



JOINT CANADA-UNITED STATES
NATIONAL STANDARD

ANSI/CAN/UL 2743:2023

STANDARD FOR SAFETY

Portable Power Packs



SCC FOREWORD

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UL Standard for Safety for Portable Power Packs, ANSI/CAN/UL 2743

Second Edition, Dated July 3, 2018

Summary of Topics

This revision of ANSI/CAN/UL 2743 dated April 14, 2023 includes the following changes:

- Clarification to definition of hazardous voltage level; [5.21](#)
- Addition of definition of "portable or moveable"; [1.7](#), [Table 1.1](#), [4.3](#), [5.29A](#)
- Alignment of requirements for sub-enclosures with UL 746C; [7.3.2](#)
- Receptacle output not supplied by AC mains; [12.3.1](#), [12.3.1A](#), [17.5](#), [70.24](#), [72.3](#), [4.3](#)
- Increase the vehicle adapter voltage rating; [11.1.2](#)
- Replacement of UL 60950-1 with UL 62368-1 for external charger standard; [11.3.2](#), [4.3](#)
- Double insulated products with functional earthing; [5.18A](#), [14.2](#) – [14.6](#)
- Alternative cell standard for Lithium and Lead Acid batteries; [28.2.1](#), [28.3.1](#), [4.3](#)
- Addition of alternative standard for inverters in the power pack; [30.1](#), [4.3](#)
- Addition of mass limitation for stability test; [37.1](#)
- Addition of the induction output and energy hazard measurement test; [12.1.2](#), [12.1.3](#), [12.4.3](#), [12.5.3](#), Section [12.6](#), Section [47A](#)
- Addition of LVLE circuit requirements and test; [5.27](#), [12.1.4](#), Section [12A](#), Section [47B](#)
- Clarification of Leakage Current Test with hazardous voltage circuits; [46.1](#), [49.1](#)
- Option of single fault condition in control circuit besides functional safety evaluation; [40.1](#), [50.1.7](#)
- Clarification of the short circuit resistance for output short circuit test; [50.2.2](#), [50.2.3](#)
- Charging current for Overcharging Test; [50.9.2](#)
- Additional requirements for large energy storage systems (ESS); [28.3.7](#), [32.4](#), Section [50.11](#), [70.23](#)
- Strain relief test for interconnecting cable; [11.2.2.1](#), [11.2.2.3](#), Section [54.1](#)
- Updates to the Impact Test and Drop Test; [55.1.2](#), [55.2.1](#), [55.3.1](#), [55.3.2](#)
- Clarification of the compliance criteria for the Rain Test; [5.15](#), [5.31A](#), [5.31B](#), [60.2](#), [60.2A](#), [60.3](#), [60.3A](#), [60.4](#), [69.1](#)

- **Power Pack Ampacity Test and booster ampacity rating marking;** [65.1](#), [69.1](#)
- **Addition of UL 969A requirements for flag labels;** [69.3](#), [4.3](#)
- **Revisions to Markings and Instructions;** [70.11](#), [70.12](#), [72.3](#)
- **Addition of instruction for booster cable connection and disconnection to battery;** [72.3](#)
- **Clarification to Annex [A](#) as Normative or Informative**

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

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated July 8, 2022 and December 2, 2022.

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ANSI/UL 2743-2023



JULY 3, 2018

(Title Page Reprinted: April 14, 2023)

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ANSI/CAN/UL 2743:2023

Standard for Portable Power Packs

First Edition – October, 2016

Second Edition

July 3, 2018

This ANSI/UL Standard for Safety consists of the Second Edition including revisions through April 14, 2023.

The most recent designation of ANSI/UL 2743 as an American National Standard (ANSI) occurred on April 14, 2023. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page, Preface, or SCC Foreword.

This standard has been designated as a National Standard of Canada (NSC) on April 14, 2023.

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Annex A – Safety Marking Translations (Normative for Canada and Informative for the US)

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Preface

This is the Second Edition of ANSI/CAN/UL 2743, the Standard for Safety for Portable Power Packs.

ULSE is accredited by the American National Standards Institute (ANSI) and the Standards Council of Canada (SCC) as a Standards Development Organization (SDO).

This Standard has been developed in compliance with the requirements of ANSI and SCC for accreditation of a Standards Development Organization.

Only metric SI units of measurement are used in this Standard. If a value for measurement is followed by a value in other units in parentheses, the second value may be approximate. The first stated value is the requirement.

Annex A is identified as Normative for Canada and Informative for the US. Informative text is for informational purposes only, and Normative text is considered to be mandatory.

This ANSI/CAN/UL 2743 Standard is under continuous maintenance, whereby each revision is approved in compliance with the requirements of ANSI and SCC for accreditation of a Standards Development Organization. In the event that no revisions are issued for a period of four years from the date of publication, action to revise, reaffirm, or withdraw the standard shall be initiated.

In Canada, there are two official languages, English and French. All safety warnings must be in French and English. Attention is drawn to the possibility that some Canadian authorities may require additional markings and/or installation instructions to be in both official languages.

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

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This Edition of the Standard has been formally approved by the Technical Committee (TC) for Portable Power Packs, TC 2743.

This list represents the TC 2743 membership when the final text in this standard was balloted. Since that time, changes in the membership may have occurred.

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International Classification for Standards (ICS): 97.180

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This Standard is intended to be used for conformity assessment.

The intended primary application of this standard is stated in its scope. It is important to note that it remains the responsibility of the user of the standard to judge its suitability for this particular application.

CETTE NORME NATIONALE DU CANADA EST DISPONIBLE EN VERSIONS FRANÇAISE ET ANGLAISE.

INTRODUCTION

1 Scope

1.1 These requirements cover portable and movable power packs provided with one or more batteries, electrochemical capacitors, 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 and one or more outputs. 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 dc maximum, to provide emergency starting power.

1.2 These requirements cover power packs suitable for outdoor use, temporary outdoor use, or indoor use only. Outdoor use packs are intended to be used outdoors with no restrictions. Temporary outdoor use packs are intended to be used outdoors in limited wet conditions and always stored indoors. Indoor use only packs are intended to be stored indoors and used indoors and are not intended to be used outdoors at any time. A power pack with a booster function is not considered indoor use only under any conditions.

1.3 These requirements cover power packs 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.

1.4 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.

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

1.6 These requirements do not cover power banks which are covered in the Outline of Investigation for Power Banks, UL 2056.

1.7 These requirements do not cover power packs having a capacity exceeding the limits specified in [Table 1.1](#) which are covered by the Standard for Energy Storage Systems and Equipment, UL 9540.

Table 1.1
Portable Power Pack Threshold Quantities

Portable power pack technology	Aggregate capacity	
	kWh	MJ
Lead-acid, all types	70	252
Lithium-ion, all types	20	72
Electrochemical Capacitors	3	10.8

2 Units of Measurement

2.1 The values given in SI (metric) units shall be normative. Any other values are for information only.

2.2 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 Standard 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 Standard, or
- b) Is superseded by a requirement in this Standard.

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 Referenced Publications

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.

4.2 Products covered by this Standard shall comply with the referenced installation codes and standards noted in this Section as appropriate for the country where the product is to be used. When the product is intended for use in more than one country, the product shall comply with the installation codes and standards for all countries where it is intended to be used.

4.3 The following publications are referenced in this Standard:

ASTM A90, Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings

ASTM E230, Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples

ASTM E376, Standard Practice for Measuring Coating Thickness by Magnetic-Field or Eddy-Current (Electromagnetic) Testing Methods

ASTM D412, Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers – Tension

ASTM B568, Standard Test Method for Measurement of Coating Thickness by X-Ray Spectrometry

ASTM A653, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

CSA C22.2 No. 0.15, Adhesive Labels

CAN/CSA C22.2 No. 0.17, Evaluation of Properties of Polymeric Mate

CAN/CSA C22.2 No. 0.2, Insulation Coordination

CSA C22.2 No. 42, General Use Receptacles, Attachment Plugs, and Similar Wiring Devices

CAN/CSA C22.2 No. 66.1, Low Voltage Transformers – Part 1: General Requirements

CAN/CSA C22.2 No. 66.2, Low Voltage Transformers – Part 2: General Purpose Transformers

CAN/CSA C22.2 No. 66.3, Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers

CAN/CSA C22.2 No. 68, Motor Operated Appliances (Household and Commercial)

CAN/CSA C22.2 No. 77, Motors With Inherent Overheating Protection

CSA C22.2 No. 107.1, Power Conversion Equipment

CSA C22.2 No. 107.2, Battery Chargers

CAN/CSA C22.2 No. 182.3, Special Use Attachment Plugs, Receptacles, and Connectors

CAN/CSA C22.2 No. 197, PVC Insulating Tape

CAN/CSA C22.2 No. 127, Equipment and Lead Wires

CAN/CSA C22.2 No. 210, Appliance Wiring Material Products

CSA C22.2 No. 223, Power Supplies With Extra Low Voltage Class 2 Outputs

CSA C22.2 No. 60335-2-29, Household and Similar Electrical Appliances – Safety – Part 2-29: Particular Requirements for Battery Chargers

CSA C22.2 E60730-1, Automatic Electrical Controls – Part 1: General Requirements

CSA C22.2 No. 60950-1, Information Technology Equipment – Safety – Part 1: General Requirements

CSA C22.2 No. 62133-2, Secondary Cells and Batteries Containing Alkaline and Non-Acid Electrolytes – Safety Requirements for Portable Sealed Secondary Cells, and for Batteries Made From Them, for Use in Portable Applications – Part 2: Lithium Systems

CSA C22.2 No. 62368-1, Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements

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

UL 101, Leakage Current for Appliances

UL 498, Attachment Plugs and Receptacles

UL 506, Specialty Transformers

UL 510, Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape

UL 635, Insulating Bushings

UL 746C, Polymeric Materials – Use in Electrical Equipment Evaluations

UL 758, Appliance Wiring Material

UL 796, Printed-Wiring Boards

UL 810A, Electrochemical Capacitors

UL 840, Insulation Coordination Including Clearance and Creepage Distances for Electrical Equipment

UL 943, Ground-Fault Circuit Interrupters

UL 969, Marking and Labeling Systems

UL 969A, Marking and Labeling Systems – Flag Labels, Flag Tags, Wrap-Around Labels and Related Products

UL 1004-3, Thermally Protected Motors

UL 1012, Power Units Other Than Class 2

UL 1097, Double Insulation Systems for Use in Electrical Equipment

UL 1236, Battery Chargers for Charging Engine-Starter Batteries

UL 1310, Class 2 Power Units

UL 1437, Electrical Analog Instruments – Panel Board Types

UL 1450, Motor-Operated Air Compressors, Vacuum Pumps, and Painting Equipment

UL 1561, Dry-Type General Purpose and Power Transformers

UL 1581, Reference Standard for Electrical Wires, Cables, and Flexible Cords

UL 1642, Lithium Batteries

UL 1741, Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources

UL 1839, Automotive Battery Booster Cables

UL 1973, Batteries for Use in Stationary and Motive Auxiliary Power Applications

UL 1977, Component Connectors for Use in Data, Signal, Control and Power Applications

UL 1989, Standby Batteries

UL 2089, Vehicle Battery Adapters

UL/ULC 2580, Batteries for Use In Electric Vehicles

UL 5085-1, Low Voltage Transformers – Part 1: General Requirements

UL 5085-2, Low Voltage Transformers – Part 2: General Purpose Transformers

UL 5085-3, Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers

UL 9540, Energy Storage Systems and Equipment

UL 60335-2-29, Household and Similar Electrical Appliances – Safety – Part 2-29: Particular Requirements for Battery Chargers

UL 60730-1, Automatic Electrical Controls – Part 1: General Requirements

UL 60950-1, Information Technology Equipment – Safety – Part 1: General Requirements

UL 62109-1, Power Converters for Use in Photovoltaic Power Systems – Part 1: General Requirements

UL 62133-2, Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes – Safety Requirements for Portable Sealed Secondary Cells, and for Batteries Made From Them, for Use in Portable Applications – Part 2: Lithium Systems

UL 62368-1, Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements

5 Glossary

5.1 For the purpose of this Standard, 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 or electric energy hazard; 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.

5.18A FUNCTIONAL EARTHING – Earthing a point or points in a system or in an installation or in equipment, for purposes other than electrical safety.

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.

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 – For temporary outdoor and outdoor use applications, hazardous voltage level is the voltage having a value exceeding 30 V dc or 21.2 V peak AC. For indoor use only applications, hazardous voltage level is the voltage having a value exceeding 60 V dc, or 42.4 V peak AC.

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 below the hazardous voltage level in [5.21](#) and supplied by a low voltage battery, a Class 2 source, or a combination of an isolating transformer and one or more resistors or a regulating network, or overcurrent protective device that, as a unit, limits the available energy as described in [47B.1](#).

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.

5.29A PORTABLE POWER PACK – A power pack which can be lifted and moved by a single person without mechanical aids and not permanently connected to an electrical system. It can be either:

a) Hand-held; or

b) Moveable and meets the following criteria:

1) 18 kg (39.7 pounds) or less in mass and is not fixed; or

2) Provided with wheels, casters, or other means to facilitate movement by an ordinary person as required to perform its intended use.

For a portable power pack powered by a detachable battery pack(s), which is mounted on the body of the portable power pack during operation, the weight of all detachable battery packs shall be included to determine if it is movable or portable.

5.30 POWER PACK – A portable or movable device that contains an integral or removable battery, or batteries, that when charged are 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.

5.31A RAINPROOF ENCLOSURE – An enclosure that provides protection to personnel against electric shock or electric energy hazards by preventing a degree of water entering inside of the portable power pack during the Rain Test.

5.31B RAIN-TIGHT ENCLOSURE – An enclosure that completely prevents water entering inside of the portable power pack during the Rain Test.

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 [70.17](#). Power packs that are not intended for use in a repair facility shall be marked in accordance with [70.18](#).

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 [70.19](#) and [70.20](#), and shall be provided with instructions in accordance with [74.5](#). Indoor use only power packs shall be marked in accordance with [70.21](#) 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 [70.22](#), 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.

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 in [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 [Table 7.1](#) and [Table 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 ^a		With supporting frame or equivalent reinforcing ^a		Minimum thickness uncoated	Minimum thickness coated
Maximum width ^b	Maximum length ^c	Maximum width ^b	Maximum length ^c		
cm (inches)	cm (inches)	cm (inches)	cm (inches)	mm (inches)	mm (inches)
10.2 (4)	Not limited	15.9 (6.25)	Not limited	0.51 (0.020)	0.58 (0.023)
12.1 (4.75)	14.6 (5.75)	17.1 (6.75)	21.0 (8.25)		
15.2 (6)	Not limited	24.1 (9.5)	Not limited	0.66 (0.026)	0.74 (0.029)
17.8 (7)	22.2 (8.75)	25.4 (10)	31.8 (12.5)		
20.4 (8)	Not limited	30.5 (12)	Not limited	0.81 (0.032)	0.86 (0.034)
22.9 (9)	29.2 (11.5)	33.0 (13)	40.6 (16)		
31.8 (12.5)	Not limited	49.5 (19.5)	Not limited	1.07 (0.042)	1.14 (0.045)
35.6 (14)	45.7 (18)	53.3 (21)	63.5 (25)		
45.7 (18)	Not limited	68.6 (27)	Not limited	1.34 (0.053)	1.42 (0.056)
50.8 (20)	63.5 (25)	73.7 (29)	91.4 (36)		
55.9 (22)	Not limited	83.8 (33)	Not limited	1.53 (0.060)	1.61 (0.063)
63.5 (25)	78.7 (31)	89.0 (35)	109.2 (43)		
63.5 (25)	Not limited	99.1 (39)	Not limited	1.70 (0.067)	1.78 (0.070)
73.7 (29)	91.4 (36)	104.1 (41)	129.5 (51)		

Table 7.1 Continued on Next Page

Table 7.1 Continued

Without supporting frame ^a		With supporting frame or equivalent reinforcing ^a		Minimum thickness uncoated	Minimum thickness coated
Maximum width ^b cm (inches)	Maximum length ^c cm (inches)	Maximum width ^b cm (inches)	Maximum length ^c cm (inches)		
^a 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. 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. ^b 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. ^c 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 12.7 mm (1/2 inch) wide.					

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

Without supporting frame ^a		With supporting frame or equivalent reinforcing ^a		Minimum thickness
Maximum width ^b cm (inches)	Maximum length ^c cm (inches)	Maximum width ^b cm (inches)	Maximum length ^c cm (inches)	
7.6 (3)	Not limited	17.8 (7)	Not limited	0.58 ^d (0.023)
8.9 (3.5)	10.2 (4)	21.7 (8.5)	24.1 (9.5)	
10.2 (4)	Not limited	25.4 (10)	Not limited	0.74 (0.029)
12.7 (5)	15.2 (6)	26.7 (10.5)	34.2 (13.5)	
15.2 (6)	Not limited	35.6 (14)	Not limited	0.91 (0.036)
16.5 (6.5)	20.4 (8)	38.1 (15)	45.7 (18)	
20.4 (8)	Not limited	48.3 (19)	Not limited	1.14 (0.045)
24.1 (9.5)	29.2 (11.5)	53.3 (21)	63.5 (25)	
30.5 (12)	Not limited	71.1 (28)	Not limited	1.47 (0.058)
35.6 (14)	40.6 (16)	76.2 (30)	94 (37)	
45.7 (18)	Not limited	106.7 (42)	Not limited	1.91 (0.075)
50.8 (20)	63.4 (25)	114.3 (45)	139.7 (55)	
63.4 (25)	Not limited	152.4 (60)	Not limited	2.41 (0.095)
73.7 (29)	91.4 (36)	162.6 (64)	198.1 (78)	
^a 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				

Table 7.2 Continued on Next Page

Table 7.2 Continued

Without supporting frame ^a		With supporting frame or equivalent reinforcing ^a		Minimum thickness mm (inches)
Maximum width ^b cm (inches)	Maximum length ^c cm (inches)	Maximum width ^b cm (inches)	Maximum length ^c cm (inches)	
3) An enclosure surface loosely attached to a frame, for example, with spring clips.				
^b 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.				
^c 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 12.7 mm (1/2 inch) wide.				

7.3 Nonmetallic enclosures

7.3.1 In addition to the performance tests specified in this Standard, 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](#).

Exception: If a metal or minimum V-1 rated sub-enclosure houses all insulated or uninsulated live parts and internal wiring that involve a risk of fire, then the outer polymeric enclosure may be classed HB or better.

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 (176°F) 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 (176°F), is used, the power pack shall be marked in accordance with [70.22](#) 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, and Evaluation of Properties of Polymeric Materials, CAN/CSA C22.2 No. 0.17, 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, and Evaluation of Properties of Polymeric Materials, CAN/CSA C22.2 No. 0.17.

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 at hazardous voltage or hazardous energy levels. Compliance is determined by the Mold Stress Test, Section [56](#).

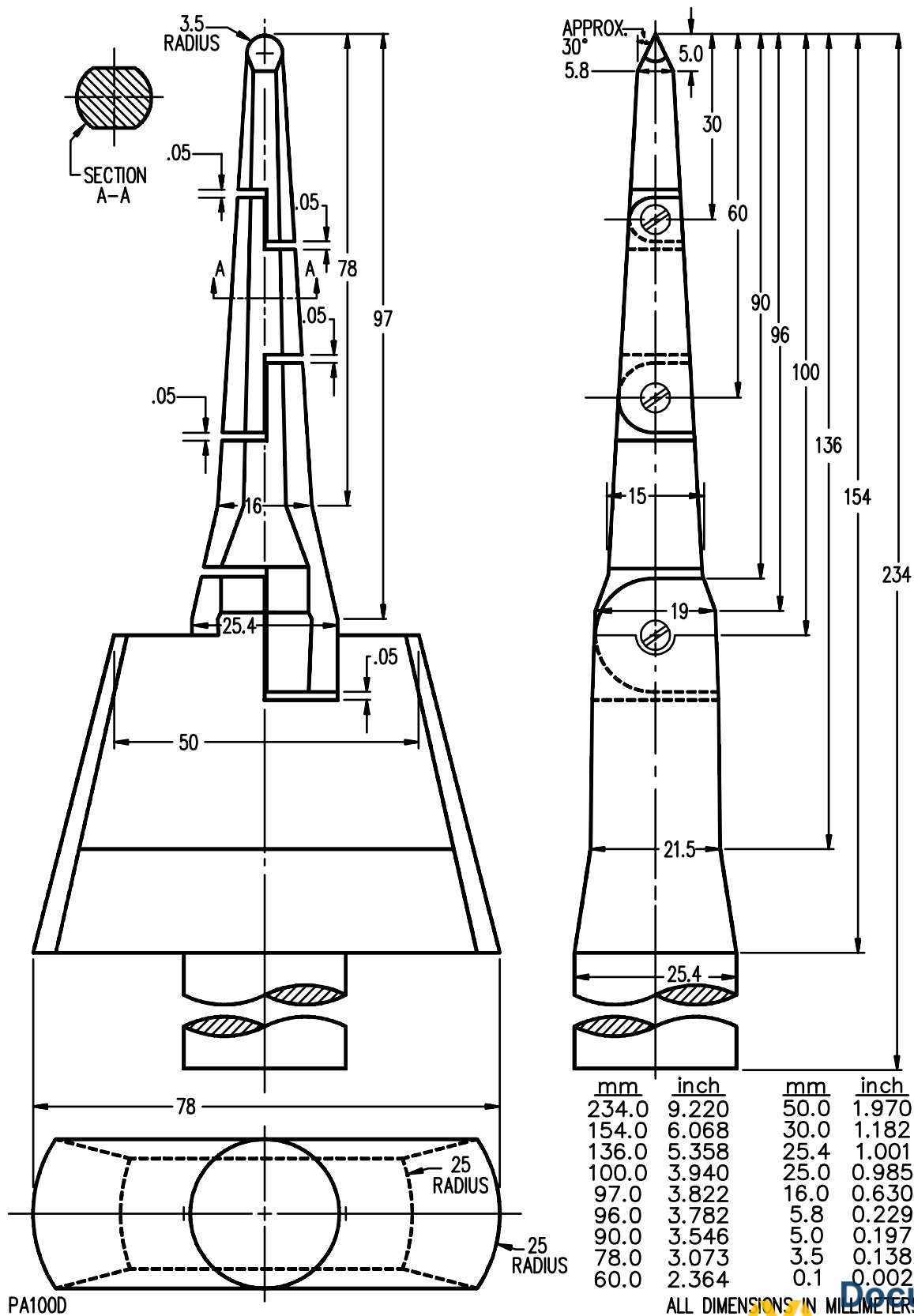
7.3.7 Enclosures constructed of nonmetallic materials shall be subjected to the Strength of Enclosure Tests, Section [55](#).

7.4 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.

Figure 7.1
Articulate probe with web stop



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, Evaluation of Properties of Polymeric Materials, CAN/CSA C22.2 No. 0.17. 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, and Evaluation of Properties of Polymeric Materials, CAN/CSA C22.2 No. 0.17. 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, and Evaluation of Properties of Polymeric Materials, CAN/CSA C22.2 No. 0.17. 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, and Evaluation of Properties of Polymeric Materials, CAN/CSA C22.2 No. 0.17.

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 3.2 mm (1/8 inch) thick shall be protected against corrosion by:

- a) A 0.0038 mm (0.00015 inch) 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 3.20 mm (0.126 inch) thick if zinc-coated or 3.12 mm (0.123 inch) 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, 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.
- 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 0.015 mm (0.00061 inch) on each surface with a minimum thickness of 0.014 mm (0.00054 inch). 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 3.20 mm (0.126 inch) thick or thicker or an enclosure of uncoated sheet steel 3.12 mm (0.123 inch) 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](#):