



Underwriters Laboratories Inc.®

A not-for-profit organization dedicated to public safety
and committed to quality service

March 15, 1996

Revision pages for

Standard for

Uninterruptible Power Supply Equipment

UL 1778, Second Edition

Attached to this transmittal notice is a revision of the Second edition of UL 1778.

A CHANGE ON A PAGE DATED MARCH 15, 1996 IS INDICATED BY A SMALL PRINT NOTE FOLLOWING THE AFFECTED ITEM, PRECEDED AND FOLLOWED BY AN ASTERISK.

THIS REVISION IS CONSIDERED NON-SUBSTANTIVE AND IS BEING ISSUED TO ELIMINATE THE OXYGEN BOMB TEST. THE OXYGEN BOMB TEST IS NO LONGER APPROPRIATE IN MOST CASES DUE TO THE ADDITION OF ANTIOXIDANTS TO RUBBER AND POLYMERIC COMPOUNDS. THEREFORE, UL IS ELIMINATING THE OXYGEN BOMB TEST AND REPLACING IT WITH AN AIR OVEN AGING TEST WHICH IS USED FOR THERMOPLASTIC COMPOUNDS. THE REQUIREMENTS ARE NOW IN EFFECT.

Attention is directed to the note on the title page of this standard outlining the procedure to be followed to retain the approved text of ANSI/UL 1778-1996.

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:

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OCTOBER 25, 1994
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UL 1778

Standard for

Uninterruptible Power Supply Equipment

First Edition – November, 1989

Second Edition

October 25, 1994

Approval as an American National Standard (ANSI) covers the numbered paragraphs on pages dated October 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.

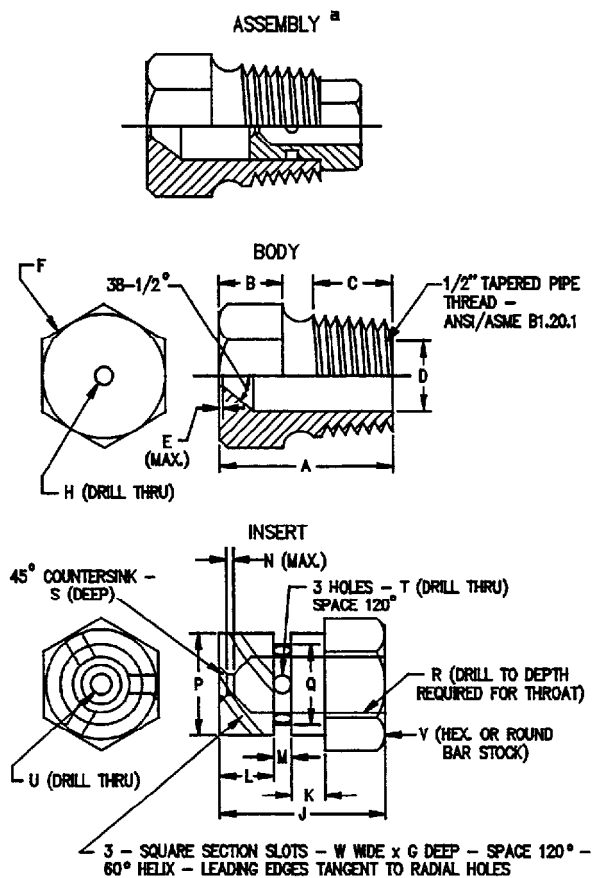
Approved as ANSI/UL 1778-1991, August 16, 1991
Approved as ANSI/UL 1778-1996, February 8, 1996

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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Figure 82.2
Rain-test spray head



Item	inch	mm	Item	inch	mm
A	1-7/32	31.0	N	1/32	0.80
B	7/16	11.0	P	.575	14.61
C	9/16	14.0	Q	.576	14.63
D	.578	14.68	R	.453	11.51
E	.580	14.73	R	.454	11.53
F	1/64	0.40	S	1/4	6.35
G	c	c	T	1/32	0.80
H	(No. 9) ^b	5.0	T	(No. 35) ^b	2.80
J	23/32	18.3	U	(No. 40) ^b	2.50
K	5/32	3.97	V	5/8	16.0
L	1/4	6.35	W	0.06	1.52
M	3/32	2.38			

^a Nylon Rain-Test Spray Heads are available from Underwriters Laboratories Inc.

^b ANSI B94.11M Drill size

^c Optional — To serve as wrench grip.

RT100C

Table 82.1
Physical properties for gaskets

Physical property ^a	Neoprene or rubber compound		Polyvinyl-chloride materials	
	Before conditioning	After conditioning	Before conditioning	After conditioning
Tensile Minimum set when 1 inch (25.4 mm) gage marks are stretched to 2-1/2 inches (63.5 mm), held for 2 minutes and measured 2 minutes after release.	1/4 inch (6.4 mm)	—	Not Specified	Not Specified
Elongation Minimum increase in distance between 1 inch gage marks at break.	250 percent [to 3-1/2 inches (88.9 mm)]	65 percent of original	250 percent [to 3-1/2 inches (88.9 mm)]	75 percent of original
Tensile Strength Minimum force at breaking point.	850 psi (5.86 MPa)	75 percent of original	1200 psi (8.27 MPa)	90 percent of original
^a To be determined using the test methods and apparatus described in Standard Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers – Tension, ASTM D412-1992, except the method for tensile set is to be as specified in this table.				

Table 82.2
Conditioning parameters

Minimum material temperature rise ^a degrees C (F)	Conditioning	
	Rubber or neoprene	Thermoplastic
35 (63)	70 hours in an air-circulated oven at 100 ±2°C (212 ±3.6°F)	7 days in an air-circulated oven at 87°C (189°F)
50 (90)	7 days in an air-circulated oven at 100 ±2°C (212 ±3.6°F)	10 days in an air-circulated oven at 100°C (212°F)
55 (99)	7 days in an air-circulated oven at 113°C (235.4°F)	7 days in an air-circulated oven at 113°C (235.4°F)
65 (117)	10 days in an air-circulated oven at 121°C (249.8°F)	7 days at 121°C (249.8°F) or 60 days at 97°C (206°F) in an air-circulated oven
80 (144)	7 days in an air-circulated oven at 136°C (276.8°F)	7 days in an air-circulated oven at 136°C (276.8°F)
^a Measured during the Temperature Test, Section 45.		

Table 82.2 revised March 15, 1996



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February 1, 1996

Revision pages for

Standard for

Uninterruptible Power Supply Equipment

UL 1778, Second Edition

Attached to this transmittal notice is a revision of the Second edition of UL 1778.

A CHANGE ON A PAGE DATED FEBRUARY 1, 1996 IS INDICATED BY A SMALL PRINT NOTE FOLLOWING THE AFFECTED ITEM, PRECEDED AND FOLLOWED BY AN ASTERISK.

THESE NEW AND REVISED REQUIREMENTS ARE NOW IN EFFECT EXCEPT FOR PARAGRAPHS 13.5, 14.5, 28.1.6, AND SECTIONS 70A AND 70B WHICH BECOME EFFECTIVE FEBRUARY 1, 1999 AS INDICATED IN THE SMALL PRINT NOTE FOLLOWING THE AFFECTED ITEM. TO RETAIN THE REQUIREMENTS IN EFFECT UNTIL FEBRUARY 1, 1999, DO NOT DISCARD THE PREVIOUS PAGES CONTAINING THE REQUIREMENTS SPECIFIED ABOVE UNTIL THIS FUTURE EFFECTIVE DATE.

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 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 October 13, 1995. The bulletin is now obsolete and may be discarded.

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

(Continued)

February 1, 1996 – UL 1778

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12.9 A bypass switch or maintenance bypass used to connect the protected load directly to the bypass source shall comply with requirements in the Standard for Automatic Transfer Switches, UL 1008.

Exception: A bypass switch or maintenance bypass tested in conjunction with the UPS need not comply with UL 1008. See 12.10, 52.12.1, and 52.12.2.

12.10 With reference to the requirement in the Exception to 12.9, solid state switches shall comply with the requirements in this standard. Mechanical and electromechanical switches shall comply with the appropriate requirements for switches such as in the Standard for General-Use Snap Switches, UL 20, the Standard for Industrial Control Equipment, UL 508, or other appropriate standards.

12.11 If a unit switch or circuit breaker is mounted such that movement of the operating handle between the on position and off position results in one position being above the other position, the upper position shall be the on position. This requirement does not apply to:

- a) A switching device having more than one on position (such as a bypass switch);
- b) A double throw switch;
- c) A rotationally-operated switch; or
- d) A rocker switch.

13 Disconnection Device

13.1 A disconnection device shall be provided for the output ac and dc power circuits of a fixed UPS, and a remote battery supply/cabinet assembly (see 13.4).

Exception No. 1: A UPS or battery supply having either a cord and plug or receptacle for connection to the output ac or dc circuit need not be provided with a disconnect device.

Exception No. 2: A UPS or battery supply provided with an instruction manual indicating that the disconnection means is to be provided by others need not be provided with a disconnect means. See 74.1.2(r).

13.2 The disconnection device shall:

- a) Open all ungrounded conductors;
- b) Consist of either a manually operated switch or circuit breaker;
- c) Employ an operating handle that is either accessible from outside of the enclosure or located under a hinged cover not requiring a tool for opening; and
- d) Be marked in accordance with 72.1.22.

13.3 If the operating handle of a disconnect device is operated vertically rather than rotationally or horizontally, the up position of the handle shall be the on position.

13.4 For a UPS investigated in combination with the remote battery supply intended to be used with the UPS, only one disconnection device need be provided for the battery supply circuit.

13.5 A battery supply for a UPS provided with a marking indicating that it is suitable for use in a computer room (see 72.1.27) shall incorporate a battery disconnect and a means for connection to the remote emergency power off circuit that disconnects the battery power source. The battery shall be disconnected within five minutes of the activation of the remote emergency power off circuit. See 70B.1.

Exception No. 1: A battery supply which meets the criteria of either (a) or (b) need not comply with this requirement:

- a) *The product of the open circuit voltage times the rating of the overcurrent protective device does not exceed 750 VA; or*
- b) *Any resistive load cannot draw more than 750 VA for more than five minutes after the main power is disconnected (see 70A.1).*

Exception No. 2: A disconnecting means shall not be required for power sources capable of supplying 750 volt-amperes or less derived from UPS equipment or from battery circuits integral to UPS equipment.

Added 13.5 effective February 1, 1999

14 Receptacles

14.1 A general-use attachment-plug receptacle in a unit shall be of the grounding type.

14.2 With reference to 14.1, if a grounding type receptacle is supplied from the secondary of a transformer:

- a) The side of the secondary winding connected to the white or silver terminal of the receptacle shall be grounded in accordance with the requirements in 17.1, 17.2, and 17.4; and
- b) The grounding terminal of the receptacle shall be conductively connected to the equipment grounding means in accordance with Section 19, Bonding of Internal Parts, and 18.14.

Exception: For an isolated-ground receptacle, the grounding terminal intended for connection to an insulated grounding conductor shall not be conductively connected to the equipment grounding means. See 14.4.

14.3 If a receptacle is supplied from the input ac supply circuit for the unit then, the white or silver terminal of the receptacle shall be connected to the grounded supply conductor, and the grounding terminal of the receptacle shall be conductively connected to the equipment grounding means in accordance with the requirements for bonding of internal parts specified in Section 19, Bonding of Internal Parts. See also 15.8.1 and 18.14.

14.4 With reference to the Exception to 14.2, a UPS provided with an isolated-ground receptacle shall comply with the following:

- a) Provisions for permanent wiring connections shall be provided for the ac supply conductors; and
- b) Provisions for connection of two equipment grounding conductors — one for grounding dead metal parts of the UPS specified in 18.1 and the other for grounding the grounding terminal of the isolated-ground receptacle — shall be provided. These provisions shall comply with the requirements in Section 18, Equipment Grounding.

14.5 A receptacle mounted on a raised outlet box cover shall be secured by at least two screws, or an equivalent means that reduces the likelihood of the receptacle loosening, turning, being pushed-back, or the like.

Added 14.5 effective February 1, 1999

15 Supply Connections

15.1 Fixed units

15.1.1 A fixed unit shall have provision for connection of a wiring system. This provision shall consist of:

- a) Either wiring terminals as specified in 15.1.3 – 15.1.13, or wiring leads as specified in 15.1.3 and 15.1.14 – 15.1.19; and
- b) A means for connection of cable or conduit as specified in 15.1.22.

Exception No. 1: The requirements described in 15.1.3 — 15.1.22 do not apply to the means for connection to accessible signal circuits complying with the requirements specified in Section 25, Accessible Signal Circuits.

Exception No. 2: The means for connection to an alternating current output power circuit of a UPS may consist of receptacles complying with the requirements specified in Section 14, Receptacles.

15.3 Openings for class 2 circuit conductors

15.3.1 An opening for the entry of a conductor or conductors of a Class 2 circuit shall be provided with an insulating bushing. The bushing may be mounted in place in the opening or may be within the enclosure so that it may be properly mounted when the unit is installed.

Exception: The bushing may be omitted if the opening is acceptable for accommodating armored cable or conduit, and the installation instructions indicate that Class 1 wiring methods are to be used as indicated in 74.1.2(x).

15.3.2 A bushing of rubber or rubber-like material provided in accordance with 15.3.1 shall be at least 1/8 inch (3.2 mm) thick, except that it may be not less than 3/64 inch (1.2 mm) thick if the metal around the hole is eyeletted or similarly treated to provide smooth edges. A bushing shall be located so that it will not be exposed to oil, grease, oily vapors, or other substances having a deleterious effect on the material of the bushing. A hole in which such a bushing is mounted shall be free from sharp edges, burrs, projections, or the like, that may damage the bushing.

15.4 Cord-connected units

15.4.1 For a stationary unit, flexible cords and attachment plugs and receptacles shall be used for connection to the alternating current and direct current input and output power circuits. The requirements described in 15.4.2 – 15.4.10 do not apply to a Class 2 circuit or to an accessible signal circuit complying with the requirements in Section 25, Accessible Signal Circuits.

Exception No. 1: The means for connection to an alternating-current output circuit of a UPS may consist of:

- a) *Either wiring terminals as specified in 15.1.3 — 15.1.13, or wiring leads as specified in 15.1.3 and 15.1.14 — 15.1.19; and*
- b) *Provision for connection of cable or conduit as specified in 15.2.1.*

Exception No. 2: The means for connection to the direct-current input or output power circuit of a unit may consist of welding cable and an attachment plug and receptacle.

15.4.2 The cord shall be Type G, SJ, SJT, SJE, SJO, SJOO, SJTO, SJTOO, S, ST, SE, SO, SOO, STO, STOO, W, SV, SVE, SVEO, SVEOO, SJEOO, SEOO, SVT, or SVTO. The length of the cord used for the alternating current input circuit as measured from the face of the attachment plug to the point where the cord emerges from the unit shall be not less than 6 feet (1.8 m).

15.4.2 revised February 1, 1996

15.4.3 The voltage rating of a flexible cord shall be at least the rated voltage of the unit, and its ampacity shall be at least the current rating of the unit.

15.4.4 The attachment plug of a supply cord shall:

- a) Have a current rating in accordance with 15.4.5; and
- b) Have a voltage rating corresponding to the rated voltage of the unit.

15.4.5 With reference to 15.4.4(a), the current rating of an attachment plug for the alternating current input circuit shall not be less than 125 percent of the rated input alternating current. The current rating of an attachment plug for a battery supply circuit for a UPS used with a remote battery cabinet shall be at least the current rating of the battery supply circuit [see 71.4].

Exception: For a UPS having a recharging mode [see 44.1(a)] duration of less than 3 hours, the current rating of the attachment plug may be based on the input current measured during the Power Input Test specified in Section 44 as follows:

- a) 125 percent of the input current required for the alternating-current output load [see 44.1(c) and (d)]; plus
- b) 100 percent of the input current required for battery charging [see 44.1(a) or (d)].

15.4.6 The attachment plug shall be of the polarized type if the unit is not provided with a grounding type attachment plug.

15.4.7 If the unit can be adapted for use on two or more different voltages by field alteration of internal connections, the attachment plug provided with the unit shall be of a type required for the voltage and current for which the unit is connected when shipped from the factory and the unit shall be marked as described in 72.1.17.

Exception: A unit need not comply with this requirement if the unit is:

- a) Equipped with an operator-adjustable voltage selector that complies with 52.13.1;
- b) Provided with a detachable power-supply cord or complies with the Exception to 15.4.8; and
- c) Marked in accordance with 72.1.20.

15.4.7 revised February 1, 1996

15.4.8 If a unit is intended for use with a detachable power supply cord, the cord shall be provided with the unit.

Exception: A unit marked in accordance with 72.1.23 and 74.1.2(n) need not comply with this requirement.

15.4.9 A unit having a rating of 208 volts single phase may be provided with an attachment plug, receptacle, or cord connector rated 250 volts if:

- a) The test described in 52.13.2 is conducted; and
- b) The marking specified in 72.2.21 – 72.2.23 is provided. See 15.4.10.

15.4.10 With reference to 15.4.9(b), the marking is not required for a unit complying with the test requirements in Sections 42 – 45 and 48, and if while energized from a 240 volt source of supply, the output voltage of the unit does not exceed its output voltage rating by more than 10 percent.

15.5 Strain relief

15.5.1 Strain relief shall be provided to reduce the risk of mechanical twisting or stress on a flexible cord or welding cable from being transmitted to terminals, splices, or interior wiring. See 54.1.1 and 54.1.3. The means for preventing twisting shall be evaluated by inspection. The tests described in 54.1.1 and 54.1.3 are to be conducted to evaluate the means for preventing stress.

Table 19.1
Quick-connect terminals for bonding internal parts

Nominal size of terminal, inches (mm)		
Width	Length	Thickness
0.187 (4.7)	1/4 (6.4)	0.020 (0.5)
0.187 (4.7)	1/4 (6.4)	0.032 (0.8)
0.205 (5.2)	1/4 (6.4)	0.032 (0.8)
0.250 (6.4)	5/16 (8.0)	0.032 (0.8)

19.6 A separate component bonding conductor shall be of copper, a copper alloy, or other material acceptable for use as an electrical conductor. Ferrous metal parts in the grounding path shall be protected against corrosion by painting, galvanizing, plating, or equivalent means. A separate bonding conductor or strap shall:

- a) Be protected from mechanical damage or be located within the outer enclosure or frame;
- b) Not be secured by a removable fastener used for any purpose other than bonding for grounding, unless the bonding conductor is unlikely to be omitted after removal and replacement of the fastener; and
- c) Not be spliced.

19.7 The bonding shall be by a positive means, such as by clamps, rivets, bolted or screwed connections, or by welding, soldering, or brazing with materials having a softening or melting point greater than 455°C (850°F). The bonding connection shall penetrate nonconductive coatings, such as paint or vitreous enamel. Bonding around a resilient mount shall not depend on the clamping action of rubber or similar material, other than as indicated in 19.9.

19.8 With reference to 19.7, if penetration of a nonconductive coating cannot be determined by examination, a Grounding Impedance Test, Section 55, shall be conducted.

19.9 A connection that depends upon the clamping action exerted by rubber or similar material may be acceptable if it complies with the requirements in the Bonding Conductor Test, Section 62, for bonding conductors under any normal 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 that are likely to occur in service. Also, the effect of assembling and disassembling, for maintenance purposes, such a clamping device is to be considered with particular emphasis on the likelihood of it being reassembled in its intended position.

19.10 A separate component-bonding conductor shall either:

- a) Not be smaller than the size specified in Column 2 of Table 17.1, (see 19.11);
- b) Not be smaller than the conductor supplying the component; or
- c) Comply with the requirements in Section 62, Bonding Conductor Test.

19.11 With reference to Column 2 of Table 17.1, if more than one size branch-circuit overcurrent device is involved, the size of the bonding conductor is to be based on the rating of the overcurrent 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 device smaller than other overcurrent devices used with the UPS, a bonding conductor for that motor is sized on the basis of the overcurrent device intended for ground-fault protection of the motor.

20 Internal Wiring

20.1 Wires

20.1.1 The internal wiring of a UPS shall be rated for the particular application with respect to the temperature and voltage, exposure to oil or grease, and other conditions of service to which the wiring can be subjected.

20.1.2 With respect to 20.1.1, the effects of vibration, impact, and exposure are to be considered for wires smaller than No. 24 AWG (0.21 mm²).

20.1.3 All wiring shall be polyvinyl chloride (PVC), polytetrafluoroethylene (PTFE), fluorinated ethylene propylene (FEP), or neoprene insulated, or shall comply with the vertical wire flame test requirements in the Standard for Thermoplastic-Insulated Wires and Cables, UL 83, as evidenced by a surface marking "VW-1."

20.1.4 Helical wraps and other continuous forms of harnessing shall be classed 94V-2 or less flammable when tested in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception No. 1: A harness need not be classed 94V-2 or less flammable if, when tested as an assembly, the assembly is classed 94V-2 or less flammable.

Exception No. 2: Lacing tape, twine, individual cable clamps, and noncontinuous cable ties need not be classed 94V-2 or less flammable.

20.1.5 Wiring that extends from the enclosure to a hinged door or other part that is subject to movement in use other than installation and servicing shall be stranded and the arrangement shall preclude twisting or stressing of conductors as a result of the movement. The wiring shall be routed or protected to reduce the likelihood of damage to the insulation. The conductors shall be:

- a) Of a jacketed type, such as Type SJ, SJO, SJT, or SVT; and
- b) Provided with strain relief so that stress will not be transmitted to terminals or splices.

Exception No. 1: The conductors of a low-voltage, limited-energy circuit described in 2.22 need not comply.

Exception No. 2: A bonding lead used for grounding a door need not be jacketed.

Exception No. 3: Wiring of a type other than those mentioned in 20.1.5 that is subject to motion, and any supplementary insulation provided on the wire may be subjected to a flexing test to determine the acceptability for the application. See 54.2.1.

20.1.5 revised February 1, 1996

20.1.6 The length of a power-supply cord inside a UPS shall be limited to that needed for electrical connections.

Exception No. 5: The spacing requirements in Tables 23.1 and 23.2 may not apply to inherent spacings of a component such as a switch, lampholder, power switching semiconductor, or a motor. See 23.1.7.

Exception No. 6: Spacings within a transformer shall be provided in accordance with Table 26.2 at locations that are not insulated, including those with film-coated magnet wire.

Exception No. 7: Spacing requirements do not apply between adjacent terminals of a power switching semiconductor device including the connection points of the terminals of the device.

23.1.2 With reference to Exception No. 2 to 23.1.1 concerning conformal coatings, minimum spacings between adjacent foils are based on voltage transient and dielectric voltage-withstand tests in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluation, UL 746C. A conformal coating on printed wiring boards is not considered as insulation in lieu of spacings between a foil on a printed wiring board and uninsulated live metal parts of opposite polarity or to dead metal parts.

23.1.2.1 As an alternative to the spacing requirements of Table 23.1 or Table 23.2, the spacing requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, may be used. If UL 840 is used, then the following considerations shall apply:

- a) The spacing requirements of UL 840 shall not be used for field wiring terminals and spacings to a dead metal enclosure;
- b) If a UPS employs a voltage limiting device for application of the requirements in UL 840, the device shall comply with the Standard for Transient Voltage Surge Suppressors, UL 1449; and
- c) Permanently connected UPS shall be considered overvoltage category 3, and cord-connected UPS with surge suppressors shall be considered overvoltage category 2. An overvoltage category is the grouping of products based on a typical installed location with respect to overvoltage protection and available energy as defined in UL 840.

23.1.2.1 added February 1, 1996

23.1.3 Units investigated for use in a controlled environment indicated in 23.1.1 shall be marked as described in 72.1.29.

Exception: A unit employing a hermetically sealed enclosure, encapsulation, or conformal coating need not comply with this requirement.

23.1.4 For a unit intended for use in a controlled environment, a spacing between an uninsulated live part and a metal enclosure or other accessible dead metal part may be less than the value specified in the fourth column of Table 23.2 but not less than the values specified in the second and third columns of Table 23.2, if the unit enclosure complies with the Mechanical Strength Test for Metal Enclosures, Section 60.

23.1.5 If an uninsulated live part is not rigidly secured in position by means other than friction between surfaces or if a movable dead metal part is in proximity to an uninsulated live part, the construction shall be such that, for any position resulting from turning or other movement of the parts in question, at least the minimum required spacings will be maintained.

23.1.6 With reference to 23.1.5, a properly applied lock washer is considered as an acceptable method of rigidly securing a part.

23.1.7 Inherent spacings of the components mentioned in Exception No. 5 of 23.1.1 shall comply with the requirements for the component in question if the spacings are less than the values specified in this standard. Spacings from such components to another component and to the enclosure shall comply with the appropriate spacings specified in this standard.

23.1.8 With respect to judging spacings, an uninsulated live part is considered to be at opposite polarity to uninsulated live parts in another circuit. Spacings are to be based on the highest of the circuit voltages. See 47.2.1 – 47.2.3.

23.1.9 Film-coated wire is considered to be an uninsulated live part in judging spacings.

23.1.10 Spacings at field-wiring terminals are to be measured with conductors installed in the terminals. The gage of these conductors is to be based on the rating of the circuit containing the terminals. See 15.1.3.

23.1.11 Spacings between uninsulated live parts of different potential and between such parts and dead metal that may be grounded in service are not specified for parts of LVLE circuits in accordance with 2.22 nor in accessible signal circuits described in Section 25, Accessible Signal Circuits.

23.1.12 Spacings between uninsulated live parts of different potential and between such parts and dead metal that may be grounded in service are not specified for parts of limited-energy circuits in accordance with 2.19. Spacings in these circuits exceeding 30 volts rms (42.4 volts peak) or 60 volts dc are judged by the applicable dielectric voltage-withstand test described in Section 47, Dielectric Voltage-Withstand Test. Also see 50.1.

Table 23.1
Spacings for units intended for use
in a general environment

Potential Involved, volts rms (peak)	Minimum spacings, Inch (mm)		
	Between any uninsulated live part and an uninsulated live part of opposite polarity, uninsulated grounded part other than the enclosure, or exposed metal part ^{a,f}		Between any uninsulated live part and the walls of a metal enclosure including a fitting for conduit or armored cable ^b
	Through air	Over surface	Shortest distance
0 – 50 (0 – 70.7)	1/16 (1.6) ^{c,d}	1/16 (1.6) ^{c,d}	1/16 (1.6) ^c
Greater than 50 to 150 (70.7 to 212.1)	1/8 (3.2) ^{c,d}	1/4 (6.4) ^d	1/4 (6.4)
Greater than 150 to 300 (212.1 to 424.2)	1/4 (6.4)	3/8 (9.5)	1/2 (12.7)
Greater than 300 to 600 (424.2 to 848.4)	3/8 (9.5)	1/2 (12.7)	1/2 (12.7)
Greater than 600 to 3000 (848.4 to 4242.0)	3/4 (19.1) ^e	3/4 (19.1) ^e	3/4 (19.1)

^a For printed-wiring boards, see Exception Nos. 2 – 4 in 23.1.1.

^b For the purpose of this requirement, a metal piece attached to the enclosure is considered to be a part of the enclosure if deformation of the enclosure is likely to reduce spacings between the metal piece and uninsulated live parts.

^c The spacing between field-wiring terminals of opposite polarity and the spacing between a field-wiring terminal and a grounded dead metal part shall not be less than 1/4 inch (6.4 mm).

^d At closed-in points only, such as a screw and washer construction of an insulated stud mounted in metal, a spacing of 3/64 inch (1.2 mm) is acceptable.

^e Between uninsulated high-voltage parts and the following:

- 1) Uninsulated high-voltage parts of opposite polarity or different potentials,
- 2) Earth-grounded metal parts,
- 3) Uninsulated primary-circuit parts,
- 4) Insulated primary-circuit parts,
- 5) Insulated high-voltage parts of opposite polarity, or of different potentials.

^f Spacings are to be applied between uninsulated live parts of enclosure-mounted components and the metal mounting surface where deformation of the enclosure is not likely to reduce spacings between the live parts and the enclosure.

Table 23.1 revised February 1, 1996

Table 23.2
Spacings for units intended for use in a controlled environment

Potential Involved, Volts rms (Peak)	Minimum Spacings, Inch (mm)		
	Between Any Uninsulated Live Part and an Uninsulated Live Part of Opposite Polarity, Uninsulated Grounded Part Other Than the Enclosure, or Exposed Metal Part ^{a,d}		Between Any Uninsulated Live Part and the Walls of a Metal Enclosure Including a Fitting for Conduit or Armored Cable ^b
	Through Air	Over Surface	Shortest Distance
0 – 50 (0 – 70.7)	3/64 (1.2) ^c	3/64 (1.2) ^c	1/16 (1.6) ^c
Greater than 50 to 150 (70.7 to 212.1)	1/16 (1.6) ^{c,e}	1/16 (1.6) ^{c,e}	1/4 (6.4)
Greater than 150 to 300 (212.1 to 424.2)	3/32 (2.4) ^{c,e}	3/32 (2.4)	1/2 (12.7)
Greater than 300 to 600 (424.2 to 848.4)	3/8 (9.5)	1/2 (12.7)	1/2 (12.7)
Greater than 600 to 3000 (848.4 to 4242.0)	3/4 (19.1) ^f	3/4 (19.1) ^f	3/4 (19.1) ^f

^a For printed-wiring boards, see Exception Nos. 2 – 4 in 23.1.1.

^b For the purpose of this requirement, a metal piece attached to the enclosure is considered to be a part of the enclosure if deformation of the enclosure is likely to reduce spacings between the metal piece and uninsulated live parts.

^c The spacing between field-wiring terminals of opposite polarity and the spacing between a field-wiring terminal and a grounded dead metal part shall not be less than 1/4 inch (6.4 mm).

^d On printed-wiring boards, their connectors and board-mounted electrical components, wired on the load side of line filters or similar-voltage-peak-reduction networks or components or both, a minimum spacing of 0.023 inch (0.58 mm) plus 0.0002 inch (0.005 mm) per volt peak shall be maintained over surface and through air between uninsulated live parts and any other uninsulated conductive part (live or dead) not of the same polarity.

^e At closed-in points only, such as a screw and washer construction of an insulated stud mounted in metal, a spacing of 3/64 inch (1.2 mm) is acceptable.

^f Between uninsulated high-voltage parts and the following:

- 1) Uninsulated high-voltage parts of opposite polarity or different potentials,
- 2) Earth-grounded metal parts,
- 3) Uninsulated primary-circuit parts,
- 4) Insulated primary-circuit parts,
- 5) Insulated high-voltage parts of opposite polarity, or of different potentials.

Table 23.2 revised February 1, 1996

23.1.13 Spacings within the following circuits that are not safety circuits are not specified:

- a) Secondary circuits supplied by a transformer winding of less than 200 volt-amperes or at a potential of 100 volts or less; and
- b) Battery circuits at a potential of 100 volts or less. See 23.1.14.

The spacings in these circuits shall be judged on the basis of the Dielectric Voltage-Withstand Test, Section 47. (See 50.1).

23.1.14 With reference to 23.1.13, spacings within a circuit derived from a battery supply rated over 100 volts are not specified provided that the voltage within the circuit is limited to 100 volts or less by a regulating network complying with the requirement in 24.11.

23.1.15 The acceptability of spacings between live and dead metal parts connected to the enclosure within an instrument shall be judged by conducting the applicable dielectric voltage-withstand test described in Section 47, Dielectric Voltage-Withstand Test.

Exception: A meter complying with the requirements in the Standard for Electrical Analog Instruments — Panelboard Types, UL 1437 need not be subjected to a dielectric voltage-withstand test.

23.2 Insulation barriers

23.2.1 An insulating liner or barrier of material such as vulcanized fiber may be employed in lieu of required spacings mentioned in Exception No. 1 to 23.1.1 but not as the sole support of uninsulated live parts involving a risk of fire, electric shock, or electrical-energy/high current provided that it is not less than 0.028 inch (0.71 mm) thick and it is so located that it will not be adversely affected by arcing. Other insulating materials used as a barrier or as either direct or indirect support of uninsulated live parts involving a risk of fire, electric shock, or electrical-energy/high current shall comply with the requirements in the Standard for Polymeric Materials — Use in Electrical Equipment Evaluations, UL 746C.

Exception No. 1: Vulcanized fiber not less than 0.013 inch (0.33 mm) thick may be used:

- a) In conjunction with an air spacing of not less than 50 percent of the minimum acceptable through air spacing; and
- b) Between a heat sink and a metal mounting surface, including the enclosure, of an isolated secondary circuit rated 50 volts rms or less.

Exception No. 2: Mica not less than 0.006 inch (0.165 mm) may be used as insulation between a heat sink and a live case of a semiconductor device.

23.2.2 Other than as indicated in 23.2.3, insulating tubing complying with the requirements in the Standard for Extruded Insulating Tubing, UL 224 may be used as insulation of:

- a) A conductor including bus bars in lieu of the minimum acceptable spacings; and
- b) A capacitor case in lieu of bonding the case for grounding, providing that the following conditions are met:
 - 1) The conductor is not subjected to compression, repeated flexure, or sharp bends;

28 Overcurrent Protection

28.1 General

28.1.1 An overcurrent protective device, the intended functioning of which requires renewal, replacement, or resetting, shall be accessible:

- a) From outside of the enclosure; or
- b) Behind a hinged cover (see 5.3.1).

Exception: A protective device that would ordinarily be unknown to the user because of its location and omission of reference to the device in the operating instructions provided with the unit need not be accessible.

28.1.2 With reference to the requirement in 28.1.1, a control-circuit fuse is not considered to require renewal as an intended function provided the fuse and the load are contained within the same enclosure.

28.1.3 The screw shell of a plug-type fuseholder and the contacts including associated live parts that can be contacted by the probe illustrated in Figure 7.1 of an extractor-type fuseholder shall be connected toward the load.

Exception: The screwshell shall not be connected toward the load if the screwshell is in accordance with (c) of Exception No. 2 to 28.1.8.

28.1.4 A fuse and a fuseholder shall have voltage and current ratings acceptable for the circuit in which they are connected. A fuseholder shall be of the cartridge, plug, or extractor type. Plug fuses are not acceptable in a circuit rated more than 125 volts or 125/250 volts, 3-wire.

Exception: Fuses intended to be replaced by only service personnel (see Section 39, Protection of Service Personnel) may be bolted in place.

28.1.5 A plug-type fuseholder shall be of the Type S construction.

28.1.6 A circuit breaker or supplementary protector shall be connected to open all ungrounded conductors of the circuit. Multipole circuit breakers and supplementary protectors shall be the common trip type.

Exception: Single-pole circuit breakers and supplementary protectors with handle ties, the combination of which complies with the applicable requirements in the Standard for Molded-Case Circuit Breakers and Circuit-Breaker Enclosures, UL 489, and the Standard for Supplementary Protectors for use in Electrical Equipment, UL 1077 respectively, may be used as the protection for each ungrounded conductor supplying line-to-line connected loads of equipment rated for connection to a grounded:

- a) Single-phase circuit;
- b) 3-wire direct-current circuit; or
- c) Circuit that is connected to a 4-wire 3-phase, or 5-wire 2-phase system with a grounded neutral.

Revised 28.1.6 effective February 1, 1999

28.1.7 A UPS shall be marked in accordance with 72.2.12 if it is provided with overcurrent protection consisting of an interchangeable fuse and if the fuse is:

- a) Accessible to the user; or
- b) Used to comply with the requirements in this standard.

28.1.8 An overcurrent protective device shall not be connected in the grounded (neutral) side of the line.

Exception No. 1: Additional overcurrent protection may be provided in the grounded side of the supply circuit provided that the protective device simultaneously disconnects the grounded and ungrounded conductors of the supply circuit.

Exception No. 2: A unit may incorporate a single-pole overcurrent protective device connected in the grounded (neutral) side of the line provided:

- a) The grounded circuit conductor is not depended upon to carry a current imbalance such as is likely in a UPS supplied by a 3-phase, 4-wire or a single-phase, 3-wire system;*
- b) Each ungrounded circuit conductor is provided with an overcurrent protective device having a current rating no higher than that of the overcurrent protective device in the grounded circuit conductor;*
- c) The screw shell of a plug fuseholder and the accessible contact of an extractor fuseholder located in the grounded circuit conductor is connected toward the grounded supply line; and*
- d) The unit is marked in accordance with 72.2.19.*

28.1.9 Temperature or current-sensitive devices such as temperature limiting thermostats, thermal cutoffs, appliance protectors, fuses, circuit breakers, or the like that are relied upon to comply with the Abnormal Tests, Section 52, shall comply with the requirements for such devices.

28.1.10 Overcurrent protection employing solid state component circuitry used for protection of circuits described in (a) – (c) shall comply with the requirements in the Standard for Molded-Case Circuit Breakers and Circuit-Breaker Enclosures, UL 489.

- a) Control circuits per 28.2.1 – 28.2.7.
- b) Output alternating current power circuits per 28.3.1 – 28.3.5.
- c) Battery supply circuits for fixed units per entries 3 and 4 in Table 28.2.

Exception No. 1: Overcurrent protection whose performance is not affected by malfunction, either by short circuit or open circuit, of any single component need not comply with these requirements.

Exception No. 2: A solid state overcurrent protection circuit provided in addition to other overcurrent protection devices such as a fuse or circuit breaker that is suitable for the application need not comply with these requirements.

28.2 Control circuits

28.2.1 A control circuit that extends from the UPS to a remote control panel, status panel, or the like shall be protected in accordance with 28.2.2 – 28.3.5 to reduce the risk of fire and electric shock that may result from overload and short circuit conditions.

28.2.2 The overcurrent protective device specified in 28.2.1 shall be a circuit breaker or fuse that is either:

- a) Acceptable for branch circuit use; or
- b) A supplementary type.

If the protective device consists of a fuse, the UPS shall be marked in accordance with 72.2.12.

28.2.3 A Class 1 power-limited circuit, in accordance with the National Electrical Code, ANSI/NFPA 70-1993, used to supply an external control circuit shall be supplied from a source having a rated output of no more than 30 volts and 1000 volt-amperes. If the source is other than a transformer, the circuit shall be protected by an overcurrent protection device rated no more than 167 percent of the volt-ampere rating divided by the rated voltage. The overcurrent device shall not be interchangeable with overcurrent devices of higher ratings.

28.2.4 An external control circuit derived from a Class 2 transformer described in 2.10 need not be provided with overcurrent protection specified in 28.2.1.

28.2.5 An external control circuit derived from the secondary of a transformer other than that described in 28.2.3 and 28.2.4 shall be provided with overcurrent protection in accordance with 28.2.6 and 28.2.7. For transformers not having a rating, the rated primary or secondary current mentioned in 28.2.6 and 28.2.7 is to consist of the maximum current during normal operation of the unit.

28.2.6 Except as described in 28.2.7, a transformer used to supply a control circuit shall be provided with overcurrent protection in the primary circuit rated as indicated in Table 28.1.

Exception: If the rated primary current of the transformer is 9 amperes or more and 125 percent of this current does not correspond to a standard rating of fuse or circuit breaker, the next higher standard rating of protective device may be used. Standard ratings of protective devices are specified in Section 240-6 of the National Electrical Code, ANSI/NFPA 70-1993.

Table 28.1
Primary overcurrent protection for
control circuit transformers

Rated primary current, amperes	Maximum rating of overcurrent device, percent of transformer primary current rating
Less than 2	300
2 or more, less than 9	167
9 or more	125

28.2.7 If a control circuit is derived from the secondary of a transformer that is provided with primary circuit overcurrent protection rated at no more than 250 percent of the rated primary current of the transformer, additional overcurrent protection is not required in the primary circuit provided that the secondary circuit is protected at no more than 125 percent of the rated secondary current of the transformer.

Exception No. 1: If the rated secondary current of the transformer is 9 amperes or more and 125 percent of this current does not correspond to a standard rating of fuse or circuit breaker, the next higher standard rating of protective device may be used in the secondary circuit. Standard ratings of protective devices are specified in Section 240-6 of the National Electrical Code, ANSI/NFPA 70-1993.

Exception No. 2: If the rated secondary current of the transformer is less than 9 amperes, the overcurrent protection in the secondary circuit may be rated or set at no more than 167 percent of the rated secondary current.

28.3 Output alternating current power circuits

28.3.1 An alternating current output power circuit shall be provided with overcurrent protection for all ungrounded conductors as described in 28.3.3 – 28.3.5. The voltage rating of the overcurrent protection shall not be less than the rating of the circuit with which it is used. The overcurrent protection device shall be a circuit breaker or a fuse acceptable for use as branch circuit protection.

Exception No. 1: Overcurrent protection need not be provided with a UPS having provision for permanent wiring connection of the output circuit and provided with an instruction manual indicating that the overcurrent protection is to be provided by others. See 74.1.2(t).

Exception No. 2: Overcurrent protection need not be provided with a UPS whose output current is limited by construction of the transformer, one or more resistors, or a regulating network complying with 24.11 to not more than 110 percent of the:

- a) Rated output current; or
- b) The output receptacle rating.

Exception No. 3: An appliance protector having a short circuit interrupting rating not less than the maximum fault current available from the UPS and complying with the requirements in the Standard for Supplementary Protectors for Use in Electrical Equipment, UL 1077, may be used in the output circuit of a UPS supplied by the power conversion portion of a UPS in lieu of a branch circuit protection fuse or circuit breaker.

Exception No. 4: A fuse having a short-circuit interrupting rating not less than the maximum fault current available from the UPS and complying with the requirements in the Standard for Fuses for Supplementary Overcurrent Protection, UL 198G, may be used in the output circuit of a UPS supplied by the power conversion portion of a UPS in lieu of a branch circuit protection fuse or circuit breaker.

Exception No. 5: For cord-connected units, output overcurrent protection may be the branch circuit protection intended for the input circuit if the attachment plug and the output receptacle have identical ratings. If the attachment plug and the output receptacle do not have identical ratings, then branch circuit protection shall be required for the output.

28.3.1 revised February 1, 1996

28.3.2 The voltage rating mentioned in 28.3.1 for a 3-phase circuit shall be based on the phase-to-phase voltage.

28.3.3 For a UPS having provision for permanent wiring connection of the alternating current output power circuit, the rating of the overcurrent protection shall not exceed the ampacity of the conductors intended to be connected to the UPS as determined in accordance with 15.1.3.

28.3.4 For a UPS provided with a cord and receptacle for connection of the alternating current output power circuit, the rating of the overcurrent protection shall not exceed the ampacity of the conductors as determined from Table 400-5 in the National Electrical Code, ANSI/NFPA 70-1993.

28.3.5 If a UPS includes one or more attachment-plug receptacles for connections to the ac output circuit, overcurrent protection shall be provided for each receptacle. A single overcurrent protection device whose rating does not exceed the ampere rating of any receptacle connected to it may be used if all receptacles are connected in parallel.

Exception No. 1: Two or more 15 ampere rated receptacles may be protected by a 20 ampere overcurrent protection device.

Exception No. 2: A stationary unit having an input ac attachment plug that has both a current and voltage rating not exceeding the current and voltage rating of any of the output ac receptacles need not be provided with overcurrent protection.

Exception No. 3: A unit having provisions for permanent input wiring connections need not be provided with overcurrent protection provided that the current and voltage ratings of the output a-c receptacles are not less than the current and voltage ratings of the intended input branch circuit overcurrent protection device. See 52.1.6.

28.4 Battery supply circuits

28.4.1 A battery supply circuit shall be provided with overcurrent protection complying with the requirements described in 28.4.2 – 28.4.4.

28.4.2 The battery supply circuit shall be provided with acceptable rated dc overcurrent protection to reduce the risk of fire and electric shock resulting from overload or short-circuit conditions. The protective device shall be located adjacent to the battery connecting means before any component which may fail short-circuited such as capacitors, solid-state devices, or the like.

28.4.3 The type and location of the overcurrent protective device shall be as indicated in Table 28.2.

Table 28.2
Battery supply overcurrent protection

Location and/or type of battery supply	Overcurrent protective device	
	Type	Location
1. Within UPS	Note 1 or 2	UPS
2. Stationary remote cabinet	Note 1 or 2	Battery cabinet, see note 3
3. Fixed remote cabinet	Note 2	Battery cabinet, see note 3
4. Remote battery room	Notes 2 and 4	UPS, see note 5
NOTES 1 Supplementary appliance type. 2 Circuit breaker or fuse suitable for branch circuit protection. 3 A battery supply cabinet assembly investigated by itself shall contain the indicated overcurrent protective device. For a UPS investigated in combination with the battery supply intended for use with the UPS, the overcurrent protection is required only in the battery supply cabinet. For a UPS investigated without the battery supply cabinet assembly, the UPS shall also employ the indicated overcurrent protective device. 4 In accordance with 74.1.2(m), the instruction manual for a UPS having an input ac rating of 5 kilovolt-amperes or larger shall indicate the rating of the overcurrent protective device. 5 Overcurrent protection need not be provided if the instruction manual contains the statement indicated in 74.1.2(s).		

28.4.4 The rating of the overcurrent protective device employed in a UPS having an integral battery supply shall be such as to protect against conditions described in 52.1.3(a) – (d). For a fixed UPS that is to be used with a fixed remote battery supply, the rating of the overcurrent protective device shall be based on the ampacity of the conductors intended to be connected between the UPS and battery supply as determined from the requirement described in 15.1.3 under reserve mode operating conditions – see 44.1(b).

28.5 Inverter storage capacitors

28.5.1 A UPS shall be protected against a surge current flowing into the discharged main storage inverter capacitors that may be caused by inadvertent closing of a manually operated battery disconnect switch when the UPS is not operating. Compliance with this requirement is to be judged by conducting the test described in 52.7.1. A UPS having a disconnect switch or a control circuit preventing closure of the disconnect switch under the above conditions need not be subjected to the test.

29 Backfeed Protection

29.1 A UPS shall be provided with backfeed protection to prevent a potential involving a risk of electric shock (see Electric Shock, Section 8) from being present on its input ac terminals during interruption of the input ac power.

29.2 With reference to the requirement in 29.1, performance of the protection is to be judged by conducting the Backfeed Protection Test, Section 48.

29.3 The protection mentioned in 29.1 shall employ an automatic switching device having air-gap contacts such as an electromechanical relay for preventing a potential involving a risk of electric shock from appearing on the input terminals. A unit provided with a remote shunt-trip circuit breaker, which will open the input ac circuit when the input ac power is interrupted, complies with this requirement. If the remote shunt-trip circuit breaker is not provided with the unit, then a marking as described in 72.1.33 shall be provided.

Exception: An electronic control employing a solid state power switching component and subjected to the tests described in 29.6 may be provided in lieu of an air-gap contact device.

29.3 revised February 1, 1996

29.4 With reference to 29.3, the conditions described in either (a) or (b) resulting from a short-circuit failure of a solid-state component during the normal mode of operation (see 44.1) that is used for isolation between the input-ac terminals and the inverter is considered to comply with the requirement in 29.3.

- a) Operation of an input-ac, overcurrent-protective device; or
- b) Shut-down of the inverter.

29.4 revised February 1, 1996

29.5 The control circuit for the backfeed protection mentioned in 29.3 is to be subjected to a failure mode and effect analysis in accordance with the method described in the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991. This analysis is to cover all modes of operation except for the reserve mode (see 44.1). If this analysis indicates that either opening or shorting of a component such as a transistor, triac, SCR, capacitor, resistor or the like will cause a potential involving a risk of electric shock to appear on the input ac terminals during the test conditions described in Section 48, Backfeed Protection Test, the environmental tests specified in 29.6 shall be conducted.

29.6 If it is determined that environmental tests in accordance with the Exception to 29.3 or with 29.5 are necessary, the protection control is to be subjected to the following tests in accordance with the method described in the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991:

- a) Transient Overvoltage Test
- b) Ramp Voltage Test
- c) Electromagnetically Susceptibility Tests

31.8 Capacitors connected across an input ac circuit shall comply with the requirements for across-the-line capacitors in the:

- a) Standard for Across-the-Line, Antenna-Coupling, and Line-By-Pass Capacitors for Radio- and Television-Type Appliances, UL 1414; or
- b) Standard for Electromagnetic-Interference Filters, UL 1283.

Exception: A capacitor subjected to a dielectric voltage-withstand test in accordance with Test No. 5 itemized in Table 47.1 need not comply with this requirement.

32 Resistors

32.1 The assembly of a power resistor, such as a wire-wound type requiring a separate support, shall be reliable. The resistor shall be prevented from loosening or rotating by a means other than friction between surfaces.

32.2 An assembly employing lock washers is considered to comply with the requirement in 32.1.

33 Lampholders

33.1 A lampholder shall be constructed or installed so that uninsulated live parts, other than a screw shell, may not be unintentionally contacted by persons removing or replacing the lamp during intended service.

33.2 A medium-base screw-shell lampholder shall not be used in a circuit involving a potential of more than 150 volts.

34 Printed-Wiring Boards

34.1 A printed-wiring board shall comply with the requirements in the Standard for Printed-Wiring Boards, UL 796, and shall be classed 94V-0, 94V-1, or 94V-2 in accordance with the requirements in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception: A printed-wiring board located outside an enclosure, such as in an external control circuit, and located in a LVLE circuit or a limited-energy circuit described in 2.22 need not be classed as minimum 94V-2.

34.2 A resistor, capacitor, inductor, or other part that is mounted on a printed-wiring board to form a printed-wiring assembly shall be secured so that it cannot be displaced to cause a risk of electric shock or fire by a force likely to be exerted on it during assembly, intended operation, or servicing of the power supply.

34.3 Consideration is to be given to a barrier or a partition that is part of the unit assembly and that provides mechanical protection and electrical insulation of a component connected to the printed-wiring board.

35 Insulating Materials

35.1 An insulating material used for supporting live parts and a barrier material shall be moisture-resistant and not be adversely affected by the temperature and stresses to which it will be subjected under conditions of use.

35.2 A material that is used for the direct support of an uninsulated live part shall comply with the Relative Thermal Index (RTI), Hot Wire Ignition (HWI), High-Current Arc Resistance to Ignition (HAI), and Comparative Tracking Index (CTI) values indicated in Table 35.1 and determined in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. A material is considered to be in direct support of an uninsulated live part if:

- a) It is in direct physical contact with the uninsulated live part; and
- b) It serves to physically support/maintain the relative position of the uninsulated live part.

Exception No. 1: A generic material complying with the thickness and RTI in Table 35.2 is considered suitable for the direct support of uninsulated live parts without additional evaluation.

Exception No. 2: A material without HWI Performance Level Category (PLC) value or with HWI PLC value higher (worse) than the HWI required by Table 35.1 may alternatively be subjected to the End-Product Abnormal Overload Test per UL 746C.

Exception No. 3: A material without HAI PLC value or with HAI PLC value higher (worse) than the HAI required by Table 35.1 may alternatively be subjected to the End-Product Arc Resistance Test per UL 746C.

Exception No. 4: A material that is used in devices that do not incorporate contacts need not comply with the HAI PLC requirements.

Exception No. 5: A material that is used in devices that incorporate contacts but is not used within 1/2 inch (12.7 mm) of the contacts need not comply with the HAI PLC requirements.

Exception No. 6: A material without CTI PLC value or with CTI PLC value higher (worse) than the CTI required by Table 35.1 may alternatively be subjected to the End-Product Arc Resistance Test per UL 746C.

Exception No. 7: A material without CTI PLC value or with CTI PLC value higher (worse) than the CTI required by Table 35.1 shall be considered in compliance with the CTI PLC requirement if:

- a) *It has a High-Voltage-Arc Tracking (HVTR) PLC value of 1 or lower (better); or*
- b) *The over surface spacings between the uninsulated live parts are at least 1/2 inch (12.7 mm).*

Exception No. 8: A printed-wiring board evaluated to UL 796, Printed-Wiring Boards, is considered to be suitable for the direct support of uninsulated live parts without additional evaluation.

35.2 revised February 1, 1996

Table 35.1
Minimum material characteristics necessary
for the direct support of uninsulated live parts

UL 94 Flame Class	RTI Elec	HWI ^b	HAI ^b	CTI ^c
94-HB	a	2	1	4
94V-2	a	2	2	4
94V-1	a	3	2	4
94V-0	a	4	3	4

^a The electrical RTI value of a material is to be determined in accordance with the Standard for Polymeric Materials - Long Term Property Evaluations, UL 746B by test or by use of the generic RTI table. This material characteristic is dependent upon the minimum thickness at which the material is being used and shall not be exceeded during the Temperature Test of Section 45.

^b The HAI and HWI Performance Level Category (PLC) value of a material is to be determined by test in accordance with the Standard for Polymeric Materials - Short Term Property Evaluations, UL 746A. This material characteristic is dependent upon the minimum thickness at which the material is being used.

^c The CTI PLC value of a material is to be determined by test in accordance with UL 746A. This material characteristic is not dependent upon the minimum thickness at which the material is being used.

Table 35.1 added February 1, 1996

Table 35.2
Generic materials considered suitable for the
direct support of uninsulated live parts^a

Generic material	Thickness, inches (mm)	RTI, °C
Diallyl Phthalate	0.028 (0.71)	105
Epoxy	0.028 (0.71)	105
Melamine	0.028 (0.71)	130
Melamine-Phenolic	0.028 (0.71)	130
Phenolic	0.028 (0.71)	150
Unfilled Nylon	0.028 (0.71)	105
Unfilled Polycarbonate	0.028 (0.71)	105
Urea Formaldehyde	0.028 (0.71)	100
Any cold-molded composition (i.e. concrete)	No Limit	No Limit
Ceramic, Porcelain & Slate	No Limit	No Limit

^a Each material shall be used within its minimum thickness and its RTI value shall not be exceeded during the Temperature Test of Section 45.

Table 35.2 added February 1, 1996

35.3 Ordinary vulcanized fiber may be used for insulating bushings, washers, separators, and barriers, but not as sole support for uninsulated live parts.

35.4 A sensor such as a current transformer, transducer, or the like shall be provided with insulation that has been evaluated for the maximum voltage and temperature involved in its application, while taking into consideration the presence of other circuits.

36 Flammability Classification of Internal Materials

36.1 General

36.1.1 The requirements in 36.1.2, 36.1.3, and 36.2.1 apply to a unit provided with a marking indicating that it is suitable for use in a computer room. See 72.1.27.

36.1.2 All combustible material used within an enclosure of a unit, including the case material of batteries used in a UPS having an integral battery supply and in remote battery cabinets investigated under the requirements of this standard, shall be classed as 94V-2, 94HF-2, 94VTM-2, or less flammable in accordance with the requirements in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception No. 1: A motor, relay, capacitor, semiconductor, transformer, switch, insulating tubing, or tape need not comply. Other electrical components need not be classed as 94V-2, 94HF-2, or less flammable if they comply with the flammability class applicable to the component.

Exception No. 2: Indicator lamps and lenses need not be classed as 94V-2, 94HF-2, or less flammable.

Exception No. 3: A component, except a printed-wiring board, within a circuit described in 24.4 — 24.12 need not be classed as 94V-2, 94HF-2, or less flammable.

Exception No. 4: The following nonelectrical components need not be classed as 94V-2, 94HF-2, or less flammable if they are isolated from uninsulated electrical parts that involve a risk of fire by either at least 0.5 inch (12.7 mm) of air or by a solid partition of material classed as 94V-1 or less flammable:

- a) A gear, cam, belt, bearing, strain-relief bushing, and other parts that contribute negligible fuel;*
- b) Tubing or duct for air handling systems classed as 94HB or less flammable; and*
- c) Foamed plastics classed as 94HBF or less flammable.*

Exception No. 5: A component within a UPS that has a volume of no more than 2 cubic feet (0.057 m³) need not be classed as 94V-2, 94HF-2, or less flammable if the component is contained within a metal enclosure having no ventilation openings.

Exception No. 6: Materials need not be classed as 94V-2, 94HF-2, or less flammable if they comply with the enclosure flammability 3/4-inch (19-mm) flame test described in the Standard for Polymeric Materials — Use in Electrical Equipment Evaluations, UL 746C.

Exception No. 7: An integrated circuit package, transistor package, opto-isolator package, capacitor, and other parts of similar size are exempt from the flammability classification of 94V-2 if the parts are mounted on material of at least the flammability classification of 94V-1.

Exception No. 8: A component within a UPS that has a volume of less than 0.125 cubic inches (2.05 cm³) and a maximum dimension of 2 inches (50.8 mm) need not comply with this requirement.

36.1.2 revised February 1, 1996

36.1.3 Materials used for barriers shall be classed as 94V-2 or less flammable in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception: Barrier materials need not be classed as 94V-2 or less flammable if they comply with the enclosure flammability 3/4-inch (19-mm) flame test described in the Standard for Polymeric Materials — Use in Electrical Equipment Evaluations, UL 746C.

36.2 Air filters

36.2.1 Air filters for use in cooling systems shall comply with the requirements in the Standard for Test Performance of Air Filter Units, UL 900, or shall be constructed of materials classed 94V-2 or 94HF-2 or less flammable in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception No. 1: This requirement does not apply to air filters in closed systems. A closed system is defined as that which, although not necessarily air-tight, is not intended to be vented outside the enclosure.

Exception No. 2: This requirement does not apply to air filters located external to the enclosure and constructed of materials classed 94HB or 94HBF or less flammable.

37 Adhesives

37.1 An adhesive that is relied upon to reduce a risk of fire, electric shock, or injury to persons shall comply with the requirements for adhesives in the Standard for Polymeric Materials — Use in Electrical Evaluations, UL 746C.

37.2 The requirement in 37.1 also applies to an adhesive used to secure a conductive part, including a nameplate, that may, if loosened or dislodged:

- a) Energize an accessible dead metal part;
- b) Make a live part accessible;
- c) Reduce spacings below the minimum acceptable values; or
- d) Short-circuit live parts.

38 Battery Supplies

38.1 General

38.1.1 The battery supply intended to be used with a UPS shall be provided with the UPS and comply with the requirements in 38.2.1 – 38.6.1.

Exception: Either the batteries or the battery cabinet need not be furnished with the following types of products [see 38.1.2 and 74.1.2(p)]:

- a) A fixed UPS; and
- b) A stationary UPS having an input rating of more than 20 amperes or 125 volts ac.

38.1.2 With reference to the requirements in the Exception to 38.1.1, a battery supply contained in a remote cabinet that is investigated by itself, that is, it is not included in the investigation of a UPS, shall comply with the requirements in 38.2.1 – 38.6.1 and other applicable requirements in this standard.

38.2 Enclosure

38.2.1 Vented batteries shall be contained in a separate enclosure or compartment (see 38.2.2) from the power conversion portion of the UPS. This requirement does not apply to valve-regulated batteries. See 2.4 and 2.5.

38.2.2 With reference to 38.2.1, vented batteries may be contained in the overall enclosure of the UPS, provided that a barrier, partition, or the equivalent is used to inhibit the passage of hydrogen gas from the battery area to the area of the enclosure containing the electronic components, switches, contactors, and controls used in the power conversion portion of the UPS.

38.2.3 The interior of a metallic enclosure or compartment housing a vented battery shall be protected by two coats of acid (or alkali, as applicable) resistant paint, two coats of enamel individually baked on, or the equivalent.

38.2.4 A polymeric enclosure or compartment housing a vented battery, such as a lead-acid storage battery, shall be constructed of materials resistant to corrosion by acids or alkalis, as applicable.

39 Protection of Service Personnel

39.1 The requirements in this section apply only to service personnel who may find it necessary to reach over, under, across, or around uninsulated electrical parts or moving parts to make adjustments or measurements while the UPS is energized. For requirements covering accessibility of live parts for protection of users, refer to Section 7.

39.2 Live parts shall be so arranged and covers so located as to reduce the risk of electric shock or electrical energy – high current levels while covers are being removed and replaced.

39.3 An uninsulated live part involving a risk of electric shock or electrical energy – high current levels and a moving part that involves a risk of injury to persons shall be located, guarded, or enclosed so as to reduce the likelihood of unintentional contact by service personnel adjusting or resetting controls, or the like, or performing mechanical service functions that may be performed with the equipment energized, such as lubricating a motor, adjusting the setting of a control with or without marked dial settings, resetting a trip mechanism, or operating a manual switch.

39.4 Live parts involving a risk of electric shock or electrical energy – high current levels – located on the back side of a door shall be either guarded or insulated to reduce the likelihood of unintentional contact of the live parts by service personnel.

39.5 A component that may require examination, resetting adjustment, servicing, or maintenance while energized shall be so located and mounted with respect to other components and with respect to grounded metal parts that it is accessible for electrical service functions without subjecting the serviceperson to the risk of electric shock, electrical energy – high current, or injury to persons by adjacent moving parts. Access to a component shall not be impeded by other components or by wiring.

39.6 For an adjustment that is to be made with a screwdriver or similar tool when the unit is energized, the requirement in 39.5 necessitates that protection be provided so that inadvertent contact with adjacent uninsulated hazardous live parts involving a risk of electric shock is not likely, taking into consideration that misalignment of the tool with the adjustment means may result when an adjustment is attempted. This protection may be provided by:

- a) Location of the adjustment means away from uninsulated hazardous live parts; or
- b) A guard to reduce the likelihood of the tool from contacting uninsulated live parts.

39.7 A live heat sink for a solid-state component, a live relay frame, and the like, involving a risk of electrical shock or electrical energy – high current levels, which may be mistaken for dead metal, shall be guarded to reduce the risk of unintentional contact by the serviceperson or be marked in accordance with 72.2.6.

Exception: A heat sink mounted on a printed-wiring board need not comply with this requirement.

39.8 Moving parts that can cause injury to persons and that must be in motion during service operations not involving the moving parts shall be located or protected so that unintentional contact with the moving parts is not likely.

39.9 A functional attachment that is made available or recommended by the manufacturer for use with the basic unit shall be included in the evaluation of the unit. Unless the manufacturer recommends the use of two or more attachments at the same time, only one attachment at a time is to be evaluated with the unit.

39.10 Whether a guard, a release, an interlock, or the like is required and whether such a device is adequate shall be determined from an investigation of the complete unit, its operating characteristics, and the likelihood of a risk of injury to persons resulting from a cause other than gross negligence. The investigation shall include consideration of the results of breakdown or malfunction of any component; but not more than one component at a time, unless one event contributes to another. If the investigation shows that breakdown or malfunction of a particular component can result in a risk of injury to persons, that component shall be investigated for reliability.

40 Harmonic Distortion

40.1 The output voltage harmonic distortion from a UPS is to be measured as described in Section 49, Harmonic Distortion Test. If the levels specified in 49.1 are exceeded (including the acceptable cases stated in Exceptions No. 1 – No. 4) the Load Temperature Test of Section 46 shall be conducted.

Exception No. 1: The output voltage distortion levels of 49.1 may be exceeded if the unit complies with all of the following requirements:

- a) The electrical input rating is a nominal 240 V and 6 A, or a nominal 120 V and 12 A, or less; and*
- b) The output voltage distortion exceeding the levels of 49.1 occurs only during reserve mode operation, and the unit is not capable of providing rated output for more than 30 minutes, with the provision for powering the unit from external batteries, under reserve mode with fully charged batteries.*

Exception No. 2: The output voltage distortion levels of 49.1 may be exceeded if the unit is intended for use with a specific product load, and if the unit is marked in accordance with 72.1.30. Additionally, the instruction manual shall contain the information described in 74.1.2(ad) when a specific type of device is used. The temperature on the load shall not exceed the allowable values applicable to the load equipment involved during the Load Temperature Test of Section 46.

Exception No. 3: The output voltage distortion levels of 49.1 may be exceeded if the unit is intended for use with a generic type of device, and the unit is marked in accordance with 72.1.31. The Load Temperature Test of Section 46 shall be conducted using representative samples of the end use products supplied by a sinusoidal voltage source, and by the UPS output under the mode which results in the worst case harmonic voltage distortion.

Exception No. 4: The output voltage distortion levels of 49.1 may be exceeded if the temperatures measured on the loads supplied by the nonsinusoidal waveform do not exceed the temperatures measured using the sinusoidal waveform by more than 5°C (9°F), and do not exceed the allowable values applicable to the load equipment involved. If representative products are used, a sufficient number of products shall be tested to allow temperature measurements of the components mentioned in 46.2(b)(1) — (5).

Exception No. 5: The Harmonic Distortion Test of Section 49 and the Load Temperature Test of Section 46 need not be conducted if the unit is intended for use with Cable TV and is marked as described in 72.1.32.

40.1 revised February 1, 1996

PERFORMANCE

41 General

41.1 A representative sample of a unit is to be subjected to the tests described in Sections 42 – 68. Unless otherwise specified, all tests are to be conducted at the applicable voltage specified in Table 41.1.

Exception: A test voltage of not less than 90 percent of the values specified in Table 41.1 may be used provided that the unit will deliver rated output power at the reduced test voltage.

68 Ignition Test Through Bottom-Panel Openings

68.1 General

68.1.1 In accordance with Exception No. 3 to 5.10.1, a ventilated, bottom-panel construction may be judged by conducting the tests described in 68.2.1 – 68.2.4.

68.2 Hot, flaming oil test

68.2.1 Openings in a bottom panel shall be so arranged and sufficiently small in size and few in number that hot, flaming No. 2 fuel oil (see 68.2.3) poured three times onto the openings from a position above the panel is extinguished as it passes through the openings.

68.2.2 A sample of the complete, finished bottom panel is to be supported in a horizontal position a short distance above a horizontal surface under a hood or in another area that is ventilated but free from drafts. Bleached cheesecloth running 14 – 15 square yards to the pound ($28 - 30 \text{ m}^2/\text{kg}$ mass) and having, for any square inch (6.4 cm^2), 32 threads in one direction and 28 in the other, is to be draped in one layer over a shallow, flat-bottomed pan that is of a size and shape to cover completely the pattern of openings in the panel but is not sufficiently large to catch any of the oil that runs over the edge of the panel or otherwise does not pass through the openings. The pan is to be positioned with its center under the center of the pattern of openings in the panel. The center of the cheesecloth is to be 2 inches (50.8 mm) below the openings. Use of a metal screen or wired-glass enclosure surrounding the test area is recommended to reduce the likelihood of splattering oil, causing injury to persons.

68.2.3 A small metal ladle no more than 2-1/2 inches (63.5 mm) in diameter, with a pouring lip and a long handle whose longitudinal axis remains horizontal during pouring, is to be partially filled with 10 cubic centimeters of No. 2 fuel oil, which is a medium-volatile distillate having a minimum API gravity of 30 degrees, a flash point of 110 – 190°F (43.3 – 87.7°C), and an average calorific value of 136,900 Btu per gallon (38.2 MJ/L) (see the American Society for Testing and Materials Specification for Fuel Oils, ASTM D396-1992). The ladle containing the oil is to be heated and the oil is to be ignited. The oil is to flame for 1 minute and then is to be poured at the approximate rate of, but no less than, 1 cubic centimeter per second in a steady stream onto the center of the pattern of openings from a position 4 inches (102 mm) above the openings. It is to be observed whether the oil ignites the cheesecloth.

68.2.4 Five minutes after completion of the pouring of the oil, the cheesecloth is to be replaced with a clean piece and a second 10 cubic centimeter of hot, flaming oil is to be poured from the ladle onto the openings, and it is again to be observed whether the cheesecloth is ignited. Five minutes later, a third identical pouring is to be made. The openings are not acceptable if the cheesecloth is ignited in any of the three pourings.

69 Tests on Transformer Insulating Materials

69.1 If required by Table 26.1(c) or (g), the transformer insulating material shall be subjected to the test described in 69.2.

69.2 The insulating material is to be placed between two opposing electrodes. The electrodes are to be cylindrical brass or stainless steel rods 1/4 inch (6.4 mm) in diameter with edges rounded to a 1/32-inch (0.8-mm) radius. The upper movable electrode is to weigh 50 ± 2 grams to exert sufficient pressure on the specimen to provide good electrical contact. The test potential is to be increased to the test value and the maximum test potential is to be maintained for 1 second. The result is acceptable if there is no dielectric breakdown.

70 Bus Bar Tests

70.1 An aluminum bus bar employing a coating mentioned in Exception No. 3 of 21.2.1 or a bus bar that has a clamped joint construction permitted by Exception Nos. 2 and 3 of 21.2.3 and 21.2.4, respectively, is to be subjected to the tests described in 70.2 – 70.4.

70.2 The temperature of the bus bar joint is to be measured during the temperature test described in Section 45, Temperature Test, and shall comply with the maximum temperature specified in Table 45.2.

70.3 The temperature rise at the joint during the five hundredth cycle shall not be more than 15°C (27°F) higher than the temperature rise at the end of the twenty-fifth cycle.

70.4 The test sample is to consist of an assembly of bus bars connected together to form a series circuit. The bus bars are to be clamped together with the joint construction used in actual production. The number and size of the bus bar are to represent the maximum ampere rating and the maximum current density in which the joint construction is employed. This may necessitate more than one test. The length of each bus bar is to be 2 feet (609 mm). The bus bar is to be connected to a power supply by any convenient means that will not affect the joint temperature. The power supply is to be adjusted to deliver a value of current that will result in a temperature of 75°C (135°F) above room temperature at the joint. The assembly is then to be subjected to a 500-cycle test. At the end of the 24th cycle, the current is to be readjusted to bring the temperature of the joint to 75°C above room temperature; and this current value is to be maintained for the remainder of the cycling test. At the end of the 25th and 500th cycles, the temperatures are to be recorded. The temperatures are to be measured on both sides of the joint as close as possible to the bolt or rivet. The cycling rate is to be 3 hours on and 1 hour off. The on period during which temperatures are recorded may be extended to more than 3 hours if necessary for the joint to attain thermal equilibrium.

Exception: The length of the bus bar may be less than 2 feet with the concurrence of those concerned.

70A Maximum Output VA Measurement Test

70A.1 If required by (b) in Exception No. 1 to 13.5, a unit is to be subjected to this test. While simulating a utility power outage, the inverter portion of the UPS is to receive power from the fully charged, intended battery bank. The battery supply is to be loaded at rated load, but not more than 750 VA. The battery current and voltage are to be monitored during this test. The maximum available VA measured at five minutes shall not exceed 750 VA.

Added 70A.1 effective February 1, 1999

70B Emergency DC Power Off Test

70B.1 If connection to a remote emergency power off circuit is required (see 13.5), then the unit is to be subjected to this test. While simulating the operation of a remote emergency power off switch, the inverter portion of the UPS is to receive power from either a fully charged battery bank or an external dc source of supply. The unit is to be operated at rated output ac load. The output battery current is to be monitored. Within five minutes of operating the remote emergency power switch, the output battery current shall be zero.

Added 70B.1 effective February 1, 1999

RATING

71 Details

71.1 A unit shall have the following ratings:

- a) Input voltage;
- b) Number of phases for input and output, except for a unit obviously intended for single-phase use only;
- c) Input and output frequency;
- d) Input in amperes (see 71.3), volt-amperes, or kilovolt-amperes;
- e) Output voltage; and
- f) Output in amperes, volt-amperes, or watts.

71.2 The a-c output rating of a unit shall include a power factor, if less than unity unless the rating is expressed in:

- a) Watts and volt-amperes; or
- b) Watts and amperes.

71.3 With reference to 71.1(d), the rms value of the input current is to be used. For a UPS intended to be connected to a 3-phase, 4-wire source of supply, the phase currents and also the neutral current shall be included.

71.4 The dc circuit of a unit intended to be used with a remote battery supply and a remote battery supply/cabinet assembly shall have the following ratings:

- a) Nominal dc voltage; and
- b) Nominal dc current. The value used shall be determined by either of the following:
 - 1) Measured value of battery current during reserve mode of operation, as described in 44.1(b), when the output voltage of the battery supply equals the nominal voltage rating of the battery supply, or
 - 2) Calculated from the following expression:

$$I = \frac{W}{NV}$$

in which:

I = Nominal dc battery current in amperes;

W = Battery power output in watts, measured when the UPS is delivering rated output power during the reserve mode of operation – see 44.1(b);

N = Total number of battery cells in a series string; and

V = Nominal voltage rating of battery cells. For lead-acid and alkali type batteries, V = 2.0 and 1.2, respectively.

71.5 The electrical rating of a unit shall include the following:

- a) The electrical rating for a 3-phase UPS that is limited to either a delta or wye connection for the supply or load circuit shall indicate the phase configuration; and
- b) The electrical rating for a UPS having a 3-phase output or a single-phase output with a neutral conductor shall indicate the unbalanced load capability of the UPS.

Exception: Units which are tested at 100 percent of the output current rating of the UPS and are found to comply with Section 45, Temperature Test, and Section 46, Load Temperature Test (if applicable) need not indicate the unbalanced load capability of the UPS.

71.5 revised February 1, 1996

MARKING

72 Details

72.1 General

72.1.1 Unless otherwise stated, all markings are required to be permanent, that is, either by being molded, die-stamped, paint-stenciled; stamped or etched metal that is permanently secured; or indelibly stamped on a pressure-sensitive label secured by adhesive that, upon investigation, is found to comply with the requirements in the Standard for Marking and Labeling Systems, UL 969.

72.1.2 A unit shall be plainly and permanently marked where it will be readily visible, after installation, with:

- a) The manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the UPS may be identified;
- b) A distinctive catalog number or the equivalent;
- c) The electrical ratings specified in Section 71; and
- d) The date or other dating period of manufacture not exceeding any three consecutive months.

Exception No. 1: The manufacturer's identification may be in a traceable code if the unit is identified by the brand or trademark owned by a private labeler.

Exception No. 2: The date of manufacture may be abbreviated, or be in a nationally accepted conventional code, or in a code affirmed by the manufacturer, provided that the 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 unit was manufactured.*

72.1.3 Markings may be located on a tag that is attached to the power supply cord and complies with the requirements in Section 67, Tests for Permanence of Cord Tag.

72.1.4 With reference to the requirement in 72.1.2(c), the symbols described in (a) – (c) may be used for markings:

- a) A circuit intended to be connected to a direct-current supply shall be identified by markings indicating that the supply shall be direct current. The symbol illustrated in Figure 72.1 may be used for this marking. See 72.1.5.
- b) A circuit intended to be connected to an alternating-current supply shall be identified by markings indicating that the supply shall be alternating current. The markings shall include the supply-circuit frequency or supply-circuit frequency-range rating (cycles per second, cycles/second, hertz, c/s, cps, or Hz). The symbol illustrated in Figure 72.2 may be used for this marking. See 72.1.5.
- c) The number of phases shall be indicated if the unit is designed for use on a polyphase circuit. The symbol illustrated in Figure 72.3 may be used in place of the word "phase." See 72.1.5.

72.1.15 A unit employing pressure terminal connectors for field wiring connections shall be provided with a marking making reference to the instruction manual for the tightening torque to be applied to the wiring terminals. See 74.1.2(f).

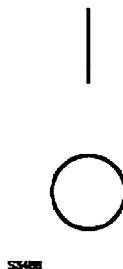
72.1.16 A UPS intended to be used with a remote battery supply shall be plainly marked indicating the polarity of the connections between the battery supply and the UPS with:

- a) The words "positive" and "negative;"
- b) The signs "+" for positive and "-" for negative;
- c) The color coding red for a positive lead and black for a negative lead; or
- d) A pictorial representation illustrating the proper polarity, orientation, and the like of the battery supply, as applicable for the type of battery supply involved. See 72.1.4(a).

72.1.17 A multiple-voltage unit for permanent connection to the branch circuit supply shall be marked to indicate the particular voltage for which it is set when shipped from the factory. The marking may be in the form of a paper tag or any other nonpermanent material. Stationary and portable unit shall be provided with instructions in accordance with 74.1.2(g).

72.1.18 Both the on and off positions of the disconnect control devices mentioned in Section 13, Disconnection Device, or the main disconnect switch on portable equipment, if provided, shall be identified. The symbols illustrated in Figure 72.5 may be used for this purpose. Identification only by illumination is not acceptable. See 72.1.19.

Figure 72.5
On and off symbols



IEC Publication 417, Symbols 5007 and 5008

72.1.19 If the symbol illustrated in Figure 72.5 is used in accordance with 72.1.18, the information described in 74.1.2(h) shall be provided.

72.1.20 With reference to the Exception to 15.4.7, a unit with an operator adjustable voltage selector switch shall be marked to instruct the operator to set the voltage selector to the voltage to which the unit will be connected.

72.1.21 A clock, timing device, or alarm circuit on or remote from a unit that remains energized with a voltage exceeding the values specified in Table 8.1 during servicing functions shall be marked to indicate that the circuit remains energized while the unit is off.

72.1.21 revised February 1, 1996

72.1.22 In accordance with 13.2(d), a marking shall be provided identifying the disconnect switch or breaker for the output ac and dc power circuits.

72.1.23 A unit not furnished with a detachable power supply cord as described in the Exception to 15.4.8 shall be marked adjacent to the appliance coupler or at an equivalent location to inform the user to see the instruction manual [see 74.1.2(n)] for proper selection of the power-supply cord.

Exception: The marking may be in the form of a tag, nonpermanent label, or product insert that is provided on or packaged with the unit so that the marking is visible at the time of installation.

72.1.24 In accordance with 5.2.1, individual modules of a modular UPS shall be marked with:

- a) Information identifying the module such as "rectifier/charger section of Model XYZ UPS" or "inverter section of Model XYZ UPS" or the equivalent; and
- b) A reference to the installation instructions.

The marking may be in the form of a paper tag or any other nonpermanent material. See 74.1.2(q).

72.1.25 If required by 15.1.17, a unit containing a field-wiring lead that is connected to a wire binding screw located in the field-wiring compartment shall be marked with information clearly indicating the intended use of the lead.

72.1.26 Low-voltage Class 2 field-wiring leads, color coded in accordance with the exception in 18.9, shall be identified. The marking shall not require the use of a separate wiring diagram to make proper connections.

72.1.27 A unit may be marked "Suitable for computer-room applications" or the equivalent provided that internal combustible materials comply with the flammability requirements in Section 36, Flammability Classification of Internal Materials, and if applicable, 5.6.4, and 5.6.5.

72.1.28 A UPS having an output ac circuit that is intended to be grounded in the field shall be marked with the following or equivalent words: "The output ac circuit is considered as a separately-derived source. If local codes require grounding of this circuit, use terminal (identify terminal) for bonding this circuit to the enclosure. Ground the enclosure to a suitable grounding electrode in accordance with local code requirements."

72.1.29 A unit investigated for use in a controlled environment specified in 23.1.3 and in accordance with the exception to 43.1 shall be marked with the following or equivalent words: "Intended for installation in a controlled environment." See 74.1.2(z). The marking shall be located outside the unit.

Exception: For a fixed unit, the marking may be located internally in a location visible where field wiring connections are made.

72.1.30 Units in accordance with Exception No. 2 of 40.1 shall have the following or equivalent marking on the unit: "For use with (manufacturer's name and model) ____ * only," where the space shall indicate the specific product used.

*72.1.30 revised and separated into 72.1.30 and 72.1.31

February 1, 1996*

72.1.31 Units in accordance with Exception No. 3 of 40.1 shall have the following or equivalent marking on this unit: "For use with _____* loads only," where the space shall indicate the generic type of device used (such as computer loads, electronic data processing load, and the like).

*72.1.30 revised and separated into 72.1.30 and 72.1.31

February 1, 1996*

72.1.32 If required by Exception No. 5 to 40.1, then a unit shall be marked to indicate that it is for use with Cable TV equipment.

72.1.32 added February 1, 1996

72.1.33 If required by 29.3, a marking shall reference the instruction manual [see 74.1.2(ae)] and shall indicate that the breaker is to be provided by the installer.

72.1.33 added February 1, 1996