

Underwriters Laboratories Inc.
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UL Standard for Safety
for

Vehicle Battery Adapters, UL 2089

First Edition, Dated June 2, 1994

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Page	Date
1	June 2, 1994 (Reprinted November 2, 1995)
2	—
3 ? 31, A1.....	June 2, 1994

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1

UL 2089

Standard for

Vehicle Battery Adapters

First Edition

June 2, 1994

Approval as an American National Standard (ANSI) covers the numbered paragraphs on pages dated June 2, 1994. These pages should not be discarded when revised or additional pages are issued if it is desired to retain the ANSI approved text.

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

Approved as ANSI/UL 2089-1995, May 10, 1995

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 published set of revision pages.

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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 employing materials or having forms of construction differing from those detailed in the requirements of this Standard may be examined and tested according to the intent of the requirements and, if found to be substantially equivalent, may be judged to comply with the 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

Section 1 effective December 4, 1995

1.1 These requirements cover portable adapters rated 24 volts dc or less that are intended to be supplied from the battery-powered electrical system of a vehicle and used in accordance with the National Electrical Code, NFPA 70. Connection to a vehicle electrical system in which the vehicle chassis is connected to the negative side of the battery supply, is by means of a connector intended for insertion into the cigarette lighter receptacle. Vehicle battery adapters may supply outputs for appliances such as portable radios, tape players, battery chargers, and tools.

1.2 Products covered by this standard include:

- a) Cord assemblies consisting of the connector for insertion into a cigarette lighter receptacle, adjacent cord, and connector intended for connection to an appliance; and
- b) Units consisting of the connector for insertion into a cigarette lighter receptacle, adjacent cord, and permanently attached filtering or regulating circuitry which may include an additional enclosure, output cord, and connector or battery receptacle.

1.3 This standard does not cover products intended for marine use in areas where ignition-protected equipment is required.

1.4 Power inverters intended to be supplied from the cigarette lighter receptacle of a vehicle are covered by the requirements in the Standard for Power Converters/Inverters and Power-Converter/Inverter Systems for Land Vehicles and Marine Craft, UL 458.

1.5 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, electric shock, or injury to persons shall be evaluated using the appropriate additional component and end-product requirements as determined necessary to maintain the acceptable 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 cannot be judged to comply with this standard. Where considered appropriate, revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

2 Components

Section 2 effective December 4, 1995

2.1 Except as indicated in 2.2, a component of a product covered by this standard shall comply with the applicable requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this standard.

2.2 A component need not comply with a specific requirement that:

- a) Involves a feature or characteristic not needed in the application of the component in the product covered by this standard; or
- b) Is superseded by a requirement in this standard.

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

2.4 Specific components are considered as being 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 for which they have been evaluated.

3 General

Section 3 effective December 4, 1995

3.1 Units of measurement

3.1.1 If a value for measurement is followed by a value in other units in parentheses, the second value may be only approximate. The first stated value is the requirement.

3.2 Undated references

3.2.1 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.

4 Glossary

Section 4 effective December 4, 1995

4.1 For the purpose of this standard the following definitions apply.

4.2 CIGARETTE LIGHTER CONNECTOR ? The male connector provided as part of a vehicle battery adapter for insertion into a cigarette lighter receptacle.

4.3 CIGARETTE LIGHTER RECEPTACLE ? The female connector typically provided in a vehicle for the purpose of energizing the vehicle's cigarette lighter. The connector typically has the center contact connected to the positive side of the vehicle battery supply and the outer shell is connected to the negative (chassis) side of the supply.

4.4 CLASS 2 OUTPUT ? An output complying with the construction, performance, and marking requirements in the Standard for Class 2 Power Units, UL 1310.

4.5 DIRECT CURRENT (DC) ? A voltage or current waveform where the instantaneous value does not vary.

4.6 LOW-VOLTAGE LIMITED-ENERGY (LVLE) CIRCUIT ? A circuit involving a potential of not more than 42.4 volts peak for AC, or 60 V DC, with limited energy as described in Low-Voltage Limited-Energy Circuits, 14.2.

4.7 RISK OF ELECTRIC SHOCK ? A risk of electric shock is considered to exist if the voltage between parts exceeds the value specified in 15.2.2.

4.8 RISK OF FIRE ? A risk of fire is considered to exist if the conditions as specified in 26.1.2(a) and (b) occur.

4.9 RISK OF INJURY ? A risk of injury to persons is considered to exist if one or more of the following conditions exist:

- a) If sharp edges, burrs, or projections are present that may result in injury during use or servicing.
- b) If the stability of a product is such that it may result in injury to persons.
- c) If there is likelihood that a part of the body could be endangered or that clothing would be entangled by the moving part, resulting in injury to persons.

The words "injury to persons" are in reference to physical harm to persons other than the physiological effects of electric shock.

4.10 TOOL ? A screwdriver, coin, key, or any other object that may be used to operate a screw, latch, or similar fastening means.

CONSTRUCTION

5 Mechanical Assembly

Section 5 effective December 4, 1995

5.1 A unit shall be formed and assembled so that it will have the strength and rigidity necessary to resist the abuses to which it is likely to be subjected, without resulting in a risk of fire, electric shock, or injury to persons due to total or partial collapse with resulting reduction of spacings, loosening or displacement of parts, or other defects.

5.2 A unit shall have all parts reliably secured in place.

5.3 An enclosure, an opening, a frame, a guard, a knob, a handle, or the like shall not be sufficiently sharp to constitute a risk of injury to persons in normal maintenance or use.

5.4 A unit shall be constructed so that it will not be necessary to open or remove the enclosure when the unit is used as intended.

5.5 Each lampholder, switch, and similar component shall be mounted securely and shall be restrained from turning by more than friction between surfaces. For example, the use of a lock washer is an acceptable means to restrain the turning of a device having a single hole mounting means.

Exception No. 1: A lampholder of a type in which the lamp cannot be replaced (such as a neon pilot or indicator light in which the lamp is sealed in by a nonremovable lens) need not be restrained from turning if rotation does not reduce spacings below the minimum acceptable values or produce stress on an electrical connection.

Exception No. 2: A switch or other similar component need not comply with this requirement if the turning of such a component and servicing of the part introduces no additional risk of fire or electric shock, such as reduced spacings below minimum acceptable values or stress on an electrical connection.

5.6 A replaceable lamp in a unit shall be replaceable without opening the enclosure.

5.7 A nonreplaceable pilot lamp, such as an indicating-type overload- or short-circuit protector, a neon light, or an indicator light, is one in which the lamp is sealed-in, such as by an unremovable lens.

5.8 A switch or an overcurrent-protective device shall be located within the unit enclosure and protected in such a manner as not to be accessible or exposed to tampering nor subject to mechanical damage during normal use or as a result of abuse. This requirement does not apply to the actuating means of a switch.

5.9 The requirements in 5.8 also apply to the actuating means ? toggle, handle, or the like ? if the dislodging of such part exposes live parts or film-coated magnet wire that can be contacted as specified in Accessibility of Live Parts, Section 15.

6 Enclosure

Section 6 effective December 4, 1995

6.1 A unit shall be provided with an enclosure that shall house all current-carrying parts that present a risk of electric shock. The enclosure shall have the strength and properties necessary to reduce the risk of mechanical damage to the various parts.

6.2 A unit shall have no openings larger than those complying with Section 15.

6.3 If an acceptable grade of vulcanized fiber is used as part of the enclosure for the support of parts (terminals and the like) that do not present a risk of fire or electric shock, the amount of fiber shall not be more than is necessary to support the parts in question. The fiber shall not be less than 1/32 inch (0.8 mm) thick and shall not introduce a risk of fire, electric shock, or injury to persons as a result of abuse.

6.4 An enclosure constructed of sheet metal shall be formed from stock having a thickness not less than that specified in Table 6.1. The thickness of enclosure sheet metal other than steel or aluminum shall not be less than that specified in Table 6.1 for uncoated steel and shall have the necessary strength and rigidity.

Table 6.1
Minimum acceptable thickness of enclosure metal

Metal	At small, flat, unreinforced surfaces and at surfaces of a shape or size to provide adequate mechanical strength	
	Inches	Millimeters
Die-cast	3/64	(1.2)
Cast malleable iron	1/16	(1.6)
Other cast metal	3/32	(2.4)
Uncoated sheet steel	0.026	(0.66)
Galvanized sheet steel	0.029	(0.74)
Nonferrous sheet metal other than copper	0.036	(0.91)
Copper	0.033	(0.84)

6.5 In addition to the performance tests specified in this standard, the material of a polymeric enclosure shall have a minimum flammability classification of 94V-0, 94V-1, or 94V-2 and shall provide the level of performance specified in Table 6.2 for the corresponding electrical properties.

Exception: An enclosure material may be accepted based on the end-product tests specified in the Standard for Polymeric Materials ? Use in Electrical Equipment Evaluations, UL 746C.

Table 6.2
Maximum performance level category (PLC) for enclosure material

Test specified ^a	Flammability rating of material ^a		
	94V-0	94V-1	94V-2
High current arc ignition (HAI)	3	2	2
Hot wire ignition (HWI)	4	3	2

^a HAI and HWI are determined in accordance with the Standard for Polymeric Materials □ Short Term Property Evaluations, UL 746A. Flammability ratings are determined in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

6.6 A conductive coating applied to a nonmetallic surface such as the inside surface of a cover, enclosure, and the like shall comply with the applicable requirements in the Standard for Polymeric Materials ? Use in Electrical Equipment Evaluations, UL 746C, unless it can be determined that flaking or peeling of the coating does not result in a reduction of spacings or the bridging of live parts that may result in a risk of fire, electric shock, or injury to persons.

6.7 An adhesive used in the assembly of the enclosure shall be investigated as specified in the Standard for Polymeric Materials ? Use in Electrical Equipment Evaluations, UL 746C.

Exception: Methods utilizing fusion techniques, such as solvent cementing, ultrasonic welding, electromagnetic induction, and thermal welding need not be investigated.

7 Protection Against Corrosion

Section 7 effective December 4, 1995

7.1 Except as noted in 7.2, iron and steel parts shall be protected against corrosion by galvanizing, plating, enameling, or other equivalent means if the corrosion of such unprotected parts would be likely to result in a risk of fire, electric shock, or injury to persons.

7.2 The requirement in 7.1 applies to all enclosing cases or to other parts upon which intended mechanical operation may depend. It does not apply to laminations and small minor parts of iron or steel, such as washers, screws, and bolts, that are not current carrying, if the corrosion of such unprotected parts would not be likely to result in a risk of fire, electric shock, or injury to persons, or result in the device not operating as intended. A part made of stainless steel does not require additional protection against corrosion.

8 Switches

Section 8 effective December 4, 1995

8.1 The requirements in 8.2 and 8.3 apply to switches not in a Class 2 circuit, and to switches in a Class 2 circuit the breakdown of which electrically or mechanically is likely to result in a risk of fire or electric shock.

8.2 A switch subjected to a temperature higher than 50°C (122°F) is to be investigated with respect to the temperature limits of the materials used.

8.3 A switch or other control device shall be acceptable for the application and shall have current and voltage ratings not less than those of the load that it controls.

9 Protective Devices

Section 9 effective December 4, 1995

9.1 A protective device built into a unit shall comply with the requirements for that device.

9.2 Crossed or nicked (reduced) cross-section conductors shall not be employed as a protective device.

9.3 Protective devices as mentioned in 9.1 include, but are not limited to, eutectic material, fuses, overtemperature and overcurrent protectors, thermal protectors, and similar devices intended to interrupt or limit the flow of current as a result of overload.

9.4 A manually reset thermostat shall be so constructed that automatic tripping of the thermostat is not precluded by any setting or position of the reset mechanism.

9.5 An automatically or manually reset protective device or replaceable overcurrent-protective device shall not open when the unit is delivering its rated output. See Temperature Test, Section 24.

9.6 A fuse or protective device shall be located in or adjacent to the cigarette lighter connector in the positive side of the supply.

9.7 The fuse or protective device required by 9.6 shall have a current rating not exceeding 8 amperes for a unit intended to be used with a 12-volt d-c supply, and 4 amperes for a unit intended to be used with a 24-volt d-c supply.

9.8 If the fuse or protective device is not located within the cigarette lighter connector, the length of wire between the connecting means and the protective device shall not be greater than 5 inches (127 mm).

9.9 A protective device shall be acceptable for the application and shall have voltage and current ratings not less than those of the circuit in which it is connected.

10 Components

Section 10 effective December 4, 1995

10.1 A component ? a fixed resistor, PTC or NTC resistor, diode, or the like ? used to limit the output of a unit to within the required current or power levels, or otherwise used to obtain acceptable performance, shall have permanence and stability so as not to decrease its limiting capacities. Among the factors considered when determining the acceptability of a limiting component are:

- a) Effect of operating temperature,
- b) Electrical stress level, and
- c) Resistance to moisture.

11 Coil Insulation

Section 11 effective December 4, 1995

11.1 Coil insulation, unless inherently moisture resistant, shall be treated so as to render it moisture resistant.

11.2 Film-coated magnet wire is considered moisture resistant.

12 Flexible Cords

Section 12 effective December 4, 1995

12.1 A unit shall be provided with a flexible cord and shall be type SP-2, SPE-2, SPT-2, SV, SVE, SVT, S, SE, SO, SP-3, SPT-3, ST, STO, SJ, SJE, SJO, SJT, or SJTO. The length of cord external to the unit and including the cigarette lighter connector shall not be less than 3 feet (0.9 m) as measured from the end of the cigarette lighter connector to the point of attachment or entry.

Exception No. 1: Output wiring for Class 2 or Low Voltage Limited Energy circuits may be parallel cord insulated with rubber, neoprene, or thermoplastic having a wall thickness of not less than 0.013 inch (0.33 mm).

Exception No. 2: An equivalent style appliance wiring material (AWM) may be employed.

13 Input Contacts

Section 13 effective December 4, 1995

13.1 The diameter of the center (positive) contact shall not be less than 9/64 inch (3.57 mm).

14 Output Connections

Section 14 effective December 4, 1995

14.1 General

14.1.1 A unit shall be provided with means for connection of the output consisting of a cord, insulated leads, or output connectors.

14.2 Low voltage limited energy circuits

14.2.1 A low-voltage limited-energy (LVLE) circuit is defined as a circuit with an open-circuit potential of not more than 42.4 volts peak ac, or 60 volts dc, with the energy available to the circuit limited:

- a) So that the current under any condition of load including short circuit is not more than 8 amperes for potentials up to 42.4 volts peak, and $150/V_{\max}$ for potentials from 30 to 60 volts dc, measured after 1 minute of operation by:
- 1) An isolating transformer, or
 - 2) A fixed impedance or reliable regulating network; or
- b) By a fuse or nonadjustable manually reset circuit protective device that is rated or set at not more than the value specified in Table 14.1.

Table 14.1
Rating for fuse or circuit protector

Open-circuit potential, volts	Current rating, amperes
0 ? 21.2 (peak)	5
21.3 ? 42.4 (peak)	3.2
Over 30 to 60 dc only	$150/V_{\max}^a$

^a V_{\max} is defined as the maximum voltage obtained under any condition of load or no load in volts rms.

14.3 Output connectors

14.3.1 Output connectors mounted on the enclosure and intended for direct connection of accessories, such as separable battery holders and the like, shall provide a secure connection between mating parts. The connections shall be polarized if the output is direct-current or if multiple outputs are provided.

14.3.2 A fitting having female contacts shall be constructed so that it will not receive the blades of a standard attachment plug. A fitting having male contacts shall be constructed so that the contacts will not touch a live part of a standard attachment-plug receptacle.

14.4 Bushings

14.4.1 At a point where a flexible cord passes or is intended to pass through an opening in a metal wall, barrier, or enclosing case, there shall be a bushing or the equivalent that shall:

- a) Be secured in place, and
- b) Have a smooth, rounded surface against which the cord may bear.

14.4.2 If the cord hole is in a nonconducting material, a smooth, rounded surface is considered to be the equivalent of a bushing.

15 Accessibility of Live Parts

Section 15 effective December 4, 1995

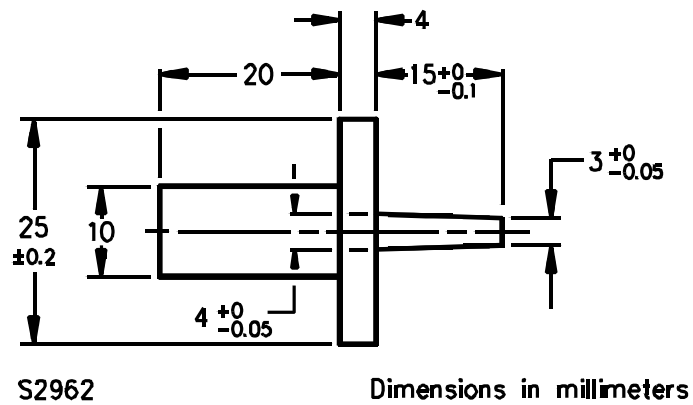
15.1 General

15.1.1 A live part that presents a risk of electric shock shall be located or enclosed so that protection against contact is provided.

15.1.2 The input impedance of the voltmeter used to measure voltage in accordance with the requirements of 15.2.1 and 15.3.1 is to be a minimum of one megohm. The input impedance of a meter with more than one megohm input impedance can be lowered by using shunt impedance.

15.1.3 A guard, baffle, or cover that can be removed without using a tool is to be removed when determining if a live part is accessible to the user. A live part that can be contacted by the test pin, articulate probe, or accessibility probe illustrated in Figure 15.1, Figure 15.2, or Figure 15.4, is considered to be accessible.

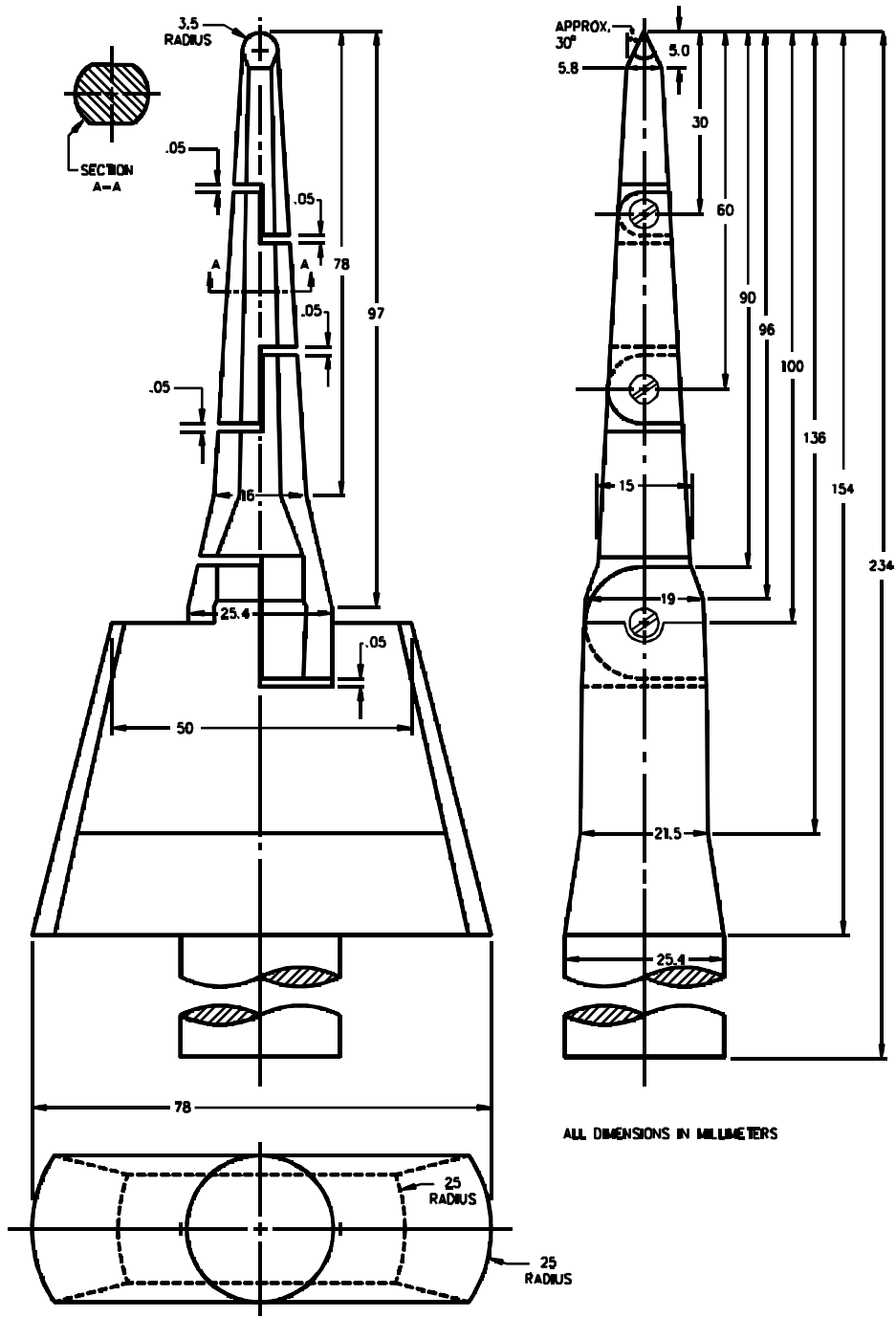
Figure 15.1
Test pin



15.2 Live parts other than exposed wiring terminals

15.2.1 The test pin and articulate probe illustrated in Figures 15.1 and 15.2, respectively, when applied as described in 15.2.3, shall not contact any live part with a voltage greater than that specified in 15.2.2 with respect to the vehicle chassis or any other live part simultaneously accessible, in a different location, to the test pin or articulate probe.

Figure 15.2
Articulate probe with web stop



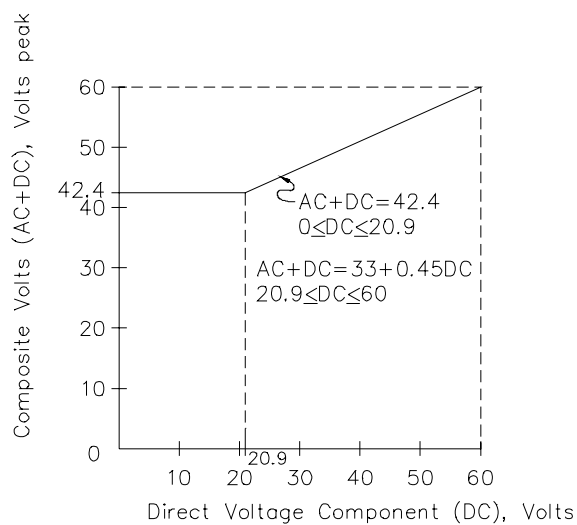
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15.2.2 The maximum voltages which may be accessible in accordance with 15.2.1 are:

- a) 42.4 volts peak for sinusoidal or nonsinusoidal ac;
- b) 60 volts for continuous dc;
- c) 24.8 volts peak for dc interrupted at a rate of 200 Hz or less with approximately 50 percent duty cycle; and
- d) As indicated in Figure 15.3 for combinations of ac and dc.

Exception: The voltage limits specified may be exceeded if the current through a 1500 ohm resistor connected between the accessible points does not exceed 0.5 mA.

Figure 15.3
Maximum acceptable voltage



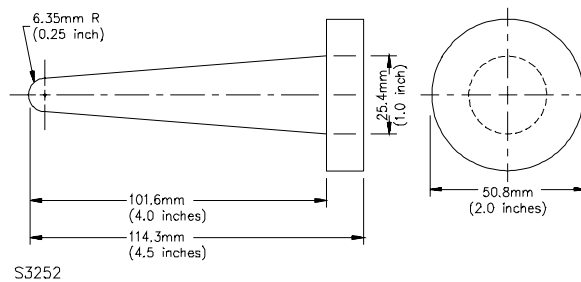
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15.2.3 The test pin and articulate probe referenced in 15.2.1 are to be applied with a force not exceeding 1 pound (4.4 N) to determine whether the live parts are accessible. The test pin shall not be applied to fuseholders and the like.

15.3 Exposed wiring terminals

15.3.1 The accessibility probe illustrated in Figure 15.4, when applied as described in 15.3.3 shall not contact an exposed wiring terminal with a voltage greater than that specified in 15.3.2 with respect to the vehicle chassis or to any other terminal simultaneously accessible to the probe.

Figure 15.4
Accessibility probe



15.3.2 The maximum voltages which may be accessible in accordance with 15.3.1 are:

- a) 42.4 volts peak for sinusoidal or nonsinusoidal ac;
- b) 42.4 volts for continuous dc;
- c) 24.8 volts peak for dc interrupted at a rate of 200 Hz or less with approximately 50 percent duty cycle; and
- d) 42.4 volts peak for combinations of ac and dc.

15.3.3 The accessibility probe referenced in 15.3.1 is to be applied with a force not exceeding 5.62 pounds (25 N) to determine whether the exposed wiring terminals are accessible.

16 Live Parts

Section 16 effective December 4, 1995

16.1 A current-carrying part shall be silver, copper, a copper alloy, plated iron or steel, stainless steel, or other corrosion-resistant alloys acceptable for the application.

16.2 An uninsulated live part shall be secured to the base or mounting surface so that it will not turn or shift in position if such motion may result in a reduction of spacings below the minimum acceptable values.

16.3 Friction between surfaces is not acceptable as a means to prevent shifting or turning of a live part but a lock washer is acceptable.

17 Strain Relief

Section 17 effective December 4, 1995

17.1 Strain relief shall be provided between the cigarette lighter connector and its adjacent cord, and shall be tested in accordance with the Strain Relief Test, Section 28.

17.2 Means shall be provided to prevent the cord or wiring from being pushed into the enclosure if such displacement is likely to subject the wiring to mechanical damage or to exposure to a temperature higher than that for which the wiring is rated, or is likely to reduce spacings below the minimum acceptable values.

18 Internal Wiring

Section 18 effective December 4, 1995

18.1 The internal wiring of a unit shall consist of insulated conductors having mechanical strength, dielectric properties, and ampacity for the application.

18.2 Each splice and connection shall be mechanically secure, shall provide reliable electrical contact, and shall be provided with insulation at least equivalent to that of the wire involved unless acceptable permanent spacing between the splice and all other metal parts will be maintained. When determining the required minimum thickness of splice insulation, the circuit voltage and interaction with other circuits shall be taken into consideration.

18.3 A wire connector for making a splice in a unit shall be a type that is applied by a tool in which the applicable force of the tool making the splice is independent of the force applied by the operator of the tool.

18.4 The connection between a lead, including a flexible cord, and the transformer winding or other part of the unit shall be soldered, welded, or otherwise securely connected within the enclosure. A soldered joint shall be mechanically secure before soldering.

18.5 If a lead is rigidly held in place without the use of solder, or if it is retained in place so as not to be subjected to any motion, no additional mechanical security is required. Mechanical securement of a lead is not required if separation of the connection does not result in a risk of fire or electric shock.

18.6 Unless it is to be considered as an uninsulated live part, insulated internal wiring ? including an equipment-grounding conductor ? shall consist of wire of a type or types acceptable for the applicable, when considered with respect to:

- a) The temperature and voltage to which the wiring is likely to be subjected;
- b) Exposure to oil, grease, cleaning fluid, or other substances likely to have a deleterious effect on the insulation; and
- c) Other conditions of service to which it is likely to be subjected.

18.7 An insulated conductor shall be located or protected to reduce the risk of contact with any sharp edge, burr, fin, moving part, or the like, that can damage the conductor insulation.

19 Insulating Materials

Section 19 effective December 4, 1995

19.1 Integral parts such as insulating washers and bushings, and bases or supports for mounting of live parts, shall be of moisture-resistant materials that will not be damaged by the temperatures and stresses to which they will be subjected under conditions of actual use.

19.2 An insulating material is to be investigated with respect to its acceptability for the application in accordance with the Standard for Polymeric Materials ? Use in Electrical Equipment Evaluations, UL 746C. Materials, such as mica, ceramic, or some molded compounds are usually acceptable for use as the sole support of live parts. If it is necessary to investigate a material to determine its acceptability, consideration is to be given to such factors as its mechanical strength, resistance to ignition sources, dielectric strength, insulation resistance, and heat-resistant properties in both the aged and unaged conditions, the degree to which it is enclosed, and any other features that could result in a risk of fire and electric shock.

20 Printed Wiring Boards

Section 20 effective December 4, 1995

20.1 A printed wiring board in a unit shall comply with the Standard for Printed-Wiring Boards, UL 796, and shall be classed 94V-1 or less flammable, in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception: A 94V-2 printed wiring board may be used if the unit is closed beneath the material or has an equivalent barrier.

PERFORMANCE

21 General

Section 21 effective December 4, 1995

21.1 The number of representative samples indicated in Table 21.1 shall be subjected to the tests described in Sections 22 ? 28. Unless otherwise specified, all tests are to be conducted at the marked d-c voltage. The test supply of rated voltage shall have a minimum capacity of 30 amperes.

21.2 With respect to 21.1 and footnotes a and b of Table 21.1, a sample may be used for more than one test, provided that the previous test did not damage the sample.

21.3 The cheesecloth mentioned in this standard is to be bleached cheesecloth running 14 ? 15 square yards per pound mass (approximately 26 ? 28 square meters per kilogram mass) and having what is known in the trade as a "count of 32 by 28," that is, for any square inch, 32 threads in one direction and 28 threads in the other direction (for any square centimeter, 13 threads in one direction and 11 in the other direction).

21.4 The tests described in Sections 22 ? 28 are to be conducted in an ambient air temperature within the range of 21 ? 30°C (70 ? 86°F).

Exception: The normal temperature test described in Section 24 with or without standard fuses, but without the other forms of overcurrent or overtemperature protectors may be conducted in an ambient air temperature within the range of 10 ? 40°C (50 ? 104°F).

Table 21.1
Performance tests

Section	Test	Number of samples to be subjected to test
22	Maximum Output Voltage	1
23	Power Input	1
24	Temperature	1
25	Dielectric Voltage Withstand	1
26	Abnormal: Battery-Supply Cord	
	Short Circuit	3
	Reverse Polarity	1
	Component Malfunction or Breakdown	1 ^a
28	Strain Relief	1
	Abuse:	
27	Resistance to Crushing	1
—	Tests for Thermoplastic Enclosures	b
	Mold Stress Relief Distortion	1
	Strain Relief Test after Mold Stress Relief Distortion	1

^a Additional samples may be required if multiple components are present. One sample is required for each component to be faulted.

^b Based on the Standard for Polymeric Materials ? Use in Electrical Equipment Evaluations, UL 746C.

21.5 For tests which specify rated load conditions, a sample is to be connected to the load specified in Table 21.2.

Table 21.2
Unit output loading

Intended use	Load for test
Other than battery charger	Variable resistor adjusted to result in rated output current.
Battery charger	Variable resistor in parallel with a 10,000 microfarad capacitor adjusted to result in rated output current; or, for the temperature test, a load as noted in 23.3, 23.4 or 23.5 if a battery charger is intended for use with specific batteries.

21.6 With reference to Table 21.2, if an output is rated in watts or volt-amperes, the rated output current is considered to be the quotient of the watt or volt-ampere rating and the voltage rating.

22 Maximum Output Voltage Test

Section 22 effective December 4, 1995

22.1 The maximum output voltage under any load condition (including no load) between any two output terminations of a unit shall not be more than the peak voltages specified in 15.2.2.

22.2 If a unit has more than one pair of output terminations, the output voltage mentioned in 22.1 is to be measured with any combination of interconnections of the output terminations.

22.3 The maximum voltage between output terminations of a multiple output unit may exceed the values specified in 22.1 when the output terminations are interconnected, if the following conditions are met:

- a) The maximum output voltage between any two terminations is not more than the values indicated in 15.2.2 when no connections are made between the output terminations; and
- b) The unit is marked in accordance with 29.1.6.

23 Power Input Test

Section 23 effective December 4, 1995

23.1 The current or watts input to a vehicle battery adapter, when connected to a supply adjusted to the rated input voltage and supplying rated output into a load as described in Table 21.2, shall not be more than 110 percent of the rated value.

23.2 A battery charger intended for use with a specific battery pack shall be tested using the battery pack as its intended load.

23.3 If a vehicle battery adapter intended to charge batteries is to be tested using a lead-acid battery or batteries as the load, each battery is to be discharged to 1.75 volts per cell ? measured with the load connected ? at a rate not to exceed the discharge rate assigned by the battery manufacturer, but in any case, the rate of the discharge is not to exceed one-sixth of the ampere-hour capacity of the battery. See Table 21.2.

23.4 If a battery charger is to be tested with a typical 1.2 volt per cell nickel-cadmium battery or batteries as the load, each battery is to be discharged to 0.9 volts per cell ? measured with the load connected ? at a rate not to exceed the discharge rate assigned by the battery manufacturer.

23.5 If a battery charger is to be tested with a battery or batteries other than those specified in 23.3 and 23.4, the battery is to be discharged in accordance with the battery manufacturer's maximum recommended discharge rate to an appropriate discharge voltage.

24 Temperature Test

Section 24 effective December 4, 1995

24.1 The unit shall be mounted as in intended service and connected as described in 23.1. With the unit operating at its maximum marked duty cycle, the unit shall not reach a temperature at any point high enough to cause a risk of fire, to damage any material used, or to exceed the temperature rises specified in Table 24.1.

Table 24.1
Maximum acceptable temperature rises

	°C	°F
A. COMPONENTS		
1. Fuses	65	117
2. Rubber- or thermoplastic-insulated conductors ^a	35	63
3. Silicon components ^b	75	135
B. ELECTRICAL INSULATION ? GENERAL		
1. Class 105 insulation systems:		
Resistance method	75	135
Thermocouple method	65	117
2. Class 130 insulation systems:		
Resistance method	95	171
Thermocouple method	85	153
3. Fiber employed as electrical insulation	65	117
4. Phenolic composition ^a	125	225
5. Varnish-cloth insulation	60	108
C. SURFACES		
1. Surface temperature, nonmetallic ^c	50	90
2. Wood or similar material	65	117
^a The limitation on phenolic composition, rubber and thermoplastic insulation does not apply to compounds that have been investigated and found to be acceptable for use at a higher temperature. The maximum acceptable temperature rise in any case is 25°C (77°F) less than the acceptable temperature limit in question.		
^b Does not apply to a material that has been investigated and found acceptable for a higher temperature.		
^c A material having a coefficient of thermal conductivity greater than 2.419 Btu per hour per square foot per foot per degree Fahrenheit (0.01 c/s/cm ² /cm/°C) is considered to be metal.		

24.2 If the load specified in 23.1 includes a variable resistance, the load is to be adjusted after 15 minutes of operation, if necessary, to return the output to the original value. If the load consists of a battery, the battery shall be discharged as specified in 23.4 or 23.5 as applicable.

24.3 If a battery charger which is not likely to be used for consecutive charging of batteries is tested with a battery load, the test is to be continued until temperatures peak. The load is to be replaced by a second discharged battery. The test is terminated when temperatures peak, or temperatures stabilize, whichever occurs first during the second load condition.

24.4 A battery charger which is likely to be used for consecutive charging of batteries is to be tested with the intended battery load. The test is to be conducted in accordance with 24.5.

24.5 With respect to 23.4, a consecutive charger is to be tested in accordance with the following:

- a) For a charger with no charge status indicator, the test is to be continued until temperatures peak. The load is to be replaced with another discharged battery. This sequence is to be repeated until maximum temperatures are obtained.
- b) For a charger with a visual charge status indicator, the test is to be continued until the visual indicator indicates that the charge cycle is complete. The load is to be replaced with another discharged battery. This sequence is to be repeated until maximum temperatures are obtained.
- c) For a charger with a charge time marking or instruction, the test is to be continued until the specified charge time has elapsed. The load is to be replaced with another discharged battery. This sequence is to be repeated until maximum temperatures are obtained.
- d) For a charger with both a visual charge status indicator and a charge time marking or instruction, the test is to be continued until the specified charge time has elapsed or until the visual indicator indicates that the charge cycle is complete, whichever occurs first. The load is to be replaced with another discharged battery. This sequence is to be repeated until maximum temperatures are obtained.

24.6 With reference to 24.1, a unit having voltage adjustment taps for intended use shall operate within the temperature limits at any setting including the maximum and intermediate positions.

24.7 A protective device shall not operate during the temperature test.

24.8 A unit intended for mounting or support in more than one position or in a confined location is to be tested in a manner representing the most severe conditions. An adjacent mounting or supporting surface is to consist of 1-inch (25.4-mm) thick soft-pine boards.

24.9 Unless investigated and found acceptable, a supporting means formed of soft rubber or rubberlike material is to be removed prior to the temperature test. If the supporting means has a metal insert, such as a screw or rivet, the test is to be conducted with the power unit supported by the metal insert. At the request of the manufacturer, the test may be conducted without any means of support.

24.10 A thermocouple junction and the adjacent thermocouple lead wires are to be held securely in good thermal contact with the surface of which the temperature is being measured. Usually adequate thermal contact will result from securely taping or cementing the thermocouple in place but, if a metal surface is involved, brazing or soldering the thermocouple to the metal may be necessary.

24.11 Coil and winding temperatures are to be measured by thermocouples located on exposed surfaces, except that the resistance method may be used for a coil that is inaccessible for mounting thermocouples, such as a coil:

- a) Immersed in sealing compound,
- b) Wrapped with thermal insulation, or
- c) Wrapped with more than two layers of material such as cotton, paper, or rayon more than 1/32 inch (0.8 mm) thick.

24.12 The temperature rise of a winding is determined by the resistance method by comparing the resistance of the winding at a temperature to be determined with the resistance at a known temperature according to the formula:

$$t = \frac{R}{r} (k\theta t_1) - k\theta t_2$$

in which:

t is the temperature rise of the winding in degrees C;

R is the resistance of the coil at the end of the test in ohms;

r is the resistance of the coil at the beginning of the test in ohms;

t_1 is the room temperature in degrees C at the beginning of the test;

t_2 is the room temperature in degrees C at the end of the test; and

k is 234.5 for copper, 225.0 for electrical conductor grade (EC) aluminum; values of the constant for other conductors are to be determined.

The winding is to be at room temperature at the start of the test.

24.13 All values for temperature rises in Table 24.1 are based on an assumed ambient temperature of 25°C (77°F).

24.14 Thermocouples are to consist of wires not larger than No. 24 AWG and not smaller than No. 30 AWG. When thermocouples are used in determining temperatures in electrical equipment, it is common practice to employ thermocouples consisting of No. 30 AWG iron and constantan wire and a potentiometer type instrument. Such equipment is to be used whenever referee temperature measurements by thermocouples are necessary. The thermocouples and related instruments are to be accurate and calibrated in accordance with good laboratory practice. The thermocouple wire is to conform with the requirements for special thermocouples as listed in the table of limits of error of thermocouples in Temperature Measurement Thermocouples, ANSI MC96.1-1982.

24.15 A temperature is considered to be constant when three successive readings taken at intervals of 10 percent of the previously elapsed duration of the test, but not less than 15 minutes, indicate no further increase.

25 Dielectric Voltage-Withstand Test

Section 25 effective December 4, 1995

25.1 General

25.1.1 While still in a heated condition, a unit shall withstand for 1 minute without breakdown the application of a 60-hertz essentially sinusoidal potential of:

- a) Five hundred volts between a circuit operating at 60 volts dc or less or 50 volts ac rms (70 volts peak) or less and dead metal parts; 1000 volts plus twice the maximum circuit voltage between a circuit operating at more than 60 volts dc or more than 50 volts ac rms (70 volts peak) but less than 1000 volts (1414 volts peak) and dead metal parts.

25.1.2 To determine whether a unit complies with the requirements in 25.1, the unit is to be tested using a 500 volt-ampere or larger capacity transformer, the output voltage of which can be varied. The applied potential is to be increased from zero until the required test level is reached, and is to be held at that level for 1 minute. The increase in applied potential is to be at substantially uniform rate as rapid as is consistent with correct indication of its value by a voltmeter.

26 Abnormal Tests

Section 26 effective December 4, 1995

26.1 General

26.1.1 A unit shall not emit flame or molten metal or become a risk of fire or electric shock when subjected to the reverse polarity, component breakdown and battery-supply cord short circuit tests.

26.1.2 A risk of fire or electric shock is considered to exist if any of the following occurs:

- a) Charring of cheesecloth;
- b) Emission of flame or molten material from the unit enclosure and output cord, if provided; or,
- c) Any condition that exposes live parts which present a risk of electric shock as specified in Section 15.

26.1.3 Each test is to be conducted on a separate sample unless the manufacturer requests that more than one test be conducted on the same sample.

26.1.4 A polarity-protection circuit provided to prevent output-current flow until a battery is connected as intended to the output is to be made inoperative so that the required output current will flow.

26.1.5 During all abnormal tests the unit is to be draped with a double layer of cheesecloth conforming to the outline of the unit.

26.2 Reverse polarity test

26.2.1 For a device intended for charging batteries and provided with nonpolarized output connections, the external output leads are to be connected in reverse polarity to a fully charged battery intended for the application. The unit is then to be connected to its maximum test voltage, and operated until the ultimate condition is observed, or 4 hours if cycling of an automatically reset protector occurs.

26.3 Component breakdown test

26.3.1 A unit having components ? such as diodes, resistors, transistors, capacitors, and the like ? with a single component fault of short or open, shall not result in the output exceeding the levels specified in 15.3.2, or any condition as specified in 26.1.2. The unit is to be connected to the maximum test voltage and operated until ultimate conditions are observed, or for 4 hours if cycling of an automatically reset protector occurs.

Exception: This test need not be conducted for component breakdowns that result in open or short circuiting of the output.

26.4 Battery-supply cord short circuit test

26.4.1 The battery-supply cord shall be short-circuited at any point on the cord, but not within 5 inches (127 mm) of the cigarette lighter connector. As a result of this test, the fuse required by 9.7 and 9.8 shall open prior to any damage to the battery-supply cord or the cigarette lighter connector.

27 Resistance to Crushing Test

Section 27 effective December 4, 1995

27.1 One sample of the cigarette lighter connector shall withstand for 1 minute a steady crushing force of 75 pounds (334 N). The cigarette lighter connector is to be tested between two parallel, flat, maple blocks, each not less than 1/2 inch (12.7 mm) thick. The crushing force is to be applied gradually in a direction normal to the mounting surface.

28 Strain Relief Test

Section 28 effective December 4, 1995

28.1 The strain relief means provided between the battery-supply cord and cigarette lighter connector shall withstand for 1 minute without displacement a direct pull of 20 pounds (89 N) applied to the cord, with the connections within the cigarette lighter connector disconnected. The strain relief is not acceptable if, at the point of disconnection of the conductors, there is such movement of the cord as to indicate that stress on the connections would have resulted.

28.2 A 20-pound (9 kg) weight is to be suspended from the cord so that the strain relief means will be stressed from any angle the construction permits.

MARKING

29 Details

Section 29 effective December 4, 1995

29.1 Cautionary markings

29.1.1 A cautionary marking shall be prefixed by the word "CAUTION," "WARNING," or "DANGER" in letters not less than 1/8 inch (3.2 mm) high. The remaining letters shall not be less than 1/16 inch (1.6 mm) high.

29.1.2 There shall be a legible and durable marking for each interchangeable fuse as described in 9.8 indicating the ampere rating and the voltage rating of the fuse to be used for replacement. The marking shall be located so that it is understood as to which fuse or fuseholder the marking applies. A single marking is acceptable for a group of fuses. The marking shall consist of the word "CAUTION" and the following or the equivalent: "For continued protection against risk of fire, replace only with same type and ratings of fuse."

29.1.3 A battery charger shall be marked, where readily visible to the user when connecting batteries, with the word "CAUTION" and the following or equivalent: "Charge only ___ type rechargeable batteries. Other types of batteries may burst causing personal injury and damage."

Exception: A reference to a specific rechargeable battery or battery pack for which the charger is intended may be used in lieu of marking the type of batteries to be charged.

29.1.4 A cautionary marking shall be permanent and shall be located on a part that cannot be removed without impairing the operation of the unit.

29.1.5 A cautionary marking to instruct the operator shall be visible and legible to the operator during the intended operation of the unit.

29.1.6 With reference to 22.3, a multi-output unit shall be marked, where readily visible after installation, with the word "WARNING" and the following or equivalent: "To reduce the risk of fire or electric shock, do not interconnect output terminations."

29.2 General markings

29.2.1 A unit shall be plainly and permanently marked where it will be readily visible with the following:

- a) The manufacturer's name, trade name, or trademark.
- b) A distinctive catalog number or the equivalent.
- c) The input and output ratings in voltage, frequency, and amperes, watts, or volt-amperes.

Exception: The output rating need not be included in a unit intended to charge a specific battery or battery pack provided the unit is marked to indicate the battery or battery pack to be used.

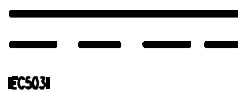
d) The date or other dating period of manufacture not exceeding any three consecutive months.

Exception: The date of manufacture may be abbreviated; or may be in a nationally accepted conventional code or in a code affirmed by the manufacturer provided that the code:

- 1) *Does not repeat in less than 20 years; and*
- 2) *Does not require reference to the production records of the manufacturer to determine when the product was manufactured.*

29.2.2 With respect to the frequency marking mentioned in 29.2.1, the symbol illustrated in Figure 29.1 may be used for this marking.

Figure 29.1
Direct current symbol



29.3 Application

29.3.1 Unless specifically exempt, marking required by this standard shall be permanent. A permanent marking shall be molded, die-stamped, paint-stenciled; stamped or etched metal that is permanently secured; or indelibly stamped on a pressure-sensitive label secured by adhesive. The marking means shall comply with the Standard for Marking and Labeling Systems, UL 969. Ordinary usage, handling, storage, and the like of the unit are to be considered in determining whether a marking is permanent.

30 Instructions ? Battery Charger

Section 30 effective December 4, 1995

30.1 A battery charger shall be provided with explicit important safety, operation, and maintenance instructions for the user; and if applicable, with assembly, moving and storage instructions.

30.2 The important safety instructions and instructions for user assembly, operation, maintenance, and moving and storage shall be in the same manual. The important safety instructions shall appear before the instructions for user assembly, operation, maintenance, and moving and storage.

30.3 In an instruction manual intended for use with more than one model or type of battery charger, the instructions applicable to each model or type of battery charger shall be explicitly identified.

Exception: Instructions that are exactly the same for more than one model or type of battery charger, and that will not result in confusion or misunderstanding due to different location of controls, operating modes, and the like, need not comply with this requirement.

30.4 Instructions shall be legible, and shall contrast with the background.

30.5 The headings for the important safety instructions, and the opening statements of the instructions specified in 30.12 ? "IMPORTANT SAFETY INSTRUCTIONS" and "SAVE THESE INSTRUCTIONS" ? shall be entirely in upper case letters not less than 3/16 inch (4.8 mm) high or emphasized to distinguish them from the rest of the text. Upper case letters in the instructions shall not be less than 5/64 inch (2.0 mm) high, and lower case letters shall not be less than 1/16 inch (1.6 mm) high.

30.6 There shall be no substitute for the word "CAUTION," "WARNING," or "DANGER" in the text of the instructions.

30.7 The text of the instructions required by 30.12 shall be verbatim, or in equally definitive terminology.

Exception: If a specific conflict in the application to a battery charger exists, or if the wording would be inappropriate, variations from the specified wording may be used.

30.8 An illustration may be used with a required instruction to clarify the intent, but shall not replace the instruction.

30.9 Important safety instructions shall warn the user of reasonably foreseeable risks of fire, electric shock, or injury to persons; and shall state the precautions that should be taken to reduce such risks.

30.10 The important safety instructions shall include the appropriate items in 30.12 followed by the appropriate instructions in Sections 31 ? 34.

30.11 The items in the list in 30.12 shall be numbered, and other instructions deemed necessary by the manufacturer to reduce the risk of fire, electric shock, or injury to persons may be included.

30.12 The important safety instructions shall include those items in the following list that are applicable to the particular battery charger. The statement "IMPORTANT SAFETY INSTRUCTIONS," shall precede the list and the statement "SAVE THESE INSTRUCTIONS" shall either precede or follow the list. The word "CAUTION," "WARNING," or "DANGER" shall be entirely in upper case letters.

IMPORTANT SAFETY INSTRUCTIONS

1. SAVE THESE INSTRUCTIONS ? This manual contains important safety and operating instructions for battery charger Model ____.

Exception: If the instructions are exactly the same for all models, specific model numbers need not be specified.

2. Before using battery charger, read all instructions and cautionary markings on battery charger, battery, and product using battery.
3. CAUTION ? To reduce risk of injury, charge only __ type rechargeable batteries. Other types of batteries may burst causing injury to persons and damage.
4. Do not expose charger to rain, moisture, or snow.

5. Use of an attachment not recommended or sold by the battery charger manufacturer may result in a risk of fire, electric shock, or injury to persons.
6. To reduce risk of damage to cigarette lighter connector and cord, pull by cigarette lighter connector rather than cord when disconnecting charger.
7. Make sure cord is located so that it will not be stepped on, tripped over, or otherwise subjected to damage or stress.
8. Do not operate charger with damaged cord or cigarette lighter connector ? replace it immediately.
9. Do not operate charger if it has received a sharp blow, been dropped, or otherwise damaged in any way; take it to a qualified serviceperson.
10. Do not disassemble charger; take it to a qualified serviceperson when service or repair is required. Incorrect reassembly may result in a risk of electric shock or fire.
11. To reduce risk of electric shock, unplug charger before attempting any maintenance or cleaning. Turning off controls will not reduce this risk.

31 Assembly Instructions

Section 31 effective December 4, 1995

31.1 The assembly instructions, if applicable, shall contain all information needed for proper assembly of parts, such as handles and shall be preceded by the heading "ASSEMBLY INSTRUCTIONS," or the equivalent.

32 Operating Instructions

Section 32 effective December 4, 1995

32.1 The operating instructions shall contain all applicable information needed to operate a vehicle battery adapter in the intended manner, and shall be preceded by the heading "OPERATING INSTRUCTIONS," or the equivalent.

32.2 The operating instructions shall:

- a) Warn that the unit must be properly assembled in accordance with the assembly instructions before it is used.
- b) Explain and describe the location, function, and operation of each control of the unit, including all user-operated devices intended to reduce the risk of fire, electric shock, or injury to persons; and warn against tampering with such devices.
- c) Explain any automatic features if the marking on the unit includes the word "Automatic" such as "Automatic Battery Charger" or "Automatic Circuit Protector."

33 Maintenance Instructions

Section 33 effective December 4, 1995

33.1 The instructions for user maintenance shall include explicit instructions for all cleaning and minor servicing ? lubrication, external adjustments, and the like ? that should be performed by the user; and shall warn the user that all other servicing should be performed by qualified service personnel. User maintenance instructions shall be preceded by the heading "MAINTENANCE INSTRUCTIONS," or the equivalent.

33.2 The user-maintenance instructions, as described in 33.1, shall not include operations that would require disassembly of the unit to accomplish.

34 Moving and Storage Instructions

Section 34 effective December 4, 1995

34.1 If moving or storage of a unit could result in damage to the unit that could create a risk of fire, electric shock, or injury to persons during subsequent use, the instruction manual shall include explicit instructions for proper moving and storage. Such instructions shall be preceded by the heading "MOVING AND STORAGE INSTRUCTIONS," or the equivalent.

APPENDIX A**Standards for Components**

Standards under which components of the products covered by this standard are judged include the following:

Title of Standard ? UL Standard Designation

Attachment Plugs and Receptacles, Electrical ? UL 498

Flexible Cord and Fixture Wire ? UL 62

Fuseholders ? UL 512

Marking and Labeling Systems ? UL 969

Plastic Materials for Parts in Devices and Appliances, Tests for Flammability of ? UL 94

Polymeric Materials ? Long Term Property Evaluations ? UL 746B

Polymeric Materials ? Use in Electrical Equipment Evaluations ? UL 746C

Printed Wiring Boards ? UL 796

Switches, Special-Use ? UL 1054

Tape, Insulating Materials-General, Systems of ? UL 1446

Temperature-Indicating and -Regulating Equipment, Electrical ? UL 873

Thermal Cutoffs for Use in Electrical Appliances and Components ? UL 1020

Wire Connectors and Soldering Lugs for Use with Copper Conductors ? UL 486A

Wires and Cables, Rubber-Insulated ? UL 44

Wires and Cables, Thermoplastic-Insulated ? UL 83