UL 1236

STANDARD FOR SAFETY

Battery Chargers for Charging Engine-Starter Batteries

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 ANSI/UL 1236 dated February 3, 2021 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made.

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

The requirements are substantially in accordance with Proposal(s) on this subject dated October 30, 2020.

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UL 1236

Standard for Battery Chargers for Charging Engine-Starter Batteries

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April 21, 2015

This ANSI/UL Standard for Safety consists of the Eighth Edition including revisions through February 3, 2021.

The most recent designation of ANSI/UL 1236 as a Reaffirmed American National Standard (ANS) occurred on January 12, 2021. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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INTRODUCTION

1 Scope

1.1 These requirements cover 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;

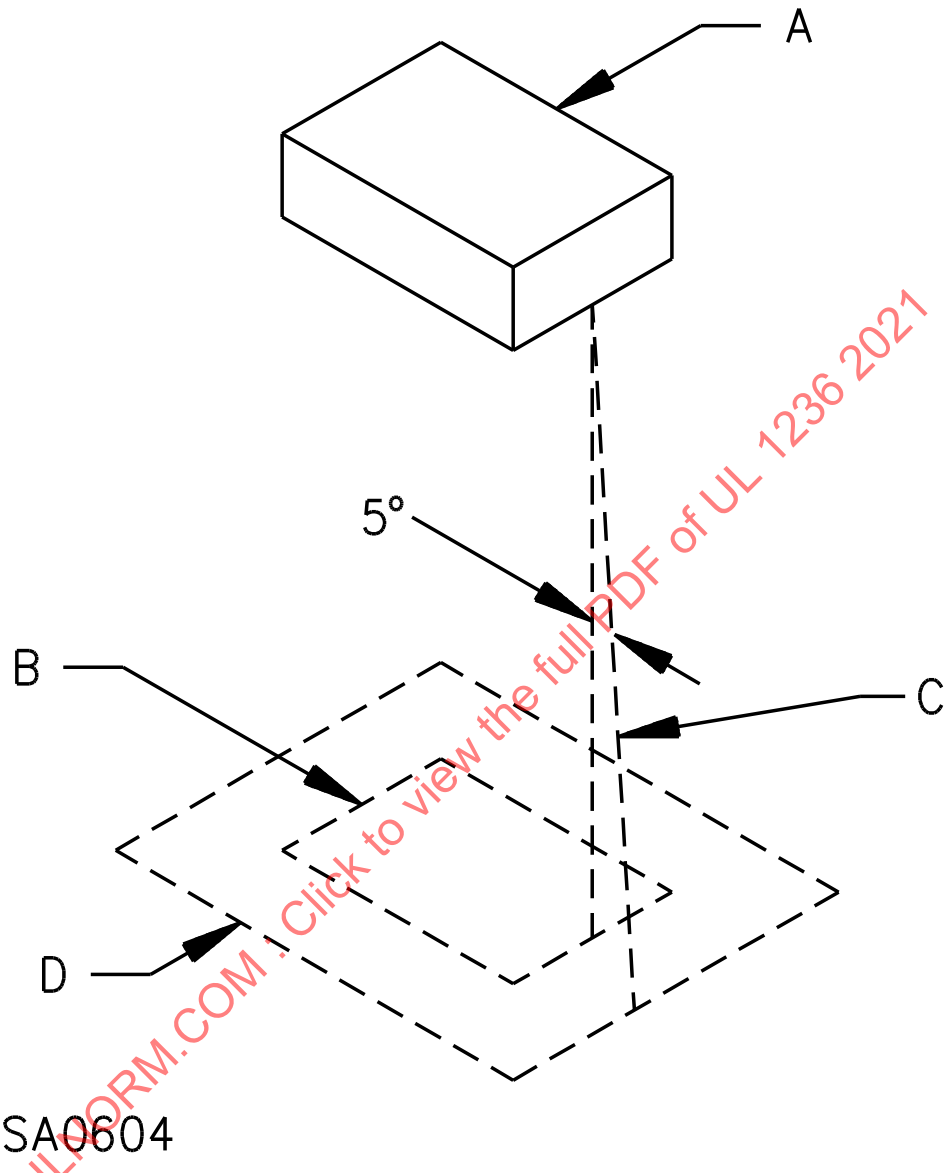
b) Be located as illustrated in Figure; and

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



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.

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.

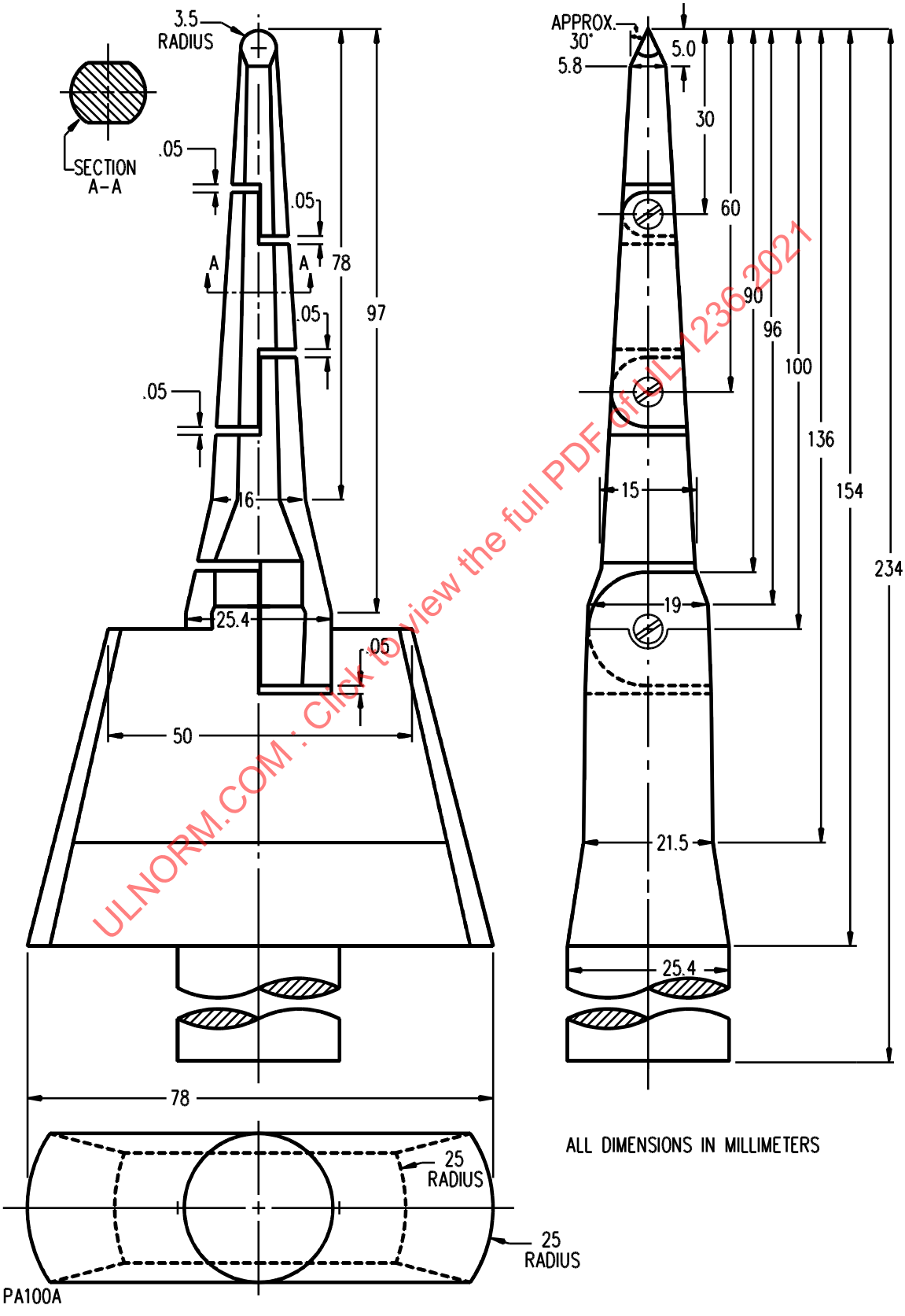
7.8.8 For a rainproof enclosure, openings for conduit shall be threaded unless they are located wholly below the lowest terminal lug or other live part within the enclosure, and there shall be provision for drainage of the enclosure if knockouts or unthreaded holes are provided other than in the bottom.

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



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 mm^2) 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 mm^2) conductor.

Exception No. 2: A No. 6 (3.5 mm diameter) screw may be used for the connection of a 16 AWG (1.3 mm^2) or 18 AWG (0.82 mm^2) 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 mm^2), 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;

I_1 is the maximum input current while delivering maximum non-continuous current;

I_2 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.

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.

16.2.2 The transformer windings mentioned in 16.2.1 include the start, all taps, finish, and crossover leads up to the point where insulated leads are provided.

16.2.3 The transformer insulation shall be as specified in Table 16.1, as applicable.

Table 16.1
Transformer insulation

Location of insulation	Acceptable types of insulation
Insulation between the primary wires of opposite polarity and between secondary wires of opposite polarity having a potential greater than 30 volts rms (42.4 volts peak)[a]	A, B, C
Insulation between the primary and any secondary winding[a, b]	A, B, C
Insulation between any winding having a potential greater than 30 volts rms (42.4 volts peak) and the core[a]	A, B, C

TYPES:

A – Electrical grade paper that is waxed or otherwise treated to retard the absorption of moisture and that has a total thickness of not less than 0.028 inch (0.71 mm), polyethylene terephthalate film not less than 0.007 inch (0.178 mm) thick, or aramid paper not less than 0.0085 inch (0.208 mm) thick.

B – A thermoplastic or thermoset coil form not less than 0.028 inch thick.

C – Material having a thickness less than those specified in Type A may be used provided that it has a dielectric breakdown strength of 5000 V for the thickness used as determined by the Tests on Insulating Materials, Section 40.

[a] Insulation is not specified where the spacing specified in Table 23.4 is provided.

[b] Insulation is not specified between primary and secondary windings that are separated by a grounded copper shield or the equivalent having a current-carrying capacity of not less than the primary winding. If conductors having a circular cross-section are used, two layers shall be employed to reduce air gaps and completely isolate the windings. Following the normal and abnormal operation tests, the insulation between the windings and the shield shall withstand the dielectric voltage withstand test described in 29.1.1.

16.2.4 Insulation between any winding or lead connection and dead metal parts other than the core shall be electrical grade paper, waxed or otherwise treated to resist the absorption of moisture:

a) Having a total thickness of not less than 0.013 inch (0.33 mm) if used in conjunction with an air spacing of one-half that specified in Table; or

b) Having a total thickness of not less than 0.028 inch (0.71 mm) if the insulation is in contact with the enclosure.

Exception No. 1: Polyethylene terephthalate not less than 0.007 inches (0.178 mm) thick or aramid paper not less than 0.0085 inches (0.205 mm) thick may be used.

Exception No. 2: A material having a thickness less than that specified in 16.2.4 (a) and (b) may be used provided that it has a dielectric breakdown strength of 2500 V in the thickness used for (a) and 5000 V in the thickness used for (b) as determined by Tests on Insulating Material, Section 40.

Exception No. 3: Where the spacing specified in Table 23.2 is provided, the insulation thickness in 16.2.4 (a) or (b) need not be provided.

16.2.5 Insulation in accordance with 16.2.6 shall be provided between the crossover leads and:

a) The turns of a different winding;

b) The metal battery charger enclosure; or

c) The core.

16.2.6 To comply with 16.2.5, insulation shall be one of the following:

a) Electrical grade paper, waxed or otherwise treated to resist the absorption of moisture, having a total thickness of not less than 0.028 inch (0.71 mm), polyethylene terephthalate film having a total thickness of not less than 0.007 inches (0.178 mm), or aramid paper having a total thickness of not less than 0.0085 inches (0.208 mm).

b) 0.013 inch (0.33 mm) thick of the material specified in (a) if used in conjunction with an air spacing of one-half that specified in Table 23.2.

c) A material having a thickness less than that specified in (a) and (b) may be used provided that it has a dielectric breakdown strength of 2500 V in the thickness used for (a) and 5000 V in the thickness used for (b) as determined by the Tests on Insulating Materials, Section 40.

Exception No. 1: Where the spacing specified in Table 23.4 is provided, the insulation thickness described in 16.2.6 need not be provided.

Exception No. 2: Any type and thickness of insulation in addition to the magnet wire coating, or a through air spacing less than that specified in 23.1 and 23.2 may be used between a crossover lead and the winding to which it is connected if the construction complies with either of the following:

a) The coil withstands the appropriate dielectric withstand potential described in 29.1. The potential shall be applied between the coil leads with the crossover lead cut at the point where it enters the inner layer, or

b) The coil withstands the induced potential test described in 29.2. See 16.2.7.

Exception No. 3: This requirement does not apply to insulation between a low-voltage limited energy secondary crossover lead and:

a) The secondary winding to which the crossover lead is connected;

b) The metallic enclosure; and

c) The core.

16.2.7 With reference to Exception No. 2 to 16.2.6, the magnet coil of a molded-bobbin transformer having a slot for the crossover or start lead – unspliced at the windings – is an acceptable crossover-lead insulation if:

a) The slot provides a graduated through air spacing to the winding, increasing to the end turns; and

b) The magnet coil winding withstands the induced potential test described in 29.2 or the dielectric voltage withstand test described in 29.1 applied between the coil end leads after breaking the inner lead where it enters the coil.

16.2.8 Insulating material, such as outerwrap and crossover-lead insulation, used to reduce the likelihood of live parts becoming accessible through openings in the outer enclosure shall not be less than 0.028 inch (0.71 mm) thick. See 8.1.

Exception: Insulation is not required to be provided if the transformer is inaccessible.

16.2.9 A bobbin wound transformer shall be constructed to maintain physical separation between the primary and secondary windings. Physical separation may be accomplished by employing a 3-flange bobbin for winding the primary and secondary windings adjacent to each other. As an alternative, a telescoping bobbin construction, each section containing an individual winding, may be used where the primary winding is wound over the secondary winding or the secondary winding over the primary winding. The bobbin insulation material shall comply with the requirements for Type B of Table 16.1.

Exception: A 2-flange bobbin having the primary winding wound over the secondary winding or the secondary winding wound over the primary with the primary winding insulated from the secondary winding by means of tape insulation is considered acceptable if:

a) The tape insulation complies with the requirement in Table;

b) The tape insulation provides a continuous 1/32-inch (0.8-mm) minimum wide bent up edge against the bobbin flanges; and

c) The Fifteen-Day Abnormal Test, Section 39, is continued for 15 days.

16.2.10 Tape used as insulation in lieu of spacings for a flanged bobbin wound transformer shall provide a continuous 1/32 inch (0.8 mm) minimum wide bent up edge against the bobbin flanges.

17 Resistors

17.1 A resistor shall be reliably supported and the assembly shall be provided with a means other than friction between surfaces to reduce the likelihood of loosening or rotating.

17.2 An assembly employing lock washers may be considered to comply with 17.1.

18 Switches and Controllers

18.1 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 circuit that it controls when the battery charger is operated as intended. See 36.4.

Exception: A switch or other control device not having an inductive rating that is connected in a transformer secondary circuit and that complies with the Normal Temperature Test, Section 28, and with the Overload of Switches and Controls Test, Section 36, need not comply with this requirement.

18.2 A primary circuit switch that controls an inductive load having a power factor less than 75 percent, such as a transformer or some ballasts, and that does not have an inductive rating, shall be rated not less than twice the full-load current rating of the load, or the switch shall be investigated for the application.

18.3 Unless rated for the application, a switch or other device that controls a motor and is not interlocked so that it will not break the locked-rotor motor current shall be subjected to the overload test required by 36.1 and described in 36.2.

18.4 A switch that controls a tungsten-filament lamp shall have a tungsten-filament-lamp current rating not less than the maximum current it will control.

Exception: A switch not having an acceptable tungsten-filament-lamp current rating and rated 3 amperes or more may be used to control a 15-watt or smaller lamp.

18.5 A switch shall not disconnect the grounded conductor of a circuit.

Exception No. 1: The grounded conductor may be disconnected by a switch that simultaneously disconnects all conductors of the circuit.

Exception No. 2: The grounded conductor may be disconnected by a switch that is so arranged that the grounded conductor may not be disconnected until the ungrounded conductors of a circuit have been disconnected.

18.6 If unintentional operation of a switch results in a risk of injury to persons, the actuator of the switch shall be located or guarded so that such operation is unlikely. The actuator of a switch may be guarded by recessing, ribs, barriers, or the like.

19 Overload Protective Devices

19.1 A protective device, such as a fuse or a circuit breaker, the intended functioning of which requires renewal, replacement, or resetting, shall be in a readily accessible location. See 50.17.

Exception: This requirement does not apply to a protective device that would ordinarily be unknown to the user because of its location and omission of reference to the device in the operating instructions, circuit diagrams, and other instructional materials provided with the battery charger.

19.2 A household battery charger shall be provided with a manually or automatically reset protector or other overload protective device that complies with the requirements in 38.1 – 38.4.

Exception: This requirement does not apply to a battery charger having low voltage limited energy output characteristics.

19.3 A thermal cutoff or other device employed to reduce a risk of fire or electric shock due to overheating of a transformer during abnormal operation shall comply with the requirements applicable to such a device in addition to the applicable requirements in this Standard – for example, a thermal cutoff shall comply with the applicable requirements in this Standard and those in the Standard for Thermal-Links – Requirements and Application Guide, UL 60691.

20 Fuses and Fuseholders

20.1 A fuse and a fuseholder shall have voltage and current ratings acceptable for the circuit in which they are connected.

20.2 An uninsulated live part of a fuseholder that is capable of causing a risk of electric shock, other than the screw shell or clips, shall not be exposed to contact by a person removing or replacing the fuse.

20.3 If a polarized attachment plug is used, the screw shell of a plug fuseholder and the accessible contact of an extractor fuseholder shall be connected toward the load.

20.4 A fuse that is used for output-lead short-circuit protection shall not be interchangeable with a fuse of a higher ampere rating.

21 Lampholders

21.1 The screw shell of a lampholder shall be connected to a conductor that is intended to be connected to the grounded conductor of the power supply circuit.

21.2 A lampholder shall be designed or installed so that uninsulated live parts, other than a screw shell, are not exposed to contact by persons removing or replacing the lamp in normal service.

22 Printed Wiring

22.1 A printed-wiring board shall comply with the requirements in the Standard for Printed-Wiring Boards, UL 796.

Exception: A printed-wiring board that contains only low voltage limited energy circuits need not comply with this requirement provided deterioration or breakage of the bond between the conductor and the base material would not result in a risk of fire or electric shock.

22.2 A resistor, capacitor, inductor, or other part that is mounted on a printed circuit board to form a printed circuit assembly shall be secured so that it cannot be displaced to cause a risk of fire or electric shock by a force likely to be exerted on it during assembly, normal operation, or servicing of the battery charger.

22.3 Consideration is to be given to a barrier or partition that is part of the battery charger assembly and that provides mechanical protection and electrical insulation for a component connected to a printed circuit board.

22.4 A printed wiring board complying with Exception No. 1 to 23.2 shall also:

a) Comply with the Standard for Printed-Wiring Boards, UL 796; and

b) Have a minimum flammability classification of V-0.

23 Spacings

23.1 Spacings at field-wiring terminals shall not be less than specified in Table 23.1 between:

a) Terminals of opposite polarity; and

b) Terminals and other uninsulated metal parts not always of the same polarity.

Table 23.1
Minimum acceptable spacings at field-wiring terminals

Potential involved, volts rms	Minimum spacing, inch (mm)			
	Over surface		Through air	
0 – 150	1/4	(6.4)	1/4	(6.4)
151 – 300	3/8	(9.5)	1/4	(6.4)
301 – 600	1/2	(12.7)	3/8	(9.5)

23.2 Spacings, other than at field-wiring terminals, between live parts of opposite polarity, and between live and dead metal parts shall not be less than specified in Table 23.2 or Table 23.4, whichever applies. If an uninsulated live part is not rigidly secured in position by means other than friction between surfaces, or if a movable dead metal part is in proximity to an uninsulated live part, the construction shall be such that at least the minimum acceptable spacings are maintained. See 23.3.

Exception No. 1: Spacings between traces on a printed-wiring board need not comply with Table 23.2 and Table 23.4 if the printed wiring board complies with the abnormal operation test in 38.11. See also 22.4. The requirements specified in 22.4 and 38.11 do not substitute for the minimum required spacings between the printed wiring board foils and dead metal parts or the spacings between the primary and secondary board as specified in Table 23.2 or Table 23.4.

Exception No. 2: This requirement does not apply to spacings complying with 23.5 – 23.9.

Exception No. 3: This requirement does not apply to spacings complying with 23.10.

23.3 The spacing requirements in Table 23.2 and Table 23.3 do not necessarily apply to the inherent spacings of a component of a battery charger, such as a switch, fuse, or attachment plug. Such spacings shall comply with the requirements for the component in question if they are less than the values specified in Table 23.2 and Table 23.3.

Table 23.2
Minimum acceptable spacings other than at field-wiring terminals

Potential involved, volts	Minimum spacing, inch (mm)			
	Through air		Over surface	
50 or less	1/16	(1.6)	1/16	(1.6)
51 – 150	1/8	(3.2)	1/4	(6.4)
151 – 300	1/4	(6.4)	3/8	(9.5)
301 – 600	3/8	(9.5)	1/2	(12.7)

Table 23.3
Minimum acceptable spacings between an uninsulated live part and a metal enclosure or other accessible dead metal part including a fitting for conduit or armored cable

Potential involved, volts	Minimum spacing	
	Through air and over surface, inch (mm)	
50 or less	1/16	(1.6)
51 – 150	1/4	(6.4)
151 – 600	1/2	(12.7)

23.4 In a low-voltage limited-energy secondary circuit, spacings between live parts of opposite polarity and between a live part and dead metal that is grounded are not specified.

23.5 Epoxy or equivalent material may be used to reduce spacings when all of the following are met:

a) Spacings of a minimum 1/32 inch (0.8 mm) are maintained prior to application of the encapsulant;

b) There are no significant voids in the encapsulant;

c) The encapsulant is a minimum 1/32 inch (0.8 mm) thick;

d) The area of reduced spacing, with the encapsulant applied, withstands the applicable dielectric voltage withstand test described in Section 29, Dielectric Voltage Withstand Test; and

Exception: When the normal operating potential between the parts under consideration does not exceed 600 V rms, the dielectric test is not required to be conducted.

e) The encapsulant temperature during the temperature test of Section 28, Normal Temperature Test, does not exceed 65°C (117°F) rise [based on an assumed operating ambient rating of 25°C (45°F)] or 90° C (194°F) limit (when tested at an ambient rating of greater than 25°C).

Exception: When the encapsulant has been investigated and rated for a higher operating temperature, the temperatures shall not exceed the material temperature rating.

23.6 As an alternative to the spacing requirements of Table 23.2, the spacing requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances For Electrical Equipment, UL 840 may be used. The spacing requirements of UL 840 are not to be used for field wiring terminals and spacings to a dead metal enclosure. In determining the pollution degree and overvoltage category, the end-use application is to be considered and may modify those characteristics given in 23.7 and 23.8.

23.7 It is anticipated that the level of pollution expected or controlled for indoor use equipment will be pollution degree 2. For outdoor use equipment, pollution degree 3 is expected. Hermetically sealed or encapsulated enclosures, or coated printed-wiring boards in compliance with the Printed-Wiring Board Coating Performance Test of the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, are considered pollution degree 1.

23.8 It is anticipated the equipment will be rated overvoltage category II and overvoltage category I as defined in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840.

23.9 In order to apply clearance B spacings, control of overvoltage shall be achieved by providing an overvoltage device or system as an integral part of the product.

23.10 For the purpose of battery chargers, all printed-wiring boards are considered to have a minimum comparative tracking index of 100 without further evaluation.

23.11 An insulating liner or barrier of material such as vulcanized fiber or thermoplastic employed in lieu of required spacings shall not be less than 0.028 inch (0.71 mm) thick and shall be so located or of such material that it is not adversely affected by arcing.

Exception No. 1: Vulcanized fiber not less than 0.013 inch (0.33 mm) thick or mica not less than 0.0065 inch (0.165 mm) thick may be used:

a) In conjunction with an air spacing of not less than 50 percent of the minimum acceptable through-air spacing;

b) In a single-plate rectifier element of an isolated secondary circuit rated 50 volts rms or less; and

c) Between a heat sink and a metal mounting surface, including the enclosure, of an isolated secondary circuit rated 50 volts rms or less.

Exception No. 2: An insulating material having a thickness less than that specified in 23.11 or Exception No. 1 may be used if, upon investigation, it is found to be acceptable for the application and is equivalent in all respects.

23.12 Insulating material having a thickness less than that specified in 23.11 may be used if, upon investigation, it is found to be acceptable for the application, and has a dielectric breakdown strength of not less than 5000 volts in the thickness used for 23.11 – 2500 volts in the thickness used for Exception No. 1 to 23.11 – as determined by Tests on Insulating Materials, Section 40.

23.13 Film coated wire is regarded as an uninsulated live part when spacings are being considered.

23.14 Spacings within a transformer shall comply with Table 23.4.

Table 23.4
Spacings within a transformer

Potential involved, volts	Minimum spacing through air and over surface between any uninsulated live part[a] and an uninsulated live part of opposite polarity, or the core	
	Inch	(mm)
0 – 50	3/64	(1.2)
Greater than 50 to 125	1/16	(1.6)
Greater than 125 to 250	3/32	(2.4)
Greater than 250 to 600	1/4	(6.4)

NOTE – This table applies only to transformers that are treated with an insulating varnish and baked or otherwise impregnated, and then only to spacings that are fully covered by the impregnation.

[a] Includes turns of a coil having a magnet wire coating.

24 Grounding

24.1 With reference to 11.1.20, in a battery charger intended to be connected to the power supply by a metal enclosed wiring system such as rigid metal conduit or armored cable, or intended to be connected indoors, by a means other than a metal enclosed wiring system such as nonmetallic-sheathed cable, the following shall be conductively connected to the grounding terminal or lead:

a) All exposed dead metal parts; and

b) All dead metal parts inside the enclosure that are exposed to contact during intended operation or adjustment of the battery charger, or during any servicing operation, including maintenance and repair, and that may become energized.

24.2 The surface of a lead intended for connection of an equipment-grounding conductor shall be green with or without one or more yellow stripes, and no other lead shall be so identified.

24.3 A wire-binding screw intended for the connection of a field-installed equipment-grounding conductor shall have a green-colored head that is hexagonal, slotted, or both. A pressure wire connector intended for connection of an equipment-grounding conductor shall be plainly identified by:

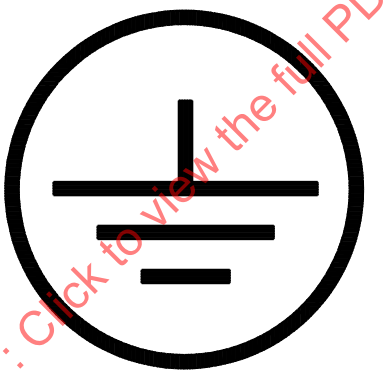
a) A marking, such as "G", "GR", "GND", "Ground", "Grounding", or the like;

b) A wiring diagram provided on the battery charger; or

c) The grounding symbol illustrated in Figure 24.1, on or adjacent to the terminal, or on a wiring diagram provided on the product.

Figure 24.1

Grounding Symbol



IEC417, Symbol 5019

24.4 The wire-binding screw or pressure wire connector referred to in 24.3 shall be located so that it is unlikely to be removed during normal servicing of the battery charger.

24.5 A terminal solely for connection of a grounding conductor shall secure a conductor of the size acceptable for the application in accordance with the National Electrical Code, NFPA 70.

24.6 The grounding conductor of a power supply cord shall be connected to the grounding blade of a grounding attachment plug and shall be connected to dead metal parts within the frame or enclosure by a screw or by an equivalent means that is not likely to be removed during any servicing operation not involving the power supply cord. Solder alone shall not be used for securing the grounding conductor.

Exception: The grounding conductor may be connected to an intermediate component, such as an inductor for electromagnetic compatibility or a printed wiring board trace, provided that:

a) The intermediate component connections to the grounding conductor and to the enclosure are not likely to be removed during servicing operations not involving the grounding path;

b) The cross sectional area of the grounding path is no less than that of the power supply cord grounding conductor;

c) The grounding path, including all splices and connections, complies with the Grounding Conductor Tests, Section 44;

d) The unit is marked in accordance with; and

e) 100 percent of production undergoes the grounding continuity test of 47.4.

24.7 If a means for grounding of the charger is provided, although not required, it shall comply with the requirements in this Section. A soldering lug, a screwless (push-in) connector, a quick-connect, or other friction-fit connector shall not be used. A sheet metal screw shall not be used to connect a grounding conductor or connection device to an enclosure.

Exception: A quick-connect terminal may be used in conjunction with solder for securing the grounding conductor.

24.8 The surface of any insulation on the grounding conductor of a flexible cord shall be green with or without one or more yellow stripes and no other conductor shall be so identified. See 50.7.

24.9 If a portable or stationary battery charger has exposed dead metal parts, it shall have provision for grounding such parts in the form of a grounding conductor in the power supply cord and a grounding attachment plug shall be provided. See 11.2.1.

PERFORMANCE

25 General

25.1 A representative sample of a battery charger shall be subjected to the tests described in Sections 26 – 47. Unless otherwise specified, all tests are to be conducted at the voltage specified in Table 25.1, and at rated frequency. A battery charger rated 50 – 60 hertz shall be tested at the frequency which will produce the highest temperatures. For tests in which the unit is to be connected to a supply circuit, the branch circuit shall be protected by a branch-circuit protective device having a rating equal to the smallest rated receptacle to which the battery charger could be connected.

Table 25.1
Values of test voltages

Rated voltage, rms	Test voltages, rms
110 – 120	120
Between 121 – 219	Rated Voltage
220 – 240	240
Between 241 – 253	Rated Voltage
254 – 277	277
Between 278 – 439	Rated Voltage
440 – 480	480
Between 481 – 525	Rated Voltage
550 – 600	600

25.2 When testing a charger with voltage sensing, the charger may need to be connected to a load that will cause the charger to operate. For example, a battery supplemented by a resistive load, or an RC load

with an additional voltage source that is removed from the circuit when the charger has turned on. Alternatively, the voltage sensing feature may be defeated provided its defeat does not otherwise impact the normal operation of the charger.

25.3 A charger with multiple functions or output settings (such as charging, float, desulfation, alternator check, crank assist or engine start, battery type, equalize, and the like) shall be tested in each mode or combination of modes.

Exception: If operation in a particular mode or combination of modes represents a worst case condition as demonstrated by type testing or analysis, testing in other operating modes is not required.

25.4 In addition to the applicable performance tests specified in Sections 26 – 43, a polymeric enclosure (see 7.5.1) shall be evaluated to the following tests in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C:

a) Mold Stress Relief Distortion; and

b) Strain Relief Test After Mold Stress Relief Distortion.

26 Leakage Current Test

26.1 The leakage current of a cord-connected battery charger, when tested in accordance with 26.2 – 26.8, shall not be more than:

a) 0.5 MIU for a portable charger; or

b) 0.75 MIU for a stationary battery charger.

To avoid undue risks of severe body tissue burns, the leakage current shall be not greater than 70 mA rms, measured as V2 (volts rms) divided by 0.5 (kilohms), using the measuring instrument of Figure 26.3 with the frequency-sensitive network disconnected.

26.2 All exposed conductive surfaces are to be tested for leakage currents. The leakage currents from these surfaces are to be measured to the grounded supply conductor individually as well as collectively if simultaneously accessible, and from one surface to another if simultaneously accessible. Parts are considered to be exposed surfaces unless guarded by an enclosure considered acceptable for protection to reduce the risk of electric shock as defined in 8.1. Surfaces are considered to be simultaneously accessible if they can be readily contacted by one or both hands of a person at the same time.

Exception: These measurements do not apply to output terminals operating at voltages less than 30 volts rms (42.4 volts peak).

26.3 If a surface other than metal is used for the enclosure or part of the enclosure, the leakage current is to be measured using a metal foil with an area of 3.94 by 7.87 inches (100 by 200 mm) in contact with the surface. If the surface is less than 3.94 by 7.87 inches (100 by 200 mm), the metal foil is to be the same size as the surface. The metal foil is not to remain in place long enough to affect the temperature of the battery charger.

26.4 The circuit for the leakage current measurement is to be as illustrated in Figure 26.1 or Figure 26.2 as appropriate. The meter that is actually used for a measurement need only indicate the same numerical value for a particular measurement as would the defined instrument; it need not have all the attributes of the defined instrument. Over the frequency range 20 Hz to 1 MHz with sinusoidal currents, the performance of the instrument is to be as follows:

a) The measured ratio V1/I1 with sinusoidal voltages is to be as close as feasible to the ratio V1/I1 calculated with the resistance and capacitance values of the measurement instrument shown in Figure 26.3.

b) The measured ratio V3/I1 with sinusoidal voltages is to be as close as feasible to the ratio V3/I1 calculated with the resistance and capacitance values of the measurement instrument shown in Figure 26.3.

Figure 26.1

Leakage current measurement circuit used for chargers intended for connection to 120 V circuit

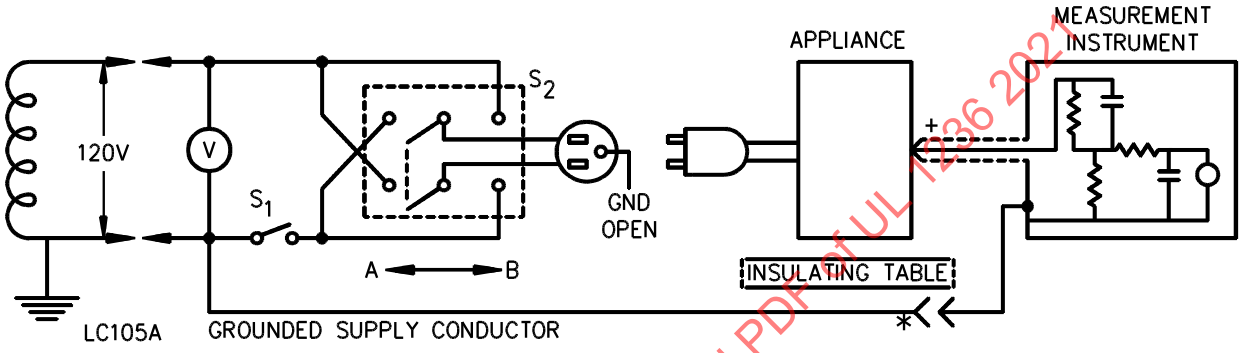
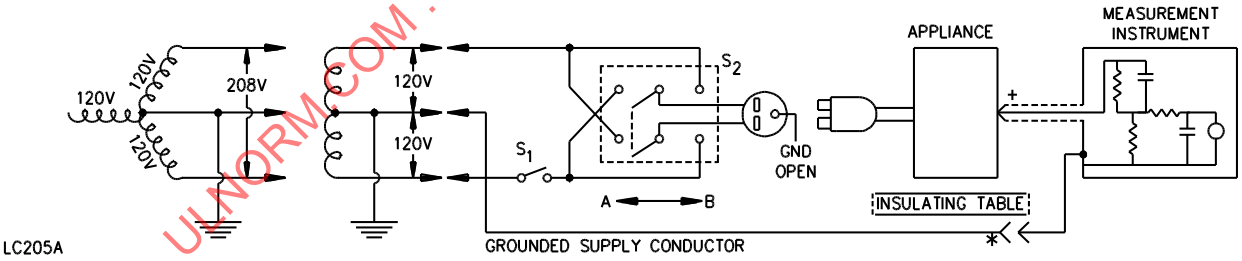


Figure 26.2

Leakage-current measurement circuit used for grounded or ungrounded 208 V or 240 V chargers intended for connection to three-wire neutral grounded circuits

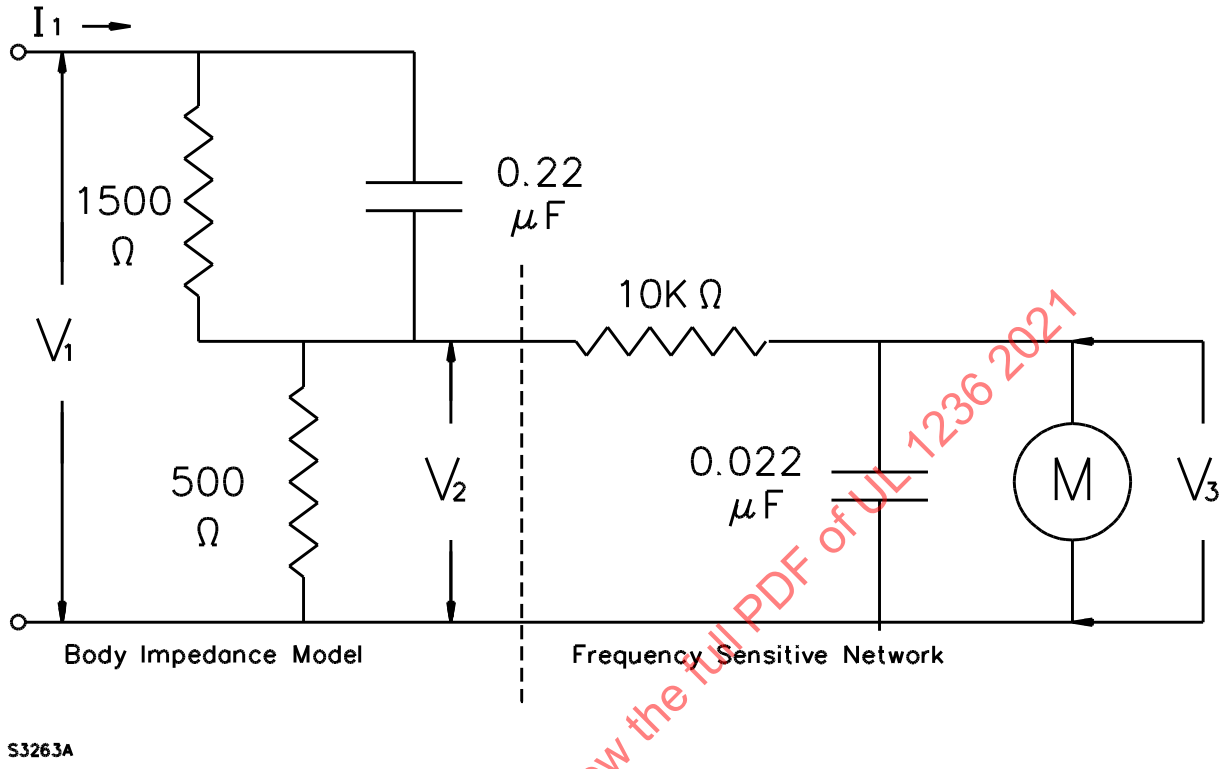


* Separated and used as clip when measuring currents between simultaneously accessible parts of the charger.

+ Probe with shielded lead.

Figure 26.3

Measurement instrument for reaction



26.5 Unless the meter is being used to measure leakage current from one part of a battery charger to another, the meter is to be connected between an accessible part and the grounded supply conductor.

26.6 A sample of the battery charger is to be tested for leakage current starting with the as-received condition (see 26.7) but with the grounding conductor, if any, open at the attachment plug. The supply voltage is to be adjusted to the voltage specified in Table 25.1. The test sequence, with reference to the measuring circuit in Figure 26.1 or Figure 26.2, is to be as follows:

a) With switch S1 open, the battery charger is to be without load and connected to the measuring circuit. Leakage current is to be measured using both positions of switch S2 and with the battery charger switching devices in all their intended operating positions.

b) Switch S1 is then to be closed energizing the battery charger, and within 5 seconds, the leakage current is to be measured using both positions of switch S2 and with the battery charger switching devices in all their intended operating positions.

c) Leakage current is to be monitored until thermal stabilization. Both positions of switch S2 are to be used in making this measurement. Thermal stabilization is considered to be obtained by operation of the battery charger as in the normal temperature test.

26.7 For the purpose of 26.6, the as-received condition is to be without prior energization except as may occur as part of the production line testing.

26.8 Normally, the complete leakage current test as described in 26.6 is to be conducted without interruption for other tests. With the concurrence of those concerned, the leakage current test may be interrupted to conduct other nondestructive tests.

27 Power Input Test

27.1 The input current and power factor to a battery charger shall be measured with the charger operating while connected to the maximum normal load. The current input shall not be more than 110 percent of the rated value.

27.2 The input current is to be measured with the load adjusted to draw the continuous output current rating. If the charger is provided with a tap switch or other means for adjustment of the output current or voltage, measurements of the primary input current are also to be made with the output load adjusted to draw the continuous output current rating.

27.3 A battery charger with a non-continuous output current rating shall comply with 27.1 while connected to a load adjusted to draw a current equal to the maximum non-continuous current output rating.

27.4 With reference to 27.1 – 27.3, the load to be used for a battery charger having a continuous or non-continuous current output rating of 20 amperes or less is to be tested with:

a) A 100,000-microfarad capacitor in parallel with a resistor adjusted to draw rated output current;

b) A battery supplemented with a resistive load bank; or

c) An acceptable battery if requested by the manufacturer.

27.5 With reference to 27.1 – 27.3, the load to be used for a battery charger having a continuous or non-continuous current output rating of more than 20 amperes is to be tested with:

a) A 185,000-microfarad capacitor in parallel with a resistor adjusted to draw rated output current;

b) A battery supplemented with a resistive load bank; or

c) An acceptable battery if requested by the manufacturer.

27.6 A battery charger for series charging of more than one battery is to be tested with a load to represent the additional batteries.

27.7 For chargers with rated output of 30 amperes or less, a battery with a reserve capacity between 100 to 120 minutes may be considered a representative load. Reserve capacity is the time in minutes that a new, fully charged battery will deliver 25 amperes at 80°F (26.7°C) and maintain a terminal voltage equal to, or higher than, 1.75 V per cell (for example, 10.5 V for a nominal 12 V battery).

27.8 For chargers with rated output of more than 30 amperes, a battery with an ampere-hour rating between 100 to 200 Ah at the 10 hour rate may be considered a representative load (such as a Battery Council International type 4D or 8D).

27.9 If a charger is to be tested using a battery or batteries as the load, the battery is to be discharged to 1.75 volts per cell at a rate not to exceed the discharge rate assigned by the battery manufacturer, but in any case, the rate of discharge is not to exceed one-sixth of the ampere-hour capacity of the battery.

27.10 Output current measurements of either half- or full-wave rectified circuits are to be based on the average current.

28 Normal Temperature Test

28.1 General

28.1.1 A battery charger tested using a load adjusted to maximum normal current, and within the output voltage requirements specified in 28.1.6, 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 limits specified in Table 28.2. A load as described in 27.4, 27.5, or 27.9 is to be used.

Exception: The temperature limits specified in Table 28.2 do not apply during the test described in 28.2.3 (b)(2).

28.1.2 All temperature limit values in Table 28.2 are based on an assumed ambient temperature of 25°C (77°F). However, with correction of temperature measurements, tests may be conducted in other ambients as described in Table 28.1.

Table 28.1
Temperature measurement correction

Ambient temperature rating of unit	Test ambient temperature	Correction of observed temperature
1. 25°C (77°F)	Range of 10 – 40°C (50 – 104°F)	See note a, item 1
2. Range of 25 – 40°C (77 – 104°F)	Range of 20 – 40°C (68 – 104°F)	See note a, item 2
3. Above 40°C (104°F)	Rated ambient, see note b	c

[a] Correction of temperature, as determined by item 1 or 2 below, shall not exceed the temperature limit specified in Table 28.2:

1) An observed temperature is to be corrected by addition (if the test ambient temperature is lower than 25°C (77°F)) or by subtraction (if the test ambient temperature is higher than 25°C (77°F)) of the difference between 25°C (77°F) and the test ambient temperature.

2) An observed temperature is to be corrected by addition (if the test ambient temperature is lower than the rated ambient temperature) or by subtraction (if the test ambient temperature is higher than the rated ambient temperature) of the difference between the rated ambient temperature and the test ambient temperature.

[b] Allowable tolerances are:

Minus – not less than 5°C (9°F) below rated ambient.

Plus – not specified.

[c] If the test ambient temperature equals rated ambient, no correction is to be made, and an observed temperature shall not exceed the temperature limit specified in Table 28.2. If the test ambient temperature is other than rated ambient, correction is to be made as described in item 2 of note a.

28.1.3 For a battery charger provided with a tap switch or other means for adjustment of the output current or voltage, the output is to be adjusted to result in maximum output power for each current setting and each voltage setting.

28.1.4 In the temperature test of a battery charger using a battery load, the battery is to be discharged as specified in 27.9, then charged until temperatures on the charger reach a maximum and begin to decrease. The temperature test is to be continued using a second battery, also discharged as specified in 27.9, until maximum temperatures are attained. See 38.7.1.

28.1.5 A circuit protector shall not operate during the normal temperature test.

Exception: A circuit protector may operate during the test described in 28.2.3(b)(2).

28.1.6 With reference to 28.1.1, a battery charger is to be loaded to a current equal to the continuous output current rating. If the charger has a non-continuous rating, the test described in 28.2.1 – 28.2.3 is also to be conducted. The output voltage shall be not less than 2 volts per cell (6.0 and 12.0 volts for a 6 and 12 volt battery charger respectively) while delivering a load current equal to the maximum output current rating.

28.1.7 The output voltage of a battery charger intended for cranking assist shall be not less than 1 volt per cell (3.0 and 6.0 volts for a 6 and 12 volt battery charger respectively) while delivering a load current equal to the maximum output current rating. The battery charger is to be at room temperature at the beginning of the test, and the output measurements are to be taken 5 seconds after energization of the primary, regardless of the duty cycle rating. The output voltage of a charger designed to charge or crank assist a series of either 6, 8, or 12 V batteries shall be a direct multiple of the voltages.

28.1.8 A battery charger designed for mounting or support in more than one position, or in a confined location, shall be tested in a manner representing the most severe conditions. An adjacent mounting or supporting surface shall consist of nominal 1 inch (25.4 mm) thick, soft pine boards.

28.1.9 Unless investigated and found acceptable – see 7.4.2 – a supporting means formed of soft rubber or a 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 battery charger supported by the metal insert. At the request of the manufacturer, the test may be conducted without any means of support.

28.1.10 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:

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

in which:

Δt 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 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.

Table 28.2
Maximum acceptable temperature limits

	Materials and components	°C	(°F)
1.	A surface upon which a fixed battery charger may be mounted in service, and surfaces that may be adjacent to the unit when so mounted	90	(194)
2.	Any point on or within a terminal box or compartment of a fixed battery charger on which field-installed conductors to be connected may rest	60[j]	(140)[j]
3.	Class 105 coil insulation systems of a relay, a solenoid, or the like		
	Thermocouple method	90[a]	(194)[a]
	Resistance method	110	(230)
4.	Class 130 coil insulation systems of a relay, a solenoid, or the like		
	Thermocouple method	110[a]	(230)[a]
	Resistance method	125	(257)
5.	Transformer insulation systems:		
	A. Class 105		
	Thermocouple method	90[a]	(194)[a]
	Resistance method	95	(203)
	B. Class 130		
	Thermocouple method	110[a]	(230)[a]
	Resistance method	120	(248)
	C. Class 155		
	Thermocouple method	135	(275)
	Resistance method	140	(284)
	D. Class 180		
	Thermocouple method	150	(302)
	Resistance method	160	(320)
	E. Class 200		
	Thermocouple method	165	(329)
	Resistance method	175	(347)
	F. Class 220		
	Thermocouple method	180	(356)
	Resistance method	190	(374)
6.	Class A motor coil insulation systems:		
	A. In an open motor:		
	Thermocouple method	90[a]	(194)[a]
	Resistance method	100	(212)
	B. In a totally enclosed motor:		
	Thermocouple method	95[a]	(203)[a]
	Resistance method	105	(221)
7.	Class B motor coil insulation systems:		
	A. In an open motor:		
	Thermocouple method	110[a]	(230)[a]
	Resistance method	120	(248)
	B. In a totally enclosed motor:		

Table 28.2 Continued on Next Page

Table 28.2 Continued

Materials and components		°C	(°F)
	Thermocouple method	110[a]	(230)[a]
	Resistance method	120	(248)
8.	Capacitor:		
	Electrolytic	65[e]	(149)[e]
	Other than electrolytic	90[f]	(194)[f]
9.	Fiber employed as electrical insulation	90	(194)
10.	Varnished-cloth insulation	85	(185)
11.	Phenolic composition employed as electrical insulation or as a part the deterioration of which would result in a risk of fire or electric shock.	150[b]	(302)[b]
12.	Wood or other combustible material	90	(194)
13.	Rubber- or thermoplastic-insulated wire and cord	60[b,c,d]	(140)[b,c,d]
14.	Sealing compound	g	g
15.	Selenium rectifier	75[h,i]	(167)[h,i]
16.	Silicon rectifier	100[i]	(212)[i]
17.	Surface temperature:		
	A. Handle or knob for lifting, carrying, or holding:		
	Metallic	50	(122)
	Nonmetallic	60	(140)
	B. Handle or knob contacted, but not involving lifting, carrying, or holding; other surfaces subjected to contact in operation:		
	Metallic	60	(140)
	Nonmetallic	85	(185)
	C. A surface subject to casual contact:		
	Metallic	70[k]	(158)[k]
	Nonmetallic	95[k]	(203)[k]

[a] At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature as measured by means of a thermocouple may be 5°C (9°F) higher than that specified if the temperature of the coil as measured by the resistance method is not more than that specified.

[b] The temperature limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to a compound that has been investigated and found to have acceptable heat-resistant properties.

[c] Rubber-insulated conductors within a Class A insulated motor and rubber-insulated motor leads, and a rubber-insulated flexible cord entering a motor may be subjected to a temperature of more than 60°C (140°F), provided that an acceptable braid is employed on the conductors of other than a flexible cord. This does not apply to thermoplastic-insulated wires or cords.

[d] A short length of rubber- or thermoplastic-insulated flexible cord inside the charger may be exposed to a temperature of more than 60°C (140°F) if supplementary-insulation acceptable for the measured temperature and of adequate dielectric properties is employed on each individual conductor.

[e] For an electrolytic capacitor that is integral with or attached to a motor, the temperature on insulating material integral with the capacitor enclosure may be not more than 90°C (194°F).

[f] A capacitor that operates at a temperature rise of more than 90°C (194°F) may be judged on the basis of its marked temperature limit.

[g] Unless a thermosetting compound, the maximum sealing compound temperature is 15°C (27°F) less than the softening point of the compound as determined in accordance with the Test of Softening Point by the Ball- and Ring-Apparatus, ASTM E28.

[h] A temperature of 85°C (185°F) is acceptable if the stack assembly is insulated with phenolic composition or other insulating material acceptable for a temperature of 150°C (302°F).

[i] The limitation does not apply to a material that has been investigated and found suitable for a higher temperature.

Table 28.2 Continued on Next Page

Table 28.2 Continued

Materials and components	°C	(°F)
[j] The temperature observed on the terminals and at points within a terminal box of a commercial battery charger marked in accordance with 50.18 may exceed the values specified but shall not exceed 90°C (194°F).		
[k] A commercial battery charger may exceed the temperature limits specified for surfaces subject to casual contact if all of the following conditions are met: a) The charger is intended to be permanently installed so that the area or surface of the battery charger is not likely to be contacted by people; b) The charger is marked as required by; and c) The charger is provided with instructions as specified in 53.5(g).		

28.1.11 Thermocouples are to consist of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.05 mm^2). When referee temperature measurements by thermocouples are necessary, 30 AWG iron and constantan wire and a potentiometer-type instrument is to be used. The thermocouples and related instruments are to be accurate and calibrated in accordance with good laboratory practice. The thermocouple wire is to comply with the requirements listed in the "Tolerances on Initial Values of EMF versus Temperature" tables in the Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M.

28.1.12 A thermocouple junction and the adjacent thermocouple lead wires are to be held securely in good thermal contact with the surface of the material of which the temperature is being measured. Usually acceptable 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.

28.1.13 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 5 minutes, indicate no further increase.

28.2 Non-continuous current rating temperature test

28.2.1 The non-continuous current rating tests shall be conducted with the unit energized from a circuit having a voltage and frequency as specified in 25.1 and branch circuit protection sized for the greater of the following:

a) 20 ampere; or

b) 125 percent of the input current rating under continuous charging conditions.

If the value for (b) does not correspond to a standard branch circuit protection rating, the next highest rating shall be used.

28.2.2 When conducting the non-continuous current rating tests described in 28.2.3 (a) and (b)(1), a circuit protector provided as part of the battery charger or the branch circuit protection mentioned in 28.2.1 shall not open.

28.2.3 With reference to 28.1.6, a capacitance sized in accordance with 27.4 or 27.5, as applicable, in parallel with a resistor is to be connected to the output of the charger and the resistor is to be adjusted to draw rated non-continuous current. This test is to be performed immediately following the measurement of constant temperatures described in 28.1.1, 28.1.3, and 28.1.4. The duty cycle is to be:

a) In accordance with the duty cycle specified by the manufacturer until temperatures are constant if a momentary contact switch interrupts the non-continuous current; or

b) In accordance with the following:

1) As described in (a) above; and

2) Continuously in the non-continuous mode of operation until temperatures are constant if either a two-position switch or no switch is provided to interrupt the non-continuous current. A circuit protector may cycle during this test. The temperature limits of Table 28.1 and Table 28.2 do not apply during this test.

28.2.4 In accordance with the test described in 28.2.3(a), during the "off" period of the duty cycle, the output of the battery charger shall not be connected to any load. See 27.4 – 27.9.

28.3 Discharge temperature test

28.3.1 A battery charger employing a discharge resistor for battery testing shall be subjected to a discharge temperature test. The temperatures measured during the first two discharges shall not exceed the temperature limits specified in Table 28.2. There shall be no emission of flame or molten metal from the charger during any of the five discharges.

28.3.2 Starting within 1 minute after completion of the temperature test described in 28.1.1, a full-charged battery of the required capacity is to be discharged through the discharge circuit. The length of the discharge time is to be as specified in Table 28.3. The discharge is to be repeated at 2-minute intervals until a total of five discharges have occurred.

Table 28.3
Discharge test time

Length of discharge recommended by manufacturer, minutes	Discharge test time
2 or less	150 percent of time recommended by manufacturer
More than 2	125 percent of time recommended by manufacturer
No recommendation	1-1/2 minutes

29 Dielectric Voltage Withstand Test

29.1 General

29.1.1 While still heated, a battery charger shall withstand for 1 minute without breakdown the application of a 40 to 70-hertz essentially sinusoidal potential of:

a) One thousand volts plus twice the maximum rated voltage between:

1) The primary circuit and dead metal parts;

2) The primary and secondary circuits;

3) A secondary winding, including any ferroresonant windings, operating at more than 50 volts and dead metal parts; and

4) A secondary winding operating at more than 50 volts and all other secondary windings.

b) One thousand volts between live and dead metal parts of a motor.

c) Five hundred volts between a secondary circuit operating at 50 volts or less and dead metal parts; and five hundred volts between secondary circuits operating at 50 volts or less.

d) A dc potential of 1.414 times (2 V + 1000), where V is the rms supply voltage, between the terminals of a capacitor used across the line for radio interference elimination or arc suppression.

Exception No. 1: If an ac potential results in excessive leakage through capacitors during the test specified in (a) – (c) above, the capacitors may be removed from the circuit for the ac potential. With the capacitors connected in the circuit, the battery charger shall withstand a dc potential of 1.414 times the ac rms potential between the points specified.

Exception No. 2: 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 with the Standard for Electromagnetic-Interference Filters, UL 1283, need not be subjected to the dielectric potential required by 29.1.1(d).

29.1.2 To determine whether a battery charger complies with the requirements in 29.1.1, the battery charger 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 a substantially uniform rate as rapid as is consistent with correct indication of its value by a voltmeter.

29.2 Induced potential test

29.2.1 If a bobbin wound transformer is required to be tested as provided in 16.2.7 (b), after constant temperatures have been reached as the result of operation under the Normal Temperature Test, Section 28, one sample of the transformer shall withstand without breakdown an induced potential test in accordance with 29.2.2 and 29.2.3.

29.2.2 While still heated, the primary winding is to be subjected to an alternating potential of twice the rated voltage at any acceptable frequency – typically 120 hertz or higher – for 7200 electrical cycles or for 60 seconds, whichever is less. Starting at one-quarter or less of the full value, the test voltage is to be increased to the full value in not more than 15 seconds. After being held for the time specified, the voltage is to be reduced within 5 seconds to one-quarter or less of the full value, and the primary winding circuit is to be opened.

29.2.3 An oven may be used to condition the samples to the temperature attained under the conditions specified in 29.2.1 and 29.2.2 before conducting the test.

30 Water Spray Test

30.1 After being subjected to the water spray as described in 30.3 for 4 hours, a battery charger as mentioned in 7.8.2 – 7.8.8 or a cart-type battery charger shall:

a) For a cord-connected battery charger rated for a nominal 120-volt supply, comply with the requirement in 26.1 in a repeated leakage current test, except that the test is to be discontinued when the leakage current stabilizes.

b) For a battery charger other than as specified in 30.1(a), have an insulation resistance of not less than 50,000 ohms.

Exception: A cart-type battery charger marked in accordance with the requirements in 50.9 need not comply with this requirement.

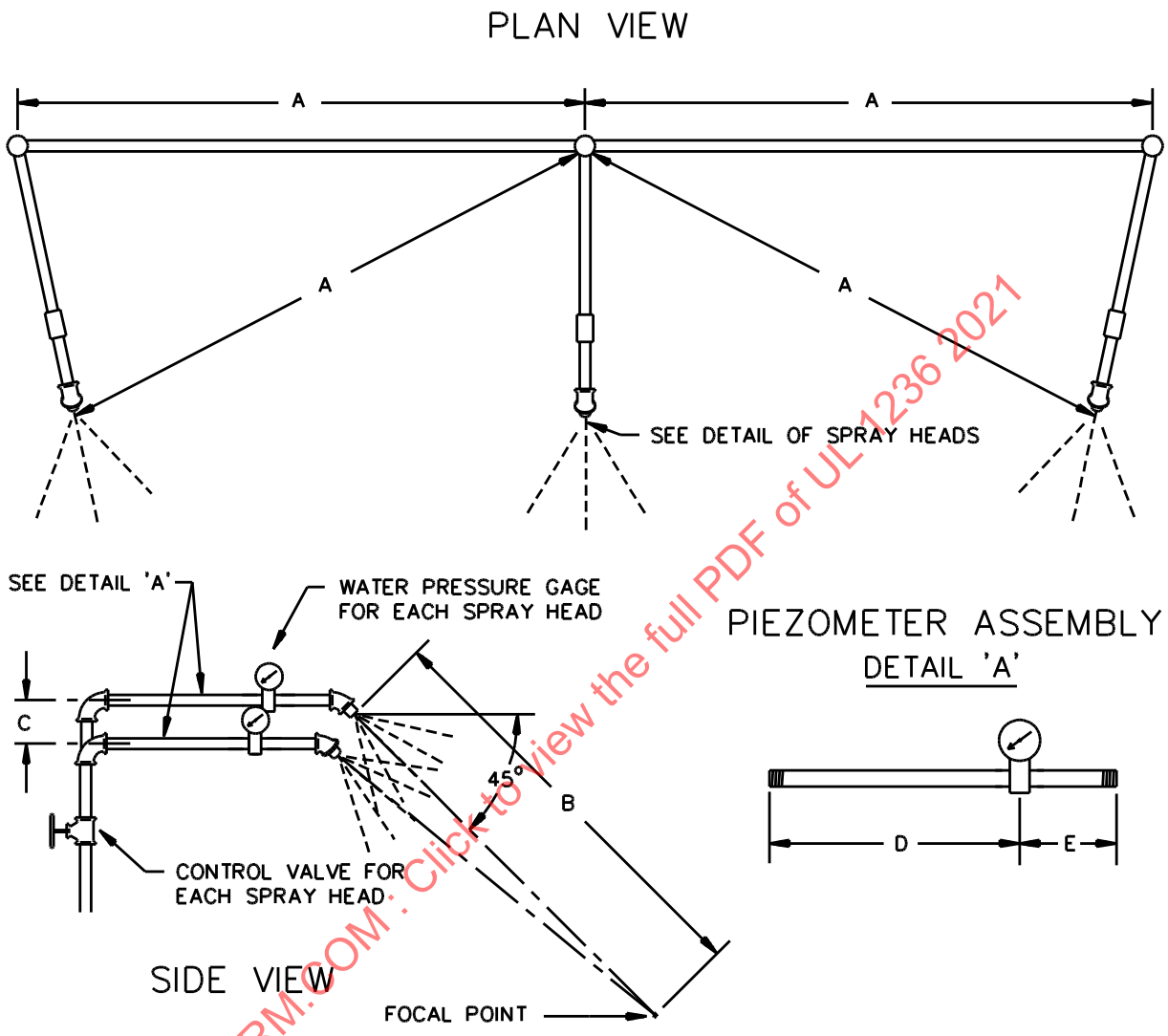
30.2 After being tested in accordance with either 30.1 (a) or (b), a battery charger shall comply with a repeated dielectric evaluation in accordance with the Dielectric Voltage Withstand Test, Section 29.

30.3 Before the test described in 30.4 is started, the resistivity of the water is to be adjusted to 3500 ohm-centimeters ±5 percent when measured at 25°C (77°F). At the conclusion of the test, the resistivity of the water is not to be less than 3200 ohm-centimeters or more than 3800 ohm-centimeters at 25°C.

30.4 The test apparatus is to consist of three spray heads constructed in accordance with the details shown in Figure 30.2 and mounted in a water supply pipe rack as shown in Figure 30.1. The water pressure is to be maintained at 5 psi (34 kPa) at each spray head. The distance between the center nozzle and the battery charger is to be approximately 5 feet (1.5 m). The battery charger is to be brought into the focal area of the three spray heads in such a position and under such conditions as are most likely to result in entrance of water into the battery charger, except that consideration is to be given to the normal mounting position. If the battery charger employs a fan or other moving part, the operation of which is likely to facilitate the entrance of water, it is to be energized and operated as intended.

Figure 30.1

Rain test spray head piping

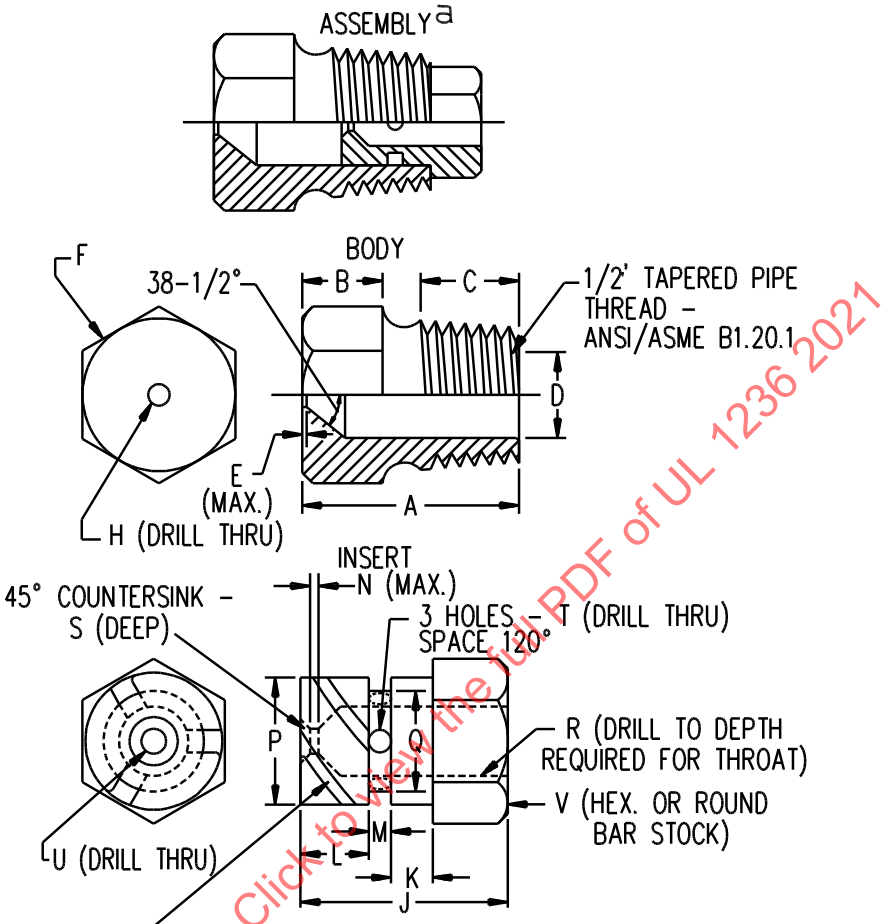


Item	mm	inch
A	710	28
B	1400	55
C	55	2–1/4
D	230	9
E	75	3

RT101F

Figure 30.2

Rain test spray head



Item	mm	inch	Item	mm	inch
A	31.0	1-7/32	N	0.80	1/32
B	11.0	7/16	P	14.61	.575
C	14.0	9/16		14.63	.576
D	14.68	.578	Q	11.51	.453
	14.73	.580		11.53	.454
E	0.40	1/64	R	6.35	1/4
F	c	c	S	0.80	1/32
G	1.52	.06	T	2.80	(No. 35) [b]
H	5.0	(No.9) [b]	U	2.50	(No. 40) [b]
J	18.3	23/32	V	16.0	5/8
K	3.97	5/32	W	1.52	0.06
L	6.35	1/4			
M	2.38	3/32			

[a] Nylon Rain-Test Spray Heads are available from Underwriters Laboratories

[b] ANSI B94.11M Drill Size

[c] Optional - To serve as a wrench grip.

RT100F

31 Impact Test

31.1 General

31.1.1 A battery charger shall be tested as described in 31.2 and 31.3 (see 31.1.2 – 31.1.4). Following the test, the battery charger shall:

a) Not permit a probe, as illustrated in Figure 8.1 and applied in accordance with 7.7.4, to contact an uninsulated live part that may involve a risk of electric shock or a moving part that may involve a risk of injury to persons; and

b) Comply with the Dielectric Voltage Withstand Test, Section 29, with the potential applied between live parts and accessible dead metal parts.

31.1.2 The test of 31.2 is to be performed on the following:

a) Units employing a polymeric enclosure, or a polymeric part forming part of the enclosure;

b) With reference to the Exception to 7.1.3, enclosures of metal; or

c) With reference to 7.5.4, material of a part the breakage of which may result in a risk of injury to persons, or a risk of electric shock.

The test for (a) and for polymeric parts of (c) shall be performed on samples after being conditioned for 3 hours in a cold chamber at minus 35°C (minus 31°F) for a fixed outdoor unit, and at 0°C (32°F) for all other units.

31.1.3 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, is to be impacted in accordance with 31.2.

Exception: This requirement does not apply to a meter complying with the requirements in the Standard for Electrical Analog Instruments – Panelboard Type, UL 1437.

31.1.4 The test of 31.3 is to be performed on three samples of a portable unit weighing less than 40 pounds (18 kg). The test shall be performed on samples after being stabilized to room temperature [nominal 25°C (77°F)].

31.1.5 With reference to the Exception to 7.1.3, a permanent distortion to the extent that spacings are reduced below the values specified in Spacings, Section 23, shall not result when a small section of a sheet metal enclosure having a thickness less than that specified in Table 7.1 is subjected to the test described in 31.2.

31.2 Ball impact test

31.2.1 With reference to 31.1.2, the enclosure section, guard, or cover is to be subjected to an impact of 5 foot-pounds (6.78 N·m) on any surface that is exposed to a blow during intended use. The impact is to be produced by dropping a steel sphere, 2 inches (50.8 mm) in diameter and weighing approximately 1.18 pounds (0.535 kg), from a height of 51 inches (1.30 m). For surfaces other than the top of an enclosure, the steel sphere is to be suspended by a cord and allowed to swing as a pendulum dropping through a vertical distance of 51 inches.

31.3 Drop test

31.3.1 With reference to 31.1.4, each sample is to be dropped three times from a height of 3 feet (0.9 m) to strike a concrete surface in the positions most likely to produce adverse results.

32 Stability Test

32.1 Under conditions of normal use, a portable or stationary battery charger intended for floor or table use shall not become physically unstable to the degree that it poses a risk of injury to persons.

Exception: This requirement does not apply to a direct plug-in or cord-connected battery charger weighing 1 pound (0.5 kg) or less.

32.2 A battery charger shall not tip over but shall return to its normal at-rest position when:

a) Tipped through an angle of 10 degrees from an at-rest position on a horizontal surface;

b) Placed on a plane inclined at an angle of 10 degrees from the horizontal; or

c) Subjected to an externally applied horizontal force of 20 percent of the weight of the battery charger or 50 pounds (22.7 kg), whichever is less. See 32.5.

32.3 A battery charger is not to be energized during the stability test. The test is to be conducted under conditions most likely to cause the battery charger to overturn. The following conditions are to be such as to result in the least stability:

a) The position of all adjustable or movable parts such as doors, drawers, or casters;

b) The supply and output cords placed in either the stored position or on the surface supporting the battery charger, whichever is more severe;

c) Provision of or omission of any normal mechanical load in the battery charger such as stored parts; and

d) Direction in which the battery charger is tipped, or the supporting surface is inclined.

32.4 With reference to the requirement in 32.2(a), for a battery charger that is constructed so that while being tipped through an angle of 10 degrees a part or surface of the battery charger not normally in contact with the horizontal supporting surface touches the supporting surface before the charger has been tipped through an angle of 10 degrees, the tipping is to be continued until the surface or plane of the surface of the charger originally in contact with the horizontal supporting surface is at an angle of 10 degrees from the horizontal supporting surface.

32.5 The force specified in 32.2(c) is to be applied in a horizontal direction at that point on the charger most likely to overturn the battery charger, but is not to be applied more than 5 feet (1.52 m) above floor level. The legs or points of support may be blocked to prevent the unit from sliding during the application of the force.

33 Static Load Test

33.1 When mounted as recommended by the manufacturer, a battery charger intended to be fixed to a supporting structure shall be loaded as described in 33.2 for 1 minute with a force equal to three times the weight of the device but not less than 20 pounds (89 N). As a result of this loading, there shall be no permanent deformation, breakage, dislocation, cracking, or other damage to the mounting means.

Exception No. 1: This test is not required for a battery charger weighing 1 pound (0.45 kg) or less.

Exception No. 2: This test is not required for a battery charger weighing 20 pounds (9.07 kg) or less and having keyhole slots in a sheet metal enclosure, or brackets welded to the enclosure, provided that the enclosure complies with the thickness requirements specified in 7.1.3 and Table 7.1.

33.2 The force is to be applied through the approximate center of gravity of the device, is to be increased gradually to reach the required value in 5 to 10 seconds, and is to be maintained at that value for 1 minute.

34 Strain Relief Test

34.1 The strain relief means provided on a flexible cord shall withstand for 1 minute without displacement a direct pull of 35 pounds (156 N) applied to the cord, with the connections within the battery charger 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.

Exception: The strain relief means provided for the output cord on a battery charger with a low voltage limited energy output shall withstand for 1 minute a direct pull of 20 pounds (89 N). The results are not acceptable if, with the output cord connected internally, movement of the cord results in a reduction of spacings to primary or dead metal parts, damage to the transformer or enclosure, or interruption of the output circuit wiring.

34.2 A 35-pound (15.9-kg) or a 20-pound (9.1-kg) weight, as applicable, is to be suspended from the cord and supported by the battery charger so that the strain relief means is stressed from any angle the construction of the battery charger permits.

34.3 With reference to 11.4.3, the strain relief for a specialized vehicle connector shall withstand a straight pull of 30 lbf (133 N) if the conductors are 18 AWG or larger, and 20 lbf (89 N) if smaller than 18 AWG, applied between the connector and the cord. The connector is to be securely supported by a rigid, flat plate mounted horizontally. The plate is to have a hole just large enough for the cord to pass through. The pull is to be applied by means of a weight for 1 minute to the flexible cord, in a direction perpendicular to the plane of the cord-entry to the connector.

35 Push-Back Relief Test

35.1 To determine compliance with 11.3.14, a product shall be tested in accordance with 35.2 without occurrence of any of the conditions specified in 11.3.14 (a) – (d).

35.2 The supply cord or lead is to be held 1 inch (25.4 mm) from the point where the cord or lead emerges from the product and is then to be pushed back into the product. When a removable bushing which extends further than 1 inch is present, it is to be removed prior to the test. When the bushing is an integral part of the cord, the test is to be carried out by holding the bushing. The cord or lead is to be pushed back into the product in 1-inch (25.4-mm) increments until the cord buckles or the force to push the cord into the product exceed 6 pounds-force (26.7 N). The supply cord or lead within the product is to be manipulated to determine compliance with 11.3.14.

36 Overload of Switches and Controls Test

36.1 Unless known to be acceptable for the application (See Switches and Controllers, Section 18), a switch or other control device shall perform acceptably when subjected to an overload test consisting of 50 cycles of operation making and breaking the applicable load. There shall be no electrical or mechanical breakdown of the device, undue burning or pitting of the contacts as a result of the overload or endurance test, or opening of the fuse in the grounding connections.

36.2 To determine whether a switch or other control device complies with the requirements in 36.1, the battery charger is to be connected to a supply circuit of rated frequency and 110 percent of maximum rated voltage. The load for the device under test is to be the same as that which it is intended to control in regular service. During the test, exposed dead metal parts of the battery charger are to be connected to ground through a 3-ampere plug fuse. The device is to be operated at a rate of not more than 10 cycles per minute, except that a faster rate of operation may be employed if agreeable to those concerned.

36.3 A switch or other device that controls a motor and has not been shown to be acceptable for the purpose, unless interlocked so that it does not break the locked rotor current of the motor, shall perform acceptably when subjected to an overload test consisting of 50 cycles of operation, making and breaking the locked-rotor current of the motor. There shall be no electrical or mechanical breakdown of the device, undue pitting or burning of the contacts, or opening of the fuse in the grounding connection.

36.4 To determine whether a switch or other control device complies with the requirement in 36.3, the battery charger is to be connected to a grounded supply circuit of rated frequency and maximum rated voltage – see Table 25.1 – with the rotor of the motor locked in position. During the test, exposed dead metal parts of the battery charger are to be connected to ground through a 3-ampere plug fuse, and the connection is to be such that any single-pole, current-rupturing device will be located in the ungrounded conductor of the supply circuit. The device is to be operated at a rate of not more than 10 cycles per minute, except that a faster rate of operation may be employed if agreeable to those concerned.

37 Strength of Handles Test

37.1 A handle used to lift or carry a charger shall withstand a force of four times the weight of the charger without breakage of the handle, its securing means, or that portion of the enclosure to which the handle is attached.

Exception: This test is not required for a handle used for pushing or pulling a battery charger employing wheels, casters, or the like.

37.2 To determine whether a battery charger complies with the requirements in 37.1, a force equal to four times the weight of the charger is to be uniformly applied over a 3-inch (76-mm) width at the center of the handle, without clamping. The load is to be started at zero and is to be gradually increased so that the test value will be attained in 5 to 10 seconds and maintained at that value for 1 minute. If more than one handle is provided on a charger and the charger cannot be carried by one handle alone, the force is to be distributed between the handles. The distribution of forces is to be determined by measuring the percentage of the weight of the charger sustained by each handle with the charger in the normal carrying position. If a charger is furnished with more than one handle and can be carried by one handle only, each handle shall withstand the total force.

38 Abnormal Tests

38.1 General

38.1.1 A battery charger shall not emit flame or molten metal or cause a risk of fire or electric shock when subjected to the tests described in 38.2 – 38.5.

38.1.2 During each test:

a) The enclosure of the battery charger is to be connected directly to ground using a conductor that includes a 3 Amp fuse;

b) The battery charger is to rest on a softwood surface covered with white tissue paper; and

c) A double layer of cheesecloth is to be draped loosely over the entire enclosure. The cheesecloth is to be untreated cotton cloth running 14 – 15 yards per pound (28.2 – 30.2 m/kg) and for any square inch, having a trade count of 32 x 28, which is a count of 32 threads in one direction and 28 in the other direction.

Exception No. 1: A nonmetallic enclosure without exposed dead metal parts is not required to be grounded.

Exception No. 2: For a battery charger without openings in the bottom panel, the unit is not required to be tested on a softwood surface covered with white tissue paper.

38.1.3 The supply circuit is to be sized such that protection which terminates the test be integral to the charger.

38.1.4 A protective device, such as a fuse or circuit breaker, provided as part of the battery charger is to remain in the circuit. The highest rated fuse the fuseholder will accept is to be installed.

Exception No. 1: A commercial battery charger may be tested with the fuse recommended by the manufacturer.

Exception No. 2: An internal fuse that is not referenced by markings, wiring diagrams, or the instruction manual need not be replaced.

38.1.5 The test voltage is to be adjusted to the value specified in Table 25.1.

38.1.6 Any user operated control is to be adjusted to the position representing the most adverse operating condition.

38.1.7 A manually or automatically reset protector or other overload-protective device in a household battery charger shall open the output circuit within 2 minutes after initiation of the test, and within 30 seconds for subsequent cycles during the output short circuit, reverse polarity, and switch position tests.

Exception: The time required to open the output circuit may exceed the time specified provided the maximum temperature rises do not exceed the rises specified in Table 28.2.

38.1.8 If a manual or automatic reset protector does not function during these tests, each test is to be continued until there is no indication of further change as a result of the test condition. If an automatically reset protector functions during the tests, the test is to be continued for 7 hours. If a manual reset protector functions during the test, it is to be operated for 10 cycles using the minimum resetting time, but not at a faster rate than 10 cycles of operation per minute. The protector should be operative upon completion of the test. The following are considered as an acceptable termination of the test:

a) Opening or shorting of one or more capacitors, diodes, resistors, semiconductor devices, printed wiring board traces, or the like, if there is no indication of further change; or

b) Opening of an internal fuse.

Exception No. 1: If the manually reset protector is a circuit breaker that complies with the Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures, UL 489, it is to be operated for 3 cycles using the minimum resetting time but not at a rate faster than 10 cycles of operation per minute.

Exception No. 2: The protector need not be operational after the Reverse Polarity Test. See 38.3.1.

Exception No. 3: For the reverse polarity test, the seven hour duration does not apply. See 38.3.2.

38.1.9 Following each test, the dielectric voltage withstand test specified in 29.1.1(a) is to be conducted with the potential applied between primary and output circuits. A risk of fire or electric shock is considered to exist if any of the following occur:

a) Flame or molten metal is emitted from the enclosure of the equipment as evidenced by ignition, glowing, or charring of the cheesecloth or tissue paper;

b) A breakdown results from the dielectric voltage withstand test; or

c) Live parts are made accessible (see 8.1).

38.1.10 A separate sample is to be used for each test unless the manufacturer requests that a single sample be subjected to more than one test.

38.2 Output short-circuit test

38.2.1 The output connections of a battery charger are to be short-circuited.

38.2.2 A polarity protection circuit that prevents output current flow until a battery is correctly connected to the output is to be made inoperative to permit the required output current flow.

38.3 Reverse polarity test

38.3.1 The external output leads are to be connected in reverse polarity to a fully charged battery.

Exception: A battery charger having output terminals or leads for fixed wiring, or leads terminating in a polarized plug or plugs is not required to be subjected to the reverse polarity test.

38.3.2 This test is to be continued for 4 hours if an automatically reset protector functions during the test. See 38.1.8 if other than an automatically reset protector functions during the test.

38.4 Switch position test

38.4.1 A battery charger employing a switch, such as a 6- and 12-volt switch to permit charging of batteries at different voltages, shall be connected to a supply circuit as described in 25.1, and to the maximum normal load described in 27.4, with the switch set at the minimum voltage position. Without changing the load, the switch is to be adjusted to its maximum voltage position. A discharged battery may be used for the load of this test.

38.5 Blocked fan test

38.5.1 With reference to the Exception to 15.1, a battery charger having a fan motor shall be operated as described in 38.1.8 with the rotor of the fan motor blocked. For a battery charger having more than one fan motor, the test is to be conducted with the rotor of each blower motor blocked, one at a time.

Exception: If agreeable to all concerned, all fan motors in a unit having more than one fan motor may be blocked simultaneously.

38.6 Component short and open test

38.6.1 Three tests of each combination, using untested components for each test, shall be conducted.

Exception: If analysis of the test results and circuit indicate that the result obtained is the only one likely to occur, the test need be conducted only once.

38.6.2 Unreliable components in the input power circuit, whose failure may result in an increased risk of fire and electric shock, shall be subjected to short or open circuit of any two terminals at a time, during any condition of operation. These components include electrolytic capacitors, diodes, and solid state devices or any other component not previously investigated and found suitable for the application.

Exception: An electromagnetic and radio frequency interference capacitor that complies with the dielectric voltage withstand test in 29.1.1(d), a resistor, a transformer, an inductor, and an optical isolator, need not be subjected to this test.

38.7 Intermediate abnormal test

38.7.1 A battery charger tested in accordance with 28.1.4 shall be subjected to a continuous load test immediately following the temperature test. Rated output current of the battery charger is to be continuously maintained by an adjustable resistor connected in parallel with the battery.

38.8 Relay and solenoid burnout

38.8.1 An electromagnetic relay or a solenoid having an open coil construction is to be tested by blocking the armature or the plunger in the de-energized position.

38.9 Transformer burnout test

38.9.1 A resistive load that will cause the primary to draw three times the normal alternating current – see 27.1 and Table 25.1 – is to be connected directly to the transformer secondary winding with the charger connected to a supply circuit at the maximum test voltage. See Table 25.1. For a transformer having a center tap secondary, a single load is to be connected across the legs of the winding that result in the greatest potential.

Exception: A transformer employed in a switch mode circuit may be subjected to the transformer overload test described in 38.10.1 in lieu of the transformer burnout test. See 5.12.

38.9.2 A ferroresonant transformer is to be tested as described in 38.9.1, except that a resistive load that will draw the maximum power input – see Power Input Test, Section 27 – is to be connected directly to the transformer secondary winding, with the battery charger connected to a supply circuit at 106 percent of the maximum test voltage specified in Table 25.1.

38.10 Transformer overload test

38.10.1 The external output connections of a switch mode battery charger are to be connected to a resistive load that will draw maximum obtainable current without causing shutdown due to operation of circuitry or overcurrent protective devices provided as part of the product.

38.11 Printed wiring board abnormal operation test

38.11.1 To comply with Exception No. 1 to 23.2, a printed wiring board is to be tested as described in 38.11.2 – 38.11.5.

38.11.2 During this test, if a printed wiring board trace opens, the gap is to be electrically shorted and the test continued until ultimate results occur. This procedure applies to each occurrence. If the circuit is interrupted by the opening of a component other than described in 38.11.3, the test is to be repeated two more times using new components as necessary.

38.11.3 Operation of an overcurrent protective device other than the branch circuit overcurrent protective device is acceptable.

38.11.4 A sample of the battery charger employing a printed wiring board is to be connected to its nominal rated supply circuit as specified for General Test requirements, Section 25. A foil trace is to be

short-circuited to each of its adjacent traces that do not have the spacing specified in Table 23.2 or Table 23.4, one at a time.

38.11.5 The test is to be continued for 1 hour or until one of the conditions described in 38.1.9 occurs. However, if at the end of 1 hour no condition described in 38.1.9 occurs, but indications are that such a condition may eventually occur, the test is to be continued until ultimate results are obtained (usually 7 hours).

39 Fifteen Day Abnormal Tests

39.1 If a transformer is required to be tested as provided in 16.2.9, the transformer shall comply with the 15 day abnormal operation tests described in 39.3 – 39.14. The abnormal tests may be conducted with a protective device built into the transformer or with an external protective device having a rating specified by the manufacturer connected in either the primary or secondary circuit, or in both. A protective device that is relied upon to open the circuit as a result of an abnormal test is to be one that has been investigated and found to be acceptable for the purpose.

39.2 For the purposes of these requirements, each secondary winding tap other than a center tap and each primary winding tap designed to supply power to a load shall be considered to be the equivalent of a secondary winding.

39.3 A transformer shall operate for the full 15 days with the secondary winding or windings loaded to the current levels described in 39.5.

39.4 For the sequence of tests described in 39.5, if an abnormal operation test continues for the full 15 days without a winding or a protective device opening, the remaining tests need not be conducted. For example, if the test described in 39.5(a) continues for 15 days, the tests described in 39.5 (b) – (i) need not be conducted.

39.5 The following loads on the secondary winding shall not result in a risk of fire or electric shock:

a) $I_L = I_{SC}$

b) $I_L = I_R + 0.75 (I_{SC} - I_R)$

c) $I_L = I_R + 0.5 (I_{SC} - I_R)$

d) $I_L = I_R + 0.25 (I_{SC} - I_R)$

e) $I_L = I_R + 0.2 (I_{SC} - I_R)$

f) $I_L = I_R + 0.15 (I_{SC} - I_R)$

g) $I_L = I_R + 0.1 (I_{SC} - I_R)$

h) $I_L = I_R + 0.05 (I_{SC} - I_R)$

i) $I_L = I_R$

where:

I_L = *Secondary winding load current;*

I_{SC} = *Short-circuit current of secondary winding; and*

I_R = *Rated current of secondary winding.*

39.6 To determine whether a transformer complies with the requirement in 39.5, a separate sample is to be subjected to each condition described in 39.5 (a) – (i). For a transformer that employs more than one secondary winding, each of the secondary windings is to be loaded for each condition specified in 39.5 with the other windings loaded to the rated current. The test conditions are to be as described in 39.7 – 39.14.

39.7 To determine the short-circuit current value for conducting the tests described in 39.5 (b) – (h), the transformer is to be at room temperature at the beginning of the measurement, and the short-circuit current is to be measured approximately 1 minute after the voltage is applied to the primary winding. An external protective device, if provided by the manufacturer, is to be short-circuited during the measurement of the short-circuit current. If the transformer winding opens within 1 minute after the application of the primary voltage, the short-circuit current is considered to be that value recorded just before the winding opens. The short-circuit current of any one winding is to be measured with the other secondary windings open-circuited.

39.8 For the loading conditions, a variable resistor is to be connected across the secondary winding. The tests described in 39.5 (a) – (i) are to be continued for 15 days unless a winding of the transformer or a protective device opens in a shorter time. In conducting the tests described in 39.5 (b) – (i), the variable resistance load is to be adjusted to the required value as quickly as possible and readjusted, if necessary, 1 minute after voltage is applied to the primary winding.

39.9 If short-circuiting the secondary winding causes one of the windings to open before 15 days, then the next test in the sequence described in 39.5 (b) – (i) that continues for the full 15 days is to have a variable load resistor reduced to zero impedance at the end of the 15 days. This is intended to cause the transformer to burn out if this condition can occur as a result of a secondary-winding short circuit.

39.10 For a transformer that is provided with a protective device built into the transformer or that is being tested in conjunction with an external protective device, a test described in 39.5 (a) – (h) is to be discontinued and the next test in the sequence is to be started if the protective device opens the circuit. This procedure is to be continued until a condition specified in 39.5 (a) – (h) is reached which allows the circuit to hold for 15 days. An automatically reset protective device is to be tested in the same manner.

39.11 A sample for the 15-day abnormal-operation test is to be prepared as follows:

a) The transformer is to be mounted in the battery charger enclosure as intended and the enclosure is to be placed on a softwood surface covered with white tissue paper.

b) Exposed dead metal parts and one end of each secondary winding are to be connected to ground through a 1-ampere nontime-delay fuse.

c) A single layer of cheesecloth is to be draped loosely over the battery charger enclosure.

d) The battery or charger is to be connected to a supply circuit as specified in 25.1.

e) All secondary windings are to be loaded to rated current before the abnormal condition is introduced. The loads, other than that connected to the winding to be overloaded, are not to be readjusted thereafter.

39.12 Each 15 day abnormal operation test is to be continued until a risk of fire develops, the circuit under test burns open, or 15 days have passed.

39.13 The results of the test are not acceptable if the cheesecloth or tissue paper glows or flames, the 1-ampere fuse opens, or a breakdown occurs when the test described in 39.14 is conducted.

39.14 While still in a heated condition from the tests described in 39.5, a transformer shall withstand the dielectric voltage withstand test described in 29.1.1 (a) – (c). The dielectric voltage withstand test potential is to be applied to the transformer approximately 1 minute after completion of the abnormal operation test.

40 Tests on Insulating Materials

40.1 If required by Exception No. 2 of 16.2.4, Type C of Table 16.1, 16.2.6(c), or 23.12, the transformer insulating material shall be subjected to the test described in 40.2.

Exception No. 1: The insulating material need not be subjected to this test if it is generic material noted in Table 40.1. See 40.3.

Exception No. 2: An insulating system consisting of N multiple layers of any thickness need not be tested in accordance with 40.2 if all possibilities of N-1 [N minus 1] layers withstand double the test potential defined in the Dielectric Voltage Withstand Test, Section 29 and applied as described in 40.2. "N" must be a minimum of 2 layers.

40.2 The insulating material is to be placed between two opposing electrodes. The electrodes are to be cylindrical brass or stainless steel rods 1/4 inch (6.4 mm) in diameter with edges rounded to a 1/32 inch (0.8 mm) radius. The upper moveable electrode is to weigh 50 ±2 grams to exert sufficient pressure on the specimen to provide good electrical contact. The test potential is to be increased to the test value and the maximum test potential is to be maintained for 1 second. The result is acceptable if there is no dielectric breakdown.

40.3 With reference to the Exception No. 1 to 40.1, insulation may be of a generic material type specified in Table 40.1 where the layer(s) of each generic material is of a minimum thickness such that all layers collectively are greater than or equal to the minimum thickness required (T):

$$T \leq A_1(EF_1) \pm A_2(EF_2) \pm A_3(EF_3)$$

In which:

A_1, A_2, and A_3 denote the total thickness of each generic material type, inches (mm);

EF_1, EF_2, and EF_3 denote the equivalency factor specified in Table 40.1 for the generic material type corresponding to A_1, A_2, A_3;

T is the thickness requirement for electrical grade paper.

Table 40.1
Equivalency factors for insulation materials[a]

Generic material	Equivalency factor (EF)
Electrical grade paper, fiber, or pressboard	1
Impregnated rag paper	1.3
Acetate sheet	1.5
Polyvinyl chloride (PVC)	1.3
Silicone rubber (SIR)	0.5
Impregnated glass or acetate cloth	1.2

Table 40.1 Continued on Next Page

Table 40.1 Continued

Generic material	Equivalency factor (EF)
Polyester	c
Polyethylene terephthalate (PETP)	c
Fluorinated ethylene propylene (FEP)	3
Polytetrafluoroethylene (PTFE)	3
Aramid paper	d
Polyamide (PI)	6
Mica[b]	4.7

[a] See 40.3.

[b] EF applies if not subject to mechanical damage.

[c] To determine equivalence to 0.028 inch (0.71 mm) thick electrical grade paper, EF=4; to determine equivalence to 0.013 inch (0.33 mm) thick electrical grade paper, EF=2.

[d] To determine equivalence to 0.028 inch thick electrical grade paper, EF=0.3; to determine equivalence to 0.013 inch thick electrical grade paper, EF=1.5.

41 Tests of Connector Guards

41.1 A required rubber or neoprene connector guard shall be tested as described in 41.2. Deterioration of the guard shall not be apparent and its hardness shall not have changed more than ten numbers as a result of the exposure.

41.2 Three connector and guard assemblies are to be used. The hardness of the rubber is to be determined as the average of five readings with an acceptable gauge such as a Rex hardness gauge or a Shore urometer. The connector guard assemblies are then to be placed in an air oven for 70 hours at 100°C (212°F). The assemblies are to be allowed to cool at room temperature for at least 4 hours after removal from the oven. The hardness is to be determined again as the average of five readings. The difference between the original average hardness reading and the average reading taken after oven aging is the change in hardness.

41.3 Samples of each basic rubber compound employed for a connector guard are to be subjected to the accelerated aging tests described in 41.1 and 41.2.

41.4 A guard of polyvinyl chloride, or a copolymer thereof, that is used in combination with a connector shall not show cracks, discoloration, or other visible signs of deterioration as a result of exposure for 96 hours in a full-draft air circulating oven at a temperature of 100 ±1°C (212 ±2°F).

41.5 Following the conditioning described in 41.1 – 41.4, the guard assemblies shall:

a) Comply with the dielectric voltage withstand test requirements as described in 29.1.1 applied between the connector and metal foil wrapped tightly around the outside of the guard; and

b) Not show apparent damage to the material, such as cracking.

42 Accelerated Aging of Gaskets, Sealing Compounds, and Adhesives

42.1 The requirements in 42.2 – 42.6 apply to gaskets and sealing compounds employed to make an enclosure raintight or rainproof as determined by the Water Spray Test, Section 30, and to a cart-type battery charger as mentioned in the Exception to 50.9. The requirements in 42.7 apply to an adhesive used to secure a gasket.

42.2 Neoprene and rubber gasket materials shall have physical properties as specified in Table 42.1 before and after accelerated aging under the conditions specified in Table 42.2.

Exception: Foamed materials as specified in 42.3 need not have the physical properties specified in Table 42.1.

42.3 Foamed neoprene and foamed rubber gasket materials shall be subjected to accelerated aging under the conditions specified in Table 42.2. The material shall not harden or otherwise deteriorate to a degree that affects its sealing properties.

42.4 Thermoplastic gasket materials shall be subjected to accelerated aging under the conditions specified in Table 42.2. A thermoplastic material shall not deform or melt, or otherwise deteriorate to a degree that will affect its sealing properties. A solid polyvinyl chloride material shall have physical properties as specified in Table 42.1 before and after the accelerated aging.

Table 42.1
Physical properties for gaskets

Property	Neoprene or rubber compound		Polyvinyl chloride material	
	Before conditioning	After conditioning	Before conditioning	After conditioning
Recovery – Maximum set when 1 inch (25.4 mm) gage marks are stretched to 2-1/2 inches (63.5 mm), held for 2 minutes, and measured 2 minutes after release	1/4 inch (6.4 mm)	–	Not Specified	
Elongation – Minimum increase in distance between 1 inch (25.4 mm) gage marks at break	250 percent [1 to 3-1/2 inches of original (25.4 – 88.9 mm)]	85 percent	250 percent [1 to 3-1/2 inches of original (25.4 – 88.9 mm)]	75 percent
Tensile Strength – Minimum force at breaking point	850 psi (5860 kPa)	75 percent of original	1200 psi (8273 kPa)	90 percent of original

42.5 Tensile strength and elongation are to be determined using the test methods and apparatus described in Tension Testing of Vulcanized Fiber, ASTM D412.

42.6 A sealing compound shall be applied to the surface it is intended to seal. For a temperature rise not exceeding 35°C (63°F), a representative sample of the surface with the sealing compound applied shall be conditioned for 7 days in an air oven at 87.0 ±1.0°C (189.0 ±1.8°F). The sealing compound shall not melt, become brittle, or otherwise deteriorate to a degree that will affect its sealing properties as determined by comparing the aged sample to the unaged sample.

42.7 For a gasket secured by an adhesive and exposed to a temperature rise not exceeding 35° C (63° F), a sample of the gasket secured to the mounting surface by the adhesive shall be exposed for 72 hours to each of the following conditions:

a) A temperature of 100.0 ±1.0°C (212.0 ±1.8°F);

b) Immersion in distilled water at a temperature of 23.0 ±1.0°C (73.0 ±1.8°F); and

c) A temperature of minus 10.0°C (14.0 ±1.8°F).

The force required to peel the gasket from its mounting surface after exposure shall not be less than 50 percent of the value determined using an unconditioned sample, but not less than 2 pounds per inch (0.04 kg/mm) of gasket width.

42.8 The temperature rises specified in this section correspond to the maximum temperature rise measured on the gasket during the temperature test. A material other than those specified in this section shall be nonabsorptive and it, and all materials having a higher temperature rise, shall provide equivalent resistance to aging and temperatures.

Table 42.2
Accelerated aging conditions

Measured temperature rise		Rubber and neoprene	Thermoplastic
°C	(°F)		
35	(63)	Air oven aging for 70 hours at 100°C (212°F)	168 hours in an air circulating oven at 87.0 ±1.0°C (188.6 ±1.8°F)
50	(90)	Air oven aging for 168 hours at 100°C (212°F)	240 hours in an air circulating oven at 100.0 ±1.0°C (212 ±1.8°F)
55	(99)	168 hours in an air circulating oven at 113.0 ±1.0°C (235.4 ±1.8°F)	168 hours in an air circulating oven at 113.0 ±1.0°C (235.4 ±1.8°F)
65	(117)	240 hours in an air circulating oven at 121.0 ±1.0°C (249.8 ±1.8°F)	168 hours at 121.0 ±1.8°C (249.8±1.8°F) or 60 days at 97.0 ±1.0°C (206.6 ±1.8°F) in an air circulating oven
80	(144)	168 hours in an air circulating oven at 136.0 ±1.0°C (276.8 ±1.8°F)	168 hours in an air circulating oven at 136.0 ±1.0°C (276.8 ±1.8°F)

43 Automatic Battery Chargers

43.1 A battery charger marked in accordance with 50.4 shall incorporate a control circuit or other means to:

a) Achieve and maintain the battery at full charge capacity (see 43.2);

b) Reduce gas formation or evaporation of the electrolyte; and

c) Maintain the temperature of the electrolyte or battery case below 120°F (49°C).

43.2 The readings for full charge capacity shall be taken one hour after being disconnected from the battery charger, and the readings shall comply with the specifications of 43.3.

43.3 The typical terminal voltage shall be 2.1 to 2.15 volts/cell.

44 Grounding Conductor Tests

44.1 A grounding means in accordance with the Exception to 24.6 may be used when, using a separate sample for each test, the grounding path does not open when:

a) Carrying currents equal to 135 and 200 percent of the rating or setting of the intended branch-circuit overcurrent-protective device for the times specified in Table 44.1; and

b) Three samples are subjected to a limited-short-circuit test using a test current as specified in Table 44.2 while connected in series with a nonrenewable fuse rated in accordance with Table 44.1.

Table 44.1
Duration of overcurrent test

Rating or setting of branch-circuit overcurrent protective device, amperes	Test time, minutes	
	135 percent current	200 percent current
0 – 30	60	2
31 – 60	60	4
61 – 100	120	6
101 – 200	120	8

44.2 The test circuit described in 44.1(b) is to have a power factor of 0.9 – 1.0 and a closed-circuit test voltage as specified in 25.1. The open-circuit voltage is to be 100 – 105 percent of the closed-circuit voltage.

Table 44.2
Circuit capacity for bonding conductor short-circuit test

Rating of power supply				Capacity of test circuit, amperes
Volt-amperes				
Single phase	3-phase	Direct current	Volts[a]	
0 – 1176	0 – 832	0 – 624	0 – 250	200
0 – 1176	0 – 832	0 – 624	251 – 600	1000
1177 – 1920	833 – 1496	625 – 1128	0 – 600	1000
1921 – 4080	1497 – 3990	1129 – 3000	0 – 250	2000
4081 – 9600	3991 – 9145	3001 – 6960	0 – 250	3500
9601 or more	9146 or more	6961 or more	0 – 250	5000
1921 or more	1497 or more	1129 or more	251 – 600	5000

[a] The nominal test voltages are 120, 240, 277, 480, or 600

45 Hot, Flaming Oil Test

45.1 In accordance with 7.6.4, a ventilated, bottom-panel construction shall comply with the tests of 46.2 – 46.5.

45.2 Openings in a bottom panel shall be so arranged and sufficiently small in size and few in number that hot, flaming No. 2 fuel oil poured three times onto the openings from a position above the panel is extinguished as it passes through the openings.

45.3 A sample of the complete, finished bottom panel is to be supported in a horizontal position a short distance above a horizontal surface under a hood or in another area that is ventilated but free from drafts. Bleached cheesecloth running 14 – 15 square yards to the pound (28 – 30 m^2/kg mass) and having, for any square inch, 32 threads in one direction and 28 in the other, is to be draped in one layer over a shallow, flat-bottomed pan that is of a size and shape to cover completely the pattern of openings in the panel but is not sufficiently large to catch any of the oil that runs over the edge of the panel or otherwise does not pass through the openings. The pan is to be positioned with its center under the center of the pattern of openings in the panel. The center of the cheesecloth is to be 2 inches (50.8 mm) below the openings. Use of a metal screen or wired-glass enclosure surrounding the test area is recommended to reduce the likelihood of splattering oil, causing injury to persons.

45.4 A small metal ladle no more than 2-1/2 inches (63.5 mm) in diameter, with a pouring lip and a long handle whose longitudinal axis remains horizontal during pouring, is to be partially filled with 10 cubic

centimeters (0.61 cubic inches) of No. 2 fuel oil, which is a medium-volatile distillate having a minimum API gravity of 30 degrees, a flash point of 110 – 190°F (43.3 – 87.7°C), and an average calorific value of 136,900 Btu per gallon (38.2 MJ/L) (see the American Society for Testing and Materials Specification for Fuel Oils, ASTM D396). The ladle containing the oil is to be heated and the oil is to be ignited. The oil is to flame for 1 minute and then is to be poured at the approximate rate of, but no less than, 1 cubic centimeter (0.061 cubic inch) per second in a steady stream onto the center of the pattern of openings from a position 4 inches (102 mm) above the openings. It is to be observed whether the oil ignites the cheesecloth.

45.5 Five minutes after completion of the pouring of the oil, the cheesecloth is to be replaced with a clean piece and a second 10 cubic centimeter (0.61 cubic inches) of hot, flaming oil is to be poured from the ladle onto the openings, and it is again to be observed whether the cheesecloth is ignited. Five minutes later, a third identical pouring is to be made. The openings are not acceptable if the cheesecloth is ignited in any of the three pourings.

MANUFACTURING AND PRODUCTION TESTS

46 Dielectric Voltage Withstand Test

46.1 Each battery charger shall withstand without electrical breakdown, as a routine production line test, the application of a potential:

a) Between the primary wiring, including connected components, and accessible dead metal parts that are likely to become energized; and

b) Between primary wiring and accessible secondary parts, including terminals.

46.2 The production line test shall be in accordance with either Condition A or Condition B of Table 46.1.

Table 46.1
Production-line test conditions

Power supply rating and form	Condition A			Condition B		
	Potential, Vac	Volts, Vdc	Time, seconds	Potential, Vac	Volts, Vdc	Time, seconds
250 volts or less with no motor rated more than 1/2 horsepower (375 W)	1000	1400	60	1200	1700	1
More than 250 volts or with a motor rated more than 1/2 horsepower	1000+2V[a]	1400+2.8V[a]	60	1200+2.4V[a]	1700+3.4V[a]	1
[a] Maximum marked voltage but not less than 250 volts.						

46.3 The battery charger may be in a heated or unheated condition for the test.

46.4 The test is to be conducted when the battery charger is complete – fully assembled. It is not intended that the battery charger be unwired, modified, or disassembled for the test.

Exception No. 1: A part such as a snap cover or a friction-fit knob that would interfere with performance of the test need not be in place.

Exception No. 2: The test may be performed before final assembly if the test represents that for the completed charger.

46.5 A battery charger employing a solid-state component that is not relied upon to reduce a risk of electric shock and that can be damaged by the dielectric potential may be tested before the component is electrically connected provided that a random sampling of each day's production is tested at the potential specified in 46.2. The circuitry may be rearranged for the purpose of the test to reduce the likelihood of solid-state component damage while retaining representative dielectric stress of the circuit.

46.6 The test equipment shall include a transformer having an essentially sinusoidal output, a means of indicating the test potential, an audible or visual indicator of electrical breakdown, and either a manually reset device to restore the equipment after electrical breakdown or an automatic reject feature of any unacceptable unit. Alternatively, the test equipment may have a dc output. See Table 46.1.

46.7 If the output of the test equipment transformer is less than 500 volt-amperes, the equipment shall include a voltmeter in the output circuit to directly indicate the test potential.

46.8 If the output of the test equipment transformer is 500 volt-amperes or larger, the test potential may be indicated:

a) By a voltmeter in the primary circuit or in a tertiary-winding circuit;

b) By a selector switch marked to indicate the test potential; or

c) In the case of equipment having a single test potential output, by a marking in a readily visible location to indicate the test potential. When a marking is used without an indicating voltmeter, the equipment shall include a positive means, such as an indicator lamp, to indicate that the manually reset switch has been reset following a dielectric breakdown.

46.9 Test equipment other than that described in 46.6 – 46.8 may be used if found acceptable to accomplish the intended factory control.

46.10 During the tests involving primary circuits, the primary switch is to be in the "on" position, both sides of the primary circuit of the battery charger are to be connected together and to one terminal of the test equipment, and the second test equipment terminal is to be connected to:

a) Accessible dead metal; or

b) The secondary circuit.

Exception No. 1: A battery charger – resistive, high-impedance winding, and the like – having circuitry not subject to excessive secondary voltage buildup in case of electrical breakdown during the test may be tested:

a) With a single-pole primary switch, if used, in the "off" position; or

b) With only one side of the primary circuit connected to the test equipment when the primary switch is in the "on" position, or when a primary switch is not used.

Exception No. 2: The primary switch is not required to be in the "on" position if the testing means applies full test potential between primary wiring and dead metal parts with the switch not in the "on" position.

47 Grounding Continuity Test

47.1 Each battery charger that has a power supply cord having a grounding conductor shall be tested, as a routine production line test, to determine that grounding continuity exists between the grounding blade of the attachment plug and accessible dead metal parts of the battery charger that are likely to become energized.

47.2 Only a single test need be conducted if the accessible metal selected is conductively connected by design to all other accessible metal.

47.3 Any acceptable indicating device such as an ohmmeter, battery-and-buzzer combination, or the like, may be used to determine whether a battery charger complies with the requirement in 47.1.

47.4 With reference to the Exception to 24.6, each battery charger shall be tested, as a routine production line test, to determine that grounding continuity exists between the grounding blade of the attachment plug and accessible dead metal parts of the battery charger that are likely to become energized. The continuity test shall consist of passing a 60 Hz current of 30 amperes for one minute. At one minute the grounding impedence shall not exceed 0.2 ohms.

RATING

48 Details

48.1 The input circuit of a battery charger shall be rated in amperes or watts and volts, and may be rated for alternating current only. For a charger having a non-continuous current output rating, the input rating shall indicate the value of amperes or wattage under the maximum normal charging conditions and non-continuous current conditions. The rating shall include the number of phases, if the charger is designed for use on a polyphase circuit, and the frequency. The voltage rating shall be in accordance with any appropriate single voltage or range of voltages such as 100 – 120, 208, 220 – 240, 254 – 277, 416, 440 – 480, 550, 575, and 600.

48.2 The output circuit of a battery charger shall be rated in volts, dc, and amperes. The minimum voltage shall be the nominal voltage of the battery intended to be charged (6, 12, 24, etc.). The output rating for a battery charger intended for non-continuous current operation, such as engine start and/or cranking assist shall include all non-continuous current ratings.

MARKINGS

49 General

49.1 A battery charger shall be legibly and permanently marked, where readily visible, with:

a) The manufacturer's name, trade name, or trademark;

b) A distinctive model number or the equivalent;

c) The date or other dating period of manufacture not exceeding any three consecutive months; and

d) The electrical rating.

e) An indication of whether it is intended for household use, commercial use, or both.

Exception: A charger complying with both household and commercial requirements is not required to be marked to indicate the intended use.

49.2 When the date of manufacture is abbreviated, it shall be in a nationally accepted conventional code or in a code affirmed by the manufacturer and shall:

a) Not repeat in less than 20 years; and

b) Not require reference to the manufacturer's records to determine when the battery charger was manufactured.

49.3 A noncontinuous duty cycle marking (such as a charger having an engine start and/or cranking assist capability) shall consist of a maximum "on" and a minimum "off" time, or a maximum "on" time and an on/off ratio. The time may be indicated in seconds or minutes, or fractions thereof. The duty cycle shall anticipate a minimum "on" time of one second.

49.4 The polarity of the output leads shall be plainly indicated by:

a) The words "positive" and "negative";

b) The signs "+" for positive and "–" for negative;

c) The abbreviations "pos" for positive and "neg" for negative; or

d) Color coding of red for positive and black for negative.

49.5 If a manufacturer produces or assembles a battery charger at more than one factory, each charger shall have a distinctive marking, which may be in code, by which it may be identified as the product of a particular factory.

49.6 If a battery charger includes a discharge test circuit, the discharge time limit in seconds or minutes may be marked on the nameplate or instruction panel of the charger.

49.7 An on-off switch shall have a marked "off" position so that the operator can readily determine by visual inspection when the battery charger is de-energized.

49.8 A user adjustable control shall be marked to indicate its function (for example, float and equalize settings for different types of batteries – gel, vented, absorbed glass matt (AGM), and the like). The function shall also be defined and explained in the operating instructions. See 55.2(b).

49.9 An enclosure that has been investigated in accordance with 7.8.3 shall be marked "Raintight" or "Rainproof" as appropriate, or with an appropriate enclosure type designation specified in the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E. A cart type or portable battery charger shall not be marked "Raintight", "Rainproof", or with any other outdoor type designation.

49.10 A commercial battery charger not provided with means as mentioned in 7.7.7 to reduce the risk of injury to persons shall be marked to instruct the user that the cover or guard must be in place during use. The marking shall be permanent and located adjacent to the part.

50 Cautionary Markings

50.1 A cautionary marking shall be permanent and be located on a part or surface, other than the bottom of the enclosure, that cannot be removed without impairing the operation of the charger.

Exception No. 1: For a direct plug-in battery charger, the marking may be on the bottom of the enclosure.

Exception No. 2: This requirement does not apply to chargers with the cautionary marking on a permanent tag as described in 50.11.

50.2 With regard to 50.1, a cautionary marking located on the back side of a battery charger shall be referenced by a marking provided on the front side of the charger.

Exception: A direct plug-in battery charger without a mounting tab need not comply.

50.3 A portable battery charger shall be marked with the word "WARNING" and the following or the equivalent:

"RISK OF EXPLOSIVE GAS MIXTURE:

1. Connect and disconnect battery leads only when supply cord is disconnected.

Exception: This marking does not apply to a battery charger having a cigar lighter plug for charging the battery through a cigar lighter or vehicle power outlet receptacle.

2. For a battery installed in a vehicle, first connect charger output lead to ungrounded battery post – not connected to automobile chassis – in accordance with polarity identification and then opposite polarity lead to chassis away from battery; do not connect to carburetor or fuel lines. Disconnect chassis lead first. For battery not installed in vehicle, refer to Instruction Manual.

Exception No. 1: This marking does not apply to a battery charger having a cigar lighter.

Exception No. 2: In lieu of the marking in item 2, a battery charger that prevents current flow in excess of 0.1 ampere until the battery is connected with correct polarity followed by the activation of a manually operated control may be marked with the following or the equivalent:

2. For a battery installed in a vehicle, first connect charger output leads to battery posts in accordance with polarity identification and then set charger controls to the "on" position. Do not disconnect battery clips during charging. Disconnect battery clips only after setting any charger controls to the "off" position and removing the AC cord from the electrical outlet. For battery not installed in vehicle, refer to Instruction Manual.

3. Do not overcharge battery – See Instruction Manual.

4. Do not smoke, strike a match, or cause a spark in vicinity of battery.

5. Use in well-ventilated area."

50.4 If a battery charger is marked "Automatic," it shall comply with the requirements for Automatic Battery Chargers, Section 43.

50.5 With regard to 50.4, a marking shall be provided referencing the Instruction Manual for further details.

50.6 Battery charging equipment as specified in 7.6.6 shall be marked with the word "WARNING" and the following or the equivalent: "This equipment employs parts, such as switches and relays, that tend to produce arcs or sparks and therefore, if used in a garage, locate in a room or enclosure provided for the purpose or not less than 18 inches above the floor."

50.7 A portable battery charger intended for outdoor use and having provision for grounding through the cord and plug in accordance with 24.8 shall be plainly marked with the word "CAUTION" and the following or the equivalent: "Risk of Electric Shock. Connect only to properly grounded outlets."

50.8 A battery charger having output voltage exceeding 42.4 volts peak shall be marked with the word "DANGER" and the following or the equivalent: "Risk of Electric Shock. Do not touch uninsulated portion of output connector or uninsulated battery terminal."

50.9 Unless a battery charger complies with the outdoor enclosure requirements of 7.8, a battery charger shall be marked with the word "CAUTION" and the following or the equivalent: "Do not expose to rain. Replace defective cords or wires immediately." or "Do not expose to rain. Replace defective cords or wires before further use."

Exception: A cart-type battery charger that complies with the corrosion protection requirements in 10.4 – 10.7 and with the outdoor enclosure requirements of 7.8, need only be marked with the word "CAUTION" and the following or the equivalent: "Replace defective cords or wires immediately." or "Replace defective cords or wires before further use."

50.10 With reference to 50.9, if cord replacement is not practical, such as for a small, totally encapsulated battery charger, or for a battery charger employing a cover that complies with the requirements in 7.5.3, the battery charger shall be marked with the word "CAUTION" and the following or the equivalent: "To prevent electric shock – Dispose of battery charger if cord becomes defective."

50.11 With reference to the Exception to 24.6, a battery charger shall be marked with the word “CAUTION” and the following or the equivalent: “To prevent electric shock – Dispose of battery charger if cord becomes defective” or “Risk of Electric Shock. No user serviceable parts. Return to manufacturer for servicing.”

50.12 A cautionary marking may be provided on a permanent tag that is secured to the cord of a direct plug-in battery charger or other small charger for which it is not practical to include the marking on the enclosure because of the size of the charger. The tag shall be attached in such a way that it cannot be easily removed. The tag shall also be marked "Do not remove this tag" in letters not less than 3/32-inch (2.4-mm) high.

50.13 The tag mentioned in 50.11 shall be made of durable material that provides mechanical strength, such as cloth, plastic, or the equivalent, and shall be large enough to accommodate the required marking in a size that is legible. The tag shall be either:

a) A flat tag having a hole large enough to accommodate the output cord of a direct plug-in battery charger, but neither so large nor so positioned that it can easily be torn from the cord. To prevent removal or tearing, the tag is not to have a slit from the cord hole; or

b) A flat-type tag with an adhesive back wrapped tightly once around and adhering to the output cord. The ends of the tag are to adhere to each other and are to project as a flag. The required markings are to be printed in contrasting color on a background other than blue or yellow, and are to be located on the projecting flag.

50.14 A cautionary marking to instruct the operator shall be visible and legible to the operator during the normal operation of the charger. With reference to the Exception to 7.7.7, a marking shall be located adjacent to the part being guarded to indicate that the cover or guard is to be replaced before the battery charger is operated as intended.

50.15 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.

50.16 A commercial battery charger that is intended to be permanently installed in accordance with footnote k in Table 28.2 shall be legibly marked where readily visible after installation with the word "CAUTION" and the following or the equivalent: "Hot Surfaces – Risk of Burns – Do not touch."

50.17 If a fuseholder is accessible to the user, the fuse type and size shall be permanently marked adjacent to the fuseholder for which it is intended to be used.

50.18 With reference to footnote j of Table 28.2, if any point within a terminal box or wiring compartment of a fixed battery charger in which the battery charger conductors are intended to be connected, including such conductors themselves, attains a temperature rise of more than 60° C (140° F) during the normal temperature test, the battery charger shall be marked "For supply connection, use wires suitable for at least ... C (... F)," or with an equivalent statement, and the temperature value shall be in accordance with

Table 50.1. This statement shall be located at or near the point where the supply connections are to be made, and shall be clearly visible both during and after installation of the power supply.

Table 50.1
Terminal box marking

Temperature attained in terminal box or compartment during test	Temperature marking
61 – 75°C (142 – 167°F)	75°C (167°F)
76 – 90°C (168 – 194°F)	90°C (194°F)

51 Permanency of Marking

51.1 Unless specifically excepted, markings required by Sections 49 and 50 and elsewhere in this Standard shall be permanent. A marking that is required to be permanent 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 that, upon investigation, is found to comply with the requirements for permanence of marking in the Standard for Marking and Labeling Systems, UL 969. Ordinary usage, handling, storage, and the like of the battery charger are to be considered in determining whether a marking is permanent.

INSTRUCTIONS

52 Instruction Manual

52.1 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.

52.2 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.

52.3 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 could not result in confusion or misunderstanding due to different location of controls, operating modes, and the like need not comply with this requirement.

52.4 Instructions shall be legible and shall contrast with the background.

52.5 The headings for the user assembly, operation, maintenance, moving and storage, and important safety instructions, and the opening statements of the instructions specified in 53.4 – "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.

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

52.7 The text of the instructions required by 53.4 and 53.5 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.

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

53 Important Safety Instructions

53.1 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.

53.2 The important safety instructions shall include the appropriate instructions in 53.4 and 53.5 followed by the appropriate instructions in Sections 54 – 57.

53.3 The items in the list in 53.4 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.

53.4 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 Models_____.

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

2. Do not expose charger to rain or snow.

Exception: A battery charger complying with the outdoor enclosure requirements of 7.8, and a cart-type battery charger that complies with the requirements for corrosion-protection in 10.4 – 10.7 and the outdoor enclosure requirements of 7.8, need not include this instruction.

3. 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.

4. To reduce risk of damage to electric plug and cord, pull by plug rather than cord when disconnecting charger.

5. An extension cord should not be used unless absolutely necessary. Use of improper extension cord could result in a risk of fire and electric shock. If an extension cord must be used, make sure:

a) That pins on plug of extension cord are the same number, size, and shape as those of plug on charger;

b) That extension cord is properly wired and in good electrical condition; and

c) That wire size is large enough for ac ampere rating of charger as specified in Table 53.1.

Exception: The portion of the chart not applicable to a specific charger may be omitted.

6. Do not operate charger with damaged cord or plug – replace the cord or plug immediately.

7. Do not operate charger if it has received a sharp blow, been dropped, or otherwise damaged in any way; take it to a qualified serviceman.

8. Do not disassemble charger; take it to a qualified serviceman when service or repair is required. Incorrect reassembly may result in a risk of electric shock or fire.

9. To reduce risk of electric shock, unplug charger from outlet before attempting any maintenance or cleaning. Turning off controls will not reduce this risk.

10. WARNING – RISK OF EXPLOSIVE GASES.

a) WORKING IN VICINITY OF A LEAD-ACID BATTERY IS DANGEROUS. BATTERIES GENERATE EXPLOSIVE GASES DURING NORMAL BATTERY OPERATION. FOR THIS REASON, IT IS OF UTMOST IMPORTANCE THAT YOU FOLLOW THE INSTRUCTIONS EACH TIME YOU USE THE CHARGER.

b) To reduce risk of battery explosion, follow these instructions and those published by battery manufacturer and manufacturer of any equipment you intend to use in vicinity of battery. Review cautionary marking on these products and on engine.

11. PERSONAL PRECAUTIONS

a) Consider having someone close enough by to come to your aid when you work near a lead-acid battery.

b) Have plenty of fresh water and soap nearby in case battery acid contacts skin, clothing, or eyes.

c) Wear complete eye protection and clothing protection. Avoid touching eyes while working near battery.

d) If battery acid contacts skin or clothing, wash immediately with soap and water. If acid enters eye, immediately flood eye with running cold water for at least 10 minutes and get medical attention immediately.

e) NEVER smoke or allow a spark or flame in vicinity of battery or engine.

f) Be extra cautious to reduce risk of dropping a metal tool onto battery. It might spark or short-circuit battery or other electrical part that may cause explosion.

g) Remove personal metal items such as rings, bracelets, necklaces, and watches when working with a lead-acid battery. A lead-acid battery can produce a short-circuit current high enough to weld a ring or the like to metal, causing a severe burn.

h) Use charger for charging a LEAD-ACID battery only. It is not intended to supply power to a low voltage electrical system other than in a starter-motor application. Do not use battery charger for charging dry-cell batteries that are commonly used with home appliances. These batteries may burst and cause injury to persons and damage to property.

i) NEVER charge a frozen battery.

12. PREPARING TO CHARGE

a) If necessary to remove battery from vehicle to charge, always remove grounded terminal from battery first. Make sure all accessories in the vehicle are off, so as not to cause an arc.

b) Be sure area around battery is well ventilated while battery is being charged.

c) Clean battery terminals. Be careful to keep corrosion from coming in contact with eyes.

d) Add distilled water in each cell until battery acid reaches level specified by battery manufacturer. Do not overfill. For a battery without removable cell caps, such as valve regulated lead acid batteries, carefully follow manufacturer's recharging instructions.

e) Study all battery manufacturer's specific precautions while charging and recommended rates of charge.

f) Determine voltage of battery by referring to car owner's manual and make sure that output voltage selector switch is set at correct voltage. If charger has adjustable charge rate, charge battery initially at lowest rate.

Exception: For a charger not having an output voltage selector switch, determine voltage of battery by referring to car owner's manual and make sure it matches output rating of battery charger.

13. CHARGER LOCATION

a) Locate charger as far away from battery as dc cables permit.

b) Never place charger directly above battery being charged; gases from battery will corrode and damage charger.

c) Never allow battery acid to drip on charger when reading electrolyte specific gravity or filling battery.

d) Do not operate charger in a closed-in area or restrict ventilation in any way.

e) Do not set a battery on top of charger.

14. DC CONNECTION PRECAUTIONS

a) Connect and disconnect dc output clips only after setting any charger switches to "off" position and removing ac cord from electric outlet. Never allow clips to touch each other.

b) Attach clips to battery and chassis as indicated in 15(e), 15(f), and 16(b) through 16(d).

15. FOLLOW THESE STEPS WHEN BATTERY IS INSTALLED IN VEHICLE. A SPARK NEAR BATTERY MAY CAUSE BATTERY EXPLOSION. TO REDUCE RISK OF A SPARK NEAR BATTERY:

a) Position ac and dc cords to reduce risk of damage by hood, door, or moving engine part.

b) Stay clear of fan blades, belts, pulleys, and other parts that can cause injury to persons.

c) Check polarity of battery posts. POSITIVE (POS, P, +) battery post usually has larger diameter than NEGATIVE (NEG, N,–) post.

d) Determine which post of battery is grounded (connected) to the chassis. If negative post is grounded to chassis (as in most vehicles), see (e). If positive post is grounded to the chassis, see (f).

e) For negative-grounded vehicle, connect POSITIVE (RED) clip from battery charger to POSITIVE (POS, P, +) ungrounded post of battery. Connect NEGATIVE (BLACK) clip to vehicle chassis or engine block away from battery. Do not connect clip to carburetor, fuel lines, or sheet-metal body parts. Connect to a heavy gage metal part of the frame or engine block.

f) For positive-grounded vehicle, connect NEGATIVE (BLACK) clip from battery charger to NEGATIVE (NEG, N, –) ungrounded post of battery. Connect POSITIVE (RED) clip to vehicle chassis or engine block away from battery. Do not connect clip to carburetor, fuel lines, or sheet-metal body parts. Connect to a heavy gage metal part of the frame or engine block.

g) When disconnecting charger, turn switches to off, disconnect AC cord, remove clip from vehicle chassis, and then remove clip from battery terminal.

h) See operating instructions for length of charge information.

Exception: The instruction manual for a battery charger, marked in accordance with Exception No. 2 to 50.3 and constructed to prevent current flow in excess of 0.1 ampere until the battery is connected (with correct polarity) followed by the activation of a manually operated control, is not required to include the following statements located in 53.4 items: 15 (e)," Connect NEGATIVE (BLACK) clip to vehicle chassis or engine block away from battery.","Connect to a heavy gage metal part of the frame or engine block."; 15 (f)," Connect POSITIVE (RED) clip to vehicle chassis or engine block away from battery.","Connect to a heavy gage metal part of the frame or engine block."; and 15 (g)," ...remove clip from vehicle chassis..."

16. FOLLOW THESE STEPS WHEN BATTERY IS OUTSIDE VEHICLE. A SPARK NEAR THE BATTERY MAY CAUSE BATTERY EXPLOSION. TO REDUCE RISK OF A SPARK NEAR BATTERY:

a) Check polarity of battery posts. POSITIVE (POS, P, +) battery post usually has a larger diameter than NEGATIVE (NEG, N, –) post.

b) Attach at least a 24-inch-long 6-gauge (AWG) insulated battery cable to NEGATIVE (NEG, N, –) battery post.

c) Connect POSITIVE (RED) charger clip to POSITIVE (POS, P, +) post of battery.

d) Position yourself and free end of cable as far away from battery as possible – then connect NEGATIVE (BLACK) charger clip to free end of cable.

e) Do not face battery when making final connection.

f) When disconnecting charger, always do so in reverse sequence of connecting procedure and break first connection while as far away from battery as practical.

g) A marine (boat) battery must be removed and charged on shore. To charge it on board requires equipment specially designed for marine use.

Exception: The instruction manual for a battery charger, marked in accordance with Exception No. 2 to 50.3 and constructed to prevent current flow in excess of 0.1 ampere until the battery is connected (with correct polarity) followed by the activation of a manually operated control, is not required to have the following statements contained in 53.4 items: 16(b)," Attach at least a 24-inch-long 6-guage (AWG) insulated battery cable to NEGATIVE (NEG, N, –) battery post."; 16(d)," Position yourself and free end of cable as far away from battery as possible – then connect NEGATIVE (BLACK) charger clip to free end of cable."; and 16(f)," ...and break first connection while as far away from battery as practical."

53.5 The instructions for a battery charger shall include (a) – (g) as applicable to the particular charger.

a) For all grounded cord-connected battery chargers:

GROUNDING AND AC POWER CORD CONNECTION INSTRUCTIONS – Charger should be grounded to reduce risk of electric shock. Charger is equipped with an electric cord having an equipment-grounding conductor and a grounding plug. The plug must be plugged into an outlet that is properly installed and grounded in accordance with all local codes and ordinances.

DANGER – Never alter AC cord or plug provided – if it will not fit outlet, have proper outlet installed by a qualified electrician. Improper connection can result in a risk of an electric shock.

b) For grounded, cord-connected battery chargers with an input rating less than 15 amperes and intended for use on a nominal 120-volt circuit:

This battery charger is for use on a nominal 120-volt circuit, and has a grounding plug that looks like the plug illustrated in sketch A in Figure 53.1. A temporary adapter, which looks like the adapter illustrated in sketches B and C, may be used to connect this plug to a two-pole receptacle as shown in sketch B if a properly grounded outlet is not available. The temporary adapter should be used only until a properly grounded outlet can be installed by a qualified electrician.

DANGER – Before using adapter as illustrated, be certain that center screw of outlet plate is grounded. The green-colored rigid ear or lug extending from adapter must be connected to a properly grounded outlet– make certain it is grounded. If necessary, replace original outlet cover plate screw with a longer screw that will secure adapter ear or lug to outlet cover plate and make ground connection to grounded outlet.

c) For all other grounded, cord-connected battery chargers:

This battery charger is for use on a circuit having a nominal rating more than 120 volts (or "This appliance is rated more than 15 amperes and is for use on a circuit having a nominal rating of 120 volts") and is factory-equipped with a specific electric cord and plug to permit connection to an acceptable electric circuit. Make sure that the charger is connected to an outlet having the same configuration as the plug. No adapter should be used with this charger.

d) For a permanently connected battery charger:

GROUNDING INSTRUCTIONS – This battery charger should be connected to a grounded, metal, permanent wiring system; or an equipment-grounding conductor should be run with circuit conductors and connected to equipment-grounding terminal or lead on battery charger. Connections to battery charger should comply with all local codes and ordinances.

e) For a direct plug-in battery charger provided with a grounding pin:

CAUTION – Risk of Fire or Electric Shock. Connect battery charger directly to grounding receptacle (three-prong). An adapter should not be used with battery charger.

f) For a direct plug-in battery charger having a tab for semipermanent installation:

Use only with duplex receptacle having center screw;

Secure unit in place by receptacle cover screw; and

CAUTION and the following or equivalent: Risk of Electric Shock or Fire. Disconnect power to receptacle before installing or removing unit. When removing receptacle-cover screw, cover may fall across plug pins or receptacle may become displaced.

g) For a commercial battery charger that is intended to be permanently installed in accordance with footnote k in Table 28.2:

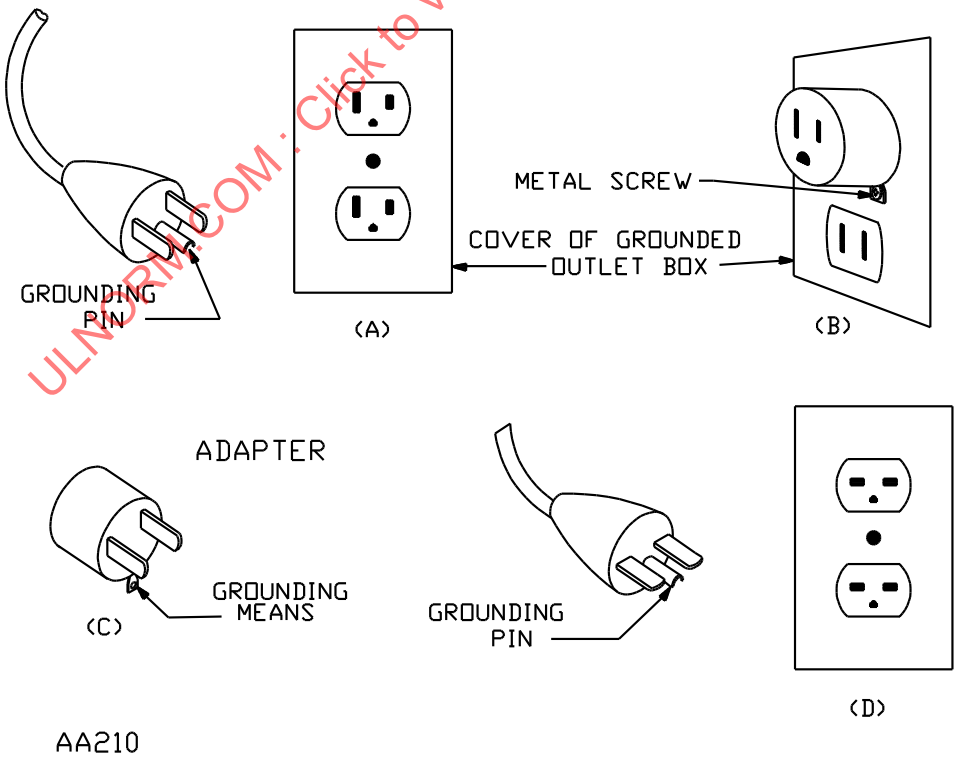
This battery charger should be installed so that it is not likely to be contacted by people.

Table 53.1
Recommended minimum AWG size for extension cords for battery chargers

AC input rating, amperes[a]		AWG size of cord			
		Length of cord, feet (m)			
Equal to or greater than	But less than	25 (7.6)	50 (15.2)	100 (30.5)	150 (45.6)
0	2	18	18	18	16
2	3	18	18	16	14
3	4	18	18	16	14
4	5	18	18	14	12
5	6	18	16	14	12
6	8	18	16	12	10
8	10	18	14	12	10
10	12	16	14	10	8
12	14	16	12	10	8
14	16	16	12	10	8
16	18	14	12	8	8
18	20	14	12	8	6

[a] If the input rating of a charger is given in watts rather than in amperes, the corresponding ampere rating is to be determined by dividing the wattage rating by the voltage rating – for example:
1250 watts/125 volts = 10 amperes

Figure 53.1
Grounding methods



54 Assembly Instructions

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

55 Operating Instructions

55.1 The operating instructions shall contain all appropriate information needed to operate a battery charger properly, and shall be preceded by the heading "OPERATING INSTRUCTIONS," or the equivalent.

55.2 The operating instructions shall:

a) Warn that the battery charger 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 battery charger, 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 battery charger includes the word "Automatic" such as "Automatic Battery Charger," "Automatic Circuit Protector," or "Automatic Input Voltage Compensation."

d) Explain any manual feature for input voltage compensation.

e) Explain any function which has limitations regarding safe operation with different battery types, such as proper use of an equalize feature.

56 Maintenance Instructions

56.1 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.

56.2 The user maintenance instructions, as described in 56.1, shall not include operations that would require disassembly of the battery charger to accomplish.

57 Moving and Storage Instructions

57.1 If moving or storage of a battery charger could result in damage to the charger 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.

58 Packaging

58.1 The packaging shall indicate whether the charger is intended for household use, commercial use, or both.

Exception: Packaging for a charger complying with both household and commercial requirements is not required to indicate the intended use.

58.2 The statements and pictures depicted on packaging shall be consistent with the safety, operation, and maintenance instructions.