Where leads are to be run through a strain relief, hub, nipple, tubing or conduit, insulation shall be suitable for raceway installation.

g) Lead color

Green coloring, with or without one or more yellow stripes shall be used only for bonding/grounding conductors. White or gray shall be used only for grounded (identified) conductors). Colors other than indicated above may be used for conductors other than grounding and grounded.

h) Solder shall not be relied upon to be the only means of securement for leads.

Table 8.1
Minimum size of leads

Lead rating (A)	Leads	
	AWG	(mm^2)
0 – 6	18	(0.82)
6.1 – 10	16	(1.3)
10.1 – 15	14	(2.1)
15.1 – 20	12	(3.3)

8.1.2 Lead sizes smaller than the ones shown in Table 8.1 are permitted if in compliance with the Temperature Test in Clause 22 and marking requirements in Table 42.1, item 26, but shall not be smaller than 18 AWG.

8.1.3 For a unit provided with field-wiring terminals, a field-wiring terminal shall be rated for the application. The terminal shall be rated for connection of a conductor as follows:

a) A terminal intended to conduct 12 A or less shall be rated for connection of a 14 AWG (2.1 mm^2) minimum supply conductor; and

b) A terminal intended to conduct more than 12 A and up to 20 A shall be rated for connection of a 12 AWG (3.3 mm^2) minimum supply conductor.

8.1.4 A terminal connector shall be prevented from moving so as to strain factory connections or reduce spacings to unacceptable values. Friction alone is not acceptable to prevent such movement.

8.1.5 Terminal parts by which connections are made shall maintain connections even under hard usage. For 8 AWG (8.4 mm^2) and larger wires, pressure wire connectors shall be used. For 10 AWG (5.3 mm^2) and smaller wires, the parts to which the wiring connections are made may consist of clamps or binding screws with terminal plates having upturned lugs or the equivalent to hold the wires in position.

8.1.6 A wiring terminal shall be prevented from turning.

8.1.7 A wire-binding screw to which field-wiring connections are made shall not be smaller than No. 8 (4.2 diameter) except that a No. 6 (3.5 mm diameter) screw may be used for a terminal to which only 14 AWG (2.1 mm^2) wire would be connected.

8.1.8 A terminal plate tapped for a wire-binding screw shall be of metal not less than 1.27 mm (0.050 in) thick and shall have not less than two full threads in the metal. A plate less than 1.27 mm (0.050 in) but not less than 0.76 mm (0.030 in) thick may be acceptable if the tapped threads have appropriate mechanical strength.

8.1.9 A terminal plate formed from stock having the minimum required thickness, as specified in 8.1.8, may have the metal extruded at the tapped hole for the binding screw so as to provide two full threads.

8.1.10 A wire-binding screw shall thread into metal.

8.1.11 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 be no less than three threads in the metal, and the construction of the unit shall be such that a conduit bushing can be attached as intended.

8.1.12 Unplated iron or steel shall not be used for wire-binding screws and terminals. Stainless steel, or steel that is protected against corrosion by zinc plating or the equivalent coating may be used, if the steel parts are not depended upon to carry current.

8.2 Outlet-box-mounted units

8.2.1 In addition to the requirements in 8.1.1 – 8.1.12, an outlet-box-mounted unit shall comply with 8.2.2 – 8.2.5.

8.2.2 Wiring terminals and other live parts and sharp-edged grounded or dead metal parts of a unit intended for mounting on an outlet box or similar enclosure shall be located or protected so that they will not be forced against wiring in the box during installation.

8.2.3 With reference to 8.2.2, back wiring terminals may be employed if they are recessed or are protected by close-fitting barriers of insulating material or the equivalent so that contact with wiring installed in the box will not occur.

8.2.4 Terminals that do not project into a box beyond the plane of the front edge of the box are acceptable.

8.2.5 With reference to 8.2.3, guards provided alongside terminals and extending at least 6.4 mm (1/4 in) beyond the terminals before wiring, with a corresponding guard between double-pole switching mechanisms, are acceptable.

8.3 Cord-connected or direct plug-in units

8.3.1 A cord-connected unit shall be provided with a multi-conductor flexible cord or cable. The cord or cable shall:

a) Be sized in accordance with Table 8.3 corresponding to the electrical rating of the equipment but shall not be smaller than 18 AWG (0.82 mm^2). Higher ampacities shall not be used unless the cord and product assembly has been tested and complies with Clause 22, Temperature Test. Temperature measurements of the cord, and adjacent components shall be monitored to demonstrate that they do not exceed their thermal ratings.

b) If the unit is intended for indoor use only, the cord or cable shall be rated ″Not Hard″ usage with an overall insulation thickness of 1.14 mm (0.45 in) or greater (such as Type SPT-2 cord), or ″Hard usage″ or ″Extra hard usage″ and shall be rated for the conditions of use.

c) If the unit is intended for outdoor use, the cord or cable shall be rated for ″Hard usage″ or ″Extra hard usage″ and for the conditions of use. The outdoor-use cord or cable shall be marked in accordance with Table 42.1, ref 27.

d) Be provided with strain-relief that complies with 35.1.

Table 8.3
Sizing of flexible supply cords and cables

Wire size, AWG (mm^2)	Three conductor cord[a], amp	Two conductor cord[b], amp
18 (0.82)	0 – 7	0 – 10
16 (1.3)	10	13
14 (2.1)	15	18
12 (3.3)	20	25

[a] Maximum current for supply cords with 3 current carrying conductors.
[b] Maximum current for supply cords with 2 current carrying conductors.

8.3.2 An attachment plug for a cord-connected or direct plug-in unit shall be a 3-wire, bonding/grounding type or a 2-wire, polarized type and shall comply with the Standard for Attachment Plugs and Receptacles, UL 498, CSA C22.2 No. 42, or NMX-J-412-ANCE. The ampere rating of the attachment plug shall not be less than 125 % of the ampere rating of the unit.

8.4 Receptacles Incorporated in Equipment

8.4.1 A receptacle shall comply with the Standard for Attachment Plugs and Receptacles, UL 498, CSA C22.2 No. 42, and NMX-J–412.

8.4.2 The bonding/grounding contact of the receptacle shall be electrically connected to dead metal that will be grounded when the unit is in use.

8.4.3 The face of a receptacle shall:

a) Be flush with or project beyond a nonconductive surrounding surface; or

b) Project at least 0.38 mm (0.015 in) beyond a conductive surrounding surface.

8.4.4 A receptacle provided onto portable equipment shall have the same voltage and current rating as the attachment plug.

8.4.5 A bonding/grounding type receptacle shall only be permitted if the attachment plug is of the bonding/grounding type.

8.4.6 A receptacle of the 5-15R configuration shall be permitted if the attachment plug is of the 5-20P configuration.

8.4.7 A receptacle of the 1-15R configuration shall be permitted if the attachment plug is of the 1-15P, 5-15P or 5-20P configurations.

8.5 Direct Plug-in

8.5.1 Outlets on direct plug-in devices shall comply with the requirements in 8.4.

8.5.2 The moment, center of gravity, and dimensions of a direct plug-in unit, see Figure 8.1, shall comply with each of the following:

a) The quotient of WY/Z shall not exceed 1.36 kg (48 oz);

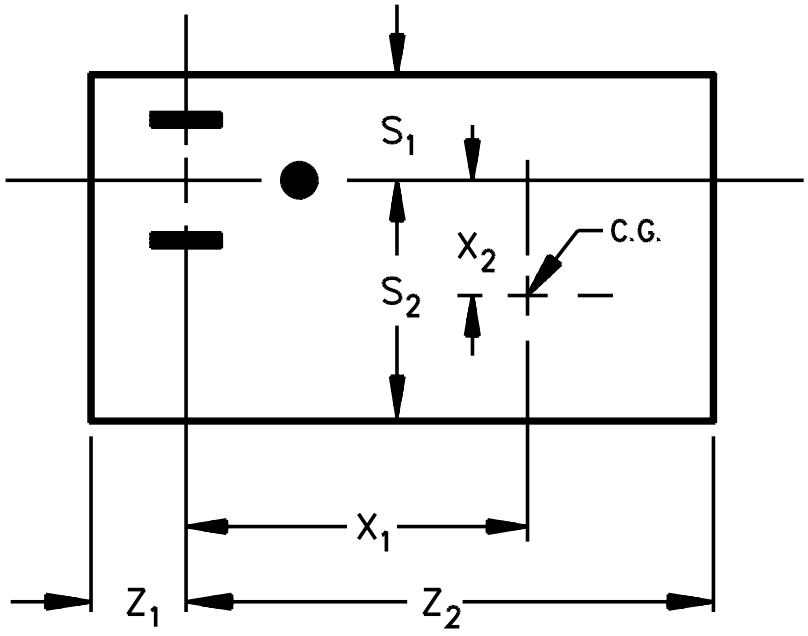
b) The quotient of WY/S shall not exceed 1.36 kg (48 oz);

c) The product of WX shall not exceed 0.56 N·m (80 oz-in);

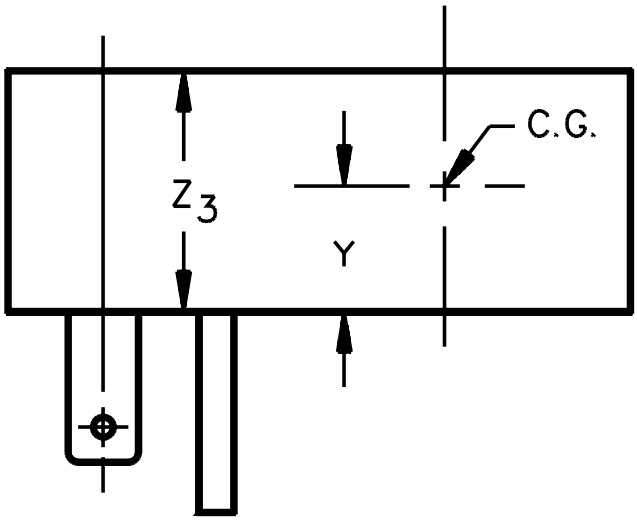
d) The dimension Z3 shall not exceed 82.6 mm (3-1/4 in); and

e) The dimensions S_1, S_2, Z_1, and Z_2 shall not exceed 127 mm (5 in).

Figure 8.1
Plug-in limits of dimensions



FRONT VIEW



SIDE VIEW

C.G. = Center of Gravity

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8.5.3 Definitions for the symbols used in 8.5.2 are as follows:

a) W is the weight of the unit in kg (oz);

b) Y is in mm (inches);

c) Z is the smaller of Z_1 or Z_2 in mm (inches);

d) S is the smaller of S_1 or S_2 in mm (inches); and

e) X is the larger of X_1 or X_2 in mm (inches).

8.6 Strain relief

8.6.1 Strain relief shall be provided so that mechanical stress on a flexible supply cord will not be transmitted to terminals, splices, or interior wiring.

8.6.2 A strain-relief device shall be subjected to the test described in Clause 35, Strain Relief and Lead Securement Tests.

8.6.3 A surface, against which a knot in a flexible cord that serves as strain relief may bear or which a flexible cord may contact, shall be free from projections, sharp edges, burrs, fins, and similar formations, that may abrade the insulation on conductors.

8.7 Bushings

8.7.1 Where a flexible cord passes or is intended to pass through an opening in a wall, barrier, or enclosing case, there shall be a substantial bushing or the equivalent that is reliably secured in place, and has a smoothly rounded surface against which the cord may bear. An insulating bushing shall be provided for a cord lighter than Type SJ that passes through a wall or barrier of metal if the construction is such that the cord may be subjected to stress or motion.

8.7.2 A cord hole with a smoothly rounded surface through wood, porcelain, phenolic composition, or other acceptable nonconductive material, is considered to be the equivalent of a bushing.

8.7.3 A soft-rubber bushing shall not be less than 1.2 mm (3/64 in) thick and shall be located so that it will not be exposed to oil, grease, oily vapor, or other substance having a deleterious effect on rubber. A hole in metal in which a soft-rubber bushing is employed shall be free from sharp edges, burrs, projections, and similar formations, that may cut into the rubber.

8.7.4 Insulating material in an insulated metal grommet employed in lieu of an insulating bushing shall not be less than 0.8 mm (1/32 in) thick and shall completely fill the space between the grommet and the metal in which it is mounted.

9 Bonding/Grounding

9.1 There shall be provision for bonding/grounding all dead metal parts that are exposed or that are likely to be touched by a person during normal operation or adjustment and that are likely to become energized through electrical malfunction.

9.2 To determine whether a part is likely to become energized, such factors as construction, the proximity of wiring, a dielectric voltage-withstand test conducted after the appropriate overload, endurance, and burnout tests shall be evaluated.

9.3 With respect to 9.1, a means for connection to an equipment bonding/grounding conductor for a permanently connected unit shall be provided by an uninsulated copper wire, an insulated wire (see 8.1.1), or a bonding/grounding terminal. A bonding/grounding terminal may be a wire-binding screw if the construction complies with 8.1.6 – 8.1.12. For a 3-wire cord-connected unit, equipment bonding/grounding shall be provided by the equipment bonding/grounding conductor in the flexible cord, and the bonding/grounding pin of a bonding/grounding attachment plug.

9.4 A terminal intended for the connection of an equipment bonding/grounding conductor shall be identified by:

a) Use of a wire-binding screw with a green-colored head that is hexagonal or slotted, or both;

b) Use of a threaded stud with a green-colored hexagonal nut;

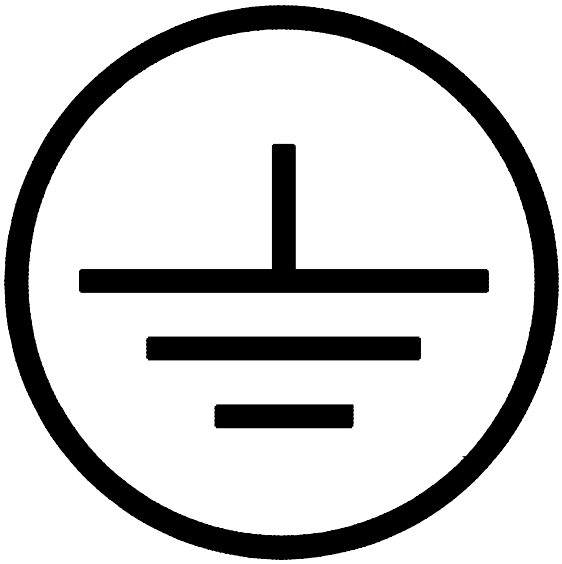
c) Use of a green-colored pressure terminal connector;

d) Being marked ″G,″ ″GR,″ ″GND,″ ″Ground,″ ″Grounding,″ or the like;

e) A marking on a wiring diagram provided on the product; or

f) The bonding/grounding symbol shown in Figure 9.1 (IEC Publication 417, Symbol No. 5019) on or adjacent to the terminal or on a wiring diagram provided on the product.

Figure 9.1
Grounding symbol



IEC417, Symbol 5019

9.5 The bonding/grounding terminal shall be provided with upturned lugs, a cupped washer, or the equivalent capable of retaining a 14 AWG (2.1 mm^2) or larger solid conductor, based on the product's rating, even though the screw or nut may become slightly loose.

9.6 A flush-type unit intended for mounting in a flush-device box shall be so constructed that a metal faceplate will be bonded to ground when installed in the intended manner.

9.7 Bonding/Grounding lead requirements

9.7.1 The size of a bonding/grounding lead shall be:

a) In accordance with Table 8.1 but not less than the size of the supply or load conductor; or

b) Of a size in compliance with the tests in 30.2.

9.8 Bonding/Grounding lead securement

9.8.1 A bonding/grounding lead smaller than 18 AWG (0.824 mm^2) shall comply with the test in 30.2.

10 Current-Carrying Parts

10.1 Current-carrying parts shall have appropriate mechanical strength and ampacity for the intended use and shall be of metal that has been investigated and found acceptable for the application.

10.2 Uninsulated live parts shall be prevented from turning or shifting in position by methods other than friction between surfaces if such motion may result in reduction of spacings to less than as indicated in 12.1. A properly applied lock washer may be acceptable.

10.3 The security of contact assemblies shall be such that the alignment of contacts will be maintained.

11 Internal Wiring

11.1 Internal wiring shall consist of general use wire, or appliance wiring material that has been investigated and found acceptable for the application, when considered with respect to the temperature, voltage, and conditions of service to which the wiring is likely to be subjected.

11.2 Internal wiring shall be supported or routed so that contact with moving parts or parts having sharp edges or burrs, that may cause abrasion of conductor insulation, will not be likely.

11.3 A bare conductor, including leads and coil leads, shall be supported so that the spacings specified in 12.1 will be maintained.

11.4 All joints and connections shall be mechanically secure and shall provide positive contact without strain on connections and terminals.

11.5 A splice shall be provided with insulation equivalent to the voltage of the circuits for the wires involved.

11.6 Aluminum conductors, insulated or uninsulated, used as internal wiring, such as for interconnection between current-carrying parts or as motor windings, shall be terminated at each end by a method acceptable for the combination of metals involved at the connection point.

11.7 With reference to 11.6, a wire-binding screw or a pressure wire connector used as a terminating device shall be acceptable for use with aluminum under the conditions involved – for example, temperature, heat cycling, vibration, and similar conditions.

12 Spacings

12.1 Spacings between any uninsulated live part and an uninsulated live part of opposite polarity or an accessible or grounded dead metal part other than the enclosure, shall be not less than 1.6 mm (1/16 in) for 0 – 300V, and 3.2 mm (1/8 in) for 301 – 600V, through air and over surface. Spacing between any uninsulated live parts and the enclosure shall be not less than 6.4 mm (1/4 in) through air and over surface.

12.2 Insulating material used in lieu of the required spacing through air shall be of a type that has been investigated and found to be acceptable for sole support of live parts and shall not be less than 0.71 mm (0.028 in) thick.

12.3 Insulating material not less than 0.13 mm (0.005 in) and of appropriate mechanical strength for the application is acceptable in heater-bimetal constructions if:

a) The insulating material is not subjected to temperatures greater than its established temperature limit under all conditions of operation; and

b) The insulating material withstands the Dielectric Voltage-Withstand Test, Clause 23.

13 Alternate Spacings – Clearances and Creepage Distances

13.1 As an alternative to the requirements in Spacings, Clause 12, the following shall be applied:

a) Class 2 Isolated transformer output: no spacing requirements are needed.

b) Alternate spacings based on the Standard for UL 840/CSA 22.2 No. 0.2 Insulation coordination. See 13.2.

c) Alternate Spacings based Limited power point determination (15W or 50W) see 13.4.

d) Abnormal PWB trace faults. See 13.5.

13.2 The spacing requirements in Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840/CSA 22.2 No. 0.2, shall not be used for spacings between field wiring terminals, or between uninsulated live parts and a metal enclosure.

13.3 The spacing requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840/CSA 22.2 No. 0.2 shall be amended as follows:

Surge protective devices or systems rated above 120V nominal are permitted to have Maximum Continuous Operating Voltage (MCOV) equal to or greater than the line-to-neutral voltage.

13.4 Limited power point determination

13.4.1 Spacings within a portion of a circuit or within the entire circuit, less than the specified values required in Clause 12, Spacings, are allowed when the tests of 13.3, as applicable, are completed with compliant results.

13.4.2 The device shall be tested under the following conditions:

a) Supplied by rated branch circuit protection at the rated voltage and frequency;

b) Metal parts are connected to ground through a ground arc indicating fuse;

c) On a soft wood surface covered with white tissue paper;

d) By a single layer of cheesecloth;

e) Adjusted to all possible operation settings; and

f) If a user replaceable fuse in the device opens during the test, the fuse shall be shorted so that it cannot open and the test repeated.

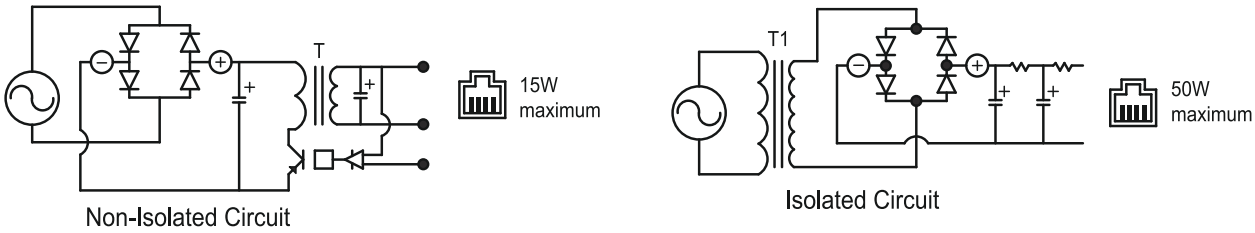
13.4.3 The maximum permitted wattage under normal operation shall be determined to be less than either (a) or (b):

a) 15W – Circuits supplied from non- isolated sources.

b) 50W – Circuits supplied from Isolated sources.

Note: Isolation is determined by dielectrics and examination of the circuit. Transformers with bridging components are not considered to be isolating unless the components are evaluated for the purpose such as opto-isolators or capacitors with reinforced isolation.

Figure 13.1
Examples of typical non-isolated and isolated circuits



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13.4.4 The location where the limited wattage begins shall be determined using the method below.

a) Starting at the input to the circuit, the maximum wattage available to the limited circuit under consideration shall be measured by connecting a variable resistive load between the load side point of each component in line with the source and the supply return. The variable resistance shall be adjusted, beginning with a maximum resistance, down to a short circuit to determine if the component will maintain no greater than the required maximum watts (15W or 50W) as measured by a wattmeter. Each component capable of maintaining the required watts or higher for a period of 5 seconds shall be identified as a critical primary circuit component.