UL 916

STANDARD FOR SAFETY

Energy Management Equipment

UL Standard for Safety for Energy Management Equipment, UL 916

Fifth Edition, Dated October 22, 2015

Summary of Topics:

This revision of UL 916 dated October 21, 2021 includes changes in requirements in Supplement SA to address energy management equipment that use remote or cloud-based interface for communication and to clarify functional safety requirements referencing UL 60730-1; SA1, SA1.4, SA1.5, SA2.1, SA2.2, SA2.4, SA2.6 – SA2.9, SA3.1 – SA3.6, Section SA4 and SA5.6.

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 new and revised requirements are substantially in accordance with Proposal(s) on this subject dated August 27, 2021.

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UL 916

Standard for Energy Management Equipment

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Fifth Edition

October 22, 2015

This UL Standard for Safety consists of the Fifth Edition including revisions through October 21, 2021.

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 energy management equipment and associated sensing devices rated 600 volts or less and intended for installation in accordance with the National Electrical Code, NFPA 70.

1.2 This equipment energizes or de-energizes electrical loads to achieve a desired use of electrical power. The equipment is intended to control electrical loads by responding to sensors or transducers monitoring power consumption, by sequencing, by cycling the loads through the use of preprogrammed data logic circuits, or any combination thereof. Devices responding to signals from a utility company may receive the signals over the power lines or as radio signals.

1.3 These requirements also cover equipment intended for connection only to a low-voltage circuit of limited power supplied by a Class 2 transformer.

1.4 These requirements do not cover switching devices operated by a mechanical or electromechanical clock mechanism to energize or de-energize loads. These requirements do cover electronic clock operated energy management equipment.

1.5 Controls intended to be installed in air handling spaces or in other environmental air space (plenums) are covered under the scope of this standard.

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 When a value for measurement is followed by a value in other units in parentheses, the first stated value is the requirement.

3.2 Unless otherwise indicated, all voltage and current values mentioned in this standard are root-mean-square (rms).

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 purpose of this standard the following definitions apply.

5.2 CLASS 2 SYSTEM – A circuit, transformer, or power source having energy- and voltage-limiting characteristics as described in the National Electrical Code, ANSI/NFPA 70.

5.3 CONTROLLED ENVIRONMENT – An environment relatively free of contaminants. A controlled environment may also be provided by means of a totally closed, gasketed enclosure or the equivalent.

5.4 DEAD-CASE-MOUNTED SEMICONDUCTOR – A semiconductor, such as a triac or silicon-controlled rectifier, employing an integral metal tab or stud that is insulated from live parts.

5.5 FIELD-WIRING TERMINAL – A wiring terminal on permanently-connected equipment to which supply connections are made when the equipment is installed in the field.

5.6 ISOLATED LIMITED-ENERGY LOW-VOLTAGE CIRCUIT – A circuit (also hereafter referred to as a low-voltage circuit) involving a potential of not more than 42.4 volts peak supplied by one of the following:

a) An energy-limiting Class 2 transformer;

b) A non-energy-limiting Class 2 transformer and an overcurrent protective device. The protective device is:

1) Not to be of the automatic reclosing type;

2) To be trip-free from the reclosing mechanism; and

3) Not to be readily interchangeable with a device of a different rating;

c) A combination of an isolated transformer secondary winding and a fixed impedance that complies with all the performance requirements for an energy-limiting Class 2 transformer or power source;

d) A dry-cell battery having output characteristics not greater than those of an energy-limiting Class 2 transformer or power source; or

e) A combination of a rechargeable battery and a fixed impedance that complies with all of the performance requirements for an energy-limiting Class 2 transformer or power source.

5.7 ISOLATED LIMITED-ENERGY SECONDARY CIRCUIT – A circuit derived from an isolated secondary winding of a transformer having a maximum capacity of 100 volt-amperes and an open-circuit secondary-voltage rating not exceeding 1000 volts.

5.8 ISOLATION – Electrical separation between two locations.

5.9 JUNCTION TEMPERATURE – A theoretical temperature based on a simplified representation of the thermal and electrical behavior of a semiconductor device.

5.10 MAXIMUM CASE TEMPERATURE – A specification, usually in the form of a curve of on-state current versus maximum case temperature, that refers to the maximum case temperature of a thyristor with regard to the on-state current. The case is an external point on the thyristor where this temperature is related to the maximum junction temperature for the thyristor.

5.11 NONISOLATED LIMITED-ENERGY LOW-VOLTAGE CIRCUIT (POWER SOURCE) – A circuit derived from a source of supply classified as line-voltage by connecting impedance in series with the supply circuit as a means of limiting the voltage and power to comply with Class 2 characteristics.

5.12 OPPOSITE POLARITY – A difference of potential between two points, where shorting of these two points would result in a condition involving overload, rupturing of printed wiring board tracks, components or fuses, and the like.

5.13 OPTICAL ISOLATOR – A photon-coupled device consisting of a light source and sensor integrated into a single package that provides circuit isolation.

5.14 PILOT DUTY RATING – A rating applied to electromagnetic loads.

5.15 PORTABLE EQUIPMENT – Cord- and plug-connected equipment that is capable of being carried or moved about.

5.16 PRIMARY CIRCUIT – The wiring and components that are conductively connected to the supply circuit.

5.17 PULSE TRANSFORMER – A transformer intended to pass pulse waveforms as distinguished from sine waves.

5.18 SAFETY CIRCUIT – A primary or secondary circuit that contains a control relied upon to reduce the risk of fire, electric shock, or injury to persons at the controlled equipment.

5.19 SAFETY CONTROL – An automatic control and interlock (including relays, switches, and other auxiliary equipment used to form a system) which is intended to reduce the risk of fire, electric shock, or injury to persons.

5.20 SECONDARY CIRCUIT – A circuit supplied from a secondary winding of an isolating transformer.

5.21 STATIONARY EQUIPMENT – Cord- and plug-connected equipment that is intended to be fastened in place, or located in a dedicated space.

5.22 USER SERVICING – Any form of servicing that can be performed by personnel other than those who are trained to maintain the particular equipment is considered user servicing. Some examples of user servicing are:

a) The attachment of accessories by means of attachment plugs and receptacles or by means of other separable connectors.

b) The changing of tapes and the like that do not involve complicated operations.

c) The replacement of recording tapes, disks, program boards, punched cards, or paper forms. Replacement of lamps and fuses and resetting of circuit breakers located in an operator-access area unless the lamps, fuses, or circuit breakers are marked to indicate replacement or resetting only by qualified service personnel.

d) The making of routine operating adjustments necessary to adapt the unit for its different intended functions.

e) Routine cleaning of data-handling media.

CONSTRUCTION

6 General

6.1 An electronic or solid-state circuit used in a back-up, limiting, or other safety control, including controls that require a calibration test, is evaluated on the basis of its compliance with the requirements in this standard. Electronic components shall comply with the requirements for the application.

6.2 A circuit extending from the equipment and intended for connection to a low-voltage Class 2 circuit as defined in the National Electrical Code, ANSI/NFPA 70, shall not involve a potential of more than 30 volts rms (42.4 volts peak) and be supplied by:

a) A primary battery;

b) A standard Class 2 transformer; or

c) A combination of a transformer and a fixed impedance that, as a unit, complies with all the performance requirements for a Class 2 transformer.

6.3 A circuit derived from a line-voltage circuit by connecting resistance in series with the supply circuit as a means of limiting the voltage and current is considered to be a low-voltage circuit when the impedance has been investigated for such use. See Isolating Resistor Evaluation, Section 67.

6.4 The equipment shall use materials that comply with the requirements for the application and shall be made and finished with the degree of uniformity and grade of workmanship practicable in a well-equipped factory.

7 Frame and Enclosure

7.1 General

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

7.1.2 Equipment that complies with the requirements in 7.1.3 – 7.8.6 is considered to comply with 7.1.1.

7.1.3 Electrical parts of the equipment, other than a supply cord or low-voltage terminals, shall be located or enclosed so that the risk of unintentional contact with uninsulated live parts will be reduced.

Exception: An enclosure is not required for equipment intended for field installation within the enclosure of another product provided that:

a) All required markings are provided as specified in Sections 72 – 75 and

b) The temperature, overvoltage and undervoltage tests are conducted with the equipment in a 40 ±2°C (104 ±3.6°F) ambient. See Barriers, Section 37, and the Overvoltage and Undervoltage Tests, Section 43.

7.1.4 Equipment incorporating an air-filtering system or utilizing a tight-fitting enclosure may be subject to an investigation to determine whether it provides the equivalent of a controlled environment.

Exception: A gasketed enclosure is considered to provide an enclosed environment.

7.1.5 An air filter acting as an enclosure part shall comply with the requirements for Class 1 filters as specified in the Standard for Air Filter Units, UL 900. If abnormal tests show that an equivalent flame barrier exists, then an air filter is not considered to be an enclosure part and may be omitted.

7.2 Covers

7.2.1 An enclosure and a part of an enclosure such as a door or cover shall be provided with means for firmly securing it in place.

7.2.2 Sheet-metal screws threading directly into metal shall not be used to attach a cover, door, or other part that is removed to install field wiring or for operation of the equipment. Machine screws and self-tapping machine screws may thread directly into sheet-metal walls. See 18.1.19.

7.2.3 Sheet-metal screws mounting internal components that are not removed for installation or operation may thread directly into metal.

7.2.4 An enclosure cover shall be hinged if it gives access to a fuse or other overcurrent device, the functioning of which requires renewal, or if it is necessary to open the cover in connection with normal operation of the device.

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

a) Supplementary fuses in control circuits, provided the devices and circuit loads are within the same enclosure;

b) Supplementary overcurrent devices rated 2 amperes or less for loads not exceeding 100 volt-amperes;

c) Extractor fuses having an integral enclosure; or

d) Overcurrent devices connected in a low-voltage circuit. See 5.6.

7.2.5 A door or cover giving access to a fuse or thermal cutout in other than a low-voltage circuit shall:

a) Shut closely against a 1/4 inch (6.4 mm) rabbet or the equivalent,

b) Have turned flanges for the full length of four edges, or

c) Have angle strips fastened to it.

Flanges or angle strips shall fit closely with the outside of the walls of the box proper and shall overlap the edges of the box not less than 1/2 inch (12.7 mm). A construction determined to provide equivalent protection or a combination of flange and rabbet may be used. See Figure 7.1 and Figure 7.2.

Figure 7.1

Rabbet

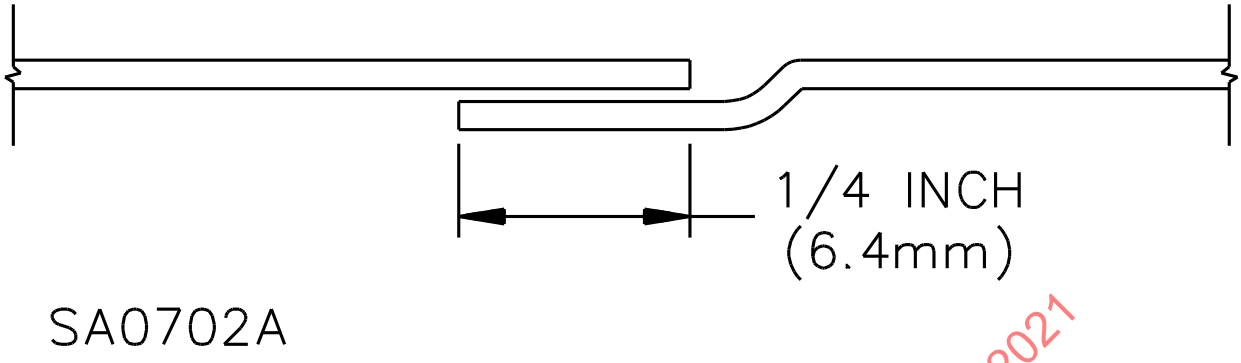
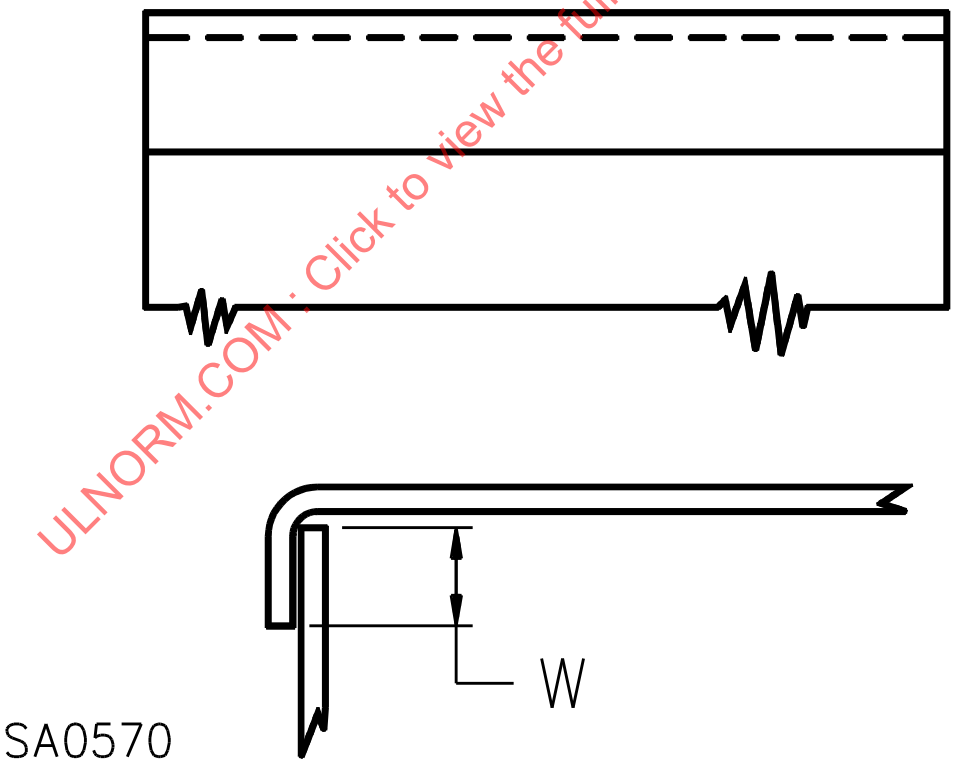


Figure 7.2

Measurement of overlap



7.2.6 A strip used to provide a rabbet and an angle strip fastened to the edges of a door shall be secured at not less than two points, not more than 1-1/2 inches (38.1 mm) from each end of each strip and at points between these end fastenings not more than 6 inches (152 mm) apart.

7.2.7 If a cover is required by 7.2.4 to be hinged, then the cover shall not depend solely upon screws or other similar means requiring the use of a tool to hold it closed, but shall be provided with a spring latch or catch, or a hand operable captive fastener.

7.2.8 A snap-on cover that gives access to bare live parts or film-coated wire and that does not require a tool for removal shall have no apparent means of removal, such as an extending tab, and shall withstand the Cover Retention Test, Section 62.

7.2.9 The continuity of a bonding means for a snap-on or fastener-attached cover shall comply with the requirements in Bonding of Internal Parts, Section 20.

7.3 Transformers

7.3.1 A transformer shall be housed within its own enclosure or within the main enclosure of the equipment, or within a combination of the two.

7.3.2 A sheet-steel transformer enclosure shall have a thickness of at least 0.026 inch (0.66 mm) if uncoated and at least 0.029 inch (0.74 mm) if galvanized.

Exception: Sheet steel having a thickness of at least 0.020 inch (0.51 mm) if uncoated and at least 0.023 inch (0.58 mm) if galvanized may be used for a drawn end bell having maximum dimensions of 2-1/4 inches (57.2 mm) on the flat portion and 1-1/2 inches (38.1 mm) at the base of the drawn portion.

7.3.3 A cast-metal transformer enclosure shall comply with the requirements in 7.4.1. A transformer enclosure of other material shall have the necessary strength and rigidity and otherwise comply with the requirements for the application.

7.4 Cast metal

7.4.1 A cast-metal enclosure shall be at least 1/8 inch (3.2 mm) thick at every point, more than 1/8 inch thick at reinforcing ribs and door edges, and at least 1/4 inch (6.4 mm) thick at tapped holes for conduit.

Exception: Other than at plain or threaded conduit holes, die-cast metal shall be minimum:

a) 3/32 inch (2.4 mm) thick for an area greater than 24 square inches (154.8 cm^2) or having any dimension more than 6 inches (152 mm).

b) 1/16 inch (1.6 mm) thick for an area of 24 square inches or less and having no dimension more than 6 inches. The area limitation may be obtained by the provision of reinforcing ribs subdividing a larger area.

c) 0.035 inch (0.89 mm) thick if the enclosure will not be used as a splice box and if the voltage rating of the complete device is such that the voltage between any two conductors is 250 volts or less and is limited to direct current or single-phase alternating current.

d) 0.028 inch (0.71 mm) thick if the enclosure houses only low-voltage circuits.

7.5 Sheet metal

7.5.1 Other than at points where a wiring system is to be connected, the thickness of a sheet-metal enclosure shall not be less than that specified in Table 7.1 and Table 7.2.

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

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness uncoated,		Minimum thickness metal coated,	
Maximum width,[b]		Maximum length,[c]		Maximum width,[b]		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					
4.75	(12.1)	5.75	(14.6)	6.75	(17.1)	8.25	(21.0)	0.020[d]	(0.51)	0.023[d]	(0.58)
6.0	(15.2)	Not limited		9.5	(24.1)	Not limited					
7.0	(17.8)	8.75	(22.2)	10.0	(25.4)	12.5	(31.8)	0.026[d]	(0.66)	0.029[d]	(0.74)
8.0	(20.3)	Not limited		12.0	(30.5)	Not limited					
9.0	(22.9)	11.5	(29.2)	13.0	(33.0)	16.0	(40.6)	0.032	(0.81)	0.034	(0.86)
12.5	(31.8)	Not limited		19.5	(49.5)	Not limited					
14.0	(35.6)	18.0	(45.7)	21.0	(53.3)	25.0	(63.5)	0.042	(1.07)	0.045	(1.14)
18.0	(45.7)	Not limited		27.0	(68.6)	Not limited					
20.0	(50.8)	25.0	(63.5)	29.0	(73.7)	36.0	(91.4)	0.053	(1.35)	0.056	(1.42)
22.0	(55.9)	Not limited		33.0	(83.8)	Not limited					
25.0	(63.5)	31.0	(78.7)	35.0	(88.9)	43.0	(109.2)	0.060	(1.52)	0.063	(1.60)
25.0	(63.5)	Not limited		39.0	(99.1)	Not limited					
29.0	(73.7)	36.0	(91.4)	41.0	(104.1)	51.0	(129.5)	0.067	(1.70)	0.070	(1.78)
33.0	(83.8)	Not limited		51.0	(129.5)	Not limited					
38.0	(96.5)	47.0	(119.4)	54.0	(137.2)	66.0	(167.6)	0.080	(2.03)	0.084	(2.13)
42.0	(106.7)	Not limited		64.0	(162.6)	Not limited					
47.0	(119.4)	59.0	(149.9)	68.0	(172.7)	84.0	(213.4)	0.093	(2.36)	0.097	(2.46)
52.0	(132.1)	Not limited		80.0	(203.2)	Not limited					
60.0	(152.4)	74.0	(188.0)	84.0	(213.4)	103.0	(261.6)	0.108	(2.74)	0.111	(2.82)
63.0	(160.0)	Not limited		97.0	(246.4)	Not limited					
73.0	(185.4)	90.0	(228.6)	103.0	(261.6)	127.0	(322.6)	0.123	(0.123)	0.126	(3.20)

[a] See 7.5.4 for description of supporting frame and method for accomplishing equivalent reinforcing.

[b] The width is the smaller dimension of a rectangular piece of sheet metal that is part of an enclosure. Adjacent surfaces of an enclosure may have common supports and be made of a single sheet.

[c] Not limited applies only if the edge of the surface is flanged at least 1/2 inch (12.7 mm) or fastened to adjacent surfaces not normally removed in use.

[d] Sheet steel for an enclosure intended for outdoor use – raintight or rainproof – shall not be less than 0.034 inch (0.86 mm) thick if zinc coated and not less 0.032 inch (0.81 mm) thick if uncoated.

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

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]					
Maximum width,[b]		Maximum length,[c]		Maximum width,[b]		Maximum length,		Minimum thickness,	
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	inch	(mm)
3.0	(7.6)	Not limited		7.0	(17.8)	Not limited			
3.5	(8.9)	4.0	(10.2)	8.5	(21.6)	9.5	(24.1)	0.023[d]	(0.58)

Table 7.2 Continued on Next Page

Table 7.2 Continued

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness,	
Maximum width,[b]		Maximum length,[c]		Maximum width,[b]		Maximum length,			
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	inch	(mm)
4.0	(10.2)	Not limited		10.0	(25.4)	Not limited			
5.0	(12.7)	6.0	(15.2)	10.5	(26.7)	13.5	(34.3)	0.029	(0.74)
6.0	(15.2)	Not limited		14.0	(35.6)	Not limited			
6.5	(16.5)	8.0	(20.3)	15.0	(38.1)	18.0	(45.7)	0.036	(0.91)
8.0	(20.3)	Not limited		19.0	(48.3)	Not limited			
9.5	(24.1)	11.5	(29.2)	21.0	(53.3)	25.0	(63.5)	0.045	(1.14)
12.0	(30.5)	Not limited		28.0	(71.1)	Not limited			
14.0	(35.6)	16.0	(40.6)	30.0	(76.2)	37.0	(94.0)	0.058	(1.47)
18.0	(45.7)	Not limited		42.0	(106.7)	Not limited			
20.0	(50.8)	25.0	(63.5)	45.0	(114.3)	55.0	(139.7)	0.075	(1.91)
25.0	(63.5)	Not limited		60.0	(152.4)	Not limited			
29.0	(73.7)	36.0	(91.4)	64.0	(162.6)	78.0	(198.1)	0.095	(2.41)
37.0	(94.0)	Not limited		87.0	(221.0)	Not limited			
42.0	(106.7)	53.0	(134.6)	93.0	(236.2)	114.0	(289.6)	0.122	(3.10)
52.0	(132.1)	Not limited		123.0	(312.4)	Not limited			
60.0	(152.4)	74.0	(188.0)	130.0	(330.2)	160.0	(406.4)	0.153	(3.89)

[a] See 7.5.4 for description of supporting frame and method for accomplishing equivalent reinforcing.

[b] The width is the smaller dimension of a rectangular piece of sheet metal that is part of an enclosure. Adjacent surfaces of an enclosure may have common supports and be made of a single sheet.

[c] Not limited applies only if the edge of the surface is flanged at least 1/2 inch (12.7 mm) or fastened to adjacent surfaces not normally removed in use.

[d] Sheet copper, brass, or aluminum for an enclosure intended for outdoor use – raintight or rainproof – shall not be less than 0.029 inch (0.74 mm) thick.

7.5.2 At points at which a wiring system is to be connected, uncoated steel shall be at least 0.032 inch (0.81 mm) thick, zinc-coated steel shall be at least 0.034 inch (0.86 mm) thick, and nonferrous metal shall be at least 0.045 inch (1.14 mm) thick.

7.5.3 Table 7.1 and Table 7.2 are based on a uniform deflection of the enclosure surface for any given load concentrated at the center of the surface regardless of metal thickness.

7.5.4 With reference to Table 7.1 and Table 7.2, a supporting frame is a structure of angle or channel, or a folded rigid section of sheet metal, that is rigidly attached and has essentially the same outside dimensions as the enclosure surface and sufficient torsional rigidity to resist the bending moments that may be applied via the enclosure surface when it is deflected. Equivalent reinforcing may be accomplished by constructions that will produce a structure that is as rigid as one built with a frame of angles or channels. Constructions considered to be without supporting frame 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.

7.6 Nonmetallic

7.6.1 The requirements in 7.6.2 – 7.6.8 apply to polymeric enclosures.

7.6.2 A nonmetallic enclosure or enclosure part shall have mechanical strength and durability and be formed so that operating parts will be protected against damage and shall resist the abuses likely to be encountered during installation and normal use and service.

7.6.3 An enclosure or enclosure part shall protect persons against a risk of electric shock, and the material shall not create or contribute to a risk of fire, electric shock, or injury to persons.

7.6.4 Among the factors that are to be taken into consideration when judging a nonmetallic enclosure are:

a) Mechanical strength;

b) Resistance to impact;

c) Moisture absorption;

d) Resistance to combustion and to ignition from electrical sources;

e) Dielectric properties, insulation resistance, and resistance to arc tracking; and

f) Resistance to distortion and creeping at temperatures to which the material may be subjected under conditions of normal or abnormal use.

A material shall not display a loss of these properties beyond the minimum required level as a result of aging. Tests on nonmetallic enclosures for stationary equipment and equipment intended to be permanently connected electrically shall be conducted in accordance with Sections 81 – 96.

7.6.5 Enclosures for portable equipment shall be evaluated in accordance with the applicable requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

7.6.6 A polymeric enclosure intended for connection to a permanent wiring system shall withstand the tests described in 61.1.1 – 61.1.6.

7.6.7 If continuity of a grounding system relies on dimensional integrity of a nonmetallic material, the dimensional stability of the material shall be considered in addition to the factors mentioned in 7.6.4. The material shall withstand the Creep and Overcurrent Test, Section 96.

7.6.8 If a bonding means is not assembled to the equipment, the equipment shall be marked in accordance with 75.7.

7.6.9 A part, such as a dial or nameplate, that is a part of an enclosure shall be metal or other material as specified for the enclosure in 7.4.1 – 7.6.4.

7.6.10 A nonmetallic part, such as a reset knob, lever, or button that protrudes through a hole in the enclosure that is not larger than an area of 1 square inch (6.45 cm^2) shall be made of material classified V-2 or better in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

7.6.11 A nonmetallic part that protrudes through a hole having an area larger than 1 square inch (6.45 cm^2) shall be made of material that complies with the requirements in 7.6.2 – 7.6.4 and 7.6.9. See 8.2.1.

7.6.12 A nonmetallic cover attached by screws shall comply with the Cover Retention Test, Section 62, with the screws loosened one full turn.

7.6.13 Electrical controls employing polymeric parts that are intended to be installed in air handling spaces or in other environmental air space (plenums) shall be investigated for the application and their fire-resistance and low-smoke-producing characteristics in accordance with the Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces, UL 2043.

7.7 Windows

7.7.1 Glass covering an observation opening shall be secured in place so that it cannot be readily displaced in service, and shall provide mechanical protection for the enclosed parts.

7.7.2 Glass for an opening not more than 4 inches (101.6 mm) in any dimension shall be at least 1/16 inch (1.6 mm) thick, and glass for a larger opening, but not more than 144 square inches (929 cm^2) in area and having no dimension greater than 12 inches (304.8 mm), shall be at least 1/8 inch (3.2 mm) thick. Glass used to cover an area larger than 144 square inches shall not be less than 1/8 inch thick and shall conform to one of the following:

a) The glass shall be of a nonshattering or tempered type that, when broken, shall conform to the performance specifications in the Performance Specifications and Methods of Test for Safety Glazing Material Used in Buildings, ANSI Z97.1-1975; or

b) Shall withstand the 2.5 foot-pound (2.4 J) impact specified in the Glass Window Impact Test, Section 64.

7.7.3 A transparent material other than glass used as a covering over an opening in an enclosure shall comply with the requirements in 7.6.2 – 7.6.4 and 7.6.9 – 7.6.12.

7.8 Raintight and rainproof enclosures

7.8.1 When subjected to the Rain Test, Section 60, an enclosure designated as:

a) Raintight shall be constructed so that rain does not enter the enclosure.

b) Rainproof shall be constructed so that rain does not interfere with the operation of the apparatus used within the enclosure.

7.8.2 A raintight or rainproof enclosure shall be marked as specified in 72.7.

7.8.3 A gasket used to make an enclosure raintight or rainproof shall be tested as specified in the Accelerated Aging Tests, Section 58.

7.8.4 A raintight or rainproof enclosure shall be provided with external means for mounting.

Exception: A rainproof enclosure may be provided with internal means for mounting if the mounting means is constructed so that water cannot enter the enclosure.

7.8.5 An opening for conduit in a raintight enclosure, other than in the bottom of the enclosure, shall either be threaded, or accommodate a specific hub complying with the requirements for such devices.

7.8.6 An opening for conduit in a rainproof enclosure shall either:

a) Be threaded or

b) Accommodate a specific hub complying with the requirements for such devices unless the opening is located wholly below the lowest terminal lug or other live part within the enclosure. There shall be provision for drainage of the enclosure if a knockout or unthreaded hole is provided other than in the bottom.

8 Openings in Enclosures

8.1 Ventilating openings

8.1.1 A ventilating opening shall not be provided in an enclosure that houses a fuse or any portion of a circuit breaker other than the operating handle, unless the construction affords containment of electrical breakdown disturbances equivalent to that provided by an enclosure complying with the requirements in 7.2.5 – 7.2.7.

8.1.2 A ventilating opening shall not be provided in a compartment or part of an enclosure that contains field-wiring splices in a line-voltage circuit.

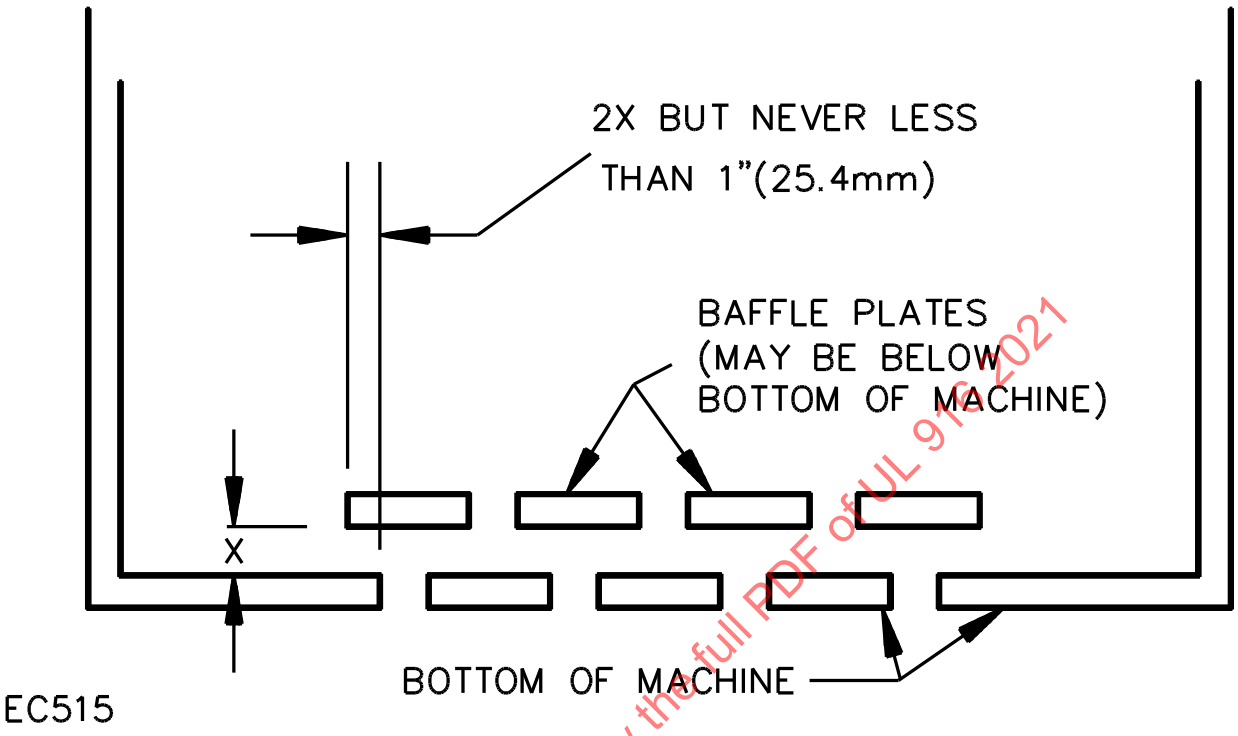
8.1.3 A ventilating opening shall not be located in a mounting surface of an enclosure.

8.1.4 The shortest distance between a ventilating opening and the bottom of an enclosure or a wall-mounting surface shall be at least one-quarter of the enclosure height or depth, respectively, or 1 inch (25.4 mm), whichever is less.

8.1.5 A ventilating opening may be provided in the bottom surface of an enclosure if the opening does not permit materials to fall directly out from the interior of the unit. Figure 8.1 illustrates a construction that meets this requirement.

Figure 8.1

Bottom panel baffles



8.1.6 There shall be no emission of flame or molten material through a ventilating opening, or manifestation of risk of fire, during normal tests or during abnormal tests, such as transformer burnout and burnout of a relay with blocked armature.

8.1.7 Unless the construction of equipment provided with forced ventilation is such that there is no direct path between live parts and the outlet opening, burnout tests in addition to those mentioned in 8.1.6 shall be conducted to determine that there is no emission of flame or molten material through that opening.

8.1.8 Air from a ventilating opening, either forced or otherwise, shall not be directed:

a) Into a duct or into a concealed space in a building,

b) Against the mounting surface, and

c) So that a disturbance may be propagated to other equipment.

8.1.9 See Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts, Section 12, for requirements for accessibility of live parts in an enclosure having ventilating openings.

8.2 Other openings

8.2.1 The smaller dimension (width) of an opening in an enclosure around a dial, adjusting knob, lever, handle, pointer, or the like shall not be more than 1/8 inch (3.2 mm) for any setting or position of the dial, knob, or other members.

8.2.2 Except for the openings described in 8.1.1 – 8.1.7, an enclosure shall have no open holes other than:

a) Not more than four unused holes intended for mounting various components inside the enclosure. The largest dimension of each such opening shall not be more than 3/16 inch (4.8 mm).

b) Not more than four holes 1/8 inch (3.2 mm) or less in diameter for the escape of air or drainage of paint during a painting process, located as close to the corners of the enclosure as possible, preferably at the rear of the enclosure.

c) A drainage opening in a rainproof enclosure that shall not exceed 1/4 by 1/4 inch (6.4 by 6.4 mm).

d) Not more than:

1) Four holes for mounting an enclosure having a maximum dimension of 18 inches (457 mm);

2) Six holes for an enclosure with a maximum dimension more than 18 inches but less than 48 inches (1.2 m); and

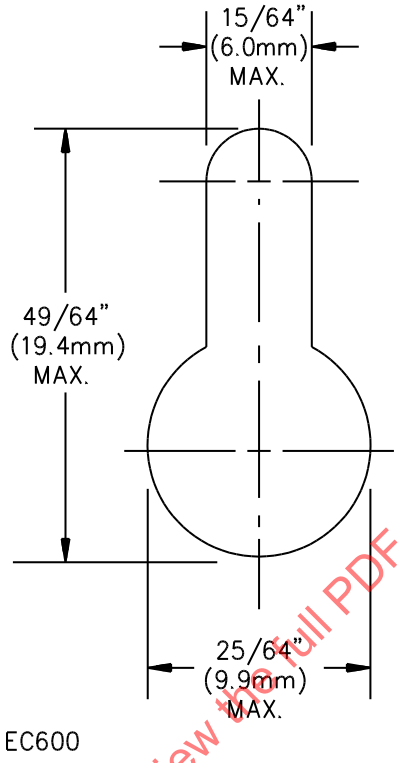
3) Eight holes for an enclosure with a maximum dimension of 48 inches or more.

Four of the holes for mounting an enclosure with a maximum dimension of 12 inches (305 mm) may be keyhole slots having the configuration illustrated in Figure 8.2. The dimensions specified in Figure 8.2 may vary if the area is equivalent. Four of the holes for mounting a larger enclosure may be keyhole slots, the dimensions of which are not specified, and which will be evaluated with regard to the enclosure dimensions and configurations.

e) The unclosed portion of an opening for passage of a capillary tube, an air pipe, a bellows, or other necessary mechanism, which shall not exceed 1/16 inch (1.6 mm).

Figure 8.2

Keyhole slot



8.2.3 A plate or plug for an unused conduit opening or other hole in an enclosure shall have a thickness not less than:

a) 0.014 inch (0.36 mm) for steel or 0.019 inch (0.48 mm) for nonferrous metal for a hole having a 1/4 inch (6.35 mm) maximum dimension and

b) 0.027 inch (0.69 mm) for steel or 0.032 inch (0.81 mm) for nonferrous metal for a hole having a 1-3/8 inch (34.9 mm) maximum dimension. A closure for a larger hole shall have a thickness equal to that required for the enclosure of the equipment, or a standard knockout seal shall be used.

Such a plate or plug shall be securely mounted.

8.3 Screens and expanded metal

8.3.1 The wires of a screen shall not be less than 16 AWG (1.3 mm^2) if used in openings 1/2 square inch (3.2 cm^2) or less in area, and shall not be less than 12 AWG (3.3 mm^2) for larger openings.

8.3.2 Perforated sheet steel and sheet steel employed for expanded metal mesh shall not be less than 0.042 inch (1.07 mm) thick – 0.045 inch (1.14 mm) if zinc coated – for mesh openings or perforations 1/2 square inch (3.2 cm^2) or less in area and shall not be less than 0.080 inch (2.03 mm) thick – 0.084 inch (2.13 mm) if zinc coated – for larger openings.

Exception: Expanded metal mesh that complies with the requirements in 8.3.3 may be used.

8.3.3 In small equipment where the indentation of a guard or enclosure will not alter the clearance between uninsulated, movable, current-carrying parts and grounded metal so as to adversely affect

performance or reduce spacings below the minimum values specified in Table 29.1, 0.020 inch (0.51 mm) expanded metal mesh – 0.023 inch (0.58 mm) if zinc coated – may be used, if:

a) The exposed mesh on any one side or surface of the device so protected has an area of not more than 72 square inches (464.5 cm^2) and has no dimension greater than 12 inches (305 mm) or

b) The width of an opening so protected is not greater than 3-1/2 inches (88.9 mm).

8.4 Wire openings

8.4.1 If threads for the connection of conduit are tapped all the way through a hole in an enclosure wall, or if an equivalent construction is used, there shall not be less than three threads in the metal, and the construction of the equipment shall be such that a conduit bushing can be attached.

8.4.2 If threads for the connection of conduit are not tapped all the way through a hole in:

a) An enclosure wall,

b) Conduit hub, or

c) A similar part,

there shall not be less than 3-1/2 threads in the metal and there shall be a smooth, rounded inlet hole for the conductors that affords protection to the conductors equivalent to that provided by a standard conduit bushing and that has an internal diameter approximately the same as that of the corresponding trade size of rigid conduit.

8.4.3 In an enclosure threaded for support by rigid conduit, at least five full threads shall be provided for engaging the conduit.

8.4.4 A conduit hub or nipple attached to the enclosure of a pressure switch or similar equipment by swaging, staking, or similar means shall withstand the pullout, torque, and bending tests described in 61.1.2 – 61.1.4.

8.4.5 Equipment provided with a conduit nipple and no mounting holes, and marked for direct attachment to an outlet box, need not be subjected to the torque, bending moment, and pull tests, but shall withstand the impact specified in 61.1.6.

Exception: A metallic enclosure with a welded-on nipple need not be subjected to the test described in 61.1.6.

8.4.6 Each clamp and fastener for the attachment of:

a) Conduit;

b) Electrical metallic tubing;

c) Armored cable;

d) Nonmetallic flexible tubing;

e) Nonmetallic-sheathed cable;

f) Service cable; or

g) Similar items

that is supplied as a part of an enclosure shall comply with the requirements in the Standard for Conduit, Tubing, and Cable Fittings, UL 514B.

8.4.7 A knockout in a sheet-metal enclosure shall be reliably secured but shall be capable of being removed without undue deformation of the enclosure.

8.4.8 A knockout shall be provided with a flat surrounding surface for proper seating of a conduit bushing, and shall be located so that installation of a bushing at any knockout likely to be used during installation will not result in a spacing between uninsulated live parts and the bushing less than that required by this standard.

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

8.4.10 With regard to the requirement in 8.4.9, means shall be provided so that an opening for conduit can be made without subjecting internal parts to contamination resulting from the presence of metallic particles.

8.4.11 In measuring a spacing between an uninsulated live part and a bushing installed in the knockout referred to in 8.4.8 and 8.4.9, it is to be assumed that a bushing having the dimensions in Table 8.1 is in place, and that a single locknut is installed on the outside of the enclosure.

8.4.12 No wire other than wires leading to a part mounted on a door or cover shall be brought out through the door or cover.

Table 8.1
Dimensions of bushings

Trade size of conduit, inches	Overall diameter, inches	(mm)	Height, inches	(mm)
1/2	1	(25.4)	3/8	(9.5)
3/4	1-15/64	(31.4)	27/64	(10.7)
1	1-19/32	(40.5)	33/64	(13.1)
1-1/4	1-15/16	(49.2)	9/16	(14.3)
1-1/2	2-13/64	(56.0)	19/32	(15.1)
2	2-45/64	(68.7)	5/8	(15.9)
2-1/2	3-7/32	(81.8)	3/4	(19.1)
3	3-7/8	(98.4)	13/16	(20.6)
3-1/2	4-7/16	(112.7)	15/16	(23.8)
4	4-31/32	(126.2)	1	(25.4)
4-1/2	5-35/64	(140.9)	1-1/16	(27.0)
5	6-7/32	(158.0)	1-3/16	(30.2)
6	7-7/32	(183.4)	1-1/4	(31.8)

9 Mounting

9.1 Equipment that is intended to be fastened in place shall have provision for mounting it securely in position. Bolts, screws, or other parts used for mounting the equipment shall be independent of those used to secure components of the equipment to the frame, base, or panel.

9.2 Portable equipment shall not be provided with means for permanent mounting.

10 Mechanical Assembly

10.1 A control switch, lampholder, attachment-plug receptacle, or plug connector provided as a part of the equipment shall be mounted securely and shall be prevented from turning by means other than friction between surfaces.

10.2 A lock washer, applied as intended, may be used to prevent a control switch from turning.

10.3 The equipment shall be assembled in accordance with 10.4 – 10.6 so that it will not be adversely affected by the vibration of normal operation.

10.4 Screws and nuts that attach operating parts to movable members shall be upset or otherwise locked to prevent loosening under the conditions of actual use.

10.5 An uninsulated live part, including a terminal, shall be secured to its supporting surface by a means other than friction between surfaces so that it will be prevented from turning or shifting in position if such motion may result in reduction of spacings to less than those required by this standard. Contact assemblies shall be secured so as to provide continued alignment of contacts.

10.6 A lock washer, applied as intended, may be used at a terminal or connection stud.

11 Operating Mechanism

11.1 The equipment shall be investigated under conditions of actual service to determine if it complies with all applicable requirements.

11.2 For equipment using electronic or solid-state components or circuits to control a motor, solenoid coil, or other inductive load, it shall be determined that the controlled load will not be caused to overheat due to half-waving or wave distortion of the controller output. This may be accomplished by testing the combination in accordance with 48.2.1, by incorporating protective devices into the controller, or by other equivalent means.

11.3 An operating mechanism shall not subject manually-operated switch parts to undue stress.

11.4 The position of an operating handle shall be marked, if necessary, as a guide for proper operation.

11.5 A control that has or is intended to have a marked off position or an implied off position shall:

a) Open all ungrounded conductors of the circuit with an air gap when the adjusting means is in the off position and

b) Be prevented from functioning automatically when in the off position either by a positive mechanical means or the equivalent.