



UL 1236

STANDARD FOR SAFETY

Battery Chargers for Charging Engine-Starter Batteries

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UL Standard for Safety for Battery Chargers for Charging Engine-Starter Batteries, UL 1236

Eighth Edition, Dated April 21, 2015

Summary of Topics

This revision of UL 1236 is being issued to reaffirm approval as an American National Standard. No changes in requirements are involved.

The revisions are substantially in accordance with Proposal(s) on this subject dated August 7, 2015.

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UL 1236

Standard for Battery Chargers for Charging Engine-Starter Batteries

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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 battery chargers rated 600 volts or less and intended for household or commercial use to charge lead-acid engine-starter and other starting, lighting, and ignition (SLI) type batteries, in accordance with the National Electrical Code, NFPA 70. The requirements also cover a battery charger intended to be permanently installed on a boat.

1.2 A battery charger for use with an internal combustion engine driving a centrifugal fire pump shall comply with the requirements of this Standard and the applicable requirements for the end product.

1.3 These requirements do not cover the following types of battery chargers:

- a) Battery chargers for use in industrial applications as covered by the Standard for Industrial Battery Chargers, UL 1564;
- b) Battery charger systems for use in electric vehicle applications covered by the Standard for Electric Vehicle (EV) Charging System Equipment, UL 2202;
- c) Battery chargers for use with portable tools or household appliances as covered by the Standard for Power Units Other Than Class 2, UL 1012, or the Standard for Class 2 Power Units, UL 1310; and
- d) Battery chargers for fire protection signaling service.

2 Components

2.1 Except as indicated in 2.2, 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 generally used in the products covered by this standard.

2.2 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.

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

2.4 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.

3 Units of Measurement

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

3.2 Unless otherwise stated, values of current and voltage are root-mean-square for alternating current and average for direct current.

4 Undated References

4.1 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.

5 Glossary

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

5.2 BATTERY, VALVE REGULATED (VR) – A battery that is sealed with the exception of a valve that opens to the atmosphere when the internal gas pressure in any cell exceeds atmospheric pressure by a preselected amount. VR batteries provide a means for recombination of internally generated oxygen and the suppression of hydrogen gas evolution to limit water consumption. The term VRLA (valve regulated lead-acid) is also used by the industry.

5.3 BATTERY, VENTED – A battery in which the products of electrolysis and evaporation are allowed to escape freely to the atmosphere. These batteries have commonly been referred to as “flooded.”

5.4 BATTERY CHARGER – A device used to replenish the capacity of batteries.

5.5 BATTERY CHARGER, AUTOMATIC – A battery charger which senses that the battery has been charged and automatically maintains or terminates the charge.

5.6 BATTERY CHARGER, COMMERCIAL – A battery charger intended or marketed for use in commercial establishments, such as automotive service stations or battery sales outlets.

5.7 BATTERY CHARGER, FIXED – A battery charger that is intended to be permanently connected electrically.

5.8 BATTERY CHARGER, HOUSEHOLD – A battery charger intended or marketed for use in residential environments.

5.9 BATTERY CHARGER, PLUG-IN – A small household battery charger for mounting by insertion of its integral attachment plug blades in a standard wall receptacle.

5.10 BATTERY CHARGER, PORTABLE – A battery charger that:

- a) Has no provision for a permanent wiring system; and
- b) Can be moved easily from one place to another for use.

5.11 BATTERY CHARGER, STATIONARY – A cord- and plug-connected battery charger that is intended to be fastened in place or located in a dedicated space.

5.12 BATTERY CHARGER, SWITCH MODE – A battery charger employing a high frequency transformer design where transformer operation is dependent on an inverter circuit.

5.13 CLASS 2 TRANSFORMER – A step-down transformer having a secondary voltage of not more than 30 volts rms (42.4 volts peak) under any condition of loading or open circuit and complying with the applicable requirements in the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1, and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3.

5.14 INJURY TO PERSONS – The words “injury to persons” are in reference to physical harm to persons other than the physiological effects of electric shock.

5.15 LINE-VOLTAGE CIRCUIT – A circuit involving a potential of not more than 600 volts, connected to the utility supply, and having circuit characteristics in excess of those described in 5.16.

5.16 LOW VOLTAGE LIMITED ENERGY CIRCUIT (LVLE) – A circuit involving a potential of not more than 30 volts alternating current (42.4 volts peak) supplied by a battery or by a standard Class 2 transformer or other suitable transforming device, or by a suitable combination of transformer and fixed impedance having output characteristics in compliance with what is required for a Class 2 transformer. A circuit obtained by connecting resistance in series with a line voltage supply circuit as a means of limiting the voltage and current is not considered to be a low voltage circuit.

5.17 MEASUREMENT INDICATION UNIT (MIU) – The output voltage (V3) in millivolts rms from the measurement instrument in Figure 26.3 divided by 500 (the value in ohms of the resistance in parallel with V2 in the measurement instrument circuit). (The indication is essentially the rms value of a 60 Hz sinusoidal leakage current in mA. It 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.)

5.18 OUTPUT RATINGS –

a) Continuous Output Current Rating – Any current rating that the battery charger is intended to provide continuously without causing any of the components of the battery charger to exceed their temperature rating, with the maximum continuous current rating that a battery charger with multiple current output ratings can supply continuously being its maximum continuous current rating.

b) Non-Continuous Current Rating – Any current rating that the battery charger can supply for a limited period of time, which is to be followed by a rest or reduced current period before being reapplied (i.e., a duty cycle). Examples of non-continuous operation include cranking assist, boost charge, engine start, and similar operating modes that involve periods of output in excess of the continuous output current rating.

5.19 RISK OF ELECTRIC SHOCK – A risk of electric shock is considered likely to occur at any part if the potential between the part and earth ground or any other accessible part is more than 42.4 volts peak and the continuous current flow through a 1500 ohm resistor exceeds 5 milliamperes.

5.20 SPECIALIZED VEHICLE CONNECTOR – A connector provided on the battery charger output cord or cable for mating with a receptacle installed in a vehicle during charging. Connectors intended for use with receptacles conforming with Appendix C of SAE J563, Standard for 12 Volt Cigarette Lighters, Power Outlets, and Accessory Plugs, are not considered specialized vehicle connectors (i.e. lighter receptacles and similarly configured power outlet receptacles).

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

CONSTRUCTION

6 General

6.1 If the operation and maintenance of a battery charger by the user involves a risk of injury to persons, a risk of electric shock, or a risk of fire, means shall be provided to reduce the risk.

6.2 When evaluating a product with respect to the requirement in 6.1, consideration shall be given to reasonably foreseeable misuse of the product.

7 Frame and Enclosure

7.1 General

7.1.1 A battery charger shall be formed and assembled so that it has the strength and rigidity necessary to resist the abuses to which it may be subjected, without increasing the 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 serious defects.

7.1.2 A battery charger shall be provided with an enclosure acceptable for the application that shall house all live parts other than the power supply cord or primary connector and the output leads or terminals that may increase the risk of fire, electric shock, or injury to persons under any condition of use.

7.1.3 A sheet metal section of the enclosure shall have a thickness not less than that specified in Table 7.1.

Exception: A part of an enclosure that complies with the requirements in 31.1.1 and 31.1.5 is not required to have the thickness specified in Table 7.1.

Table 7.1
Minimum acceptable thicknesses of enclosure metal

Metal	Minimum thickness, inch (mm)	
	At surfaces other than those to which a wiring system is to be connected in the field	At surfaces to which wiring system is to be connected in the field
Uncoated sheet steel	0.026 (0.66)	0.032 (0.81)
Galvanized sheet steel	0.029 (0.74)	0.034 (0.86)
Nonferrous sheet metal other than copper	0.036 (0.91)	0.045 (1.14)

7.1.4 An enclosure or part of an enclosure that also serves as a compartment for a rechargeable vented or valve regulated battery shall be ventilated to permit dispersion of gases from the battery. See 5.2 and 5.3.

7.2 Mounting

7.2.1 A portable battery charger intended for wall mounting shall employ a keyhole slot or the equivalent as a mounting means.

7.2.2 A barrier or the equivalent may be used to prevent wall-mounting screws from projecting into a compartment containing electrical parts and reducing spacings to less than that specified in Spacings, Section 23.

7.2.3 Mounting instructions shall be furnished with a battery charger intended for permanent mounting. If the mounting hardware is not readily available commercially, the manufacturer shall provide the hardware with the charger.

7.3 Integral meters

7.3.1 If an electrical instrument, such as a meter, forms part of the enclosure, the face or the back of the instrument housing, or both together, shall comply with the requirements for an enclosure.

Exception No. 1: An electrical instrument connected in a secondary circuit need not comply with this requirement if damage to or deterioration of the materials of which the housing is made will not result in a risk of fire or electric shock.

Exception No. 2: This requirement does not apply to a meter complying with the requirements in the Standard for Electrical Analog Instruments – Panelboard Types, UL 1437.

7.4 Supporting materials

7.4.1 Material supporting terminals or used as internal electrical insulation of an electrical instrument shall comply with the requirements for Insulating Materials, Section 14. Acceptability of spacings between live and dead metal parts connected to the enclosure within the instrument shall be determined by the Dielectric Voltage Withstand Test, Section 29.

Exception: An electrical instrument connected in a secondary circuit need not comply with this requirement if damage to or deterioration of the materials will not result in a risk of fire or electric shock.

7.4.2 Polymeric supporting feet of a battery charger that form part of the enclosure or are necessary for ventilation shall have the aging, physical, and flammability properties of the material investigated. The effect of oil and the absorption of moisture on the mounting feet of the battery charger are also to be considered.

7.5 Materials

7.5.1 In addition to the performance tests specified in this Standard, the factors to be considered when evaluating the suitability of a polymeric enclosure are:

- a) Material flammability properties;
- b) Resistance to arcing properties; and
- c) Moisture absorptive properties.

These properties shall comply with the requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. See also 25.4.

7.5.2 A conductive coating applied to a nonmetallic surface such as the inside surface of a cover, enclosure, and the like shall comply with the appropriate 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.

7.5.3 An adhesive used to attach a cover to a battery charger shall comply with the requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception: This requirement does not apply to methods utilizing fusion techniques, such as solvent cementing, ultrasonic welding, electromagnetic induction, and thermal welding.

7.5.4 The material of a part, such as an enclosure, a frame, a guard, or the like, the breakage of which results in a risk of injury to persons, shall have properties that meet the demand of expected loading conditions.

7.5.5 The requirement in 7.5.4 applies to those portions of a part adjacent to a moving part considered to involve a risk of injury to persons.

7.6 Barriers

7.6.1 A rotating member, such as a fan blade, the breakage of which results in a risk of injury to persons, shall be enclosed or guarded to reduce the risk of injury.

7.6.2 The combination of enclosure and internal barriers of a battery charger shall reduce the likelihood of molten metal, burning insulation, flaming particles, or the like, falling on combustible materials, including the surface upon which the charger is supported. An internal barrier may be an integral part of a component or of the charger enclosure.

7.6.3 To comply with the requirement in 7.6.2, an enclosure having openings in the bottom shall be provided with a barrier in accordance with 7.6.4 and with Figure 7.1.

Exception: The following components do not require a barrier:

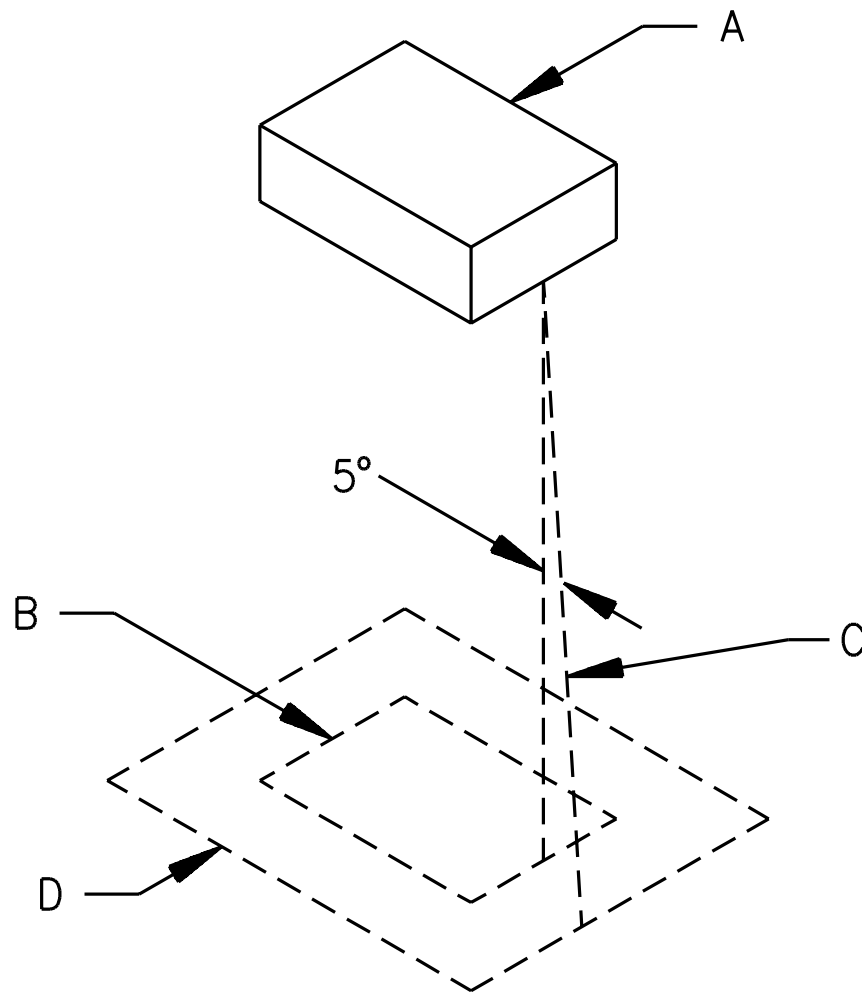
- a) An individually enclosed component if it contains arcing parts, such as a switch, relay, or contactor;*
- b) A motor without openings in the bottom of the housing, or a motor constructed in accordance with 7.6.5;*
- c) Internal wiring insulated with neoprene, thermoplastic, fiberglass, or an equally fire-retardant material;*
- d) An individually enclosed fuse, such as an extractor type. Consideration will be given to a fuse enclosed within a transformer winding; and*
- e) A component having a magnetic winding or coil (such as a transformer, relay or solenoid) complying with the applicable abnormal tests of Section 38, Abnormal Tests.*

7.6.4 The barrier mentioned in 7.6.3 shall:

- a) Be horizontal;
- b) Be located as illustrated in Figure; and
- c) Have an area in accordance with Figure 7.1.

The barrier may be a perforated metal plate as described in Table; a galvanized or stainless steel screen having a 14- by 14-mesh per inch (25.4-mm) constructed of wire with a diameter of 0.018 inch (0.5 mm) minimum; or other construction complying with the Hot, Flaming Oil Test, Section 45.

Figure 7.1
Location and extent of barrier



SA0604

A – Region to be shielded by barrier. This region consists of the entire component if it is not otherwise shielded, and consists of the unshielded portion of a component partially shielded by the component enclosure or equivalent.

B – Projection of outline of component on horizontal plane.

C – Inclined line that traces out minimum area of barrier. When moving, the line is always:

- 1) Tangent to the component,
- 2) 5 degrees from the vertical, and
- 3) So oriented that the area traced out on a horizontal plane is maximum.

D – Location (horizontal) and minimum area for barrier. The area is that included inside the line of intersection traced out by the inclined line C and the horizontal plane of the barrier.

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Table 7.2
Perforated metal plates for enclosure bottom

Minimum thickness		Maximum diameter of holes		Minimum spacings of holes center to center	
inch	(mm)	inch	(mm)	inch	(mm)
0.026	(0.66)	0.045	(1.14)	0.067	(1.70)
233 holes per inch ² (645 mm ²)					
0.026	(0.66)	0.047	(1.19)	0.093	(2.36)
0.030	(0.76)	0.045	(1.14)	0.067	(1.70)
0.030	(0.76)	0.047	(1.19)	0.093	(2.36)
0.032	(0.81)	0.075	(1.91)	0.125	(3.18)
72 holes per inch ² (645 mm ²)					
0.035	(0.89)	0.075	(1.90)	0.125	(3.18)
0.036	(0.91)	0.063	(1.60)	0.109	(2.77)
0.036	(0.91)	0.078	(1.98)	0.125	(3.18)
0.039	(0.99)	0.063	(1.60)	0.109	(2.77)
0.039	(0.99)	0.079	(2.00)	0.118	(3.00)

7.6.5 As indicated in Exception(b) to 7.6.3, a motor does not require a barrier if:

a) The overload protection provided with the motor is such that no burning insulation or molten material falls to the surface that supports the charger when the motor is energized under each of the following fault conditions:

- 1) Open main winding;
- 2) Open auxiliary winding; and
- 3) Starting switch short-circuited;

b) The motor is provided with a thermal motor protector – a protective device that is sensitive to temperature and current – that prevents the temperature of the motor winding from exceeding:

- 1) 125°C (257°F) when the motor is running at the maximum load at which it can operate without causing the protector to cycle; and
- 2) 150°C (302°F) with the rotor of the motor locked; or

c) The motor complies with the requirements for impedance protected motors and the temperature of the motor windings will not exceed 150°C (302°F) during the first 72 hours of operation with the rotor locked.

7.6.6 A component of a cart-type battery charger that may produce arcing, such as a snap switch, a relay, or a receptacle, shall be located at least 18 inches (457 mm) above the floor. Other types of battery chargers for use in commercial garages shall be marked in accordance with 50.6.

7.7 Protection against injury to persons

7.7.1 A part that could cause injury to persons shall be enclosed.

7.7.2 A rotating or moving part that, if it should become disengaged may create a risk of injury to persons, shall be provided with a means to retain the part in place under conditions of use.

7.7.3 Whether a guard, a release, an interlock, or the like is required, and whether such a device is adequate, shall be determined from an investigation of the complete battery charger, its operating characteristics, and the likelihood of a risk of injury to persons resulting from a cause other than gross negligence. The investigation shall include consideration of the results of breakdown or malfunction of any component, but not more than one component at a time, unless one event contributes to another. If the investigation shows that breakdown or malfunction of a particular component can result in a risk of injury to persons, that component is to be investigated for reliability.

7.7.4 An opening in a guard or enclosure around a moving part that involves a risk of injury to persons shall have a minor dimension less than 1 inch (25.4 mm), and shall not permit the probe illustrated in Figure 8.1 to contact the part when the probe is inserted with a force of 1 pound (4.4 N) through the opening to its maximum depth in a straight or articulated position.

7.7.5 Among the factors to be considered in judging the acceptability of an exposed moving part posing a risk of injury are:

- a) The degree of exposure necessary to perform its intended function;
- b) The sharpness of the moving part;
- c) The likelihood of unintentional contact;
- d) The speed of the moving part; and
- e) The likelihood that a part of the body would be endangered or that clothing would be entangled by the moving part.

These factors are to be considered with respect to both intended operation of the battery charger and reasonably foreseeable misuse.

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

7.7.7 A guard or portion of an enclosure acting as a guard for a part that may involve a risk of injury to persons shall be either:

- a) Mounted to the assembly so that the part cannot be operated with the guard or portion of the enclosure removed;
- b) Secured to the assembly using fasteners requiring a tool for removal; or
- c) Provided with an interlock to reduce the risk of contacting the part.

Exception: This requirement does not apply to a commercial battery charger marked as required by 49.10 and 50.14.

7.8 Outdoor enclosures

7.8.1 The enclosure of a battery charger for outdoor use shall be constructed to exclude a beating rain.

7.8.2 The requirements in 7.8.3 – 7.8.8 apply to battery chargers not marked in accordance with 50.9.

7.8.3 An outdoor enclosure shall be subjected to the Water Spray Test, Section 30. Alternatively, an outdoor enclosure shall comply with the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E. When subjected to the Water Spray Test, Section 30, an enclosure designated as:

- a) Raintight shall prevent rain from entering the enclosure.
- b) Rainproof shall prevent rain from interfering with the successful operation of the battery charger.

7.8.4 An outdoor enclosure shall be marked as specified in 49.9.

7.8.5 A gasket employed in a battery charger, including a cart-type charger as specified in the Exception to 50.9, shall be tested in accordance with Accelerated Aging of Gaskets, Sealing Compounds, and Adhesives, Section 42.

7.8.6 A raintight or rainproof enclosure shall be provided with external means for mounting.

Exception: A rainproof enclosure may be provided with internal means for mounting if the mounting means is constructed to prevent water from entering the enclosure.

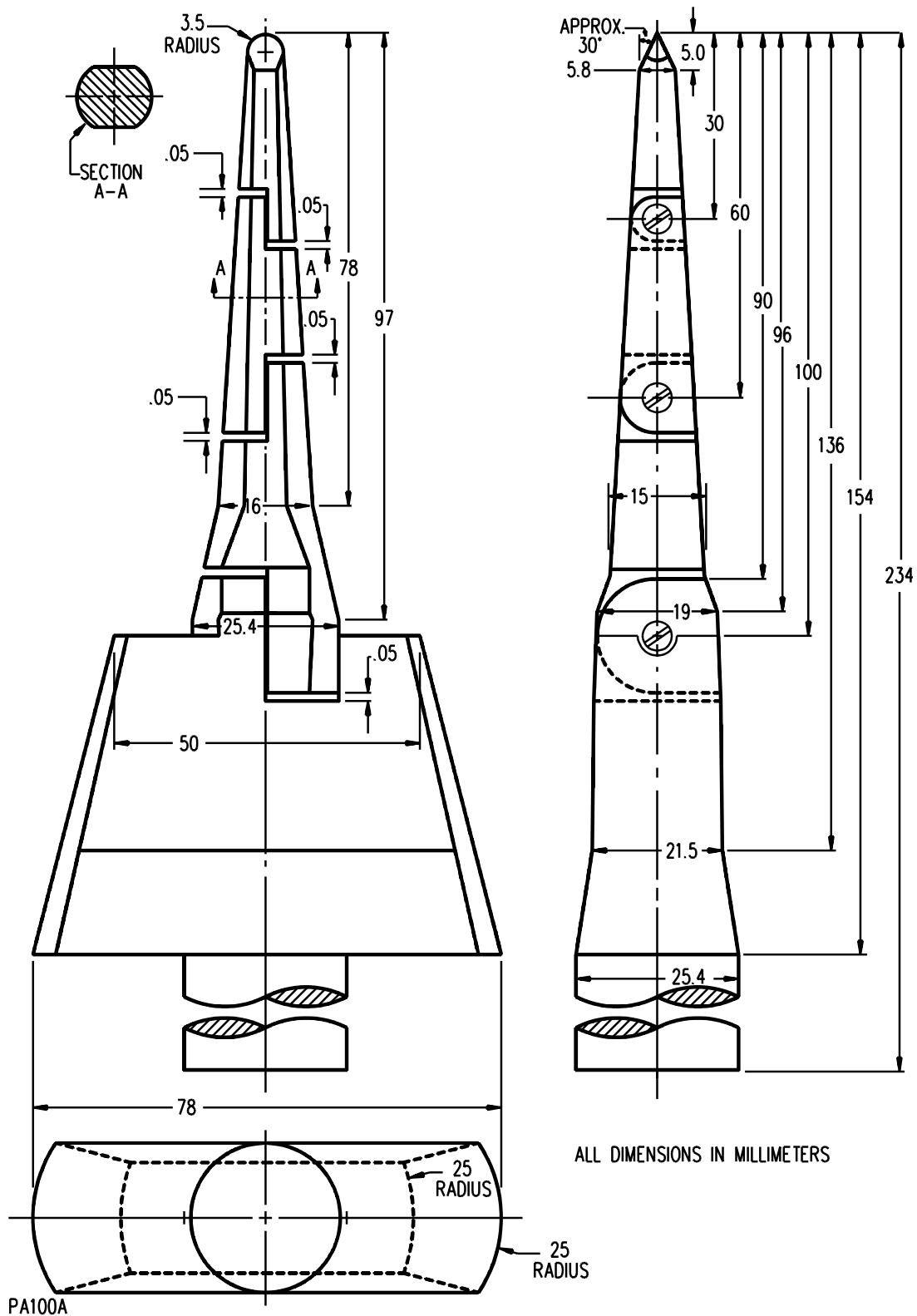
7.8.7 For a raintight enclosure, all openings for conduit other than in the bottom shall be threaded.

7.8.8 For a rainproof enclosure, openings for conduit shall be threaded unless they are located wholly below the lowest terminal lug or other live part within the enclosure, and there shall be provision for drainage of the enclosure if knockouts or unthreaded holes are provided other than in the bottom.

8 Accessibility of Live Parts

8.1 An opening in the enclosure of a battery charger is acceptable if a probe as illustrated in Figure 8.1, when inserted through the opening, cannot be made to touch any uninsulated live part that can cause electric shock. See 5.19.

Figure 8.1
Articulate probe with web stop



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8.2 Thermoplastic covering an opening for user servicing, such as replacement of a pilot lamp, and that reduces the risk of unintentional contact with a live part involving a risk of electric shock shall be considered an enclosure and evaluated as described in 7.5.1 and 25.4. It shall be reliably retained in place.

8.3 An uninsulated live part that can cause electric shock shall be located or enclosed so that protection against unintentional contact is provided.

8.4 A door or cover that provides access to a live part that can cause electric shock shall be securely held in place so that it can be opened or removed only by using a tool.

Exception: A door or cover that provides access to a live part that does not involve a risk of electric shock shall be securely held in place, but need not be secured so that it is necessary to use a tool to open or remove it.

8.5 The door or cover of an enclosure shall be hinged or attached in an equivalent manner if it provides access to an overload-protective device, the functioning of which requires renewal, or if it is necessary to open the cover in connection with the operation of the protective device. A door or cover providing access to a fuseholder shall be tight-fitting and shall be positively held closed. See 19.1.

Exception: A hinged cover is not required if the only overload-protective devices enclosed are:

- a) Connected in control circuits, provided the protective devices and the circuit loads are within the same enclosure;*
- b) Rated 2 amperes or less for loads not exceeding 100 volt-amperes;*
- c) Extractor fuses having an integral enclosure; or*
- d) Fuses connected in a low-voltage limited energy circuit.*

8.6 The operating handle of a circuit breaker, an operating button of a manually operable protector, the capped portion of an extractor-type fuseholder, or a similar part may project outside the enclosure.

9 Assembly

9.1 An uninsulated live part shall be secured to the base or surface so that it is prevented from rotating or shifting in position as the result of normal stresses, if such movement results in a reduction of spacings below the minimum acceptable values. See Spacings, Section 23.

9.2 A component such as a control switch, lampholder, attachment plug receptacle, or plug connector shall be mounted securely and shall be prevented from turning by means other than friction between surfaces.

Exception No. 1: A switch is not required to be mounted as described if all of the following conditions are met:

- a) The switch is a plunger or other type that does not tend to rotate when operated. A toggle switch is considered to be subject to forces that tend to turn the switch;*
- b) The means for mounting the switch makes it unlikely that operation of the switch will loosen it;*

- c) Spacings are not reduced below the minimum acceptable values if the switch rotates; and
- d) Operation of the switch is by mechanical means rather than by direct contact by persons.

Exception No. 2: A lampholder of the type in which the lamp cannot be replaced, such as a sealed neon pilot or indicator light, is not required to be mounted in accordance with 9.2 if rotation cannot reduce spacings below the minimum acceptable value.

9.3 A small stem-mounted device having a single-hole mounting means may be prevented from rotating by a properly applied lock washer.

10 Protection Against Corrosion

10.1 Iron and steel parts shall be protected against corrosion by enameling, painting, galvanizing, plating, or an equivalent means.

Exception No. 1: This requirement does not apply to bearings, laminations, and other parts of iron or steel such as washers and screws.

Exception No. 2: A part need not be protected from corrosion if corrosion of the part would not result in a risk of fire, electric shock, or injury to persons.

10.2 The interior of a metal compartment housing a battery shall be protected by two coats of acid-resistant paint, two coats of enamel individually baked on, or the equivalent.

10.3 An enclosure of sheet-steel intended for outdoor use shall be protected against corrosion by one of the following coatings:

a) Hot-dipped mill-galvanized sheet steel conforming with the coating Designation G90 in the Weight (Mass) of Coating Requirements table in the Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM A653, with not less than 40 percent of the zinc on any side, based on the minimum single-spot test requirement in this ASTM designation. The weight of the zinc coating may be determined by any acceptable method; however, in case of question, the weight of the coating shall be established in accordance with the Test Method of ASTM Designation A90.

b) A zinc coating, other than that provided on hot-dipped mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00061 inch (0.0155 mm) on each surface with a minimum thickness of 0.00054 inch (0.0137 mm). An annealed coating shall comply with 10.5.

c) A zinc coating conforming with (1) or (2) below and with one coat of an organic finish of the epoxy or alkyd-resin type or other outdoor paint on each surface, applied after forming. The acceptability of a paint can be determined by consideration of its composition or by corrosion tests if these are considered necessary.

1) Hot-dipped mill-galvanized sheet steel conforming with the coating Designation G60 or A60 in the Weight (Mass) of Coating Requirements table in the Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM A653, with not less than 40 percent of the zinc on any side, based on the minimum single-spot test requirement in this ASTM designation. The weight of zinc coating may be determined by any acceptable method;

however, in case of question, the weight of coating shall be established in accordance with the Test Method of ASTM Designation A90. An A60 alloyed coating shall comply with 10.5.

2) A zinc coating, other than that provided on hot-dipped mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00041 inch (0.0104 mm) on each surface with a minimum thickness of 0.00034 inch (0.0086 mm). An annealed coating shall comply with 10.5.

d) Other finishes, including paints, metallic finishes, or combinations of the two may be accepted when comparative tests with galvanized sheet steel – without annealing, wiping, or other surface treatment – conforming with 10.3(a) indicate they provide equivalent protection. Among the factors that are taken into consideration when judging the acceptability of such coating systems are exposure to salt spray, moist carbon dioxide-sulfur dioxide-air mixtures, moist hydrogen sulfide-air mixtures, ultraviolet light, and water.

10.4 A sheet-steel enclosure for a cart-type battery charger as specified in the Exception to 50.9 shall be protected against corrosion by one of the coatings specified in 10.3 or by a hot-dipped mill-galvanized sheet-steel coating conforming with the coating Designation G60 in the Weight (Mass) of Coating Requirements table in the Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM A653, with not less than 40 percent of the zinc on any side, based on the minimum single-spot test requirement in this ASTM designation. The weight of the zinc coating may be determined by any acceptable method; however, in case of question, the weight of the coating shall be established in accordance with the Test Method of ASTM Designation A90.

10.5 An annealed coating on sheet steel that is bent or similarly formed, or extruded or rolled at the edge of holes after annealing, shall be additionally painted in the affected area if the process damages the zinc coating.

10.6 If flaking or cracking of the zinc coating at the outside radius of the bent or formed section is visible at 25 power magnification, the zinc coating is considered to be damaged. Simple sheared or cut edges and punched holes are not required to be additionally protected, but extruded and rolled edges at holes are to comply with the requirements in 10.5.

10.7 The acceptability of outdoor paint may be determined by consideration of its composition or, if necessary, by tests.

11 Supply and Output Connections

11.1 Permanently connected battery chargers

11.1.1 A fixed battery charger shall have provision for the connection of one of the wiring systems that is acceptable for the application in accordance with the National Electrical Code, NFPA 70.

11.1.2 A knockout in a sheet metal enclosure shall be secured and shall be removable without undue deformation of the enclosure.

11.1.3 A knockout shall be surrounded by a flat surface acceptable for seating a conduit bushing or locknut of the appropriate size.

11.1.4 A terminal box or compartment in which field-wiring connections are to be made shall be located so that the connections may be readily inspected after the battery charger is installed as intended.

11.1.5 A field-wiring compartment intended for connection of a wiring system shall be attached to the battery charger so that it will be prevented from turning.

11.1.6 If a separate field-wiring compartment is not provided, space for field-wiring connections shall be located near the connecting means and shall permit routing of the wiring away from live parts, rough metal, and wiring of other circuits. See 11.1.4.

11.1.7 A field-wiring terminal is a terminal to which power supply, control, output, or other permanent connections will be made in the field when the charger is installed.

11.1.8 Field-wiring terminals or leads shall be acceptable for the connection of conductors having an ampacity appropriate for the rating of the charger.

11.1.9 A wiring terminal shall be provided with a soldering lug or pressure terminal connector securely fastened in place— for example, firmly bolted or held by a screw.

Exception: A wire-binding screw may be employed at a wiring terminal intended for connection of a 10 AWG (5.3 mm²) or smaller conductor if upturned lugs or the equivalent are provided to hold the wire in position.

11.1.10 A wiring terminal shall be provided with a means other than friction between surfaces to reduce the likelihood of turning or shifting in position. This may be accomplished by two screws or rivets; by square shoulders or mortises; by a dowel pin, lug, or offset; by a connecting strap or clip fitted into an adjacent part; or by an equivalent method.

11.1.11 A wire-binding screw at a field-wiring terminal shall not be smaller than No. 10 (4.8 mm diameter).

Exception No. 1: A No. 8 (4.2 mm diameter) screw may be used at a terminal intended only for the connection of a 14 AWG (2.1 mm²) conductor.

Exception No. 2: A No. 6 (3.5 mm diameter) screw may be used for the connection of a 16 AWG (1.3 mm²) or 18 AWG (0.82 mm²) control circuit conductor.

11.1.12 A wire-binding screw shall thread into metal.

11.1.13 A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.050 inch (1.27 mm) thick.

Exception: A plate not less than 0.030 inch (0.76 mm) thick may be used if the tapped threads have acceptable mechanical strength.

11.1.14 There shall be two or more full threads in the metal of a terminal plate. The metal may be extruded at the tapped hole to provide at least two full threads.

11.1.15 Upturned lugs, a cupped washer, or the equivalent shall be capable of retaining a conductor of the size required by 11.1.11, but not smaller than 14 AWG (2.1 mm²), under the head of the screw.

11.1.16 The free length of a lead inside an outlet box or wiring compartment shall be 6 inches (152 mm) or more if the lead is intended for field connection to an external circuit.

Exception: A lead may be less than 6 inches (152 mm) long if it is evident that the use of a longer lead may result in a risk of fire or electric shock.

11.1.17 A fixed battery charger rated 125 volts or less, 125/250 volts (3-wire) or less, or 277 volts, and employing a lampholder of the Edison screw-shell type, or a single-pole switch or overcurrent-protective device other than an automatic control without a marked off position shall have one terminal or lead identified for the connection of the grounded conductor of the supply circuit. A single-pole switch or single-pole overcurrent-protective device, other than an automatic control without a marked off position, shall not be connected to the terminal or lead intended for connection to the grounded conductor of the supply circuit.

11.1.18 A field-wiring terminal intended for connection of a grounded circuit conductor shall be made of or plated with metal substantially white in color and shall be readily distinguishable from the other terminals; or proper identification of that terminal shall be clearly shown in some other manner, such as on an attached wiring diagram.

11.1.19 The surface of a lead for the connection of a grounded circuit conductor shall be white or grey and shall be readily distinguishable from other leads.

11.1.20 A battery charger shall have a terminal or lead for connecting the metal enclosure and enclosure parts to ground. See 24.1.

11.2 Cord connected battery chargers

11.2.1 A portable or stationary battery charger shall be provided with a flexible cord in accordance with Table 11.1 and an attachment plug for connection to the branch circuit. The blade assembly for connection to the branch circuit shall be of the polarized- or grounding-type. The length of cord external to the battery charger and including the attachment plug shall not be less than 6 feet (1.8 m) as measured from the face of the attachment plug to the point of attachment or entry.

Exception: A stationary battery charger may employ a cord less than 6 feet (1.8 m) to facilitate the interchange of equipment to maintain continuous service or otherwise meet conditions of use. Normally, a 24 inch (610 mm) length of cord will be sufficient for the plug and receptacle connector.

Table 11.1
Acceptable flexible cords for battery chargers

Type of charger	Type of cord ^a
Household	At least as serviceable as SP-2, SPT-2, SV, SVO, SVT, or SVTO
Commercial	Oil resistant and suitable for use in damp locations, at least as serviceable as SJEO, SJEOO, SJO, SJOO, SJTO, SJTOO, SO, SOO, STO, or STOO
Household or commercial intended to be used outdoors	Oil resistant and at least as serviceable as SJEO-W, SJEOO-W, SJO-W, SJOO-W, SJTO-W, SJTOO-W, SO-W, SOO-W, STO-W, or STOO-W
^a A metal strain relief clamp or band may be used without supplementary protection on a Type SVO, SJEO, SJEOO, SJO, SJOO, SJTO, SJTOO, SO, SOO, STO, or STOO cord. A metal strain relief clamp or band may be used on a Type SVTO cord only if supplementary nonconductive, mechanical protection is provided over the cord.	

11.2.2 The current and voltage ratings of a flexible cord and attachment plug for a battery charger having a current input rated:

- a) 15 amperes or less shall not be less than the input rating of the charger.
- b) More than 15 amperes shall not be less than the input rating of the charger except that if the charger is intended to be continuously loaded for 3 hours or more, the ampacity of the attachment plug shall not be less than 125 percent of the input rating.

11.2.3 For a battery charger having a non-continuous charging output current rating, the rating mentioned in 11.2.2 applies to the input current while the charger is delivering maximum continuous output current. See 5.18(a).

11.2.4 The ampacity of the flexible cord for a battery charger having a non-continuous charging current output and marked with a duty cycle is to be calculated by using the following equation:

$$I = \sqrt{I_1^2 d + I_2^2 (1-d)}$$

in which:

I is the ampacity of the cord as given in the National Electrical Code, NFPA 70;

I₁ is the maximum input current while delivering maximum non-continuous current;

I₂ is the maximum input current measured while delivering its continuous output rating; and

d is the rated duty cycle expressed as a fraction of total time.

11.2.5 A flexible cord incorporating a pendant switch connected in a line-voltage circuit shall be equivalent to the power supply cord.

11.2.6 In a portable or stationary battery charger rated 125 volts or less, 125/250 volts (3-wire) or less, or 277 volts, a switch or overcurrent-protective device of the single-pole type, other than an automatic control without a marked "off" position, shall be connected in a circuit to the cord conductor not intended to be grounded.

11.3 Output wiring

11.3.1 A battery charger shall be provided with an output cord or leads terminating in a battery connector.

11.3.2 The output cord or leads required by 11.3.1, whether permanently attached to the battery charger or provided as a separate cord set, shall not be less than 6 feet (1.8 m) long measured from the point of exit.

11.3.3 The output wiring of a battery charger shall be either:

- a) A flexible cord with an insulation grade equivalent to the power supply cord; or
- b) Individual conductors that comply with the requirements in 11.3.9.

11.3.4 A battery charger intended for connection to an automobile cigar lighter receptacle shall be provided with a plug that complies with the enclosure and input contacts requirements in the Standard for Vehicle Battery Adapters, UL 2089. The connector plug shall incorporate a fuse or other protective device having a current rating not greater than 8 Amps for a nominal 12 Vdc output, and 4 Amps for a unit with a nominal 24 Vdc output.

Exception: The protective device may be provided in the output cord not more than 5 inches (127 mm) from the connector plug.

11.3.5 With reference to 11.3.4, if a fuse is employed, the fuse type and size shall be marked on the fuseholder, as described in 50.17.

11.3.6 A commercial battery charger having output voltage greater than 42.4 volts peak and intended for charging several batteries connected in series shall have connector guards secured to reduce the likelihood of exposure of a connector more than is necessary to make connection to a battery terminal, and shall have a cautionary marking in accordance with 50.8.

11.3.7 The output leads and connectors of a battery charger shall be of adequate size and have insulation thick enough to withstand the mechanical abuses to which they are subjected. The insulation of the output connectors on a battery charger with an output voltage of 42.4 volts peak or less shall be reliably secured and substantially cover the connector. A battery charger having an output voltage greater than 42.4 volts peak shall employ closed-loop lugs or the equivalent for connection to the battery terminals.

Exception: The portion of a connector that attaches to battery terminals is not required to be covered.

11.3.8 A spring clip is not considered to be equivalent to a closed-loop lug unless provided with an insulator secured so that grounding or short-circuiting is not likely to result if the connector is displaced.

11.3.9 With reference to 11.3.3, the leads shall be of a size and rating acceptable for the application and insulated with neoprene or other equivalent insulation in accordance with 11.3.10. Equivalent insulation shall be resistant to acid and alkalies; and comply with the Cold Bend Test as specified in one of the following Standards, except the conditioning temperatures shall be at minus 25°C for a fixed outdoor unit, and 0°C for all other units:

- a) For a lead 14 AWG or larger, the Standard for Thermoset-Insulated Wires and Cables, UL 44, or the Standard for Thermoplastic Insulated Wires and Cables, UL 83.
- b) For a lead smaller than 14 AWG, the Standard for Appliance Wiring Material, UL 758.

11.3.10 With reference to 11.3.9:

- a) The wall thickness of the insulation on the leads shall not be less than:
 - 1) For a charger not exceeding 42.4 volts output, 1/32-inch (0.8-mm) thermoplastic, 3/64-inch (1.2-mm) rubber or neoprene of the type specified in 13.1.1, or 1/16-inch (1.6-mm) rubber or neoprene.
 - 2) For a charger exceeding 42.4 volts output, 1/16-inch (1.6-mm) thermoplastic or 5/64-inch (2.0-mm) rubber or neoprene of the type specified in 13.1.1.
- b) The wall thickness of insulation on a connector guard shall not be less than:
 - 1) For a charger not exceeding 42.4 volts output, 1/32-inch (0.8-mm) thermoplastic or 1/16-inch (1.6-mm) rubber or neoprene.
 - 2) For a charger exceeding 42.4 volts output, 1/16-inch (1.6-mm) thermoplastic or 5/64-inch (2.0-mm) rubber or neoprene.

11.3.11 Acceptability of the material of a connector guard is to be determined for a battery charger having an output exceeding 42.4 volts. A connector guard of rubber, neoprene, polyvinyl chloride, or a copolymer thereof shall be tested in accordance with Tests of Connector Guards, Section 41. A connector guard of insulating material other than those specified in Section 41 shall be investigated in accordance with the requirements in 14.2.

11.3.12 A metal enclosure of a battery charger shall not be connected to an electrical circuit of the charger.

Exception: A capacitor complying with the Standard for Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384-14, or the Standard for Electromagnetic Interference Filters, UL 1283, may be connected between an electrical circuit and the metal enclosure.

11.3.13 Strain relief shall be provided such that a pull or twist exerted on the supply or output cord is not transmitted to terminals, splices, or interior wiring.

11.3.14 If a knot in a flexible cord serves as strain relief, the surfaces that the knot may touch shall be free from burrs, fins, sharp edges, and projections that may damage the cord.

11.3.15 Means shall be provided to prevent the flexible cord or lead from being pushed into the enclosure through the cord-entry hole when such displacement results in:

- a) Subjecting the supply cord or lead to mechanical damage;
- b) Exposing the supply cord or lead to a temperature higher than that for which it is rated;
- c) Reducing spacings (such as to a metal strain-relief clamp) below the minimum required values; or
- d) Damaging internal connections or components.

To determine compliance, the supply cord or lead shall be tested in accordance with Section 35, Push-Back Relief Test.

11.3.16 A bushing or the equivalent shall be provided at a point where a flexible cord passes through an opening in a wall, barrier, or enclosing case. The bushing shall be substantial, reliably secured in place, and shall have a smooth, rounded surface against which the cord may bear.

Exception: For a cord hole in wood, porcelain, phenolic composition, or other acceptable nonconductive materials, a smooth, rounded surface is considered to be the equivalent of an insulating bushing.

11.3.17 Ceramic materials and some molded compositions may be used for insulating bushings.

11.3.18 Vulcanized fiber may be employed if the bushing is not less than 3/64 inch (1.2 mm) thick, and if formed and secured in place so that it is not adversely affected by conditions of ordinary moisture.

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11.3.19 A separate soft rubber, neoprene, or polyvinyl chloride bushing may be used in the frame of a motor or in the enclosure of a capacitor attached to a motor, if the bushing is:

- a) Not less than 3/64 inch (1.2 mm) thick; and
- b) Located so that it will not be exposed to oil, grease, oily vapor, or other substances having a deleterious effect on the compound employed.

11.3.20 A bushing of a material specified in 11.3.19 may be employed at any point in a battery charger if used in conjunction with a type of cord for which an insulating bushing is not required.

11.3.21 If a bushing of a material mentioned in 11.3.19 is used, the hole in which the bushing is mounted is to be smooth and free from sharp edges.

11.3.22 An insulating bushing molded integrally with the supply cord is acceptable on a cord provided the built-up section is not less than 1/16 inch (1.6 mm) thick where the cord passes through the enclosure.

11.3.23 An insulated metal grommet is acceptable as an insulating bushing if the insulating material is not less than 1/32 inch (0.8 mm) thick and completely fills the space between the grommet and the metal in which it is mounted.

11.4 Specialized Vehicle Connector

11.4.1 A specialized vehicle connector (see 5.20) shall comply with the Type 1B connector requirements in the Standard for Component Connectors for Use in Data, Signal, Control and Power Applications, UL 1977.

Exception: A connector protected by a fuse rated 8 A or less located within 5 inches (12.7 cm) of the connector may comply with the Type 0 connector requirements of UL 1977. If the fuse is user replaceable, it shall have an adjacent marking in accordance with 50.17.

11.4.2 The connector shall have no exposed current carrying pins that could be short-circuited when placed on a flat metal surface.

11.4.3 Strain relief shall be provided such that a pull exerted on the output cord does not transmit strain to internal connections of the connector when tested in accordance with 34.3.

12 Live Parts

12.1 A current-carrying part shall be of silver, copper, a copper alloy, or other material acceptable for the application.

12.2 Plated iron or steel may be used for a current-carrying part:

- a) If acceptable in accordance with Components, Section 2;
- b) Within a motor; and
- c) In a secondary circuit rated 42.4 volts peak – 30 volts rms – or less.

Unplated iron or steel is not acceptable. Stainless steel and other corrosion-resistant alloys may be used for current-carrying parts.

12.3 An uninsulated live part shall be secured to an insulating base or mounting surface so that it is prevented from turning or shifting in position if such motion results in a reduction of spacings below the minimum acceptable values.

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

13 Internal Wiring

13.1 General

13.1.1 The internal wiring of a battery charger shall consist of wire of a type that is acceptable for the application when considered with respect to:

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

Exception: Internal wiring in a secondary circuit of 50 volts open circuit or less need not comply with this requirement if it is acceptable when judged as bare wire with respect to intermingling with the primary circuit wiring and separation from uninsulated live parts and grounded metal.

13.1.2 The length of the power supply cord inside a battery charger shall be not more than that needed for electrical connections.

13.1.3 The jacket of a flexible cord inside the enclosure shall not be stripped to expose the individual conductors unless:

- a) The insulation on the individual conductors is acceptable for the application;
- b) The individual conductors are supported in a manner positively separating them from live parts and dead metal parts; or

c) Supplementary insulation acceptable for the application is reliably secured on each individual conductor.

13.2 Tubing

13.2.1 Insulation of internal wiring consisting of coated fabric, thermoplastic, or other types of tubing is to be considered with respect to electrical, mechanical, and flammability properties of the material.

13.3 Protection of wiring

13.3.1 Internal wiring shall be protected if, when judged in accordance with 8.1, it is accessible.

Exception: Internal wiring need not be protected if it is located and secured within the enclosure so that it is not likely to be subjected to stress or mechanical damage.

13.3.2 Wires within an enclosure, compartment, raceway, or the like shall be located or protected to reduce the likelihood of contact with any sharp edge, burr, fin, moving part, or the like that can damage the conductor insulation.

13.3.3 A hole in a sheet metal wall within the overall enclosure of a charger through which insulated wires pass shall be provided with smooth, rounded surfaces upon which the wires may bear, to reduce the likelihood of abrasion of the insulation.

13.4 Electrical connections

13.4.1 Aluminum conductors, insulated or uninsulated, used as internal wiring, such as for interconnection between current-carrying parts or in a component winding, shall be terminated at each end by a method acceptable for the combination of metals involved at the points of connection.

13.4.2 With reference to 13.4.1, a wire-binding screw or a pressure wire connector used as a terminating device shall be acceptable for use with aluminum under the conditions involved – for example, temperature, heat cycling, and vibration.

13.4.3 A splice or connection shall be mechanically secure and shall make reliable electrical contact.

13.4.4 A soldered connection shall be mechanically secured before being soldered.

13.4.5 A splice shall be provided with insulation equivalent to that of the wires involved unless permanent spacings will be maintained between the splice and other metal parts.

13.4.6 If the voltage involved is 250 volts or less, insulation consisting of two layers of thermoplastic tape, of two layers of friction tape, or of one layer of friction tape and one layer of rubber tape, that has been investigated and found acceptable for the purpose, is acceptable on a splice.

13.4.7 In determining if splice insulation consisting of coated fabric, thermoplastic, or other tubing is acceptable, consideration is to be given to such factors as its electrical and mechanical properties and its flammability. Thermoplastic tape wrapped over a sharp edge is not acceptable.

13.4.8 The means of connecting stranded internal wiring to a wire-binding screw shall be such that loose strands of wire will be prevented from contacting other live parts not always of the same polarity as the wire, and from contacting dead metal parts. This may be accomplished by the use of a pressure terminal connector, a soldering lug, a crimped eyelet, soldering of all strands together, or other reliable means.

13.5 Separation of circuits

13.5.1 Unless provided with insulation acceptable for the highest of the circuit voltages, insulated conductors of different circuits within a battery charger, including wires in a terminal box or compartment, shall be separated by barriers or shall be segregated, and shall be so separated or segregated from uninsulated live parts connected to different circuits.

13.5.2 Segregation of insulated conductors may be accomplished by clamping, routing, or an equivalent means that maintains permanent separation from insulated and uninsulated live parts and from conductors of a different circuit.

13.6 Barriers

13.6.1 A barrier used to separate or segregate internal wiring shall have adequate mechanical strength and shall be reliably held in place.

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

14 Insulating Materials

14.1 An insulating washer, a bushing, or the like and a base or a support for mounting a live part shall be of moisture-resistant material that is not affected adversely by the temperatures and stresses to which it is subjected under conditions of use.

14.2 Insulating material is to be judged with respect to its acceptability for the application. Materials such as mica, ceramic, and some molded compounds are usually acceptable for the sole support of live parts. If an investigation is necessary to determine whether a material is acceptable, consideration is to be given to:

- a) Its mechanical strength, resistance to ignition, dielectric strength, insulation resistance, and heat resistance qualities in both the aged and unaged conditions;
- b) The degree to which it is enclosed; and
- c) Any other feature affecting the risk of fire, electric shock, or injury to persons.

All factors are to be considered with respect to conditions of service.

15 Motors

15.1 A fan motor used in a battery charger shall be provided with either of the following:

- a) Thermal protection complying with the requirements in the Standard for Thermally Protected Motors, UL 1004-3; or
- b) Impedance protection complying with the Standard for Impedance Protected Motors, UL 1004-2.

Exception: A motor need not comply with 15.1 if it complies with:

- a) The requirements in 7.6.3(b); and*
- b) The abnormal test required by 38.5.1.*

15.2 A motor winding shall resist the absorption of moisture.

16 Transformers

16.1 General

16.1.1 A transformer shall be employed to supply output circuits. The transformer shall have its primary winding electrically isolated from its secondary winding and shall be constructed as specified in 16.1.2, 16.1.3, and 16.2.1 – 16.2.9 so that there is no electrical connection – under normal and overload conditions – between the primary and secondary windings, between the primary winding and the core, or between separate adjacent secondary windings if such a connection might result in a risk of fire or electric shock.

Exception: The requirements in 16.2.1 – 16.2.9 do not apply to control circuit transformers used only for controlling internal loads within the battery charger such as pilot lights, fans, contactor coils, relays, and timers.

16.1.2 A transformer coil, unless inherently moisture resistant, shall be treated with an insulating varnish and baked or otherwise impregnated to exclude moisture or acid vapor. Film-coated magnet wire is considered to be moisture resistant.

16.1.3 With reference to 16.1.2, the requirement concerning acid vapor applies only to a battery charger with a self-contained battery.

16.2 Insulation

16.2.1 A transformer shall be constructed to provide insulation required for the transformer temperature class between:

- a) The primary wires of opposite polarity;
- b) The primary winding and any secondary winding;
- c) The primary winding and the core;
- d) A secondary winding having a potential of more than 30 volts rms (42.4 volts peak) and the core;
- e) The primary winding or lead connections and the transformer enclosure or other dead metal parts;
- f) The primary lead connections and the adjacent winding;
- g) The secondary lead connections of a coil having a potential greater than 30 volts rms (42.4 volts peak) and the adjacent winding; and
- h) The secondary lead connections and the primary winding.

Exception No. 1: Insulation is not required where the spacing specified in Table 23.4 is provided.

Exception No. 2: Insulation may be reduced or waived between the primary and core when all of the following conditions are met:

- a) The core is of a low electrical conductance material, for example ferrite used in switch-mode product;*
- b) The core is treated as a live and electrically conductive part when judging insulation and spacings between the core and:*
 - 1) Accessible metal parts;*
 - 2) The secondary windings; and*
 - 3) Any other output circuitry.*
- c) In applying (b), the core shall be considered to be at the maximum potential of the primary winding; and*
- d) Insulation of Type A, B, or C per Table 16.1 between secondary windings and core.*

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