
Supplementary insulation	1/8 (3.2)	1/16 (1.6)	1/16 (1.6)	1/8 (3.2)	1/16 (1.6)	1/4 (6.4)	1/4 (6.4)	1/8 (3.2)	1/4 (6.4)	1/8 (3.2)
Double or reinforced insulation	1/4 (6.4)	1/8 (3.2)	1/8 (3.2)	1/4 (6.4)	1/8 (3.2)	1/2 (12.7)	1/2 (12.7)	1/4 (6.4)	1/2 (12.7)	1/4 (6.4)

^a A space that is not specially protected from deposition of dirt.
^b A space that is specially protected from deposition of dirt.
^c Smaller spacings may be acceptable where they are inherent in a suitable component.
^d Shall not be less than 1/32 inch (0.8 mm) at a printed wiring board without conformal coating.
^e For printed wiring boards with suitable conformal coating which has been determined to comply with the requirements for conformal coatings in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, spacings are able to be reduced to 1/32 inch (0.8 mm), and are able to be further reduced when the coating is determined to be suitable and a special dielectric withstand test is performed between the conductors.

Table 11.2
Field wiring terminals spacings

Voltage (RMS)	Spacing distance (over surface or through air)	
	Opposite polarity inch (mm)	To ground inch (mm)
0 – 150	1/4 (6.4)	1/2 (12.6)
151 – 300	3/8 (9.5)	1/2 (12.6)
301 – 600	1/2 (12.6)	1/2 (12.6)
601 – 1000	1 (25.4)	1 (25.4)

11.4 Except as permitted in note c to Table 11.1, when a groove or a slot in insulating material is less than 1/64 inch (0.4 mm) wide, the contour of the slot or groove is to be disregarded in measuring spacings over the surface.

11.5 Spacings measured along the boundary of insulating materials that have been joined together are regarded as over surface spacings unless it is shown that the dielectric strength of the boundary is not less than that of any of the materials joined.

11.6 In determining compliance with the provisions of Spacings, Section 11, or Clearances and Creepage Distances, Section 12, parts not locked in position, parts subject to random orientation (such as non-circular heads of screws), adjustable parts of terminal connectors, and similar parts, are to be moved to the most adverse position.

11.7 In determining spacings through openings in a housing of insulating material, the use of metal foil is permitted to bridge the opening but is not to be pressed into the opening.

11.8 Film-coated magnet wire is regarded as uninsulated in determining spacings.

12 Clearances and Creepage Distances

12.1 As an alternative to the spacings requirements specified in Spacings, Section 11, and other than as noted in 12.2 and 12.3, clearances and creepage distances are able to be evaluated in accordance with the requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, as described in 12.4.

12.2 Clearances between an uninsulated live part and the walls of a metal enclosure, including fittings for conduit or armored cable, shall be as noted in this section. The clearances shall be determined by physical measurement.

12.3 The clearance and creepage distance at field wiring terminals shall be in accordance with the requirements in Spacings, Section 11.

12.4 In conducting evaluations in accordance with the requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, the following guidelines shall be used:

- a) Unless specified elsewhere in this standard, the pollution degree shall be regarded as pollution degree 3;
- b) Equipment which operates in the direct line of the source of power to the load equipment shall be regarded as Overvoltage Category II. Other equipment covered under this Standard shall be regarded as Overvoltage Category III;
- c) Pollution degree 2 is regarded as existing on a printed wiring board between adjacent conductive material that is covered by any coating which provides an uninterrupted covering over at least one side and the complete distance up to the other side of conductive material;
- d) Any printed-wiring board which complies with the requirements in the Standard for Printed-Wiring Boards, UL 796, shall be identified as providing a Comparative Tracking Index (CTI) of 100, and if it further complies with the requirements for Direct Support, Section 22, in UL 796 then it shall be identified as providing a CTI of 175;
- e) For the purposes of compliance with the requirements for coatings of printed-wiring boards used to achieve pollution degree 1 in accordance with UL 840, a coating which complies with the requirements for Conformal Coatings, Section 44, in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, meets the intent of the requirement;
- f) Pollution degree 1 is also capable of being achieved at a specific printed-wiring board location by application of at least a 1/32-inch (0.79-mm) thick layer of silicone rubber or for a group of printed-wiring boards through potting, without air bubbles, in epoxy or potting material;
- g) Evaluation of only clearances to determine equivalence with current through air spacings requirements is capable of being conducted in accordance with Clearance A (Equivalency), Section 4, of UL 840. An impulse test potential having a value as determined in UL 840 is to be applied across the same points of the device as is required for the Dielectric Voltage-Withstand Test, Section 24;
- h) Evaluation of clearances and creepage distances shall be conducted in accordance with the requirements in UL 840 for Clearance B (Controlled Overvoltage), Section 5, and Creepage Distances, Section 6;
- i) The voltage used in the determination of clearances shall be the equipment phase-to-ground rated supply voltage, or the voltage measured in the circuit under consideration, rounded to the next higher value (in the table for determining clearances for equipment) for all points on the supply side of an isolating transformer or the entire product when no isolating transformer is provided. The system voltage used in the evaluation of secondary circuitry is capable of being interpolated with interpolation continued across the table for the rated impulse voltage peak and clearance; and
- j) Determination of the dimensions of clearances and creepage distances shall be conducted in accordance with the requirements for Measurement of Clearances and Creepage Distances, Section 7, of UL 840.

13 Operating Mechanism

13.1 Compliance with the provisions of System Operational Test Requirements, Section 21, shall not be prevented by manipulation or restraint of accessible control levers, knobs, and similar parts, of a device.

13.2 A device that has tripped in accordance with the provisions of System Operational Test Requirements, Section 21, shall not be capable of automatic reclosure.

Exception No. 1: A device with an automatic supervisory circuit shall be permitted to have an automatic reset function which permits operation following an acceptable test.

Exception No. 2: A device that has been evaluated to the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991, the Standard for Software in Programmable Components, UL 1998, or both, shall be permitted to have an automatic reset function when:

- a) There is a delay of 15 minutes between the tripping function and the reset, and*
- b) The device does not reset more than 4 times.*

A manual intervention is able to override the delay to the automatic reset. See 37.4.

13.3 A device that trips immediately due to closing onto a fault shall not automatically reset.

13.4 Under the condition where a device opens because of a loss of power on the line side, it shall automatically continue to provide service when power is restored.

13.5 In a permanently-connected device that is not capable of tripping without power from the line, the grounded circuit conductor shall be electrically continuous during normal operation of the device.

13.6 A 120/240 Vrms or polyphase device shall function to provide protection with one or more ungrounded line terminals energized.

Exception: The device is able to automatically disconnect the load when one or more ungrounded line terminals become de-energized, when that is capable of leading to a condition that results in the risk of injury to persons.