39 Power Supplies

39.1 A power supply shall comply with one of the following:

a) For a Class 2 Power Supply, UL 1310 or UL 60950-1, and with the Class 2 or limited power source requirements.

b) For a power supply that is other than Class 2, UL 1012 or UL 60950-1; or

c) For a switch mode power supply unit not complying with (a) or (b), the relevant requirements in this Standard, including the Switch Mode Power Supply Units – Overload Test, Section 66A, shall be applied.

39.2 *Deleted*

40 Solar Photovoltaic (PV) Systems

40.1 Solar photovoltaic (PV) modules or PV cells on a vending machine shall comply with UL 1703.

40.2 A charge controller, inverter, converter or other components intended for use as part of the PV system shall comply with UL 1741.

40.3 A vending machine with PV modules or cells shall be provided with a factory installed ground-fault circuit-interrupter (GFCI) that complies with UL 943. If the vending machine is:

a) Cord-connected, the GFCI shall comply with 16.1.5 and 16.1.6;

b) Intended for permanent connection to the source of electrical supply or is a stand-alone solar PV system, the GFCI shall be in the circuit supplying power from the PV modules or cells and shall:

1) Automatically disconnect the ungrounded conductors of the faulted circuit; or

2) Enable the inverter or charge controller fed by the faulted circuit to automatically cease supplying power to the output circuits.

40.4 A vending machine with a solar PV system shall be provided with overcurrent protection in the circuit supplying power from the PV modules or cells. The overcurrent protective device size shall not exceed 125 percent of the inverter output current.

40.5 A means shall be provided to disconnect all ungrounded conductors of a solar PV power source and any additional source, such as batteries, from all other conductors within the vending machine. The disconnecting means shall be readily accessible and provided with the marking in 80.2.13.

40.6 In reference to 40.5, manual operation of the main PV disconnect shall not activate the GFCI or result in grounded conductors becoming ungrounded.

40.7 A vending machine with an interactive solar PV system shall be provided with a:

a) Dedicated and marked field wiring termination means of connection. This means shall include the branch circuit overcurrent protective device as required by 40.4;

b) Means to disconnect and isolate the inverter from all other circuitry within the equipment; and

c) Secondary, independent means of controlling the battery charging process when the utility is not present or when the primary charge controller fails or is disabled.

40.8 A vending machine that includes batteries for a solar PV system shall not have more than twenty-four 2 volt cells connected in series (48 volts nominal).

40.9 When a solar PV system on a vending machine includes batteries, overcurrent protection shall be installed in each battery circuit. The protection shall be accessible and be located adjacent to or near the batteries.

40.10 In reference to 40.9, the battery overcurrent protection shall not exceed 125 percent of the total battery output current.

40.11 Charging circuits used with PV supplies shall comply with 39.1.

41 Information Technology Equipment

41.1 Information technology equipment such as a printer, visual display unit, router, communication connectors/data ports or computer shall comply with UL 60950-1.

42 Terminal Blocks

42.1 Terminal blocks shall comply with UL 1059, and, if applicable, be suitably rated for field wiring.

42.2 In reference to 42.1, if a fabricated part performs the function of a terminal block, the part shall comply with the requirements in Terminals, Section 17.3.2, Current-Carrying Parts, Section 18, Insulating Material, Section 19, and the spacings requirements as applicable to the type of circuit as specified below:

a) High-Voltage Circuits, Section 46.1; or

b) Low-Voltage Circuits, Section 46.2.

42.3 If a fabricated terminal block complies with the alternate spacings requirements in Alternate Spacings – Clearances and Creepage Distances, Section 46.3, but not with the spacings requirements in High-Voltage Circuits, Section 46.1, the terminal block shall not be used for field wiring.

43 Transformers

43.1 A transformer (including an autotransformer), shall comply with UL 5085-1 in conjunction with UL 5085-2 or UL 5085-3.

44 Wireways, Auxiliary Gutters and Associated Fittings

44.1 Wireways, auxiliary gutters and associated fittings shall comply with UL 870.

45 Secondary Circuits

45.1 A secondary circuit shall be judged under the applicable requirements in this standard.

Exception No. 1: A circuit supplied by the secondary winding of a transformer that complies with the requirements for a Class 2 transformer need not be investigated.

Exception No. 2: A circuit supplied by a single source consisting of an isolating transformer with an open circuit potential of 30 volts rms (42.4 volts peak) or less need not be investigated from the point at which the current and voltage are limited if the combination of the transformer and a fixed impedance or regulating network complies with the performance requirements for a Class 2 transformer or a secondary circuit fuse having a maximum current rating as specified in Table 45.1 is provided.

Table 45.1
Rating of fuse or circuit protector

Open-circuit volts (peak)	Rating, amperes
0 – 21.2	5.0
21.3 – 42.4	3.2

45.2 With reference to Exception No. 2 to 45.1, if an interchangeable fuse – a fuse is interchangeable if any fuse of a higher ampere rating will fit the fuseholder – is used, a legible and permanent marking shall be provided next to the fuseholder indicating the ampere rating of the fuse to be used for replacement. See 81.6.

46 Spacings

46.1 High-voltage circuits

46.1.1 The following electrical spacing requirements apply to high-voltage circuits as defined in 5.16.

46.1.2 Unless specifically noted otherwise, the spacings between uninsulated live parts of opposite polarity and between an uninsulated live part and a dead metal part shall be not less than the values indicated in Table 46.1.

Table 46.1
Electrical spacings in air-handling compartments

Ratings		Minimum spacing					
Volt-amperes	Volts	Through air[a]		Over surface[a]		To enclosure[c]	
		Inch	(mm)	Inch	(mm)	Inch	(mm)
2000 or less	300 or less	1/8[b]	(3.2)	1/4	(6.4)	1/4	(6.4)
	301–600	3/8	(9.5)	1/2	(12.7)	1/2	(12.7)
More than 2000	150 or less	1/8[b]	(3.2)	1/4	(6.4)	1/2	(12.7)
	151–300	1/4	(6.4)	3/8	(9.5)	1/2	(12.7)
	301–600	3/8	(9.5)	1/2	(12.7)	1/2	(12.7)

[a] At points other than field-wiring terminals, the spacings for heater elements only may be as indicated below provided the elements are not subject to moisture, such as may result from condensation on cooled surfaces:

1/16 inch (1.6 mm) Through Air and Over Surface for heaters rated 0–300 volts.

1/4 inch (6.4 mm) Through Air and Over Surface for heaters rated 301–600 volts.

[b] The spacings between wiring terminals of opposite polarity or between a wiring terminal and ground shall be not less than 1/4 inch (6.4 mm), except that if short-circuiting or grounding of such terminals will not result from projecting strands of wire, spacing need not be greater than 1/8 inch (3.2 mm). Wiring terminals are those connected in the field and not factory wired.

[c] Includes fittings for conduit or metal-clad cable.

46.1.3 The ″Through Air″ and ″Over Surface″ spacings given in Tables 46.1 and 46.2 at an individual component part are to be based on the total volt-ampere consumption of the load or loads which the component controls. For example, the spacings at a component which controls only a motor are based on the volt-amperes of the motor. The spacings at a component which controls loads in addition to a motor are based on the sum of the volt-amperes of the loads so controlled, except that spacings at a component which independently controls separate loads are based on the volt-amperes of the larger load. The volt-ampere values for the loads referred to above are to be determined by the marked rating of the loads, except that for loads which are not required to have a marked rating, the measured inputs are to be used in determining the volt-ampere values.

46.1.4 With reference to 46.1.2 and 46.1.3, the spacings to enclosure are not to be applied to an individual enclosure of a component part within an outer enclosure or cabinet.

46.1.5 The spacings indicated in Table 46.2 are applicable only to electrical components mounted in totally enclosed nonair handling compartments which are free of moisture, including that caused by condensation. At wiring terminals and for circuits over 250 volts or over 2000 volt-amperes, spacings in Table 46.1 apply.

Table 46.2
Spacings in non-air handling compartments

Ratings		Minimum spacing in inches (mm)					
Volt-amperes	Volts	Through air		Over surface		To enclosure[a]	
		Inch	(mm)	Inch	(mm)	Inch	(mm)
0 – 2000	0 – 125	1/16	(1.6 mm)	1/16	(1.6 mm)	1/4	(6.4 mm)
	125 – 250	3/32	(2.4 mm)	3/32	(2.4 mm)	1/4	(6.4 mm)

NOTE – See 46.1.5.

[a] Includes fittings for conduit or metal-clad cable.

46.1.6 All uninsulated live parts connected to different circuits shall be spaced from one another as though they were parts of opposite polarity in accordance with the requirements indicated above and shall be judged on the basis of the highest voltage involved.

46.1.7 The above spacing requirements do not apply to the inherent spacings of a component part of the equipment, such as a motor, snap switch, controller, attachment-plug cap, and the like, for which spacing requirements are given in a standard for the component. However, the electrical clearance resulting from the assembly of a component into the complete machine, including clearance to dead metal or enclosures, shall be as indicated herein.

46.1.8 An insulating liner or barrier of fiber or similar material, employed where spacings would otherwise be less than the required values, shall be no less than 0.028 inch (0.7 mm) thick and shall be so located or of such material that it will not be adversely affected by arcing.

Exception No. 1: Fiber no less than 0.013 inch (0.3 mm) thick may be used in conjunction with an air spacing of no less than 50 percent of the spacing required for air alone.

Exception No. 2: Material having a lesser thickness may be used if it has equivalent insulating, mechanical, and flammability properties when compared with materials in thicknesses specified above.

46.1.9 If higher than rated potential is developed in a motor circuit through the use of capacitors, the rated voltage of the system shall be employed in applying the spacings indicated in this section.

Exception: If the developed steady-state potential as determined in the Temperature and Pressure Test exceeds 500 volts, the developed potential is to be used in determining spacings for the parts affected.

46.1.10 The spacing between uninsulated live terminals of the components in an electric-discharge lamp circuit and a dead metal part or enclosure shall be not less than 1/2 inch (12.7 mm) if the potential is 600 volts or less and not less than 3/4 inch (19.1 mm) if the potential is 601 – 1000 volts.

46.2 Low-voltage circuits

46.2.1 The following electrical spacing requirements apply to low-voltage circuits a defined in 5.21.

46.2.2 A circuit derived from a source of supply classified as a high-voltage circuit, by connecting resistance in series with the supply circuit as a means of limiting the voltage and current, is not considered to be a low-voltage circuit.

46.2.3 The spacings for low-voltage electrical components which are installed in a circuit which includes a pressure-limiting device, motor overload protective device, or other protective device, where a short or grounded circuit may result in unsafe operation of the equipment shall comply with the following:

a) The spacing between an uninsulated live part and the wall of a metal enclosure, including fittings for the connection of conduit or metal-clad cable, shall be not less than 1/8 inch (3.2 mm).

b) The spacing between wiring terminals, regardless of polarity, and between the wiring terminal and a dead metal part, including the enclosure and fittings for the connection of conduit, which may be grounded when the device is installed, shall be not less than 1/4 inch (6.4 mm).

c) The spacing between uninsulated live parts, regardless of polarity, and between an uninsulated live part and a dead metal part, other than the enclosure, which may be grounded when the device is installed, shall be not less than 1/32 inch (0.8 mm) provided that the construction of the parts is such that spacings will be maintained.

46.2.4 The spacings in low-voltage circuits which do not contain devices such as indicated in the previous paragraph are not specified.

46.3 Alternate spacings – clearances and creepage distances

46.3.1 Other than as indicated in 46.3.2, the spacings requirements in UL 840, are applicable as an alternative to the specified spacings requirements in the following:

a) High-Voltage Circuits, Section 46.1; and

b) Low-Voltage Circuits, Section 46.2.

46.3.2 The spacing requirements in UL 840, shall not be used for spacings between field wiring terminals or between uninsulated live parts and a metal enclosure.

46.3.3 The items specified in (a) – (f) shall be considered when evaluating a vending machine to the requirements in UL 840:

a) Hermetically sealed or encapsulated enclosures are identified as pollution degree 1.

b) Coated printed wiring boards are identified as pollution degree 1 if they comply with one of the following:

1) The Printed Wiring Board Coating Performance Test in UL 840; or

2) Conformal coating requirements as outlined in UL 746E.

c) Indoor use vending machines are identified as pollution degree 2.

d) Outdoor use vending machines are identified as pollution degree 3.

e) Category II is the overvoltage category.

f) Printed wiring boards are considered as having a minimum comparative tracking index (CTI) of 100 unless further investigated for a higher CTI index.

46.3.4 Clearance B (Controlled Overvoltage) clearances as specified in UL 840, shall be achieved by providing an overvoltage device or system as an integral part of the vending machine.

47 Grounding

47.1 A vending machine shall have provision for the grounding of all exposed dead metal parts that may become energized.

47.2 Except as specified in 47.3 and 47.4, all exposed dead metal parts and all dead metal parts within the enclosure that are exposed to contact by the user, route person, or service person and that may become energized shall be reliably connected to one of the following:

a) The equipment-grounding terminal or lead of a:

1) Permanently installed vending machine; or

2) Vending machine with a stand-alone solar PV system.

b) The equipment-grounding conductor of the cord of a cord-connected vending machine.

47.3 In reference to 47.2(a)(2), a vending machine with a stand-alone solar PV system shall have provision for permanent connection to a grounding means and the equipment grounding connection requirements in 17.2 – 17.4 shall be applied except that the vending machine is not required to have a permanent connection to a grounding means or an equipment grounding connection if the vending machine is marked as specified in 80.2.18.

47.4 Metal parts that do not comply with 47.2 shall be one of the following:

a) An adhesive-attached metal-foil marking, a screw, a handle, and the like, on the outside of an enclosure or cabinet and isolated from electrical components or wiring by grounded metal parts so that they are not likely to become energized;

b) An isolated metal part, such as a magnet frame and an armature, small assembly screws, and the like, that are positively separated from wiring and uninsulated live parts;

c) A panel or a cover that does not enclose an uninsulated live part if wiring is positively separated from the panel or cover so that it is not likely to become energized; and

d) A panel or a cover that is insulated from electrical components, including wiring, by an insulating barrier of vulcanized fiber, varnished cloth, phenolic composition, or similar material not less than 1/32 inch (0.8 mm) thick and reliably secured in place.

47.5 Metal-to-metal hinges may be used as a means for bonding a door for grounding.

47.6 A separate component bonding conductor of adequate size shall be copper, copper alloy, or other material acceptable for use as an electrical conductor.

47.7 A separate bonding conductor or strap shall be protected from mechanical damage or be located within the outer enclosure or frame, and not be secured by a removable fastener used for a purpose in addition to bonding unless the bonding conductor is unlikely to be omitted after removal and replacement of the fastener.

47.8 Bonding shall be by a positive means, such as by clamping, riveting, bolted or screwed connection, welding, or soldering and brazing materials having a softening or melting point higher than 454°C (850°F). The bonding connection shall reliably penetrate nonconductive coatings such as paint or vitreous enamel. Bonding around a resilient mount shall not depend upon the clamping action of rubber or similar material.

Exception: A connection depending on the clamping action exerted by rubber or a similar material may be acceptable if it complies with the requirements in 60.1 under any degree of compression permitted by a variable clamping device and if the results are still acceptable after exposure to the effects of oil, grease, moisture, and thermal degradation likely to occur in service.

47.9 A clamping device is to be considered with particular emphasis on the likelihood of the device being reassembled in its intended fashion in testing the effect of assembling and disassembling the vending machine for maintenance purposes.

47.10 If the adequacy of a bonding connection cannot be determined by examination, its acceptability shall be determined by the test described in 63.1.

47.11 In a cord-connected vending machine, the cross-sectional area of a bonding conductor or strap shall not be less than that of the grounding conductor of the supply cord.

47.12 The size of a conductor or strap employed to bond an electrical enclosure or a motor frame for a:

a) Permanently connected vending machine shall be based on the rating of the branch circuit overcurrent device to which the equipment will be connected.

b) Stand-alone solar PV system vending machine having provision for a permanent connection to a grounding means, shall be based on the rating of the overcurrent protective device required in accordance with 40.4.

47.13 Except as specified in 47.14, the size of the bonding conductor or strap required by 47.12 shall not be less than the applicable value stated in Table 47.1.

47.14 A bonding conductor or strap not complying with 47.12 or 47.13 shall:

a) Comply with the Bonding Connection Test, Section 63; or

b) Not be smaller than the conductors supplying power to the component or components within the vending machine enclosure.

47.15 In reference to 47.14(a), if the Bonding Connection Test, Section 63 is conducted, the components to be tested shall include any connections that may be provided as part of the bonding conductor or strap.

47.16 If more than one rating of branch-circuit overcurrent-protective device is involved, the size of the bonding conductor shall be based on the rating of the overcurrent-protective device intended to provide ground-fault protection for the component bonded by the conductor. For example, if a motor is individually protected by a branch-circuit overcurrent-protective device of lesser rating than other overcurrent-protective devices used with the vending machine, a bonding conductor for that motor is sized on the basis of the device intended for ground-fault protection of the motor.

Table 47.1
Minimum acceptable size of bonding conductor

Rating of overcurrent device, amperes[a]	Size of bonding conductor[b]	
	Copper wire, AWG	Aluminum wire, AWG
15	14	12
20	12	10
30	10	8
40	10	8
60	10	8
100	8	6

[a] See 47.16.
[b] Or equivalent cross-sectional area.

47.17 Functional grounding shall not be relied upon for equipment grounding or bonding.

48 Accessories

48.1 Paragraphs 48.1.1 – 48.6 apply to accessories intended for installation on or connection to a vending machine to modify or supplement the functions of the vending machine or accessory.

48.1.1 A vending machine shall comply with all the requirements of this standard with or without the accessory installed.

48.2 A vending machine having provisions for the use of accessories to be attached in the field shall be so constructed that the use of these accessories will not introduce a risk of fire, electric shock, or injury to persons. See 48.6.

48.3 The installation of an accessory by a route person shall be restricted to an arrangement that can be accomplished by means of a receptacle and plug-in connector.

48.4 The installation of an accessory by a qualified person is acceptable if connections are made to existing terminals by use of wire connectors.

48.5 The installation of an accessory shall not require the field rearrangement of components or wiring, the cutting or splicing of wiring, or the soldering of connections.

48.5.1 An accessory strain-relief means shall be provided for the wiring if there is a possibility of transmitting stress to the terminal connections during installation. The strain-relief shall comply with the Strain Relief Test, Section 68.

48.5.2 Unless correct connections are evident, the wiring connections for the accessory shall be identified on both the accessory and on the vending machine.

48.5.3 The accessory mounting location shall be:

a) Identified on the vending machine; or

b) Fixed due to the function of the accessory and its arrangement within the vending machine. In this case, the accessory installation instructions shall specify the mounting location of the accessory.

48.5.4 Accessories intended for connection to a source of field power supply independent of that of the vending machine shall comply with the requirements in:

a) Section 16 if intended to be a cord-connected accessory.

b) Section 17if intended to be a permanently connected accessory. A permanently connected accessory shall not be used with any supply cord connected equipment.

48.6 As part of the investigation, an accessory shall be tested and trial installed to determine that its installation is feasible, that the instructions are detailed and correct, and that the use of the accessory does not introduce a risk of fire, electric shock, or injury to persons. See 80.4.2.

49 Coin and Credit Mechanisms

49.1 A coin or credit mechanism shall be acceptable for the temperatures involved and for controlling the connected load or loads. The mechanism shall be installed in the vending machine at the factory.

Exception: A coin or credit mechanism may be installed in the field, if the mechanism and vending machine comply with the requirements in 49.2 – 49.5 and 80.2.8, 81.4, and 81.5.

49.2 The installation of a coin or credit mechanism shall be by means of receptacles and plug-in connectors. Unless bonding for grounding is accomplished automatically by normal mounting of the mechanism in the vending machine, a separate bonding conductor shall be provided in the receptacle and plug-in connector.

49.3 A strain-relief means shall be provided for the wiring in the mechanism if there is a possibility of transmitting stress to the terminal connections during installation.

49.4 A coin or credit mechanism shall be trial-installed to determine that its installation is feasible and that the instructions are detailed and correct. A risk of electric shock shall not be present during installation of a mechanism unless the marking required by 81.4 is provided. Following installation, the use of a mechanism shall not result in a risk of fire, electric shock, or injury to persons.

49.5 A vending machine without a coin or credit mechanism shall be evaluated for the accessibility of live or moving parts capable of causing injury to persons without a mechanism installed and with the enclosure of the vending machine open to the extent permitted by the absence of the coin or credit mechanism.