

46 1640

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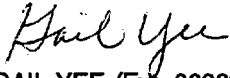
April 29, 1996

This bulletin should be kept with your copy of the standard.

Questions regarding interpretations of requirements should be directed to the responsible UL staff. Please see Appendix B of the bulletin regarding designated responsibility for the subject product categories.

UNDERWRITERS LABORATORIES INC.

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SR:GLD

1640 __.4TB

A P P E N D I X A**PORTABLE POWER DISTRIBUTION PANELS
[POWER DISTRIBUTION EQUIPMENT — PORTABLE]
(QPSM)**

This Listing covers portable power distribution panels built for specific applications.

These products are assemblies of Listed products, Recognized components, or both, contained in complete electrical enclosures. They may incorporate disconnecting means, overcurrent devices, receptacles for attachment plugs, stage and studio type inlets and connectors, and the like.

These panels are intended for use in applications specified for "portable power distribution units" in the National Electrical Code.

For additional information, see Power Distribution Equipment - Portable (QPRW) Guide.

LISTING MARK

The Listing Mark of Underwriters Laboratories Inc. on the product is the only method provided by UL to identify products manufactured under its Listing and Follow-Up Service. The Listing Mark for these products includes the name and symbol of Underwriters Laboratories Inc. (as illustrated in the Introduction of this Directory) together with the word "LISTED," a control number, and the following product name: "Portable Power Distribution Panel."

APPENDIX B

**DESIGNATED RESPONSIBILITY FOR UL
PRODUCT CATEGORY
QPSM, PORTABLE POWER DISTRIBUTION PANELS**

The individuals shown in the following table are involved with the investigation of products covered under the subject category. The Primary Designated Engineer (**shown in UPPERCASE letters**) coordinates the establishment and uniform interpretation of UL requirements applicable to the product categories. The Designated Engineers (**shown in lowercase letters**) work with the Primary Designated Engineer to interpret requirements and maintain standards.

Should you have questions regarding the interpretation of the requirements proposed in this bulletin or any adopted requirements that affect your product, you are encouraged to contact the individual at the office to which you normally submit your products.

The Industry Advisory Group (IAG) Chairman for the subject category is Joe Kubisz at UL's Santa Clara office. The IAG Chairman oversees the significant interpretations made by the Primary Designated Engineer and arbitrates any differences regarding interpretation of UL requirements.

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Standard for Safety

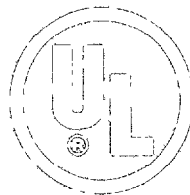
UL 1640

ISBN 1-55989-906-9

Portable Power Distribution Units



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October 30, 1995

Standard for

Portable Power Distribution Units

UL 1640, First Edition

Accompanying this transmittal notice is a copy of the first edition of UL 1640.

THIS EDITION OF THE STANDARD BECOMES EFFECTIVE JULY 1, 1997.

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

The requirements in this standard are substantially in accordance with UL's bulletin on this subject dated January 6, 1995. This bulletin is now obsolete and may be discarded.

Revised and/or additional pages may be issued from time to time.

OCTOBER 30, 1995

1

UL 1640

Standard for

Portable Power Distribution Units

First Edition

October 30, 1995

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

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 published set of revision pages.

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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 differing from those detailed in the requirements of this Standard may be examined and tested according to the intent of the requirements and, if found to be substantially equivalent, 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

Section 1 effective July 1, 1997

1.1 These requirements cover portable power distribution units intended to distribute power in accordance with the National Electrical Code, NFPA 70 (NEC).

1.2 These requirements cover portable power distribution equipment intended for use in the following locations:

- a) Carnivals, circuses, fairs, and similar locations in accordance with Article 525 of the NEC;
- b) Exhibition halls in accordance with Article 518 of the NEC;
- c) Motion picture, and television studios and similar locations in accordance with Article 530 of the NEC;
- d) Theaters, audience areas of motion picture, and television studios and similar locations in accordance with article 520 of the NEC; and
- e) Construction sites in accordance with Article 305 of the NEC.

1.3 These requirements do not cover portable power distribution equipment intended to be mounted above or adjacent to the lighting unit it supplies.

1.4 These requirements cover power distribution units rated 600 volts or less and 1200 amperes maximum. They may be intended for either single- or multi-phase supply.

1.5 A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involve a risk of fire, electric shock, or injury to persons shall be evaluated using the appropriate additional component and end-product requirements as determined necessary to maintain the acceptable 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 cannot be judged to comply with this standard. Where considered appropriate, revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

2 General

Section 2 effective July 1, 1997

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 generally used in the products covered by this standard.

2.1.2 A component need not comply with a specific requirement that:

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

- b) Is superseded by a requirement in this standard.

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

2.1.4 Specific components are recognized as being 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 for which they have been recognized.

2.2 Units of measurement

2.2.1 If a value for measurement is followed by a value in other units in parentheses, the second value may be only approximate. The first stated value is the requirement.

2.2.2 All applicable alternating-current electrical measurements are in root-mean-square (rms) units unless otherwise stated.

2.3 Undated references

2.3.1 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.

3 Glossary

Section 3 effective July 1, 1997

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

3.2 **BUS BAR CLAMP (SISTER LUG)** – A connector that terminates a single conductor cable and that is secured to a bus bar with an integral set screw. May secure the conductor by soldering, integral pressure wire connector, or by crimping of the clamp body.

3.3 **CABLE CONNECTOR** – A portable receptacle that is intended to provide power, with means for attachment of flexible cord or cable and not intended for permanent mounting.

3.4 **CABLE SPLICING BLOCK (SPIDER BOX)** – Power distribution units intended to provide a termination for cable assemblies. Not provided with overcurrent protection; only provide a means to extend runs of single or multi-conductor cable. Partially enclosed, plastic framed cable splicing blocks are sometimes referred to as "see-thru spiders."

3.5 **COVER** – An unhinged, removable covering member that is a required part of the enclosure.

3.6 **DAMP LOCATION** – Protected locations outdoors and interior locations subject to moderate degrees of moisture. This would also include areas near where artificial rain is being produced, or when effect machines that utilize water vapor to generate fog or mist effects are being used. Areas not subject to direct water spray or rain.

3.7 **DEAD-FRONT** – A panel that may or may not form a part of the enclosure and that may be used behind a door, which may have openings for the passage of cords, to cover wiring and uninsulated live parts.

- 3.8 **DOOR** – A hinged, sliding, or similarly attached covering member that is capable of being removed only by the use of a tool and that is a required part of the enclosure.
- 3.9 **ENCLOSURE** – That part of a power distribution unit that:
- a) Renders inaccessible all or any parts of the equipment that may otherwise present a risk of electric shock or
 - b) Retards propagation of flame initiated by an electrical fault occurring within the equipment.
- 3.10 **FORMED HINGE** – A strip of metal secured to or integral with the enclosure or trim and formed so that it will cooperate with a slot in a door to form a hinge.
- 3.11 **INLET ASSEMBLY, INTERLOCKED** – An assembly of locking type single pole pin and sleeve inlets. The assembly is interlocked as specified under 3.18.
- 3.12 **INLET ASSEMBLY, SEQUENTIALLY INTERLOCKED** – An assembly of locking type single pole pin and sleeve inlets. The assembly is sequentially interlocked as specified under 3.19.
- 3.13 **INTERLOCKED INLET** – An inlet having a device, either mechanical or electrical, that is intended to reduce the likelihood of energizing the contacts before complete engagement with a plug, and that either is intended to reduce risk of the plug being withdrawn while its contacts are energized or de-energizes the line contacts before separation.
- 3.14 **PIN AND SLEEVE DEVICE** – A plug or receptacle utilizing contacts which generally are cylindrical or circular in shape and telescoping and are shrouded by an extension of the enclosure of the mating devices.
- 3.15 **PLUG (ATTACHMENT PLUG)** – A device intended to receive power when inserted in a receptacle or cable connector, which establishes connection between conductors of the attached flexible cord or cable and the conductors connected to the receptacle or cable connector.
- 3.16 **POWER INLET (INLET)** – A permanently mounted plug intended to receive power from a cable connector.
- 3.17 **RECEPTACLE (OUTLET)** – A device that is intended to provide power to an inserted plug, and that is installed as a fixed outlet on equipment.
- 3.18 **RECEPTACLE ASSEMBLY, INTERLOCKED** – An assembly consisting of a number of locking type single pole pin and sleeve type receptacles. Supply receptacles are interlocked to the source so it is not possible to connect or disconnect the plugs when the source of supply is energized.
- 3.19 **RECEPTACLE ASSEMBLY, SEQUENTIALLY INTERLOCKED** – An assembly consisting of a number of locking type single pole receptacles that are electrically or mechanically interlocked in such a manner that plugs must be connected in the following sequence and disconnected in the reverse order:
- a) Equipment grounding conductor connection, if provided;
 - b) Grounded circuit conductor connection, if provided; and
 - c) Ungrounded conductor connection.

3.20 **SHIELDING** – A hinged or fixed member that is attached to the enclosure but is not a required part of the enclosure, such as a rain shield.

3.21 **TERMINAL, PRESSURE-WIRE** – A terminal in which the conductor is clamped under a pressure plate or saddle by one or more screws or nuts.

3.22 **TERMINAL, SET SCREW** – A terminal that provides clamping by the end of the screw bearing directly on the conductor.

3.23 **TERMINAL, WIRE-BINDING SCREW** – A terminal having the conductor bent around the screw and clamped directly under the head of the screw when it is tightened. The conductor is intended to encircle the terminal screw at least three-fourths the circumference without overlapping.

3.24 **UNIT** – The term "unit" is considered to refer to a portable power distribution unit.

PART I – ALL EQUIPMENT

CONSTRUCTION

4 General

Section 4 effective July 1, 1997

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

4.2 A unit shall be constructed so as to reduce the risk of intentional contact with enclosed electrical devices and to provide internal devices with protection from specified external conditions.

4.3 A unit shall be complete when it is shipped from the factory and shall not have provisions for the mounting of additional equipment. Internal wiring and connections between components shall be completed at the factory.

5 Current Carrying Parts

Section 5 effective July 1, 1997

5.1 General

5.1.1 Current carrying parts shall be of silver, copper, or alloys of these metals or others determined to be the equivalent.

5.1.2 Iron or steel shall not be used for a part that is depended upon to carry current.

5.2 Bus bars

5.2.1 General

5.2.1.1 The bending of a bus bar shall not result in visible cracks, but roughening or slight surface checking is not prohibited.

5.2.2 Ampacity

5.2.2.1 Other than as covered in 5.2.2.4 and 5.2.2.5, the ampacity or size of a bus bar is considered sufficient if the current density is not more than as specified in Table 5.1 or the size is not less than as specified in Table 5.2.

Exception: Bus bars operated at ampacities greater than as specified in Table 5.1 shall be tested in accordance with and comply with the Temperature Test, Section 17.

Table 5.1
Ampacity of single or multiple bus bars and clamped joints

Bus bar material ^a	Current, amperes	Current density in amperes per square inch (6.45 square cm)	
		Bus bar cross section ^b	Contact area at clamped joints
Copper	0 – 600	1000 ^d	200
Copper	601 – 1200	1000 ^d	200 ^c
Brass	0 – 600	500	200

^a Multiple bus bars in parallel shall be of the same material and cross section.

^b See 5.2.2.1 – 5.2.2.4 regarding the ampacity.

^c Joints bolted and plated with silver, tin, nickel, or cadmium.

^d See Table 5.2 for 800 ampere maximum single bus bars.

5.2.2.2 The material at any cross section along the length of a bus bar shall have at least 70 percent of the required ampacity and the remaining metal in any 6 inch (152 mm) length of the bus bar shall have at least 93 percent of the metal of a bus bar having the required ampacity in accordance with Table 5.1.

Exception: Bus bars with a larger amount of material removed shall be tested in accordance with and comply with the Temperature Test, Section 17.

5.2.2.3 In determining the area of contact surfaces of bolted or riveted connections, no additions or subtractions for the diameters and areas of screws, bolts, or rivets shall be made.

Table 5.2
Rating and sizes of single bus bars — 800 amperes maximum

Current rating, amperes	Copper bus			
	Bus size ^a ,		Cross section,	
	Inch	(mm)	inch ²	(mm ²)
225	0.125 by 0.875	3.2 by 22.2	0.109	70.3
400	0.250 by 1.500	4.8 by 38.1	0.375	242.0
600	0.250 by 2.000	4.8 by 50.8	0.500	322.6
800	0.250 by 3.000	4.8 by 76.2	0.750	483.9

NOTES

1 For multiple buses in parallel, refer to Table 5.1.

2 A bus connection to a fused power circuit device, to a transfer switch with Class L fuses, or to a molded case circuit breaker rated for continuous use at 100 percent of its rating shall be sized in accordance with Table 5.1 or shall be tested in accordance with the limitation on temperature rise specified in Table 17.1.

3 Joints bolted and plated with silver, tin, nickel, or cadmium.

A bus bar having other dimensions may also be used if it has not less than the cross-sectional area specified in the table and if it has been determined to have equivalent rigidity.

5.2.2.4 The contact area shall not be less than the minimum 1 square inch (6.5 cm²) per 200 amperes specified in Tables 5.1 and 5.2 unless the construction complies with one of the following:

- a) The contact area between a plated bus bar and circuit breaker or switch shall not be less than the area on the pressure wire connector that is supplied with a breaker or the full contact area on the circuit breaker, if no pressure wire connector is supplied.
- b) If the full available contact area between a bus bar and pressure terminal connector is not used, the contact area shall not be less than the area that results when two of the same type connectors are bolted together back-to-back with wires leaving in opposite directions or at right angles, whichever results in the smallest area.

5.2.2.5 The limitations on current density mentioned in Tables 5.1 and 5.2 do not apply to:

- a) A connecting strap, bus bar, or the like, comprising all integral part of a circuit breaker, switch, or fuseholder.
- b) A portion of a strap, bus bar, jumper, or the like, adjacent and connected to a terminal of a switch, circuit breaker or fuseholder [but not more than 1 inch (25.4 mm) from the terminal], when a reduced cross section in that portion is necessary because of the recessing of the terminal or because of barriers adjacent to it.

5.2.2.6 A wire or bus bar leading to a noninterchangeable trip circuit breaker shall have an ampacity not less than the current rating of the breaker.

5.2.2.7 A wire or bus bar leading to a circuit breaker frame constructed for use with interchangeable trip units shall have an ampacity not less than the maximum current rating of the frame.

5.2.3 Bolted construction

5.2.3.1 A spring washer shall be used at one end of a bolt that secures current carrying parts together.

Exception No. 1: A spring washer is not required in a construction that has been tested in accordance with and complies with the Clamped Joint Temperature Test, Section 18.

Exception No. 2: A spring washer shall not be replaced with a split-ring lockwasher and a flat washer unless all the current carrying parts in the joint, including the tang of a pressure terminal connector, are copper.

Exception No. 3: A flat washer, a split-ring lockwasher, or a bolthead that has an outer diameter of at least 150 percent of the bolt shaft shall not be used in place of a spring washer unless the only aluminum in the joint is the tang of a pressure terminal connector.

5.2.3.2 Unless investigated for such use, a bolted connection between two bus bars or between a bus bar and another current carrying part shall not depend upon any polymeric insulation to maintain the clamping force and shall not depend on thermoplastic material in any case.

5.2.3.3 A bolted joint in a bus bar shall be accessible for tightening without removing insulating tape or any other part.

5.2.4 Riveted construction

5.2.4.1 Each riveted connection involving current carrying parts shall have a spring washer at one end and either a spring washer or a flat washer at the other end.

Exception No. 1: The washers are not required in a construction that has been tested in accordance with and complies with the Clamped Joint Temperature Test, Section 18.

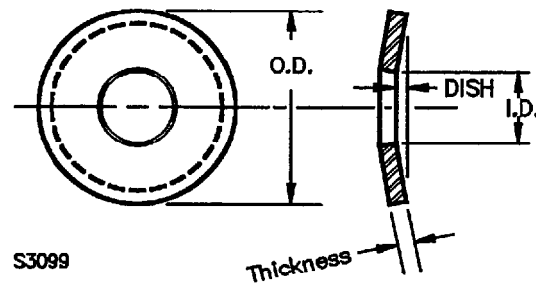
Exception No. 2: The washers are not required in a connection rated 220 amperes or less having copper bus bars only.

5.2.5 Washers

5.2.5.1 The flat washer as specified in 5.2.3.1 shall have a thickness of at least 1/6 of the diameter of the rivet shank or bolt and shall have an outer diameter of at least 150 percent of the rivet shank or bolt but not less than the outer diameter of the spring washer.

5.2.5.2 A spring washer as specified in 5.2.3.1 is a dished washer of stainless or hardened or tempered steel having an outer diameter of not less than 150 percent of the bolt diameter, having a thickness not less than 1/8 of the bolt diameter, and dished not less than 3-1/2 percent of the bolt diameter. A typical spring washer is shown in Figure 5.3. The intended orientation of the spring washer is shown in Figure 5.4.

Figure 5.3
Spring washer



NOTES

- 1 The spring washer shall comply with the following:

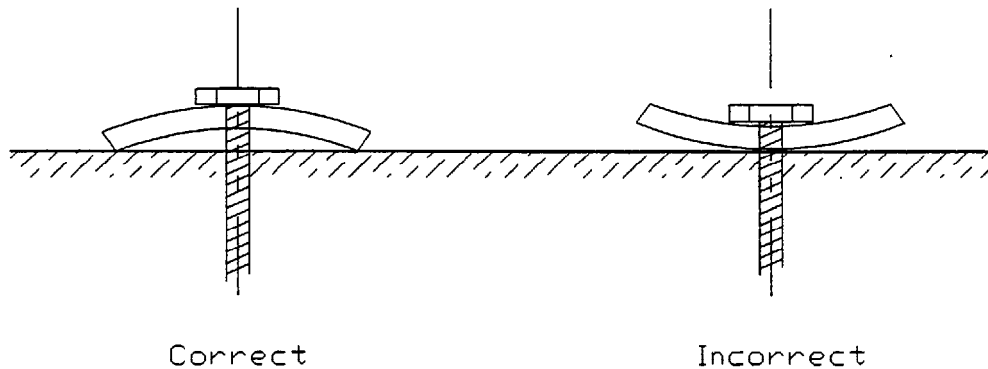
$$\begin{aligned} OD &\geq 1.5 D \\ T &\geq 0.125 D \\ H &\geq 0.035 D \end{aligned}$$

in which:

OD is the outer diameter of washer,
D is the diameter of bolt or rivet shank,
T is the thickness of washer, and
H is the depth of "dish" of spring washer.

- 2 Spring washers are also referred to as Belleville and ramp-conical washers.

Figure 5.4
Orientation of spring washer



SM1105

5.3 Support and securement of live parts

5.3.1 A bus bar shall either be supported independently of any component to which it is connected (switch, circuit breaker, or the like) or shall be supported by parts that do not depend on a bus bar for support.

5.3.2 A bus bar or an insulated live part shall be secured so that ordinary vibration will not loosen the securing means and shall be prevented from turning or shifting in position if such turning or shifting would result in spacings less than 1/2 of those specified in Table 13.1.

5.3.3 Friction between surfaces is not intended as the sole means to prevent turning or shifting of an uninsulated live part. Turning or shifting shall be prevented by the use of two screws or rivets; by non-circular shoulders or mortises; by a dowel pin, lug, or offset; by a connecting strap or clip fitted into an adjacent part; or by another method determined to be the equivalent.

5.3.4 In evaluating means to prevent turning or shifting in regard to 5.3.3, any screw or nut is to be loosened and retightened fingertight without a tool. The bus bar is then to be pushed to the extent limited by the screws or other means and the resulting spacings checked.

5.4 Internal wiring

5.4.1 Type

5.4.1.1 All internal wiring shall be of stranded copper conductors and have insulation rated 90°C (194°F) minimum and for the voltage involved.

Exception: This requirement does not apply to insulation rated less than 90°C that has been tested in accordance with and complies with the Temperature Test, Section 17.

5.4.2 Routing

5.4.2.1 Wires shall be routed away from sharp edges, screw threads, burrs, fins, or the like that are capable of abrading the wire insulation. A hole through which insulated wires pass in a sheet metal wall shall be provided with a smooth, well rounded bushing or have smooth, well rounded surfaces upon which the wires may bear to reduce the risk of abrasion of the insulation.

5.4.3 Terminations

5.4.3.1 A wire connector shall comply with the Standard for Wire Connectors and Soldering Lugs for Use with Copper Conductors, UL 486A; the Standard for Wire Connectors for Use with Aluminum Conductors, UL 486B; or the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E.

Exception: A wire connector used at an equipment grounding terminal or bonding connection shall comply with 5.4.3.1 above or the Standard for Grounding and Bonding Equipment, UL 467.

5.4.3.2 Open type eyelets shall be of the type with upturned edges or of the type which crimp around the screw shank, or all wiring shall be done in harnesses or shall be formed so that loosening of the terminal screw will not result in the conductor coming away from the intended connection.

5.4.3.3 Quick connect terminals shall be used under the following conditions:

- a) They mate as intended with terminals integrally provided on components that have been investigated for the intended use;
- b) They have a dimple, depression, or spring type connection such that a snap-action connection is accomplished; and
- c) They are suitable for the number and sizes of wires involved.

5.4.3.4 Wire binding screws or studs and nuts shall be used to secure a No. 10 AWG (5.3 mm²) or smaller conductor only.

5.4.3.5 A wire binding screw or stud of a wiring terminal shall not be smaller than No. 10 (4.8 mm diameter) and shall not have more than 32 threads per inch.

Exception: This requirement does not apply to a No. 8 (4.2 mm diameter) machine screw having not more than 32 threads per inch used at a terminal intended only for the connection of a No. 14 AWG (2.1 mm²) conductor.

5.4.3.6 Wire binding screw terminals shall have upturned edges, cupped washers, or other means determined to be the equivalent to retain the conductor. No strands shall protrude from the terminal connector.

5.4.3.7 A wire binding screw shall thread into metal.

5.4.3.8 A terminal plate tapped for a wire binding screw shall be of non-ferrous metal not less than 0.030 inch (0.76 mm) thick. There shall be two or more full threads in the metal.

5.4.3.9 A splice shall be provided with insulation that has been determined to be equivalent to that of the wires involved.

5.4.3.10 Soldered connections shall be mechanically secure prior to soldering.

5.4.4 Size

5.4.4.1 The minimum conductor size shall be No. 18 AWG (1.82 mm²).

Exception: Conductor size less than No. 18 AWG shall not be used unless investigated and determined to be rated for the purpose.

5.4.5 Ampacity

5.4.5.1 For circuits rated 100 amperes and larger, conductors of 75°C (167°F) ampacity shall be used. For circuits rated 100 amperes or less, conductors of 60°C (140°F) ampacity shall be used. See Table 5.4.

Exception: Higher ampacities shall not be used unless the assembly has been tested in accordance with and complies with the Temperature Test, Section 17.

Table 5.4
Ampacity of insulated conductors

Wire size,		60°C (140°F) ^a	75°C (167°F) ^a	90°C (194°F) ^{a,b}
AWG	(mm ²)	Copper	Copper	Copper
14	2.1	15	15	15
12	3.3	20	20	20
10	5.3	30	30	30
8	8.4	40	50 ^c	55
6	13.3	55	65 ^c	75
4	21.2	70	85 ^c	95
3	26.7	85	100 ^c	110
2	33.6	95	115 ^c	130
1	42.4	100	130 ^c	150
1/0 ^d	53.5 ^d	See footnote e	150	170
2/0 ^d	67.4 ^d	See footnote e	175	195
3/0 ^d	85.0 ^d	See footnote e	200	225
4/0 ^d	107.2 ^d	See footnote e	230	260
kcmil		See footnote e		
250 ^d	127 ^d	See footnote e	255	290
300 ^d	152 ^d	See footnote e	285	320
350 ^d	177 ^d	See footnote e	310	350
400 ^d	203 ^d	See footnote e	335	380
500 ^d	253 ^d	See footnote e	380	430
600 ^d	304 ^d	See footnote e	420	475
700 ^d	355 ^d	See footnote e	460	520
750 ^d	380 ^d	See footnote e	475	535
800 ^d	405 ^d	See footnote e	490	555
900 ^g	456 ^d	See footnote e	520	585
1000	506	See Footnote e	545	615
1250	633	See footnote e	590	665
1500	760	See footnote e	625	705
1750	887	See footnote e	650	735
2000	1013	See footnote e	665	750

^a The numbers 60°C (140°F), 75°C (167°F), and 90°C (194°F) indicate the wire temperature rating.

^b Except as noted in the Exception to 5.4.5.1, the ampacity of 90°C (194°F) wire is to be considered the same as 75°C (167°F) wire.

^c The ampacity of these sizes is to be considered the same as for 60°C (140°F) wire when connected to molded case circuit breakers unless the breaker is marked 75°C (167°F).

^d For a multiple conductor connector at a terminal, the ampacity value is to be multiplied by the number of conductors that the terminal will accommodate [1/0 AWG (53.5 mm²) and larger].

^e For wire sizes 1/0 AWG (53.5 mm²) and larger, it is assumed that wire with at least a 75°C (167°F) temperature rating will be used.

5.4.6 Neutral

5.4.6.1 The supply neutral input and any associated current carrying parts shall have at least the ampacity of the largest ungrounded supply conductor.

Exception No.1: Units intended for single conductor supply cables and that are rated for use with 3-phase, 4-wire with ground systems and are intended for use with electronic dimmers shall have the neutral input and any associated current carrying parts with ampacity at least equal to 130 percent of the largest ungrounded supply conductor and be marked in accordance with 30.1. Also see 5.2.2.1 – 5.2.2.7 and 5.4.5.1 regarding ampacity of internal conductors.

Exception No.2: Units rated for use on both 208Y/120 volt 3-phase 4-wire and 120/240 volt single phase 3-wire supplies at the same output rating shall have the neutral input and any associated current carrying parts with ampacity at least equal to 200 percent of the largest ungrounded supply conductor and shall be marked in accordance with 30.2. Units using single conductor feeders may use two neutral termination inlets for this purpose. Also see 5.2.2.1 – 5.2.2.7 and 5.4.5.1 regarding ampacity of internal conductors.

5.4.7 Plating

5.4.7.1 A plated steel screw, nut, and stud shall be used to secure a soldering lug, pressure wire connector, or bus bar.

5.4.7.2 Copper and brass shall not be used for plating wire binding screws, nuts, and stud terminals; however, a plating of cadmium, zinc, tin, or silver is not prohibited.

6 Electrical Insulation Material

Section 6 effective July 1, 1997

6.1 An insulation material shall have a Performance Level Category (PLC) that does not exceed the value specified in Table 6.1. The specified values are derived from the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception: This requirement does not apply to an insulation material that has been evaluated to and complies with the end-product tests specified in UL 746C.

6.2 Units with enclosure designation 3R or marked "Suitable For Use In Damp Locations" shall use electrical insulation that does not exhibit a dimensional change greater than 2.0 percent after immersion for 168 hours in distilled water as described in the Standard for Polymeric Materials – Short-Term Property Evaluations, UL 746A. Untreated fiber and the like are examples of materials that shall not be used.

6.3 A base of a ceramic type material shall not be less than 1/2 inch (12.7 mm) thick.

6.4 With respect to footnote e to Table 6.1, a live screw head, rivet, or nut on the underside of a base intended for surface mounting shall be countersunk not less than 1/8 inch (3.2 mm) in the clear, and covered to a depth of not less than 1/8 inch with a waterproof, insulating sealing compound that will not soften at a temperature of 90°C (194°F) as determined by the test for softening point by ring and ball apparatus in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

Exception No. 1: The test is not required for a thermosetting material.

Exception No. 2: A sealing compound is not required if the live part specified in 6.4 is prevented from loosening by being staked or upset, by a lock washer or by other means. The spacings through air from the mounting surface to the live part shall comply with Table 13.1

Table 6.1
Maximum performance level category (PLC) for insulation materials other than insulating barriers

Test specified ^b	Flammability rating of material ^a		
	94V-0	94V-1	94V-2
Comparative tracking index under moist conditions (CTI) ^{d,e}	3 ^c	3 ^c	3 ^c
High current arc resistance to ignition (HAI) ^{d,f}	3	2	2
Hot wire ignition (HWI) ^{d,g}	4	3	2

^a These flammability ratings are derived from the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

^b The following additional parameters shall be considered:

Property	Tests	Method	Units	Minimum levels related to flammability classification
Distortion under load and mold stress relief	Heat deflection temperature, or	UL 746A	Minimum °C	10°C (18°F) greater than use temperature but not less than 90°C (194°F), or
	Vicat softening point, or	UL 746A	Minimum °C	25°C (45°F) greater than use temperature but not less than 105°C (221°F), or
	Ball pressure temperature	UL 746A	Minimum °C	Greater than the use temperature by the difference between 40°C (72°F) and the ambient, but not less than 95°C (203°F).

^c A material having a comparative tracking index PLC of 4 shall not be used unless the voltage involved is 250 volts or less.

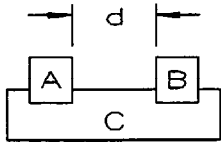
^d See the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A, for this specified test.

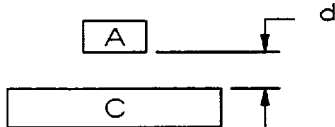
^e Refer to figurative examples 1 and 2 of Figure 6.1 for application of this requirement.

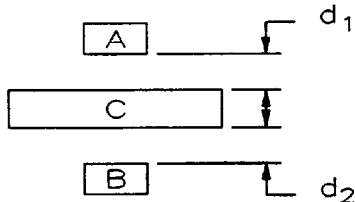
^f Refer to figurative examples 1 – 3 of Figure 6.1 for application of this requirement.

^g Refer to figurative examples 1 – 3 of Figure 6.1 for application of this requirement.

Figure 6.1
Figurative examples for Table 6.1

1. 

In which:
 $d < 1/2$ inch (12.7mm)
 d = Over-surface spacing requirement
2. 

In which:
 $d < 1/2$ inch
3. 

In which:
 d_1, d_2 = Through-air spacing
 $d_1 + d_2 < Sa$
 and Sa = Applicable through-air spacing requirement

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A – An uninsulated live part

B – (1) An uninsulated live part having a difference in potential from part A or

(2) A dead metal part that may be grounded in service or that is exposed to contact.

C – The polymeric material under consideration.

7 Enclosure

Section 7 effective July 1, 1997

7.1 General

7.1.1 An enclosure of portable power distribution equipment shall be constructed and assembled so that it has the strength and rigidity necessary to resist the abuses to which it is likely to be subjected, without total or partial collapse resulting in a risk of fire, electric shock, or injury to persons due to reduction of spacings, loosening or displacement of parts, or other serious defects.

7.1.2 An enclosure shall be constructed so as to reduce the risk of unintentional contact with enclosed electrical devices, and to provide internal devices with protection from specified external conditions.

7.1.3 An enclosure marked type 3R or "Suitable For Use in Damp Locations" shall be provided with means for the drainage of water to the outside. The drainage opening(s) shall be located below the level of the lowest live part when the unit is oriented in the intended manner.

7.2 Cast metal

7.2.1 A cast-metal enclosure shall be at least 1/8 inch (3.2 mm) thick at every point, and more than 1/8 inch thick at reinforcing ribs and door edges.

Exception: Malleable iron and die-cast or permanent mold cast aluminum, brass, bronze, or zinc shall be:

- a) At least 3/32 inch (2.4 mm) thick for an area greater than 24 square inches (155 cm²) or having any dimension more than 6 inches (152 mm) and
- b) At least 1/16 inch (1.6 mm) thick for an area of 24 square inches or less having no dimension more than 6 inches. The area considered may be bounded by reinforcing ribs subdividing a larger area.

7.3 Sheet metal

7.3.1 General

7.3.1.1 The thickness of a sheet-metal enclosure shall not be less than that specified in Tables 7.1 and 7.2.

Exception: Enclosure thickness need not comply with these requirements if the enclosure complies with the Compression Test, Section 28, and the Deflection Test, Section 29, in the Standard for Enclosures for Electrical Equipment, UL 50.

7.3.1.2 With reference to Tables 7.1 and 7.2, a supporting frame is a structure of angle or channel or folded rigid section of sheet metal that is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and that has sufficient torsional rigidity to resist bending moments applied to the enclosure surface when it is deflected. A structure that is as rigid as one built with a frame of angles or channels is considered to have equivalent reinforcing. Constructions considered to be without supporting frames include:

- a) A single sheet with single formed flanges – formed edges;
- b) A single sheet that is corrugated or ribbed;
- c) An enclosure surface loosely attached to a frame, for example, with spring clips; and
- d) An enclosure surface having an unsupported edge.

Table 7.1
Minimum thickness of sheet metal for enclosures — carbon steel or stainless steel

Without supporting frame ^a		With supporting frame or equivalent reinforcing ^a		(Column 5) Minimum thickness uncoated,	(Column 6) Minimum thickness metal coated,
(Column 1) Maximum width, ^b	(Column 2) Maximum length, ^c	(Column 3) Maximum width, ^b	(Column 4) Maximum length,		
Inches (cm)	Inches (cm)	Inches (cm)	Inches (cm)	Inch (mm)	Inch (mm)
4.0 10.2	Not limited	6.25 15.9	Not limited	0.020 0.51	0.023 0.58
4.75 12.1	5.75 14.6	6.75 17.1	8.25 21.0		
6.0 15.2	Not limited	9.5 24.1	Not limited	0.026 0.66	0.029 0.74
7.0 17.8	8.75 22.2	10.0 25.4	12.5 31.8		
8.0 20.3	Not limited	12.0 30.5	Not limited	0.032 0.81	0.034 0.86
9.0 22.9	11.5 29.2	13.0 33.0	16.0 40.6		
12.5 31.8	Not limited	19.5 49.5	Not limited	0.042 1.07	0.045 1.14
14.0 35.6	18.0 45.7	21.0 53.3	25.0 63.5		
18.0 45.7	Not limited	27.0 68.6	Not limited	0.053 1.35	0.056 1.42
20.0 50.8	25.0 63.5	29.0 73.7	36.0 91.4		
22.0 55.9	Not limited	33.0 83.8	Not limited	0.060 1.52	0.063 1.60
25.0 63.5	31.0 78.7	35.0 88.9	43.0 109.2		
25.0 63.5	Not limited	39.0 99.1	Not limited	0.067 1.70	0.070 1.78
29.0 73.7	36.0 91.4	41.0 104.1	51.0 129.5		
33.0 83.8	Not limited	51.0 129.5	Not limited	0.080 2.03	0.084 2.13
38.0 96.5	47.0 119.4	54.0 137.2	66.0 167.6		
42.0 106.7	Not limited	64.0 162.6	Not limited	0.093 2.36	0.097 2.46
47.0 119.4	59.0 149.9	68.9 172.7	84.0 213.4		

(Continued)