



UL 1012

STANDARD FOR SAFETY

Power Units Other Than Class 2

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

Eighth Edition, Dated November 9, 2010

Summary of Topics

This revision of ANSI/UL 1012 dated March 30, 2021 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made.

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

The requirements are substantially in accordance with Proposal(s) on this subject dated January 22, 2021.

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Standard for Power Units Other Than Class 2

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The most recent designation of ANSI/UL 1012 as a Reaffirmed American National Standard (ANS) occurred on March 30, 2021. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

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INTRODUCTION

1 Scope

1.1 These requirements cover 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, ANSI/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 do not cover the following types of battery chargers:

- a) Battery chargers intended to charge motor-starting batteries as covered by Standard for Battery Chargers for Charging Engine-Starter Batteries, UL 1236;
- b) Battery chargers for charging industrial batteries which power material handling trucks, tractors, personnel carriers, and similar motive equipment, as covered by the Standard for Industrial Battery Chargers, UL 1564;
- c) Chargers or charging functions incorporated into converter or inverters for use in recreational vehicles and boats, as covered by the Standard for Power Converters/Inverters and Power Converter/Inverter Systems for Land Vehicles and Marine Crafts, UL 458; and
- d) Charge controllers or charging functions incorporated into equipment for use in independent power systems, as covered by the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741.

1.5 A battery charger not wholly within the scope of one of the standards specified in [1.4](#) shall be investigated to the requirements of this Standard supplemented by the applicable requirements of whichever of the standards in [1.4](#) is most applicable.

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.

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 power system, the primary function of which is maintaining continuity of an alternating power source in case of input power failure, is covered under the Standard for Uninterruptible Power Systems, UL 1778.

2 Components

2.1 Except as indicated in 2.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of Standards covering components used in the products covered by this Standard.

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

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

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

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

3 Units of Measurement

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

4 Terminology

4.1 Unless otherwise stated, values of current and voltage are root-mean-square (rms).

4.2 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.

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

5 Undated References

5.1 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.

6 Glossary

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

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

6.3 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."

6.4 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."

6.5 CLASS 2 OUTPUT – An output complying with the requirements for Class 2 Output Circuits. See [38.1](#).

6.6 CLASS 3 OUTPUT – An output having limited voltage and energy capacity and complying with the requirements for Class 3 Output Circuits. See [38.2](#). See also the Maximum Output Voltage Test, Section [83](#), and the Output Current and Power Test, Section [84](#).

6.7 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.

6.8 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).

6.9 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.

6.10 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.

6.11 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 [87.1](#).

6.12 INTENDED FOR USE BY TRAVELERS – A multiple voltage rated direct plug-in power unit with a 125 V 15 A (parallel) input blade configuration, or a multiple voltage rated cord-connected power unit with a non-detachable power supply cord terminating in a 125 V 15 A (parallel) blade plug.

6.13 ISOLATED LIMITED-ENERGY CIRCUIT – A circuit derived from an isolated secondary winding of a transformer having a maximum capacity in accordance with Section [51](#) 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.

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

6.15 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 [36.5](#) – [36.13](#).

6.16 MULTIPLE VOLTAGE RATED POWER UNIT – A power unit with a rated voltage range (such as 100 – 240 volts) or a power unit with more than one discrete voltage rating (such as 120/240 volts).

6.17 POWER UNIT, COMMERCIAL – A power unit other than the household type as defined in [6.18](#).

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

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

6.20 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.

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

6.22 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.

6.23 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 [50](#).
- 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.

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

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

ALL POWER UNITS

CONSTRUCTION

7 Frame and Enclosure

7.1 General

7.1.1 A power unit shall be formed and assembled so that it has the strength and rigidity necessary to resist the abuses to which it is 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.

7.1.2 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 present a risk of fire, electric shock, or injury to persons under any condition of use.

7.1.3 A cast- or sheet-metal section of the enclosure shall have a thickness not less than that specified in [Table 7.1](#).

Exception: A part of an enclosure that complies with the Mechanical Strength Tests for Metal Enclosures, Section [45](#), need not comply with the thickness specified in [Table 7.1](#).

Table 7.1
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	(mm)	Inches	(mm)	Inches	(mm)
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)

7.1.4 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.

7.1.5 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 [39.4](#).

7.1.6 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.

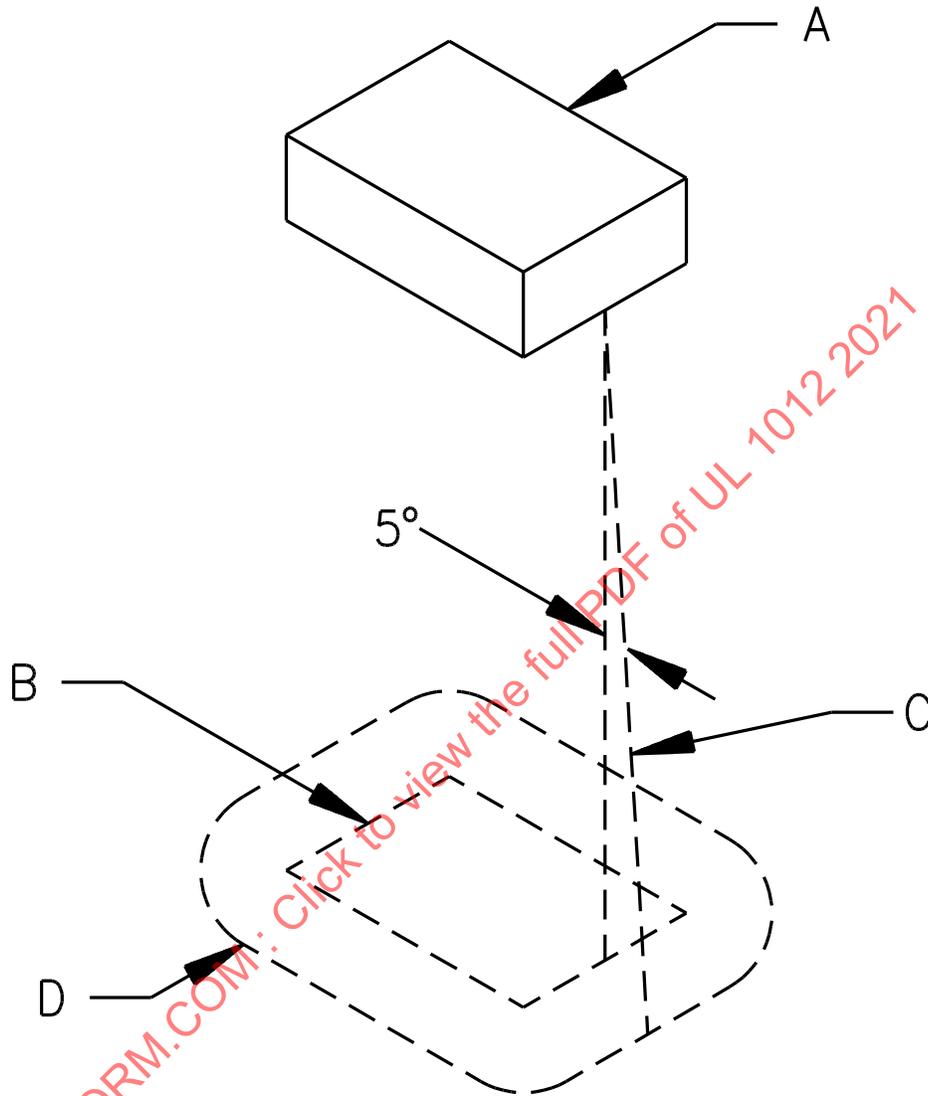
7.1.7 The enclosure of a power unit shall prevent molten metal, burning insulation, flaming particles, or the like from falling on combustible materials, including the surface upon which the power unit is supported. A barrier as mentioned in [7.1.10](#) shall:

- a) Be horizontal;
- b) Comply with [Figure 7.1](#); and
- c) Comply with [7.1.8](#) if it is made of a polymeric material.

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

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Figure 7.1
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.

7.1.8 With reference to [7.1.7](#), 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.

7.1.9 The requirement in [7.1.7](#) 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 does 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 7.2](#); 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 [57](#).

Table 7.2
Perforated metal plates for enclosure bottom

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

NOTE – In accordance with Exception No. 2 to [7.1.9](#).

7.1.10 With regard to [7.1.7](#), 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.

7.1.11 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.

7.1.12 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 [7.6.3](#), [7.6.4](#), or [9.1.4](#) shall be securely retained in place, and shall comply with:

- a) Mechanical Strength Tests for Metal Enclosures, Section [45](#);
- b) Abnormal Tests, Section [54](#); and
- c) Flammability tests for thermoplastic enclosures as specified in [7.1.5](#).

7.1.13 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.

7.2 Mounting means

7.2.1 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.

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

7.2.3 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 [35](#).

7.2.4 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.

7.3 Integral meters

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

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

Exception No. 2: This requirement does not apply to a meter as described in [7.3.2](#).

7.3.2 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.

7.4 Supporting material

7.4.1 Material supporting terminals or used as internal electrical insulation of an electrical instrument shall comply with Insulating Materials, Section [24](#).

Exception: This requirement does not apply to an electrical instrument connected in a secondary circuit if damage to or deterioration of the materials does not result in a risk of fire or electric shock.

7.4.2 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 [65.2.1](#).

Exception: This requirement does not apply to a power unit subjected to the Temperature Test, Section [42](#), with the supporting means removed. See [42.9](#).

7.4.3 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 are not required to be investigated.

7.5 Doors and covers

7.5.1 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.

7.5.2 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 [28.1](#).

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 [29.1](#).

7.6 Protection against injury to persons

7.6.1 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.

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

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

7.6.4 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.

7.6.5 With reference to [7.6.3](#), a part that is within the enclosure or casing of the power unit and that cannot be contacted by the probe illustrated in [Figure 8.1](#) is considered to be acceptably guarded. An opening in a guard shall not exceed 1 inch (25.4 mm) in diameter.

7.6.6 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 [61.1.14](#).

7.6.7 A rotating or moving part that creates 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.

7.6.8 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: This requirement does not apply to a sharp edge that might be exposed to enable the power unit to perform its intended function.

7.7 Modular units

7.7.1 Individual modules of a modular unit may be of the open construction – either no enclosure or a partial enclosure is supplied – provided that when the modules are assembled together in the field as intended, the unit complies with the requirements of this Standard. Identification of the modules and instructions for assembling shall be provided in accordance with [61.2.22](#) and [62.1.11](#). The provisions for electrical connection between modules shall comply with Section [14](#), Interconnections Between Sections.

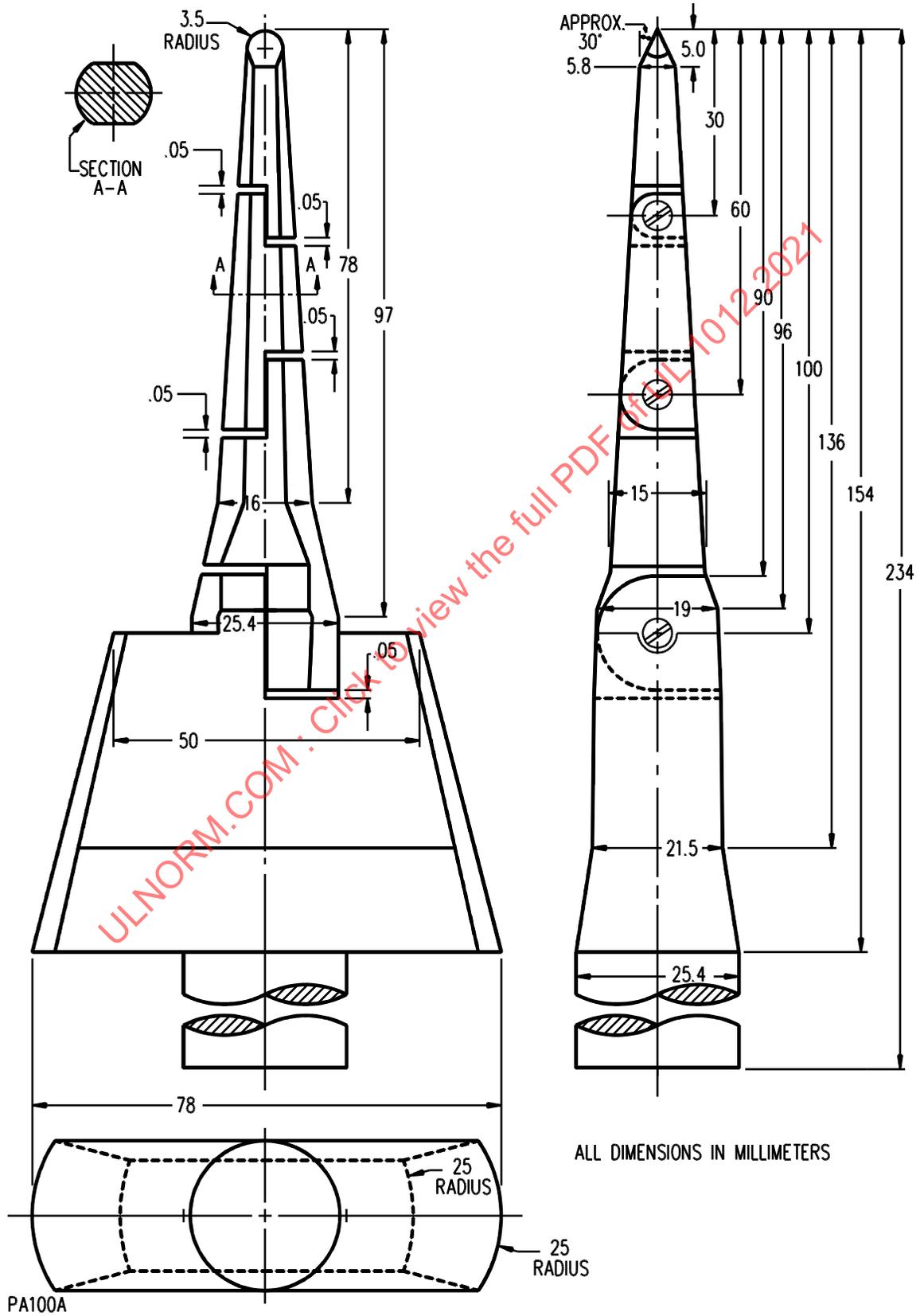
8 Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts

8.1 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 8.1](#), 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.

8.2 The probe illustrated in [Figure 8.1](#) is to be applied to any depth that the opening permits 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.

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Figure 8.1
Articulate probe with web stop



8.3 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 8.1](#) when inserted through an opening in a permanently-attached guard or baffle is considered to be accessible.

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

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

9 Protection of Service Personnel

9.1 General

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

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

9.1.3 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.

9.1.4 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 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.

9.1.5 A live heat sink for a solid-state component, a live relay frame, a live part that can be mistaken for dead metal, and the like shall comply with the requirements in [9.2.2](#) and [9.3.1](#). Such a part shall also either be guarded to prevent contact by persons or be marked in accordance with [61.1.2](#).

Exception: This requirement does not apply to a heat sink mounted on a printed wiring board.

9.1.6 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 [61.1.15](#).

9.2 Mechanical servicing

9.2.1 The requirements in [9.2.2](#) 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.