

UL916

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for
Energy Management Equipment, UL 916

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A change is indicated by a note following the affected item. The note is preceded and followed by an asterisk.

The requirements are substantially in accordance with UL's Announcement Bulletin on this subject dated November 18, 1996. The bulletin is now obsolete and may be discarded.

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

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CANADIAN REQUIREMENTS COMPARISON GUIDE

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FOREWORD

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product employing materials or having forms of construction differing from those detailed in the requirements of this Standard may be examined and tested according to the intent of the requirements and, if found to be substantially equivalent, may be judged to comply with the Standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

6.1.8 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.

6.1.9 See Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts, Section 10, for requirements for accessibility of live parts in an enclosure having ventilating openings.

6.2 Other openings

6.2.1 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.

6.2.2 Except for the openings described in 6.1.1 – 6.1.7 and 6.2.1, 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 (4.8mm).
- 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 four holes for mounting an enclosure having a maximum dimension of 18 inches (457 mm), six holes for an enclosure with a maximum dimension more than 18 inches, but less than 48 inches (1.2 m); 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 6.2. The dimensions specified in Figure 6.2 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 judged with respect 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).

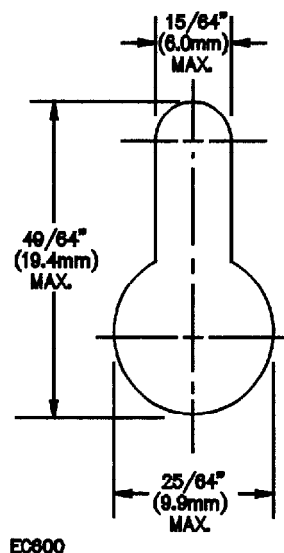
6.2.3 A plate or plug for an unused conduit opening or other hole in an enclosure shall have a thickness not less than:

- 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.

Figure 6.2
Keyhole slot



6.3 Screens and expanded metal

6.3.1 The wires of a screen shall not be less than No. 16 AWG (1.3 mm²) if used in openings 1/2 square inch (3.2 cm²) or less in area, and shall not be less than No. 12 AWG (3.3 mm²) for larger openings.

6.3.2 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 cm²) 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 6.3.3 may be used.

6.3.3 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 27.1, 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 cm²) 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).

6.4 Wire openings

6.4.1 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.

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Exception No. 2: A small internal assembly screw, or other small fastener, such as a rivet, a handle for a pull-out disconnect switch, or a magnet or armature of a relay or contactor.

Exception No. 3: A metal panel or cover, that:

- a) Is insulated from electrical components and wiring by an insulating barrier of vulcanized fiber, varnished cloth, phenolic composition, or other moisture-resistant material not less than 1/32 inch (0.8 mm) thick and reliably secured in place;*
- b) Does not enclose uninsulated live parts, and wiring is positively separated from the panel or cover so that it is not likely to become energized; or*
- c) Is isolated from live parts and wiring by grounded or bonded interposing metal so that the interposing metal would be subject to an electrical fault before the isolated metal panel or cover.*

18.1.2 A guard, baffle, or cover that can be removed without a tool is to be removed when determining whether a part is exposed to contact by the user. A part that can be contacted by a 3/8-inch (9.5-mm) diameter rod having a hemispherical end inserted through an opening in a permanently attached guard or baffle for a distance of 4 inches (102 mm) is considered exposed for the purposes of grounding.

Exception: A snap-on cover that complies with the requirements in Cover Retention Test, Section 59 need not be removed.

18.1.3 Uninsulated metal parts, such as cabinets, electrical enclosures and covers, motor frames and mounting brackets, controller mounting frames and brackets, capacitors, other electrical components, interconnecting tubing and piping, valves, and pneumatic accessories, shall be electrically bonded together if they may be contacted by a user or service person. See 18.1.5 and Exceptions to 18.1.1 for parts to which this requirement does not apply.

18.1.4 Operations and adjustments that subject parts to contact by a user include actions taken at the time of installation and during normal use, such as seasonal adjustments, relamping, replacing fuses, resetting overload devices, and oiling motors. These procedures and those specified in Protection of Users and Service Personnel, Section 37 subject parts to contact by a serviceperson.

18.1.5 A part on the back side of a component mounting panel and a part located so as to require major disassembly by using tools are not considered to be exposed to the user; such parts are not considered to be exposed to a serviceperson unless it is likely that servicing will be performed while the equipment is energized after disassembly.

18.1.6 Uninsulated live parts and wiring shall be held away from moving parts, such as relay and contactor magnets and armatures, by clamping, routing, or equivalent means that will provide permanent separation.

18.1.7 If a component is likely to be separated from its grounding means after installation for the purposes of testing or adjustment while the equipment is energized, it shall be provided with a bonding terminal or with a bonding conductor so that it is not necessary to remove it from the component for such service.

18.2 Construction and connection

18.2.1 Parts shall be bonded by metal-to-metal contact or by a separate bonding jumper in accordance with 18.2.2 – 18.2.9.

18.2.2 A separate bonding conductor shall be copper, a copper alloy, or other material that may be used as an electrical conductor.

18.2.3 A ferrous metal part in a grounding path shall be protected against corrosion by enameling, galvanizing, plating, or other equivalent means.

18.2.4 A separate bonding conductor or strap

a) Shall be protected from mechanical damage or shall be located within an outer enclosure or frame, and

b) Shall not be secured by a removable fastener used for any purpose other than bonding unless the bonding conductor is unlikely to be omitted after removal and replacement of the fastener.

18.2.5 The ends of a bonding conductor shall be in metal-to-metal contact with the parts to be bonded.

18.2.6 A wire used for bonding purposes shall not be spliced.

18.2.7 An internal connection for bonding internal parts to an enclosure for grounding, but not for a field-installed grounding conductor or for the grounding wire in a supply cord, may use a quick-connect terminal provided:

a) The connector is not likely to be displaced,

b) The terminal has the dimensions specified in Table 18.1, and

c) The component is limited to use on a circuit having a branch-circuit protective device as specified in Table 18.1.

Table 18.1
Quick-connect terminals for grounding internal parts

Nominal size of terminal, inch (mm)						Rating of branch-circuit protective device, amperes
Width		Thickness		Length		
.187	4.7	0.020	0.5	1/4	6.35	20 or less
.187	4.7	0.032	0.8	1/4	6.35	20 or less
.205	5.2	0.032	0.8	1/4	6.35	20 or less
.250	6.4	0.032	0.8	5/16	8.00	60 or less

18.2.8 A separate component-bonding conductor shall not be smaller than:

a) That specified in Table 18.2,

b) The conductor supplying the motor or component, whichever is the smaller, or

the bonding conductor shall comply with the performance requirements in Bonding Conductor Tests, Section 60.

- b) Uninsulated live parts of any other circuit of the equipment, and from any uninsulated live parts the short-circuiting of which may result in a risk of fire or electric shock.

Exception No. 1: Field-installed Type RH, T, RFH-2, or equivalent conductors may contact wiring terminals.

Exception No. 2: Field-installed conductors that have insulation less than RFH-2 or RH wire may contact low-voltage wiring terminals provided that the short-circuiting of such terminals would not result in a risk of fire or electric shock.

- c) Factory-installed conductors connected to any other circuit, unless the conductors of both circuits will be insulated for the maximum voltage of either circuit.

31.4 With reference to 31.3 (a), if the intended uses of the equipment are such that in some applications a barrier is required while in some other applications no barrier is required, a removable barrier or one having openings for the passage of conductors may be employed. Instructions for the use of such a barrier shall be a permanent part of the equipment. Complete instruction in conjunction with a wiring diagram may be provided in lieu of a barrier if, upon investigation, the combination is determined to comply with these requirements.

31.5 Field-installed conductors may be segregated from each other and from uninsulated live parts or factory-installed conductors of the device connected to different circuits by arranging the location of openings in an enclosure for the various conductors – with respect to the terminals or other uninsulated live parts – so that a minimum permanent 1/4 inch (6.4 mm) separation is provided.

31.6 With reference to 31.5, if the number of openings in the enclosure does not exceed the minimum required for the proper wiring of the equipment, and if each opening is located opposite a set of terminals, it is to be assumed that a conductor entering an opening will be connected to the terminal opposite that opening. If more than the minimum number of openings are provided, the possibility of a conductor entering an opening other than the one opposite the terminal to which it is intended to be connected and the likelihood of it contacting insulated conductors or uninsulated current-carrying parts connected to a different circuit is to be investigated.

31.7 To determine if the equipment complies with 31.3, it is to be wired as intended for service with a reasonable amount of slack left in each conductor within the enclosure and not more than average care is to be exercised in stowing the slack into the wiring compartment.

32 Isolation Devices

32.1 All devices that are necessary to provide electrical isolation, such as optical isolators, pulse transformers, and the like, shall comply with the requirements for such devices and with the requirements in 32.2 – 32.5.

32.2 An isolation device shall be provided if it reduces a risk of fire, electric shock, or injury to persons, or if isolation is required by this standard in specific circuits.

32.3 Equipment that incorporates Class 2 outputs and isolates these Class 2 outputs from circuits involving a risk of electric shock shall be subjected to tests to determine the effects on the insulating properties of the isolating medium. The testing shall include subjecting the insulation to the tests described in 45.4.1 – 45.4.3.

32.4 Resistors employed to obtain isolation shall comply with requirements for such devices. See Isolating Resistor Evaluation, Section 64. In addition, each line in a circuit that contains such resistors and that is exposed during user servicing shall be provided with an impedance that satisfies the following equation:

$$\frac{V}{Z} \leq 0.5 \text{ mA}$$

in which:

V is the open-circuit voltage of the line circuit, and

Z is the minimum impedance, including tolerances.

Exception: The value in the equation is 5.0 milliamperes for circuits exposed only during servicing by qualified personnel.

32.5 The power rating of a resistor used to obtain isolation shall be at least three times the power it dissipates in normal operation.

32.6 Other types of impedances used in accordance with 32.2 are to be subjected to a special investigation.

33 Connections to Separate Equipment

33.1 General

33.1.1 If the combination of the equipment is investigated together, the connections in the combination may be evaluated to determined compliance with these requirements.

33.2 Fuel-control circuit

33.2.1 The interconnections of equipment or controller to the fuel control circuit of a separate gas, oil, or electric furnace or boiler, or air-cooling equipment, or the like, shall not

- a) Result in bypassing or defeating a safety control or protective device,
- b) Require rewiring,
- c) Introduce a new power supply to the separate equipment,
- d) Add a load to the existing components which may interfere with proper operation of the controlled equipment, or
- e) Interpose in the control circuit other controls, the malfunction of which may result in a condition that the control is intended to prevent.

Also see Separation of Circuits, Section 31 and Interconnection of Class 2 Circuits, Section 34.

33.2.2 Compliance with the requirement in 33.2.1 may be accomplished by

- a) Connection of the controller ahead of the power-supply terminals of the separate equipment,

- b) Connection of isolated contacts ahead of the control,
- c) Connection of isolated contacts to thermostat terminals or to the water-temperature-regulating control terminals of the separate equipment, or
- d) Equivalent connection that meets the intent of in 33.2.1.

33.2.3 The controller shall not furnish power or be connected to the circuit of a thermopile-powered furnace or boiler.

Exception: The controller may furnish power or be connected to the circuit:

- a) *Through an isolated contact connected in a separate compartment; or*
- b) *If the control is marked to specify use of an isolating relay.*

33.3 Circulator or auxiliary-control circuit

33.3.1 The interconnection of a controller to a separate furnace fan, boiler pump, or the like, shall be by means of an isolated contact that is to be connected only to the fan or pump controls so as not to require rewiring or adding a power supply to the separate equipment. The controller shall be marked accordingly.

34 Interconnection of Class 2 Circuits

34.1 The output of a transformer supplying a Class 2, low-voltage circuit and provided as a part of the equipment shall not be interconnected with the output of another such transformer. See 70.6.

Exception: The output of two or more transformers provided as a part of the equipment may be interconnected if the voltage and current measurements at the output terminals are within the values for a single Class 2, 30-volt or less transformer.

34.2 The outputs of two or more transformers, all of which are judged as Class 2 in accordance with 4.2 and that are not interconnected, are to be considered as separate circuits.

34.3 If the wiring terminals or leads for two or more Class 2 circuits are located in the same wiring compartment, the compartment shall be such that ample room is provided for proper wiring without crowding, and such that the stowed wiring of one circuit will not be forced against terminals or live parts of another circuit. The equipment shall be marked in accordance with 72.8.

35 Barriers

35.1 A barrier used to provide separation between the wiring of different circuits shall be of metal or of insulating material having the necessary mechanical strength if exposed or otherwise likely to be subjected to mechanical damage, and shall be held in place.

35.2 Unclosed openings in a barrier for the passage of conductors shall not be larger than 1/4 inch (6.4 mm) in diameter and the number of openings shall not be more than the number of conductors that will need to pass through the barrier. The closure for any other opening shall have a smooth surface wherever an insulated wire may contact it and the area of any such opening, with the closure removed, shall not be larger than required for the passage of the necessary wires. See 16.1.20.

35.3 A barrier used to provide separation between the field wiring of one circuit and the wiring or uninsulated live parts of another shall not be spaced more than 1/16 inch (1.6 mm) from the enclosure walls and from interior mechanisms and component-mounting panels, or the like, that serve to provide segregated compartments.

35.4 A metal barrier used to provide segregation shall have the necessary strength and rigidity, and shall be at least the thickness specified under the column in Table 5.1 titled With supporting frame, for the dimensions of the barrier.

35.5 A barrier of insulating material shall be of such thickness and be so supported that it cannot be readily deformed so as to defeat its purpose; in any case, the thickness shall not be less than 0.028 inch (0.71 mm).

35.6 A barrier between uninsulated live parts connected to different circuits, and a barrier between uninsulated live parts of one circuit and the wiring of another circuit shall also comply with the requirement in 27.2.11 and 27.2.12.

PROTECTION AGAINST INJURY TO PERSONS

36 General

36.1 Scope

36.1.1 The requirements in 36.2.1 – 36.7.8 apply to equipment the normal operation of which may involve a risk of injury to persons.

36.1.2 There are risks of injury to persons inherent in some equipment that, if completely eliminated, would defeat the utility of the equipment. The requirements in this section are intended to reduce such risks, while retaining the intended function of the equipment.

36.2 Sharp corners and edges

36.2.1 An enclosure, a frame, a guard, a handle, or the like, shall not be sufficiently sharp to constitute a risk of injury to persons in normal maintenance and use.

Exception: This requirement does not apply to a part or portion of a part needed to perform a working function.

36.3 Moving parts

36.3.1 A hinged or pivoted panel or cover shall be positioned or arranged so that it is not subject to falling or swinging due to gravity or normal vibration in such a manner as to cause injury to persons by the panel or cover, by other moving parts capable of causing injury to persons, or by uninsulated live parts.

36.4 Enclosures and guards

36.4.1 The rotor of a motor, a pulley, a belt, a gear, a chain, a fan, or other moving part that could cause injury to persons shall be enclosed or guarded to reduce the risk of unintentional contact with the moving part.

36.4.2 A moving part that may involve a risk of injury to persons shall comply with the requirements specified in Table 10.1, and shall be considered with respect to:

- a) The degree of exposure,
- b) The sharpness of the moving part,
- c) The likelihood of unintentional contact with the moving part,
- d) The speed of the moving part, and
- e) The likelihood that:
 - 1) A part of the body could be endangered by the moving part, or
 - 2) Clothing could be entangled, resulting in a risk of injury to persons.

36.4.3 Unless it complies with 48.1, a guard or enclosure for a moving part capable of causing injury to persons shall be secured to the equipment so that it cannot be removed without using a tool.

36.5 Surface temperatures

36.5.1 During the Temperature Test, Section 40, the maximum temperature of a handle, a lever, a button, or a knob that is contacted by a user during normal operation shall not exceed 60°C (140°F) for a metal surface or 85°C (185°F) for a nonmetallic surface.

36.5.2 With reference to 36.5.1, a handle, a lever, a button, a knob, or the like, made of a material other than metal, that is plated or clad with metal 0.005 inch (0.13 mm) thick or less shall be judged as a nonmetallic part.

36.5.3 The maximum temperatures specified in 36.5.1 do not apply to equipment intended specifically for use in an ambient temperature exceeding 85°C (185°F).

36.6 Mounting devices

36.6.1 Equipment weighing more than 5 pounds (2.3 kg) and relying on a mounting means other than its own enclosure, if malfunction of the mounting means will result in a risk of injury to persons, shall withstand for 1 minute, without dislocation of the mounting means or evidence of damage, a force as described in 36.6.2.

36.6.2 With the equipment mounted in accordance with the manufacturer's instructions, a force equal to three times the weight of the equipment but not less than 20 pounds-force (89 N) is to be applied through the approximate center of gravity of the equipment. The force is to be increased gradually to reach the required value in 5 – 10 seconds and is to be maintained at that value for 1 minute.

36.7 Strength of parts

36.7.1 A device that is actuated by an external source of pressure and that employs a Bourdon tube, a flexible metal bellows, a diaphragm, or the like, rated 300 psig (2068 kPa) or more and not contained within an enclosure, shall withstand for 1 minute the hydrostatic pressure specified in 36.7.2 without bursting, leakage, or rupture.

Exception: Certain leakage conditions may occur only as indicated in 36.7.3 – 36.7.7.

36.7.2 To determine whether a part complies with the requirement in 36.7.1, a sample shall be subjected to a hydrostatic pressure test. The sample is to be filled with water to exclude air and is to be connected to a hydraulic pump. The pressure is to be raised gradually to four times the maximum rated operating pressure of the device.

36.7.3 Leakage at a gasket or fitting during the hydrostatic pressure test may occur unless it occurs at a pressure 50 percent or less of the required test pressure.

36.7.4 If leakage occurs during the test, the test is to be continued to four times the maximum rated operating pressure of the device, test equipment permitting. If the leakage is due to external fittings, modifications may be made to permit completion of the test.

36.7.5 A Bourdon tube, a flexible metal bellows, a diaphragm, or the like that is contained within an enclosure shall comply with the requirement in 36.7.1 or shall:

- a) Withstand for 1 minute without visible leakage a hydraulic pressure in accordance with the second column of Table 36.1; and
- b) Except as indicated in 36.7.7, withstand a hydraulic pressure for 1 minute equal to four times the maximum rated operating pressure of the device without rupture that may present a risk of injury to persons.

Table 36.1
Test pressures for devices with enclosures

Marked maximum operating-pressure rating, psig (kPa)	Test pressure for	
	36.7.5(a)	36.7.7(a)
300 – 2000 (2068 – 137,900)	2 times maximum rated operating pressure	3 times maximum rated operating pressure

36.7.6 With reference to 36.7.5(b), a Bourdon tube, diaphragm, or bellows may split if no part is released outside the enclosure; a joint or a gasket may leak if the required pressure value is reached and maintained for 1 minute, a leaking gasket or flexible member may be replaced by a heavier disc to permit the required pressure value to be reached.

36.7.7 With reference to 36.7.6, if leakage becomes excessive so that the four-times pressure cannot reasonably be reached – that is, if the part functions as if it has a rupture disc – the part complies if:

- a) A pressure in accordance with the third column in Table 36.1 is reached;
- b) No part capable of causing injury to persons is released outside the enclosure; and
- c) It can be demonstrated by test – which may be at a low pressure – or otherwise, that the outer enclosure can either relieve a pressure equal to the maximum rated operating pressure of the device without rupture that presents a risk of injury to persons, or can withstand a pressure equal to the maximum rated operating pressure.

36.7.8 A pressure vessel, a compressed air filter, a piston operator, or similar device shall withstand hydrostatic strength tests consistent with the intended use unless it is certified by the National Board of Boiler and Pressure Vessel Inspectors and bears an ASME Code inspection symbol other than the UM symbol.

37 Protection of Users and Service Personnel

37.1 General

37.1.1 The requirements in this section do not apply to live parts in low-voltage circuits as defined in 3.6.

37.1.2 Live parts shall be arranged and covers located so that persons are not likely to be exposed to a risk of electric shock while removing and replacing a cover.

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37.1.3 Live parts shall be:

- a) Recessed at least 1/8 inch (3.2 mm) from the plane of the front of the fixed portion of an enclosure;
- b) Recessed at least 1/8 inch from the front edge of a wiring compartment, in the case of equipment mounted to the face of a wiring compartment; or
- c) Provided with equivalent protection by projections or guards.

37.1.4 To determine whether live parts recessed or protected in accordance with 37.1.3 comply with the requirement in 37.1.2, the cover is to be removed and replaced; contact of either a person or a conductive cover with a live part shall not occur.

37.1.5 Unless a cover complies with the requirements for hinged covers in 5.2.4 and 5.2.7, and unless all live parts are protected as specified in 37.1.6, a handle, a knob, or other manual operating means shall be arranged so that it can be operated from outside the enclosure. The position of such an operating means shall be marked, if necessary, as a guide for proper operation.

Exception: Equipment that involves manual operations that may be performed by a user only at the time of installation, during a servicing procedure, or seasonally, need not comply provided that it complies with the requirements in 37.1.6, 37.2.3, 37.2.5, 37.3.2, and 37.3.3. The requirements in Bonding of Internal Parts, Section 18, apply in any case.

37.1.6 An uninsulated live part or a moving part capable of causing injury to persons shall be located, guarded, or enclosed so as to reduce the likelihood of contact with such part by a person while changing a lamp or fuse, lubricating a motor, adjusting a control, or during other normal operations, including those performed only at the time of installation, during a servicing procedure, or seasonally.

37.1.7 A live heat sink for a solid-state component, a live relay frame, and the like, shall comply with 37.1.6, 37.2.2, and 37.3.2, and unless the equipment is marked in accordance with 72.6, shall also be guarded to reduce the likelihood of contact by persons, regardless of the location of the parts.

Exception: As provided in 37.1.9 and 37.1.10.

37.1.8 With reference to 37.1.7, the size, shape, material, and color give a heat sink or relay-frame the appearance of a dead metal part. Other live parts that can be mistaken as being dead parts are to be judged similarly.

37.1.9 A guard, baffle, or cover that can be removed without a tool is to be removed when determining whether a part is exposed to contact by a user. A part that can be contacted by a 3/8-inch (9.5-mm) diameter rod having a hemispherical end inserted through an opening in a permanently attached guard or baffle for a distance of 4 inches (102 mm) is considered to be exposed for the purpose of protecting persons.

Exception: A snap-on cover that complies with the requirements in Cover Retention Test, Section 59, need not be removed.

37.1.10 A part on the back side of a component mounting panel or located so that major disassembly by using a tool is necessary to expose it is not considered to be exposed to a user; such a part is not considered to be exposed to service personnel unless it is likely that servicing will be performed while the part is energized after disassembly.

37.1.11 If a marking or an operating instruction refers a user to a hole or opening in an enclosure through which a tool is to be inserted for adjustment or a similar purpose, it shall not be possible to contact an uninsulated live part through the hole or opening with a 1/16-inch (1.6-mm) diameter rod.

37.2 Mechanical servicing

37.2.1 The requirements in 37.2.2 are intended to provide a reasonable degree of protection to service personnel performing a mechanical function on energized equipment. Such a service function does not in itself cause exposure to live parts or moving parts capable of causing injury to persons, but it is commonly necessary to perform the function with the equipment energized.

37.2.2 An uninsulated live part or a moving part capable of causing injury to persons shall be located, guarded, or enclosed so as to reduce the risk of unintentional contact by service personnel adjusting or resetting a control, or performing a mechanical service function that may have to be performed with equipment energized.

37.2.3 Mechanical service functions that may have to be performed with equipment energized include operating a valve or connecting a fitting that may be necessary during charging or adjusting a pneumatic system, adjusting the setting of a temperature or pressure control with or without marked dial settings, resetting a control trip mechanism, operating a manual switch, or lubricating a motor. A control that has the set point sealed at the factory and that does not have marking or instructions for adjustment is not considered to be adjustable.

37.2.4 The requirements in 37.2.2 do not apply to a mechanical service function that is not normally performed with equipment energized.

37.2.5 An adjustable or resettable electric control or manual-switching device may be located or oriented with respect to uninsulated live parts so that manipulation of the mechanism for adjustment, resetting, or operation can be accomplished in the normal direction of access if uninsulated live parts are not located:

- a) In front (in the direction of access) of the mechanism, and
- b) Near any side or behind the mechanism, unless guarded.

37.3 Electrical servicing

37.3.1 The requirements in 37.3.2 require that certain electrical components within an overall assembly be located so that the necessary space is provided for working on the components while the equipment is energized.

37.3.2 An electrical component that may need to be examined, adjusted, serviced, or maintained while the equipment is energized shall be located and mounted with respect to other components and with respect to grounded metal parts so that it is accessible for electrical servicing without subjecting service personnel to a risk of electric shock or to a risk of injury to persons by adjacent moving parts. Access to a component shall not be impeded by other components or by wiring.

37.3.3 Compliance with 37.3.2 may be obtained by mounting control components in an assembly so that unimpeded access to each component is provided through an access cover or panel in the outer cabinet, if provided, and the cover of the control assembly enclosure.

37.3.4 Electrical components to which 37.3.2 and 37.3.3 apply include fuses, adjustable or resettable overload relays, manual or magnetic motor controllers, magnetically operated relays, adjustable or resettable pressure or temperature controllers, manual switching devices, clock timers, and incremental-voltage tap and motor-speed tap terminals for variable-speed motors. Such components in a limited-energy circuit of 30 volts or less shall comply with 37.3.2 in their relation to bare live parts in a circuit of greater energy level and to moving parts capable of causing injury to persons.

37.3.5 The following are not considered to be uninsulated live parts:

- a) Coils of controllers, relays and solenoids, and transformer windings, if the coils and windings are provided with insulating overwraps at least 1/32 inch (0.8 mm) thick, or the equivalent, in accordance with 27.2.6;
- b) Enclosed motor windings;
- c) Terminals and splices with insulation that complies with the applicable requirements; and
- d) Insulated wire.

37.3.6 A device having exposed Class 2 outputs that:

- a) May be contacted during normal operation or servicing, and
- b) Have clearances between the Class 2 circuit and an overvoltage protected line-voltage circuit that have been evaluated in accordance with Clearance B requirements in the requirements for insulation coordination including clearances and creepage distances for electrical equipment, UL 840,

shall be provided with a mechanism to indicate the failure of the overvoltage protective device or system. For example, the provision of a detection circuit that would indicate a transient voltage surge suppressor is no longer functional due to the absorption of an excessive amount of energy.

PERFORMANCE

38 General

38.1 The performance of energy management equipment shall be investigated by subjecting a representative sample or samples in commercial form to the tests described in Sections 39 – 64. Consideration shall be given to heat-sink construction, solid-state-device ratings, and other construction criteria in selecting samples for testing that are representative of a line of similarly constructed equipment.

38.2 Unless otherwise noted, tests shall be conducted at rated frequency and at the test potential specified in Table 38.1.

Table 38.1
Values of voltage for tests

Voltage rating of equipment and corresponding test potential, volts ^a				
110 – 120	220 – 240	254 – 277	440 – 480	550 – 600
120	240	277	480	600

^a If the rating of the equipment does not fall within any of the indicated voltage ranges, it is to be tested at its rated voltage.

39 Power Input Test

39.1 The power input to the equipment shall not exceed the marked rating by more than 10 percent when it is operated under the conditions of normal use while connected to a supply circuit as specified in Table 38.1.

40 Temperature Test

40.1 When tested as described in this section, the equipment shall not attain a temperature at any point sufficiently high to constitute a risk of fire, to damage any materials employed in the equipment, or to exceed the temperature rises specified in Table 40.1.

40.2 To determine if the equipment complies with the temperature test requirements, it is to be operated under normal conditions and is to carry its rated current continuously at the test potential specified in Table 38.1 until temperatures are constant.

Exception: The test on parts other than coils and transformer windings may be conducted at a potential between 90 and 110 percent of the potential specified if the ampere load is adjusted to produce the maximum normal heating.

40.3 A protective device shall not trip during the temperature test.

40.4 Permanently-connected equipment is to be tested with 4 feet (1.22 m) of wire attached to each field-wiring terminal. The wire is to be of the smallest size having an ampacity of at least 125 percent of the test current for motor loads, continuous duty loads, and combination loads, and at least 100 percent for other loads. Wire size is to be determined in accordance with Table 310-16 of the National Electrical Code, ANSI/NFPA 70-1990. The size is to be based upon wire that is rated for a temperature of 60°C (140°F) for a rating of 100 amperes or less, and upon wire that is rated for 75°C (167°F) for a rating greater than 100 amperes. The type of insulation is not specified.

40.5 Permanently-connected equipment is to be installed so that it is located as close to the wall or corner as the construction will permit. Cord-connected equipment is to be placed on a horizontal supporting surface and spaced 1 inch (25 mm) from a vertical wall surface of wood or comparable material, unless the arrangement of ventilation and similar cooling factors is such that operation against a wall, as compared with operation in the open, will not increase operating temperatures, or unless the construction of the equipment is such that a spacing greater than 1 inch is maintained. Doors and covers that may be closed during operation of the equipment are to be closed during the test.

40.6 All values in Table 40.1 are based on an assumed ambient temperature of 25°C (77°F), but a test may be conducted at any ambient temperature within the range of 10 – 40°C (50 – 104°F). However, if the operation of an automatic thermal control during the test limits the temperatures under observation, no temperature shall exceed 25°C plus the specified maximum rise.

40.7 A short length of rubber- or thermoplastic-insulated flexible cord exposed to a temperature higher than that for which it is rated, such as at terminals, may be used if supplementary heat-resistant insulation having the necessary dielectric strength is provided on the individual conductors of the cord to reduce the likelihood of deterioration of the conductor insulation.

40.8 Open-type equipment is to be tested in a 40°C (104°F) ambient, and temperature corrections as specified in 40.9 are to be made.

47.1.10 If an ampere-rated device has the same ampere rating at more than one voltage, a test at the highest voltage is considered to be representative of tests at the lower voltages, but if the device has a higher ampere rating at the lower voltage than at the higher ones, tests are to be conducted at the highest and lowest voltages.

47.1.11 An alternating-current device that does not have a frequency rating is to be tested on a circuit having a frequency of 60 hertz, except that a circuit having a lower frequency may be used with the concurrence of those concerned.

47.1.12 A multiple-pole, a sequencing, a double-throw, or a double-pole, single-throw (normally open, normally closed – sometimes called double-pole, opposite-throw) control, and the like are to be tested with a load on each pole. The loads on a double-pole or multiple-pole control are to be connected so that opposite polarity on the poles results unless the same polarity rating is assigned to the control.

47.1.13 If an electronic control for controlling a contactor, a relay, or other magnetically operated device is integral within a system the test is to be conducted with the actual electromagnet as the load.

47.1.14 If a horsepower-rated device has more than one voltage rating, the overload test or tests are to cover the conditions of maximum voltage, power, and current.

47.1.15 Other than as noted in 47.1.4 and 48.3, a current-interrupting device for use on direct current shall be tested with a noninductive resistance load. A current-interrupting device for use on alternating current shall be tested with an inductive load.

47.1.16 The power factor of an inductive load shall be 0.75 – 0.80, except that it shall be 0.40 – 0.50 for a load simulating locked-rotor conditions in a motor, and shall not be more than 0.35 for a pilot-duty load.

47.1.17 Tables 47.2 and 47.3 give full-load currents corresponding to motor horsepower ratings, and are to be used in determining loads for the various tests specified for horsepower-rated equipment.

47.1.18 Current-interrupting tests for an alternating current device are to be conducted at the voltage specified in Table 38.1. For a direct-current device, current-interrupting tests are to be conducted at 50 percent of the voltage specified in Table 38.1 in accordance with 47.1.8 and 48.1.

47.1.19 A circuit in which the closed-circuit voltage is 100 – 110 percent of the test potential specified in Table 38.1 may be used for the tests mentioned in 47.1.18.

Exception: For a device rated more than 25 horsepower (18.7 kW output) or more than 100 amperes, the open-circuit voltage is to be 110 percent of the value specified in Table 38.1, or as much above that value as the closed-circuit voltage is below it, whichever is less.

47.1.20 Alternating-current interrupting tests are to be conducted on a circuit having a frequency of 60 hertz. Tests at 25 – 60 hertz may, however, be considered to be representative.

47.1.21 A 2-pole or 4-pole device is to be tested on a single-phase or direct-current circuit. In a 4-pole device, adjacent poles are to be used, one pole being that nearest the enclosure. If the pole spacing varies, an additional test is to be conducted between the poles with the smallest spacing, to cover use on 2-phase interconnected systems.

47.1.22 A 3-pole device for polyphase use is to be tested on a 3-phase circuit. A 3-pole device for use on a direct-current or single-phase system with a grounded neutral is to be tested with rated voltage applied to the outside poles and with the middle pole electrically connected to the line and to the midpoint of a balanced load.

Table 47.2
Full-load motor-running currents in amperes
corresponding to various d-c horsepower ratings

Horsepower (watts output)		90 volts	110 – 120 volts	180 volts	220 – 240 volts	500 volts	550 – 600 volts
1/10	75	—	2.0	—	1.0	—	—
1/8	93	—	2.2	—	1.1	—	—
1/6	124	—	2.4	—	1.2	—	—
1/4 ^a	187	4.0	3.1	2.0	1.6	—	—
1/3	249	5.2	4.1	2.6	2.0	—	—
1/2	373	6.8	5.4	3.4	2.7	—	—
3/4	560	9.6	7.6	4.8	3.8	—	1.6
1	746	12.2	9.5	6.1	4.7	—	2.0
1-1/2	1.1 kW	—	13.2	8.3	6.6	—	2.7
2	1.5 kW	—	17.0	10.8	8.5	—	3.6
3	2.2 kW	—	25.0	16.0	12.2	—	5.2
5	3.7 kW	—	40.0	27.0	20.0	—	8.3
7-1/2	5.6 kW	—	58.0	—	29.0	13.6	12.2
10	7.5 kW	—	76.0	—	38.0	18.0	16.0
15	11 kW	—	110.0	—	55.0	27.0	24.0
20	15 kW	—	148.0	—	72.0	34.0	31.0
25	18.7 kW	—	184.0	—	89.0	43.0	38.0
30	22.4 kW	—	220.0	—	106.0	51.0	46.0
40	30 kW	—	292.0	—	140.0	67.0	61.0
50	37.3 kW	—	360.0	—	173.0	83.0	75.0
60	45 kW	—	—	—	206.0	99.0	90.0
75	60 kW	—	—	—	255.0	123.0	111.0
100	75 kW	—	—	—	341.0	164.0	148.0
125	93.3 kW	—	—	—	425.0	205.0	185.0
150	112 kW	—	—	—	506.0	246.0	222.0
200	150 kW	—	—	—	675.0	330.0	294.0

^a The full-load current for a 1/4-horsepower, 32-volt d-c motor is 8.6 amperes.

47.1.23 For a device that is intended for connection to a grounded-neutral system and is marked in accordance with 72.10 or 72.11, the enclosure is to be connected during the test through a 3-ampere cartridge fuse to the grounded conductor of the circuit. For any other system the enclosure is to be connected through such a fuse to the live pole least likely to arc to ground.

47.2 Tungsten-filament-lamp load characteristics

47.2.1 The test circuit, including the generator or other source of supply for a device with a tungsten-filament-lamp load rating for use on direct current, is to provide a current inrush through the switch and load of not less than eight times the normal current when the circuit is closed on a 20-ampere load; and the circuit is to be such that the peak value of the inrush current will be reached within 1/240 of a second after the circuit is closed. If a synthetic load is used, its characteristics are to, in addition, be such that the current-inrush factor is not less than 9 with a 15-ampere load, not less than 10 with a 10-ampere load, not less than 11 with a 5 ampere load, not less than 12 with a 3-ampere load, not less than 12-1/2 with a 2-ampere load, and not less than 13 with a 1-ampere load.

Exception: If the required inrush is available for a lower current rating with testing limited to such rating, a tungsten-filament-lamp load and the supply circuit need not be sufficient for the 20 ampere load test.

Table 47.3
Full-load motor-running currents in amperes
corresponding to various a-c horsepower ratings

Horsepower (watts output)	110 – 120 volts		220 – 240 volts ^a		440 – 480 volts		550 – 600 volts	
	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase
1/10 75	3.0	—	1.5	—	—	—	—	—
1/8 93	3.8	—	1.9	—	—	—	—	—
1/6 124	4.4	—	2.2	—	—	—	—	—
1/4 187	5.8	—	2.9	—	—	—	—	—
1/3 249	7.2	—	3.6	—	—	—	—	—
1/2 373	9.8	4.0	4.9	2.0	2.5	1.0	2.0	0.8
3/4 560	13.8	5.6	6.9	2.8	3.5	1.4	2.8	1.1
1 746	16.0	7.2	8.0	3.6	4.0	1.8	3.2	1.4
1-1/2 1.1 kW	20.0	10.4	10.0	5.2	5.0	2.6	4.0	2.1
2 1.5 kW	24.0	13.6	12.0	6.8	6.0	3.4	4.8	2.7
3 2.2 kW	34.0	19.2	17.0	9.6	8.5	4.8	6.8	3.9
5 3.7 kW	56.0	30.4	28.0	15.2	14.0	7.6	11.2	6.1
7-1/2 5.6 kW	80.0	44.0	40.0	22.0	21.0	11.0	16.0	9.0
10 7.5 kW	100.0	56.0	50.0	28.0	26.0	14.0	20.0	11.0
15 11 kW	135.0	84.0	68.0	42.0	34.0	21.0	27.0	17.0
20 15 kW	—	118.0	88.0	54.0	44.0	27.0	35.0	22.0
25 19 kW	—	136.0	110.0	68.0	55.0	34.0	44.0	27.0
30 22 kW	—	160.0	136.0	80.0	68.0	40.0	54.0	32.0
40 30 kW	—	208.0	176.0	104.0	88.0	52.0	70.0	41.0
50 37 kW	—	260.0	216.0	130.0	108.0	65.0	86.0	52.0
60 45 kW	—	—	—	154.0	—	77.0	—	62.0
75 50 kW	—	—	—	192.0	—	96.0	—	77.0
100 75 kW	—	—	—	248.0	—	124.0	—	99.0
125 94 kW	—	—	—	—	—	156.0	—	125.0
150 112 kW	—	—	—	—	—	180.0	—	144.0
200 150 kW	—	—	—	—	—	240.0	—	192.0

^a To obtain full-load currents for 200 and 208 volt motors, increase corresponding 220 – 240 volt-currents by 15 and 10 percent, respectively, for single- and 3-phase motors. To obtain full-load currents for 265- and 277-volt motors, decrease the corresponding 220 – 240 volt currents by 13 and 17 percent respectively. The 265- and 277-volt ratings are applicable for equipment rated 2 horsepower or less, single-phase only.

47.2.2 The test circuit, including the generator or other source of supply for a device with a tungsten-filament-lamp load rating used on alternating current, shall provide a peak current inrush through the switch and load not less than the value given in Table 47.4 when the circuit is closed on a load corresponding to a rating equal to or greater than the rating of the device; and the circuit shall be such that the highest value of the inrush current will be reached within 1/240 of a second after the circuit is closed.

Exception: If the required inrush is available for a lower current rating with testing limited to such rating, a tungsten-filament-lamp load and the supply circuit need not be sufficient for the 20 ampere load test described above.

Table 47.4
Tungsten-filament-lamp load test circuit characteristics

Steady-state current (rms), amperes	Minimum inrush current (Peak), amperes
10	141
15	191
20	226

47.2.3 A synthetic load and a combination synthetic and tungsten-filament-lamp load, used to simulate a tungsten-filament-lamp load for testing on alternating current, is to be tested as described in 47.2.4 and 47.2.9, and also with respect to special conditions which are introduced by use on alternating current.

47.2.4 Oscillograph studies are to be used to determine compliance of a test circuit, including the generator or other source of supply, for testing with a tungsten-filament-lamp. If the circuit is tested at a normal (steady state) current flow of 20 amperes and inrush currents as indicated in 47.2.1 and Table 47.4 are recorded, the test circuit is considered to have a capacity for testing switches rated up to and including 60 amperes. With reference to a 60-hertz timing wave, the peak values of inrush current as shown by oscillograms are to be reached within 1/4 cycle.

47.2.5 The characteristics of a direct-current test circuit shall be determined from 12 or more oscillograms, and testing equipment may be used if not less than half the oscillograms show at least the minimum current-inrush factor.

47.2.6 The characteristics of an alternating-current test circuit shall also be determined from 12 or more oscillograms. Those which indicate that the current is decreasing (that the part of the sine wave in question is approaching the zero point) shall be disregarded. Twelve or more oscillograms taken at other points on the sine wave should indicate whether the capacity of the test circuit can produce the minimum current-inrush factor based on observed peak values.

47.2.7 If tungsten-filament-lamps are used as the load for a device designed for use with such lamps, the load shall be made up of the smallest possible number of lamps having standard ratings. In determining the smallest number of lamps necessary, the maximum lamp size required to be used is 500 watts. Larger lamps may be used if desired. The operating cycle shall be such that the lamps are off for at least 55 seconds of each test cycle. If a device is operated at the rate of 10 cycles per minute, at least ten banks of lamps controlled by a commutator are necessary for each switch under test.

47.2.8 A synthetic load may be used instead of tungsten-filament-lamps and may consist of noninductive resistors if they are so connected and controlled that a portion of the resistance is shunted during the closing of the switch under test or if a portion of the load is cut out prior to opening the switch. A synthetic load may also consist of a noninductive resistor or resistors and a capacitor in parallel, in which case the load is to be calibrated immediately after the capacitor has been charged and discharged in the usual manner. A combination load consisting of tungsten-filament-lamps and resistors and/or capacitor shall be considered a synthetic load.

47.2.9 A test circuit (including the generator or other source of supply) for testing with a synthetic load shall be determined to comply in a manner similar to that described in 47.2.6, consideration being given to the provision of higher current-inrush factors with the lower current loads, as required in 47.2.1.

47.2.10 A synthetic load is to be calibrated against and equivalent to a tungsten-filament-lamp load in the test circuit. The calibration of a synthetic load is to be checked at intervals to determine that none of the constants of the circuit or load change with time or use.

47.2.11 The characteristics of a synthetic load are to be such that the inrush current will be as specified in 47.2.1 – 47.2.3. In addition, the current in the capacitor/resistance load or the combination load mentioned in 47.2.8 shall not be less than half the required inrush current at 1/60 second and not less than twice the steady-state current at 7/120 second after the circuit is closed; and the current in a straight resistance load shall be the full inrush value for at least 15 milliseconds after the circuit is closed.

48 Endurance Test

48.1 A switch is to be operated manually, by means of a machine, or by automatic means for the number of cycles specified in Table 48.1, and at the rate specified unless the device requires a longer time to complete a cycle of operation. If an electrical load is involved, and except as otherwise noted, a switch shall make and break its rated current at the voltage specified in Table 38.1. Switch contacts for control of a motor are to be tested with full-load motor current; if the switch is rated in horsepower instead of full-load motor current, the latter value shall be determined from Table 47.2 or 47.3, as applicable. If the switch contacts control a direct-current motor, and the switch normally will make but not break the motor circuit under locked-rotor conditions, the potential of the test circuit is to be 50 percent of the value specified in Table 38.1. There shall be no electrical or mechanical breakdown of the device, nor undue burning, pitting, or welding of the contacts.

48.2 The conditions for the endurance test shall be as described in 47.1.10 – 47.1.23.

48.3 A contact device designated for pilot duty is to be operated for the number of cycles specified in Table 48.1, making and breaking a circuit of rated frequency at the voltage specified in Table 38.1. Unless the design of the device requires a longer time to complete a cycle of operation, the rate of operation for the test shall be as follows: for a manually operable device, the first 1000 cycles shall be at the rate of 1 cycle per second – except that the first 10 or 12 cycles shall be made as rapidly as possible – and the remaining cycles shall be at the rate of 6 cycles per minute, with the device closed for approximately 1 second each cycle; and for a self-actuated device the cycle rate shall be as specified in Table 48.1. The load shall consist of an electromagnet representative of the magnet-coil load that the device is intended to control. The normal current shall be determined from the voltage and volt-ampere rating of the device. The test current is to be the normal current; and for an alternating-current device, the power factor shall be 0.35 or less and the inrush current shall be ten times the normal current, unless marked in accordance with 69.12. The test is to be conducted with the contactor free to operate, that is, not blocked either open or closed. There shall be no electrical or mechanical breakdown of the device nor undue pitting or burning of contacts.

48.4 If a device requiring an endurance test of 100,000 cycles has two or more electrical ratings – for example, different currents at different voltages – it may be tested for not less than 25,000 cycles at each rating, but the total number of cycles on any one sample is not to be more than 100,000. At least one sample is to be tested for 100,000 operations.

Table 48.1
Number of cycles for endurance test

Types of devices	Number of cycles of operation ^a					
	With current	Without current	First	Maximum cycles per minute	Last	Maximum cycles per minute
Safety controls	100,000	–	75,000	6	25,000	1 ^b
Refrigeration controls	30,000	–	24,000	6	6,000	1 ^b
Water-heater controls	30,000	–	30,000	1 ^b	–	–
Manually operated switches	6,000	–	6,000	6	–	–
Protective switches not normally required to make and break a circuit, such as manually reset safety controls, high-pressure and high-temperature cutouts used in addition to the regular operating control, and the like, but not including automatically-reset controls	1,000	5,000	1,000	1 ^b	5,000	c
Motor controllers and ampere-rated devices not mentioned above, and timing mechanisms	6,000	–	6,000	1 ^b	–	–

^a Magnetic, manual and motor-operated switches, or the like, and switches that snap with lost motion and do not creep, may be tested at the rate of 6 cycles per minute.

^b For all controls, the test is to be conducted with 50 ±20 percent on time. A temperature- or pressure-operated control is to be so tested, using a slow rate of change.

^c When no current is used, the switch may be operated at any convenient speed.

48.5 If a device requiring an endurance test of 30,000 cycles has two or more electrical ratings, it may be tested for not less than 7,500 cycles at each rating, but the total number of cycles on any one sample is not to be more than 30,000. At least one sample is to be tested for 30,000 operations.

48.6 With reference to 48.4 and 48.5, the volt-amperes of the smallest rating shall be at least 75 percent of the volt-amperes of the largest rating.

49 Dielectric Voltage-Withstand Test

49.1 General

49.1.1 The equipment shall withstand for 1 minute without breakdown the application of an alternating potential of 1000 volts plus twice maximum rated voltage between:

- Line-voltage live parts and grounded or exposed metal parts or the enclosure with the contacts open and closed,

- b) Line-voltage live parts of opposite polarity with the contacts closed, and
- c) Live parts of line- and low-voltage circuits, line-voltage and isolated-limited-power secondary circuits, and different line-voltage circuits.
- d) Live parts of different secondary circuits.

49.1.2 Equipment using a low-voltage circuit shall withstand for 1 minute without breakdown the application of an alternating potential of 500 volts applied between low-voltage live parts of opposite polarity with contacts, if any, closed, and between low-voltage live parts and the enclosure and grounded dead metal parts.

49.1.3 The opposite polarity dielectric voltage-withstand test may be omitted for a portion of a low-voltage, nonsafety circuit that is beyond any fixed impedance.

49.1.4 A transformer shall withstand for 1 minute without breakdown the application of an alternating potential of 1000 volts plus twice the maximum rated primary voltage, at rated frequency, between primary and secondary windings and between the primary winding and the core or enclosure.

49.1.5 If the equipment involves a meter or meters, such instruments are to be disconnected from the circuit and the complete equipment subjected to a dielectric voltage-withstand test as described in 49.1.1 – 49.1.4. The meter or meters is then to be tested separately in accordance with the tests outlined in 49.1.1 or 49.1.2 – whichever is applicable – except that an ammeter in a line-voltage circuit shall be tested at 1000 volts.

49.1.6 To determine whether the equipment complies with the requirements in 49.1.1 – 49.1.5, it is to be tested using a 500 volt-ampere or larger capacity transformer the output voltage of which is essentially sinusoidal and can be varied. The applied potential is to be increased from zero until the required test level is reached, and is to be held at that level for 1 minute. The increase in the applied potential is to be at a substantially uniform rate and as rapid as is consistent with its value being correctly indicated by a voltmeter.

49.1.7 If the charging current through a capacitor or capacitor-type filter connected across the line, or from line to earth ground, is large enough to make it impossible to maintain the required alternating-current test potential, the capacitors and capacitor-type filters may be tested as described in 49.1.8.

49.1.8 The capacitors and capacitor-type filters mentioned in 49.1.7 are to be subjected to a direct-current test potential of 1414 volts for equipment rated 250 volts or less or 1414 volts plus 2.828 times the rated circuit voltage for equipment rated at more than 250 volts. The direct-current test potential is to be maintained for 1 minute without breakdown.

49.1.9 The test potential may be obtained from any convenient source of sufficient capacity to maintain the potential specified in Table 49.1, except in case of breakdown. The output voltage of the test apparatus is to be monitored. Starting at zero, the applied potential is to be increased at a rate of approximately 200 volts per second until the required test value is reached and is to be held at that value for 1 minute. A direct-current source is to be used for testing a direct-current circuit.

49.1.10 Printed-wiring assemblies and other electronic-circuit components that can be damaged by application of the test potential or that would short-circuit the test potential are to be removed, disconnected, or otherwise rendered inoperative before the dielectric voltage-withstand tests are conducted. A representative subassembly may be tested instead of an entire unit. Rectifier diodes in the power supply may be individually shunted before the test is made to protect them in the case of a fault elsewhere in the secondary circuits.

Table 49.1
Magnitude of test potential

Maximum voltage (rms) in the circuit ^a	Test potential
30 or less (42.4 peak)	No test
More than 30 (42.4 peak) but not more than 333.3 (471.3 peak)	Ten times maximum voltage in circuit (maximum of 1,000 V rms)
More than 333.3 (471.3 peak) but not more than 1,000 (1,414 peak)	Three times maximum voltage in circuit
More than 1,000 (1,414 peak)	1,750 V plus 1.25 times voltage in circuit
^a If the peak voltage is greater than 120 percent of 1.414 times the rms voltage, the circuit shall be tested as if the voltage were peak voltage divided by 1.414.	

49.2 Secondary circuits (controlled environment)

49.2.1 Secondary circuits other than those with a voltage of 42.4 volts peak (30 volts rms) or less shall withstand for 1 minute the test potential specified in Table 49.1 applied:

- a) Between primary and secondary circuits, and
- b) Successively between secondary circuits and earth ground with all chassis-connected components (earth grounded) disconnected at the chassis-to-earth-ground connection.

49.3 Power transformers

49.3.1 Each power transformer shall operate without breakdown while the potential specified in Table 49.1 is induced for 1 minute in each secondary winding that furnishes power at a higher potential than the primary windings. Windings of special transformers that do not serve a prime power-supply function, such as the resonant winding of a constant-voltage transformer, are excluded from this requirement.

49.3.2 A power transformer shall withstand for 1 minute without breakdown the application of an alternating potential of 1000 volts plus twice the maximum rated primary or secondary voltage, at rated frequency, between primary and secondary windings, and shall withstand under the same conditions the application of an alternating potential of 1000 volts plus twice the rated voltage of each winding, at rated frequency, between each winding and the core or enclosure, except that the test between primary and secondary windings is omitted for an autotransformer.

49.3.3 Primary- and secondary-circuit wiring connected to a transformer is to be disconnected for the test mentioned in 49.3.1. An essentially sinusoidal source is to be used, and the frequency of the source may be in the range of 180 – 1000 hertz if necessary to prevent saturation of the core.

49.4 Induced potential (crossover lead)

49.4.1 Each of three separate magnet-coil-winding samples shall withstand without breakdown the test specified in 27.3.1 (b) (2) after constant temperatures have been reached as the result of operation under the conditions specified in the Temperature Test, Section 40. While still heated, the coil winding shall be subjected to an alternating potential of twice the rated voltage at any acceptable frequency – typically 120 hertz or higher – for 7200 electrical cycles or for 60 seconds, whichever is less. The required

test voltage is to be obtained by starting at one-quarter or less of the full value and increasing to the full value in not more than 15 seconds. After being held for the time specified, the voltage is to be reduced within 5 seconds to one-quarter or less of the maximum value, and the circuit is to be opened.

49.5 Induced potential repeated

49.5.1 While heated following operation at 110 percent of rated voltage as specified in the Overvoltage and Undervoltage Tests, Section 41, each of three samples shall withstand without breakdown a repeated induced potential test at 65 percent of the potential applied in accordance with 49.4.1.

49.5.2 If the temperature that a coil winding reaches in the tests described in 49.4.1 and 49.5.1 is known, an oven may be set at the required temperature and used to condition the sample to that temperature before conducting the test.

49.6 Dead-case-mounted semiconductors

49.6.1 A power-switching semiconductor that has not previously been investigated and determined to comply with the requirements shall be subjected to the tests specified in 49.6.2 – 49.6.5.

49.6.2 Six samples in the as-received condition are to be subjected to 2500 volts rms between all live parts and all dead metal parts for 1 minute. The as-received condition is without prior energization, except as may occur as part of the production-line testing.

49.6.3 The same samples used for the test in 49.6.2 are to be conditioned in a 0°C (32°F) ambient for 3 hours and then subjected to the same dielectric voltage-withstand test as described in 49.6.2.

49.6.4 Six additional samples are to be conditioned for 7 hours in an air-circulating oven the temperature of which is to be set at the maximum operating junction temperature of the thyristor. The samples are then to be removed and immediately subjected to the dielectric voltage-withstand test described in 49.6.2.

49.6.5 Six additional samples are to be exposed for 24 hours to an environment of 85 percent relative humidity at 32°C (89.6°F). The samples are then to be removed and immediately subjected to the dielectric voltage-withstand test described in 49.6.2.

50 Volt-Ampere Capacity

50.1 An isolated limited-secondary circuit shall have a continuous-use capacity of 100 volt-amperes or less when energized from a circuit of rated frequency at the voltage specified in Table 38.1.

50.2 A single-wound secondary transformer is to attain a temperature rise on the enclosure, core, or coil of at least 50°C (90°F) when the secondary is loaded to the maximum output obtainable or 100 volt-amperes, whichever is less.

Exception: If the product of the open-circuit voltage and the short-circuit current is 100 volt-amperes or less, the 50°C (90°F) temperature rise need not be obtained.

50.3 Each secondary winding of a multi-secondary transformer is to be loaded in turn with a variable resistor. Starting with a cold transformer for each part of the test, the load resistance is to be decreased from open- to short-circuit in such a manner that the elapsed time is between 1-1/2 and 2-1/2 minutes. Depending upon the open-circuit voltage of the winding, the maximum outputs obtained by this method are to be as follows:

- a) 350 volt-amperes for 0 – 15 volts.

- b) 250 volt-amperes for 15.1 – 30 volts.
- c) 200 volt-amperes for 30.1 – 1000 volts.

51 Burnout Test

51.1 A continuous-duty resistor shall not burn out or be adversely affected by carrying the full normal current on any step continuously. A resistor intended for intermittent use shall carry its rated current on any step for as long a time as the apparatus that it controls will permit.

51.2 When a power transformer, other than a transformer supplying a low-voltage, electronic, or isolated-limited-secondary circuit is operated as described in 51.3, there shall be no damage to the enclosure or emission of flame or molten metal.

51.3 The device is to be operated continuously at the voltage and frequency specified in Table 38.1 and 47.1.11 with the enclosure grounded. The load connected to the output terminals is to be a resistance of such value that three times full rated current will be drawn from the secondary winding of the device, and operation is to be continued until constant temperatures are attained on the enclosure or until burnout occurs.

51.4 A circuit on which a transformer is tested is to be protected by fuses rated at least ten times the primary current rating of the transformer. Opening of the fuses may occur. The test is to be conducted with the output terminals short-circuited, if such a condition results in less than three times full-rated current being drawn from the secondary. If other means of limiting the load to less than three times normal is inherent in or provided as part of the device, these features are to be given consideration and the burnout test conducted at the maximum load permitted by the limiting features.

51.5 A transformer supplying a low-voltage circuit is to be tested in the same manner as a standard Class 2 transformer, with low-voltage wiring terminals short-circuited, and wiring not complying with 16.1.4 short-circuited. A transformer supplying an isolated-limited-secondary circuit or an electronic circuit is to be tested in accordance with 51.2 – 51.4, except all secondary windings are to be directly short-circuited. If a portion of an isolated-limited-secondary or electronic circuit is connected to low-voltage field-wiring terminals, separate samples are to be subjected to the standard Class 2 test and the shorted-secondary test.

52 Limited Short-Circuit Test

52.1 General

52.1.1 A device such as a dead-case solid-state switch and a bonding conductor shall be subjected to the tests described in this section. After the test the equipment shall be examined with respect to the following results:

- a) Damage to equipment such as welding of contacts and short-circuiting or opening of power semiconductor devices of the equipment may occur, but the test shall not result in damage to other parts of the equipment that would impair its function.
- b) The cotton indicator shall not ignite.
- c) The fuse connected between the live pole and the enclosure shall not open.

RATINGS

68 Details

68.1 The equipment shall be rated in volts, and, as appropriate for the intended use, also in horsepower, amperes, amperes resistive (or resistance only or noninductive), volt-amperes or watts, or any combination thereof. The rating of the equipment shall include the current in amperes if the wattage rating is not a close indication of the volt-ampere input. The rating shall indicate whether the equipment is for direct or alternating current and, for alternating-current equipment, the number of phases and, if necessary, the frequency, except that a single-pole or other device obviously intended only for single-phase use need not include the phase rating.

68.2 A contact device intended for control of a solenoid coil of a relay contactor, valve, or the like, shall be rated in volts and volt-amperes using the sealed value and shall be marked in accordance with 69.11 – 69.13.

68.3 Normal pilot duty ratings for alternating current are 125, 360, and 720 volt-amperes; and for direct current are 57.5, 120, and 250 volt-amperes; but other ratings may be used.

68.4 Other than as noted in 68.5 – 68.8, equipment intended to control a motor shall be rated in accordance with one of the following:

- a) The equipment may be rated in horsepower only.
- b) The equipment may be rated in horsepower and, in addition, may be rated in full-load and locked-rotor current provided the relationship between the three values is in accordance with Tables 47.1 and 47.2 or 47.3, whichever is applicable.
- c) If the equipment is intended to control a motor rated 2 horsepower (1.5 kW output) or less, the equipment may be rated in full-load current that need not correspond with that in Table 47.2 or 47.3, and in locked-rotor current six times the rated full-load current – if alternating-current – and ten times the rated full-load current – if direct-current. The equipment may be marked with a lesser locked rotor current rating, but tests shall be conducted at the values specified.

68.5 Except for equipment rated 265 or 277 volts, a refrigeration controller or a remote control intended to control a compressor motor shall be rated in accordance with 68.4 or shall be rated in horsepower and in full-load and locked-rotor current. The full-load current rating may be greater than the equivalent of 2 horsepower (1.5 kW output), and the locked-rotor current rating need not be six times the full-load current rating for control of an alternating-current motor. Current ratings shall be plainly marked to indicate that they apply only to a hermetic compressor motor and shall be separated from other ratings to distinguish them from those ratings.

68.6 Equipment intended to control a single phase, alternating-current motor rated 265 or 277 volts, 2 horsepower (1.5 kW output) or less – or an equivalent current rating – shall be rated in full-load current and in locked-rotor current. The equipment may be marked with a locked-rotor current rating less than six times full-load current, but tests are to be conducted at six times the full-load current rating. If the rated full-load current is in accordance with footnote a to Table 47.3, the equipment may also be rated in horsepower. See 69.14.

68.7 A refrigeration controller or a remote controller rated 265 or 277 volts single-phase, alternating current, that is intended to control a compressor motor and that may also control a conventional motor shall be rated in accordance with 68.6 and may also have rating of 2 horsepower (1.5 kW output) or

less – or an equivalent current rating – for a hermetic compressor motor. The locked-rotor current rating and test current need not be six times the full-load current rating. The conventional motor rating as specified in 68.6 and the hermetic compressor motor rating shall be marked in accordance with 69.14.

68.8 The ratings of a component intended only for installation as part of other equipment:

- a) Need not comply with 68.4 – 68.7 and
- b) May exceed 2 horsepower (1.5 kW output) or the equivalent at 265 or 277 volts, single-phase, alternating current. See Exception No. 1 to 69.1.

MARKINGS

69 General

69.1 The equipment shall be legibly and permanently marked with:

- a) The manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product may be identified;
- b) The date or other dating period of manufacture not exceeding any three consecutive months;
- c) A distinctive model number or the equivalent; and
- d) The electrical rating.

Exception No. 1: A component need not be marked with a rating, if intended only for factory installation:

- a) In end-use equipment; or*
- b) As part of other equipment and a different catalog designation is used for each different rating.*

Exception No. 2: The manufacturer's identification may be in a traceable code if the equipment is identified by the brand or trademark owned by a private labeler.

Exception No. 3: The date of manufacture may be abbreviated or in a nationally accepted conventional code or in a code affirmed by the manufacturer (the code may be traceable by or included as part of the serial number of the equipment), provided the date code:

- a) Does not repeat in less than 20 years, and*
- b) Does not require reference to the production records of the manufacturer to determine when the product was manufactured.*

69.2 Information necessary for the proper operation of the equipment, for a definite mounting position that is required but not obvious, for the selection of heaters for overload relays or thermostat anticipation, and for the setting of controls, and the like, shall be permanently marked on the equipment.

Exception: Equipment that must be mounted in a definite position in order to function properly may have the directions for mounting either marked on the equipment or on an instruction sheet supplied with the equipment.

CRG 916**CANADIAN REQUIREMENTS COMPARISON GUIDE**

UL AND CANADIAN
STANDARDS FOR
ENERGY MANAGEMENT EQUIPMENT



Product Category: Energy Management Equipment
UL Category Control Number: PAZX, PAZX2, PAZX7, PAZX8

UL Standard: Standard for Energy Management Equipment
UL 916
Second Edition

Canadian Standard: Signal Equipment
CSA C22.2 No. 205-M1983
First Edition

This Canadian Requirements Comparison Guide is only intended to identify Canadian requirements that must be applied in addition to the requirements in the UL Standard to obtain a C-UL Mark. The guide is not intended to replace a thorough review and comparison of the requirements applicable to the product category as contained in the applicable UL and Canadian Standards. Where requirements are not specifically addressed, compliance with the requirements in the UL Standard satisfy the requirements in the Canadian Standard.

The actual requirements applied for a C-UL product investigation may differ from those identified in this guide based on the specific features, characteristics, components, materials, or systems used in the product.

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Revisions of this guide will be made by issuing revised or additional pages bearing their date of issue. A Canadian Requirement Comparison Guide is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revision pages for the Guide

The following outlines the requirements contained in CSA 22.2 No. 205-M1983 that are in addition to the requirements in UL 916 that must be met in order for a product to bear the appropriate UL Marking. UL provides a certification program for products that meet the Canadian requirements. The C-UL Mark is the manufacturers assurance that products, as evaluated by UL, continue to comply with the appropriate Canadian requirements.

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<u>Requirements Topics</u>	<u>CSA Clause</u>	<u>Comparison</u>
Enclosure	4.2.4	The minimum allowable thicknesses for sheet metal enclosures specified in Table 1 of CSA C22.2 No. 205-M1983 are less than those specified in UL 916.
Power Supply Cords	4.3.1	CSA C22.2 No. 205-M1983 specifies that power supply cords shall not be less than 1.8 m long and shall not be greater than 2.4 m long.
Capacitors	4.16	The tests for capacitors noted in CSA C22.2 No. 205-M1983 are similar to the tests described in UL 1414. (Capacitors used in products evaluated to UL 916 are required to be tested in accordance with the requirements of UL 1414). However, the test procedures and the sample requirements for the tests described in C22.2 No. 205 and UL 1414 differ slightly. Therefore, a comparison of the test procedures in both standards is required to determine whether additional testing of capacitors is required.
Attachment Plugs and Receptacles	4.17.2	CSA C22.2 No. 205-M1983 requires that equipment provided with integral receptacles shall use a grounding-type supply cord and cannot be marked double-insulated.
Spacings	4.19	Regarding the parameters used to determine spacing requirements, CSA C22.2 No. 205-M1983 does not distinguish between (1) devices used in a controlled environment and those used in a general environment, and (2) equipment having a limited volt-ampere rating and those without a limited volt-ampere rating. In addition, most of the requirements of UL 916 used to reduce or waive spacings are not explicitly covered in C22.2 No. 205.
	4.19.1	Some of the minimum allowable spacings specified in Table 3 of CSA C22.2 No. 205-M1983 are less than those specified in UL 916. Therefore, a comparison between the spacing requirements of Table 3 and those of UL 916 is to be conducted to determine the appropriate spacings.
Markings	5.1(h)	When required, the phrase "FIRE HAZARD CAUTION: MAXIMUM LAMPS...WATTS, LAMP TYPE..." is to be marked on products evaluated to CSA C22.2 No. 205-M1983. The phrase is to appear in both English and French.

<u>Requirements Topics</u>	<u>CSA Clause</u>	<u>Comparison</u>
Markings (Cont'd)	5.4	The phrase "CERTIFIED FOR ELECTRICAL SHOCK AND ELECTRICAL FIRE HAZARD ONLY: or the equivalent is to be marked on products provided with the features specified in Clause 5.4 of CSA C22.2 No. 205-M1983. The phrase is to appear in both English and French.
	5.5	The phrase "CAUTION – DISCONNECT SUPPLY BEFORE OPENING" or the equivalent is to be marked on products when required as described in Clause 4.15.2 of CSA C22.2 No. 205-M1983. The phrase is to appear in both English and French.
Temperature Test	6.3.1	CSA C22.2 No. 205-M1983 requires that the maximum temperature of interior surfaces of wooden enclosures and exposed surfaces of user controls be measured during the Temperature Test.
Temperature (Abnormal)	6.4.1	Direct plug-in products are to be subjected to an 18-Day Temperature (Abnormal) Test.
Dielectric Strength	6.5.3	Double-insulated equipment is to be subjected to the Withstand Test voltages specified in Table 5 of CSA C22.2 No. 205-M1983.
Leakage Current	6.6.1	Prior to conducting the leakage current test for cord-connected products, the device is to be conditioned in a humidity chamber for 72 hours. Also, CSA C22.2 No. 205-M1983 does not allow leakage current of up to 0.75 mA to be measured from stationary units employing a standard attachment plug rated 20 amperes or less.
Capacitor Test	6.8	There are some differences between the capacitor tests of Clauses 6.8.2 through 6.8.5(d) of CSA C22.2 No. 205-M1983 and those of UL 1414. When these tests are required to be conducted, or when a UL Recognized capacitor is being used, a comparison of the test procedures in CSA C22.2 No. 205 and UL 1414 is to be done on a case-by-case basis.

<u>Requirements Topics</u>	<u>CSA Clause</u>	<u>Comparison</u>
Evaluation of Coatings of Printed Wiring Boards	6.9	A printed wiring board covered with conformal coating in lieu of reduced spacings in accordance with Clause 4.19.7 of CSA C22.2 No. 205-M1983 is to be subjected to the tests described in Clauses 6.9.2 – 6.9.5. When the conformal coating is a UL Recognized material, a comparison between the tests noted above and the appropriate tests described in Section 11 of UL 840 shall be conducted to determine whether they are identical.
Swivel Test	6.10	CSA C22.2 No. 205-M1983 requires that lampholders provided with swivel joints be subjected to the Swivel Test.
Electrolytic Capacitors	6.13.1	To determine compliance with Clause 4.16.3 of CSA C22.2 No. 205-M1983, electrolytic capacitors shall be tested in accordance with Clause 6.13 of C22.2 No. 205.
Isolation Capacitors and Networks	6.14	The Discharge Test and the Life Test noted in Clause 6.14 are similar to those described in UL 1414. However, because of the differences in how these tests are conducted, the testing procedures noted in CSA C22.2 No. 205-M1983 and UL 1414 are to be compared on a case-by-case basis.

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**Underwriters Laboratories Inc.®**A not-for-profit organization dedicated to public safety
and committed to quality service**May 24, 1996****Revision pages for****Standard for****Energy Management Equipment****UL 916, Second Edition**

Attached to this distribution notice is a revision of the second edition of UL 916.

A CHANGE ON A PAGE DATED MAY 24, 1996 IS INDICATED BY A SMALL PRINT NOTE FOLLOWING THE AFFECTED ITEM, PRECEDED AND FOLLOWED BY AN ASTERISK.

THESE NEW AND REVISED REQUIREMENTS IN THIS STANDARD ARE NOW IN EFFECT EXCEPT FOR THOSE PARAGRAPHS, SECTIONS, TABLES, FIGURES, AND OTHER ELEMENTS OF THE STANDARD HAVING FUTURE EFFECTIVE DATES AS INDICATED IN THE NOTE FOLLOWING THE AFFECTED ITEM. TO RETAIN THE REQUIREMENTS IN EFFECT UNTIL THESE FUTURE EFFECTIVE DATES, DO NOT DISCARD THE PAGES REPLACED BY THOSE HAVING FUTURE EFFECTIVE DATES UNTIL THOSE DATES.

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

The new and revised requirements are substantially in accordance with UL's Bulletin on this subject dated January 25, 1996. The bulletin is now obsolete and may be discarded.

As indicated on the title page (page 1), this UL Standard for Safety is an American National Standard. Attention is directed to the note on the title page of this Standard outlining the procedures to be followed to retain the text of this ANSI/UL Standard.

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

With the inclusion of the accompanying material, the standard consists of pages dated as shown in the following checklist:

Page	Date
1	April 25, 1994 (Reprinted May 24, 1996)
2	—
3 – 6	April 25, 1994
7, 8, 8A	April 26, 1994
9 – 27	April 25, 1994

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28 – 30, 30A	August 3, 1995
31 – 71	April 25, 1994
72, 73	April 26, 1994
74 – 95	April 25, 1994
96	May 24, 1996
97 – 126, A1	April 25, 1994

APRIL 25, 1994
(Title Page Reprinted: May 24, 1996)



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UL 916

Standard for

Energy Management Equipment

First Edition – August, 1984

Second Edition

April 25, 1994

Approval as an American National Standard (ANSI) covers the numbered paragraphs on pages dated April 25, 1994. These pages should not be discarded when revised or additional pages are issued if it is desired to retain the ANSI approved text.

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

Approved as ANSI/UL 916-1987, August 13, 1987
Approved as ANSI/UL 916-1993, November 18, 1993

Revisions of this standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest published set of revision pages.

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53.5 A nonrenewable fuse that will not open in less than 12 seconds when carrying twice its rated current is to be connected to one pole of the supply circuit. The fuse is to have a current rating equal to that of the branch-circuit overcurrent-protective device to which the equipment will be connected, but not less than 20 amperes.

54 Strain Relief and Flexing Test

54.1 Strain relief

54.1.1 A strain-relief device shall withstand without damage to the cord or conductors and without displacement a direct pull of 35 pounds (156 N) applied to the cord for 1 minute. Supply connections within the equipment are to be disconnected from terminals or splices during the test.

54.1.2 A pigtail lead intended for field-wiring connection shall withstand without damage or displacement a direct pull of

- a) 20 pounds (89 N) for 1 minute applied to a lead extending from the enclosure such as through a hub or nipple, and
- b) 10 pounds (44.5 N) for 1 minute applied to a lead within a wiring compartment.

54.2 Flexing

54.2.1 With reference to 16.1.9, wiring that is subjected to movement at times other than installation and servicing is to be tested by cycling the moving part through the maximum travel permitted by the construction. The duration of the test is to be 500 cycles. Following this, the equipment is to be subjected to the Dielectric Voltage-Withstand Test, Section 49, and the wiring is to be examined for damage to determine if any conductors are broken or if individual strands have penetrated the insulation.

55 Accelerated Aging Tests

55.1 General

55.1.1 The requirements in 55.2.2 – 55.3.2 apply to gaskets and sealing compounds used to make an enclosure raintight or rainproof as determined in accordance with the requirements in Rain Test, Section 57. With requirements in 55.4.1 and 55.4.2 apply to adhesives required to secure such gaskets to an enclosure or cover.

55.2 Gaskets

55.2.1 The temperature rises mentioned in this section correspond to the maximum temperature rise measured on the gasket during the temperature test. Materials other than those mentioned in this section shall be nonabsorptive and they, and any materials having higher temperature rises, shall provide equivalent resistance to aging and temperatures.

55.2.2 Neoprene or rubber compounds, except foamed materials, used for gaskets to seal an enclosure shall have physical properties as specified in Table 55.1 before and after accelerated aging under the conditions specified in Table 55.2.

55.2.3 Foamed neoprene or rubber compounds used for gaskets to seal an enclosure are to be subjected to accelerated aging under the conditions specified in Table 55.2. The compounds shall not harden or otherwise deteriorate to a degree that will affect their sealing properties.