

UL 1012

ISBN 1-55989-587-X

Power Units Other Than Class 2

Underwriters Laboratories Inc. (UL)
333 Pfingsten Road
Northbrook, IL 60062-2096

UL Standard for Safety for UL Standard for Safety for Power Units Other Than Class 2, UL 1012

Sixth Edition, Dated June 28, 1994

Revisions: This Standard contains revisions through and including May 24, 2000.

UL is in the process of converting its Standards for Safety to the Standard Generalized Markup Language (SGML), and implementing an SGML compliant document management and publishing system. SGML - an international standard (ISO 8879-1986) - is a descriptive markup language that describes a document's structure and purpose, rather than its physical appearance on a page. Significant benefits that will result from UL's use of SGML and these new systems include increased productivity, reduced turnaround times, and data and information consistency, reusability, shareability, and portability. However, the fonts, pagination, and general formatting of UL's new electronic publishing system differ from that of UL's previous publishing system. Consequently, when revision pages are issued for a Standard with the new publishing system, these differences may result in the printing of pages on which no requirements have been changed - these additional pages result from relocation of text due to repagination and reformatting of the Standard with the new publishing system.

Text that has been changed in any manner is marked with a vertical line in the margin. Changes in requirements are marked with a vertical line in the margin and are followed by an effective date note indicating the date of publication or the date on which the changed requirement becomes effective.

The revisions dated May 24, 2000 include a reprinted title page (page1) for this Standard.

The revisions dated May 24, 2000 were issued for NEC code updates and includes other editorial corrections.

The revisions dated November 17, 1999 were issued for editorial corrections. These corrections include any combination of the following: Updated Foreword (item D); Updated Scope; title changes to UL 489 and/or UL 1950; Withdrawn standards, UL 519 and UL 547, being replaced by UL 2111; Removal of the "94" flammability classification. These revisions may also include other miscellaneous editorial corrections.

The revisions dated July 7, 1999 were issued to correct cross references. These revisions were also issued to remove the "94" prefix from the flammability classifications. This type of flame classification has become familiar globally, therefore there is no need to retain the "94" designation.

The revisions dated October 9, 1997 include a change of references to UL 519, Standard for Impedance-Protected Motors, and UL 547, Standard for Thermal Protectors for Motors, to UL 2111, Standard for Overheating Protection for Motors. UL 519 and UL 547 have been withdrawn and replaced by UL 2111.

Also included in the revisions dated October 9, 1997 are revisions related to the process of converting UL Standards for Generalized Markup Language (SGML). The changes are needed to modify the format and layout of this Standard to allow it to be converted to SGML. These are editorial changes now in effect.

As indicated on the title page (page 1), this UL Standard for Safety is an American National Standard. Attention is directed to the note on the title page of this Standard outlining the procedures to be followed to retain the approved text of this ANSI/UL Standard.

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New product submittals made prior to a specified future effective date will be judged under all of the requirements in this Standard including those requirements with a specified future effective date, unless the applicant specifically requests that the product be judged under the current requirements. However, if the applicant elects this option, it should be noted that compliance with all the requirements in this Standard will be required as a condition of continued Listing, Recognition, and Follow-Up Services after the effective date, and understanding of this should be signified in writing.

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This Standard consists of pages dated as shown in the following checklist:

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95-96B	July 7, 1999
97-100	September 6, 1996
A1	November 17, 1999
A2	June 28, 1994
SR1-SR2	October 9, 1997

No Text on This Page

JUNE 28, 1994
(Title Page Reprinted: May 24, 2000)



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UL 1012

Standard for Power Units Other Than Class 2

The first through fourth editions were titled the Standard for Power Supplies.

First Edition – September, 1976
Second Edition – September, 1978
Third Edition – March, 1982
Fourth Edition – July, 1989
Fifth Edition – August, 1992

Sixth Edition

June 28, 1994

Approval as an American National Standard (ANSI) covers the numbered paragraphs on pages dated June 28, 1994 . These pages should not be discarded when revised or additional pages are issued if it is desired to retain the ANSI approved text.

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

Approved as ANSI/UL 1012-1981, September 30, 1981
Approved as ANSI/UL 1012-1988, October 14, 1988
Approved as ANSI/UL 1012-1996, February 8, 1996

Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements.

ISBN 1-55989-587-X

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FOREWORD

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product employing materials or having forms of construction which conflict with specific requirements of the Standard cannot be judged to comply with the Standard. A product employing materials or having forms of construction not addressed by this Standard may be examined and tested according to the intent of the requirements and, if found to meet the intent of this Standard, may be judged to comply with the Standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

INTRODUCTION

1 Scope

1.1 These requirements cover portable, stationary, and fixed power units having an input rating of 600 volts or less, direct- and alternating- current, with at least one output not marked Class 2, and that are intended to be employed in ordinary locations in accordance with the National Electrical Code, INNS/NFPA 70.

1.2 These requirements cover general purpose power supplies and power supplies for uses such as to supply some household appliances, school laboratories, cathodic protection equipment; power supply-battery charger combinations; and industrial equipment, including inverters, divided into two classes – those rated 10 kilovolt-amperes or less and those rated more than 10 kilovolt-amperes.

1.3 Power units with all outputs identified as Class 2 are covered under The Standard for Class 2 Power Units, UL 1310.

1.4 These requirements cover battery chargers other than the type intended to charge motor-starting batteries and those for charging industrial batteries which power material handling trucks, tractors, personnel carriers, and similar motive equipment. These battery chargers are covered under The Standard For Battery Chargers for Charging Engine-Starter Batteries, UL 1236, and the Standard for Industrial Battery Chargers, UL 1564, respectively.

1.5 A battery charger for charging automotive-type batteries for other than motor-starting purposes, such as powering a trolling motor, is investigated to the requirements in this standard and the applicable requirements for battery chargers under UL 1236, the Standard for Battery Chargers for Charging Engine-Starter Batteries, or UL 1564, the Standard for Industrial Battery Chargers.

1.6 These requirements do not cover a power supply for a fire-protective or burglary-protective signaling system, electrostatic-air cleaning equipment, recreational vehicles, electric discharge or neon tubing, test equipment for commercial or industrial laboratories; or an appliance or system in which the power supply is used.

Revised 1.6 effective October 9, 2002

1.7 These requirements cover power supplies for centralized ac or dc power systems, including dc power supplies, rectifiers, and the like, that form part of these systems.

1.8 A power supply that is intended for use with a specific type of product other than as referenced in 1.2 is investigated under the standard for that end product.

1.9 These requirements do not cover the effect that a power supply may have on an equipment or a system to which it is connected.

1.10 A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involves a risk of fire or of electric shock or injury to persons shall be evaluated using appropriate additional component and end-product requirements to maintain the level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific

requirements or provisions of this standard does not comply with this standard. Revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

1.10 revised May 24, 2000

2 General

2.1 Components

2.1.1 Except as indicated in 2.1.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of Standards covering components used in the products covered by this Standard.

2.1.1 revised May 24, 2000

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

a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or

b) Is superseded by a requirement in this standard.

2.1.2 revised May 24, 2000

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

2.1.3 revised May 24, 2000

2.1.4 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.

2.1.4 revised May 24, 2000

2.2 Units of measurement

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

2.2.1 revised May 24, 2000

2.3 Terminology

2.3.1 Unless otherwise stated, values of current and voltage are root-mean-square.

2.3.2 The term "product" as used in these requirements refers to all power units or any part thereof covered by these requirements unless specifically noted otherwise.

2.3.3 The term "power unit" as used in these requirements refers to all power supplies, battery chargers, and transformers covered by these requirements.

2.4 Undated references

2.4.1 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.

2.4.1 revised May 24, 2000

3 Glossary

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

3.2 BATTERY, SEALED – A battery that has no provision for the addition of water or electrolyte or for external measurement of electrolyte specific gravity.

No Text on This Page

3.3 BATTERY, VALVE-REGULATED – A battery in which the venting of the products of electrolysis is controlled by a reclosing pressure-sensitive valve. These batteries have commonly been referred to as "maintenance-free, starved electrolyte."

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

3.5 CLASS 2 OUTPUT – An output complying with the requirements for Class 2 Output Circuits. See 30.1.

3.5 revised September 6, 1996

3.5.1 CLASS 3 OUTPUT – A source having limited voltage and energy capacity and complying with the requirements for Class 3 Output Circuits. See 30.2. See also the Maximum Output Voltage Test, Section 77, and the Output Current and Power Test, Section 78.

3.5.1 added September 6, 1996

3.5.2 CONDUCTIVELY CONNECTED – A part connected to another part such that the current through a 1500 ohm resistor connected between the parts exceeds 5 mA rms or 7.07 mA peak.

3.5.2 added September 6, 1996

3.6 CONTROLLED ENVIRONMENT – An environment that is relatively free of conductive contaminants, such as carbon dust and the like that may result from the end-use equipment that the power unit will be installed with or that may be due to the location of the end-use equipment, and that is provided with protection against humidity and the formation of condensation. A temperature and humidity controlled indoor area free of conductive contaminants, is considered to be a controlled environment. An equivalent environment may be provided within the enclosure of an appliance by means of:

- a) A hermetically sealed enclosure,
- b) Encapsulation,
- c) A conformal coating,
- d) A gasketed, tight-fitting enclosure, or
- e) A filter system reducing the level of contamination in conjunction with a system reducing the level of condensation (for example, maintaining the surrounding air at constant temperature and low relative humidity).

3.7 DIRECT CURRENT (DC) – A voltage or current waveform where voltage across two points does not change polarity, and the current through a conductor does not change direction.

3.7 revised September 6, 1996

3.8 ELECTRICAL ENERGY – HIGH CURRENT LEVELS – The capability for damage or injury to persons (other than by electric shock) from available electrical energy is considered to exist, if between a live part and an adjacent dead metal part or between live parts of different polarity, there exists a potential of 2 volts or more and either:

- a) An available continuous power level of 240 volt-amperes or more, or
- b) A reactive energy level of 20 joules or more.

For example, a tool, or other metal short-circuiting a component can cause a burn or a fire if enough energy is available at the component to vaporize, melt, or more than warm the metal.

3.8.1 ENERGY LIMITING CIRCUIT/IMPEDANCE – A circuit or component depended on to limit an output to Class 3 levels. Reliability of circuit components shall be determined unless the unit is tested as specified in 80.1.

3.8.1 added September 6, 1996

3.9 ISOLATED LIMITED-ENERGY CIRCUIT – A circuit derived from an isolated secondary winding of a transformer having a maximum capacity in accordance with Section 43 and an open-circuit secondary voltage rating not exceeding 1000 volts. A circuit derived from a line-voltage source of supply by connecting resistance in series with the supply circuit as a means of limiting the voltage and current is not considered to be an isolated limited-energy circuit.

3.10 LINE-VOLTAGE CIRCUIT – Wiring and components that are conductively connected to a branch circuit.

3.11 LOW VOLTAGE LIMITED ENERGY (LVLE) CIRCUIT – A circuit involving a potential of not more than 42.4 volts peak or 60 V dc with limited energy as described in 29.5 – 29.12.

3.11 revised September 6, 1996

3.12 POWER UNIT, COMMERCIAL – A power unit other than the household type as defined in 3.14.

3.13 POWER UNIT, FIXED – A power unit that is intended to be permanently connected electrically.

3.14 POWER UNIT, HOUSEHOLD – A power unit intended for use with equipment found in the home.

3.15 POWER UNIT, PORTABLE – A cord and plug connected power unit that:

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

3.15 revised July 7, 1999

3.16 POWER UNIT, STATIONARY – A cord and plug connected power unit that is intended to be fastened in place or located in a dedicated space.

3.17 RISK OF ELECTRIC SHOCK – A risk of electric shock is considered likely to occur at any part if the potential between the part and earth ground or any other accessible part is more than 30 volts rms, 42.4 volts peak, or 60 V dc, and the continuous current flow through a 1500-ohm resistor exceeds 5 milliamperes.

3.18 RISK OF INJURY – A risk of injury to persons is considered likely to occur if one or more of the following conditions exist:

- a) If power-operated moving parts such as gears and linkages are accessible during intended operation and are capable of causing a cut or laceration.
- b) If sharp edges, burrs, or projections are present that can cause injury during use or servicing.
- c) If the stability of a product is such that it can cause injury to persons. See Stability Test, Section 41.

- d) If there is likelihood that a part of the body could be endangered or that clothing would be entangled by the moving part resulting in an injury.

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

3.19 SPECIAL APPLICATION BATTERY CHARGER – A battery charger intended to charge batteries employed in wheel chairs or other similar types of mobility aids.

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

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ALL POWER UNITS

CONSTRUCTION

4 Frame and Enclosure

4.1 General

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

4.1.2 A power unit shall be provided with an enclosure to house all parts other than the power supply cord or primary connector and the output leads or output connector that may present a risk of fire, electric shock, or injury to persons under any condition of use.

4.1.3 A cast- or sheet-metal section of the enclosure shall have a thickness not less than that specified in Table 4.1.

Exception: A part of an enclosure that complies with the Mechanical Strength Tests for Metal Enclosures, Section 37, need not comply with the thickness specified in Table 4.1.

Table 4.1
Minimum acceptable thickness of enclosure metal

Metal	At small, flat, unreinforced surfaces and at surfaces of a shape or size to provide adequate mechanical strength		At surfaces to which a wiring system is to be connected in the field		At relatively large unreinforced flat surfaces	
	Inches	Millimeters	Inches	Millimeters	Inches	Millimeters
Die-cast	3/64	(1.2)	—	—	5/64	(2.0)
Cast malleable iron	1/16	(1.6)	—	—	3/32	(2.4)
Other cast metal	3/32	(2.4)	—	—	1/8	(3.2)
Uncoated sheet steel	0.026	(0.66)	0.032	(0.81)	0.026	(0.66)
Galvanized sheet steel	0.029	(0.74)	0.034	(0.86)	0.029	(0.74)
Nonferrous sheet metal other than copper	0.036	(0.91)	0.045	(1.14)	0.036	(0.91)
Copper	0.033	(0.84)	0.043	(1.09)	0.033	(0.84)

4.1.4 An enclosure or part of an enclosure that also serves as a compartment for a rechargeable vented battery shall be ventilated to permit dispersion of gases from the battery.

4.1.5 In addition to the criteria specified in this standard, the following factors are to be considered when judging the suitability of a polymeric enclosure:

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

These properties shall comply with the requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. See also 31.4.

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

4.1.7 The enclosure of a power unit shall prevent molten metal, burning insulation, flaming particles, or the like from falling on combustible materials, including the surface upon which the power unit is supported. A barrier as mentioned in 4.1.10 shall:

- a) Be horizontal,
- b) Comply with Figure 4.1, and
- c) Comply with 4.1.8 if it is made of a polymeric material.

Openings for drainage, ventilation, and the like may be employed in the barrier provided such openings would not permit molten metal, burning insulation, or the like, to fall on combustible material.

4.1.8 With reference to 4.1.7, a barrier made of a polymeric material shall:

- a) Have a flammability classification of V-1 or better in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94; and
- b) Comply with the requirements for physical barriers specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

4.1.8 revised July 7, 1999

4.1.9 The requirement in 4.1.7 necessitates that a switch, a relay, a solenoid, or the like, be completely and individually enclosed, unless it can be shown that:

- a) Malfunction of the component would not result in a risk of fire, or
- b) There are no openings in the enclosure through which molten metal, burning insulation, flaming particles or the like could fall.

Exception No. 1: This requirement does not apply to terminals.

Exception No. 2: Ventilation openings may be provided in the bottom of an enclosure if the openings incorporate a perforated metal plate as described in Table 4.2; a galvanized or stainless steel screen having a 14- by 14- mesh per inch (25.4-mm) constructed of wire with a diameter of 0.018 inch (0.5 mm) minimum; or other construction complying with the Hot, Flaming Oil Test, Section 46A.

4.1.9 revised February 13, 1995

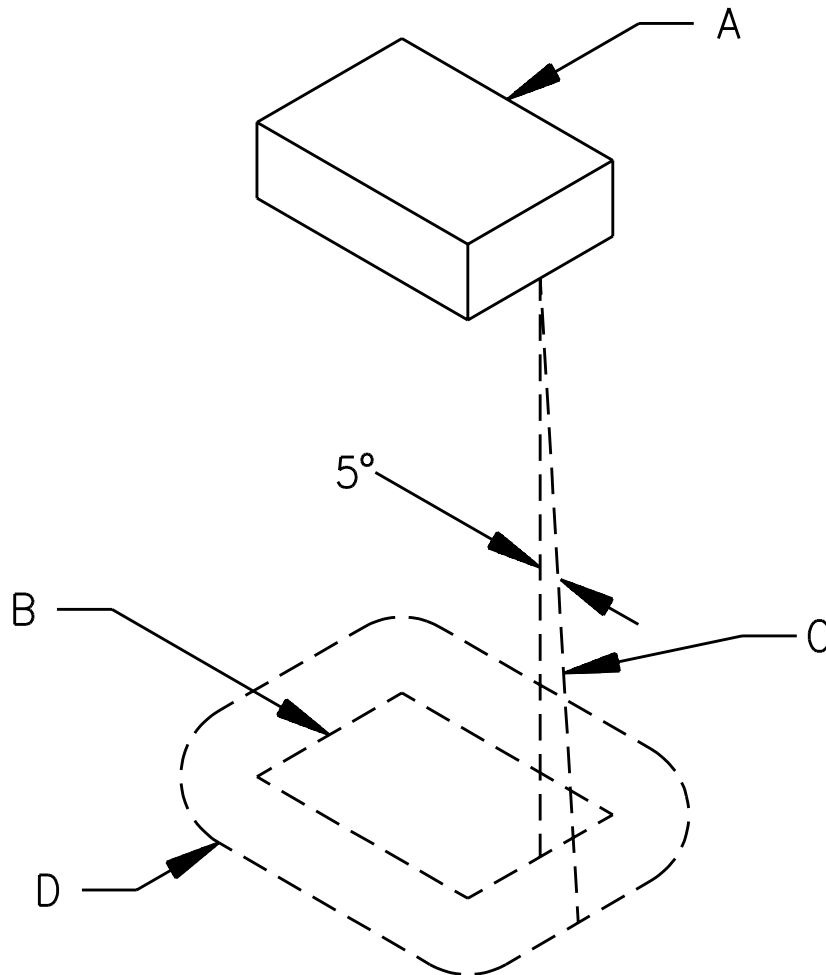
Table 4.2
Perforated metal plates for enclosure bottom

Table 4.2 revised July 7, 1999

Minimum thickness,		Maximum diameter of holes,		Minimum spacings of holes center to center,	
inch	(mm)	inch	(mm)	inch	(mm)
0.026	(0.66)	0.045	(1.14)	0.067	(1.70)
				233 holes per inch ² (645 mm ²)	
0.026	(0.66)	0.047	(1.19)	0.093	(2.36)
0.030	(0.76)	0.045	(1.14)	0.067	(1.70)
0.030	(0.76)	0.047	(1.19)	0.093	(2.36)
0.032	(0.81)	0.075	(1.91)	0.125	(3.18)
				72 holes per inch ² (645 mm ²)	
0.035	(0.89)	0.075	(1.90)	0.125	(3.18)
0.036	(0.91)	0.063	(1.60)	0.109	(2.77)
0.036	(0.91)	0.078	(1.98)	0.125	(3.18)
0.039	(0.99)	0.063	(1.60)	0.109	(2.77)
0.039	(0.99)	0.079	(2.00)	0.118	(3.00)
NOTE – In accordance with Exception No. 2 to 4.1.9.					

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Figure 4.1
Location and extent of barrier



SA0604-1

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

B – Projection of outline of component on horizontal plane.

C – Inclined line that traces out minimum area of barrier. The line is always:

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

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

4.1.10 With regard to 4.1.7, if openings in the enclosure are provided, it will also necessitate the use of a barrier:

- a) Under wire, unless it is of the flame-retardant type, such as neoprene- or thermoplastic-insulated wire; and
- b) Under a fuse, unless a complete, unventilated enclosure is provided for each fuse.

Exception: A barrier is not needed under:

- a) A supplementary fuse,*
- b) A fuse connected in a Class 2 circuit,*
- c) An individually enclosed fuse such as an extractor fuse, or*
- d) A fuse within a complete unventilated enclosure.*

Consideration will be given to a fuse enclosed within a transformer winding.

4.1.11 A compartment or part of an enclosure that contains field-wiring splices in other than a Class 2 circuit shall not be provided with ventilating openings.

4.1.12 Glass or thermoplastic covering an opening for user servicing, such as replacing a pilot lamp, and enclosing live parts that are guarded in accordance with 4.6.3, 4.6.4, or 7.1.4 shall be securely retained in place, and shall comply with:

- a) The Impact Test, Section 37,
- b) Abnormal Tests, Section 44, and
- c) Flammability tests for thermoplastic enclosures as specified in 4.1.5.

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

4.2 Mounting means

4.2.1 A power unit intended to be fastened in place shall have a means for securely mounting it in position. Bolts, screws, and other parts used for mounting the power unit shall be independent of those used for securing components.

4.2.2 A portable power unit intended for wall mounting shall employ a keyhole slot or the equivalent as a mounting means.

4.2.3 A barrier or the equivalent may be used to prevent wall-mounting screws from projecting into a compartment containing electrical parts and reducing spacings to less than that specified in Spacings, Section 28.

4.2.4 Mounting instructions shall be furnished with each power unit designed for permanent mounting. If special hardware is required, it shall be provided by the manufacturer.

4.3 Integral meters

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

Exception No. 1: An electrical instrument connected in a secondary circuit need not comply with the requirements for an enclosure if damage or deterioration of the materials comprising the housing will not result in a risk of fire or electric shock.

Exception No. 2: A meter as described in 4.3.2 need not comply with the requirements for an enclosure.

4.3.2 A panel mounted analog meter shall comply with the Standard for Electrical Analog Instruments – Panelboard Types, UL 1437.

Exception: An analog meter connected to an isolated circuit of not more than 42.4 V peak or 60 V dc need not comply if the meter housing does not constitute part of the power unit enclosure.

4.4 Supporting material

4.4.1 Material supporting terminals or used as internal electrical insulation of an electrical instrument shall comply with Insulating Materials, Section 17.

Exception: An electrical instrument connected in a secondary circuit need not comply with Section 17 if damage to or deterioration of the materials will not result in a risk of fire or electric shock.

4.4.2 Supporting feet of a power unit that form part of the enclosure or that are needed for ventilation shall be reliably secured in place and the aging, physical, and flammability properties of the material shall be investigated. A rubber or neoprene material shall comply with the physical properties test requirements in 57.2.1.

Exception: A power unit subjected to the Temperature Test, Section 34, with the supporting means removed need not comply with this requirement. See 34.9.

4.4.3 An adhesive used to attach a cover to a power unit shall be investigated with respect to exposure to environmental conditions, such as high and low temperatures, high and low humidity, and the like, to determine its ability to retain the cover in position.

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

4.5 Doors and covers

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

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

4.5.2 A door or cover of an enclosure shall be hinged or attached in an equivalent manner if:

- a) It provides access to an overload-protective device the intended functioning of which requires renewal; or
- b) It is necessary to open the cover in connection with intended operation of the protective device.

A door or cover providing access to a fuseholder shall be tight-fitting and shall be positively held closed. See 22.1.

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

- a) Connected in control circuits, provided the protective devices and the circuit loads are within the same enclosure,*
- b) Rated 2 amperes or less for loads not exceeding 100 volt-amperes,*
- c) Extractor fuses having an integral enclosure,*
- d) Fuses connected in a low-voltage limited energy circuit, or*
- e) In accordance with the Exception to 22.1.*

4.6 Protection against injury to persons

4.6.1 If operation, maintenance, or reasonably foreseeable misuse of a power unit by the user involves a risk of injury to persons, protection shall be provided to reduce such risk to an acceptable degree.

4.6.2 Specific service functions of a power unit that are not intended to be performed will be given appropriate consideration.

4.6.3 A part capable of causing injury to persons shall be enclosed or guarded.

4.6.4 A rotating member, such as a fan blade, the breakdown of which could result in a risk of injury to persons, shall be enclosed or guarded to reduce the likelihood of injury.

4.6.5 With reference to 4.6.3, a part that is within the enclosure or casing of the power unit and that cannot be contacted by the probe illustrated in Figure 6.1 is considered to be acceptably guarded. An opening in a guard shall not exceed 1 inch (25.4 mm) in diameter.

4.6.6 A cover or guard for a moving part that involves a risk of injury to persons – such as a fan blade – is to be arranged so that if it is removed, it must be replaced before intended operation of the power unit. Other features of a cover or guard to be considered include:

- a) Removability without the use of a tool;
- b) Removability for servicing;
- c) Strength and rigidity;

- d) Completeness; and
- e) Creation of additional risks of injury such as pinch points during servicing, replacement of fuses, and maintenance.

Exception: A commercial or power unit may be provided with a marking – in lieu of other means – located adjacent to the part being guarded, to instruct the user that the cover or guard should be replaced before intended operation of the power unit. See 49.1.13.

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

4.6.8 An enclosure, a frame, a guard, a handle, or the like shall not be sharp enough to cause a risk of injury to persons in normal maintenance or use.

Exception: A sharp edge that might be exposed to enable the power unit to perform its intended function need not comply with this requirement.

5 Components

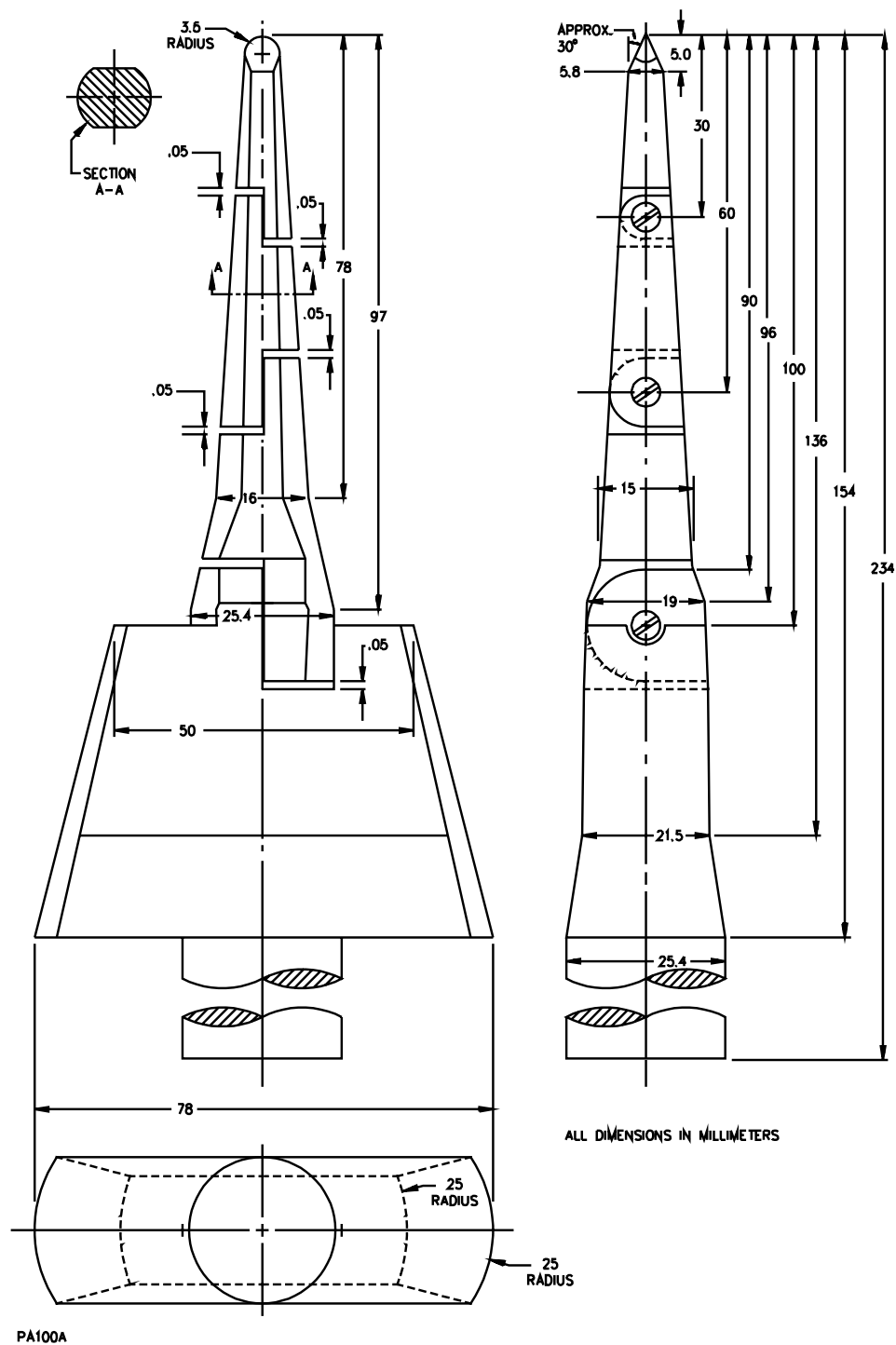
5.1 Deleted September 6, 1996

6 Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts

6.1 An opening in the enclosure of a power unit shall not permit entrance of a 1-inch (25.4-mm) diameter rod. A smaller opening is acceptable if a probe as illustrated in Figure 6.1, when inserted through the opening, cannot be made to touch any uninsulated live part that may involve a risk of electric shock, film-coated wire that may involve a risk of electric shock, or moving part that may involve a risk of injury to persons.

6.2 The probe illustrated in Figure 6.1 is to be applied to any depth that the opening will permit and with a force not greater than 1 pound (4.4 N), and is to be rotated or angled before, during, and after insertion through the opening to any position that is necessary to examine the power supply. The probe is to be applied in any possible configuration, and, if necessary, the configuration is to be changed after insertion through the opening.

Figure 6.1
Articulate probe with web stop



6.3 A guard, baffle, or cover that can be removed without using a tool is to be removed when determining if a part is accessible to the user. A part that can be contacted by the probe illustrated in Figure 6.1 when inserted through an opening in a permanently-attached guard or baffle is considered to be accessible.

6.4 A part on the back of a component mounting panel and a part located so as to require major disassembly by using a tool are not considered to be accessible to the user; such parts are not considered accessible to the serviceman unless it is likely that servicing will be done while the parts are energized after disassembly.

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

7 Protection of Service Personnel

7.1 General

7.1.1 These requirements apply to live parts used in circuits involving a risk of electric shock.

7.1.2 Live parts shall be so arranged and covers so located as to reduce the risk of electric shock while covers are being removed and replaced.

7.1.3 Consideration shall be given to a construction in which live parts are recessed at least 1/8 inch (3.2 mm) from the plane of the front of the fixed portion of the enclosure, and to an equivalent construction incorporating projections or guards.

7.1.4 An uninsulated live part involving a risk of electric shock and a moving part that involves a risk of injury to persons shall be located, guarded, or enclosed so as to reduce the likelihood of unintentional contact with such part by persons while changing a lamp or fuse, lubricating a motor, adjusting a control, or performing other like operations, including those performed only at the time of installation or during servicing procedures.

7.1.5 A live heat sink for a solid-state component, a live relay frame, and the like shall comply with the requirements in 7.2.2 and 7.3.1. Such a part shall also either be guarded to prevent contact by persons or be marked in accordance with 49.1.2.

Exception: A heat sink mounted on a printed wiring board need not comply with this requirement.

7.1.6 With reference to the requirement in 7.1.5, the size, shape, material, and color give a heat sink or relay-frame the appearance of a dead metal part. Other live parts that can be mistaken for dead metal are to be similarly judged.

7.1.7 A means such as a bleeder resistor shall be provided to drain the charge stored in a capacitor to the extent that the potential, V, measured between the terminals of the capacitor 1 minute after the capacitor has been disconnected from its source of energy is less than 50 volts, and the energy stored, J, is less than 20 joules as determined by the following relation, in which C is in microfarads:

$$J = 5 \times 10^{-7} CV^2$$

Exception: The requirement does not apply if a tool is necessary to remove a panel to reach the capacitor and the power unit is marked to warn service personnel as specified in 49.1.14.

7.2 Mechanical servicing

7.2.1 The requirements in 7.2.2 are intended to provide a reasonable degree of protection to the service personnel performing mechanical functions on energized equipment. Such functions do not in themselves require exposure to live parts involving a risk of electric shock or to moving parts that involve a risk of injury to persons, but it is usually necessary to perform them with the equipment energized.

7.2.2 An uninsulated live part involving a risk of electric shock and a moving part that involves a risk of injury to persons shall be located, guarded, or enclosed so as to prevent unintentional contact by service personnel adjusting or resetting controls, and the like, or performing mechanical service functions that may be performed with the equipment energized, such as lubricating a motor, adjusting the setting of a control with or without marked dial settings, resetting a trip mechanism, or operating a manual switch.

7.2.3 An adjustable or resettable electrical control or manual switching device may be located or oriented with respect to uninsulated live parts so that manipulation of the mechanism for adjustment, resetting, or operation can be accomplished in the normal direction of access if uninsulated live parts:

- a) Are not located in front – in the direction of access – of the mechanism, and
- b) Are not located near any side or behind the mechanism, unless guarded.

Exception: An uninsulated live part not involving a risk of electric shock need not comply with this requirement.

7.3 Electrical servicing

7.3.1 An electrical component that may require examination, adjustment, servicing, or maintenance while energized shall be so located and mounted with respect to other components and with respect to grounded metal parts that it is accessible for electrical service functions without subjecting service personnel to the likelihood of electric shock or risk of injury to persons. Access to components in a power unit is not to be impeded by other components or by wiring in the direction of access.

7.3.2 Protection against the risk of electric shock and injury to persons may be obtained by mounting control components so that unimpeded access to each component is provided by an access cover or panel in the outer cabinet.

7.3.3 The electrical components referred to in 7.3.1 and 7.3.2 include the following: fuses, adjustable or resettable overload relays, magnetically operated relays, manual-switching devices, clock timers, and incremental voltage taps. Such components in a limited-energy circuit of 30 volts rms or less as defined in 3.9 and 3.11 shall comply with the requirements in 7.3.1 with respect to uninsulated live parts in a circuit of greater energy level and to moving parts involving a risk of injury to persons.

7.3.4 The following are not considered to be uninsulated live parts: coils and windings of relays, solenoids, and transformers that are provided with acceptable insulating overwraps at least 1/32 inch (0.8 mm) thick, or the equivalent; enclosed motor windings; terminals and splices with acceptable insulation; and insulated wire.

8 Assembly

8.1 An uninsulated live part shall be secured to the base or surface so that it will be prevented from rotating or shifting in position as the result of stresses if such movement might result in a reduction of spacings below the minimum acceptable values.

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

Exception No. 1: A switch need not comply with this requirement if all of the following conditions are met:

- a) The switch is a plunger or other type that does not tend to rotate when operated – a toggle switch is considered to be subject to forces that tend to turn the switch;*
- b) The means for mounting the switch makes it unlikely that operation of the switch will loosen it;*
- c) Spacings are not reduced below the minimum acceptable values if the switch rotates; and*
- d) Intended operation of the switch is by mechanical means rather than by direct contact by persons.*

Exception No. 2: A lampholder of the type in which the lamp cannot be replaced, such as a sealed neon pilot or indicator light, need not comply with this requirement if rotation cannot reduce spacings below the minimum acceptable value.

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

9 Protection Against Corrosion

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

Exception No. 1: Bearings, laminations, and other parts of iron or steel such as washers and screws need not comply with this requirement.

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

10 Supply Connections

10.1 Permanently-connected power units

10.1.1 A fixed power unit shall have provision for the connection of a wiring system.

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

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

10.1.4 If threads for the connection of conduit are tapped all the way through a hole in an enclosure wall, or if an equivalent construction is employed, there shall not be less than three nor more than five full threads in the metal, and the construction of the device shall be such that a conduit bushing can be properly attached.

10.1.5 If threads for the connection of conduit are not tapped all the way through a hole in an enclosure wall, conduit hub, or the like, there shall not be less than 3-1/2 threads in the metal and there shall be a smooth, rounded inlet hole for the conductors that shall afford protection to the conductors equivalent to that provided by a standard conduit bushing and that shall have an internal diameter approximately the same as that of the corresponding trade size of rigid conduit.

10.1.6 For an enclosure not provided with conduit openings or knockouts, spacings not less than the minimum required in this standard shall be provided between uninsulated live parts and a conduit bushing installed at any location likely to be used during installation. Permanent marking on the enclosure, a template, or a full-scale drawing furnished with the power unit may be used to limit such a location.

10.1.7 A field-wiring compartment in which power unit connections are to be made shall be located so that the connections may be readily inspected after the power unit is installed as intended.

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

10.1.9 An outlet box, terminal box, wiring compartment, or the like in which connections to the power unit circuit will be made in the field shall be free from any sharp edge, including screw threads, a burr, a fin, a moving part, or the like, that may abrade the insulation on conductors or otherwise damage the wiring.

10.2 Wiring terminals and leads

10.2.1 The field-wiring terminals mentioned in 10.2.2 – 10.2.12 are terminals to which supply, control, output, or other permanent connections will be made in the field when the power unit is installed.

10.2.2 Field-wiring terminals or leads shall be sized for the connection of conductors having an ampacity appropriate for the rating of the power unit.

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

Exception No. 1: A wire-binding screw may be employed at a wiring terminal intended for connection of a No. 10 AWG (5.3 mm²) or smaller conductor if upturned lugs or the equivalent are provided to hold the wire in position.

Exception No. 2: A wiring terminal need not be provided with a pressure terminal connector if the terminal is intended for connection of a No. 8 AWG (8.4 mm²) or larger conductor, and the power unit complies with the requirements in 10.2.11.

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

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

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

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

10.2.6 A wire-binding screw shall thread into metal.

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

Exception No. 1: A plate not less than 0.030 inch (0.76 mm) may be used if the tapped threads will not strip when subjected to the tightening torque specified in Table 10.1.

Exception No. 2: A plate less than 0.030 inch (0.76 mm) thick may be used in a Class 2 circuit, Class 3 circuit, or an isolated-limited-energy circuit if the tapped threads will not strip when subjected to the tightening torque specified in Table 10.1.

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

Exception: Two full threads are not required for a terminal in a Class 2 circuit, Class 3 circuit, or an isolated limited-energy circuit if a lesser number of threads results in a secure connection in which the threads will not strip when subjected to the tightening torque specified in Table 10.1.

Table 10.1
Tightening torque for wire-binding screws

Size of terminal screw, number	Wire sizes to be tested, AWG	Tightening torque	
		Pound-inches	Newton-meters (N·m) or kilogram-meters (kg·m)
6	16 – 22 ^a	12	1.4 or 0.14
8	14 ^b and 16 – 22 ^a	16	1.8 or 0.18
10	10 – 14 ^b and 16 – 22 ^a	20	2.3 or 0.23
^a Stranded wire. ^b Solid wire.			

10.2.9 Upturned lugs, a cupped washer, or the equivalent shall be capable of retaining a conductor of the size specified in 10.2.5 under the head of the screw or washer.

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

10.2.11 With reference to Exception No. 2 to 10.2.3, a pressure terminal connector is not required to be provided with a wiring terminal when the following conditions are met:

- a) A terminal assembly shall be either:
 - 1) Supplied by the manufacturer – installed or shipped separately, or
 - 2) Specified in a marking on the power unit in accordance with 49.2.12 and 49.2.13.
- b) A fastening device, such as a stud, nut, bolt, spring or flat washer, or similar device, as required for an effective installation, shall either be provided as part of the terminal assembly or be mounted on or separately packaged with the power unit.

c) The installation of the terminal assembly shall not involve the loosening or disassembly of parts other than the cover or other part giving access to the terminal location. The means for securing the terminal connectors shall be readily accessible for tightening before and after installation of conductors.

d) When the pressure terminal connector provided in a terminal assembly requires the use of a special tool for securing the conductor, any required instructions shall be included in the assembly package or with the power unit. See 49.2.14.

e) After installation of the pressure terminal connector in the intended manner, the power unit shall comply with the requirements in this standard.

10.2.11 revised September 6, 1996

10.2.12 Revised and relocated as 13A.1 September 6, 1996

10.2.13 A terminal intended for connection of a grounded power supply conductor shall be made of or plated with metal substantially white in color and shall be readily distinguishable from other terminals.

Exception: This requirement does not apply if proper identification of that terminal is clearly shown in some other manner, such as on an attached wiring diagram.

10.2.14 The surface of a lead for the connection of a grounded power unit conductor shall be white or natural grey and shall be readily distinguishable from the other leads.

10.3 Cord-connected power units

10.3.1 A portable or stationary power unit shall be provided with a flexible cord in accordance with Table 10.2 and an attachment plug for connection to the power supply circuit. The supply cord shall be attached permanently to the unit or shall be in the form of a detachable power supply cord with a means for connection to male contacts affixed to the unit. The length of cord external to the power unit and including the attachment plug shall not be less than 6 feet (1.8 m) as measured from the face of the attachment plug to the point of attachment or entry.

Exception No. 1: A power unit weighing 1 pound (454 g) or less need not comply with the cord length requirements if the total length of the input and output cords is 6 feet (1.8 m) or more and the length of the input cord is at least 3 feet (0.91 m).

Exception No. 2: This requirement does not apply to rack mounted power units. See 10.3.2.

Exception No. 3: A power unit marked in accordance with 49.2.17 and provided with instructions in accordance with 50.1.8 need not be provided with the detachable power supply cord.

Exception No. 4: If a power unit is intended for use in a country other than the U.S.A., the detachable power supply cord shall comply with the requirements of the country of destination.

10.3.1 revised May 24, 1995

10.3.2 A rack mounted power unit shall be provided with the shortest length of flexible cord for the purpose.

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Table 10.2
Acceptable flexible cords for power units^{a,b}

Intended use of power unit	Flexible cord type	Maximum length, feet (m)
A. Desk, countertop, rack mounted, or the like	SP-2, SPE-2, SPT-2, SV, SVE, SVT	10 (3)
B. Floor mounted, stationary, or the like	S, SE, SO, SP-3, SPT-3, ST, STO, SJ, SJE, SJO, SJT, SJTO	Not specified
^a Refer to 10.3.1 and to sections pertaining to specific types of power units.		
^b See 10.3.3.		

10.3.3 A stationary power unit intended to be fastened in place may require a form of supply connection that will facilitate the interchange of equipment to maintain continuous service or otherwise meet special conditions of use. For such service, a Type S, SE, or equivalent flexible cord may be employed and may be of a length appropriate for the purpose, but no longer than 10 feet (3 m). Normally, a 24 inch (610 mm) length of cord will be sufficient for the plug and receptacle connection.

10.3.4 A supply cord shall be:

- a) Of a type that is acceptable for the usage, and
- b) Acceptable for use at a voltage and ampacity no less than the rated voltage and ampacity of the power unit.

10.3.5 The ampacity of the attachment plug for a power unit intended to be continuously loaded for 3 hours or more shall not be less than 125 percent of the input rating.

10.3.6 If a unit with a permanently attached power supply cord can be adapted for use on two or more different voltages by field alteration of internal connections, the attachment plug provided with the unit shall be of a type required for the voltage and current for which the unit is shipped from the factory. The power unit shall be provided with instructions as described in 50.1.4.

10.3.6 revised May 24, 1995

10.3.6.1 If a multiple voltage rated power unit is intended for use with a detachable power supply cord, the cord shall be provided with the unit if either of the following apply:

- a) The power unit is provided with an operator adjustable voltage selector and complies with 44.5.1; or
- b) The power unit is capable of operating at different voltages without user adjustment.

Instructions shall be provided as described in 50.1.4.1. The power unit shall also be marked in accordance with 50.1.5.

Exception: A power unit marked in accordance with 49.2.17 and provided with instructions in accordance with 50.1.8 need not be provided with the detachable power supply cord.

10.3.6.1 added May 24, 1995

10.3.6.2 If a multiple voltage rated power unit is provided with a permanently attached power supply cord, and it is intended for use by travelers, the power unit shall comply with (a) – (e):

- a) The power supply cord shall terminate in a 125 volt, 15 amp plug configuration;
- b) The power unit shall employ a user adjustable voltage selector and comply with 44.5.1, or be capable of operating at different voltages without user adjustment;
- c) The input voltage rating shall include nominal 120 volt;
- d) The power unit shall be marked as indicated in 49.2.18; and
- e) The power unit shall be provided with instructions per 50.1.5.1.

10.3.6.2 added May 24, 1995

10.3.7 In a power unit rated 125 volts or less, 125/250 volts (three-wire) or less, or 277 volts, the screw shell of an Edison-screw-shell lampholder shall be electrically connected to the cord conductor intended to be grounded. A switch or overcurrent-protective device of the single-pole type, other than an automatic control without a marked off position, shall be connected in a circuit to the cord conductor not intended to be grounded.

10.3.8 A power unit shall employ a polarized or grounding-type attachment plug.

10.3.8 effective September 1, 1997

10.4 Strain relief

10.4.1 Strain relief shall be provided to prevent mechanical twisting or stress on the supply cord or output cord from being transmitted to terminals, splices, or interior wiring. The means for preventing twisting is to be evaluated by inspection. The suitability of the strain relief is to be evaluated in accordance with 38.1.

10.4.2 A metal strain-relief clamp or band is acceptable without supplementary protection on a Type SV, SVO, SJ, SJE, SJO, S, SO, SJT, SJTO, ST, or STO cord. A metal strain-relief clamp or band is acceptable on a Type SP-2, SPE-2, SPT-2, SVE, SVT, or SVTO cord only if supplementary nonconductive, mechanical protection is provided over the cord.

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

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

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

d) Damaging internal connections or components.

To determine compliance, the supply cord or lead shall be tested in accordance with Section 38A, Push-Back Relief Test.

10.4.4 revised July 7, 1999

10.5 Bushings

10.5.1 A bushing or the equivalent shall be provided at a point where a flexible cord passes through an opening in a wall, barrier, or enclosing case. The bushing shall be substantial, mechanically secured in place, and shall have a smooth, rounded surface against which the cord may bear. If a Type SP-2, SPE-2, or SPT-2 cord is employed, the wall or barrier is of metal, and the construction is such that the cord may be subjected to stress or motion, the bushing shall be an insulating bushing.

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

10.5.2 Ceramic materials and some molded compositions are acceptable for insulating bushings.

10.5.3 A bushing molded integrally with the supply cord is acceptable on Type SP-2, SPE-2, or heavier cord provided it is not less than 1/16 inch (1.6 mm) thick in the area where the cord passes through the enclosure.

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

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11 Output Connections

11.1 Output terminals shall not be exposed unless they are used for Class 2 output circuits.

Exception No. 1: A power unit may employ exposed terminals if the terminals are located in an isolated secondary circuit and all of the following conditions are met:

- a) The maximum output voltage (V_{max}) does not exceed 42.4 volts peak ac or 60 volts dc.*
- b) The output current rating does not exceed 8 amperes for ac or dc voltages up to 30 V rms, or $150/V_{max}$ amperes for dc voltages between 30 V and 60 V.*
- c) The exposed terminals comply with the requirements in 10.2.1 – 10.2.9.*
- d) A nonmetallic terminal cover is employed to reduce the likelihood of bridging between terminals. The cover shall be close-fitting over the top and all sides of the terminal block, with no opening other than those necessary for entry of conductors. The cover shall be attached so that it cannot be discarded. The nonmetallic material shall comply with the requirements in 4.1.5, and shall also comply with the requirements for resistance to hot-wire ignition in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.*
- e) The power unit is marked as required by 49.1.5.*

Exception No. 2: A battery charger may employ exposed terminals if an interlock switch is provided within the charger enclosure to de-energize accessible live parts.

Exception No. 3: A battery charger may employ exposed terminals if it is provided with output contacts located in a recessed compartment to accommodate a battery or battery pack and the output is supplied by a Low Voltage Limited Energy (LVLE) circuit. See 3.11.

11.2 A metal enclosure of a power unit shall not be used as an output-circuit current-carrying part.

11.3 A power unit having a flexible power supply cord shall be provided with an integral output cord terminating in a connector, or with a connector directly attached to the enclosure.

Exception No. 1: A stationary power unit intended to be fastened in place may be provided with terminals for the output connections if the terminals are enclosed but readily accessible by means of a hinged cover, access opening, or the equivalent. A standard trade size conduit knockout shall be provided for connection of the output conduit system. See 10.3.3.

Exception No. 2: A power unit output circuit complying with Exception No. 1 to 11.1 need not comply with this requirement.

11.4 The output flexible cord required by 11.3, whether permanently attached to the power unit or provided in the form of a separate cord set, is to be equivalent to the power supply cord specified in Table 10.2.

Exception: Output wiring for Class 2 circuits may be parallel cord insulated with rubber, neoprene, or thermoplastic having a wall thickness not less than 0.013 inch (0.33 mm).

11.5 A special application battery charger shall be provided with a special use polarized connector complying with the requirements in the Standard For Attachment Plugs and Receptacles, UL 498.

11.6 A connector for an output circuit, other than one intended for use with a Class 2 circuit, shall comply with the requirements in the Standard for Attachment Plugs and Receptacles, UL 498.

11.7 A connector intended for use with other than line voltage shall have a nonstandard pin configuration.

11.8 A strain-relief means and a bushing for the output cord shall comply with the requirements in 10.4 and 10.5.

11.9 A rubber or neoprene bushing intended for use with Class 2 or Class 3 field-installed output wiring shall not be less than:

- a) 1/8 inch (3.2 mm) thick with the opening in which the bushing is mounted free from rough or sharp edges that may damage the bushing, or
- b) 3/64 inch (1.2 mm) thick with an opening that is eyeletted or otherwise provided with smooth edges.

12 Grounding Connections

12.1 Power units required to comply with applicable grounding requirements are:

- a) A fixed or stationary power unit.
- b) A portable outdoor or commercial power unit.
- c) A portable power unit for use in a circuit involving a potential of more than 150 volts to ground.
- d) A power unit provided with a grounding means, whether required or not.

12.2 A fixed power unit shall be provided with a terminal or lead for grounding all dead metal parts that are exposed or are likely:

- a) To be touched by a person during operation or adjustment of the power unit, and
- b) To become energized through an electrical fault.

12.3 To determine if a part is likely to become energized, the following factors are to be evaluated:

- a) The proximity of wiring,
- b) The results of a dielectric voltage-withstand test after a test such as the overload or the endurance test, and
- c) The results of appropriate burnout tests.

12.4 The grounding connection shall be located so that it is unlikely to be removed during normal servicing. The grounding connection shall penetrate any nonconductive coating, such as paint or vitreous enamel, over the part to be grounded.

12.5 A wire-binding screw for the connection of a field-installed equipment grounding conductor shall have a green colored head that is either hexagonal, slotted, or both. A pressure wire connector intended for connection of such a conductor shall be plainly identified such as by being marked "G," "GR," "GND," "Ground," "Grounding," or the like; or by a marking on a wiring diagram attached to the power unit. The wire-binding screw or pressure wire connector shall be so located that it is unlikely to be removed during intended servicing. The symbol illustrated in Figure 12.1 may be used to identify the grounding connector.

12.6 The grounding terminal shall be capable of securing a conductor of a size required for the application in accordance with Column 2 of Table 13.2.

Exception: A grounding terminal capable of securing a conductor of a size specified in 49.2.10 is able to be used.

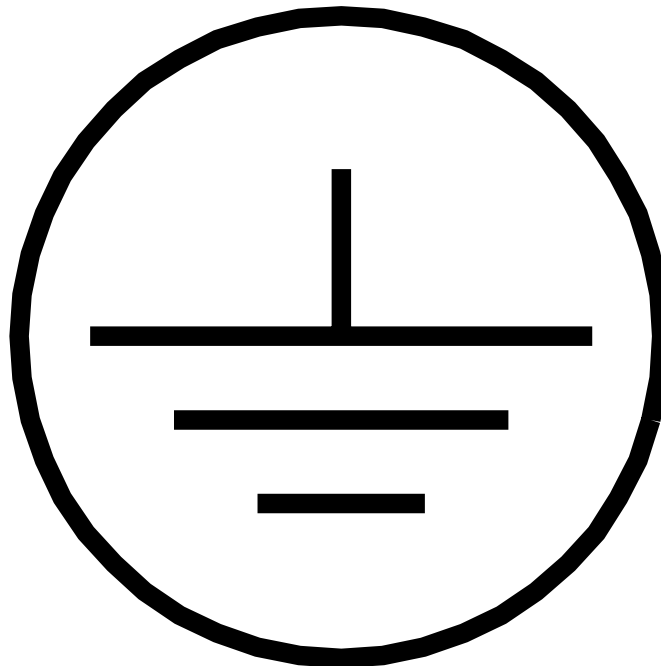
12.6 revised September 6, 1996

12.7 A soldering lug, a screwless (push-in) connector, a quick-connect, or other friction-fit connector shall not be used.

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

Figure 12.1
Grounding symbol

Figure 12.1 revised October 9, 1997



12.8 A grounding conductor shall be a size specified in Column 2 of Table 13.2 or larger. A grounding lead shall have a free length of at least 6 inches (152 mm), and the surface of the insulation shall be green with or without one or more yellow stripes. No other lead in a field-wiring compartment or visible to the installer shall be so identified.

Exception: The color coding requirement does not apply to a Class 2 circuit when the low voltage leads or terminals are either:

- a) Located remote from the line-voltage connections and the segregation complies with the requirements in 16A.1 – 16A.3; or*
- b) Specifically marked so that reference to a wiring diagram is not required.*

12.8 revised September 6, 1996

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

12.10 The grounding conductor shall be connected to the grounding blade of a grounding attachment-plug and shall be connected to dead metal parts within the frame or enclosure by means such as a screw or stud, nut, and lockwasher. An external force applied to the power supply cord shall not transmit stress to the grounding connection on the frame or enclosure before the line-voltage connections are broken.

12.11 A grounding connection, grounding conductor, enclosure, frame, component mounting panel, or any other part connected to earth ground shall not carry current except during an electrical fault.

Exception No. 1: A Class 2 or an isolated limited-energy circuit may be connected to a single-point reference ground. Current is not to be carried through the field-equipment-grounding connection, metallic raceway, or other grounding means.

Exception No. 2: A line by-pass capacitive impedance circuit for a radio frequency signal circuit need not comply with this requirement.

12.12 A grounded circuit conductor shall not be connected to any grounding or bonding circuit or device in a power unit.

13 Bonding of Internal Parts

13.1 General

13.1.1 If grounding is required – see 12.1 – an exposed dead metal part that is likely to become energized by an electrical fault shall be bonded to the point of connection of the field-equipment-grounding means. See 12.2 and 12.3. See also Bonding Conductor Test, Section 46.