



# UL 2743

## STANDARD FOR SAFETY Portable Power Packs

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The new requirements are substantially in accordance with Proposal(s) on this subject dated May 6, 2016 and September 9, 2016.

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UL 2743

Standard for Portable Power Packs

First Edition

October 14, 2016

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## INTRODUCTION

### 1 Scope

1.1 These requirements cover portable and movable power packs provided with one or more batteries or electrochemical capacitor modules. If provided with a battery, the battery shall be either a lead acid or lithium ion battery. The power packs are provided with one or more inputs as shown in 1.2; and they are provided with one or more outputs as shown in 1.3. For power packs provided with a booster function, the power packs are used for providing a temporary power source to a depleted land vehicle battery, rated 24 V maximum, to provide emergency starting power.

1.2 Power packs shall be provided with one or more of the input options as shown below:

- a) Cord and plug connection, rated at 240 V ac maximum, to and/or 60 Hz;
- b) Photovoltaic panel or device with inverter;
- c) Vehicle adapter, rated 12 V dc maximum; or
- d) USB input port (can also act as output port).

1.3 Power packs covered by this outline shall be provided with one or more of the following outputs, with the exception that one of the outputs in items (a) – (c) are provided as a minimum:

- a) Booster cables to provide a temporary power source to a depleted land vehicle battery, rated 24 V maximum, to provide emergency starting power or recharging of the external vehicle battery;
- b) One or more receptacles, each rated no more than 125 V ac, 15 A;
- c) DC output connectors rated 24 V dc maximum; or
- d) Standard USB port outputs.

1.4 Power packs may be considered suitable for outdoor use, suitable for temporary outdoor use, or suitable for indoor use only. Outdoor use packs can be used outdoors with no restrictions. Temporary outdoor use packs may be used outdoors but should be used carefully in wet conditions and always stored indoors. Indoor use only packs must be stored indoors and used indoors and cannot be used outdoors at any time. A power pack with a booster function shall not be considered indoor use only under any conditions.

1.5 With reference to 1.3, power packs may also be provided with additional systems such as an air compressor (tankless type) for inflating tires or other inflatable items, or with a light to act as warning lights to oncoming traffic, as a flashlight, or the like. These functions are also powered by the internal battery.

1.6 These requirements cover the power pack options such as lights, voltmeters, internal air compressor assemblies, associated gauges, inverters, vehicle adapters, and internal batteries, as well as the charging of the internal batteries, when these options are integral to the power pack.

1.7 These requirements do not cover wiring or cabling used in the recharging function of electric vehicle recharging equipment.

## 2 Units of Measurement

2.1 Values stated without parentheses are the requirement. Values within parentheses are considered explanatory or approximate information.

## 3 Components

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

3.2 A component is not required to comply with a specific requirement that:

- a) Involves a feature or characteristic not required in the application of the component in the product covered by this outline, or
- b) Is superseded by a requirement in this outline.

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

3.4 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

## 4 Undated References

4.1 Any undated reference to a code or standard appearing in the requirements of this outline shall be interpreted as referring to the latest edition of that code or standard.

## 5 Glossary

5.1 For the purpose of this document, the following definitions apply:

5.2 ACCESSIBLE – Able to be contacted by an accessibility probe.

5.3 BATTERY – An electrical storage unit consisting of two or more cells.

5.4 BOOSTER CABLE – The conductors that originate at the power pack's internal battery and terminate at the clamps that are intended to be temporarily connected to the land vehicle's battery. If the cable is connected through a switch and therefore does not have a continuous path to the exterior of the power pack's enclosure, then the definition shall apply to the portion of cable that exits the power pack's enclosure.

5.5 BOOSTER FUNCTION – When the power packs are used for providing a temporary power source to a depleted land vehicle battery, rated 24 V maximum, to provide emergency starting power.

5.6 CAPACITOR MODULE – A single or multiple series and/or parallel-connected, electrochemical capacitors with associated circuitry.

5.7 CHARGING SYSTEM – Combination of circuitry intended to charge, balance, and/or maintain the state of charge of the battery.

5.8 CLAMP – Devices located at the ends of the power pack's booster cables, and which contain the jaw ends, connectors, and handle ends, which are used to make the temporary connections to the land vehicles battery.

5.9 CLAMP: CONNECTORS – Portion of the clamp that contacts the battery terminals.

5.10 CLASS 2 POWER SUPPLY – A source having limited voltage and energy capacity. Requirements for voltage and energy capacity limitations are as indicated in this document.

5.11 CLEARANCE – Shortest distance between two conductive parts, or between conductive parts and the conductive dead metal parts of the enclosure, measured through air.

5.12 CONDUCTORS – Wiring used internally and externally on the power pack.

5.13 CREEPAGE DISTANCE – Shortest distance between two conductive parts, or between conductive parts and the conductive dead metal parts of the enclosure, measured along the surface of insulating material.

5.14 ELECTROCHEMICAL CAPACITOR – An electric energy storage device where electrical charge is stored as a result of non-Faradaic processes at one or both of the electrodes. (A subset of electrochemical capacitors referred to as an "asymmetric electrochemical capacitor" have non-Faradaic processes at one electrode and Faradaic processes at the other electrode.) The unique highly-porous electrode increases its surface area for holding charge resulting in much larger capacitance and energy density than other types of capacitors. Electrochemical capacitors differ from common electrolytic capacitors in that they store charge at the liquid-solid interface of the electrodes when a potential is applied rather than in a solid dielectric material covering the surfaces of the electrodes. Some other common names for an electrochemical capacitor are "double layer capacitor", "ultra-capacitor", "electrochemical double layer capacitor", "super-capacitor", and EDLC.

5.15 ENCLOSURE – That part of the product that:

- a) Renders inaccessible all or any parts of the equipment that may otherwise present a risk of electric shock, and
- b) Retards propagation of flame initiated by electrical disturbances occurring within.

5.16 EXPOSED – Visible but not necessarily able to be contacted by an accessibility probe.

5.17 FULLY CHARGED BATTERY – A battery charged to the maximum state of charge permitted by the battery charging system intended for use with the appliance and in accordance with the manufacturer's instructions.

5.18 FULLY DISCHARGED BATTERY – A battery that has been discharged at the manufacturer's recommended rate until the battery reaches a total voltage with an average voltage per cell equal to the end discharge voltage for the cell chemistry being used, or as specified by the manufacturer.

5.19 HANDLE END – Portion of the clamp that is held by the user and used to open the jaw ends to allow for the temporary connection to the positive battery terminal and to the land vehicle's grounded chassis.

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5.20 HAZARDOUS ENERGY LEVEL – A potential of 2 volts or more and either an available continuous power level of 240 volt-amperes or more, or a reactive energy level of 20 joules or more, between a live part and an adjacent dead metal part or between live parts of different polarity.

5.21 HAZARDOUS VOLTAGE LEVEL – Voltage between parts having an average value exceeding 30 V dc, 21.2 V peak.

5.22 INSULATION – Protective covering of the conductors, cable, and clamps.

5.23 INTERNAL BATTERY – The battery internal to the power pack's enclosure, which is used to provide the temporary power output of the power pack.

5.24 JAW END – Portion of the clamp that opens in order to accommodate the land vehicle's battery terminals.

5.25 LAND VEHICLE – An automobile, light duty truck, or other vehicle having a 12 or 24 volt dc electrical system.

5.26 LEAKAGE CURRENT – Electric current which flows through a person upon contact between accessible parts of a power pack and ground or other accessible parts of the power pack.

5.27 LOW VOLTAGE, LIMITED ENERGY (LVLE) – A circuit involving a potential of not more than 30 volts DC, or 21.2 volts peak, and supplied by a battery, a Class 2 source, or a combination of an isolating transformer and a fixed impedance that, as a unit, limits the available energy as described in 12.4.3.

5.28 MAXIMUM CHARGING CURRENT – Highest current that lithium-ion cell is permitted to pass during charging for a specified range of temperatures in the Standard for Lithium Batteries, UL 1642. This is the maximum current used as the basis of the charging current during the abnormal charging test.

5.29 MIDDLE CONNECTOR – A connector located in the middle of the cables that is disconnected prior to the clamps being connected to the vehicle battery and then used to complete the connection once the clamps are connected to the respective vehicle battery terminals.

5.30 POWER PACK – A portable or movable device that contains an internal battery, that when charged, is intended to provide power to various outputs of the device, including booster functions for providing temporary emergency power to land vehicles, or power to receptacles and other outputs. All can be further designated as outdoor use, temporary outdoor use, or indoor use only.

5.31 PROTECTIVE DEVICE – A device that operates in a specific manner to prevent a hazardous situation under abnormal operation conditions.

5.32 REPAIR FACILITY – A building or portion of a building where automotive repairs and maintenance work are conducted on gasoline powered land vehicles, whether only a portion of the land vehicles or all the land vehicles are gasoline powered.

5.33 SPECIFIED OPERATING REGION – Range of permissible operation expressed by lithium-ion cell parameter limits.

5.34 SPECIFIED OPERATING REGION FOR CHARGING – Conditions during charging in which the lithium-ion cell operates within its voltage and current range as specified by the cell manufacturer and evaluated in accordance with the Standard for Lithium Batteries, UL 1642. In general, the permissible range of voltage and current are dependent upon temperature.

5.35 UNINSULATED LIVE PART – A conductive part within the device that is not provided with integral insulation and during intended use has a potential difference with respect to earth ground or any other conductive part.

5.36 UPPER LIMIT CHARGING VOLTAGE – Highest voltage that a lithium-ion cell is permitted to attain during normal charging for a specified range of temperatures in the Standard for Lithium Batteries, UL 1642. This is the maximum voltage that is employed during the abnormal charging test.

## CONSTRUCTION

### 6 General

6.1 If the operation and maintenance of a power pack 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. When evaluating a power pack, consideration shall be given to reasonably foreseeable misuse of the product.

6.2 Power packs intended for use within a repair facility, and marked as such as indicated in 69.4, shall be provided with instructions containing the statement in 74.3 and shall be marked as shown in 70.19. Power packs that are not intended for use in a repair facility shall be marked in accordance with 70.20.

6.3 Outdoor use power packs shall be evaluated for all environmental considerations addressed by this standard and are intended to be used and stored either outdoors or indoors. Temporary outdoor use power packs shall be evaluated for exposure to rain, shall be marked in accordance with 70.20 and 70.21, and shall be provided with instructions in accordance with 74.5. Indoor use only power packs shall be marked in accordance with 70.22 and shall be provided with instructions in accordance with 74.6. Indoor use only packs need not comply with the environmental considerations in 7.5.

6.4 For power packs not marked in accordance with 70.23, the device shall be subjected to the Vibration Test, Section 51.

## 7 Frame and Enclosure

### 7.1 General

7.1.1 An enclosure of a power pack 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 power pack shall be provided with an enclosure suitable for the application. The enclosure shall house all live parts that may increase the risk of fire, electric shock, or injury to persons under any condition of use. This requirement does not apply to the power supply cord, the output leads, or output terminals.

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

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

7.1.4 The enclosure for a power pack provided with an internal lead acid battery shall be ventilated to permit dispersion of gases from the internal battery during normal use and charging. See 7.4.

7.1.5 Enclosures for power packs shall comply with the requirements for Environmental considerations, Section 7.5.

### 7.2 Metallic enclosures

7.2.1 Enclosures constructed of metallic materials shall be subjected to the Strength of Enclosure Tests, Section 55.

7.2.2 A metallic enclosure shall have a thickness not less than that specified in Tables 7.1 and 7.2

7.2.3 Metallic enclosures, if not constructed of a material that is corrosion resistant, shall be provided with corrosion protection in accordance with Corrosion Protection, Section 10.

**Table 7.1**  
**Minimum thickness of sheet metal for enclosure carbon steel or stainless steel**

| Without supporting frame <sup>a</sup>      |                                             | With supporting frame or equivalent reinforcing <sup>a</sup> |                                             | Minimum thickness uncoated, |  | Minimum thickness coated, |  |
|--------------------------------------------|---------------------------------------------|--------------------------------------------------------------|---------------------------------------------|-----------------------------|--|---------------------------|--|
| Maximum width, <sup>b</sup><br>inches (cm) | Maximum length, <sup>c</sup><br>inches (cm) | Maximum width, <sup>b</sup><br>inches (cm)                   | Maximum length, <sup>c</sup><br>inches (cm) | inch (mm)                   |  | inch (mm)                 |  |
| 4.0 (10.2)                                 | Not limited                                 | 6.25 (15.9)                                                  | Not limited                                 | 0.020 (0.51)                |  | 0.023 (0.58)              |  |
| 4.75 (12.1)                                | 5.75 (14.6)                                 | 6.75 (17.1)                                                  | 8.25 (21.0)                                 |                             |  |                           |  |
| 6.0 (15.2)                                 | Not limited                                 | 9.5 (24.1)                                                   | Not limited                                 | 0.026 (0.66)                |  | 0.029 (0.74)              |  |
| 7.0 (17.8)                                 | 8.75 (22.2)                                 | 10.0 (25.4)                                                  | 12.5 (31.8)                                 |                             |  |                           |  |
| 8.0 (20.4)                                 | Not limited                                 | 12.0 (30.5)                                                  | Not limited                                 | 0.032 (0.81)                |  | 0.034 (0.86)              |  |
| 9.0 (22.9)                                 | 11.5 (29.2)                                 | 13.0 (33.0)                                                  | 16.0 (40.6)                                 |                             |  |                           |  |
| 12.5 (31.8)                                | Not limited                                 | 19.5 (49.5)                                                  | Not limited                                 | 0.042 (1.07)                |  | 0.045 (1.14)              |  |
| 14.0 (35.6)                                | 18.0 (45.7)                                 | 21.0 (53.3)                                                  | 25.0 (63.5)                                 |                             |  |                           |  |
| 18.0 (45.7)                                | Not limited                                 | 27.0 (68.6)                                                  | Not limited                                 | 0.053 (1.34)                |  | 0.056 (1.42)              |  |
| 20.0 (50.8)                                | 25.0 (63.5)                                 | 29.0 (73.7)                                                  | 36.0 (91.4)                                 |                             |  |                           |  |
| 22.0 (55.9)                                | Not limited                                 | 33.0 (83.8)                                                  | Not limited                                 | 0.060 (1.53)                |  | 0.063 (1.61)              |  |
| 25.0 (63.5)                                | 31.0 (78.7)                                 | 35.0 (89.0)                                                  | 43.0 (109.2)                                |                             |  |                           |  |
| 25.0 (63.4)                                | Not limited                                 | 39.0 (99.1)                                                  | Not limited                                 | 0.067 (1.70)                |  | 0.070 (1.78)              |  |
| 29.0 (73.7)                                | 36.0 (91.4)                                 | 41.0 (104.1)                                                 | 51.0 (129.5)                                |                             |  |                           |  |

<sup>a</sup> A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal which is rigidly attached to and has the same outside dimensions as the enclosure surface and which has torsional rigidity to resist the bending moments which is capable of being applied via the enclosure surface when it is deflected. A construction that is determined to have equivalent reinforcing can be accomplished by constructions that produce a structure which is as rigid as one built with a frame of angles or channels. Constructions determined to be without a supporting frame include:

- 1) A single sheet with single formed flanges (formed edges);
- 2) A single sheet which is corrugated or ribbed; and
- 3) An enclosure surface loosely attached to a frame, for example, with spring clips.

<sup>b</sup> The width is the smaller dimension of a rectangular sheet metal piece which is part of an enclosure. Adjacent surfaces of an enclosure can have supports in common and be made of a single sheet.

<sup>c</sup> For panels which are not supported along one side, for example, side panels of boxes, the length of the unsupported side shall be limited to the dimensions specified unless the side in question is provided with a flange at least 1/2 inch (12.7 mm) wide.

**Table 7.2**  
**Minimum thickness of sheet metal for enclosures aluminum, copper, or brass**

| Without supporting frame <sup>a</sup>      |                                             | With supporting frame or equivalent reinforcing <sup>a</sup> |                                             | Minimum thickness,<br>inches (mm) |
|--------------------------------------------|---------------------------------------------|--------------------------------------------------------------|---------------------------------------------|-----------------------------------|
| Maximum width, <sup>b</sup><br>inches (cm) | Maximum length, <sup>c</sup><br>inches (cm) | Maximum width, <sup>b</sup><br>inches (cm)                   | Maximum length, <sup>c</sup><br>inches (cm) |                                   |
| 3.0 (7.6)                                  | Not limited                                 | 7.0 (17.8)                                                   | Not limited                                 | 0.023 <sup>d</sup> (0.58)         |
| 3.5 (8.9)                                  | 4.0 (10.2)                                  | 8.5 (21.7)                                                   | 9.5 (24.1)                                  |                                   |
| 4.0 (10.2)                                 | Not limited                                 | 10.0 (25.4)                                                  | Not limited                                 | 0.029 (0.74)                      |
| 5.0 (12.7)                                 | 6.0 (15.2)                                  | 10.5 (26.7)                                                  | 13.5 (34.2)                                 |                                   |
| 6.0 (15.2)                                 | Not limited                                 | 14.0 (35.6)                                                  | Not limited                                 | 0.036 (0.91)                      |
| 6.5 (16.5)                                 | 8.0 (20.4)                                  | 15.0 (38.1)                                                  | 18.0 (45.7)                                 |                                   |
| 8.0 (20.4)                                 | Not limited                                 | 19.0 (48.3)                                                  | Not limited                                 | 0.045 (1.14)                      |
| 9.5 (24.1)                                 | 11.5 (29.2)                                 | 21.0 (53.3)                                                  | 25.0 (63.5)                                 |                                   |
| 12.0 (30.5)                                | Not limited                                 | 28.0 (71.1)                                                  | Not limited                                 | 0.058 (1.47)                      |
| 14.0 (35.6)                                | 16.0 (40.6)                                 | 30.0 (76.2)                                                  | 37.0 (94.0)                                 |                                   |
| 18.0 (45.7)                                | Not limited                                 | 42.0 (106.7)                                                 | Not limited                                 | 0.075 (1.91)                      |
| 20.0 (50.8)                                | 25.0 (63.4)                                 | 45.0 (114.3)                                                 | 55.0 (139.7)                                |                                   |
| 25.0 (63.4)                                | Not limited                                 | 60.0 (152.4)                                                 | Not limited                                 | 0.095 (2.41)                      |
| 29.0 (73.7)                                | 36.0 (91.4)                                 | 64.0 (162.6)                                                 | 78.0 (198.1)                                |                                   |

<sup>a</sup> A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal which is rigidly attached to and has the same outside dimensions as the enclosure surface and which has torsional rigidity to resist the bending moments which are capable of being applied via the enclosure surface when it is deflected. Construction that is determined to have equivalent reinforcing can be accomplished by constructions that produce a structure which is as rigid as one built with a frame of angles or channels. Construction determined to be without supporting frame includes:

- 1) Single sheet with single formed flanges (formed edges);
- 2) A single sheet which is corrugated or ribbed; and
- 3) An enclosure surface loosely attached to a frame, for example, with spring clips.

<sup>b</sup> The width is the smaller dimension of a rectangular sheet metal piece which is part of an enclosure. Adjacent surfaces of an enclosure can have supports in common and be made of a single sheet.

<sup>c</sup> For panels which are not supported along one side, for example, side panels of boxes, the length of the unsupported side shall be limited to the dimensions specified unless the side in question is provided with a flange at least 1/2 inch (12.7 mm) wide.

### 7.3 Nonmetallic enclosures

7.3.1 In addition to the performance tests specified in this outline, the factors to be considered when evaluating the suitability of a polymeric enclosure include the requirements in 7.3.2 through 7.3.4.

7.3.2 The enclosure material shall have a minimum flame rating of V-1 in accordance with 8.1.

7.3.3 The enclosure material shall have a minimum Relative Thermal Index (RTI) value that exceeds the maximum temperature observed on the material during operation but no less than 80°C for packs intended to be stored in the trunk or passenger compartment of a vehicle. If an RTI value that exceeds the maximum temperature observed on the material during operation, but is lower than 80°C, is used, the power pack shall be marked in accordance with 70.23 and provided with instructions as shown in 74.7.

7.3.4 A conductive coating applied to a nonmetallic surface such as the inside surface of an enclosure, shall be evaluated in accordance with 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.

7.3.5 An adhesive used to secure parts of an enclosure shall comply with the requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

7.3.6 Enclosures of molded or formed nonmetallic materials shall be constructed so that any shrinkage or distortion of the material over time will not allow for the user to contact live parts. Compliance is determined by the Mold Stress Test, Section 56.

7.3.7 Enclosures constructed of nonmetallic materials shall be subjected to the Strength of Enclosure Tests, Section 55.

7.3.8 Enclosures constructed of nonmetallic materials shall be subjected to the Strength of Enclosure Tests, Section 55.

### 7.4 Openings in enclosures

7.4.1 Power pack enclosures shall not allow the entrance of water in accordance with 7.5.

7.4.2 A probe as illustrated in Figure 7.1, when inserted through an opening, shall not touch any uninsulated live part that can cause electric shock.



7.4.3 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 evaluated as an enclosure. It shall be reliably retained in place.

7.4.4 An uninsulated live part at hazardous voltage or hazardous energy levels shall be located or enclosed so that protection against unintentional contact is provided.

7.4.5 A door or cover that provides access to a live part at hazardous voltage or hazardous energy levels 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 is not at hazardous voltage or hazardous energy levels 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.*

7.4.6 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.

*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.*

7.4.7 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.

## 7.5 Environmental considerations

7.5.1 The enclosure of an outdoor use or temporary outdoor use power pack shall be constructed to exclude a beating rain in accordance with 7.5.2.

7.5.2 All outdoor use or temporary outdoor use power packs shall be subjected to the Rain Test, Section 60.

7.5.3 A gasket employed in a power pack in order to comply with 7.5.1 shall be tested in accordance with Accelerated Aging of Gaskets, Sealing Compounds, and Adhesives, Section 62.

7.5.4 A nonmetallic enclosure for an outdoor use power pack shall be judged on the basis of the effect of exposure to ultraviolet light and water in accordance with the applicable tests in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. Temporary outdoor use power packs need not comply with this requirement.

## 8 Flammability of Materials

8.1 Nonmetallic materials used for enclosures shall have a minimum flammability rating of V-1 in accordance with the requirements in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94. As an alternative, finished enclosures may be tested in accordance with the 20 mm end-product flame test in the Standard for Polymeric Materials - Use in Electrical Equipment Evaluations, UL 746C. Metallic materials used for enclosures are considered to comply without further evaluation, except magnesium shall not be used for enclosure materials.

8.2 Nonmetallic materials used for internal parts within the overall enclosure shall be rated V-2 minimum.

*Exception No. 1: The internal insulating system of components where component requirements exist need not comply with this requirement.*

*Exception No. 2: A small part, gasket, or other nonmetallic part that is located such that it cannot propagate flame from one area to another within the equipment, and is not located in close proximity to uninsulated live parts, is not required to comply with this requirement.*

8.3 Nonmetallic materials located outside the enclosure, and not used to complete the enclosure, are considered decorative parts. These parts shall be rated HB minimum.

8.4 Printed wiring board materials shall be rated V-1 minimum.

8.5 For the requirements outlined in 8.2 – 8.4, the flammability rating of the material shall be provided as part of the material rating or the flammability rating may be determined in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

## 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 values indicated in Spacings, Section 29.

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

9.3 With reference to 9.2, a switch is not required to be mounted as described in 9.2, 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 values indicated in Spacings, Section 29, if the switch rotates; and
- d) Operation of the switch is by mechanical means rather than by direct contact by persons.

9.4 With reference to 9.2, 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 values indicated in Spacings, Section 29.

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

## 10 Corrosion Protection

10.1 Metal shall be used in combinations that are galvanically compatible.

10.2 Hinges and other attachments shall be resistant to corrosion.

10.3 The requirements in 10.5 – 10.15 do not contemplate corrosion that might be caused by exposure to the earth or other corrosive agents.

10.4 The requirements in 10.5 – 10.15 do not apply to a part, such as a decorative grill, that is not required to form a part of the enclosure.

10.5 A metallic enclosure shall be protected against corrosion as specified in 10.6 – 10.15.

10.6 Copper, bronze, brass containing not less than 80 percent copper, or stainless steel may be used without additional protection against corrosion. Sheet, extruded, or cast aluminum, die-cast zinc, and other metals shall be of a grade or alloy known to be resistant to atmospheric corrosion, shall be subjected to tests, or shall be additionally protected against corrosion.

10.7 An enclosure of cast iron or malleable iron at least 1/8 inch (3.2 mm) thick shall be protected against corrosion by:

- a) A 0.00015 inch (0.0038 mm) thick coating of zinc, cadmium, or the equivalent on the outside surface, and a visible coating of such metal on the inside surface, or
- b) One coat of an organic finish of the epoxy or alkyd-resin type or other outdoor paint on each surface.

10.8 Unless suitability of a paint can be determined by consideration of its composition, corrosion tests are required.

10.9 An enclosure of sheet steel less than 0.126 inch (3.20 mm) thick if zinc-coated or 0.123 inch (3.12 mm) thick if uncoated shall be protected against corrosion by one of the following means or by other metallic or nonmetallic coatings that have been found to give equivalent protection as described in 10.12:

- 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/A653M, with not less than 40 percent of the zinc on any side, based on the minimum single-spot-test requirement in this ASTM specification. The weight of zinc coating may be determined by any method; however, in case of question, the weight of coating shall be established in accordance with the Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings, ASTM A90/A90M.

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 (0.015 mm) on each surface with a minimum thickness of 0.00054 inch (0.014 mm). An annealed coating shall also comply with 10.14.

c) A zinc coating conforming with 10.10 (a) or (b), with one coat of an organic finish of the epoxy or alkyd-resin type or other outdoor paint on each surface applied after forming. See 10.8.

10.10 An enclosure of zinc coated steel 0.0126 inch (3.20 mm) thick or thicker or an enclosure of uncoated sheet steel 0.123 inch (3.12 mm) thick or thicker shall be protected against corrosion by one of the following means or by other metallic or nonmetallic coatings that have been shown to give equivalent protection as described in 10.12:

a) 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/A653M, with not less than 40 percent of the zinc on any side, based on the minimum single-spot-test requirement in this ASTM specification. The weight of zinc coating may be determined by any method; however, in case of question, the weight of coating shall be established in accordance with the Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings, ASTM A90/A90M.

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 0.00041 inch (0.010 mm) on each surface with a minimum thickness of 0.00034 inch (0.009 mm).

c) Two coats of an organic finish of the epoxy or alkyd-resin type or other outdoor paint on each surface. See 10.8.

d) Any one of the means specified in 10.9.

10.11 The requirements in 10.10 also apply to an enclosure of zinc-coated sheet steel 0.056 inch (1.42 mm) thick or thicker and an enclosure of uncoated sheet steel 0.053 inch (1.35 mm) thick or thicker if the enclosure is intended to be mounted within and protected from direct exposure to weather by the enclosure of other equipment. Such an enclosure shall not be marked rainproof or raintight.

10.12 With reference to 10.9 – 10.11, other finishes, including paints, metallic finishes, and combinations of the two, may be accepted if comparative tests with galvanized sheet steel – without annealing, wiping, or other surface treatment – conforming with 10.9(a) or 10.10(a), as applicable, indicate that they provide equivalent protection. Among the factors that are to be taken into consideration when judging the suitability 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.

10.13 If tests are required, test specimens of a finish as described in 10.7, 10.9(c), 10.10(c), or 10.12 are to be consistent with the finish that is to be used in production with respect to the base metal, cleaning, or pretreatment method, application method, number of coats, curing method, thickness, and the like.

10.14 A hot-dipped, mill-galvanized A60 (alloyed) coating or an annealed zinc coating that is bent or similarly formed after annealing and that is not otherwise required to be painted, shall be painted in the bent or formed area if the bending or forming process has damaged the zinc coating, except that such an area on the inside surface of an enclosure that is not exposed to water during the water spray test need not be painted. The zinc coating is considered to be damaged if flaking or cracking of the zinc coating at the outside radius of the bent or formed section is visible at 25-power magnification. Simple sheared or cut edges and punched holes are not considered to be formed.

10.15 If verification of the thickness of coatings in 10.9 and 10.10 is required, the thickness shall be established by the Metallic Coating Thickness Test, Section 63.

## 11 Supply Connections

### 11.1 General

11.1.1 Power packs are intended to be connected to the power supply circuit in order to recharge the internal battery. Additionally, outputs of the power pack may be powered when the pack is connected to the supply circuit.

11.1.2 The power supply connection shall consist of the input types described under clause 1.2.

### 11.2 Flexible cord connection

#### 11.2.1 General

11.2.1.1 For flexible cord connections, the power pack shall be connected to the power supply circuit by means of a flexible cord and an attachment plug. The flexible power cord shall be either a detachable or non-detachable type. For devices intended for use with a detachable cord set, the cord set need not be provided with the device, when the power pack is marked in accordance with 70.18 and the instructions are in accordance with 73.2.

11.2.1.2 For power packs intended for use in a repair facility, a detachable flexible cord shall be provided with a means to insure that the flexible cord cannot be inadvertently detached during use.

*Exception: A device intended for use in a repair facility that is provided with a means to insure that the appliance inlet on the device is inherently located at a height above 18 inches (457 mm) may also be provided with a detachable cord set without a means to insure inadvertent detachment, when the power pack is marked in accordance with 70.18 and the instructions are in accordance with 73.2.*

11.2.1.3 A flexible cord shall have a voltage rating not less than the rated voltage of the equipment, and shall have an ampacity not less than the current rating of the equipment.

11.2.1.4 The attachment plug shall have an ampacity not less than the rated current of the product or the actual current measured during the Power Input Test, Section 42, whichever is greater, and a voltage rating equal to the rated voltage of the product. If a product is adaptable for use on two or more different values of voltage by field alteration of internal connections, the attachment plug provided with the product shall be rated for the voltage for which the product is connected when leaving the factory.

11.2.1.5 A flexible cord shall be Type G, SO, SJO, SJEO, SJTO, STO, or W, or a type at least equally serviceable for the particular application.

11.2.1.6 The length of a flexible cord, including the attachment plug, shall not be less than 6 feet (1.8 m).

11.2.1.7 If a product incorporates a disconnecting means, such as an appliance inlet, the arrangement shall be such that no live parts will be exposed under any normal conditions.

11.2.1.8 A permanently attached flexible cord shall exit the enclosure in an area that is not in close proximity to a hot spot or moving part.

## 11.2.2 Strain relief

11.2.2.1 Strain relief shall be provided on a non-detachable flexible cord to reduce the risk of mechanical stress being transmitted to terminals, splices, or interior wiring. See Strain Relief Test, Section 54. A knot in the flexible cord is not considered a form of strain relief.

11.2.2.2 A metal strain relief clamp or band provided in accordance with 11.2.2.1 shall be provided with auxiliary insulation over the cord if damage to the cord insulation results when the strain relief test is conducted without auxiliary insulation.

11.2.2.3 Means shall be provided to prevent a flexible cord from being pushed into the equipment through the cord entry hole if such displacement would:

- a) Result in mechanical damage to the cord;
- b) Expose the cord to a temperature than that for which it is rated; or
- c) Reduce spacings, such as to a metal strain relief clamp, below the minimum values indicated in Spacings, Section 29.

To determine compliance, the flexible cord shall be tested in accordance with the Push-Back Strain Relief Test, Section 54.2.

## 11.2.3 Bushings

11.2.3.1 At the point where a non-detachable flexible cord passes through an opening in the enclosure, there shall be a bushing or the equivalent that is secured in place, and that has a smooth, well rounded surface against which the cord may bear. An insulating bushing shall be provided, if the enclosure is of metal, or if the construction is such that the cord may be subjected to strain or motion. A bushing that complies with the applicable requirements in the Standard for Insulating Bushings, UL 635, is considered to comply with this requirement.

11.2.3.2 A hole in porcelain, phenolic composition, or other non-conducting material, having a smooth, rounded surface, is considered to be equivalent to a bushing.

11.2.3.3 A bushing of the same material as, and molded integrally with, a supply cord is acceptable if the built-up section is not less than 1/16 inch (1.6 mm) thick at the point where the flexible cord passes through the enclosure.

11.2.3.4 At a point of flexure, no additional flexible cords or wires shall be routed through a bushing or opening with the power supply cord.

### 11.3 External power supplies

11.3.1 As an alternative to flexible cord connections, the power pack may be provided with a DC voltage rated input connector intended for connection to the output of an external power supply.

11.3.2 The output rating of the external power supply shall be equal to or greater than the input rating of the power pack; and the output of the external power supply shall be considered a limited power source in accordance with the Standard for Information Technology Equipment - Safety - Part 1: General Requirements, UL 60950-1 or a Class 2 power source in accordance with the Standard for Class 2 Power Units, UL 1310.

### 11.4 Vehicle adapters

11.4.1 A power pack intended for connection to an automobile cigar lighter receptacle shall be provided with a vehicle adapter 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 15 A.

*Exception: The protective device may be provided in the output cord of the vehicle adapter not more than 5 inches (127 mm) from the vehicle adapter enclosure.*

11.4.2 With reference to 11.4.1, if the fuse is user replaceable, the vehicle adapter shall be marked in accordance with 70.10. This marking shall appear adjacent to the fuseholder.

### 11.5 Photovoltaic panels

11.5.1 Power packs provided with a photovoltaic panel as an input for charging the internal battery shall be provided with an inverter and shall be in accordance with the applicable requirements in the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741; or with the applicable requirements in the Standard for Power Converters for Use in Photovoltaic Power Systems – Part 1: General Requirements, UL 62109-1.