



UL 1640

STANDARD FOR SAFETY

Portable Power-Distribution Equipment

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UL Standard for Safety for Portable Power-Distribution Equipment, UL 1640

Third Edition, Dated October 25, 2012

Summary of Topics

This revision was issued to confirm that UL 1640 has been approved for publication as an American National Standard. None of the requirements for UL 1640 have been revised.

The revised requirements are substantially in accordance with Proposal(s) on this subject dated August 28, 2015.

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OCTOBER 25, 2012
(Title Page Reprinted: January 25, 2016)



ANSI/UL 1640-2016

1

UL 1640

Standard for Portable Power-Distribution Equipment

The first edition was titled Portable Power Distribution Units.

First Edition – October, 1995
Second Edition – July, 2000

Third Edition

October 25, 2012

This ANSI/UL Standard for Safety consists of the Third Edition including revisions through January 25, 2016.

The most recent designation of ANSI/UL 1640 as an American National Standard (ANSI) occurred on January 25, 2016. 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 <http://csds.ul.com>.

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CONTENTS

INTRODUCTION

1 Scope	7
2 Components	7
3 Units of Measurement	8
4 Undated References	8
5 Glossary	8

PART 1 – ALL EQUIPMENT

CONSTRUCTION

6 General	10
7 Current-Carrying Parts	10
7.1 General	10
7.2 Bus bars	10
7.3 Support and securement of live parts	15
7.4 Internal wiring	16
8 Electrical Insulation Material	19
9 Enclosure	22
9.1 General	22
9.2 Specific enclosures	22
9.3 Cast metal	22
9.4 Sheet metal	23
9.5 Doors and covers	26
9.6 Inlet and receptacle covers	31
9.7 Polymeric	32
9.8 Enclosure of switches, circuit breakers, or fuses	33
9.9 Accessibility of live parts	33
10 Enclosure Performance	37
11 Corrosion Protection	38
12 Grounding and Bonding	40
12.1 General	40
12.2 Output receptacle grounding	42
13 Input Connections	42
13.1 General	42
13.2 Cord-connected equipment	43
13.3 Multi-conductor inlet input	45
13.4 Single-conductor inlets and plugs	45
13.5 Interlocked inlet assemblies	46
13.6 Sequentially-interlocked inlet assemblies	46
13.7 Bus bars	46
14 Output Connections	46
14.1 General	46
14.2 Receptacles	47
15 Overcurrent Protection	47
15.1 General	47
15.2 Circuit breakers	47
15.3 Fuses	49

15.4 Fuseholders	49
16 Spacings	49
17 Switches	54
18 Transformers	54

PERFORMANCE

19 General	55
20 Temperature Test	56
21 Clamped-Joint Temperature Test	58
22 Dielectric Voltage-Withstand Test	59
22.1 General	59
22.2 Clamped insulating joint	59
22.3 Insulating barriers	60
23 Strain-Relief Test	60
24 Resistance to Rain Test	60
25 Icing Test	63
26 Gasket Tests	63
27 Spring-Closing Cycling Test	64
28 Metallic Coating Thickness Test	64

RATINGS

29 Details	65
------------------	----

MARKINGS

30 General	66
31 Public Access	67
32 Conductors in Parallel	67
33 Enclosure Type	67
34 Neutral Connection	68
35 Qualified Personnel	68
36 Receptacle Ratings	69
37 Multi-Pole Receptacle Configuration	69
38 Single-Pole Inlets or Output Receptacles	69
39 Supply Cord Without Attachment Plug	70
40 Switches or Circuit Breakers	70

PART 2 – BUS BAR CLAMPS

CONSTRUCTION

41 General	70
------------------	----

PERFORMANCE

42 General	71
------------------	----

MARKINGS

43 Details	72
------------------	----

PART 3 – CABLE-SPLICING BLOCKS**CONSTRUCTION**

44 General	72
------------------	----

PERFORMANCE

45 General	74
46 Temperature Test	74
47 Loose Connection Test	74
48 Drop Test	74
49 Pullout Test	74
50 Crushing Test	75
51 Insulation Resistance and Dielectric Voltage-Withstand Test	75
52 Impact Test	75

RATINGS

53 Details	75
------------------	----

MARKINGS

54 Details	75
------------------	----

PART 4 – CONSTRUCTION-SITE EQUIPMENT FOR TEMPORARY INSTALLATIONS IN ACCORDANCE WITH ARTICLE 590 OF THE NEC**CONSTRUCTION**

55 General	76
56 Mounting Legs	76
57 Ground-Fault Protection for Personnel	76
58 Receptacles	77
59 Supply Connection	77
60 Overcurrent Protection	77
61 Enclosures	78
62 Spacings	78

PERFORMANCE

63 General	79
64 Loading Tests	79
65 Resistance to Rain Test	79
66 Door Endurance Test	79

MARKINGS

67 Details	79
------------------	----

SUPPLEMENT SA - FOLLOW-UP INSPECTION INSTRUCTIONS

General

SA1 Scope	SA1
SA2 Glossary	SA1

RESPONSIBILITY OF THE MANUFACTURER

SA3 General	SA2
-------------------	-----

RESPONSIBILITY OF THE FIELD REPRESENTATIVE

SA4 General	SA3
SA5 General	SA4
SA6 Enclosures	SA5
SA6.1 Sheet metal thickness	SA5
SA6.2 Corrosion protection	SA5
SA6.3 Types	SA6
SA6.4 Current-carrying parts (bus bars)	SA6
SA6.5 Grounding	SA6
SA7 Overcurrent Protection	SA7
SA8 Details	SA7
SA9 General	SA8
SA10 Standard Listing Mark	SA9
SA11 Bus Bar Clamps	SA9
SA12 Construction-Site Equipment	SA9
SA13 Open-Framed Cable-Splicing Blocks	SA9

APPENDIX A

Standards for Components	A1
--------------------------------	----

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INTRODUCTION

1 Scope

1.1 These requirements cover portable power-distribution equipment 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) Temporary installations at construction sites in accordance with Article 590 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 equipment rated 600 volts or less and 1600 amperes maximum. They may be intended for either single- or multi-phase supply.

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.

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

4 Undated References

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.

5 Glossary

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

5.2 **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.

5.3 **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.

5.4 **CABLE-SPLICING BLOCK** – Power-distribution equipment 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.

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

5.6 **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. Damp Locations are not subject to direct water spray or rain.

5.7 **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.

5.8 **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.

5.9 **ENCLOSURE** – That part of power-distribution equipment that:

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

5.10 **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.

5.11 INLET ASSEMBLY, INTERLOCKED – An assembly of locking-type, single-pole pin-and-sleeve inlets. The assembly is interlocked as specified under 5.18.

5.12 INLET ASSEMBLY, SEQUENTIALLY INTERLOCKED – An assembly of locking-type, single-pole pin-and-sleeve inlets. The assembly is sequentially interlocked as specified under 5.19.

5.13 INTERLOCKED INLET – An inlet having a device, either mechanical or electrical, that is intended to reduce the risk 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.

5.14 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.

5.15 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.

5.16 POWER INLET (INLET) – A permanently mounted plug intended to receive power from a cable connector.

5.17 RECEPTACLE (OUTLET) – A device that is intended to provide power to an inserted plug, and that is installed as a fixed outlet on equipment.

5.18 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.

5.19 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.

5.20 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.

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

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

5.23 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.

PART 1 – ALL EQUIPMENT

CONSTRUCTION

6 General

6.1 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 the reduction of spacings, loosening or displacement of parts, or other serious defects.

6.2 Portable power-distribution equipment 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.

6.3 Portable power-distribution equipment 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.

7 Current-Carrying Parts

7.1 General

7.1.1 Current-carrying parts shall be of silver, copper, or alloys of these metals or others determined to be the equivalent. Current-carrying parts of other materials that are used in the construction of components shall comply with the appropriate requirements for that component as specified in Appendix A.

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

7.2 Bus bars

7.2.1 General

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

7.2.2 Ampacity

7.2.2.1 Other than as covered in 7.2.2.4 and 7.2.2.5, the ampacity or size of a bus bar is considered sufficient if the current density is not more than as specified in Table 7.1 or the size is not less than as specified in Table 7.2.

Exception: Bus bars operated at ampacities greater than as specified in Table 7.1 shall be tested in accordance with and comply with the Temperature Test, Section 20.

Table 7.1
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 – 1600	1000 ^{d,e}	200 ^c
Brass	0 – 600	500	200

^a Multiple bus bars in parallel shall be of the same material and cross section.
^b See 7.2.2.1 – 7.2.2.4 regarding the ampacity.
^c Joints bolted and plated with silver, tin, nickel, or cadmium.
^d See Table 7.2 for 800 ampere maximum single bus bars.
^e Reference the Standard for Dead-Front Switchboards, UL 891, for 100 percent rated device rated 3,000 amperes or more.

Table 7.2
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	(6.38 by 38.1)	0.375	(242.0)
600	0.250 by 2.000	(6.38 by 50.8)	0.500	(322.6)
800	0.250 by 3.000	(6.38 by 76.2)	0.750	(483.9)

NOTES
1 For multiple buses in parallel, refer to Table 7.1.
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 7.1 or shall be tested in accordance with the limitation on temperature rise specified in Table 18.1.
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.

7.2.2.2 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 7.1.

Exception: Bus bars with a larger amount of material removed shall be tested in accordance with and comply with the Temperature Test, Section 20.

7.2.2.3 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.

7.2.2.4 The contact area shall not be less than the minimum 1 square inch (6.5 cm²) per 200 amperes specified in Tables 7.1 and 7.2 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.

7.2.2.5 The limitations on current density mentioned in Tables 7.1 and 7.2 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.

7.2.2.6 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.

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

7.2.3 Bolted construction

7.2.3.1 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 21.

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.

7.2.3.2 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.

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

7.2.4 Riveted construction

7.2.4.1 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.

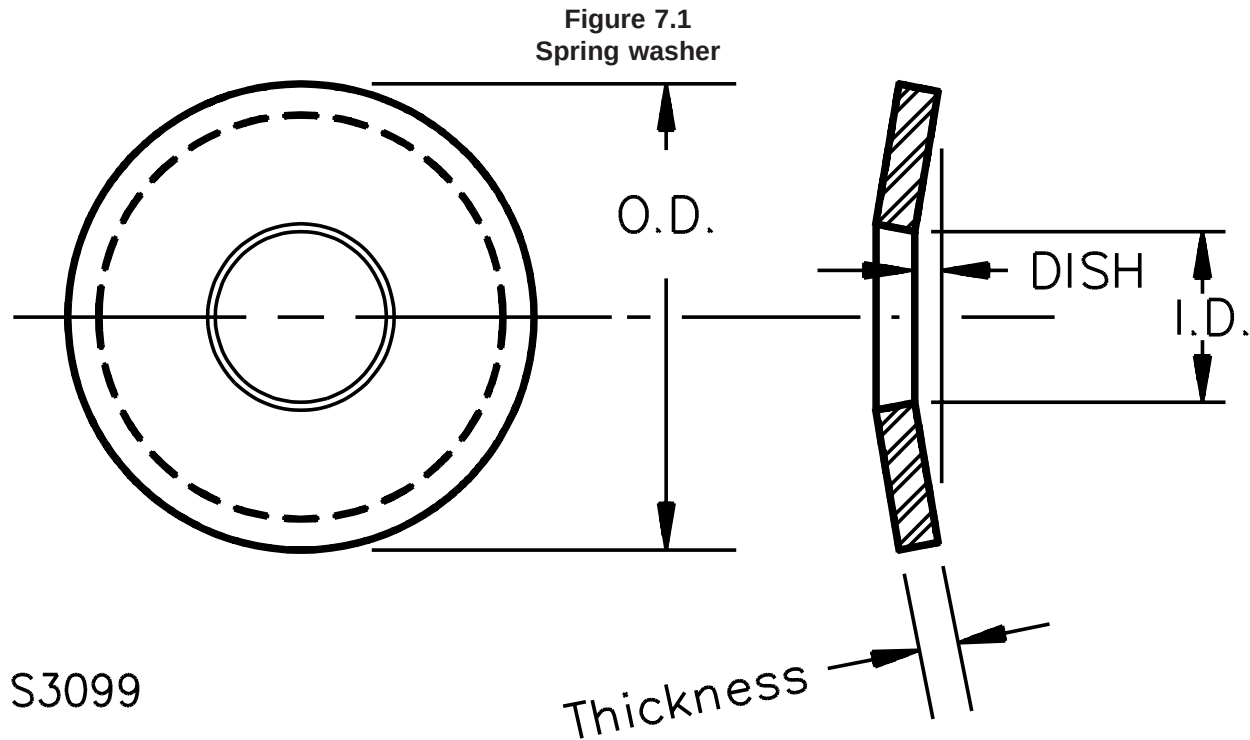
Exception No. 1: The washers are not required in a construction that has been tested in accordance with and complies with the Clamped Joint Temperature Test, Section 21.

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

7.2.5 Washers

7.2.5.1 The flat washer as specified in 7.2.3.1 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.

7.2.5.2 A spring washer as specified in 7.2.3.1 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 7.1. The intended orientation of the spring washer is shown in Figure 7.2.



NOTES

1 The spring washer shall comply with the following:

$$OD \geq 1.5 D$$

$$T \geq 0.125 D$$

$$H \geq 0.035 D$$

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.

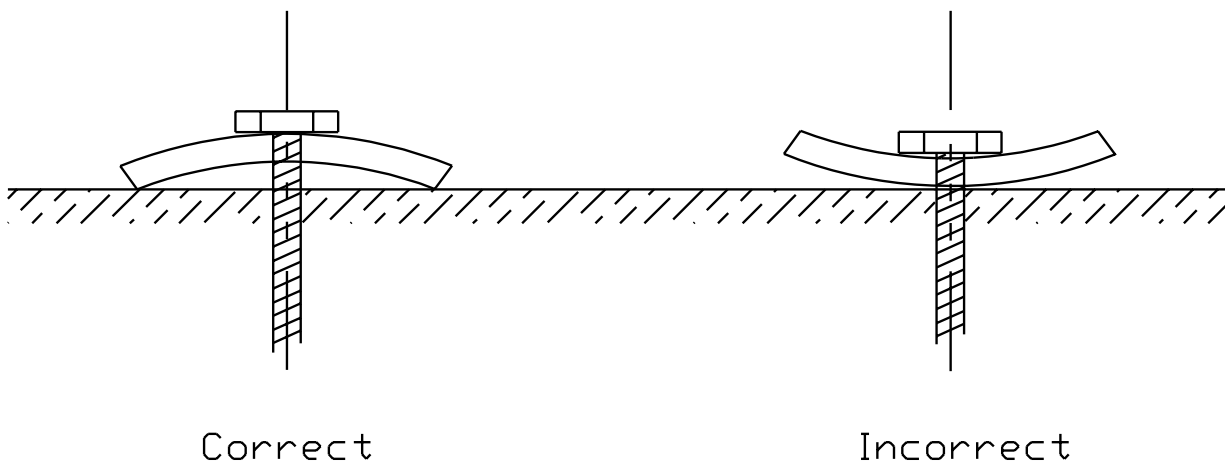
2 Spring washers are also referred to as Belleville and ramp-conical washers.

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Figure 7.2
Orientation of spring washer



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7.3 Support and securement of live parts

7.3.1 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.

7.3.2 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 16.1.

7.3.3 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.

7.3.4 In evaluating means to prevent turning or shifting in regard to 7.3.3, 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.

7.4 Internal wiring

7.4.1 Type

7.4.1.1 All internal wiring shall be of 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 20.

7.4.2 Routing

7.4.2.1 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.

7.4.3 Terminations

7.4.3.1 A wire connector shall comply with:

- a) The Standard for Wire Connectors, UL 486A-486B; or
- b) 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 7.4.3.1 or the Standard for Grounding and Bonding Equipment, UL 467.

7.4.3.2 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.

7.4.3.3 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.

7.4.3.4 Wire-binding screws or studs and nuts shall be used to secure a 10 AWG (5.3 mm²) or smaller conductor only.

7.4.3.5 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 14 AWG (2.1 mm²) conductor.

7.4.3.6 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.

7.4.3.7 A wire-binding screw shall thread into metal.

7.4.3.8 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.

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

7.4.3.10 Soldered connections shall be mechanically secure prior to soldering.

7.4.4 Size

7.4.4.1 The minimum conductor size shall be 18 AWG (1.82 mm²).

Exception: Conductor size less than 18 AWG shall not be used unless investigated and determined to be rated for the purpose.

7.4.5 Ampacity

7.4.5.1 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 7.4.

Exception: Higher ampacities shall not be used unless the assembly has been tested in accordance with and complies with the Temperature Test, Section 20. Higher ampacities shall not be used for conductors terminating to components unless the components have been evaluated for such use.

Table 7.4
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)	110	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 ^d	(456)	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 7.4.5.1, 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.

7.4.6 Neutral

7.4.6.1 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: Equipment 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 34.1. Also see 7.2.2.1 – 7.2.2.7 and 7.4.5.1 regarding ampacity of internal conductors.

Exception No. 2: Equipment 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 34.2. Equipment using single-conductor feeders may use two neutral termination inlets for this purpose. Also see 7.2.2.1 – 7.2.2.7 and 7.4.5.1 regarding ampacity of internal conductors.

7.4.7 Plating

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

7.4.7.2 Steel that is corrosion-resistant (stainless) or protected against corrosion by zinc plating, cadmium plating, silver plating, or an equivalent coating is not prohibited from being used for wire-binding screws and nuts and for a clamp and for stud terminals when the steel parts are not depended upon to carry current.

7.4.7.3 Copper and brass shall not be used for plating steel wire-binding screws, nuts, and stud terminals.

8 Electrical Insulation Material

8.1 An insulation material shall have a Performance Level Category (PLC) that does not exceed the value specified in Table 8.1. 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.

8.2 Equipment with enclosure designation 3, 3R, 3X, 3RX, 3S, 3SX, 4, 4X, 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.

Table 8.1
Maximum performance level category (PLC) for insulation materials other than insulating barriers

Test specified ^b	Flammability rating of material ^a		
	V-0	V-1	V-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 additional parameters specified in Table 8.2 shall be considered. ^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 8.1 for application of this requirement. ^f Refer to figurative examples 1 – 3 of Figure 8.1 for application of this requirement. ^g Refer to figurative examples 1 – 3 of Figure 8.1 for application of this requirement.			

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

8.4 With regard to footnote e to Table 8.1, 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 method in 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.

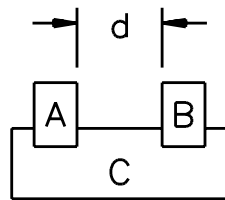
Exception No. 2: A sealing compound is not required if the live part specified in 8.4 is prevented from loosening by being staked or upset, by a lock washer or by other means. The spacings through air from the mounting surface to the live part shall comply with Table 16.1.

Table 8.2
Additional parameters

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°).

Figure 8.1
Figurative examples for Table 8.1

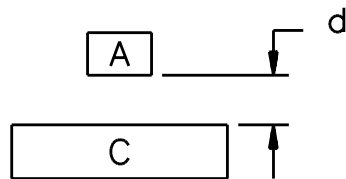
1.



In which:

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

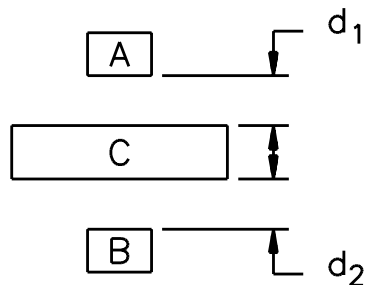
2.



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

S3661

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.

9 Enclosure

9.1 General

9.1.1 A portable power-distribution equipment enclosure 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.

9.1.2 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.

9.2 Specific enclosures

9.2.1 An enclosure shall comply with the construction requirements applicable to an enclosure of the type numbers or numbers with which it is marked. See 33.1.

9.2.2 TYPE 2 – A Type 2 enclosure shall have provision for drainage of water. The drainage opening(s) shall be located below the level of the lowest live part when the equipment is oriented in the intended manner.

9.2.3 An enclosure marked Type 3R, 3RX, 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 equipment is oriented in the intended manner.

9.3 Cast metal

9.3.1 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.*

9.4 Sheet metal

9.4.1 General

9.4.1.1 The thickness of a sheet-metal enclosure shall not be less than that specified in Tables 9.1 and 9.2.

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.

Table 9.1
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, inch (mm)	(Column 6) Minimum thickness metal coated, inch (mm)
(Column 1) Maximum width, ^b inches (cm)	(Column 2) Maximum length, ^c inches (cm)	(Column 3) Maximum width, ^b inches (cm)	(Column 4) Maximum length, inches (cm)		
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)		
52.0 (132.1)	Not limited	80.0 (203.2)	Not limited	0.108 (2.74)	0.111 (2.82)
60.0 (152.4)	74.0 (188.0)	84.0 (213.4)	103.0 (261.6)		
63.0 (160.0)	Not limited	97.0 (246.4)	Not limited	0.123 (3.12)	0.126 (3.20)
73.0 (185.4)	90.0 (228.6)	103.0 (261.6)	127.0 (322.6)		

NOTE – Sheet steel for a Type 3R, 3RX enclosure or one marked "Suitable for Use in Damp Locations" shall not be less than 0.034 inch thick when zinc coated and not less than 0.032 inch thick when uncoated.

^a See 9.4.1.2 regarding sheet metal construction.

^b See 9.4.2.1 regarding width of enclosure.

^c "Not limited" applies only if the edge of the surface is flanged at least 1/2 inch (127 mm) or is fastened to adjacent surfaces not normally removed in use.

Table 9.2
Minimum thickness of sheet metal for enclosures– aluminum, copper, or brass

Without supporting frame ^a		With supporting frame or equivalent reinforcing ^a		(Column 5) Minimum thickness, inch (cm)
(Column 1) Maximum width, ^b inches (cm)	(Column 2) Maximum length, ^c inches (cm)	(Column 3) Maximum width, ^b inches (cm)	(Column 4) Maximum length, inches (cm)	
3.0 (7.6) 3.5 (8.9)	Not limited 4.0 (10.2)	7.0 (17.8) 8.5 (21.6)	Not limited 9.5 (24.1)	0.023 (0.58)
4.0 (10.2) 5.0 (12.7)	Not limited 6.0 (15.2)	10.0 (25.4) 10.5 (26.7)	Not limited 13.5 (34.3)	0.029 (0.74)
6.0 (15.2) 6.5 (16.5)	Not limited 8.0 (20.3)	14.0 (35.6) 15.0 (38.1)	Not limited 18.0 (45.7)	0.036 (0.91)
8.0 (20.3) 9.5 (24.1)	Not limited 11.5 (29.2)	19.0 (48.3) 21.0 (53.3)	Not limited 25.0 (63.5)	0.045 (1.14)
12.0 (30.5) 14.0 (35.6)	Not limited 16.0 (40.6)	28.0 (71.1) 30.0 (76.2)	Not limited 37.0 (94.0)	0.058 (1.47)
18.0 (45.7) 20.0 (50.8)	Not limited 25.0 (63.5)	42.0 (106.7) 45.0 (114.3)	Not limited 55.0 (139.7)	0.075 (1.91)
25.0 (63.5) 29.0 (73.7)	Not limited 36.0 (91.4)	60.0 (152.4) 64.0 (162.6)	Not limited 78.0 (198.1)	0.095 (2.41)
37.0 (94.0) 42.0 (106.7)	Not limited 53.0 (134.6)	87.0 (221.0) 93.0 (236.2)	Not limited 114.0 (289.6)	0.122 (3.10)
52.0 (132.1) 60.0 (152.4)	Not limited 74.0 (188.0)	123.0 (312.4) 130.0 (330.2)	Not limited 160.0 (406.4)	0.153 (3.89)
^a See 9.4.1.2 regarding sheet metal construction.				
^b See 9.4.2.1 regarding width of enclosure.				
^c For panels which are not supported along one side, for example, side panels of boxes, the length of the unsupported side.				

9.4.1.2 With reference to Tables 9.1 and 9.2, 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.

9.4.2 Instructions for using Tables 9.1 and 9.2

9.4.2.1 The width is the smaller dimension of a rectangular sheet metal piece which is part of an enclosure. Adjacent surfaces of an enclosure are not prohibited from having supports in common and be made of a single sheet.

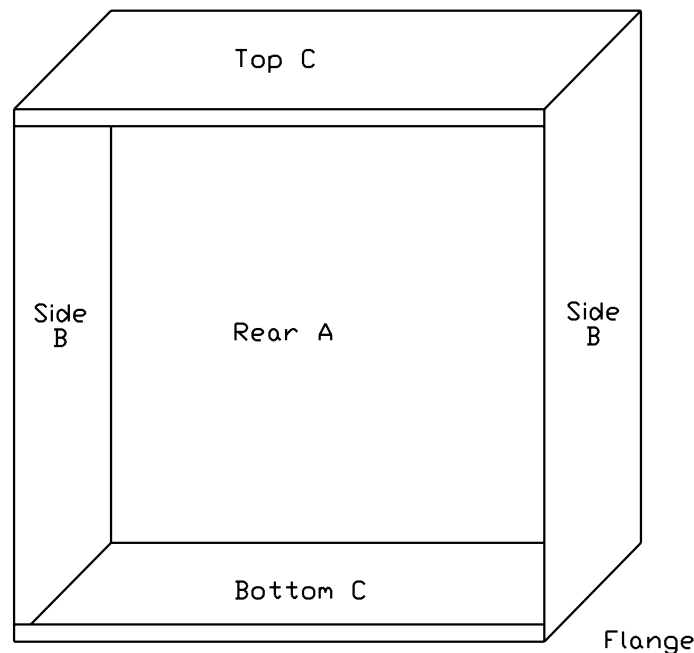
9.4.2.2 Determine if the portion of the enclosure is supported or unsupported using the following criteria:

a) Supported – Supported edges flanged at least 1/2 inch (12.7 mm) or fastened to adjacent surfaces not normally removed in use. (Surfaces A and C of Figure 9.1 are considered supported.)

b) Nonsupported –

- 1) A single sheet with formed flanges or formed edges;
- 2) A single sheet that is corrugated or ribbed;
- 3) An enclosure surface loosely attached to its frame, for example, with spring clips; and
- 4) An enclosure surface having an unsupported edge. (Surface B of example Figure 9.1 is unsupported.)

Figure 9.1
Enclosure surfaces



SM787