UL 924

Underwriters Laboratories Inc.

Standard for Safety

Emergency Lighting and Power Equipment

Underwriters Laboratories Inc. (UL)
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UL Standard for Safety for Emergency Lighting and Power Equipment, UL 924

Ninth Edition, Dated February 24, 2006

Revisions: This Standard contains revisions through and including May 30, 2008

Summary of Topics

These revisions were issued to incorporate the following:

• Editorial corrections and updates to references and editorial revisions to simplify, clarify, or consolidate requirements

• Revised definitions for automatic load control relay and central station battery lighting and power systems; new definition for floor proximity exit sign

• Simplification of and alternative requirements for enclosures

• Clarification that evidence must exist to support a performance characteristic claim for polymeric material

• Clarification of required testing based on risks associated with conductor secureness

• Adjustment of electronic circuit operational requirements

• Adjustment of derangement signal operational requirements

• Revisions to test switch requirements to use consistent terminology and establish mandatory language and to limit access to a maintained-break type test switch to service personnel

• Clarification of requirements for self-testing/self-diagnostic equipment

• Consolidation and clarification of requirements for disconnect switches and fuses

• Allowing UL 746E as an alternative to the conformal coating requirements in Sections 56 and 57

• Re-aligning requirements for flashing exit signs with UL 1638, delete the flashing rate stability reference, and adjust the reference for energizing at rated voltage

• Clarification of test voltages to expand the range of product voltage ratings subject to testing at either 120 or 240 volts

• Revision of the leakage current test to not require continuation of leakage current measurements through thermal stabilization

• Clarification of normal operation test requirements for manual test switches

• Revision of test method for standby rating input test

• Separating the over and undervoltage tests into two separate sections, editing for consistent terminology, and adjusting the test voltage to represent a modestly more severe condition

• Deletion of the humidity test in 56.3.1 as it is covered by 56.2.1

• Revision of test requirements for low frequency inverters

• Revision of test requirements for high frequency inverters

• Deletion of the alternative test program for battery recognition, Supplement SA

• Addressing redundant requirements in Supplement SB – Retrofit Fluorescent Fixture Inverter/ Charger Packs

• Separation of extended ambient ratings from damp/wet ratings

• Eiminating low temperature testing of fluorescent and electroluminescent lamps

• Deletion of requirements for battery temperature regulation in Supplements SC and SD

• Not specifying both gasket adhesion tests in SD4.8.1

• Revising photoluminescent sign conditioning and activation levels

• Deletion of the exemption for minimum light output testing in Section SH2

• Luminance and illuminance measurement equipment parameters

• Revising requirements for instructions to require instructions to be available via internet and available to authorities having jurisdiction

• Deleting requirement that photoluminescent signs in accordance with Supplement G are for use only indoors

• Deleting requirements detailing how to mount a photoluminescent sign

• New and revised marking requirements for photoluminescent exit signs

• Adding an exception to not require a marking when equipment is solely for the control of remote loads

• Requiring overload and endurance testing of relays

• Adding required marking of relays based on type of load

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Text that has been changed in any manner is marked with a vertical line in the margin. Changes in requirements are marked with a vertical line in the margin and are followed by an effective date note indicating the date of publication or the date on which the changed requirement becomes effective.

The new and/or revised requirements are substantially in accordance with UL's Proposal(s) on this subject dated January 18, 2008 and April 4, 2008.

The revisions dated May 30, 2008 include a reprinted title page (page1) for this Standard.

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

As indicated on the title page (page1), this UL Standard for Safety has been adopted by the Department of Defense.

The UL Foreword is no longer located within the UL Standard. For information concerning the use and application of the requirements contained in this Standard, the current version of the UL Foreword is located on ULStandardsInfoNet at: http://ulstandardsinfonet.ul.com/ulforeword.html

The master for this Standard at UL's Northbrook Office is the official document insofar as it relates to a UL service and the compliance of a product with respect to the requirements for that product and service, or if there are questions regarding the accuracy of this Standard.

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The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the note following the affected item. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a ″SUPERSEDED REQUIREMENTS″ notice.

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

This Standard consists of pages dated as shown in the following checklist:

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Standard for Emergency Lighting and Power Equipment

The first, second, third, and fifth editions were titled Standard for Emergency Lighting Equipment.

First Edition – December, 1958
Second Edition – May, 1973
Third Edition – October, 1973
Fourth Edition – April, 1977
Fifth Edition – February, 1979
Sixth Edition – March, 1984
Seventh Edition – November, 1990
Eighth Edition – March, 1995

Ninth Edition

February 24, 2006

The most recent designation of ANSI/UL 924 as an American National Standard (ANSI) occurred on May 30, 2008.

This ANSI/UL Standard for Safety, which consists of the Ninth Edition with revisions through May 30, 2008 is under continuous maintenance, whereby each revision is ANSI approved upon publication.

An effective date included as a note immediately following certain requirements is one established by Underwriters Laboratories Inc. and is not part of the ANSI standard.

The Department of Defense (DoD) has adopted UL 924 on November 14, 1982. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

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 set of revised requirements. Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at http://csds.ul.com.

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INTRODUCTION

1 Scope

1.1 This Standard applies to emergency lighting and power equipment for use in unclassified locations and intended for connection to branch circuits of 600 volts or less. Such equipment is intended to automatically supply illumination or power or both to critical areas and equipment in the event of failure of the normal supply, in accordance with Article 700 or 701 of the National Electrical Code, NFPA 70, the Life Safety Code, NFPA 101, and the International Building Code, IBC.

1.2 Examples of equipment described in 1.1 include:

Exit Signs

Emergency Luminaires

Unit Equipment

Central Station Battery Banks

Inverters

Automatic Battery Charging and Control Equipment

Automatic Load Control Relays

Derangement Signal Equipment

1.3 This Standard also applies to auxiliary lighting and power equipment for use in unclassified locations. Auxiliary equipment has not been investigated to determine compliance with the performance requirements of Article 700 or 701 of the National Electrical Code, NFPA 70, the Life Safety Code, NFPA 101, or the International Building Code. Such equipment includes luminaires with an integral battery backup power supply, illuminated directional signs, battery assemblies, and related devices.

1.4 This Standard does not include requirements for equipment covered by other Standards, such as:

Luminaires, UL 1598

Uninterruptible Power Systems, UL 1778

Luminous Egress Path Marking Systems, UL 1994

Transfer Switch Equipment, UL 1008

Electric Signs, UL 48

2 References

2.1 Any undated reference to a code or a standard appearing in the requirements in this standard shall be interpreted as referring to the latest edition of that code or standard.

3 Resistance to Environmental Conditions

3.1 Equipment marked with an enclosure type number, such as 4X, shall comply with the following:

a) The enclosure shall comply with the applicable requirements specified in the Standard for Enclosures for Electrical Equipment, UL 50, and

b) The equipment shall comply with the requirements in this standard for use in the environment indicated by the enclosure type designation.

4 Glossary

4.1 For the purpose of this standard the following definitions apply.

4.2 AUTOMATIC BATTERY CHARGING EQUIPMENT – Equipment provided to maintain the central storage battery bank in a charged condition at all times when the normal supply is available.

4.3 AUTOMATIC LOAD CONTROL RELAY – A separate or integral device intended to energize, to appropriate power or illumination levels, switched or normally off emergency equipment from an emergency supply in the event of failure of the normal supply, and to de-energize or return the equipment to normal status when the normal supply is restored. These devices are not transfer switches, but instead transmit power only from a single upstream source (typically, the emergency source) to specific loads. They connect to a second (typically, the normal) source of power only for monitoring purposes.

4.3 revised May 30, 2008

4.4 AUXILIARY LIGHTING AND POWER EQUIPMENT – Equipment associated with or related to, but not interconnected with or required as part of a facility's emergency lighting or power system. This equipment is not evaluated for compliance with the minimum output (power or light) requirements of the National Electrical Code, ANSI/NFPA 70, the Life Safety Code, NFPA 101, or the International Building Code, and is so marked.

4.5 BATTERY BANK – An enclosed group of batteries intended to supply power to remote lighting or power equipment.

4.6 CENTRAL STATION BATTERY LIGHTING AND POWER SYSTEMS – Systems intended to supply power for emergency lighting equipment, typically consisting of a central storage battery bank, automatic battery charging equipment, inverters, automatic control relays, multi-circuit distribution equipment, derangement alarm equipment, and other applicable accessories. Such equipment may be integrally housed in a single overall enclosure or may be separately enclosed for remote connection to a central control unit.

4.6 revised May 30, 2008

4.7 CENTRAL STORAGE BATTERY BANK – Storage batteries arranged and connected so as to provide the required emergency system voltage.

4.8 CLASS 2 CIRCUIT – A circuit supplied by an isolating source that complies with the Standard for Class 2 Power Units, UL 1310 or the Class 2 requirements of either the Standard for Class 2 and Class 3 Transformers, UL 1585, or the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1 and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3.

4.9 COMBINATION UNIT – A single piece of equipment that functions as an Exit Light and as Unit Equipment.

4.10 COMBUSTION – The decomposition of materials from solid to vapor state, through the application of heat, typically evidenced by flames, smoldering, charring, or mechanical deformation.

4.11 COMPOSITE SOLID STATE SWITCH-INVERTER – Electronic switching circuitry that permits an inverter to function in the emergency mode using only the battery supply.

4.12 CONTINUOUS ILLUMINATED LETTER OR DIRECTIONAL INDICATOR – The letter of a legally required legend or directional indicator that is continuous over its entire illuminated height, width or stroke width. Up to two structural members, each no more than 0.3 inches (8 mm) in width, may be provided in letters with physically disconnected center sections.

4.13 DERANGEMENT ALARM – An audible or visible (or both) signal to indicate disruption or failure in an emergency power circuit.

4.14 DUTY CYCLE – As applicable to flashing exit fixtures and exit lights, duty cycle refers to the light pulse duration (″on″ time) expressed either as a percentage or fraction of the cycle duration or as both the light pulse duration and duration between successive light pulses (″off″ time).

4.15 ELECTROLUMINESCENT – The emission of light from a phosphor excited by an electromagnetic field.

4.16 EMERGENCY LUMINAIRE – An illumination source with:

a) Two or more lamps intended to be separately connected to a normal and an emergency source of power (no automatic control equipment) or

b) One or more lamps with a means for transferring from the normal to the emergency source of power.

4.17 EXIT FIXTURE – A fixture with one or more lamps intended:

a) To be permanently connected to only one source of power (normal or emergency) and

b) To illuminate an integral legally required legend.

4.18 EXIT LIGHT – A complete, enclosed unit assembly arranged for permanent connection, with one or more lamps that illuminate an integral legally required legend upon failure of the normal power supply. An exit light may have an automatic load control device and may be provided with a storage battery. If a battery is used, a means for charging the battery is included.

4.19 EXIT SIGN – A general term used to refer to an Exit Light, Exit Fixture, and Self-Luminous or Photoluminescent Exit Sign.

4.20 FIELD-WIRING TERMINAL – Any terminal of the equipment as well as any terminal of any component unit (circuit breaker, switch, and the like) in the equipment to which conductors are to be connected in the field.

4.20.1 FLOOR PROXIMITY EXIT SIGN – An exit sign intended to be mounted with the bottom edge no less than 6 inches (150 mm) and no more than 18 inches (455 mm) above floor grade.

4.20.1 added May 30, 2008

4.21 FULL-SIZE ILLUMINATED LEGEND – A legally required legend that provides illuminated letters of minimum 6 inches (152 mm) high by 2 inches (51 mm) wide (except for the letter ″I″), with a 3/4 inch (19.1 mm) stroke width.

4.22 GRAPHICAL SYMBOL – A pictorial representation (also known as a pictogram) serving as a non-language based visual indicator of meaning. Legally required graphical symbols within the context of this Standard are as described in the Standard for Fire Safety Symbols, NFPA 170.

4.23 HIGH-FREQUENCY INVERTER – An arrangement of solid-state circuitry designed to convert direct-current power to high-frequency (greater than 800 hertz), alternating current and the voltage required to operate electric discharge lamps.

4.24 ILLUMINANCE – The amount of light imposed on the surface of a material or object, measured in foot-candles or lux.

4.25 INSTALLATION-WIRING LEAD – Any wire lead to which a supply or other wire is intended to be spliced by an installer in the field.

4.26 INSTALLATION-WIRING TERMINAL – Any terminal to which a supply or other wire is intended to be connected by an installer in the field.

4.27 INVERTER/CHARGER PACK – An assembly with batteries, a charger, high frequency inverter, and control circuitry intended to provide emergency power to one or more fluorescent lamps upon loss of normal power.

4.28 ISOLATED CIRCUIT – A circuit supplied by a source with no direct electrical connection between input and output (such as a transformer or optical isolator). A common grounding means for the input and output does not violate the isolating nature of the source.

4.29 LAMPHEAD – As applicable to unit equipment, a lamp assembly mounted externally to the main enclosure of the equipment with a swivel or equivalent mounting means so as to be adjustable.

4.30 LEGALLY REQUIRED LEGEND – Words or symbols intended to transmit a specific message associated with life safety, in accordance with an adopted building or fire code. Examples are the words ″EXIT″, ″STAIRS″, ″FIRE ESCAPE″, and ″FIRE EXIT″. Comparable text (in English or other languages as appropriate for the installation site) or graphical symbols identifying means of egress as shown in the Standard for Fire Safety Symbols, NFPA 170, or similar standards are also considered legally required legends.

4.31 LIMITING IMPEDANCE CIRCUIT – A circuit supplied by an impedance that, when a direct short is applied across the source output:

a) Has a calculated power dissipation of 15 W or less, and

b) Does not incur any opened or shorted components.

The limiting impedance shall additionally function as intended under any single fault condition unless it consists of a single resistor, or of a single capacitor that complies with the Standard for Capacitors and Suppressors for Radio- and Television-Type Appliances, UL 1414.

4.32 LOW-FREQUENCY INVERTER – An arrangement of solid-state circuitry designed to convert direct-current power to low-frequency (50 – 800 hertz), alternating current and the voltage required to operate lighting and power equipment.

4.33 LOW-VOLTAGE, LIMITED-ENERGY CIRCUIT – A circuit supplied by a source of maximum 30 V AC or 42.4 V peak open circuit potential and maximum 8 A available current measured after one minute of operation. See Section 49.

4.34 LUMINANCE – The amount of light emitted from a surface, measured in foot-lamberts or candelas per square meter.

4.35 MULTI-CIRCUIT DISTRIBUTION EQUIPMENT – Any multi-circuit distribution panel incorporating individual branch circuit overcurrent protection. This equipment may be provided with individual branch circuit monitoring control relays.

4.36 NON-CONTINUOUS ILLUMINATED LETTER OR DIRECTIONAL INDICATOR – The letters of a legally required legend, or a directional indicator, that is not continuous over its entire illuminated height, width, or stroke width. Examples of such constructions are exit signs with a series of point light sources (such as light-emitting diodes – LEDs) or illuminated segments separated from each other by nonluminous (opaque) spaces.

4.37 OTHER ACCESSORIES – Any equipment that may be provided as a component part of a central station battery lighting and power system, other than remotely connected lighting fixtures (such as battery disconnect switching devices, phase monitor equipment, and the like).

4.38 PHOTOLUMINESCENT – Having the property of emitting light that continues for a length of time after excitation by visible or invisible light has been removed.

4.39 QUALIFIED SERVICE PERSONNEL – Persons trained in the installation and servicing of the product.

4.40 REDUCED-SIZE ILLUMINATED LEGEND – A legally required legend having full size letters in accordance with 40.5, the illuminated areas of which are smaller with dimensions between 5-1/2 to 6 inches (139.7 to 152.4 mm) high by 1-1/2 to 2 inches (38.1 to 50.8 mm) wide with a 1/4 to 3/4 inch (6.4 to 19.1 mm) stroke.

4.41 REMOTE LAMP ASSEMBLY – A unit with one or more lamps intended to be connected to unit equipment or central station battery lighting and power systems.

4.42 RETROFIT – An assembly intended to be permanently field installed in existing equipment.

4.43 RISK OF ELECTRIC SHOCK – A risk of electric shock is considered to exist if the open-circuit potential between any two uninsulated parts, or an uninsulated part and ground, is higher than 30 V AC or 42.4 volts peak, and the available current that would flow between the parts, through a 1500-ohm resistance, is more than 5 mA.

4.44 RISK OF FIRE – A risk of fire exists in all electrical circuits except:

a) A Class 2 circuit;

b) An isolated, low-voltage, limited-energy circuit; or

c) A limiting impedance circuit.

4.45 ROUTINE MAINTENANCE – Periodic tasks to maintain the equipment in proper working order and intended to be performed by other than qualified service personnel. Examples are, replacing fuses (branch-circuit or load-circuit type), replacing light sources, adding water to batteries and checking specific gravity of electrolyte. An enclosure or compartment is not considered subject to routine maintenance activities when it requires a tool for access and is marked per 70.1.14.

4.46 ROUTINE OPERATION – Operation of a test switch located inside or outside the overall enclosure, resetting of switches and circuit breakers, and similar operations.

4.47 SEALED BATTERY/CELL – A battery/cell that has no provision for the addition of water or electrolyte or for external measurement of electrolyte specific gravity.

4.48 SELF-LUMINOUS EXIT SIGN – A sign with an integral legally required legend that is powered continuously by a self-contained energy source other than a battery, such as radioactive tritium gas. Operation of a self-luminous exit sign is independent of external power supplies or other external forms of energy. This definition does not include exit signs dependent upon photoluminescent materials.

4.49 SERVICE – Tasks intended to be performed on-site by qualified personnel and that require a tool to access any compartment for performance of the task.

4.50 TRANSLUCENT – The property of letting light through without being transparent. As applicable to exit signs, a luminous surface that is not transparent, but provides the same effect as a translucent material that is illuminated from the back is also considered to be translucent. For example, a composite construction consisting of a transparent material applied over a luminous non-transparent surface as in edge-lighted exit sign constructions is considered to be translucent.

4.51 UNFILTERED – In the context of a luminaire intended to activate a photoluminescent exit sign, the lack of a lens or diffuser that removes any appreciable portion of the UV spectrum.

4.52 UNIT EQUIPMENT – A complete, enclosed unit assembly, consisting of a rechargeable battery, a battery charging means, provisions for one or more lamps either mounted on the equipment or remote or both, and a device arranged to energize the lamps automatically upon failure of the normal supply. Terminals or leads are provided for the connection of remote lamps.

4.53 VENTED BATTERY/CELL – A battery/cell provided with positive openings that permit free interchange of cell gases with the outside atmosphere.

4.54 VISIBLE – Legible (as pertains to text) and distinguishable from other text or symbols.

5 Components

5.1 Except as indicated in 5.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this standard.

5.2 A component need not comply with a specific requirement that:

a) Involves a feature or characteristic not needed in the application of the component in the product covered by this standard or

b) Is superseded by a requirement in this standard.

5.3 A component shall be used in accordance with its recognized rating established for the intended conditions of use. Load control devices shall be rated for the type(s) of loads controlled.

5.3 revised May 30, 2008

5.4 Specific components are recognized as being incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions for which they have been recognized.

5.5 A component not marked with a short-circuit current rating is considered rated for use in a circuit having a maximum available fault current as shown in Table 5.1.

Table 5.1
Assumed maximum short-circuit current rating for unmarked components

Component	Short-circuit current rating, kA
1. Circuit breaker (including GFCI type)	5
2. Clock-operated switch	5
3. Fuseholder	10
4. Lighting fixture (circuit) internal	5
5. Miniature fuse	10[a]
6. Plug fuse	10
7. Industrial control equipment:	
a) Auxiliary device	5
b) Switches (other than mercury tube type)	5
c) Mercury tube switches rated over 60 amperes or over 250 volts	5
8. Meter socket base	10
9. Photoelectric switches	5
10. Receptacle (other than GFCI type)	10
11. Snap switch	5
12. Terminal block	10
13. Thermostat	5

Table 5.1 Continued on Next Page

Table 5.1 Continued

Component	Short-circuit current rating, kA
[a] The use of these fuses is limited to 125-volt circuits.	

5.6 The short-circuit current available in the secondary circuit of a transformer rated 10 kVA or less is considered to be 5,000 amperes or less.

5.7 The short-circuit current available on the load side of a 15 ampere current-limiting circuit breaker or Class CC, G, J, RK-1, RK-5, or T fuse is considered to be 5,000 amperes. In a single-phase 120-volt circuit, the short-circuit current available on the load side of a 20 ampere circuit breaker or Class CC, G, J, RK-1, RK-5, or T fuse is considered to be 10,000 amperes or less.

5.8 Emergency power equipment intended for connection to a supply source capable of more than 5,000 amperes capacity shall comply with the requirements for short circuit current ratings for industrial control panels in Supplement SB of the Standard for Industrial Control Panels, UL 508A.

6 Units of Measurement

6.1 If a value for measurement is followed by a value in other units in parentheses, the second value may be only approximate. The first stated value is the requirement.

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

7 Radioactive Energy Sources

7.1 Self-luminous exit signs utilizing a radioactive material as the energy source are subject to the requirements of the United States Nuclear Regulatory Commission or Agreement State as applied to a generally licensed device.

CONSTRUCTION

8 Frame and Enclosure

8.1 General

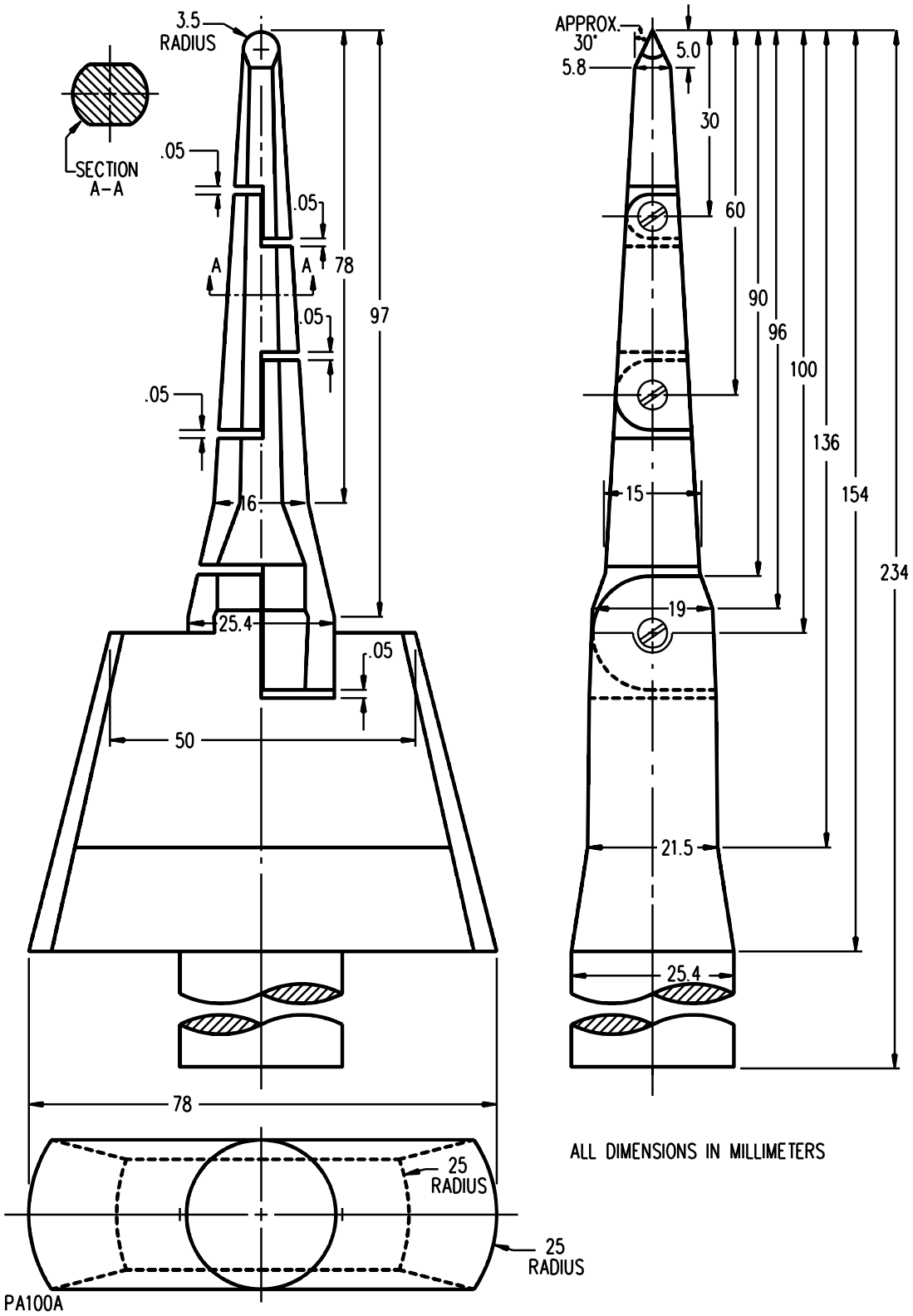
8.1.1 A frame and enclosure shall be formed and assembled so that it will have the strength and rigidity necessary to resist the abuses to which it is likely to be subjected, without increasing the risk of fire, electric shock, or injury to persons due to total or partial collapse, with resulting reduction of spacings, loosening or displacement of parts, or other serious defects.

8.1.2 An operating part, such as a relay and similar devices, shall be protected against dust or other material that may adversely affect the intended operation.

8.2 Uninsulated live parts

8.2.1 Uninsulated electrical parts that pose a risk of electric shock shall be located or enclosed such that they are not able to be contacted by the probe illustrated in Figure 8.1, with the probe articulated into any configuration and rotated or angled to any position before, during, or after insertion into the area being investigated.

Figure 8.1
Articulate probe with web stop



8.2.2 An uninsulated live part considered to be a source of electric shock in a compartment that is intended to be opened for routine maintenance or routine operation shall be located or guarded so as to reduce the risk of inadvertent contact with such a part. Any barrier or guard provided to shield a live part during routine maintenance or routine operation shall remain in place while applying the probe for the purpose of this requirement.

Exception: This requirement does not apply to the lamp contacts of a lampholder or automatic starter holder to which a lamp or automatic starter connects.

8.2.3 Deleted May 30, 2008

8.3 Metallic enclosures

8.3.1 The sheet metal enclosure of a unit equipment shall comply with the requirements in the Standard for Luminaires, UL 1598, or have a minimum thickness of: 0.029 inch (0.74 mm) if of zinc-coated steel, 0.026 inch (0.66 mm) if of uncoated steel, and 0.036 inch (0.91 mm) if of aluminum.

Exception: Sheet metal for the enclosure of the connection to a wiring system shall have a minimum thickness of: 0.034 inch (0.86 mm) if of zinc-coated steel, 0.032 inch (0.81 mm) if of uncoated steel, and 0.045 inch (1.14 mm) if of aluminum.

8.3.2 The thickness of the sheet metal enclosure of emergency equipment shall be no less than indicated in Table 8.1 and Table 8.2.

Exception No. 1: The enclosure of an exit sign or luminaire shall comply with the requirements in the Standard for Luminaires, UL 1598.

Exception No. 2: The sheet metal enclosure of a central station storage battery with integral automatic battery charging equipment shall have an average thickness of no less than: 0.045 inch (1.14 mm) if of zinc-coated steel, 0.042 inch (1.07 mm) if of uncoated steel, and 0.058 inch (1.47 mm) if of aluminum.

Exception No. 3: Lesser thicknesses may be used if the construction is shown by investigation to provide equivalent mechanical strength.

8.3.3 Table 8.1 and Table 8.2 are based on a uniform deflection of the enclosure surface for any given load concentrated at the center of the surface regardless of metal thickness.

8.3.4 The thickness of cast metal for an enclosure shall be as indicated in Table 8.3.

Exception: Cast metal of lesser thickness may be used if, upon investigation (consideration being given to the shape, size, and function of the enclosure), it is found to have equivalent mechanical strength.

8.4 Nonmetallic enclosures

8.4.1 A nonmetallic enclosure or enclosure part shall have mechanical strength and durability, shall be formed so that operating parts will be protected against damage, and shall resist the abuses likely to be encountered during installation and intended use and service. The mechanical strength shall be at least equivalent to a sheet metal enclosure of the minimum thickness specified in Table 8.1. The enclosure or enclosure part shall protect persons from a risk of electric shock, and the material shall not create or contribute to a risk of fire, electric shock, or injury to persons.

8.4.2 Among the factors considered when evaluating an enclosure or frame of nonmetallic material are:

a) Mechanical strength;

b) Resistance to damage from impact;

c) Moisture-absorptive properties;

d) Flammability;

e) Resistance to arcing;

f) Resistance to temperatures to which the material may be subjected under the conditions of use; and

g) Aging characteristics.

8.4.3 An enclosure made of a polymeric material shall comply with the requirements specified in Polymeric Materials, Section 10.

Table 8.1
Minimum thickness of sheet metal for electric enclosures carbon steel or stainless steel

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness			
Maximum width,[b]		Maximum length,[c]		Maximum width,[b]		Maximum length,		Uncoated,		Zinc coated,	
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	inches	(mm)	inches	(mm)
4.0	10.2	Not limited		6.25	15.9	Not limited		0.020	0.51	0.023	0.58
4.75	12.1	5.75	14.6	6.75	17.1	8.25	21.0				
6.0	15.2	Not limited		9.5	24.1	Not limited		0.026	0.66	0.029	0.74
7.0	17.8	8.75	22.2	10.0	25.4	12.5	31.8				
8.0	20.3	Not limited		12.0	30.5	Not limited		0.032	0.81	0.034	0.86
9.0	22.9	11.5	29.2	13.0	33.0	16.0	40.6				
12.5	31.8	Not limited		19.5	49.5	Not limited		0.042	1.07	0.045	1.14
14.0	35.6	18.0	45.7	21.0	53.3	25.0	63.5				
18.0	45.7	Not limited		27.0	68.6	Not limited		0.053	1.35	0.056	1.42
20.0	50.8	25.0	63.5	29.0	73.7	36.0	91.4				
22.0	55.9	Not limited		33.0	83.8	Not limited		0.060	1.52	0.063	1.60
25.0	63.5	31.0	78.7	35.0	88.9	43.0	109.2				
25.0	63.5	Not limited		39.0	99.1	Not limited		0.067	1.70	0.070	1.78

Table 8.1 Continued on Next Page

Table 8.1 Continued

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness			
Maximum width,[b] inches	(cm)	Maximum length,[c] inches	(cm)	Maximum width,[b] inches	(cm)	Maximum length, inches	(cm)	Uncoated, inches	(mm)	Zinc coated, inches	(mm)
29.0	73.7	36.0	91.4	41.0	104.1	51.0	129.5				
33.0	83.8	Not limited		51.0	129.5	Not limited		0.080	2.03	0.084	2.13
35.0	88.9	47.0	119.4	54.0	137.2	66.0	167.6				
42.0	106.7	Not limited		64.0	162.6	Not limited		0.093	2.36	0.097	2.46
47.0	119.4	59.0	149.9	68.0	172.7	84.0	213.4				
52.0	132.1	Not limited		80.0	203.2	Not limited		0.108	2.74	0.111	2.82
60.0	152.4	74.0	188.0	84.0	213.4	103.0	261.6				
63.0	160.0	Not limited		97.0	246.4	Not limited		0.123	3.12	0.126	3.20
73.0	185.4	90.0	228.6	103.0	261.6	127.0	322.6				

[a] A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal that is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and that has such torsional rigidity as to resist the bending moments which may be applied via the enclosure surface when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure that is as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes:

1) A single sheet with single formed flanges (formed edges);

2) A single sheet which is corrugated or ribbed; and

3) An enclosure surface loosely attached to a frame, for example, with spring clips.

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

[c] For panels not supported along one side (for example, side panels of boxes), the length of the unsupported side shall be limited to the dimensions specified.

Table 8.2
Minimum thickness of sheet metal for electric enclosures aluminum, copper, or brass

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness,	
Maximum width,[b] inches	(cm)	Maximum length,[c] inches	(cm)	Maximum width,[b] inches	(cm)	Maximum length, inches	(cm)	inch	(mm)
3.0	7.6	Not limited		7.0	17.8	Not limited		0.023	0.58
3.5	8.9	4.0	10.2	8.5	21.6	9.5	24.1		
4.0	10.2	Not limited		10.0	25.4	Not limited		0.029	0.74
5.0	12.7	6.0	15.2	10.5	26.7	13.5	34.3		
6.0	15.2	Not limited		14.0	35.6	Not limited		0.036	0.91
6.5	16.5	8.0	20.3	15.0	38.1	18.0	45.7		
8.0	20.3	Not limited		19.0	48.3	Not limited		0.045	1.14
9.5	24.1	11.5	29.2	21.0	53.3	25.0	63.5		
12.0	30.5	Not limited		28.0	71.1	Not limited		0.058	1.47
14.0	35.6	16.0	40.6	30.0	76.2	37.0	94.0		

Table 8.2 Continued on Next Page

Table 8.2 Continued

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness,	
Maximum width,[b] inches	(cm)	Maximum length,[c] inches	(cm)	Maximum width,[b] inches	(cm)	Maximum length, inches	(cm)	inch	(mm)
18.0	45.7	Not limited		42.0	106.7	Not limited		0.075	1.91
20.0	50.8	25.0	63.5	45.0	114.3	55.0	139.7		
25.0	63.5	Not limited		60.0	152.4	Not limited		0.095	2.41
29.0	73.7	36.0	91.4	64.0	162.6	78.0	198.1		
37.0	94.0	Not limited		87.0	221.0	Not limited		0.122	3.10
42.0	106.7	53.0	134.6	93.0	236.2	114.0	289.6		
52.0	132.1	Not limited		123.0	312.4	Not limited		0.153	3.89
60.0	152.4	74.0	188.0	130.0	330.2	160.0	406.4		

[a] A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal that is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and that has such torsional rigidity as to resist the bending moments which may be applied via the enclosure surface when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure that is as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes:

1) A single sheet with single formed flanges (formed edges);

2) A single sheet which is corrugated or ribbed; and

3) An enclosure surface loosely attached to a frame, for example, with spring clips.

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

[c] For panels not supported along one side (for example, side panels of boxes), the length of the unsupported side shall be limited to the dimensions specified.

Table 8.3
Thickness of cast metal enclosures

Use, or dimension of area involved	Minimum thickness			
	Die-cast metal,[a]		Cast metal other than die-cast-type,	
	inch	(mm)	inch	(mm)
Area of 24 square inches (155 cm^2) or less having no dimension greater than 6 inches (152 mm)	1/16[b]	1.6	1/8	3.2
Area greater than 24 square inches or having any dimension greater than 6 inches	3/32	2.4	1/8	3.2
At a threaded conduit hole	1/4	6.4	1/4	6.4
At an unthreaded conduit hole	1/8	3.2	1/8	3.2

[a] Die-cast metal may be used if, upon investigation, it is found to have such mechanical strength as to withstand conditions likely to be encountered in service.

[b] The area limitations for metal 1/16 inch (1.6 mm) thick may be obtained by the provision of reinforcing ribs subdividing a larger area.

8.5 Battery compartment ventilation

8.5.1 A compartment containing storage batteries shall not permit the accumulation of hydrogen gas. If the compartment is sealed in such a manner as to prevent the dissipation of hydrogen gas, it shall comply with the Battery Compartment Ventilation Test, Section 47.

8.5.1 revised May 30, 2008

8.6 Enclosure openings

8.6.1 A ventilating opening in an enclosure, including a perforated hole, louver, and an opening protected by means of wire screening, expanded metal, or perforated cover, that has a minor dimension of less than 1 inch (25.4 mm) is acceptable if a probe as illustrated in Figure 8.1, inserted through the opening, cannot be made to touch any uninsulated live part or film-coated wire that involves the risk of electric shock. The probe shall be applied in all possible articulated positions before, during, and after insertion.

8.6.2 An opening of a type as described in 8.6.1 that is 1 inch (25.4 mm) or larger in an enclosure, as illustrated in Figure 8.2, is acceptable if, within the enclosure, there is no uninsulated live part or film-coated wire less than R distance from the inside edge of the perimeter of the opening and X distance from the plane of the opening. T equals the enclosure thickness, R equals X minus T, and X equals 5 times the diameter of the largest round rod that can be inserted through the opening but no less than 6-1/16 inches (154 mm).

8.6.3 The thickness of perforated sheet steel and sheet steel used for expanded-metal mesh shall be in accordance with the values in Table 8.4.

Exception: The thickness of expanded steel mesh may be less than specified in Table 8.4, but no less than specified in Table 8.5, if:

a) The indentation of a guard or enclosure will not:

1) Alter the clearance between uninsulated movable live parts and grounded metal, such that performance would be adversely affected or

2) Reduce spacings below the minimum values given in 38.1.1 – 38.2.6; and

b) Either:

1) Exposed mesh or any one side or surface of the protected device has an area of no more than 72 square inches (465 cm^2) and has no dimensions greater than 12 inches (305 mm) or

2) The width of a protected opening is no greater than 3-1/2 inches (89 mm).

8.6.4 The wires of screen shall be no smaller than 16 AWG (1.3 mm^2) if the screen openings are 1/2 square inch (3.23 cm^2) or less in area, and shall be no smaller than 12 AWG (3.3 mm^2) for larger screen openings.

Figure 8.2
Opening in enclosure

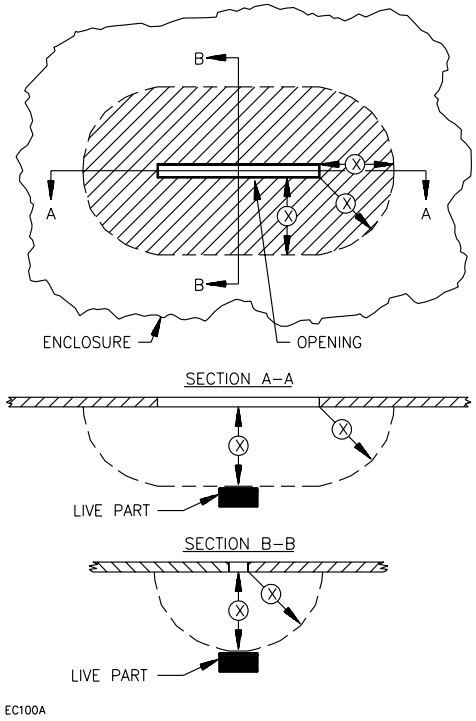


Table 8.4
Minimum thickness of expanded metal mesh

Openings	Uncoated,		Zinc-coated,	
	inch	(mm)	inch	(mm)
Maximum 1/2 square inch (3.23 cm^2)	0.042	1.07	0.045	1.14
More than 1/2 square inch	0.080	2.03	0.084	2.13
NOTE – In accordance with 8.6.3.				

Table 8.5
Minimum thickness of expanded metal mesh

Uncoated,		Zinc-coated,	
inch	(mm)	inch	(mm)
0.020	0.51	0.024	0.61
NOTE – In accordance with conditions given in the Exception to 8.6.3.			

8.6.5 An enclosure housing a fuse or any other overload protective device and provided with a ventilating opening shall afford protection against the emission of flame or molten metal.

8.6.6 An enclosure of an electrical part that presents a risk of fire shall not have unused openings through which molten or burning particles could pass directly to the floor or to the mounting surface. This may be accomplished by the use of a barrier or baffle that is resistant to combustion. An opening for battery compartment ventilation, if provided, shall be located so that it will not vent into concealed spaces of a building structure when the equipment is installed as intended.

Exception No. 1: Surface mounted emergency luminaires, unit equipment, and exit signs that comply with the enclosure opening requirements for surface mounted luminaires in the Standard for Luminaires, UL 1598, are permitted.

Exception No. 2: An enclosure that can only be mounted directly over an outlet box may have unused opening(s) facing the mounting surface, when all such openings fall within the 2-inch (50.8 mm) wide by 3 inches (76.2 mm) high, cross-sectional area of the smallest standard, single, gang-box pattern.

8.6.6 revised May 30, 2008

8.7 Enclosure covers

8.7.1 An enclosure cover shall be hinged if:

a) It gives access to a fuse or any other overload protective device the intended functioning of which requires renewal or resetting or

b) It is necessary to open the cover in connection with the routine operation or routine maintenance of the unit.

Exception: A cover, panel, door, or other part of the enclosure that, by its function or size, obviously must be in place to complete the overall enclosure need not be hinged.

8.7.2 Routine operation of the unit, as specified in 8.7.1(b), is any operation or similar operation as defined in 4.46. Routine maintenance of the unit as specified in 8.7.1(b) is any maintenance, or maintenance as defined in 4.45.

8.7.3 A hinged cover shall be provided with a positive means for latching, such as a spring latch, a magnetic latch, a dimple, or any other mechanical arrangement that will hold the cover in place and that would require some effort on the user's part to open. Gravity alone is not considered to be a positive means for holding the cover in place.

8.7.3 revised May 30, 2008

8.7.4 Deleted May 30, 2008

9 Environmental Rating

9.1 An enclosure shall not be marked with a type designation unless it has been determined to comply with the requirements applicable to that designation(s) as specified in the Standard for Enclosures for Electrical Equipment, UL 50.

9.2 An enclosure shall not be marked ″raintight,″ ″rainproof,″ ″watertight,″ or with other similar terms suggesting suitability for specific environmental conditions, unless the enclosure has been determined to comply with the requirements applicable to the corresponding type designation(s) specified in the Standard for Enclosures for Electrical Equipment, UL 50.

9.3 The integrity of an enclosure marked with a type designation shall not be compromised by the introduction of openings or by the penetration of unevaluated fittings or component parts through the enclosure wall. Only fittings or component parts that have been evaluated and marked with a type designation equal to or better than that of the enclosure shall be used and installed in accordance with the part manufacturer's instructions. The enclosure type designation shall be removed in all other circumstances unless the completed assembly is reevaluated and found to comply with the applicable requirements in the Standard for Enclosures for Electrical Equipment, UL 50.

9.4 Equipment intended for use in damp or wet locations shall be evaluated for compliance with Supplements SC or SD, as applicable.

9.4 revised May 30, 2008

10 Polymeric materials

10.1 General

10.1.1 Polymeric materials used for the purposes covered by 10.2 – 10.6 shall comply with the applicable requirements of this section. When a material is used for more than one purpose, compliance with all relevant properties is required. Materials that have not been identified as conforming to any required performance characteristic shall comply with the applicable alternative evaluation program of UL 746C.

10.1.1 revised May 30, 2008

10.1.2 When there are any uninsulated live parts that represent a risk of fire located within 0.032 inches (0.8 mm) of a polymeric material covered by this section, the material shall additionally have hot-wire ignition (HWI) and high-current arc resistance to ignition (HAI) ratings of 3 or less.

10.1.3 When there are any arcing parts, such as unenclosed switch contacts, located within 0.5 inches (13 mm) of a polymeric material covered by this section, the material shall additionally have a hot-wire ignition (HWI) rating of 3 or less.

10.2 Enclosures

10.2.1 A polymeric enclosure that serves to contain a risk of fire or limit access to a risk of electric shock shall:

a) Have a minimum 5VA flammability rating for fixed or stationary equipment, or minimum V-2 rating for portable auxiliary equipment;

b) Have a mechanical or generic temperature index equal to or greater than the maximum temperature measured on the part during the normal temperature test;

c) Comply with the Resistance to Impact requirements of UL 746C;

d) Comply with the Mold Stress-Relief Distortion requirements of UL 746C when molded or constructed of formed thermoplastic;

e) Comply with the UV Light Exposure requirements of UL 746C when the product is intended for (outdoor) wet locations or contains internal fluorescent light sources.

For the Resistance to Impact test on equipment marked for use in ambients of 0°C (32°F) or below, the cold conditioning prior to impact shall be at 5°C below the marked low ambient temperature.

10.2.1 revised May 30, 2008

10.2.2 Snap-fit parts are permitted to become dislodged as a result of the impact test of 10.2.1(c) if they are able to be properly reattached to the product without the use of tools.

10.2.2 revised May 30, 2008

10.2.3 An enclosure intended for connection to rigid metallic conduit (such as products provided with circular openings or knockouts) shall comply with the Polymeric Enclosure Rigid Metallic Conduit Connection Tests of the Standard for Enclosures for Electric Equipment, UL 50.

10.2.4 An enclosure intended for use with rigid non-metallic conduit – cemented or threaded – shall comply with the applicable requirements in Standard for Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers, UL 514C.

10.2.5 When an enclosure is provided with knockouts but has not been evaluated in accordance with both 10.2.3 and 10.2.4, appropriate information shall be provided in the installation instructions as described in 73.6.

10.3 Mechanical Support

10.3.1 A polymeric part used to suspend another part, the failure of which would result in a risk of fire or electric shock, shall have:

a) A minimum HB flammability rating and

b) A mechanical or generic temperature index equal to or greater than the maximum temperature measured on the part during the normal temperature test.

10.3.2 When the suspended part weighs more than 2 lbs. (0.9 kg), the polymeric part shall be additionally capable of supporting four times the weight of the suspended part for one minute without distortion. The test shall be performed in a chamber maintained at 10°C above the maximum temperature measured on the part during the normal temperature test. The polymeric part under evaluation shall be installed as intended. The part shall be allowed to acclimate to the temperature in the chamber for one hour prior to application of the weight, which shall then be gradually applied and evenly distributed.

10.4 Barriers

10.4.1 A polymeric material used as a barrier shall:

a) Have a minimum HB flammability rating;

b) Have a mechanical or generic temperature index equal to or greater than the maximum temperature measured on the part during the normal temperature test;

c) Comply with the Mold Stress-Relief Distortion requirements of UL 746C when molded or constructed of formed thermoplastic; and

d) Withstand for one minute without breaking or cracking a force of 10 lbs. (44.5 N) applied over an area of 1 in^2(6.45 cm^2).

10.4.1 revised May 30, 2008

10.5 Grounding or Bonding Means

10.5.1 A polymeric material that affects the integrity of a grounding or bonding means shall:

a) Have a minimum HB flammability rating;

b) Have a mechanical or generic temperature index equal to or greater than the maximum temperature measured on the part during the normal temperature test; and

c) Comply with the Mold Stress-Relief Distortion requirements of UL 746C followed by the Grounding Continuity Test of Section 62 when molded or constructed of formed thermoplastic.

10.6 Structural Support

10.6.1 A polymeric material that is relied upon for providing structural support related to compliance with the performance requirements of this Standard shall:

a) Have a mechanical or generic temperature index equal to or greater than the maximum temperature measured on the part during the normal temperature test;

b) Comply with the Mold Stress-Relief Distortion requirements of UL 746C when molded or constructed of formed thermoplastic; and

c) Be subjected to the Resistance to Impact test of UL 746C. Results shall be considered complying if the relevant performance feature of the end-product is not significantly impaired.

11 Mounting Means

11.1 Means for permanent mounting of equipment shall be provided except for cord-connected auxiliary lighting equipment or equipment that weighs 100 lbs (45 kg) or more. Keyhole slots for mounting screws are considered means for permanent mounting if there is at least one round hole sized or all screwheads will be accessible for tightening during installation.

11.1 revised May 30, 2008

11.2 Deleted May 30, 2008

12 Corrosion Resistance

12.1 Iron and steel parts shall be made resistant to corrosion by enameling, galvanizing, sherardizing, plating, or equivalent means. This requirement applies to all enclosure cases whether of sheet steel or cast iron, and to all springs and other parts upon which intended mechanical operation may depend. Bearing surfaces should be of such materials and design as to inhibit binding due to corrosion.

Exception: The following need not be made corrosion-resistant:

a) A bearing, and the like, where such protection is impracticable;

b) A minor part (such as a washer, a screw, a bolt, and the like) if the malfunction of such an unprotected part would not be likely to result in a risk of fire, electric shock, injury to persons, or result in adverse operation of the equipment; and

c) A part made of stainless steel (polished or treated if necessary).

12.2 The interior of a storage battery compartment shall be protected so that it will not be adversely affected by contact with the electrolyte.

Exception: A compartment for a sealed battery need not be so protected.

13 Insulation Material

13.1 An uninsulated live part shall be mounted on material of porcelain or phenolic composition, or on an equivalent insulation material.

13.2 Vulcanized fiber used as an insulation bushing, washer, separator, or barrier, shall not also serve as the sole mechanical support for an uninsulated live part if shrinkage, current leakage, or warpage would degrade its mechanical support or insulating capabilities.

13.2 revised May 30, 2008

13.3 Deleted May 30, 2008

13.4 A countersunk live part shall be covered to a depth of not less than 1/8 inch (3.2 mm) with a waterproof insulation compound that will not soften at a temperature 15°C (27°F) higher than the maximum intended operating temperature of the assembly, and not less than 90°C (194°F) in any case. The softening point of the compound is determined in the Standard Test Methods for Softening Point by Ring-and-Ball Apparatus, ASTM E28.

14 Mounting of Parts

14.1 All parts of equipment shall be mounted in position and prevented from loosening or turning, if such movement may interfere with the intended performance of the equipment, or may result in a risk of fire, electric shock, or injury to persons.

14.2 Adhesive-secured parts shall be investigated for compliance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C if loosening of the part(s) could cause a risk of fire or electric shock, or result in the equipment being unable to function as required by this Standard. The initial (as received) adhesive strength shall be four times the force applied to the part during normal operation (four times the weight of the part if only subjected to gravitational forces). The “reduced number of specimens” program of UL 746C shall be considered for this evaluation.

14.2 revised May 30, 2008

14.3 An uninsulated live part, other than a pressure wire connector as covered in 37.1.7, shall be secured to its supporting surface so that it will be prevented from turning or shifting in position if such movement may result in a reduction of spacings to less than those indicated in Table 37.1. The security of contact assemblies shall be such as to provide continued alignment of contacts.

14.4 The means for preventing the turning, loosening, or shifting of a part, as required in 14.1 and 14.3, shall consist of more than friction between surfaces – for example, a lock washer, correctly applied, is considered an equivalent means for preventing the turning of a small stem-mounted switch or other device having a single-hole mounting means.

14.5 Lampheads that are subject to pulling or torsional forces during unpacking, installation, maintenance, or service shall comply with the Swivel Torsion and Pull Test, Section 64.

15 Operating Mechanisms

15.1 A part of an operating mechanism shall be constructed of material that has the mechanical strength to withstand the stresses of intended use.

15.2 The assembly of an operating mechanism shall be such that it will not be adversely affected by any condition of intended operation.

15.2 revised May 30, 2008

15.3 A moving part (lamphead swivel, hinge, and the like) shall have sufficient play at bearing surfaces to restrict binding.

15.4 Provision shall be made so that an adjusting screw or similar adjustable part will not loosen under the conditions of intended use.

15.5 Deleted May 30, 2008

15.6 An electromagnetic device shall be designed so as to provide positive electrical and mechanical performance under all conditions of intended operation.

16 Current-Carrying Parts

16.1 A current-carrying part shall have sufficient mechanical strength and ampacity for the intended service.

16.1 revised May 30, 2008

16.2 A bearing, hinge, or the like shall not be used for carrying current between fixed and moving parts.

16.2 revised May 30, 2008

17 Installation – Wiring Connections

17.1 General

17.1.1 Emergency lighting equipment intended for permanent connection to the power supply shall be provided with either lead wires or wiring terminals. Wiring terminals shall be sized to accommodate 60°C (140°F) rated wire, corresponding to the amperage ratings of the equipment.

17.1.1 revised May 30, 2008

17.1.2 Unless equipment is marked to indicate the required size, wiring terminals intended for the connection of the remote lamps or fixtures shall be sized to accommodate at least one size larger than required in 17.1.1.

17.2 Terminals

17.2.1 A terminal part by which a connection is made shall provide an effective connection even under hard usage. Soldering lugs or solderless (pressure) wire connectors shall be used.

Exception: For 10 AWG (5.3 mm^2) or smaller wire, a part to which wiring connections are made may consist of a clamp or a binding screw with a terminal plate having upturned lugs or the equivalent to hold the wires in position.

17.2.2 A wiring terminal shall be prevented from turning.

17.2.3 A wire-binding screw to which field-wiring connections are made shall be no smaller than No. 8 (4.2 mm major diameter).

Exception: A No. 6 (3.5 mm major diameter) screw may be used for a terminal to which 14 AWG (2.1 mm^2) or smaller wire is intended to be connected.

17.2.4 A terminal plate tapped for a wire-binding screw shall be of metal no less than 0.050 inch (1.27 mm) thick and shall have no fewer than two full threads in the metal.

Exception: A terminal plate less than 0.050 but no less than 0.030 inch (0.76 mm) thick may be used if the tapped threads are determined to have equivalent mechanical strength.

17.2.5 A terminal plate formed from stock having the minimum required thickness, as given in 17.2.4, may have the metal extruded at the tapped hole for the wire-binding screw so as to provide two full threads.

17.2.6 A wire-binding screw shall thread into metal.

17.3 Field-wiring leads

17.3.1 Field-wiring leads provided for splice connections shall be no smaller than 18 AWG (0.82 mm^2) and shall be rated for the current, voltage, temperature, and conditions of use (dry, damp, or wet locations) to which they will be subjected.

17.3.2 The free length of an installation wiring lead shall be no less than 6 inches (152 mm).

17.4 Polarity identification

17.4.1 A field-wiring terminal for connection of a grounded power supply conductor shall be of, or plated with, a metal white in color. Such a terminal shall be distinguishable from the other terminals, or identification of that terminal shall be shown in some other manner, such as on a wiring diagram adjacent to the terminal.

17.4.2 The surface of a lead intended for field connection of a grounded power supply conductor shall be white or gray, and that lead shall be distinguishable from the other leads.

17.4.3 The color-coding requirement in 17.4.2 does not apply to internal wiring that is not visible in a wiring compartment in which field connections are to be made.

17.4.4 In equipment having a rating more than 51 volts and intended to be connected to a grounded supply circuit, and using a lampholder of the Edison screw-shell type, or a single-pole switch or overcurrent protective device other than an automatic control, one terminal or lead shall have identification for the connection of the grounded conductor of the supply circuit. That terminal or lead shall be the one that is connected to screw shells of lampholders and not to any switch or overcurrent protective device of the single-pole type.

17.4.5 With regard to the requirement in 17.4.4, an automatic control is considered to be a device having automatic resetting contacts that are normally closed and having no means for manual control.

17.5 Termination of wiring systems

17.5.1 Equipment shall have provision for the connection of one of the wiring systems required for the equipment. Separate openings shall be provided for the entrance of emergency circuit wiring and for the wiring of any other circuits.

Exception No. 1: The equipment enclosure may be used if instructions are furnished with it indicating the sections of the unit intended to be drilled in the field for the connection of raceways.

Exception No. 2: An exit light or emergency lighting fixture supplied from two sources, and provided with means intended for mounting to an outlet box, may be provided with a single opening.

17.6 Knockouts

17.6.1 The requirements specified in 17.6.2 – 17.6.6 apply to knockouts intended for field connection of a wiring system in accordance with the National Electrical Code, ANSI/NFPA 70.

17.6.2 A knockout in a metal enclosure shall be secured in place, but shall be removable in accordance with the manufacturer's instructions without deformation of the enclosure that would result in damage to electrical components or reduction in electrical spacings.

17.6.3 A knockout in a metal or polymeric enclosure shall remain in place when tested as described in the Security of Knockout Test, Section 63.

17.6.4 The diameter of a knockout shall be as specified in Table 17.1 for the trade size conduit or cable fitting intended to be used.

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

17.6.6 In measuring a spacing between an uninsulated live part and a bushing installed in a knockout, it is to be assumed that a bushing having the dimensions indicated in Table 17.1 is in place, in conjunction with a single locknut installed on the outside of the enclosure.

Table 17.1
Knockout or hole sizes and dimensions of bushings

Trade size of conduit		Knockout or hole diameter,		Bushing dimensions			
Nominal size,	Outside diameter,			Overall diameter,		Height,	
inches	(mm)	inches	(mm)	inches	(mm)	inches	(mm)
1/2	21.3	7/8	22.2	1	25.4	3/8	9.5
3/4	26.7	1-3/32	27.8	1-15/64	31.4	27/64	10.7
1	33.4	1-23/64	34.5	1-19/32	40.5	33/64	13.1
1-1/4	42.2	1-23/32	43.7	1-15/16	49.2	9/16	14.3
1-1/2	48.3	1-31/32	50.0	2-13/64	56.0	19/32	15.1
2	60.3	2-15/32	62.7	2-45/64	68.7	5/8	15.9
2-1/2	73.0	3	76.2	3-7/32	81.8	3/4	19.1
3	88.9	3-5/8	92.1	3-7/8	98.4	13/16	20.6
3-1/2	101.6	4-1/8	104.8	4-7/16	112.7	15/16	23.8
4	114.3	4-5/8	117.5	4-31/32	126.2	1	25.4
4-1/2	127.0	5-1/8	130.2	5-35/64	140.9	1-1/16	27.0
5	141.3	5-5/8	142.9	6-7/32	158.0	1-3/16	30.2
6	168.3	6-3/4	171.5	7-7/32	183.4	1-1/4	31.8

18 Cord-Connected Unit Equipment

18.1 General

18.1.1 Flexible cord for connection to the supply circuit is permitted on emergency lighting unit equipment having integral lampheads only, rated at no more than 18 amperes, 277 volts, and constructed in accordance with the requirements in 18.1.1 – 18.8.6 and applicable requirements elsewhere in this standard. See 70.1.23.

18.1.1 revised May 30, 2008

18.1.2 Flexible cord for connection to the supply circuit is permitted on auxiliary lighting and power equipment.

18.1.2 revised May 30, 2008

18.2 Flexible cord

18.2.1 Flexible cord shall be one of the types specified in Table 18.1 and, if grounding is required per 20.1, shall be a 3-conductor grounding cord terminating in an attachment plug. The cord shall be no longer than 36 inches (914 mm) measured from the face of the plug to the point at which the cord enters the unit.

18.2.1 revised May 30, 2008

Table 18.1
Cord types

SPT-3[a], SP-3[a], SPE-3[a]	SJT	SO
SJ	SJTO	SOO
SJE	SJTOO	ST
SJO	S	STO
SJOO	SE	STOO

[a] These cords are for use only with permanently mounted equipment.

18.2.2 The cord shall have an ampacity no less than the current rating of the equipment.

18.3 Alternative connection

18.3.1 If it is intended that the power supply cord can be removed from the unit and permanent connection made to the supply circuit, the compartment in which the connections of the cord are made shall be constructed in accordance with 18.3.2 – 18.3.4.

18.3.2 The cord shall enter the wiring compartment through a 7/8 inch (22.2 mm) diameter hole that, after the cord and any bushing or fitting provided have been removed, provides an opening for the attachment of the intended wiring system.

18.3.3 The power supply cord shall be connected to the internal wiring by a device such as a terminal block, terminal leads, pressure cable connector, or the like, that will accommodate permanent wiring of the correct size for the unit.

18.3.4 The internal wiring terminals and leads for connection to the power supply shall have identification in accordance with 17.4.1, 17.4.2, 20.3, and 20.9.

No Text on This Page

18.4 Attachment plug

18.4.1 The rating of the attachment plug shall be at least equivalent to the electrical rating of the equipment. If the equipment is adaptable for use at different voltages by field alteration of internal connections, the attachment plug provided shall be rated for the voltage to which the equipment is intended to be connected when shipped from the factory. The attachment plug shall be of the 3-blade, grounding type, and may be of the locking type.

18.5 Grounding

18.5.1 The insulation of one of the conductors of the flexible cord shall be green in color with or without one or more yellow stripes. The attachment-plug grounding pin shall be connected to one end of this green grounding conductor, and the unit end of the grounding conductor shall terminate in an effective conductive connection to all accessible, dead-metal parts of the unit.

18.6 Strain relief

18.6.1 Strain relief shall be provided such that a stress on a flexible cord will not be transmitted to terminals, splices, or internal wiring in the unit or in the attachment plug. A knot in the cord is not considered a strain relief means.

18.6.2 A metal strain relief clamp or band without auxiliary protection is acceptable with a power supply cord, unless it is determined that the clamp or band may damage the cord insulation.

18.6.3 The strain relief means shall be tested in accordance with the Strain Relief Test, Section 58.

18.7 Push-in prevention

18.7.1 Means shall be provided to prevent the flexible cord from being pushed into the unit through the cord entry hole if such displacement is likely to:

a) Damage the cord;

b) Expose it to a temperature in excess of that for which it is rated;

c) Reduce spacings (such as from a live part to a metal strain relief clamp) below the minimum acceptable values; or

d) Damage or interfere with internal components.

18.8 Bushings

18.8.1 At a point where a flexible cord passes through an opening in a wall, barrier, or enclosure, a bushing or the equivalent shall be secured in place, and shall be provided with a smooth, rounded surface against which the cord may bear.

18.8.2 If the cord entry hole is in a material of wood, porcelain, phenolic composition, or other nonconductive material, a smooth, rounded surface is considered to be the equivalent of a bushing.

18.8.3 Ceramic material and some molded compositions are generally effective for insulating bushings, but separate bushings of wood or hot-molded tar and shellac compositions are not.

18.8.4 Vulcanized fiber may be used if the bushing is no less than 0.047 inch (1.19 mm) thick and if it is so formed and secured in place that it will not be adversely affected by conditions of intended use, including exposure to moisture.

18.8.5 A bushing of the same material as the cord and molded integrally with it can be used provided the built-up section is no less than 1/16 inch (1.6 mm) thick at the point where the cord passes through the hole in the enclosure.

18.8.6 An insulated metal grommet may be considered equivalent to an insulating bushing, provided the insulating material is no less than 1/32 inch (0.8 mm) thick and completely fills the space between the grommet and the metal in which it is mounted.

19 Internal Wiring

19.1 Wires

19.1.1 Internal wiring shall consist of general use wire or appliance wiring material rated in accordance with the temperature, voltage, and other conditions of service to which the wiring is likely to be subjected.

19.1.2 With regard to the requirements in 19.1.1, some commonly used types of appliance wiring material are as indicated in Table 19.1.

Table 19.1
Appliance wiring material

Types of insulation	Nominal thickness of insulation[a]	
	600-volt applications, inch (mm)	300-volt applications, inch (mm)
Thermoplastic	0.030 (0.76)	0.015 (0.38)
Rubber	0.030 (0.76) plus an impregnated-braid cover	0.015 (0.38) plus an impregnated-braid cover, or 0.030 (0.76) without a braid cover
Neoprene	0.045 (1.14)	0.015 (0.38) plus an impregnated-braid cover, or 0.030 (0.76) without a braid cover
Silicone rubber	0.030 (0.76) plus an impregnated-braid cover, or 0.030 (0.76) without a braid cover[b]	0.015 (0.38) plus an impregnated-braid cover, or 0.030 (0.76) without a braid cover[b]

[a] The minimum thickness is 0.027 inch (0.69 mm) for 0.030 inch (0.76 mm) nominal thick insulation; the minimum thickness is 0.013 inch (0.33 mm) for 0.015 inch (0.038 mm) thick nominal insulation.

[b] Only if routed away from live parts of opposite polarity and protected from mechanical damage both during installation of field wiring and while in operation, unless material demonstrates resistance to mechanical damage.

19.1.3 The thermoplastic or rubber insulation of conductors that are in circuits operating at potentials of 50 volts or less and segregated from all higher voltage wiring shall have no less than 0.015 inch (0.38 mm) nominal thickness.

19.1.4 Leads to an adjustable lamphead shall be of stranded wire and of such length to permit full adjustment of the lamphead without applying stress to the leads or connections. The leads may be flexible cord, such as Type SP-2, SPE-2, or SPT-2, when protected (closely routed to lamp head support), or one of the cord types indicated in Table 18.1, when not closely routed.

19.1.5 Leads connected to parts mounted on a hinged cover shall be of stranded wire and of sufficient length to permit the full opening of the cover without applying stress to the leads or their connections. These leads may be Type SP-2, SPE-2, or SPT-2 cord or appliance wiring material.

19.1.6 Overtinned stranded wire may be used for the purposes described in 19.1.4 or 19.1.5 when the wire complies with the Overtinned Wire Flexibility Test, Section 60. A tin coating shall additionally comply with ASTM B33-91, Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes, and a tin/lead coating shall comply with ASTM B189-90, Standard Specification for Lead-Coated and Lead-Alloy Coated Soft Copper Wire for Electrical Purposes.

19.1.7 A bare conductor, including pigtails and coil leads of automatic, load-control relays, shall be supported so that the spacings required in 37.1.1 will be maintained, unless the conductor is covered by insulating sleeving or tubing.

19.1.8 Supplementary insulation, such as coated fabric or extruded thermoplastic insulating tubing, shall be rated for the use and shall not be adversely affected by the temperature to which it may be subjected under any conditions of service.

19.2 Wireways

19.2.1 A wiring space or compartment intended to enclose wires shall be free of any sharp edge, burr, fin, moving part, or the like that may abrade the insulation on conductors or otherwise damage wires.

19.2.2 A hole in a sheet-metal wall 0.042 inch (1.1 mm) thick or less, through which insulated wiring passes, and on the edges of which it may bear, shall be provided with a smoothly rounded bushing. A hole in a wall thicker than 0.042 inch shall have smooth, well-rounded edges.

19.2.3 With respect to the requirement in 19.2.2, a bushing of a vulcanized fiber, neoprene, or equivalent material can be used.

19.3 Electrical connections

19.3.1 An electrical connection shall be soldered, welded, or otherwise effectively connected. A soldered joint shall be mechanically secure before soldering.

19.3.2 A lead is considered to be mechanically secure when one or more of the following is provided:

a) At least one full wrap around a terminal.

b) At least one right angle bend when passed through an eyelet or opening.

c) Twisting with other conductors.

19.3.3 A plug and connector may be used with internal wiring if:

a) The plug and connector are rated for the maximum voltage and temperature involved, and the construction complies with the requirements of this standard with regard to insulating materials, current-carrying parts, and spacings;

b) The contacts do not attain a maximum temperature in excess of the temperature rating of the insulating material involved;

c) The connector complies with the test requirements for current rupturing (disconnection under load) in accordance with the Overload Tests in the Standard for Attachment Plugs and Receptacles, UL 498, if the connection is likely to be broken under load; and

d) No live parts that are a potential risk of electric shock as described in 8.2.1, are exposed when the male and female parts are connected or disconnected as determined with the probe described in 19.3.4 applied externally to the plug and connector openings.

Exception: The Overload Tests specified in (c) are not required for connectors rupturing a current less than 10 A, if the open circuit potential between any two adjacent pins or any pin and ground is 15 V or less.

19.3.4 The probe mentioned in 19.3.3(d) is to be in the form of a cylinder having a radius of 0.205 inch (5.21 mm). The end of the probe which is used to determine the accessibility of live parts is to be rounded into a hemisphere with a radius of 0.205 inch (5.21 mm).

19.3.5 A stranded conductor clamped under a wire-binding screw or similar part shall have the individual strands soldered together or the equivalent to provide an effective connection.

19.3.6 A splice shall be provided with insulation equivalent to that of the wires involved.

19.3.7 An aluminum conductor, insulated or uninsulated, used as internal wiring, such as for interconnection between current-carrying parts or as motor windings, shall be terminated at each end by a method that is effective for the combination of metals involved at the connection point.

19.3.8 If a wire-binding screw construction or a pressure-wire connector is used as a terminating device, it shall be investigated for use with aluminum under the conditions likely to be encountered in service (for example, temperature, heat cycling, or vibration).

19.4 Separation of circuits

19.4.1 Internal wiring of circuits that operate at different potentials shall be separated by barriers or shall be segregated unless the conductors of the circuits of lower voltage are provided with insulation rated for the higher voltage of the combination.

19.4.2 Segregation of insulated conductors may be accomplished by clamping, routing, or equivalent means that provides permanent separation.

19.4.3 A barrier used to separate circuits operating at different potentials shall be secured in place and shall be of metal no less than 0.026 inch (0.66 mm) thick or of an insulation material no less than 0.028 inch (0.71 mm) thick. The barrier shall be of greater thickness if necessary as determined by an investigation.

19.5 Conductor secureness

19.5.1 Internal wiring that involves a risk of electric shock or fire and is subject to handling during installation or routine maintenance shall be evaluated for compliance with the Conductor Secureness Test, Section 59.

Exception: A component with an integral wiring connection that has already been evaluated for conductor secureness need not be re-evaluated.

19.5.1 revised May 30, 2008

19.5.2 An insulating bushing incorporating strain relief shall be sized for the type conductor for which it is intended and shall be mounted in a hole of the size and shape for which it is intended.

20 Grounding

20.1 Equipment with dead metal conductive parts that can become energized and that are accessible to contact during normal operation or routine maintenance or service shall have provisions for connection to the building grounding system.

20.2 The following constitute effective means for grounding of equipment:

a) In a unit intended to be connected only by a metal-enclosed wiring system – a knockout or equivalent opening in the metal enclosure of a unit. Such equipment shall be marked in accordance with 70.1.18.

b) In a unit capable of being connected by a nonmetal-enclosed wiring system (for example, nonmetallic-sheathed cable) – an equipment grounding terminal or lead for each equipment grounding conductor of the system.

20.3 A wire-binding screw intended for the connection of an equipment-grounding conductor shall have a green-colored head that is hexagonal, slotted, or both. A pressure-wire connector intended for connection of such a conductor shall have identification such as by being marked ″G,″ ″GR,″ ″GND,″ ″Ground,″ ″Grounding,″ or the like, or by an equivalent marking on a wiring diagram provided on the equipment.

20.4 An equipment-grounding terminal or lead-grounding point shall be connected to the frame or enclosure by a positive means, such as by a bolted or screwed connection.

20.5 An equipment-grounding connection shall penetrate a nonconductive coating, such as paint or vitreous enamel.

20.6 An equipment-grounding point shall be located so that the grounding means is not likely to be inadvertently removed during servicing.

20.7 An equipment-grounding connection, equipment-grounding conductor, enclosure, frame, component mounting panel, or any other part connected to earth ground shall not carry current except during an electrical malfunction.

Exception No. 1: A low-voltage, limited-energy circuit as described in Determination of Low-Voltage Limited-Energy Circuit Status, Section 49, may be connected to a single-point reference ground. Current is not to be carried through the field-equipment-grounding connection, metallic raceway, other grounding means, or an earth ground.

Exception No. 2: A line-bypass, capacitive, impedance circuit for a radio frequency signal circuit or a transient-surge protective device need not comply with this requirement.

Exception No. 3: A transient voltage surge suppressor used to limit transient voltages on power lines need not comply with this requirement.

20.8 A grounded circuit conductor shall not be connected to any equipment-grounding or bonding conductor in a unit.

20.9 The surface of an insulated lead intended for field connection of an equipment grounding conductor shall be green with or without one or more yellow stripes, and no other lead shall have this identification.

20.10 A terminal for connection of an equipment-grounding conductor (input) shall be capable of securing a conductor of a size no less than required in 17.1.1.

20.11 A soldering lug, a push-in (screwless) connector, or a quick-connect or similar friction-fit connector shall not be used for the grounding terminal.

Exception: A plug and connector may be used in a grounding or bonding conductor if:

a) The circuit and grounding connections are made by mating one plug and connector; that is, the grounding connection is not to be made through a connector separate from that for the circuit connections;

b) The grounding connection is made no later and broken no sooner than the circuit connections upon plugging and unplugging of the plug and connector; and

c) The plug and connector are of the locking construction requiring two separate and distinct actions for disengagement.

20.12 Small, isolated (insulated) dead-metal parts are not required to be grounded.

20.13 A secondary circuit shall be isolated from ground unless it can be shown that neither a risk of fire nor electric shock will result if that circuit is grounded.

21 Bonding of Internal Parts

21.1 In a unit having provisions for grounding, all uninsulated metal parts of the enclosure, component mounting brackets, capacitors, and other electrical components likely to become energized and that involve a risk of electric shock shall be bonded for grounding if they can be contacted by persons or inadvertently contacted by service personnel.

Exception: A metal part as described in (a) – (f) need not be bonded for grounding:

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

b) An isolated metal part, such as a small assembly screw, that is positively separated from wiring and uninsulated live parts.

c) A panel or cover that does not enclose uninsulated live parts if wiring is positively separated from the panel or cover so that it is not likely to become energized.

d) A panel or cover that is insulated from electrical components and wiring by an insulating barrier of vulcanized fiber, varnished cloth, phenolic composition, or similar material no less than 1/32 inch (0.8 mm) thick and secured in place. A barrier or liner of other materials or a

lesser thickness than specified may be used if it complies with the requirements for internal barriers in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

e) An isolated metal part that is mounted on a printed-wiring board – such as a transformer core or a heat sink – and not exposed to contact during routine operation or maintenance.

f) A capacitor sleeved with insulating tubing that complies with 37.3.1.

21.2 When the effectiveness of any portion of a required bonding system is uncertain, the complete unit shall be subjected to the Grounding Continuity Test, Section 62.

21.3 Regarding 21.1, dead-metal parts that are likely to become energized are normally non-current-carrying, metallic parts separated from any current-carrying parts by less than two layers of insulation. Solid insulation rated for the voltage involved (such as insulated wiring) represents a single layer of insulation. A reliably maintained air gap in accordance with the required spacing for the voltage involved also represents a single layer of insulation. Except for air, multiple layers of insulation relied upon to isolate dead-metal parts from current-carrying parts shall be constructed of dissimilar materials.

21.4 If the continuity of the grounding system relies on the dimensional integrity of a non-metallic material, the material shall be acceptable for the purpose when investigated for creep in accordance with the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

21.5 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.

21.6 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 (851°F). The bonding connection shall penetrate nonconductive coatings, such as paint or vitreous enamel.

21.7 A separate component-bonding conductor, including a printed-wiring board trace, shall either:

a) Not be smaller than the size specified in Table 21.1;

b) Not be smaller than the conductor supplying the component; or

c) Comply with the requirements in the Bonding Conductor Test, Section 61.

Exception: The bonding conductor size for exit fixtures, emergency lighting fixtures, remote lamp assemblies, exit lights, and unit equipment electric discharge lighting fixtures with integral component power supplies shall comply with the requirements for lighting fixtures.

Table 21.1
Size of equipment grounding and bonding conductor

Maximum current rating,[a] amperes	Minimum size of equipment grounding or bonding conductor			
	Copper,		Aluminum or copper-clad aluminum,	
	AWG or kcmil	(mm^2)[b]	AWG or kcmil	(mm^2)[b]
20	12	3.3	10	5.3
60	10	5.3	8	8.4
90	8	8.4	6	13.3
100	8	8.4	6	13.3
150	6	13.3	4	21.2
200	6	13.3	4	21.2
300	4	21.2	2	33.6
400	3	26.7	1	42.4
500	2	33.6	1/0	53.5

[a] Maximum ampere rating of the input circuit overcurrent protective device in 65.2.3 or the output circuit overcurrent protective device described in 26.1 – 26.2.

[b] The equipment grounding conductor in the cord for cord-connected unit equipment may be the same size as the current-carrying conductors.

22 Batteries

22.1 A battery provided as part of any assembly shall have a rating and capacity such as to comply with 46.1. A battery shall be of the rechargeable (secondary) type.

Exception: This requirement does not apply to an auxiliary equipment battery.

22.2 The rated battery voltage is to be calculated on the basis of 2.0 volts per cell for lead-acid types and 1.2 volts per cell for nickel cadmium or nickel-metal-hydride types.

22.3 A battery shall be located and mounted so that the terminals of cells will be prevented from coming into contact with terminals of adjacent cells or with metal parts of the battery compartment as the result of shifting of the battery. Cells of the nickel cadmium or nickel-metal-hydride type in jars of conductive material shall be installed in trays of nonconductive material.

22.4 A battery, whether of acid, nickel cadmium or nickel-metal-hydride types, shall be designed and constructed to meet the requirements of emergency service. Automotive type batteries shall not be used.

22.5 A lead-acid type battery shall have transparent or translucent jars unless it is of the maintenance-free type (addition of water not required).

22.6 A sealed battery with a transparent, translucent, or opaque enclosure shall be subjected to an investigation in accordance with 46.1 in this standard and the Pressure Release Test requirements specified in the Standard for Standby Batteries, UL 1989.

Exception: An auxiliary equipment battery need not comply with the requirements in 46.1.

22.7 A sealed battery/cell with a pressure release device shall comply with the Pressure Release Test requirements specified in the Standard for Standby Batteries, UL 1989.

22.8 A vented battery with flame arrestor vent caps shall comply with the Flame Arrester Vent Cap Test requirements specified in the Standard for Standby Batteries, UL 1989.

Exception: The Back Pressure Test specified in UL 1989 need not be conducted.

22.9 Battery packs that contain individually replaceable batteries shall not utilize cells of standard sizes (specifically AAA, AA, Sub-C, C, D, and 9V transistor batteries). Standard cell sizes can be utilized in packs that cannot be interchanged with individual cells. Packs shall not connect using standard cell connections such as button/spring connections or 9V transistor.

23 Electronic Circuits

23.1 Electronic components and circuits relied upon to reduce the risk of fire or electric shock shall be evaluated for performance reliability in accordance with the applicable component standard. Where compliance with such standards has not been established, the equipment shall be subject to the Component Breakdown Test program of Section 65.

23.1 revised May 30, 2008

23.2 Deleted May 30, 2008

23.3 Equipment containing solid-state components shall be subject to the Voltage Surge Test, Section 54.

23.3 revised May 30, 2008

23.4 Electronic circuits that activate emergency lighting in response to an external signal (loss of normal power, fire alarm, motion sensor or the like) shall function so that no single internal component fault shall inhibit the intended level of equipment activation. These circuits shall be subject to the Normal Operation Test, Section 45.

23.4 revised May 30, 2008

24 Capacitors

24.1 A capacitor shall use such materials and shall be constructed so that it will not constitute a risk of fire. It shall not be damaged by the temperatures to which it may be subjected under the more severe conditions of intended use. A paper capacitor shall be impregnated or enclosed to exclude moisture. An electrolytic or other special type of capacitor, or a capacitor intended for connection directly across the line, shall be investigated in all respects for the particular application.

25 Lampholders

25.1 The potential on an integral screw shell lampholder of the medium base type or smaller shall not exceed 150 volts open circuit, either to ground or between conductors, as measured at the terminals of the lampholder.

26 Overcurrent (Overload) Protection

26.1 Equipment with batteries of capacity greater than 20 ampere-hours with provision for the connection of remote lighting or power equipment shall have integral overcurrent protection for the output circuit, or shall be marked to identify the overcurrent protection to be provided by others.

26.2 The overcurrent protection specified in 26.1 may include fuses, circuit breakers, supplementary protectors, or circuit impedance as determined appropriate for the application.

26.3 If a circuit breaker is operated vertically rather than rotationally or horizontally, the up position of the handle shall be the on position.

26.4 A fuseholder in equipment rated and marked for an rms symmetrical short-circuit current rating of more than 10,000 amperes shall have provision for accommodating a Class CC, G, J, L, RK-1, RK-5, or T fuse. The fuseholder shall not accommodate a Class H or K fuse nor a miscellaneous or miniature fuse.

Exception: A fuseholder on the secondary side of a control transformer may accommodate a Class H or K fuse, Type S fuse, Edison-base plug type fuse, or a miscellaneous or miniature fuse.

26.5 A fuseholder used in series with a circuit breaker in equipment having a marked short-circuit current rating higher than the interrupting capacity rating of the circuit breaker shall have provision for accommodating a Class CC, G, J, L, RK-1, RK-5, or T fuse. The fuseholder shall not accommodate a Class H or K fuse nor a miscellaneous or miniature fuse.

27 Coil Windings

27.1 The insulation of coil windings in relays, transformers, and the like shall be such as to resist the absorption of moisture.

27.2 Film-coated wire does not require additional treatment to prevent moisture absorption.

28 Derangement Signals

28.1 Equipment incorporating storage batteries and battery-charging means shall provide audible or illuminated visible indicator(s) detectable to facility occupants without the need to adjust or remove any equipment covers or parts, under any of the following conditions:

a) Disconnection or unavailability of the emergency power source;

b) The battery is actively supplying a remote (but not concurrently a local) load; or

c) The battery charger is not receiving its intended charging voltage.

28.1 revised May 30, 2008

29 Test Switch

29.1 Emergency lighting and power equipment provided with an automatic load control relay switching device shall be provided with a manually operable test switch, or provisions for the connection of an external test switch, to simulate the conditions under which the load control relay switching device is intended to operate (such as loss of the normal supply). The test switch shall be evaluated per 45.3.

29.1 revised May 30, 2008

29.2 A test switch of the maintained-break type shall be accessible only to service personnel. A maintained-break type switch shall open all ungrounded conductors.

29.2 revised May 30, 2008

29.3 Deleted May 30, 2008

30 Self-Testing/Self-Diagnostic Equipment

30.1 Equipment that contains self-testing/self-diagnostic capability shall automatically perform a diagnostic function at least once every 30 days to verify the following:

a) Automatic load transfer system functionality;

b) Battery charger system functionality;

c) Battery terminal voltage no less than 87.5 percent of nominal;

d) Increase of its connected load impedance (indicative of light source failure) by more than 50 percent for exit signs and inverters, and not more than 10 percent for central systems and unit equipment; and

e) Other systems specified by the manufacturer.

The equipment shall be tested in accordance with 45.4 and 45.5.

30.1 revised May 30, 2008

30.2 A self-testing function that discharges more than 30 minutes of the total capacity of the system battery shall have provisions, such as a random clock generator provided during initialization, to reduce the risk that more than one unit is discharged at one time as a result of the self-test.

30.3 Equipment that is self-diagnostic only shall be marked in accordance with 70.1.39.

30.4 Equipment that allows self-testing/self-diagnostic capability to be disengaged shall allow access to the disengagement means only to service personnel.

31 Disconnect Switches and Fuses

31.1 Deleted May 30, 2008

31.2 Equipment having provision for connection of remote equipment shall have means (switches, fuses, or similar) to disconnect all remote equipment from both the normal and emergency supply sources. The disconnecting means shall be accessible only to service personnel and shall open all conductors that represent a risk of fire or electric shock.

31.2 revised May 30, 2008

31.3 Deleted May 30, 2008

31.4 If a disconnect switch handle is operated vertically rather than rotationally or horizontally, the up position of the handle shall be the ″ON″ position.

31.4 revised May 30, 2008

31.5 Means shall be provided, accessible only to service personnel, to disable the battery circuit of an inverter/charger pack during installation and servicing.

31.5 revised May 30, 2008

32 Transformers

32.1 A transformer relied upon to reduce the risk of electric shock shall be of the isolating type; that is, one having no connections common to both primary and secondary windings.

Exception: This requirement does not apply to a sealed unit that is marked as specified in 70.1.13.

32.2 Transformers shall comply with Supplement SE, Alternative Requirements for Transformers.

33 Impedance Networks

33.1 Battery-charging circuits provided with impedance networks in the input stage rather than an isolating-type transformer shall be subjected to the Abnormal Test conditions specified in 77.3.1(d).

34 Printed-Wiring Board

34.1 A printed-wiring board or printed-wiring assembly provided as part of equipment shall be investigated for the particular application.

34.2 A resistor, capacitor, inductor, transformer, transistor, diode, or other component or part that is mounted on a printed-wiring board, to form a printed-wiring assembly, shall be securely mounted.

34.3 Consideration is to be given to the mechanical protection and electrical insulation afforded to the component or part by a barrier or partition.

35 Motors

35.1 A motor provided as part of equipment shall be investigated for the particular application and shall be capable of intended operation, without introducing a risk of fire, electric shock, or injury to persons.

35.2 A motor winding shall resist the absorption of moisture.

36 Equipment Using Simple Reactance Ballasts and Lamps Having Integral Starters

36.1 Exit lights, exit fixtures, or other emergency lighting equipment intended for use with simple reactance ballasts and lamps having integral starters shall comply with the requirements specified in the Temperature Test, Section 50, when tested with the intended lamp types and wattages indicated in the lamp replacement marking.

36.1 revised May 30, 2008

37 Spacings

37.1 General

37.1.1 Where a risk of fire or electric shock exists, minimum spacings shall be in accordance with Table 37.1 or Table 37.2, as applicable.

Exception No. 1: The spacings given in Table 37.1 do not apply:

a) Within snap switches, lampholders, and similar wiring devices;

b) Between uninsulated live parts of a wiring device and dead-metal that is part of the wiring device (including mounting screws, rivets, yoke, clamp, and the like); or

c) Between such live parts and that part of a dead-metal surface on which the device is mounted in the intended manner.

Exception No. 2: Clearances and creepage distances on printed-wiring board assemblies may be in accordance with the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840. Environmental conditions shall be assumed to be pollution degree 3 unless specific measures are included in the equipment to provide for less severe conditions.

Table 37.1
Spacings

Spacing involved between uninsulated live parts and:		Minimum spacing							
		0 – 50 volts rms,[a]		51 – 150 volts rms,[a]		151 – 300 volts rms,[a]		301 – 600 volts rms,[a]	
		inch	(mm)	inch	(mm)	inch	(mm)	inch	(mm)
Uninsulated live parts of opposite polarity	Through air	1/16[b]	1.6	1/8[c]	3.2	1/4	6.4	3/8	9.5
	Over surface	1/16[b]	1.6	1/4	6.4	3/8	9.5	1/2	12.7
Uninsulated grounded dead-metal parts other than the enclosure, or exposed dead-metal parts that are isolated	Through air	1/16[b]	1.6	1/8[c]	3.2	1/4	6.4	3/8	9.5
	Over surface	1/16[b]	1.6	1/4	6.4	3/8	9.5	1/2	12.7
Wall of metal enclosure, including fittings for conduit or armored cable[d]	Through air	1/4	6.4	1/2	12.7	1/2	12.7	1/2	12.7
	Over surface	1/4	6.4	1/2	12.7	1/2	12.7	1/2	12.7

[a] For peak voltages and battery voltages, multiply applicable rms voltage by √2.

[b] The spacing between installation-wiring terminals of opposite polarity and between a wiring terminal and a grounded, dead-metal part shall be no less than 1/8 inch (3.2 mm) through air and 1/4 inch (6.4 mm) over surface.

[c] The spacing between installation-wiring terminals of opposite polarity and between a wiring terminal and a grounded, dead-metal part shall be no less than 1/4 inch (6.4 mm).

[d] A metal piece attached to a metal enclosure is considered to be a part of the enclosure if deformation of the enclosure is likely to reduce spacings.

Table 37.2
Minimum spacings of printed-wiring board assemblies

Table 37.2 revised May 30, 2008

RMS voltage[a]	Minimum spacings,[b]		Coating program section[c]
	inch	(mm)	
0 – 30[d]	1/64	0.4	56 or 57
0 – 50[e,f]	1/32	0.8	56 or 57
51 – 600	1/32	0.8	56
0 – 125	1/16	1.6	None
126 – 250	3/32	2.4	None
251 – 600	1/2	12.7	None

[a] For peak voltages and battery voltages, multiply applicable rms voltage by √2.

[b] The minimum required spacing applied over the surface or through air between adjacent traces. Spacings between line voltage parts and grounded or accessible, dead-metal parts shall comply with Table 37.1. Spacings between primary and isolated secondary circuits are to be determined using the primary circuit voltage.

[c] The minimum coating thickness for the Conformal Coating Test Program I, Section 56, is 1/64 inch (0.64 mm).

[d] Applies to low voltage, limited-energy circuits only. See Determination of Low-Voltage, Limited-Energy Circuit Status, Section 49.

[e] A coating is not required for spacings greater than 1/32 inch (0.8 mm) if the board assembly is in a compartment that is enclosed when not being serviced, does not have ventilation or other unused openings, and does not contain a normally vented, wet, electrolyte battery. A compartment that complies with the Dust Test or Atomized Water Test criteria for a type 12 enclosure, as specified in the Standard for Electrical Enclosures, UL 50, is considered unventilated.

[f] Spacings between adjacent conductors may be less than indicated where connected to integrated circuits or similar components.

[g] A conformal coating compliant with the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E, is considered equivalent to a coating evaluated under either Section 56 or 57.

37.1.2 The spacing between uninsulated live parts of different circuits involving different voltages shall be no less than that required for the circuit of the higher voltage.

37.1.3 The spacings at fuses and fuseholders, measured with the fuses in place, are to be based on the use of fuses having maximum standard dimensions.

37.1.4 The spacing at an installation-wiring terminal is to be measured with wire of the correct size for the rating connected to the terminal as in intended service, but with wire no smaller than 14 AWG (2.1 mm^2) in any case.

37.1.5 The voltage under which spacings are to be evaluated is the voltage measured under normal operating conditions as in the Temperature Test, Section 50, with any lamps operating.

37.1.6 Film-coated wire is considered to be a live part in determining compliance of a device with the spacing requirements, but the film can be used as turn-to-turn insulation in coils.

37.1.7 A pressure wire connector shall be prevented from turning by a restraint, such as a shoulder or boss, if such movement would reduce spacings to values less than those required. A lock washer alone shall not be used for this purpose.

Exception: Means to prevent turning need not be provided if spacings are no less than the minimum required values:

a) When the lug or connector, and any lug or connector of opposite polarity, have each been turned 30 degrees toward the other and

b) The lug or connector has been turned 30 degrees toward other opposite-polarity live parts and toward grounded, dead-metal parts.

37.2 Barriers

37.2.1 A barrier or liner of insulating material, used in place of the spacings specified in Table 37.1, shall be investigated for the particular application and shall be no less than 0.028 inch (0.71 mm) thick.

Exception No. 1: A barrier or liner of insulating material less than 0.028 inch but no less than 0.013 inch (0.33 mm) may be used in conjunction with no less than one-half of the spacing through air specified in Table 37.1, provided the insulation material is found to be resistant to moisture, reliably held in place, and located so that it will not be adversely affected by operation of the equipment in service – particularly arcing. If the barrier or liner is exposed or otherwise likely to be subject to mechanical damage, the material shall be of such mechanical strength as to withstand the abuses to which it is likely to be subjected.

Exception No. 2: A barrier or liner of insulating material may be less than 0.028 inch provided that the results of a separate investigation, in accordance with the requirements for internal barriers specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, indicate acceptable performance. For examples, see Exception Nos. 3 and 4.

Exception No. 3: 0.007-inch (0.18-mm) thick, polyethylene terephthalate (PETP) film is considered equivalent to 0.028-inch (0.71-mm) thick, vulcanized fiber.

Exception No. 4: Resin-bonded mica, 0.006-inch (0.15-mm) thick, is considered electrically equivalent to 0.028-inch (0.71-mm) thick, vulcanized fiber; however, its use is limited to applications where it is protected from mechanical abuse or movement.

37.3 Insulating barriers

37.3.1 Insulating tubing that complies with the requirements in the Standard for Extruded Insulating Tubing, UL 224, may be used as insulation of a conductor including bus bars in lieu of the minimum required spacings and a capacitor case in lieu of bonding the case for grounding, if the following conditions are met:

a) The conductor is not subjected to compression, repeated flexure, or sharp bends;

b) The conductor or case covered with the tubing is well-rounded and free from sharp edges;

c) The tubing is used in accordance with the manufacturer's instructions; and

d) The conductor or case is not subjected to a temperature or voltage higher than that for which the tubing is rated.

37.3.2 A wrap of thermoplastic tape that complies with the requirements in the Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape, UL 510, may be used if all of the following conditions are met:

a) The wrap is not less than 0.013 inch (0.33 mm) thick, is applied in two or more layers, and is used in conjunction with not less than one-half the required through-air spacing;

b) The wrap is not less than 0.028 inch (0.71 mm) thick when used in conjunction with less than one-half the required through-air spacing;

c) The temperature rating of the tape is not less than the maximum temperature observed during the Temperature Test, Section 50;

d) The tape is not subject to compression; and

e) The tape is not wrapped over a sharp edge.

38 Field-Wiring Space

38.1 General

38.1.1 There shall be sufficient space within the enclosure for the installation of those wires and cables likely to be used in connecting the normal and emergency circuits to the equipment.

38.1.2 In the investigation of wiring spaces, it is assumed that the size, type, and conductor material of a wire to be used for installation of wiring connections will be in accordance with the National Electrical Code, ANSI/NFPA 70.

38.2 Wire-bending space

38.2.1 Wire-bending space when the conductor does not enter or leave the enclosure through the wall opposite its terminal shall be as specified in Table 38.1.

Table 38.1
Minimum wire-bending space in inches when conductor does not enter or leave enclosure through the wall opposite its terminals

Wire size,		Wires per terminal (pole),	
AWG or kcmil	(mm^2)	1	2
14 – 10	2.1 – 5.3	Not specified	Not specified
8 – 6	8.4 – 13.3	1-1/2	–
4 – 3	21.2 – 26.7	2	–
2	33.6	2-1/2	–
1	42.4	3	–
0 – 2/0	53.5 – 67.4	3-1/2	5
3/0 – 4/0	85.0 – 107.2	4	6
250	127.0	4-1/2	6

NOTES

1 For SI units: 1 inch = 25.4 millimeters.

2 Wire-bending space at terminals shall be measured in a straight line from the center of the wire opening, in the direction the wire leaves the terminal, to the wall, barrier, or obstruction. See 38.2.5.

3 The minimum wire-bending space required for wire sizes or combinations of wires not covered will be determined by investigation.

38.2.2 Wire-bending space when the conductor enters or leaves the enclosure through the wall opposite its terminal shall be as specified in Table 38.2.

38.2.3 For the purpose of wire-bending space requirements, a removable wire connector is one that can be removed from its intended location without disturbing structural or electrical parts, other than a cover, and that can be reinstalled with the conductor in place.

38.2.4 If a conductor is restricted by a barrier or other means from being bent where it leaves the connector, the distance is to be measured from the end of the barrier.

Table 38.2
Minimum wire-bending space in inches when conductor enters or leaves enclosure through the wall opposite its terminals

Wire size,		Wires per terminal (pole),			
		1		2	
AWG or kcmil	(mm^2)				
14 – 10	2.1 – 5.3	Not specified		Not specified	
8	8.4	1-1/2		–	
6	13.3	2		–	
4	21.2	3		–	
3	26.7	3		–	
2	33.6	3-1/2		–	
1	42.4	4-1/2		–	
0	53.5	5-1/2		5-1/2	
2/0	67.4	6		6	
3/0	85.0	6-1/2	(1/2)[a]	6-1/2	(1/2)[a]
4/0	107.2	7	(1)[a]	7-1/2	(1-1/2)[a]
250	127.0	8-1/2	(2)[a]	8-1/2	(2)[a]

NOTES

1 For SI units: 1 inch = 25.4 millimeters.

2 Wire-bending space at terminals shall be measured in a straight line from the edge of the terminal closest to the wall, in a direction perpendicular to the enclosure wall. See 38.2.5.

3 The minimum wire-bending space required for wire sizes or combinations of wires not covered will be determined by investigation.

[a] For removable wire terminals (as defined in 38.2.3) and lay-in wire terminals intended for only one wire, bending space shall be permitted to be reduced by the number of inches shown in parentheses.

38.2.5 For wire-bending space measurement, the lug or connector is to be at the smallest angle to the perpendicular to the box wall that it can assume without defeating any means provided to prevent its turning (such as a boss, shoulder, walls of a recess, multiple bolts securing the connector, and the like). However, it is assumed that the connector is not oriented so that the wire will be directed into a corner of the box to such extent that the transverse wall would necessitate additional bending. If a terminal is provided with one or more lugs or connectors for the connection of conductors in multiple, the distance is to be measured from the wire opening closest to the wall of the enclosure. If the connectors for a circuit are fixed in position (for example, by the walls of a recess) so that they are turned toward each other, the distance is to be measured at the wire opening nearest to the wall in a direction perpendicular to the wall. A barrier, shoulder, or the like is to be disregarded when the measurement is being made if it does not reduce the radius to which the wire must be bent otherwise.

38.2.6 A wiring space in which knockouts are provided shall be of such a width to accommodate (with respect to bending) conductors of the maximum size likely to be used at that knockout.

Exception: The wiring space may be of lesser width if:

a) Knockouts of required size are provided elsewhere in the equipment;

b) The wiring space at such other point or points is sufficiently wide to accommodate the conductors in question; and

c) The knockout or knockouts at such other points can be conveniently used in the intended wiring of the device. The values of the minimum acceptable width of a wiring space, with respect to conductors entering the knockout, are the same as the values of minimum bending space given in Table 38.1.

39 Accessibility of Insulated Current-Carrying Parts

39.1 General

39.1.1 The requirements contained in this section apply to exit fixtures, exit lights and emergency lighting fixtures having insulated current-carrying parts that are determined to be accessible during routine operation or routine maintenance.

39.2 Accessibility determination

39.2.1 Current-carrying parts are considered accessible if they can be contacted by the articulate probe that is illustrated in Figure 8.1. The probe may be positioned as specified in 39.2.2.

39.2.2 With respect to the requirement in 39.2.1, the probe may be articulated into any configuration, and may be rotated or angled to any position, before, during, or after inserting into the opening, and the penetration may be to any depth allowed by the opening size, including a minimum depth combined with the maximum articulation.

39.3 Insulated parts

39.3.1 The following insulated current-carrying parts are permitted to be accessible. Contact with all other insulated, current-carrying parts, except for those indicated in 39.3.2, shall be inhibited by an accessibility barrier as specified in 39.4.1 and 39.4.2.

a) Any flexible cord used as specified in 19.1.4 or 19.1.5, if it is Type SP2, SPT2, or heavier cord.

b) Any wire used as specified in 19.1.4 or 19.1.5 or any 600-volt rated, appliance wiring material specified in Table 19.1 that:

1) Does not terminate in a lamp-supported lampholder;

2) Has a minimum 0.027-inch (0.69-mm) thick insulation;

3) Is visible for the entire length that it is accessible;

4) Is routed in close proximity to a structural part of the fixture;

Exception: Wiring to an adjustable spotlight or similar construction need not be routed in close proximity to a structural part of the fixture.

5) Secured to a structural part of the fixture at least every 3 inches (76.2 mm), if stranded wire; or every 4 inches (101.6 mm), if solid wire; and

Exception: Wiring to an adjustable spotlight or similar construction need not be secured where flexing of the wire is required for adjusting of the light.

6) Contains no splices, other than factory-made splices using insulated, crimp-type connectors, within the accessible length, and the accessible end of the wire does not terminate at either the starter or lampholder required to be pulse-rated.

c) Any wire used as specified in 19.1.4 or 19.1.5 or any 600-volt rated, thermoplastic-insulated, appliance wiring material specified in Table 19.1 that complies with all of the following:

1) Terminates in a lamp-supported lampholder;

2) Has a minimum 0.027-inch (0.69-mm) thick insulation; and

3) Has no splices between the ballast or transformer and the lampholder.

d) The integral enclosure of a transformer or any other component device that complies with 39.4.1 and 39.4.2.

e) Any part which does not pose a risk of electric shock (see 4.43) or fire (see 4.44).

39.3.2 The following insulated current-carrying parts are permitted to be accessible to incidental contact only during routine maintenance, including lamp replacement:

a) The terminals of a ballast, capacitor, or terminal block and the ballast coil, if insulated with materials that are mechanically secured in place and comply with 39.4.1;

b) Factory-made splices employing insulated, crimp-on wire connectors or wire connectors (other than the twist-on type) that comply with the Standard for Splicing Wire Connectors, UL 486C, provided they do not have to be moved to accomplish the maintenance operation; and

c) Any unspliced, insulated wiring, as long as it does not have to be moved to accomplish the maintenance operation.

39.4 Accessibility barriers

39.4.1 The accessibility barrier referenced in 39.3.1, shall be one of the following:

a) Metal (ferrous, aluminum, brass, zinc, or copper) minimum 0.016 inch (0.41 mm) thick;

b) Glass, or porcelain, minimum 1/8-inch (3.2-mm) thick;

c) Impregnated glass fiber sleeving at least 0.01-inch (0.25-mm) thick that is rated for the temperature involved;

d) Vulcanized fiber minimum 0.028-inch (0.71-mm) thick; or

e) A polymeric material that complies with 10.4.

Exception: An accessibility barrier may be of a thickness less than that specified in (a) – (d) if it complies with the requirement in 39.4.2.

39.4.2 The accessibility barrier as referenced in 39.3.1 need not be one of the minimum thicknesses specified in 39.4.11, if the application of a force of 10 pounds (44.5 N) over an area of 1 square inch (6.45 cm^2) on the barrier does not result in permanent distortion of a metal barrier, temporary displacement of a metal barrier that results in a reduction in spacings, or breaking or cracking of a glass, porcelain, or polymeric barrier. Permanent or temporary distortion of a polymeric barrier is acceptable if parts required to be inaccessible continue to be inaccessible as specified in 39.3.1 both during and after the application of the force.

EXIT SIGN VISIBILITY

40 General

40.1 These requirements apply to exit signs that illuminate an integral legally-required legend for installation in accordance with the National Electrical Code, ANSI/NFPA 70, and the Life Safety Code, ANSI/NFPA 101, including exit signs intended to be placed near the floor.

40.2 An exit sign shall not be provided with a thermally-sensitive protective device unless the sign complies with all the performance requirements of Performance, Section 41, when the protective device operates.

40.3 A recessed incandescent exit fixture shall comply with the requirements for inherently protected Type IC fixtures in the Standard for Luminaires, UL 1598, except that the Abnormal Temperature Test need not be conducted.

40.4 The light source in an exit sign shall be replaceable without cutting or splicing wires, de-soldering and re-soldering lamps or lamp assemblies, or similar operations. A lampholder, plug and connector arrangement, or similar means shall be used to comply with this requirement.

Exception: This limitation does not apply when replacement of the light source is not a routine maintenance activity (per 4.45) and the compartment containing the light source is marked per 70.1.14, or the unit is sealed and marked per 70.1.13.

40.5 The minimum overall height of all letters of the legend shall be 6 inches (152 mm). The ratios of letter height to width, width to stroke width, and stroke width to inter-character spacing shall be as indicated in Table 40.1. Measurement of the overall dimensions is to include any illuminated borders of the letters or, in the case of reduced size illuminated legends, the non-illuminated (opaque) borders of the illuminated letters. Corners of the letters may be slightly rounded with a maximum radius of 0.100 inch (2.54 mm). Letter dimension measurements which include such rounded corners may be extended to the point where the (non-rounded) intersecting lines would otherwise meet. The extrapolation of lines need not be considered when measuring distances between characters.

40.6 The overall sign height and width shall be such that an area of sign background exists, of minimum dimension no less than the required inter-character spacing, between the edges of the legend and directional indicators, if any, and the outside border or frame of the sign.

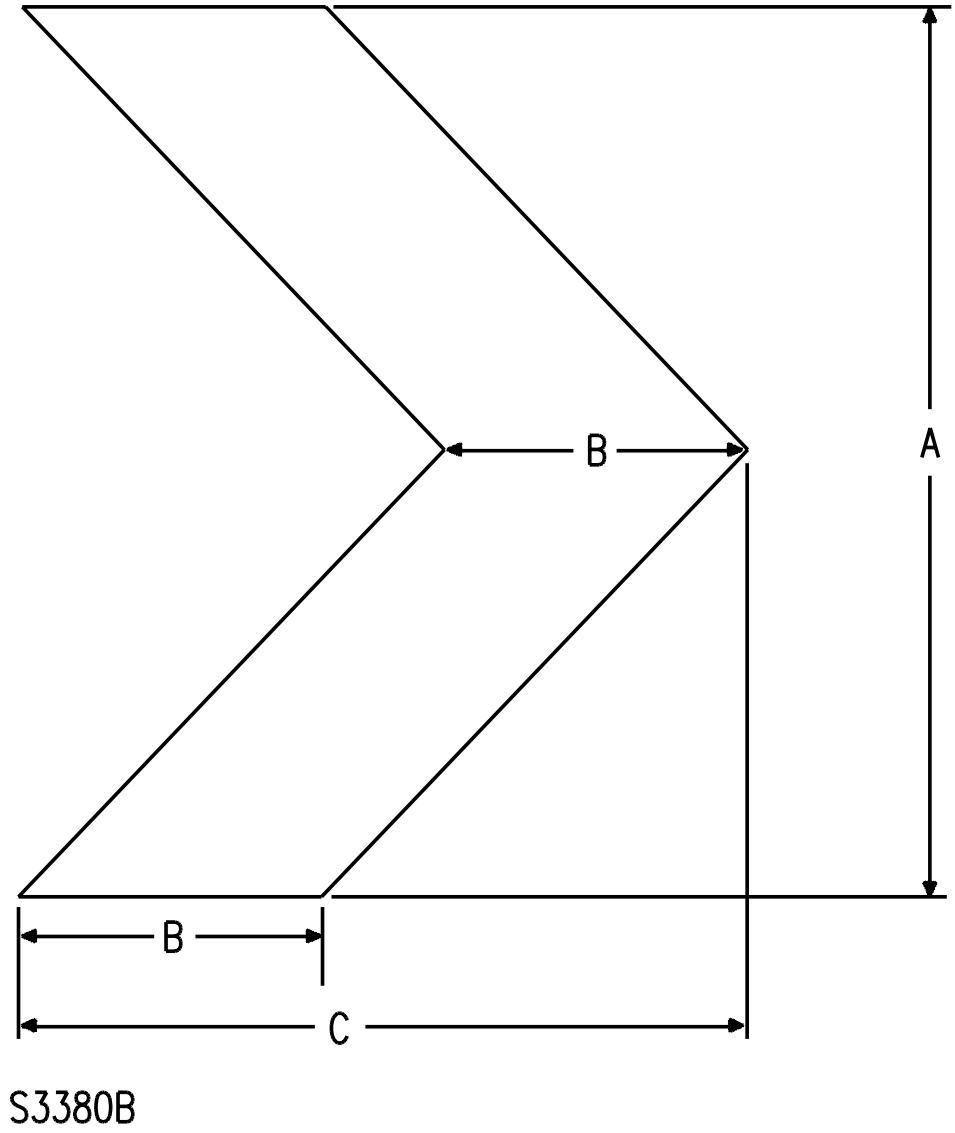
40.7 Dimensions of the illuminated letters shall be as specified in Table 40.2. Measurement of the letter height, width, and stroke are to be made of the areas that are illuminated under the intended operating and external ambient illumination conditions, including complete darkness. However, an external illumination level greater than zero that obscures the illuminated legend dimensions shall not be used.

Table 40.1
Height to width ratio of legend letters

	Maximum	Minimum
Overall height to overall width[a]	3:1	not specified
Overall width to stroke width	not specified	2.6:1
Overall stroke width to inter-character spacing	2:1	not specified

[a]Except letter "I"

Figure 40.1
Directional indicator



	Minimum dimensions					
	A,		B,		C,	
	inches	(mm)	inch	(mm)	inches	(mm)
	1.25	31.8	0.42	10.6	1.04	26.5

A larger directional indicator shall retain the following proportions:

Relationship	Ratio
height : width	1.2 : 1 maximum
height : horizontal strokewidth	3 : 1 maximum

Table 40.2
Illuminated legend minimum dimensions

	Letter height,		Stroke width,		Letterwidth,[a]		Spacing between letters,	
	inch	(mm)	inch	(mm)	inch	(mm)	inch	(mm)
Full size illuminated legend[b]	6	152.4	3/4	19.1	2	50.8	3/8	9.5
Reduced size illuminated legend[c]	5-1/2 – 6	139.7 – 152.4	1/4 – 3/4	6.4 – 19.1	1-1/2 – 2	38.1 – 50.8	3/8	9.5

NOTE – Illuminated borders of the letters are to be included.

[a] Except for the letter "I".

[b] If the letter height is greater than 6 inches (152.4 mm), then the other dimensions shall increase proportionally in accordance with Table 40.1.

[c] Letters of the minimum dimensions specified for a full size legend shall be present on the face of the sign upon which reduced size illuminated letters are to be centered.

40.8 The spacing between adjacent illuminated points or segments of a non-continuous illuminated letter or directional indicator shall not exceed 1/2 inch (12.7 mm). The spacing is to be measured as the shortest distance between the edge of one illuminated point or segment to the nearest edge of the next illuminated point or segment. A non-continuous illuminated directional indicator shall be vertically centered relative to the adjacent legend character.

40.9 A directional indicator shall be as shown in Figure 40.1. Corners of the directional indicator may be slightly rounded with a maximum radius of 0.060 inch (1.5 mm). Directional indicator dimension measurements which include such rounded corners may be extended to the point where the (non-rounded) intersecting lines would otherwise meet. The extrapolation of lines shall not be considered when measuring the distance to the legend letters in accordance with 40.11(a).

40.10 For measurement of the dimensions, only the continuously-illuminated directional indicator areas that are visible under intended operating and ambient illumination conditions, including in darkness, are to be used. Non-continuous illuminated directional indicators shall be tested as described in 41.2.

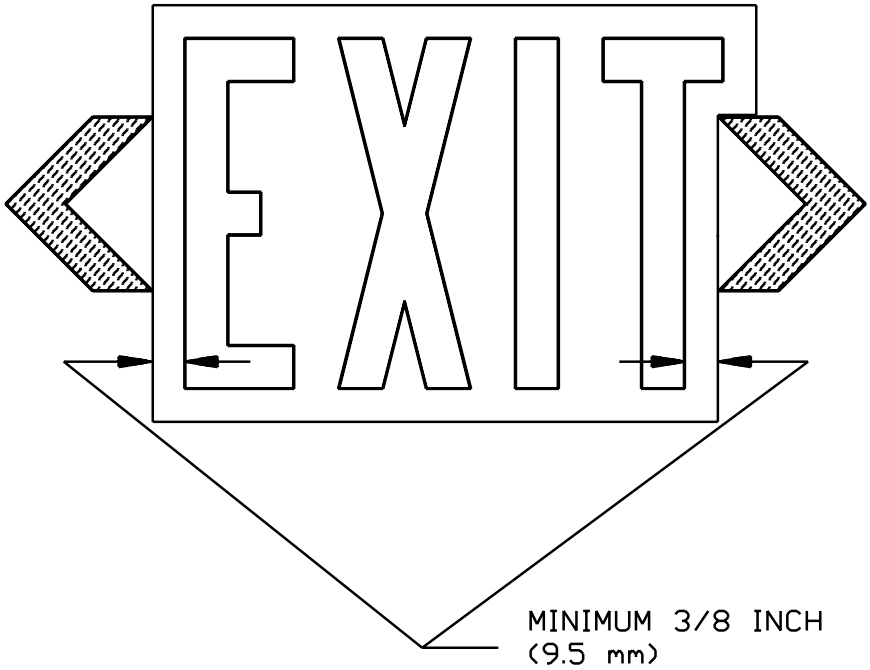
40.11 A directional indicator shall be:

a) Located outside of the legend and no less than 3/8 inch (9.5 mm) from any letter as shown in Figure 40.2;

b) Located at the same end of the sign as the direction indicated; and

c) Secured in a manner that cannot readily be changed. A directional indicator attached with an adhesive is not considered to be readily changeable. This requirement does not preclude a directional indicator, the direction of which is determined at the time of installation, but does preclude constructions that allow inadvertent concealment or reversal during cleaning or relamping, or concealment or reversal by unauthorized persons without the use of tools. The possibility that the faces of a double-faced directional exit sign will be inadvertently interchanged is not to be considered for the purpose of this requirement.

Figure 40.2
Minimum distance between directional indicator and legend



40.12 If an exit sign is provided with directional indicators and a means for selecting the proper direction(s) for an installation, the means provided shall conceal or otherwise make indistinguishable, under any condition of use, the directional indicators not intended to be used. If the means used to conceal (or otherwise make indistinguishable) an unused directional indicator has the shape of or can be confused with a directional indicator, the contrast ratio of the concealing means and the background shall not exceed 0.1 as determined in accordance with 41.3 except that the luminance measurement points are to be on the means used to conceal unused directional indicators and the background. A measurement point on a screw, slot, or slit in the directional indicator cover is to be avoided if such points cannot be considered part of a directional indicator.

40.13 The legend and directional indicator, of an exit sign, shall be visible as determined by compliance with Performance Section 41, of this Standard.

40.14 An exit sign provided with flashing capabilities shall have a flashing rate between 12 and 120 cycles per minute as determined in accordance with 41.5.1 and shall be marked per 70.1.30.

40.14 revised May 30, 2008

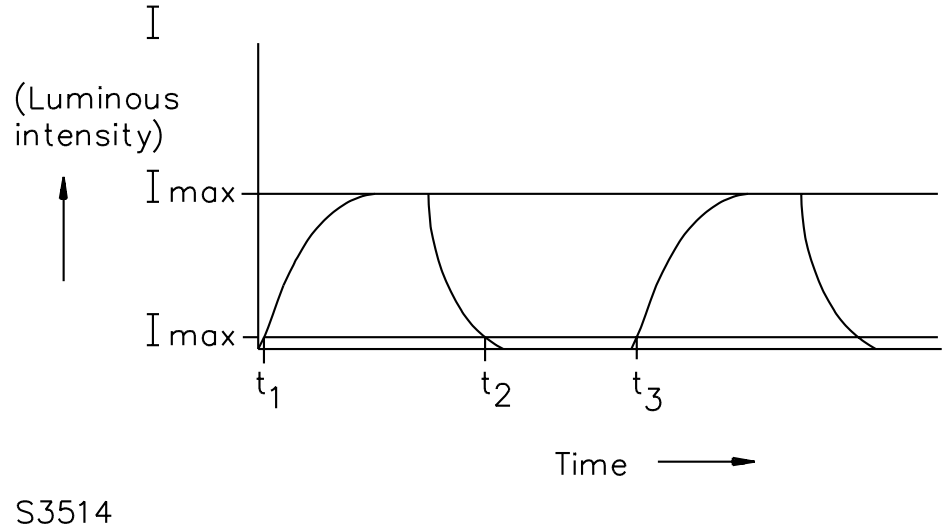
40.15 The duration between successive light pulses (t_3 minus t_2 as shown in Figure 40.3) shall be no less than 200 milliseconds and the duty cycle no more than 40 percent as measured between the 10 percent amplitude values of the leading edges of successive light pulses.

40.15 revised May 30, 2008

40.16 Deleted May 30, 2008

40.17 An exit sign provided with exposed light emitting diodes (LEDs) or LEDs that are visible as point light sources (i.e., behind a transparent lens) shall have a viewing angle $2\theta_{1/2}$(where $\theta_{1/2}$ is the off-axis angle from lamp centerline at which the luminous intensity is one-half the on-axis luminous intensity), but not less than 36 degrees.

Figure 40.3
Light pulse duration



t_2 minus t_1: light pulse duration (″on″ time).

t_3 minus t_2: duration between successive light pulses (″off″ time).

41 Performance

41.1 General

41.1.1 Persons conducting the Observation Visibility Tests shall have a visual acuity of not less than 20/40 or corrected to not less than 20/40 as determined by using a standard eye chart or by other appropriate means, such as the Titmus Vision Test Series.

41.1.2 A full size, continuously illuminated exit sign shall be subject to either the Observation Visibility Test, Section 41.2, or the Luminance Measurement Test, Section 41.3. A reduced size or non-continuously illuminated exit sign shall be subject to the Observation Visibility Test.

41.1.3 All exit signs shall be subject to the Non-Energized Contrast Measurement Test, Section 41.4.

41.1.4 For illuminance measurements in foot-candles (lux), the metering equipment shall:

a) Have an accuracy of ±5 percent and

b) Be cosine corrected.

41.1.4 revised May 30, 2008

41.1.5 For luminance measurements in foot-lamberts (cd/m^2), the measurement equipment shall:

a) Have an accuracy of ±5 percent;

b) Be color corrected (f1') to within 10 percent of the CIE relative photopic luminosity curve; and

c) Be rated no more than 5 percent susceptible to light outside the measurement area ($f_2(u)$), in accordance with CIE Standard 69, Methods of Characterizing Illuminance Meters and Luminance Meters: Performance, Characteristics, and Specifications.

41.1.5 revised May 30, 2008

41.1.6 An exit sign intended for connection to an electrical utility source shall be subject to the Observation Visibility Test, Section 41.2, or the Luminance Measurement Test, Section 41.3, while supplied at rated input voltage. See also 41.1.7 and 41.1.8.

41.1.6 revised May 30, 2008

41.1.7 An exit sign intended for connection to a remote battery-powered emergency source shall be subject to the Observation Visibility Test, Section 41.2, or the Luminance Measurement Test, Section 41.3, while supplied at 87.5 percent of the rated emergency input voltage. If applicable, this test is in addition to the test of 41.1.6.

41.1.8 An exit sign provided with integral batteries serving as an emergency source of power shall be subject to the Observation Visibility Test, Section 41.2, or the Luminance Measurement Test, Section 41.3, while supplied by a constant-voltage power supply set at the minimum battery voltage measured during the Battery Discharge Test, Section 46. If applicable, this test is in addition to the test of 41.1.6.

41.1.9 A self-luminous exit sign shall be subject to the Observation Visibility Test, Section 41.2, or the Luminance Measurement Test, Section 41.3, while in a condition representative of that expected at its marked replacement date.

41.1.10 A photoluminescent exit sign shall be subject to the Observation Visibility Test, Section 41.2, or the Luminance Measurement Test, Section 41.3, in accordance with the procedures described in Supplement SG, Photoluminescent Exit Signs.

41.1.11 A flashing sign shall be subject to the Luminance Measurement Test, Section 41.3, with the flashing circuit or device defeated so that the sign is continuously illuminated.

41.2 Observation visibility test

41.2.1 When the Observation Visibility Test is to be used as indicated in 41.1.2 the test shall be conducted as described in this Section.

41.2.2 Eight individuals, two each from the age groups 18 – 30, 31 – 40, 41 – 50, and 51 – 70 years and having a visual acuity as specified in 41.1.1 shall make the observations as required in 41.2.5.

41.2.3 Exit sign samples representative of production, as specified in (a), (b), and/or (c) are to be subject to testing:

a) To evaluate directional indicators, four sample sets of two identical signs configured as follows:

1) Set 1 – directional indicator on the right, point right (out)

2) Set 2 – directional indicator on the right, point left (in)

3) Set 3 – directional indicator on the left, point left (out)

4) Set 4 – directional indicator on the left, point right (in)

b) To evaluate a text legend, two sample sets of three identical signs each configured with between 10 – 15 percent of the legend different between the two sets. For the legend ″EXIT″, the lower horizontal element of the ″E″ and the lower right portion of the ″X″ shall be masked (so that the letters appear similar to ″F″ and ″Y″). For other text legends, visual elements of comparable size and significance shall be altered to distinguish between the two sample sets.

c) To evaluate a graphical symbol (pictogram), two sample sets of three identical signs each configured with between 10 – 15 percent of a non-background visual element different between the two sets.

41.2.4 The samples are to be positioned above the floor against a flat black surface in a corridor or a similar test area in which all ambient illumination can be eliminated (total darkness). The distance between the sign and point of observation shall be measured along a line perpendicular to and through the center of the face of the sign as follows:

a) For a directional indicator, 40 feet (12.2 m);

b) For a legend, either the viewing distance marked in accordance with 42.8 or 100 feet (30.5 m), whichever is less.

41.2.5 The observers' eyes are to be acclimated for at least 5 minutes to normal ambient light conditions [50 foot-candles (538 lux)] and then allowed to adapt to the dark condition in the viewing corridor for 5 minutes immediately prior to commencing each set of observations (a 'set of observations' consisting of either eight signs with directional indicators or six signs with legends). After each observation set, the observers' eyes shall be re-adapted to the normal (50 foot-candle) light condition for 5 minutes. The tests signs are to be presented to the observers in random order, with no more than two signs presented at any time. Each observer shall record the distinguishing characteristic of each sign (either the direction of

the directional indicator or the altered and/or non-altered element of a legend) within 10 seconds of commencing the observation of that sign. If the visual element being observed cannot be distinguished, the observer shall record no observation.

41.2.6 The number of correct responses by each observer for each observation set shall be recorded. A correct response is one that correctly identifies the distinguishing element of the sign within 10 seconds from the beginning of the observation. Lack of a response at the end of 10 seconds is to be recorded as an incorrect response.

41.2.7 The mean (PC) of the correct number of responses for an observation set shall be calculated using formula (1). If the mean is 80 percent or more (6.4 out of 8 for a directional indicator observation set, or 4.8 out of 6 for a legend observation set), the results are acceptable. If the mean is less than 80 percent, the Standard deviation (S) and the lower cutoff limit (LCL) are to be determined using formulas (2) and (3), respectively. Individual data points that fall below the LCL are to be discarded and a revised mean is to be determined. The results are acceptable if the revised mean, or the average of the revised means, is 80 percent or more. See 41.2.8 and 41.2.9 for illustrative examples and sample calculations.

$$(1) \quad \text{Mean, } PC = \frac{\sum pc(i)_s}{n}$$

$$(2) \quad \text{Sample Standard Deviation, } S = \left[\frac{\sum [pc(i) - PC]^2}{n - 1}\right]^{1/2}$$

(3) Lower Cutoff Limit, LCL = PC −0.896S

in which:

pc(i) is the number of correct responses for each individual observer, and

n is the number of observers.

41.2.8 For the purpose of illustration, consider the following example. The Observation Visibility Test data obtained on an exit light is recorded in Table 41.1. Since the average of the means was less than 6.4, the Standard deviation (S) and the lower cutoff limit (LCL) were calculated using formulas (2) and (3) given in 41.2.7. Since the data for observer No. 1 (normal operation) and those for observer Nos. 2 and 3 (emergency operation) were below their respective LCLs, they were discarded and revised means were calculated. Since the average of the revised means is more than 6.4, the results are considered acceptable.

41.2.9 For the purpose of illustration, consider the following example. The Observation Visibility Test data obtained on an exit light are recorded in Table 41.2. Since the average of the means was less than 4.8, the standard deviation (S) and the lower cutoff limit (LCL) were calculated using formulas (2) and (3) given in 41.2.7. Since the data for observer No. 1 (normal operation) and those for observer Nos. 2 and 3 (emergency operation) were below their respective LCLs, they were discarded and revised means were calculated. Since the average of the revised means is more than 4.8, the results are considered acceptable.

Table 41.1
Example of visibility test data analysis and calculations

Observer no.	Number of correct responses	
	Normal operation	Emergency operation
1	6	5
2	8	4
3	7	4
4	7	5
5	7	5
6	8	7
7	8	6
8	8	7
Mean (PC)	7.37	5.37
Average of the means	6.37	
Standard deviations (S)	0.77	1.19
Lower cutoff limit (LCL)	6.7	4.30
Observer nos. omitted	1	2 and 3
Revised mean	7.57	5.83
Average of the revised means	6.70	

Table 41.2
Example of visibility test data analysis and calculations

Observer no.	Number of correct responses	
	Normal operation	Emergency operation
1	4	4
2	6	3
3	5	3
4	5	4
5	5	4
6	6	5
7	6	4
8	6	5
Mean (PC)	5.37	4.00
Average of the means	4.68	
Standard deviations (S)	0.74	0.76
Lower cutoff limit (LCL)	4.7	3.3
Observer nos. omitted	1	2 and 3
Revised mean	5.57	4.33
Average of the revised means	4.95	

41.3 Luminance measurement test

41.3.1 When the Luminance Measurement Test is to be used as indicated in 41.1.2, the test shall be conducted as described in this Section.

41.3.2 The luminance of the legend, directional indicators, graphical symbols, and background shall be measured on a candidate sign operating under each condition specified in 41.1.6 – 41.1.8, as applicable. Measurements shall be taken in a test room having no illumination other than that provided by the candidate sign. Typical measurement points for certain sign designs are shown in Figures 41.1 – 41.6. For all sign designs, the visually brightest and dimmest locations on any luminous element shall be included in the measurements. Additionally, the following measurement procedures apply:

a) Measurements shall be circular areas not smaller than 0.030 inch (0.8 mm) in diameter and not larger than the area under test will permit, maintaining a minimum distance of 0.015 inch (0.4 mm) between the perimeter of the circular target area and the surrounding edges of the letters, directional indicators, borders, and the sign frame.

b) Measurements on the background of a panel face or edgelit sign shall be within 1 inch (25.4 mm) of the outer edge of any letters, directional indicators, or graphical symbols.

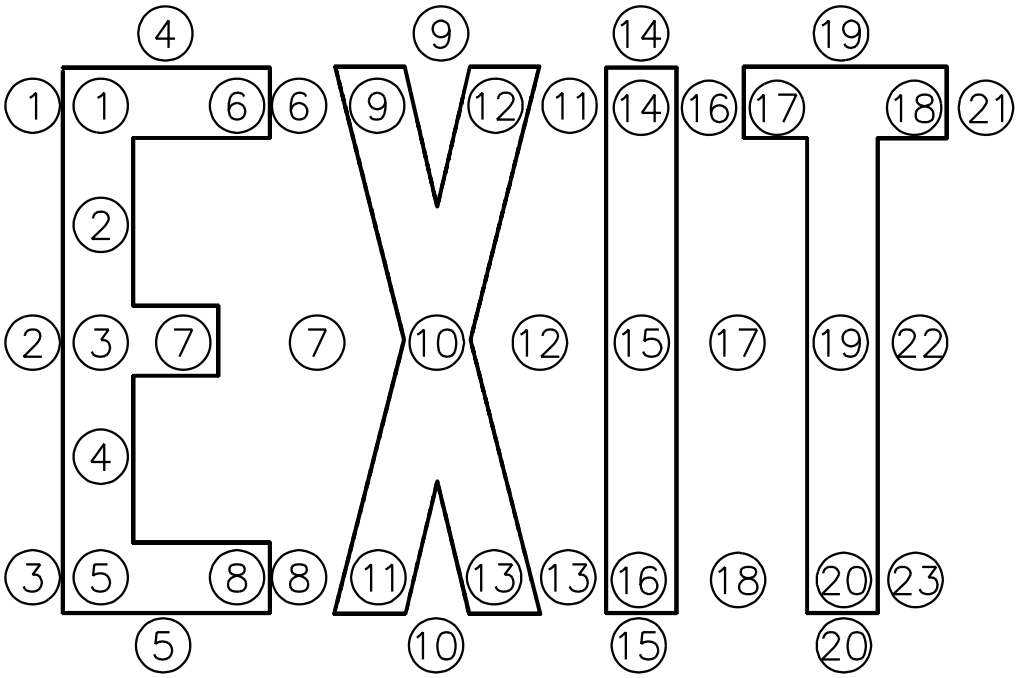
c) Measurement of the combined luminance of letters and borders (points 1 – 33 of Figure 41.3 and points LB1 – LB21 of 41.4) shall be a maximum 0.050-inch (1.27-mm) diameter circular target area centered upon the junction of the letter and border. A spacing equal to at least the radius of the target area is to be maintained between the perimeter of the target area and adjacent contrasting border lines.

41.3.2 revised May 30, 2008

41.3.3 For exit sign designs not represented by Figures 41.1 – 41.6, and for graphical symbols, no less than two measurements shall be taken for each continuous luminous element exceeding 1 inch (25.4 mm) in major dimension, at intervals not exceeding 2 inches (50.8 mm) linear distance between measurements.

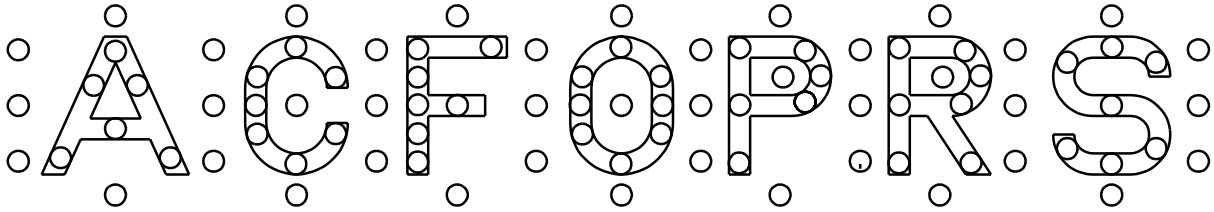
41.3.3 revised May 30, 2008

Figure 41.1
Luminance measurement points



S2951

Figure 41.2
Luminance measurement points



S3517

Note – Measurement points may be shifted up to 1/4 inch (6.4 mm) in either direction along the letter or background surface to avoid interference with a structural member if provided.

Figure 41.3
Luminance measurement points for exit signs with letters and directional indicators having illuminated borders less than 0.10 inch (2.54 mm) wide

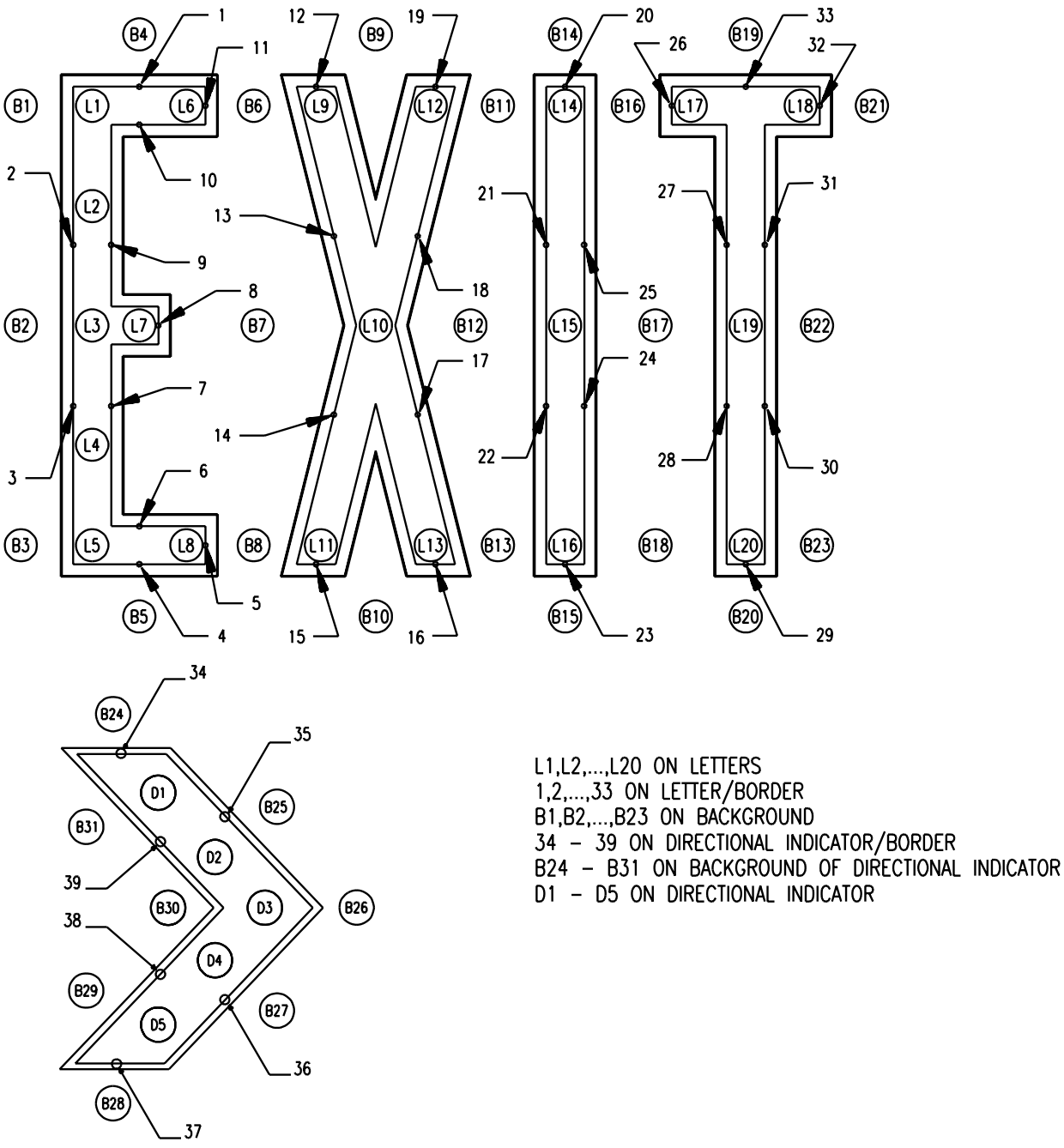


Figure 41.4
Luminance measurement points for exits signs with letters and directional indicators less than 0.10 inch (2.54 mm) wide having illuminated borders

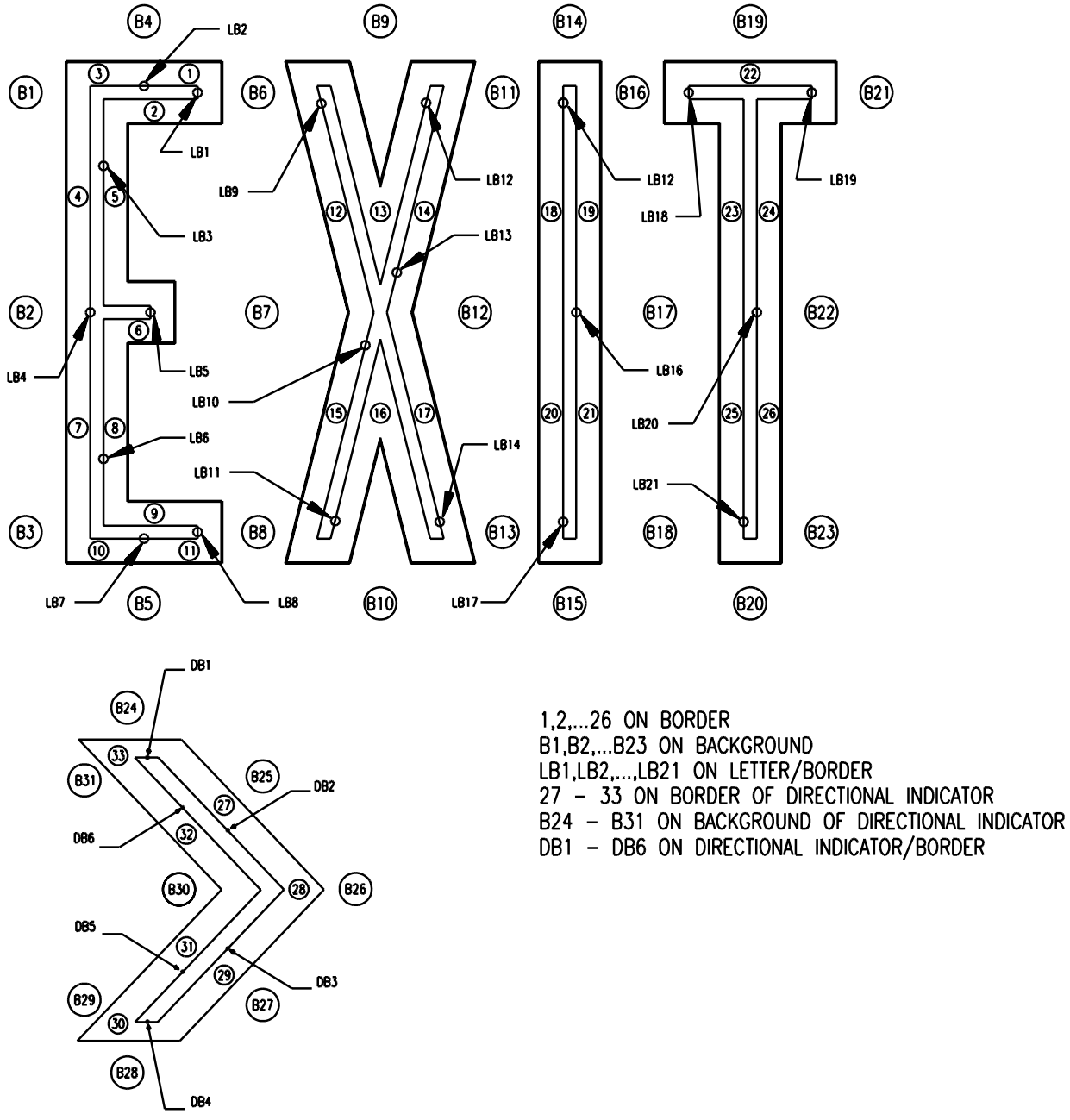
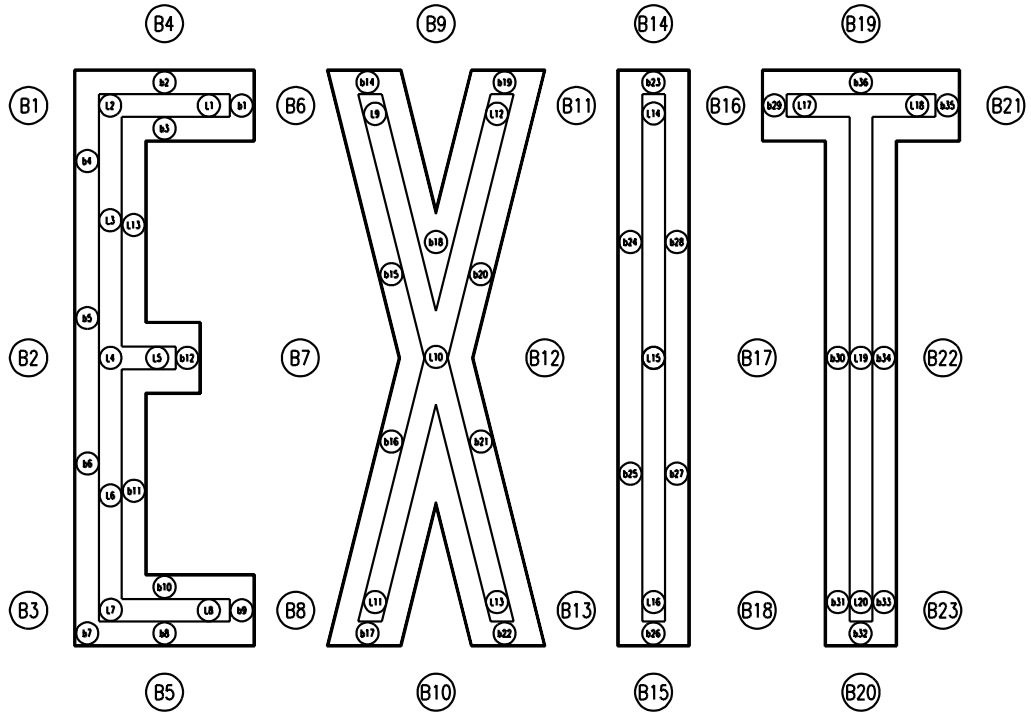
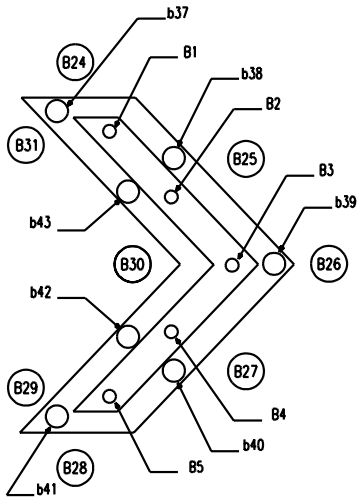


Figure 41.5
Luminance measurement points for exits signs with illuminated letters and borders and directional indicators each greater than 0.10 inch (2.54 mm) width





L1,L2,...L20 ON LETTERS
b1,b2,...b36 ON BORDERS
B1,B2,...B23 ON BACKGROUND
b37 – b43 ON BORDERS OF DIRECTIONAL INDICATORS
B24 – B31 ON BACKGROUND OF DIRECTIONAL INDICATORS
D1 – D5 ON DIRECTIONAL INDICATORS

S3379A

Table 41.3
Contrast ratios for exit signs with letters having illuminated borders

Contrast ratio	Measurement points		
	Figure 41.3	Figure 41.4	Figure 41.5
C1	L1 – L20 and B1 – B23	1 – 26 and B1 – B23	L1 – L20 and B1 – B23
C2	1 – 33 and B1 – B23	LB1 – LB21 and B1 – B23	b1 – b36 and B1 – B23
NOTE – Average luminance values that are to be used for calculation of the contrast ratios.			

Figure 41.6
Directional indicator luminance measurement points

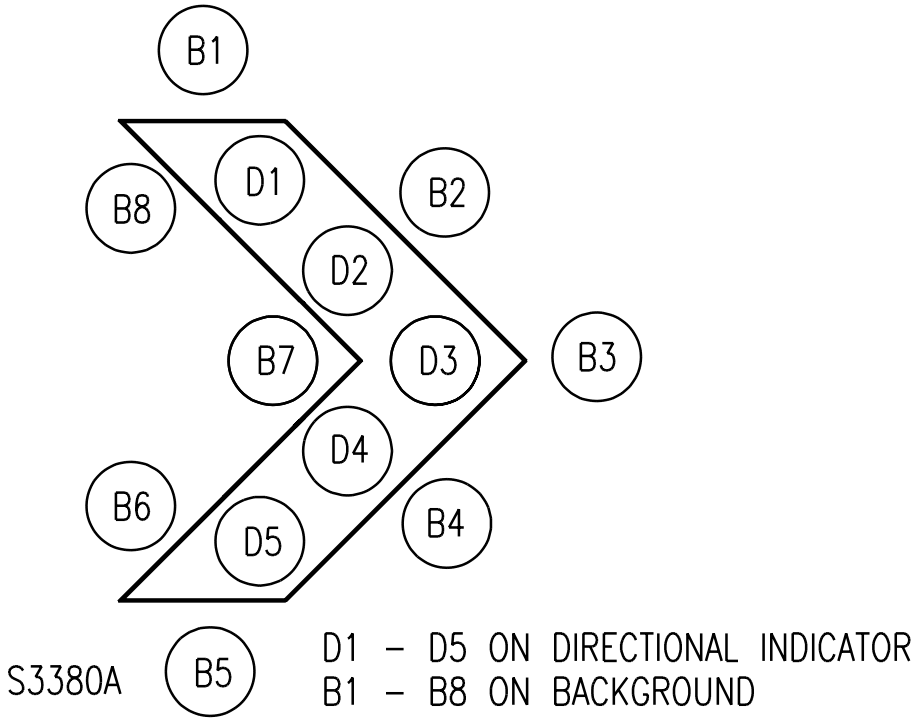


Table 41.4
Contrast ratios for directional indicators having illuminated borders

Contrast ratio	Measurement points		
	Figure 41.3	Figure 41.4	Figure 41.6
C1	D1 – D5 and B24 – B31	27 – 33 and B24 – B31	D1 – D5 and B24 – B31
C2	34 – 39 and B24 – B31	DB1 – DB6 and B24 – B31	b37 – b43 and B24 – B43
NOTE – Average luminance values at the specified measurement points that are to be used for calculation of the contrast ratio.			

41.3.4 The contrast ratio between adjacent luminous elements that require contrast for each element to be visible shall be 0.5 or greater, calculated using the formula:

$$C = \frac{L_g - L_l}{L_g}$$

in which:

C is the contrast ratio;

L_g is the greater luminance, average of measurements; and

L_l is the lesser luminance, average of measurements.

The luminance values obtained on the letters, on the background, and on the borders (if applicable) are to be separately averaged. For an exit sign having illuminated borders, two contrast ratios (C1 and C2) are to be determined. Refer to Table 41.3.

41.3.4 revised May 30, 2008

41.3.5 The minimum luminance on any point of an illuminated exit sign element (legend, directional indicator, graphical symbol) shall be 2.50 foot-lamberts (8.57 cd/m^2) when operated under normal power conditions (in accordance with 41.1.6) and 1.50 foot-lamberts (5.14 cd/m^2) under emergency conditions representative of its end of rated time (in accordance with 41.1.7 – 41.1.10, as applicable). If the background of a panel face or edge lit sign is brighter than the legend, directional indicators, or graphical symbol, the background (rather than the other elements) is subject to the minimum luminance requirements.

Exception: For exit signs having illuminated borders that are the same illuminated color as the stroke, (for example a red light source illuminating a red legend and border, not a white light source illuminating a red legend and a clear or frosted border as the legend would be red and the border would be white) the border can be considered as part of the stroke if the contrast ratio is no more than 0.20 between the border and the stroke.

41.3.5 revised May 30, 2008

41.3.6 The measured luminance range (brightest-to-dimmest) within any individual continuous element intended to be evenly luminous shall not vary by more than a 20-to-1 ratio. The measured luminance range for the luminous elements of the background shall not vary by more than a 50-to-1 ratio. The measured luminance range for the luminous elements not of the background (i.e., legend plus indicators) shall not vary by more than a 50-to-1 ratio.

41.3.6 revised May 30, 2008

41.4 Non-energized contrast measurement test

41.4.1 All exit signs shall be evaluated in accordance with this Section to determine a minimum level of visibility exists due to contrast between the sign legend and its background under circumstances where intended maintenance has not occurred (such as delayed replacement of dysfunctional light sources or inadequate power sources).

41.4.2 A sample sign shall be mounted where subject to 30 foot candles (323 lux) illumination evenly imposed on the sign face. The reflected luminance from the sign face shall be measured at ten locations each on the legend and on the background, with the measurement points evenly distributed across each area. If directional indicators are provided, two measurements are to be made on each directional indicator. Background measurement points shall include two each above, below, to the right, to the left, and between the letters of the legend.

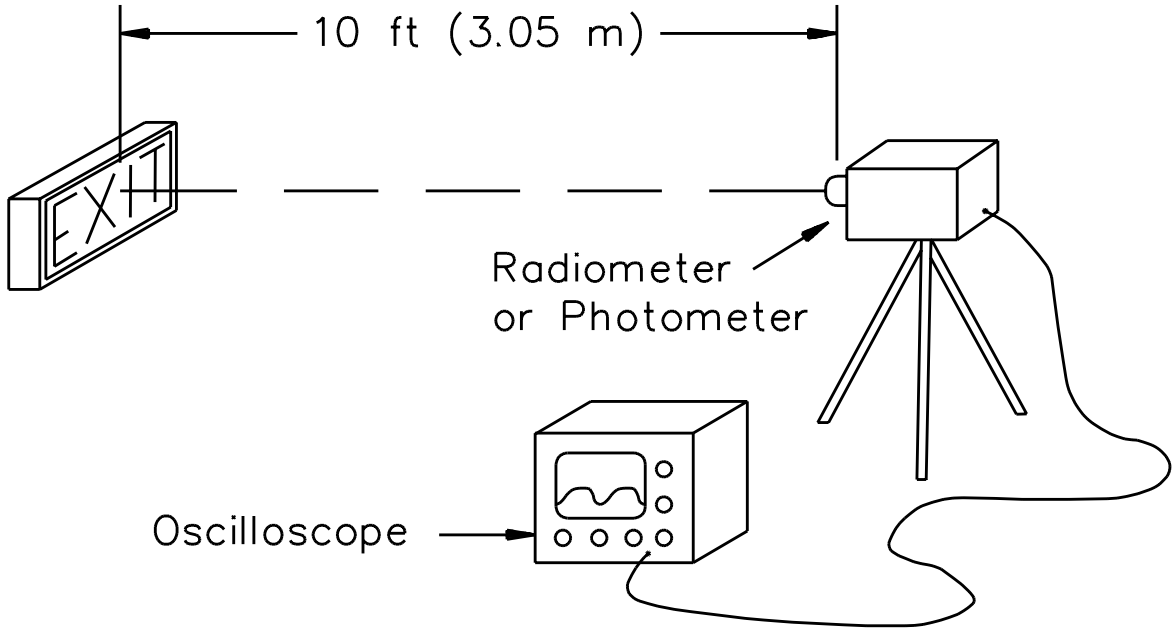
41.4.3 The measurement of 41.4.2 shall be used to determine compliance with 41.3.4.

41.5 Flashing rate, flashing rate stability, light pulse duration, and duration between successive light pulses measurements

41.5.1 To determine the flashing rate, light pulse duration, and duty cycle as specified in 40.14 and 40.15, the exit sign shall be placed in a vertical plane inside a dark room having no illumination other than that from the test sample reaching the sensor of the measuring instrument. The sample is to be energized at its rated supply voltage, per 43.2, and operated in the flashing mode for one minute before measurements commence. An exit sign intended to be cycled on and off by an external control such as a fire alarm control panel is to be operated at the rate specified by the manufacturer and marked on the product and in the instruction manual. Measurements shall be taken with a radiometer or photometer in conjunction with an oscilloscope, or similar equipment, placed 10 feet (3.05 m) from the exit sign, perpendicular to the face of the sign as shown in Figure 41.7. A minimum of ten full successive pulses of light shall be recorded.

41.5.1 revised May 30, 2008

Figure 41.7
Flashing rate duration between successive light pulses



S3515

42 Markings

42.1 In addition to other required markings, an exit sign shall be marked with:

a) Rated voltage;

b) Frequency;

c) Maximum input in:

i) Either amperes or watts for equipment having a power factor of 0.9 to 1.0;

ii) Either amperes or both watts and power factor for equipment having a power factor less than 0.9. The power factor shall be lagging unless marked leading;

d) Lamp replacement information as specified in 42.3, 42.4, 42.6 or 42.7; and

e) A catalog number.

Exception No. 1: An incandescent exit fixture with lamps intended to be directly connected to the supply source, without a transformer or step down circuit, need not be marked as indicated in (b) and (c).

Exception No. 2: Items (a) – (d) do not apply to self-luminous or photoluminescent exit signs.

42.2 An exit fixture shall be marked as indicated in 42.1 and also in accordance with the applicable requirements in the Standard for Luminaires, UL 1598.

42.3 An exit fixture or exit light with an incandescent lamp shall be marked where visible during relamping with the following or equivalent wording, either ″Notice: Relamp only with ____ watt ____ type ____ volt lamps″, or ″Notice: Relamp only with ____ watt ____ type ____ volt lamps or with ____ lamp assembly.″ The type designation in the marking shall indicate either frosted, clear, or other treatment as appropriate, in addition to the ANSI designation for bulb shape. The blank space for the specific lamp assembly is to be filled in with the emergency lighting manufacturer's or the lamp manufacturer's identity and lamp type designation or part number.

Exception: An incandescent lamp not readily available (not contained in a lamp manufacturer's catalog) is permitted to be marked only ″Notice: Relamp only with ____ lamp assembly″ or the equivalent. The blank space is to be filled in with the emergency lighting manufacturer's or the lamp manufacturer's identity and lamp type designation or part number.

42.4 An exit fixture or exit light with a fluorescent lamp shall be marked where visible during relamping, with the following or equivalent wording, either ″Notice: Relamp only with ____ watt ____ type lamps″ or ″Notice: Relamp only with ____ watt ____ type lamps or with ____ lamp assembly.″ The type designation in the marking shall indicate ″cool white,″ ″daylight,″ or other lamp type as appropriate. The blank space for the specific lamp assembly is to be filled in with the emergency lighting manufacturer's or the lamp manufacturer's identity and lamp type designation or part number.

Exception: A fluorescent lamp not readily available (not contained in a lamp manufacturer's catalog) is permitted to be marked only ″Notice: Relamp only with ____ lamp assembly″ or the equivalent. The blank space is to be filled in with the emergency lighting manufacturer's or the lamp manufacturer's identity and lamp type designation or part number.

42.5 The markings required in 42.1 – 42.4, 42.6 and 42.7 shall be permanent and shall be in the form of paint-stencilled, die-stamped, or indelible lettering or an indelibly printed label.

42.6 A self-luminous exit sign shall be marked with the date, expressed in the month and year, on or before which the exit sign is to be replaced.

42.7 An exit fixture or an exit light with a lamp type other than those covered in 42.3 and 42.4, such as an electroluminescent panel or light-emitting diodes, shall be marked ″Notice: Relamp only with ____ lamp assembly″ or the equivalent. The blank space is to be filled in with the manufacturer's identity and lamp type designation or part number.

42.8 Exit signs subjected to the Observation Visibility Test, Section 41.2, at a viewing distance of less than 100 feet shall be marked with the following or an equivalent statement: ″Notice – Maximum Viewing Distance, ____ Feet″. The blank shall contain ″50″ or ″75″ in accordance with the viewing distance at which the sign was found to comply with the requirements. The marking shall be visible after installation and in letters of minimum 1/8 inch (3.2 mm) height. The marking shall be embossed, engraved, or on a permanent label that, if secured by adhesive, complies with the Standard for Marking and Labeling Systems, UL 969, for the surface to which it is adhered.

PERFORMANCE

43 General

43.1 The performance of equipment shall be investigated by testing in accordance with the applicable provisions of Sections 44 – 67.

43.2 All tests are to be conducted with the product connected to a supply circuit of rated frequency. The voltage of the supply circuit is to be:

a) 120 volts, for a product rated from 110 – 125 volts;

b) 240 volts, for a product rated from 220 – 250 volts; or

c) The maximum rated voltage of the product, for a product rated other than as specified in (a) and (b).

43.2 revised May 30, 2008

43.3 If equipment must be mounted in a specific position in order to function as intended, it shall be tested in that position and marked in accordance with 70.1.22.

43.4 If a discharged battery or equipment with a discharged battery is required to be used in a test, the battery is to be discharged as described in 46.7(h).

43.5 Cheesecloth used for tests is to be untreated cotton running 14 – 15 yd^2/lb (26 – 28 m^2/kg) and having what is known to the trade as a count of 32 by 28; that is, for any square inch, 32 threads in one direction and 28 threads in the other direction (for any square centimeter, 13 threads in one direction and 11 threads in the other direction).

43.6 Tests involving cheesecloth are to be made in a room free of drafts.

43.7 Tissue paper used for tests is to be untreated white paper of the type commonly used as gift wrapping.

44 Leakage Current Test

44.1 The leakage current of a cord-connected unit, when measured in accordance with 44.2 – 44.7, shall not exceed 0.75 milliampere.

44.1 revised May 30, 2008

44.2 Leakage current refers to all currents, including capacitively coupled currents, that may be conveyed between exposed conductive surfaces and ground or other exposed conductive surfaces.

44.3 All exposed conductive surfaces are to be tested for leakage currents. The leakage currents from these surfaces are to be measured to the grounded supply conductor individually and, where the surfaces are simultaneously accessible, collectively. A part is considered to be exposed unless guarded by an enclosure considered to provide protection against electric shock as described in Frame and Enclosure, Section 8. Surfaces are considered to be simultaneously accessible when they can be contacted by one or both hands of a person at the same time.

Exception: Leakage current measurements need not be taken at terminals operating at voltages that are not considered to present a risk of electric shock.

44.4 If part or all of an enclosure is of material other than metal, a piece of metal foil measuring 100 by 200 mm (3.9 by 7.9 inches) is to be placed on the enclosure so that all the foil is in contact with the surface of the appliance. Leakage current is then to be measured from the foil to the grounded supply conductor, from the foil and other exposed surfaces to the grounded supply conductor, and from the foil to exposed conductive surfaces of the appliance. The foil is not to remain in place long enough to affect the temperature of the appliance.

Exception: For a surface smaller than 100 by 200 mm the piece of foil is to be the same size as the surface.

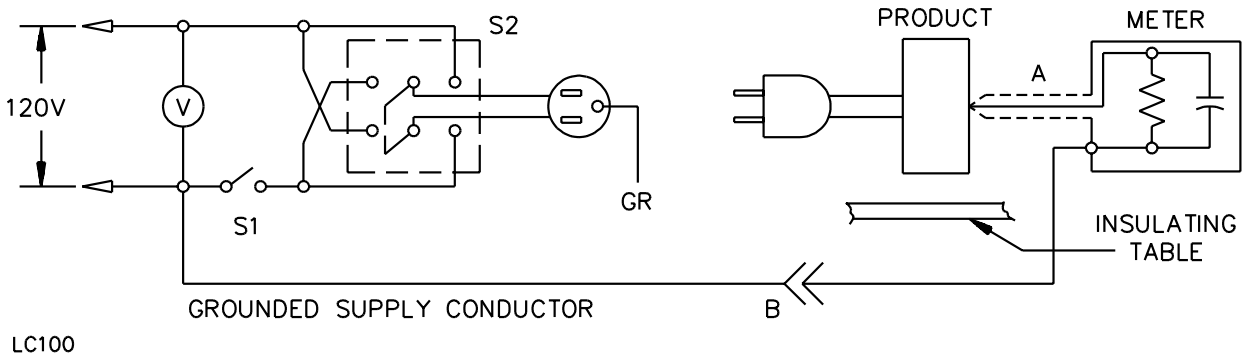
44.5 The measurement circuit for leakage current is to be as illustrated in Figure 44.1. The measurement instrument is defined in (a) – (c). The meter that is actually used for a measurement need only indicate the same numerical value for a particular measurement as would the defined instrument. The meter used need not have all the attributes of the defined instrument as follows:

a) The meter is to have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.15 microfarad;

b) The meter is to indicate 1.11 times the average of the full-wave rectified composite waveform of voltage across or current through the resistor; and

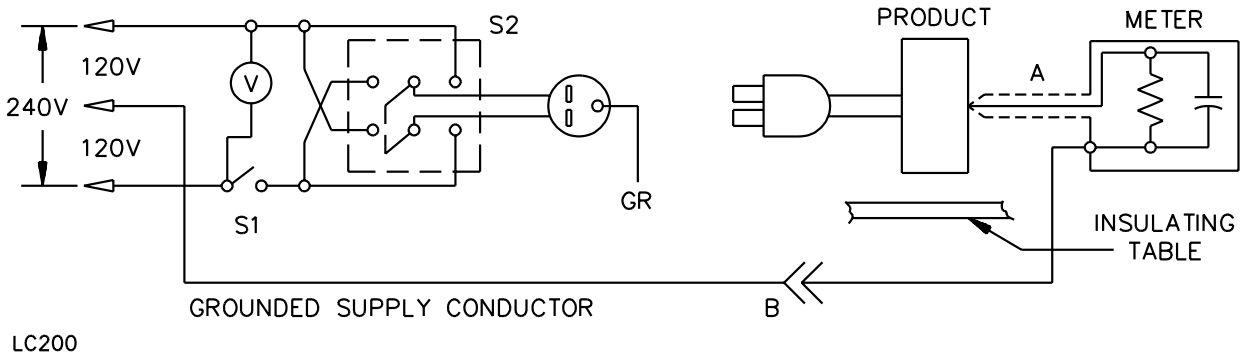
c) For a frequency range of 0 – 100 kilohertz, the measurement circuitry is to have a frequency response (ratio of indicated to actual value of current) equal to the ratio of the impedance of a 1500 ohm resistor shunted by a 0.15 microfarad capacitor to 1500 ohms. At an indication of 0.5 or 0.75 milliampere, the measurement is to have an error of no more than 5 percent at 60 hertz.

Figure 44.1
Leakage current measurement circuits



LC100

Product intended for connection to a 120-volt power supply.



LC200

Product intended for connection to a 3-wire, grounded-neutral power supply.

Notes:

A – Probe with shielded lead.

B – Separated and used as clip when measuring currents from one part of device to another.

44.6 Unless the meter is being used to measure leakage from one part of a unit to another, the meter is to be connected between the accessible part (or parts) and the grounded supply conductor.

44.7 A sample of the unit is to be tested for leakage current with the grounding conductor open at the attachment plug. The test sequence with respect to Figure 44.1 is to be as follows:

a) With the switch S1 open, the unit is to be connected to the measuring circuit. Leakage current is to be measured using both positions of switch S2, and with the unit switching devices in intended operating positions.

b) Switch S1 is then to be closed, energizing the unit, and within 5 seconds, the leakage current is to be measured using both positions of switch S2, and with the switching devices on the unit in their intended operating positions.

44.7 revised May 30, 2008

44.8 Deleted May 30, 2008

45 Normal Operation Test

45.1 Equipment intended to automatically respond upon loss of normal power or upon activation of an emergency signal, or with self-testing/self-diagnostic circuitry intended to assess equipment status, shall operate as intended in accordance with this Section.

45.2 An automatic load control relay, either as a separate device or as an electronic function integral to the equipment, shall be connected as intended to its supply source and controlled load(s). Signal inputs indicating loss of normal power, and any other emergency signal for which the equipment is intended to respond, shall be individually transmitted to the relay. The relay shall transmit normal or emergency power levels, whichever is appropriate for the condition represented by the signal.

45.2 revised May 30, 2008

45.2.1 If the relay function incorporates electronic devices or circuits subject to component fault per 23.4, the test of 45.2 shall be repeated under each single fault condition.

45.2.1 added May 30, 2008

45.2.2 A circuit intended to activate emergency lighting in response to an external motion-sense signal shall have a minimum ″ON″ time of 15 minutes.

45.2.2 added May 30, 2008

45.2.3 Equipment that is rated for use below 20°C (68°F) shall be subjected to testing per 45.2, 45.2.1, and 45.2.2 while maintained in an ambient 5°C (9°F) lower than that rating. Equipment that is rated for use above 30°C (86°F) shall be subject to testing per this section while maintained at an ambient 5°C higher than that rating. Equipment rated for use in from 20 – 30°C (68 – 86°F) shall be tested in a 25°C (77°F) ambient.

45.2.3 added May 30, 2008

45.3 Equipment with a manual test switch (per 29.1) shall be connected to a supply circuit of rated voltage and frequency. The test switch shall be actuated to validate that emergency power is transmitted to the controlled load(s).

45.3 revised May 30, 2008

45.4 Audible and/or visible signaling devices that serve as derangement signals required in accordance with Derangement Signals, Section 28, or required as part of a self-testing/self-diagnostic circuit in accordance with Self-Testing/Self-Diagnostic Equipment, Section 30, shall be evaluated by connecting the equipment as intended in service and individually simulating each condition intended to activate a signal.

45.5 Equipment that incorporates self-testing/self-diagnostic circuitry shall be connected as intended in service and operated in a manner that will trigger the operation of each diagnostic function specified in 30.1. This will require initiation of the self-testing/self-diagnostic mode and simulation of both intended (normal) working conditions and relevant individual component failures. A timing acceleration device may be used to verify the minimum 30-day cycle time of the self-testing/self-diagnostic system. The duration shall be as specified in the manufacturer's literature and instructions, but in no case less than 30 seconds.

46 Battery Discharge Test

46.1 Equipment storage battery terminals shall retain at least 87.5 percent nominal voltage while supplying its rated load when tested in accordance with this section. The rated load shall be as marked per 68.1(b)(1) or 68.1(b)(2), as applicable.

Exception: As an alternative to measuring battery terminal voltage, the lumen output level of emergency lighting equipment with integral batteries, or unit equipment, shall maintain at least 60 percent of the initial illumination level when tested in accordance with 46.3.

46.1 revised May 30, 2008

46.2 Equipment that is rated for use below 20°C (68°F) shall be subject to testing per this section while maintained in an ambient 5°C (9°F) lower than that rating. Equipment that is rated for use above 30°C (86°F) shall be subject to testing per this section while maintained at an ambient 5°C higher than that rating. Equipment rated for use in from 20 – 30°C (68 – 86°F) shall be tested in a 25°C (77°F) ambient.

46.2 revised May 30, 2008

46.3 Where lumen output measurements are to be made, in accordance with the Exception to 46.1, the tests are to be performed in a completely darkened room with dark colored walls. The light meter used is to be color and cosine corrected. The light meter is to be mounted approximately 6 feet (1.8 m) from the light source, in a plane that is perpendicular to the light source.

46.3 revised May 30, 2008

46.4 The load is to be the integrally mounted lamps or the maximum number of lamps to make up the rating of the equipment. Electric discharge lamps shall be aged for minimum 100 hours prior to taking measurements. For tungsten lamp loads, the load current is to be determined by either the marked current rating or by calculation using the marked wattage rating and the nominal rated system voltage. The nominal rated system voltage is to be calculated on the basis of 2.0 volts per cell for the lead acid types and 1.2 volts per cell for the nickel cadmium or nickel-metal-hydride types. The tungsten lamp load is to be adjusted to the rated value 1 minute after the start of the initial discharge test, and no further adjustment of the load is to be made during the tests. Fine adjustment of the load current is to be made by the use of small wattage tungsten lamps or small variable resistors.

46.4 revised May 30, 2008

46.5 Deleted May 30, 2008

46.6 For testing of equipment having flashing or audible signaling or both features, the equipment is to be in the flashing or audible signaling or flashing and audible signaling mode.

46.7 The equipment shall be subject to the following test sequence. Measurements shall be taken at steps (d), (f), and (j) to validate that battery terminal voltage is not less than 87.5 percent of the nominal rated voltage or, if applicable, the lumen output is not less than 60 percent of the level measured in step (c).

a) The battery is to be charged as specified in 46.8. The time of charge is not to exceed 168 hours.

b) For a wet lead-acid battery, the specific gravity of the electrolyte is to be measured with a hydrometer and recorded.

c) The charged battery is then to be connected to its maximum rated load and permitted to discharge. For equipment subject to lumen output measurements, a lumen measurement shall be recorded one minute into the discharge.

d) Permit the battery to discharge at maximum rated load for the indicated marked rated time (not less than 1-1/2 hours). At the end of the discharge, measure the closed-circuit battery terminal voltage or the lumen output, as applicable.

e) Following the measurement, recharge the battery as specified in 46.8, but for not more than 24 hours.

f) Discharge the battery at maximum rated load for 1 hour, and then measure the closed-circuit battery terminal voltage or the lumen output, as applicable.

g) Following the measurement, recharge the battery as specified in 46.8, but not more than 168 hours.

h) Discharge the battery at maximum rated load for 24 hours. An automatic cutoff circuit provided to prevent discharge of the battery beyond a fixed point is not to be defeated if provided as part of the unit.

i) Recharge the battery as specified in 46.8, but for not more than 168 hours.

j) Discharge the battery at maximum rated load for the indicated marked rated time, and then measure the closed-circuit battery terminal voltage or lumen output, as applicable.

46.7 revised May 30, 2008

46.8 With regards to 46.7 (a), (e), (g) and (i), the battery is to be charged for the shortest period of time marked on the product, or in the instructions, or other literature provided for the product. If different charge times are provided with clear identification of the differences, the shortest time indicating the initial charge is to be utilized (not the time to test). For example, if the instructions are marked ″Charge 12 hrs for test″, and the unit is marked ″Charge for 168 hrs for full recharge″, then testing is to be performed at the 168 hour charge time. If the equipment is not marked or otherwise provided with a battery charge time specification, the battery is to be charged as specified by the manufacturer. In no case is the charge time to exceed 168 hours for (a), (g), or (i) and 24 hours for (e).

47 Battery Compartment Ventilation Test

47.1 To determine compliance with the Exception to 8.5.1, the hydrogen gas concentration within a sealed battery compartment shall be measured under the charging conditions described in 47.2. The hydrogen gas concentration within a sealed battery compartment containing 3 or more series-connected cells shall also be measured under the discharging conditions described in 47.3. The maximum hydrogen gas concentration measured under any of the test conditions shall not exceed 2 percent by volume.

47.2 The battery compartment assembly and its associated charging circuit are to be installed in an enclosure of representative construction, placed in a chamber maintained at 10°C (50°F) or at the lowest marked ambient temperature, and connected to a supply source of the highest marked input voltage. The battery shall be fully discharged, per 46.7(h), and then recharged in accordance with 46.7(i). Gas concentration measurements shall be taken at 75 percent into the recharge cycle and again at 125 percent of the recharge cycle time.

47.3 For a sealed battery compartment containing 3 or more series-connected cells, gas concentrations shall be additionally measured with one cell of the battery pack, after completion of the last gas concentration measurement of 47.2, in a fully discharged condition and the remaining cells in a fully charged condition.

48 Input Test

48.1 The measured input to a unit in amperes or both watts and power factor shall not exceed the marked rating by more than 10 percent if measured in watts or 5 percent if measured in amperes, when the unit is operated under the conditions of intended use and connected to a supply circuit of rated voltage and frequency.

48.2 The input to a unit incorporating a battery charger is to be determined after the battery has been discharged as specified in 46.7(h). A dual-rate charger is to be operated at the higher rate.

48.3 Equipment marked per 70.1.40 with a standby electrical rating is to be charged for the minimum period of time for full recharge marked either on the product or in the instructions or other literature provided with the product. If the equipment is not marked or otherwise provided with a battery charge time specification, the battery is to be charged for 168 hours. After being charged, the input current and wattage are to be measured periodically or continuously monitored over a 24 – 48 hour period. The average of no less than six measurements evenly spaced over the time period shall be determined. The marked standby rating shall be not less than 90 percent of the average value measured.

48.3 revised May 30, 2008

49 Determination of Low-Voltage, Limited-Energy Circuit Status

49.1 When evaluated per 49.2 – 49.4, a circuit may be considered low-voltage, limited-energy when the maximum open circuit voltage potential of its supply source does not exceed 30 V AC or 42.4 V_{peak}, and the maximum available current does not exceed 8 A, measured after one minute of operation.

49.2 The input to the source under evaluation shall be connected as intended in the end product. The output to the circuit under evaluation shall be connected to a variable resistance load. If the source under evaluation has multiple outputs, the outputs are to be evaluated individually with all other outputs open-circuited. The variable resistance load on the output under test shall then be adjusted from open circuit to short circuit until an available current of 8 A can be obtained and sustained for one minute of operation. If 8 A cannot be sustained for one minute under any condition of load, the test shall be discontinued.

49.3 When a secondary fuse or similar device is used to limit the output current, it shall be rated as indicated in Table 49.1. Any value may be used for the primary fuse; however, the maximum available output current levels shall be maintained. A fuse replacement marking (voltage and current rating) shall be provided adjacent to any fuse relied upon to limit the output current level, per 70.2.1.

49.4 When a fixed impedance or regulating network is used to limit the voltage and/or current, it shall limit the voltage and current accordingly under any single component fault condition.

Table 49.1
Output limiting secondary fuse

Open circuit potential, V_{peak}	Maximum fuse rating, amps
0 – 20	5.0
>20 – 42.4	$100/V_{peak}$

50 Temperature Test

50.1 Equipment shall exhibit no visual indication of combustion and shall comply with the Dielectric Withstand Test, Section 55, and the Normal Operation Test, Section 45, if applicable, after the Temperature Test described in this Section.

Exception: A fluorescent emergency luminaire or exit fixture that is temperature test exempt in accordance with the Standard for Luminaires, UL 1598, need not be subjected to the Temperature Test.

50.2 Equipment subject to the Temperature Test shall exhibit no temperature rise greater than that indicated in Table 50.1.

50.3 The values for temperature rise in Table 50.1 are based on an assumed ambient temperature of 25°C (77°F), and tests are to be conducted at an ambient temperature of 25 ±5°C (77 ±9°F). Equipment intended for use above 30°C (86°F) ambient shall be tested at 5°C (9°F) above its maximum rated ambient. An inverter/charger pack shall be tested in a 55°C (131°F) ambient.

50.3 revised May 30, 2008

50.4 Temperature readings may be obtained by thermocouples, and a temperature is considered to be constant when three successive readings, taken at intervals of 10 percent of the previously elapsed duration of the test but no less than 10-minute intervals, indicate no change.

50.5 Ordinarily, the method of measuring the temperature of a coil or winding is the resistance method, but temperature measurements by either the thermocouple or resistance method can be used.

Exception: The thermocouple method is not to be used for a temperature measurement at any point at which supplementary insulation is used.

50.6 The thermocouple method consists of the determination of temperature by the application of thermocouples to the hottest accessible parts.

50.7 Thermocouples are to consist of wires no larger than 24 AWG (0.21 mm^2) and no smaller than 30 AWG (0.05 mm^2). It is the standard practice to use thermocouples consisting of 30 AWG iron and constantan wires and a potentiometer-type indicating instrument; such equipment is to be used whenever referee temperature measurements with thermocouples are necessary. The thermocouple wire shall comply with the requirements for special thermocouples as listed in the Initial Calibration Tolerances for Thermocouples table in Temperature Measurement Thermocouples, ANSI/ISA MC96.1.

Table 50.1
Maximum temperature rises

Materials and component parts	°C	(°F)
1. Rubber or thermoplastic insulation	35[a]	63[a]
2. Any point on a selenium rectifier	50[a]	90[a]
3. A silicon rectifier	75[a]	135[a]
4. Field-wiring terminals[b]	50	90
5. Supply wire connections	35[g]	63[g]
6. Varnished-cloth insulation	60	108
7. Surfaces adjacent to or upon which the unit may be mounted in service	65	117
8. Fuse clips with dummy fuse installed	30	54
9. Fuse clip with rated fuse installed	85	153
10. Fiber used as electrical insulation	65	117
11. Wood or other combustible material	65	117
12. Class 105 insulation systems on windings of relays, solenoids, and the like	65[c]	117[c]
13. Transformer enclosure	65	117
14. Contacts	65	117
15. Connecting straps	65	117
16. Class 130 insulation systems on windings of relays, solenoids, and the like	85[c]	153[c]
17. Phenolic composition used as electrical insulation	125[a]	225[a]
18. On the embedding material of resistors	300	540
19. On bare resistor material	375	675
20. Capacitors	Rated temperature limit[d]	
21. Sealing compound	e	e
22. Polymeric material used for enclosure or structural parts	f	f

[a] This limitation does not apply to an insulated conductor, a rectifier, or a material that has been investigated and is found effective for a higher temperature.

Table 50.1 Continued on Next Page

Table 50.1 Continued

Materials and component parts	°C	(°F)
[b] The temperature on a wiring terminal or lug is measured at the point most likely to be contacted by the insulation of a conductor installed as in actual service.		
[c] 10°C (18°F) higher in coil insulation if measured by the resistance method.		
[d] These are temperature limits, not temperature rises.		
[e] Unless a thermosetting material, the maximum sealing compound temperature, when corrected to a 25°C (77°F) ambient temperature, is 15°C (27°F) less than the softening point of the compound as determined in the Test Method for Softening Point by Ring-and-Ball Apparatus, ASTM E28-1992.		
[f] The maximum temperature of a polymeric material, when corrected to a 25°C ambient temperature, shall not exceed the temperature index specified in 10.5.		
[g]Unless the equipment is marked for use with 75°C or 90°C supply wire.		

50.8 The temperature rise of a winding by the change of resistance method is to be calculated from the formula (windings are to be at room temperature at the start of the test):

$$\Delta t = \frac{R}{r}(k + t_1) - (k + t_2)$$

in which:

Δt is the temperature rise;

R is the resistance of the coil at the end of the test;

r is the resistance of the coil at the beginning of the test;

t_1 is the room temperature (°C) at the beginning of the test;

t_2 is the room temperature (°C) at the end of the test; and

k is 234.5 for copper and 225.0 for electrical conductor grade (EC) aluminum. Values of k for other grades must be determined.

50.9 If it is necessary to de-energize the winding before measuring R, the value of R at shutdown may be determined by taking several resistance measurements at short intervals, beginning as quickly as possible after the instant of shutdown. A curve of resistance values and the time may be plotted and extrapolated to give the value of R at shutdown.

50.10 To determine if a unit complies with the requirements in 50.1, it is to be connected to a supply circuit of rated voltage and frequency and operated continuously, under representative intended service conditions that are likely to produce the highest temperature, until constant temperatures are attained. Rated voltage is considered to be 120 volts if the marked rating is within the range 110 – 125 volts or 240 volts if the marked rating is within the range of 220 – 250 volts. If the rating of the unit does not fall within either of the indicated voltage ranges, the unit is to be tested at its rated voltage. Conditions of operation are indicated in 50.11 – 50.16 for some items of equipment. Other items and items having features not incorporated in these procedures may be tested as necessary to meet the intent of these requirements.

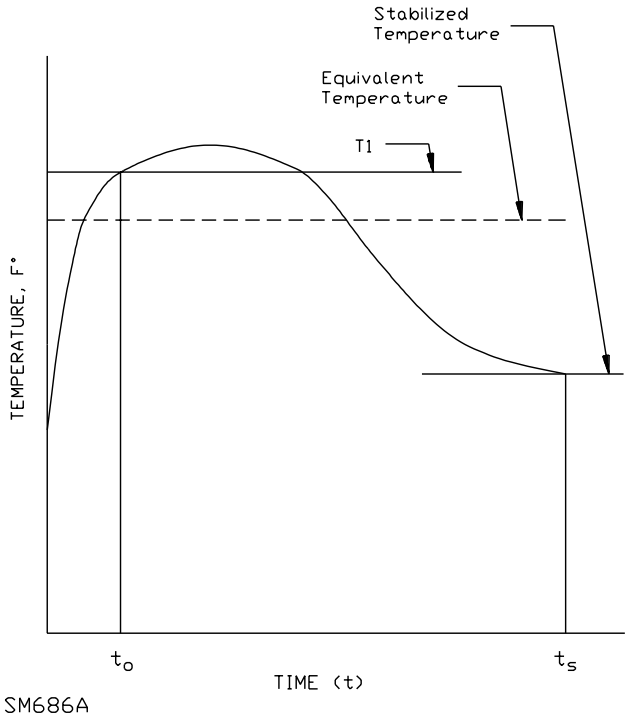
50.11 Battery charging equipment and a unit provided with storage batteries and a battery charger are to be tested with discharged batteries as described in 43.4 such that the charging circuit will deliver the maximum charging current to the battery until temperatures reach a maximum and begin to decrease. Testing is to commence within one minute after the 24-hour battery discharge in accordance with 46.7(h), or within one minute after actuation of a low-voltage disconnect circuit, whichever occurs first. A dual-rate charger is to be operated at both the high rate and the trickle charge rate unless the test at one rate is representative of a test at the other. When the temperature of a coil or winding is measured by the resistance method, the resistance R specified in 50.8 is to be measured with the coil at its peak temperature. The maximum (peak) temperature is not to have a rise greater than the values specified in Table 50.1.

Exception: The maximum (peak) temperature may have a rise greater than the values specified in Table 50.1 if the equivalent continuous normal use temperature determined in accordance with 50.12 does not have a temperature rise in excess of the values specified in Table 50.1.

50.11 revised May 30, 2008

50.12 With regard to the Exception to 50.11, the equivalent, continuous, normal-use temperature is to be determined as follows. The graph of the temperature plotted against time from the start of the test until a stabilized condition has been established is to be obtained, and the area under the curve over the period of time, t_s minus t_o, is to be determined. Figure 50.1 shows to as the time when the graph first crosses the line, T1, and t_s as the time when a stabilized temperature is obtained. [T1 represents the temperature index or the temperature acceptable for the material, component, or the insulation system in question. For example, for a Class 105 transformer insulation system, T1 is 65°C (117°F) plus the ambient temperature in which measurements were made.] The area under the curve, divided by the period of time (t_s minus t_o), will yield the equivalent, continuous, normal-use temperature. The area under the curve may be determined mathematically (Simpson's Rule), graphically, or by using a planimeter.

Figure 50.1
Determination of the equivalent, continuous, normal-use temperature



50.13 A distribution panel of a central battery station is to be tested with each branch circuit carrying rated current.

50.14 A separate, automatic-control relay is to be tested with the operating circuit connected to a supply circuit of rated voltage and frequency and with the load circuit carrying rated current. Tests are to be made with the relay in both the normal and emergency positions unless the test in one position is representative of a test in the other position. An automatic control relay that is provided as part of a power supply or a unit equipment is to be tested as part of that equipment.

50.15 Equipment incorporating a simple reactance ballast and lamps with integral starters shall additionally be tested with the starter short-circuited, under which condition the equipment shall maintain compliance with item 7 of Table 50.1.

50.15 revised May 30, 2008

50.16 For a device using a fuseholder for emergency branch circuit protection, a copper bar, copper tubing, or an equivalent material with negligible impedance is to be used during the test instead of a regular fuse.

51 Abnormal Temperature Test

51 deleted May 30, 2008

52 Overvoltage Withstand Test

52.1 The normal supply voltage sensing circuit and the charging circuit of equipment, including the operating coil of a solenoid or magnetically-operated switch, shall be capable of withstanding 110 percent of the rated voltage continuously without visual indication of damage.

52.1 revised May 30, 2008

52.2 To determine if the normal supply voltage sensing circuit and the charging circuit of equipment complies with the requirement in 52.1, the equipment is to be subjected to the increased voltage, under intended operating conditions, until the operating coil and the charging circuit components attain a constant temperature as defined by 50.4.

52.2 revised May 30, 2008

52.3 Revised and relocated as 52A.1 May 30, 2008

52A Undervoltage Recharge Capability Test

52A.1 Starting with a fully-charged battery, the equipment is to be discharged at maximum rated load for 1-1/2 hours. The battery is then to be recharged with the input voltage to the equipment adjusted to 85 percent of the minimum rated voltage [per 68.1(a)(1)] for 168 hours or for the time specified by the manufacturer for the maximum charge condition, whichever is less. If the equipment is provided with a normal supply voltage sensing circuit set to operate at more than 85 percent of the minimum rated voltage, the input voltage shall be adjusted to the voltage just above the point at which the unit transfers to the emergency mode. The battery shall then be discharged for 1 hour at maximum rated load. At the end of one hour, the battery terminal voltage shall be no less than 87.5 percent of nominal battery voltage or, where lumen output measurements are used, the lumen output shall be no less than 60 percent of the initial level measured under 46.7(c).

52.3 revised and relocated as 52A.1 May 30, 2008

52A.2 Equipment that is rated for use below 20°C (68°F) shall be subject to testing per this section while maintained in an ambient 5°C (9°F) lower than that rating. Equipment that is rated for use above 30°C (86°F) shall be subject to testing per this section while maintained at an ambient 5°C higher than that rating. Equipment for use in from 20° – 30°C (68 – 86°F) shall be tested in a 25°C (77°F) ambient.

52A.2 added May 30, 2008

53 Composite, Solid-State Switch Inverter Test

53.1 Equipment containing a composite, solid-state switch inverter shall perform effectively when subjected to the following types of operation: Overload, Overvoltage, and Undervoltage Tests, in that order. Results should show that the equipment operates as intended at the conclusion of the test. Each test may be interrupted for periods of time, as specified by the manufacturer, to permit recharging of the batteries.

a) Fifty cycles of overload consisting of making and breaking a test current as described in Table 53.1.

b) Fifty cycles of overvoltage while connected to an input of 110 percent of rated input voltage and to rated output load at unity power factor, or to rated lamp load if rated for a particular lamp load only.

c) Fifty cycles of undervoltage, while connected to an input of 85 percent of rated input voltage and to rated output load at unity power factor, or to rated lamp load if rated for a particular lamp load only.

Table 53.1
Test current, power factor, and cycles per minute for overload tests

Device used for	Rated in amperes	Load test current	Load power factor	Cycles per minute
All equipment	AC	1.5 × rated current	0.75 – 0.80 (lag)	6[a]
	DC	1.5 × rated current	Noninductive resistive load	6[a]
All equipment having output circuits rated other than unity power factor shall be subjected to this test outlined above for all equipment	AC	1.5 × rated current[b]	Minimum load power factor marked in accordance with 66.1(b). The test will be conducted once for minimum ″lag″ power factor, and repeated for minimum ″lead″ power factor	6[a]
	DC	Not applicable	Not applicable	

[a] The operating cycle is to be such that the device conducts load current for approximately 1 second each cycle.

[b] Test currents may be less than 1.5 times the rated current if an overcurrent protector is provided in the load circuit of the equipment and the test is conducted at the maximum value at which the overcurrent protector will not open.

54 Voltage Surge Test

54.1 Equipment containing a solid-state component or device such as a diode, a transistor, an integrated circuit, an electroluminescent lamp, and the like shall be subjected to the following conditions. Results for condition a) shall show no tripping of circuit protection, no risk of fire or electric shock, and the equipment shall be operable at the conclusion of the test. The results for condition b) may show tripping of circuit protection but with no risk of fire or electric shock.

a) Ten random applications of a 3-kilovolt surge impulse at 60-second intervals as described in 54.2 and

b) Ten random applications of a 6-kilovolt surge impulse at 60-second intervals as described in 54.2.

Exception: Circuits provided with a surge protective device that complies with the Standard for Surge Protective Devices, UL 1449, protects the circuit containing solid-state components, and has a suppression voltage rating not higher than the voltage rating of the solid-state components, need not be tested.

54.2 A sample of the equipment is to be placed on a white tissue-paper-covered, softwood surface, covered with a single layer of cheesecloth, and connected to a supply circuit of rated voltage. A separate sample is to be used for tests under conditions 54.1 (a) and (b) unless the use of the same sample for both conditions is agreeable to those concerned. The grounding lead or terminal of the sample is to be connected to the supply conductor serving as the neutral. The sample is to be in the ″on″ condition with no load connected. For each application, the surge is to have the specified initial peak amplitude of 3 or 6 kilovolts when applied to the 60-hertz supply to the unit under test. Each of the ten applications is to be random with respect to the phase of the 60-hertz supply voltage.

54.3 With regard to 54.1, a risk of fire or electric shock is considered to exist if:

a) There is glowing, charring, or ignition of the cheesecloth or tissue paper or

b) The insulation breaks down when the equipment is subjected to the Dielectric Voltage-Withstand Test, Section 55.

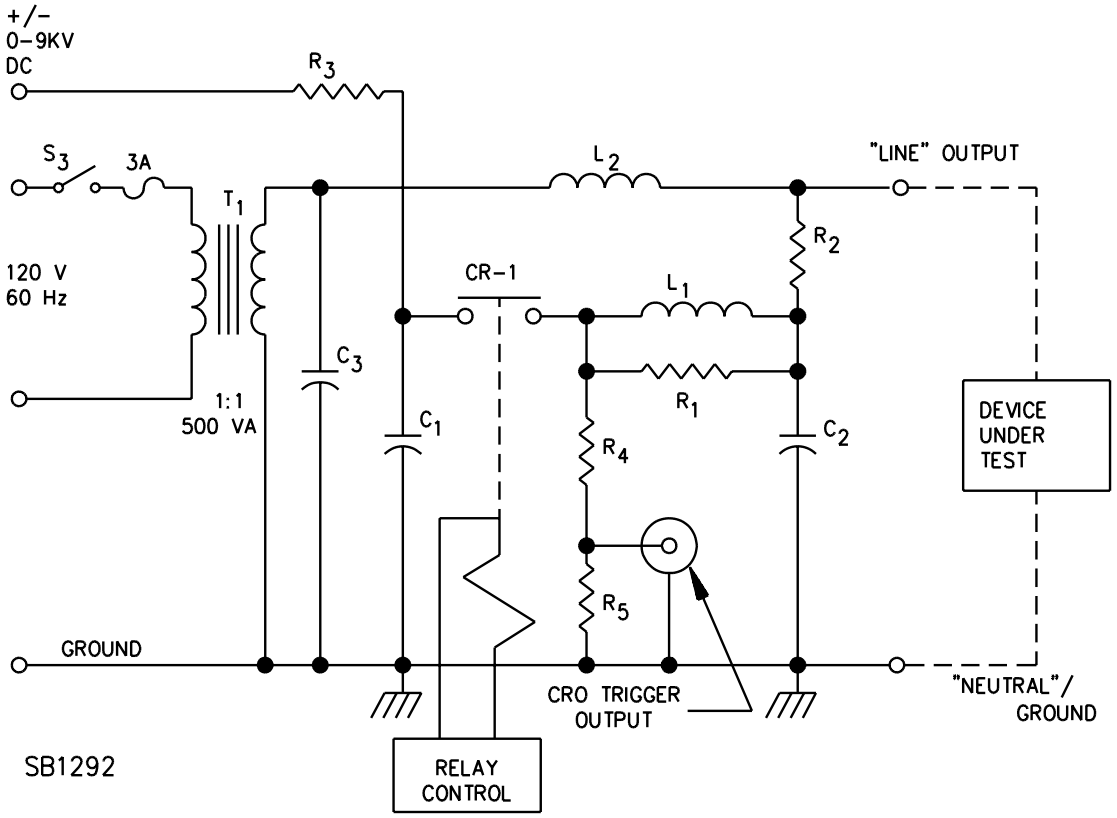
54.4 The surge generator is to have a surge impedance of 50 ohms. Figures 54.1 and 54.2 show a typical surge generator and control relay. When there is no load on the generator, the wave form of the surge is to be essentially as follows:

a) Initial rise time, 0.5 microsecond between 10 percent and 90 percent of peak amplitude;

b) The period of the following oscillatory wave, 10 microseconds; and

c) Each successive peak, 60 percent of the preceding peak.

Figure 54.1
Surge generator circuit



C_1 = 0.025 µF, 10kV

C_2 = 0.01 µF, 10kV

C_3 = 4 µF, 400V

L_1 = 15 µH [23 turns, 23 AWG (0.26 mm^2) wire, 0.7-inch (17.8-mm) diameter air core]

L_2 = 70 µH [28 turns, 23 AWG (0.26 mm^2) wire, 2.6-inch (66.0-mm) diameter air core]

R_1 = 22 ohms, 1 W, composition

R_2 = 12 ohms, 1 W, composition

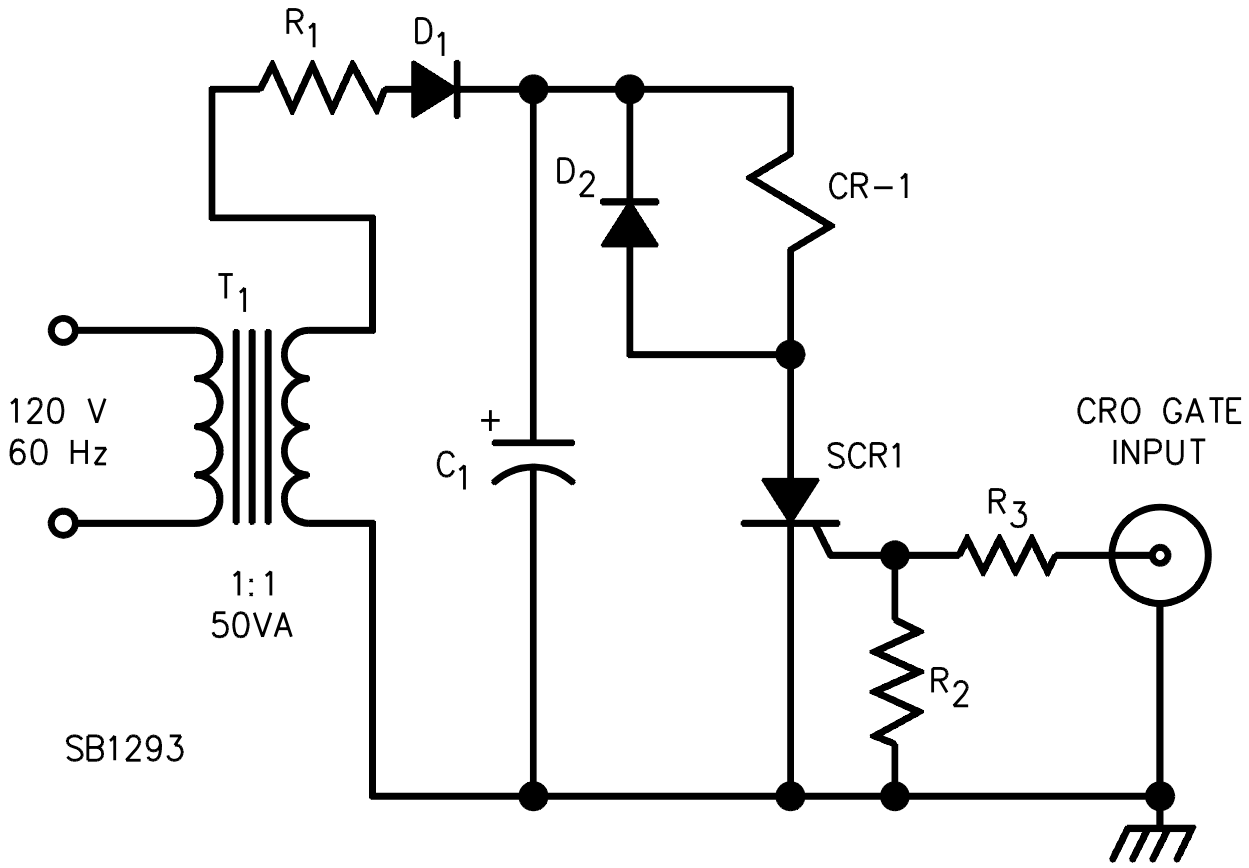
R_3 = 1.3M ohms (12 × 110K ohms, 1/2 W)

R_4 = 47K ohms (10 × 4.7K ohms, 1/2 W)

CR-1 = Relay

R_5 = 200 ohms, 1/2 W

Figure 54.2
Relay control circuit for surge generator



R_1 = 10K ohms, 1 W

R_2 = 1K ohms, 1/2 W

R_3 = 1K ohms, 1/2 W

C_1 = 32 µF, 250 V

D_1 = IN5060 or equivalent

D_2 = IN5060 or equivalent

SCR1 = GE C 122B or equivalent

CR-1 = Relay GE CR 2790 E 100 A2 or equivalent

T_1 = Traid N4S X or equivalent

55 Dielectric Voltage-Withstand Test

55.1 Equipment shall be subjected, for 1 minute, to the application of a 60-hertz essentially sinusoidal potential:

a) Between all live parts and the enclosure;

b) Between all live parts and exposed dead-metal parts;

c) Between live parts of circuits operating at different potentials or at different frequencies;

d) Between terminals of a capacitor connected directly across the input AC line prior to a transient suppressive device, a rectifier or similar network; and

e) Between terminals of a line-bypass capacitor connected between the line and the enclosure or dead-metal parts.

The test potential shall be 500 volts for circuits operating at 50 volts or less, and 1000 volts plus twice the rated voltage for circuits operating at more than 50 volts. In (c), the test potential shall be the value determined by the higher voltage of the different circuits. Results are acceptable if there is no dielectric breakdown.

Exception: A direct-current potential may be used for an AC circuit, and if used, the test potential is to be 1.414 times the rms value of the alternating-current voltage specified. The direct-current voltage is to be maintained for 1 minute without breakdown.

55.2 With regard to 55.1 (d) and (e), the test is not required for a capacitor complying with either the Standard for Capacitors and Suppressors for Radio- and Television-Type Appliances, UL 1414, or the Standard for Electromagnetic Interference Filters, UL 1283.

55.3 To comply with 55.1, it may be necessary to disconnect solid state components interconnecting the two circuits.

55.4 To determine if equipment complies with the requirements in 55.1 while the equipment is at maximum normal operating temperature, it is to be tested by means of a 500 volt-ampere or larger transformer, the output voltage of which can be varied. The applied potential is to be increased from zero until the required test value is reached, and is to be held at that value for 1 minute. The applied potential is to be increased at a uniform rate, as rapidly as consistent with its value being correctly indicated by the voltmeter.

56 Conformal Coating Test Program I

56.1 General

56.1.1 The following test program shall be used to determine the effectiveness of a conformal coating in lieu of full electrical spacings under the conditions specified in Table 37.2.

56.2 Coating on printed-wiring board in lieu of spacings

56.2.1 Three samples of the printed wiring board without electrical components installed, and coated with the conformal coating, shall be subjected to this test. In each case, the results of the dielectric voltage-withstand test between tracks on a printed-wiring board should show no peeling of the coating material due to the conditioning test. Each sample shall be subjected to a 5000-volt, alternating-current dielectric voltage-withstand test, followed in turn by:

a) A 7-day heating-cooling cycling period, each cycle consisting of 4 hours on at 105°C (221°F) followed by 4 hours off at 25°C (77°F);

b) A 7-day oven conditioning period of 100°C (212°F);

c) A 7-day humidity conditioning period at 85 percent relative humidity at 65°C (149°F); and

d) A repeated dielectric voltage-withstand test at 2500-volts alternating current.

56.3 Humidity test

56.3.1 Deleted May 30, 2008

57 Conformal Coating Test Program II

57.1 General

57.1.1 The following test program shall be used when investigating conformal coating for compliance with Table 37.2.

57.2 Samples

57.2.1 Eight samples of the printed wiring board without electrical components installed, and coated with the conformal coating, shall be used for the tests described in 57.3.1 – 57.5.2. Test leads are to be attached to the printed wiring so as to allow for convenient application of specified test potential.

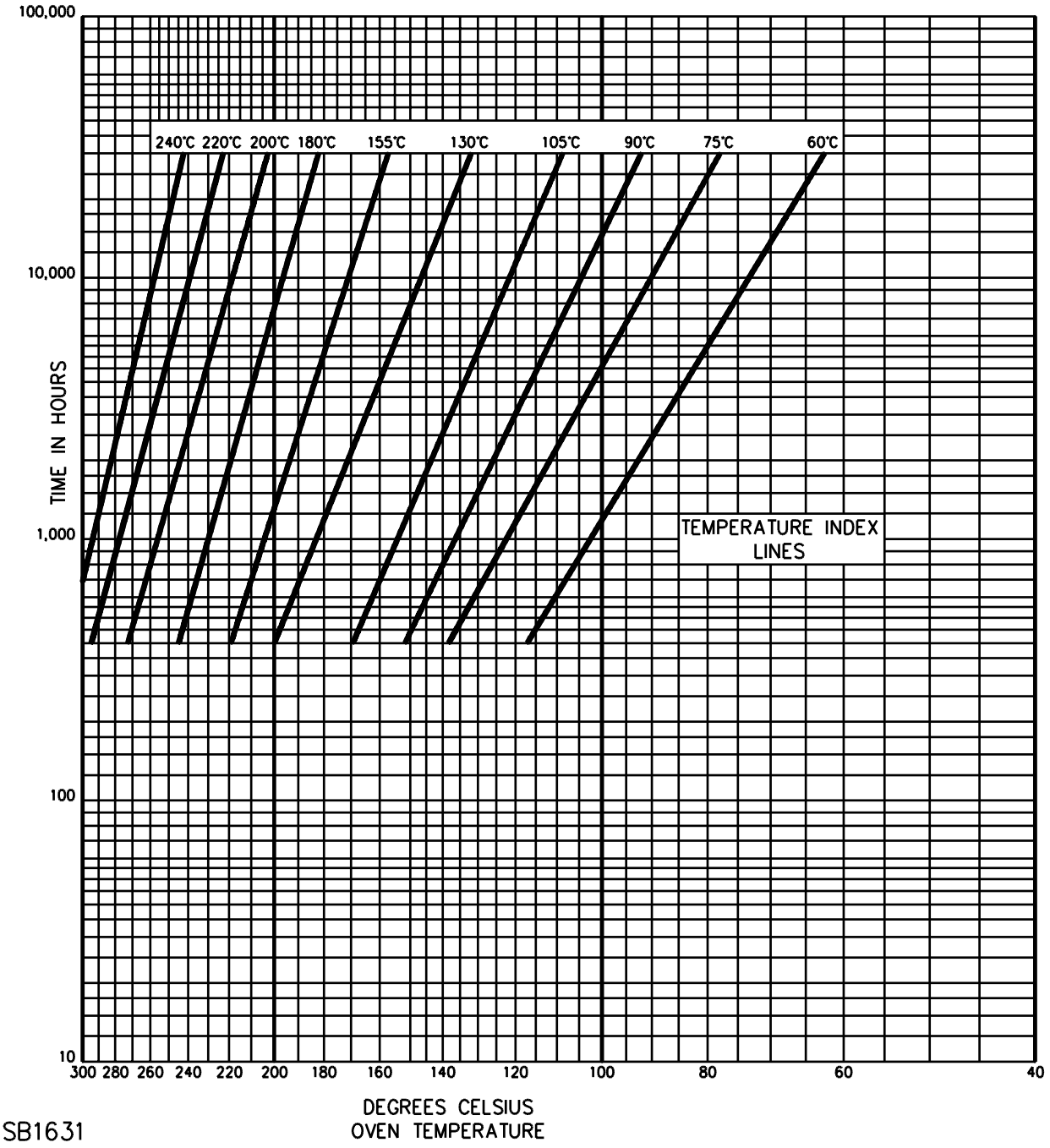
57.3 Room ambient conditioning

57.3.1 Four specimens shall be exposed to ambient air at a temperature of 25 ±5°C (77 ±9°F) and 50 ±5 percent relative humidity for no less than 24 hours. Following room ambient conditioning, four samples shall be subjected to the dielectric voltage-withstand test described in 57.5.1. All specimens shall be smooth, homogeneous, and free of heat deformation such as bubbles and pin holes, as determined by visual examination. There shall be no indication of dielectric breakdown during the dielectric voltage-withstand test.

57.4 Thermal conditioning

57.4.1 Four samples shall be exposed to ambient air at a temperature selected from the applicable curve shown in Figure 57.1, according to the operating temperature in service of the coating. It is recommended that the temperature selected from the appropriate curve correspond to no less than 1000 hours of exposure. However, any value of temperature may be selected provided it corresponds to no fewer than 300 hours of exposure. The samples are then to be subjected to the dielectric voltage-withstand test. All specimens shall be smooth, homogeneous, and free of defects such as bubbles and pin holes, as determined by visual examination. Results should show no crazing, cracking, chipping, or other visual evidence of deterioration after conditioning nor a dielectric breakdown.

Figure 57.1
Aging time versus aging temperature



57.5 Dielectric voltage-withstand test for conformal coating

57.5.1 Each sample shall be subjected to a 500 volt alternating-current potential applied between printed wiring board paths of opposite polarity.

57.5.2 Starting at zero, the test potential is to be gradually increased to the maximum voltage of 500 volts and maintained at that level for 1 minute. Results should show no dielectric breakdown.

58 Strain Relief Test

58.1 General

58.1.1 A strain relief means shall be tested by removing or severing the electrical connections of the power supply cord within the unit and then applying the force specified in 58.2.1. The strain relief means is acceptable if there is no insulation damage and no movement of the conductors of the cord indicating that a stress would have been transmitted to the connections.

58.2 Strain

58.2.1 A force of 35 pounds (156 N) is to be applied to the power supply cord from any angle that the construction of the equipment permits. The force is to be maintained for one minute.

59 Conductor Secureness Test

59.1 Internal wiring as specified in 19.5.1 shall withstand, without damage or detachment from an integral connector, a direct pull of 20 pounds (89 N) for one minute. The direction shall be that which is most representative of the strain to which the wire will be subjected in the equipment. Each half of a mating plug/receptacle assembly shall be tested separately.

Exception: If the wire terminates in a mating plug/receptacle assembly, the pulling force applied shall be the lesser of 20 pounds or 150 percent of the force required to disengage the mating plug and receptacle. The force required to disengage the mating plug and receptacle shall be the largest measured force from three independent plug/receptacle assembly samples.

60 Overtinned Wire Flexibility Test

60.1 Overtinned stranded wire used as a lead wire to an adjustable lamphead or to a part mounted on a hinged cover, as described in 19.1.6, shall be subjected to the mechanical cycling test described in 60.2. Following the mechanical cycling, there shall be no insulation breakdown when a dielectric withstand test (as described in 55.1) is conducted between adjacent conductors and between the conductors and any adjacent conductive surfaces.

60.2 With the product assembled as intended, an adjustable lampholder and/or a hinged cover shall be subjected to 500 mechanical cycles through the full range of motion permitted by the construction. Any restraints, such as an end-stop or chain, are to remain in place and may be used to define the limits of motion.

61 Bonding Conductor Test

61.1 A bonding conductor that does not comply with the requirements in 21.7 (a) or (b) is acceptable if, using separate samples for each test, neither the bonding conductor nor the connection opens when:

a) Carrying currents equal to 135 and 200 percent of the rating or setting of the intended branch-circuit overcurrent-protective device for the times specified in Table 61.1 and

b) Three samples are subjected to the Limited-Short-Circuit Test using a test current as specified in Table 61.2 while connected in series with a nonrenewable fuse having a rating equal to the intended branch-circuit overcurrent-protective device.

Exception: If a fuse smaller than that indicated in (a) and (b) is used in the unit for protection of the circuit to which the bonding conductor is connected, the magnitude of the test current and size of fuse used during the test may be based on the rating of the smaller fuse.

Table 61.1
Duration of overcurrent test

Rating or setting of branch-circuit overcurrent protective device, amperes	Test time, minutes	
	135 percent of current	200 percent of current
0 – 30	60	2
31 – 60	60	4
61 – 100	120	6
101 – 200	120	8

Table 61.2
Circuit capacity for bonding conductor short-circuit test

Rating of unit, volt-amperes		Volts	Capacity of test circuit, amperes
Single-phase	3-phase		
0 – 1176	0 – 832	0 – 250	200
0 – 1176	0 – 832	251 – 600	1000
1177 – 1920	833 – 1496	0 – 600	1000
1921 – 4080	1497 – 3990	0 – 250	2000
4081 – 9600	3991 – 9145	0 – 250	3500
9601 or more	9146 or more	0 – 250	5000
1921 or more	1497 or more	251 – 600	5000

62 Grounding Continuity Test

62.1 To determine compliance with 21.2, one sample is to be tested for grounding continuity between the grounding means and any accessible dead metal required to be grounded.

62.2 Any indicating instrument may be used to determine compliance with 62.1. However, if results are unacceptable, a minimum, 25-amp alternating- or direct-current from a power supply of not more than 12 volts is to be passed from the equipment grounding means point of connection to the test point in the grounding circuit. The resulting drop in voltage is to be measured between the two points. The resistance in ohms is to be calculated by dividing the drop in potential (in volts) by the current (in amperes). The results comply if the resistance does not exceed 0.1 ohm.

63 Security of Knockout Test

63.1 To determine compliance with the requirements specified in 17.6.3, a knockout in an enclosure made of metal or a polymeric material shall comply with the requirement in 63.3 when tested as described in 63.2.

63.2 A force of 10 pounds (44.5 N) is to be gradually applied and maintained for 1 minute perpendicular to the plane of the enclosure surface in which the knockout is located. The flat end of a metal rod 1/4 inch (6.4 mm) in diameter is to be pressed against the knockout from the outside surface at the point(s) considered most likely to provide separation of the knockout from the enclosure.

63.3 Test results are acceptable if the knockout does not separate more than 1/16 inch (1.6 mm) from the enclosure.

64 Swivel Torsion and Pull Test

64.1 A lamphead swivel joint, as described in 14.5, shall be tightened in accordance with the manufacturer's installation instructions and subjected to each of the following for one minute:

a) A torsion of 20 ±0.5 lb-in (2.26 ±0.56 N-m) and

b) A straight pull of 35 pounds (16 kg).

There shall be no visible damage to the lamphead, mounting means, or conductor insulation as a result of the test. Removal of the lamphead from the mounting means during the straight pull test is acceptable if the lamphead can be reinstalled without tools and without damage. Movement of the lampholder during the torsion test is acceptable if the lamphead can subsequently be returned and tightened to its intended position.

65 Component Breakdown Test

65.1 General

65.1.1 To determine compliance with 23.1, components of emergency and auxiliary lighting and power equipment that are not known to be reliable and whose failure could result in a risk of fire or electric shock shall be subjected to the tests of this section.

65.1.1 revised May 30, 2008

65.1.2 With reference to the requirement in 65.1.3, a risk of fire or electric shock is considered to exist if any of the following occur:

a) Glowing, charring, or flaming of the cheesecloth or tissue paper as specified in 65.2.1;

b) Opening of the 3-ampere fuse specified in 65.2.2;

c) Emission of flame, sparks, or molten metal from the enclosure;

d) Development of an opening in the overall enclosure that exposes live parts involving a risk of electric shock to contact by persons (see 8.2.1); or

e) Loss of structural integrity to a degree that the equipment collapses or experiences such displacement of parts that may lead to short-circuiting or grounding of live parts.

65.1.3 The circuit between any two terminals of the component under test shall be opened or shorted. Only one fault condition is to be imposed at one time. For a multi-terminal device, only two terminals are to be short-circuited at a time. Simulated circuits may be used, but if the tests performed on simulated circuits indicate likely damage to other parts of the equipment the test shall be repeated on the equipment.

65.1.3 revised May 30, 2008

65.1.4 Each test is to be conducted on a separate sample unless it is agreeable to those concerned that more than one test be conducted on the same sample.

65.1.5 A part of equipment that is subject to removal during routine operation or maintenance is to be omitted if it will result in a more severe test, and the part is:

a) Not necessary for the functioning of the equipment;

b) Not exposed to view during intended operation; and

c) Not captive.

65.1.5 revised May 30, 2008

65.2 General test conditions

65.2.1 During these tests, the sample is to be placed on a softwood surface covered with white tissue paper if there are any bottom openings. A single layer of cheesecloth is to be draped loosely over all ventilating openings.

65.2.1 revised May 30, 2008

65.2.2 During each test, exposed dead-metal parts of the sample are to be connected to earth ground through a 3-ampere, nontime-delay fuse.

65.2.3 The supply circuit is to have branch circuit overcurrent protection, the size of which equals 125 percent of the input current rating (20-ampere minimum), except that where this value does not correspond with the standard rating of a fuse or a circuit breaker, the next higher standard device rating shall be used. The test voltage and frequency are to be adjusted to the values specified in 43.2.

Exception: If a marking on the product indicates the use of branch circuit protection exceeding 125 percent of the input current, such protection shall be used.

65.2.4 A fuse that may be replaced during routine maintenance is to be effectively defeated unless marked in accordance with 70.2.1. A fuse that is soldered in place, or is located such that it is accessible only to qualified service personnel, and marked in accordance with 70.2.1, and any other overcurrent protective device not subject to replacement during routine maintenance may be left in the circuit.

65.2.5 Each component fault condition test is to be conducted for 7 hours or until one or more of the following results are observed:

a) Any of the conditions noted in 65.1.2.

b) The branch-circuit fuse opens.

c) The equipment protective device opens.

d) Any other circuit component opens.

e) A minimum of one hour elapses, circuit conditions stabilize, and there is no further evidence of overheating of parts.

65.2.6 The overheating of parts referred to in 65.2.5(e) shall be detected by direct temperature measurement or by an indicator such as an odor, smoke, discoloration, cracking of materials, charring, flaming, glowing, arcing, changes in circuit current through the applied fault, or any similar phenomenon.

65.2.6 revised May 30, 2008

65.2.7 If a fault condition is terminated by opening of a circuit component as specified in 65.2.5(d), the test is to be conducted two more times using new components for each test. If the same component opens on three consecutive tests, without incurring any of the conditions noted in 65.1.2, the results for that component fault are considered acceptable.

65.2.8 Deleted May 30, 2008

66 Humidity Conditioning Test

66.1 After conditioning as described in 66.2, an electroluminescent exit fixture or exit light shall:

a) Continue to operate in the intended manner. An exit light shall comply with the Normal Operation Test, Section 45, in both the normal ac and emergency modes of operation.

b) Have no damage to the insulation system or the structure of the equipment as determined by visual examination. Damage includes conditions such as smoking, burning, or melting of insulation, burn marks as a result of insulation breakdown between parts of opposite polarity, such as between the insulating sheets of the electroluminescent lamp panel; cracking, deformation, or displacement of structural parts that may lead to a risk of fire, electric shock, injury to persons, or unacceptable visibility.

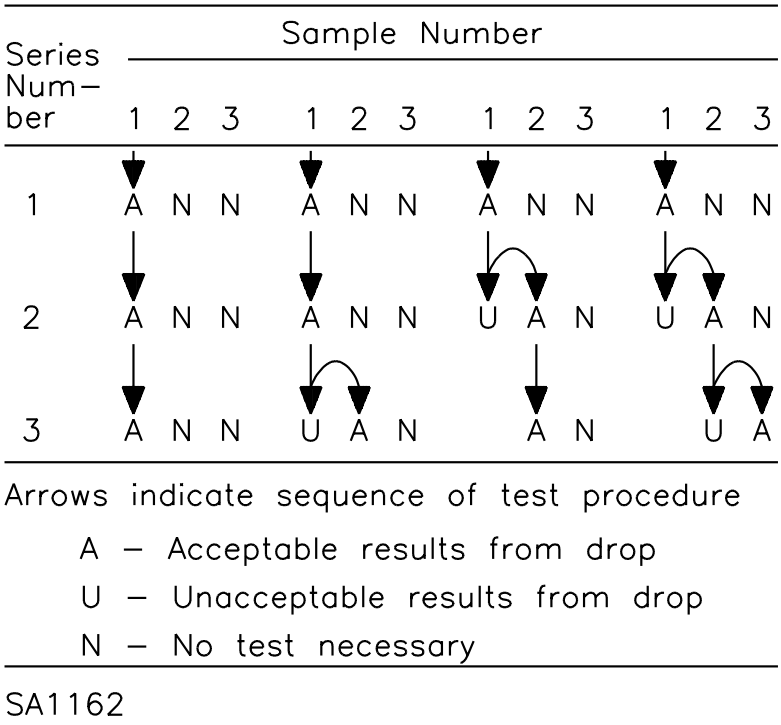
c) Comply with the Dielectric Voltage-Withstand Test, Section 55, conducted between all live parts and exposed dead-metal parts as described in 55.1 – 55.4.

66.2 Two samples are to be tested. One sample is to be conditioned unenergized and the other is to be conditioned while energized at rated voltage. The samples are to be conditioned for 240 hours at 95 to 100 percent relative humidity at 65.0 ±2.0°C (149 ±3.6°F). An exit light sample that is to be conditioned while energized is to be operated with the lamps on during the conditioning. If the lamps are on in both the normal AC and emergency operating modes, the sample is to be operated in the normal AC mode.

67 Impact Test

67.1 Each of three samples of a floor-proximity exit sign shall be subjected to a single impact at any point on the face of the sign. If the manufacturer so elects, fewer samples may be used in accordance with Figure 67.1. The points selected are to be such that the impacts produce the most adverse results. The samples are to be mounted or otherwise restrained in a manner representative of the most unfavorable condition of intended installation. The impact is to be produced by a solid, smooth steel sphere, 2 inches (50.8 mm) in diameter and weighing 1.18 pounds (0.54 kg). The steel sphere is to be suspended by a cord and swung as a pendulum, dropping through the vertical distance necessary to cause it to strike the surface with the required impact. The impact force is to be 5 foot-pounds (6.8 N·m). The results of the Impact Test are acceptable if there is no cracking, breakage, or detachment of the sign face, the lens or diffuser, the light source (lamp envelope), the legend, or a directional indicator, if provided, and no breakage of the means of support or mounting. The sample shall remain operable, except failure of lamps to illuminate (due to breakage of the filament, for example), is acceptable. In a self-luminous exit sign, any cracking of the glow tubes (containers of the radioactive material) is not acceptable.

Figure 67.1
Procedure for impact test



RATINGS

68 General

68.1 The electrical ratings of emergency lighting and power equipment shall include:

a) For each input supply circuit, the following:

1) Input voltage;

2) Frequency expressed in hertz, Hz, cycles-per-second, cps, cycles/second, or c/s;

3) Maximum input expressed in:

i) Either amperes or watts for equipment having a power factor of 0.9 to 1.0;

ii) Either amperes or both watts and power factor for equipment having a power factor less than 0.9. The power factor shall be lagging unless marked leading; and

4) The number of phases or wires (if other than single phase).

Exception: An exit fixture intended to be directly connected to the supply source, without a transformer or a step down circuit, and using incandescent lamps need only be rated for voltage.

b) For each output circuit, the following:

1) Direct Current Output Circuits:

i) The maximum output current or wattage;

ii) The nominal system voltage; and

iii) The phrase ″DC.″

2) Alternating Current Output Circuits:

i) The maximum current or volt-ampere (VA) output. Low frequency inverters shall be rated in amperes or kW output at unity power factor;

ii) The nominal system voltage;

iii) The permissible load power factor range expressed in both lead and lag;

Exception: The permissible specific load types (tungsten, ballast, motor) shall be provided for automatic load control relays supplying remote loads.

iv) The number of phases or wires (if other than single phase); and

v) The frequency expressed in hertz, Hz, cycles-per-second, cps, cycles/second, or c/s.

c) For fuses – the maximum ampere rating of the fuse to be installed in each fuseholder provided as a part of the device.

68.1 revised May 30, 2008

68.2 With regard to 68.1(b), the output power rating is to include the total of all integral and remote loads. See also 70.1.9.

69 Standby Operation

69.1 Battery-operated emergency lighting and power equipment may be provided with a standby electrical input rating expressed in amperes, watts, or both, to indicate the electrical consumption under standby operating conditions. See 70.1.40.

69.1 revised May 30, 2008

MARKINGS

70 General

70.1 Details

70.1.1 Equipment shall be plainly and permanently marked, where the marking will be visible after installation, with:

a) The manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the equipment may be identified. If a manufacturer produces or assembles equipment at more than one factory, each unit shall have a distinctive marking, which may be in code, by which it may be identified as the product of a particular factory;

b) A distinctive catalog number or the equivalent;

c) The electrical ratings specified in Ratings, Section 68;

Exception: Self-contained units, where the output load is part of the unit, and units that do not have provisions for remote loads shall be marked "Output: Operates the installed lamps for ____ minutes (hours)" where the blank is to contain the rated discharge time. The term "internal" may be used in place of "installed" where applicable, in lieu of the output rating specified in 68.1(b).

and

d) The date or other dating period of manufacture not exceeding any three consecutive months.

Exception: The date of manufacture may be abbreviated, or in a nationally-accepted conventional code, or in a code affirmed by the manufacturer, provided that the code:

1) Does not repeat in less than 20 years and

2) Does not require reference to the production records of the manufacturer to determine when the unit was manufactured.

70.1.2 With regards to 70.1.1, the forms of markings considered to be permanent include:

a) Molded and die-stamped;

b) Stamped or etched metal that is permanently secured;

c) Indelibly-printed, pressure-sensitive labels secured by adhesive that, upon investigation, is found to comply with the Standard for Marking and Labeling Systems, UL 969, and is rated for the type of surface and temperatures of the surface to which it is affixed; and

d) Painted, stencilled, and ink stamping determined to comply with the Legibility Test of the Standard for Marking and Labeling Systems, UL 969.

70.1.3 When a marking is required to be visible after installation, the marking shall be on the exterior surface at a location where it will be visible after the equipment is installed or on the inside of a door or cover. A marking that becomes visible when a cover or trim of the enclosure, a lamp lens, a diffuser, or a similar part is removed, without disassembling or removing a component or device, is considered visible after installation.

70.1.4 An exit fixture provided with two or more lamps intended to be connected in parallel in the field and provided with individual field-wiring input leads or terminals shall be marked ″For connection to a single source of supply such that all lamps are simultaneously illuminated″ or the equivalent.

Exception: An exit fixture provided with an instruction manual that complies with 71.2 need not be marked.

70.1.5 Equipment subjected to the Normal Operation, Section 45, Battery Discharge, Section 46, Temperature, Section 50, and Undervoltage Recharge Capability, Section 52A, Tests, as applicable, at an ambient of other than 25°C (77°F) is permitted to be marked with a rated ambient temperature range in accordance with the tests conducted. The rating shall be in temperature increments no smaller than 5°C (9°F).

70.1.5 revised May 30, 2008

70.1.6 Equipment provided with batteries shall be marked to specify the rated operating time in the emergency mode in multiples of 1/2 hour (30 minutes), but not less than 1-1/2 hours (90 minutes). An additional marking or separate instructions provided with the equipment shall specify the minimum charge time required to attain full battery capacity, per 46.8.

Exception: This requirement does not apply to auxiliary equipment.

70.1.6 revised May 30, 2008

70.1.7 Boxes and enclosures of emergency equipment shall be permanently marked where readily visible after installation to be readily identifiable as a component of the emergency system. The marking shall state ″EMERGENCY CIRCUITS″ or the equivalent in block letters at least 1/4 inch (6.4 mm) high. The marking shall be on a red background and in a contrasting color.

Exception: This requirement does not apply to emergency-lighting fixtures, exit fixtures, exit lights, fluorescent fixture inverter/charger packs, remote lamp assemblies, and unit equipment.

70.1.8 Product markings, instruction manuals, or other literature for the product shall not claim that the product can be used in any way that conflicts with the marking and instructions specified in Sections 70 – 73.

70.1.9 Equipment having provision for connection of remote loads shall be marked with the word ″CAUTION″ and one of the following or equivalent:

a) ″To avoid electrical overload, total connected lamp load (factory and field installed) should not exceed output rating.″

b) ″Do not overload.

Total Load ____ Max.

Remote Load ____ Max.″

c) ″Do not overload.

Total load including integral lamps ____ Max.″

The blank space for total load in (b) and (c) is to be filled with a value not exceeding the marked output rating. See 68.2.

Exception: This marking is not required when equipment is solely for the control of remote loads.

70.1.9 revised May 30, 2008

70.1.10 Instructions necessary for the intended installation, operation, and maintenance of equipment shall be permanently attached to the equipment.

Exception No. 1: The instructions are permitted to be separately provided in a manual if the equipment is marked ″See instruction manual for installation, operation, and maintenance instructions.″

Exception No. 2: The instructions are permitted to be separately provided on a publicly accessible web site if the equipment is marked ″See (specific URL inserted here) for installation, operation, and maintenance instructions.″

70.1.10 revised May 30, 2008

70.1.11 Emergency and auxiliary lighting fixtures, exit lights, and unit equipment lighting fixtures having more than one power source that might present a risk of electric shock shall be marked, where visible after installation, with the word ″CAUTION″ and the following: ″This unit has more than one power supply connection point. To reduce the risk of electric shock disconnect both the branch circuit-breakers or fuses and emergency power supplies before servicing.″

70.1.12 Emergency and auxiliary equipment having more than one power source that might present a risk of electric shock, and having provisions for connection of remote loads, shall be marked where readily visible during any approach to servicing, with the word ″CAUTION″ and the following or the equivalent: ″This equipment provides more than one power supply output source. To reduce the risk of electric shock disconnect both normal and emergency sources within this unit before servicing any equipment connected to this unit.″

70.1.13 A sealed unit shall be marked where readily visible after installation: ″CAUTION: Sealed unit. ____ not replaceable. Replace entire unit when necessary. ″ The blank space shall be filled in with the appropriate part: ″light source,″ ″battery,″ ″components,″ or similar item.

70.1.14 An enclosure or compartment not intended to be opened for routine maintenance activities shall be marked ″CAUTION – Service by Qualified Personnel Only. De-energize before opening.″ The marking shall be visible on the exterior surface(s) of the subject enclosure or compartment most likely to be removed for access.

70.1.15 A marking elsewhere required in this Standard that begins with the word ″CAUTION″ shall be permanent and shall be in the form of paint-stencilled, die-stamped, or indelible lettering or an indelibly printed label. The word ″CAUTION″ shall be in letters not less than 1/8 inch (3.2 mm) in height.

70.1.16 Equipment, other than exit signs, with either an incandescent or a fluorescent lamp shall be marked where visible during relamping ″Relamp only with ____ watt, ____ type lamps.″

70.1.17 Unless the intended wiring connections are evident, installation wiring terminals or leads shall be identified to indicate the intended connections.

70.1.18 Unless unit equipment is provided with an equipment grounding terminal or lead as described in 19.4, it shall be marked to limit it to use with a metal enclosed wiring system.

70.1.19 Equipment incorporating or intended to incorporate batteries shall be marked with ″CAUTION: Replace battery only with (blank) part number (blank).″ The first blank is to be filled in with the battery manufacturer or equivalent identification and the second blank is to contain the catalog designation. This information is to be placed on the unit in a location visible during battery replacement. Markings that appear only on the battery are not considered in compliance with this marking requirement.

Exception: This marking is not required if unit is marked in accordance with 70.1.13.

70.1.20 The marking required in 70.1.19 shall be prominently located inside the battery compartment. The marking may be provided on a label or the equivalent.

70.1.21 Emergency equipment designed to require provision of battery circuit wiring shall be marked to indicate the minimum wire size required for the purpose. Such marking shall be in accordance with wire ampacity ratings and shall be located where visible during installation and inspection in the field.

70.1.22 Equipment that must be mounted in a specific position to function properly shall be marked to indicate the correct position for mounting, unless the correct position is obvious without the marking.

70.1.23 Emergency lighting unit equipment that is cord connected in accordance with Cord-Connected Unit Equipment, Section 18, shall be provided with a marking indicating that the equipment and the receptacle to which it is connected should be mounted at a height that will reduce potential damage and inadvertent disconnection. The marking may be provided on a tie-on tab or stuffer sheet packed with the equipment.

70.1.24 A cord-connected unit that, in accordance with 18.4.1, is adaptable in the field to a different voltage than indicated by the attachment plug, shall be provided with marking to indicate:

a) The correct internal connections for each voltage for which the unit is rated and

b) The type of attachment plug to be used on the cord to connect to that voltage.

70.1.25 Exposed components such as meters, pilot lights, and switches shall be identified as to their function. Products employing magnetic test switches shall be marked to indicate how to use or activate that test switch in the field.

70.1.26 Auxiliary power and light equipment shall be marked “NOTICE – This equipment has not been evaluated for compliance with Article 700 of the National Electrical Code,ANSI/NFPA 70”, or the equivalent.

70.1.27 Low-frequency equipment that produces other than an essentially sinusoidal output wave form, and that has not been marked for use only with specific loads, shall be marked ″This equipment has not been evaluated to determine its effect on equipment or systems to which it may be connected. Loads connected to this equipment should be evaluated together with this equipment to determine reliable operation of the combination.″

70.1.28 An exit fixture intended to accommodate or that is provided with branch circuit wires for through wiring shall be marked, in a location visible during installation, to indicate that if the exit fixture is installed for emergency use, the through branch circuits are only for supplying emergency loads. In addition, the number, size, and temperature rating of the branch circuit conductors are to be specified in the marking.

70.1.29 A fluorescent emergency lighting fixture intended for installation as an air-handling register for cool or return air shall be marked ″Emergency Lighting Fixture, Suitable for Air-Handling Use. Not for use as a Heated-Air Outlet″ or the equivalent.

Exception: An air-handling emergency lighting fixture that has been investigated for use with heated air may be marked ″Suitable for use as an air-handling emergency lighting fixture″ or the equivalent.

70.1.30 An exit light or exit fixture that flashes or produces an audible signal or both shall be provided with a marking to specify that such features are incorporated in the construction and that such equipment is intended for installation in locations where permitted by local codes. A flashing exit light or exit fixture shall additionally be marked to specify the flash rate and duty cycle of operation.

70.1.31 If a field-wiring terminal is marked to indicate that aluminum as well as copper wire may be used at that terminal (such as being marked ″AL – CU″ or ″CU – AL″), but because of wiring space or other factors in the equipment, in which aluminum wire may not be used, the equipment shall be marked ″Use copper wire only.″

70.1.32 If the wiring space and other factors are such that all field-wiring terminals of the equipment may be used with aluminum conductors as well as with copper conductors, the equipment shall be marked ″Use copper or aluminum wire.″

70.1.33 If the wiring space and other factors are such that some field-wiring terminals of the equipment may be used with aluminum conductors as well as with copper conductors, while the remainder of the field-wiring terminals may be used with copper conductors only, the equipment shall be marked ″Use copper wire only except at terminals ____.″ The terminals that may be used with aluminum wire shall be positively identified in the blank space.

70.1.34 A marking using a wording different from that specified in 70.1.33 may be used if it clearly and completely conveys the significant information.

70.1.35 A marking provided in accordance with 70.1.31 shall be readily and clearly visible and legible after installation. A marking that becomes visible when a cover or trim of the enclosure is removed or a door is opened to access the field-wiring terminal is considered to be readily visible.

70.1.36 Except as indicated in 70.1.34, only the quoted words used in 70.1.31 – 70.1.33 shall be used when these markings are provided, and any abbreviation designating copper and aluminum shall be ″Cu – Al″ or ″Al – Cu.″

70.1.37 The characters in the markings described in 70.1.31 – 70.1.33 shall not be less than 3/32 inch (2.4 mm) high.

70.1.38 Equipment with an input power factor of 0.85 or greater may be marked with the following or equivalent statement, ″Power Factor Corrected″. Equipment with an input power factor of 0.9 or greater may be marked with following statement, ″High Power Factor″ or ″HPF″, or the equivalent.

70.1.39 Self-diagnostic (only) equipment shall be marked on the outside of the product, where visible after installation and in color-contrasting, minimum 1/16-inch (1.6-mm) high lettering, ″NOT SELF-TESTING PER ANSI/NFPA 101″, or the equivalent. The product literature and instruction sheets shall also include, in minimum 1/8-inch (3.2-mm) high letters on a contrasting background, the following statement: ″This equipment is not self-testing in conformance with the Life Safety Code, ANSI/NFPA 101,″ or the equivalent.

70.1.40 Equipment provided with a standby electrical input rating in accordance with 48.3 shall be marked with the following or equivalent statement, ″Standby power consumption ____.″ The blank is to be filled in with the rated standby wattage. The marking shall be separated from the electrical rating marking required by 70.1.1 (c) by a blank line or the equivalent. See also 73.5.

70.1.41 An exit sign investigated in accordance with the Impact Test, Section 67, for installation near the floor shall be marked where visible during and after installation with the following or equivalent wording: ″Suitable for floor proximity installation.″

70.2 Fuse replacement

70.2.1 A fuse replacement marking shall be:

a) Provided adjacent to a fuse or fuseholder or in another location provided that it is obvious to which fuseholder the marking applies, if the fuse is used to meet the requirements of this standard and

b) Located where readily visible during replacement of the fuse.

The marking shall specify the ampere rating, and the voltage rating if higher than 125 V, of the fuse to be used for replacement. Where fuses with special fusing characteristics such as time delay are necessary, the type shall also be included. If the fuse is soldered in place and the presence of the fuse would ordinarily be known to routine maintenance personnel because of the fuse location or reference to it in the operating instructions or circuit diagrams, the marking shall, in addition to the above, include the following or the equivalent: ″REFER REPLACEMENT TO QUALIFIED SERVICE PERSONNEL.″

Exception: For equipment having only one fuse, the marking shall be visible during fuse replacement, but need not be provided adjacent to the fuse.

INSTRUCTION MANUAL

71 General

71.1 An instruction manual or the equivalent shall be provided with all equipment. The instructions shall include a safety instruction section which shall specifically warn the user against reasonably foreseeable uses or misuses so as to reduce the risk of fire, electric shock, and injury to persons.

Exception: An instruction manual or the equivalent need not be provided with an exit fixture.

71.2 If an instruction manual is provided for an exit fixture provided with two or more lamps intended to be connected in parallel in the field and provided with individual field wiring input leads or terminals, it shall state that the exit fixture is for connection to a single source of supply such that all lamps are simultaneously illuminated.

Exception: The instruction manual need not comply with this requirement if an exit fixture is marked in accordance with 70.1.4.

72 Safety Instructions

72.1 The safety instructions shall be a permanent part of the manual but separated in format and preceding all other instructions (such as installation, operation, and maintenance instructions).

72.2 The safety instructions shall include instructions or illustrations to identify important safety features, in addition to the important safeguards listed in 72.5.

72.3 The height of lettering in the text and illustrations of the safety instructions shall be as follows:

a) The phrases ″IMPORTANT SAFEGUARDS″, ″READ AND FOLLOW ALL SAFETY INSTRUCTIONS″, and ″SAVE THESE INSTRUCTIONS″ shall be in letters not less than 3/16 inch (4.8 mm) in height.

b) Other upper-case letters shall not be less than 1/12 inch (2.1 mm) in height.

c) Lower-case letters shall not be less than 1/16 inch (1.6 mm) in height.

72.4 The items may be numbered. The phrases ″READ AND FOLLOW ALL SAFETY INSTRUCTIONS″ and ″SAVE THESE INSTRUCTIONS″ shall be first and last, respectively, in a list of items. Other important safeguard items considered appropriate by the manufacturer may be inserted.

72.5 For all equipment, the safety instructions shall include the following safeguards verbatim or in equally definitive terminology.

Exception: If a specific safeguard does not apply to a particular type of equipment, the safeguard may be modified or deleted as appropriate.

IMPORTANT SAFEGUARDS

When using electrical equipment, basic safety precautions should always be followed including the following:

a) READ AND FOLLOW ALL SAFETY INSTRUCTIONS.

b) Do not use outdoors(this item may be omitted if the product is suitable for outdoor use).

c) Do not let power supply cords touch hot surfaces.

d) Do not mount near gas or electric heaters.

e) Use caution when servicing batteries. Battery acid can cause burns to skin and eyes. If acid is spilled on skin or in eyes, flush acid with fresh water and contact a physician immediately.

f) Equipment should be mounted in locations and at heights where it will not readily be subjected to tampering by unauthorized personnel.

g) The use of accessory equipment not recommended by the manufacturer may cause an unsafe condition.

h) Caution: Halogen cycle lamp(s) are used in this equipment. To avoid shattering: Do not operate lamp in excess of rated voltage, protect lamp against abrasion and scratches and against liquids when lamp is operating, dispose of lamp with care.

i) Halogen cycle lamps operate at high temperatures. Do not store or place flammable materials near lamp.

j) Do not use this equipment for other than intended use.

SAVE THESE INSTRUCTIONS

73 Other Instructions

73.1 The instruction manual shall include instructions for installation, operation, and maintenance recommended by the manufacturer. The instructions shall warn the user that all servicing should be performed by qualified service personnel.

73.2 A fluorescent fixture inverter/charger pack that is limited to specific ballasts shall be provided with a marking or instructions that specify the type and wattage of lamps and ballasts to which the unit is intended to be connected.

73.3 A fluorescent emergency lighting fixture intended for installation as an air-handling register for cool or return air shall be provided with instructions that specify the fixture is not for use as a heated-air outlet.

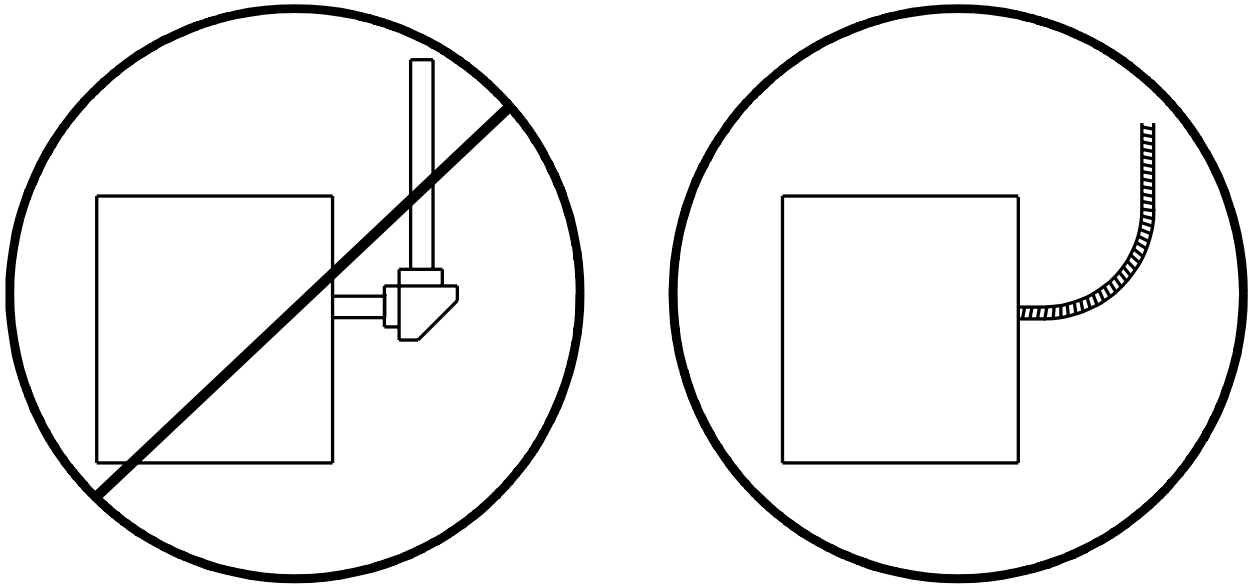
Exception: An air-handling emergency lighting fixture that has been investigated for use with heated air may be provided with instructions that specify the fixture is suitable for use as an air-handling emergency lighting fixture.

73.4 An exit light or exit fixture that flashes or produces an audible signal or both shall be provided with instructions to specify that such features are incorporated in the construction and that such equipment is intended for installation in locations permitted by local codes. For flashing exit lights or exit fixtures, the instructions shall additionally specify the flash rate and duty cycle of operation. The instructions shall also indicate whether an exit light or exit fixture is intended to be cycled on and off by an external control, such as a fire alarm control panel.

73.5 Equipment marked with a standby electrical input rating in accordance with 70.1.40 shall be provided with instructions explaining the purpose of the rating. The instructions shall caution the installer from using the standby rating to determine the suitability of the branch circuit to which the equipment can properly be connected in accordance with the National Electrical Code, ANSI/NFPA 70.

73.6 When equipment with polymeric enclosures is intended for connection only to a non-rigid wiring system, the installation instructions shall state, adjacent to the respective diagrams shown in Figure73.1, that the equipment must be installed with such a wiring system. The statement shall read, ″No rigid conduit″ or ″Flexible conduit only.″ Equipment with polymeric enclosures intended for connection only to a rigid metallic conduit system, as specified in 10.2.3, or to a rigid non-metallic conduit system, per 10.2.4, but not both, shall include a statement of this limitation in the installation instructions.

Figure 73.1
Flexible conduit marking



LOW-FREQUENCY INVERTERS

74 General

74.1 Low-frequency inverters (50 – 800 hertz) shall comply with requirements elsewhere in this standard and with the requirements in Performance, Section 75.

75 Performance

75.1 Output load power factor test

75.1.1 To determine that low-frequency inverters comply with the requirements in 68.1(b) throughout the marked output power factor rating of the equipment, the output circuit shall be connected to the maximum rated load at rated leading power factor. The unit shall supply the load for one 5-minute cycle of emergency operation. The test shall be repeated using the maximum rated load at rated lagging power factor. The output voltage shall remain within 10 percent of rated value for each power factor setting.

75.1.1 revised May 30, 2008

75.2 Battery discharge test

75.2.1 Low-frequency inverters shall be capable of maintaining at least 87.5 percent nominal battery voltage for a period not less than indicated in the marking, but in no case less than 1-1/2 hours, while supplying maximum total associated load.

75.2.1 revised May 30, 2008

75.2.2 To determine if low-frequency inverters comply with the requirement in 75.2.1, the unit shall be tested per 46.7 at unity power factor load or at the rated power factor load which draws the maximum battery current.

75.2.2 revised May 30, 2008

75.3 Output voltage and frequency test

75.3.1 The output voltage of a low-frequency inverter shall not exceed the marked output voltage rating by more than 10 percent, and the output voltage waveform shall contain no peaks greater than 1.7 times the marked rated rms output voltage. Measurements shall be made with the inverter connected first to its marked rated load and then to a load of 15 percent of the marked rated load. A variable voltage control shall be adjusted in accordance with installation instructions. The measurement shall be made with fully charged batteries at 1 minute after energizing the equipment in ″emergency operation″.

75.3.2 The output frequency of a low-frequency inverter shall not vary from the marked rated frequency by more than ±5 percent when tested under the conditions described in 75.3.1.

HIGH-FREQUENCY INVERTERS

76 General

76.1 High-frequency inverters (greater than 800 hertz and intended to operate electric discharge lamps), as defined in 4.23, shall comply with the appropriate requirements elsewhere in this standard and with the requirements in Performance, Section 77, and Marking, Section 78.

77 Performance

77.1 General

77.1.1 To determine if an inverter complies with the applicable requirements for output voltage and current and abnormal conditions, a representative sample of the inverter shall be subjected to the tests described in 77.2 and 77.3.

77.1.1 revised May 30, 2008

77.1.2 Deleted May 30, 2008

77.2 Output voltage and current test

77.2.1 Deleted May 30, 2008

77.2.2 Deleted May 30, 2008

77.2.3 Deleted May 30, 2008

77.2.4 Deleted May 30, 2008

77.2.5 The voltage to ground or on exposed, dead-metal parts of the inverter shall be measured in accordance with 77.2.6. If the measured voltage exceeds 300 volts rms and the current through the 500 ohm resistor exceeds the values shown in Table 77.1, the inverter shall be marked in accordance with 78.1.

77.2.5 revised May 30, 2008

Table 77.1
Maximum current

Frequency, hertz	Maximum allowable current[a] milliamperes peak
0 – 100	7.07
500	9.4
1000	11.0
2000	14.1
3000	17.3
4000 and more	20.0

[a] Straight-line interpolation between adjacent values in the table may be used to determine the maximum allowable current values corresponding to frequencies not shown.

77.2.5.1 The accessible voltage on an inverter required by 77.2.5 to be marked per 78.1 shall not exceed the voltage versus capacitance values outlined in Table 77.2.

77.2.5.1 added May 30, 2008

Table 77.2
Maximum voltage across capacitance

Voltage across capacitor prior to discharge	Capacitance,[a] microfarads
300	5.86
280	6.57
260	7.43
240	8.49
220	9.81
200	11.5
180	13.7
160	16.8
140	21.0
120	27.4
100	37.4
90	45.0
80	55.2
70	69.9
60	91.8
50	127.0
45	154.0
42.4	172.0

[a] Straight-line interpolation between adjacent values in the table may be used to determine the capacitance corresponding to voltages not shown.

77.2.6 The inverter is to be connected to a circuit of maximum rated input voltage. The voltage from each terminal or output lead for each lampholder to ground or exposed dead-metal parts of the inverter is to be measured under each of the following operating conditions: lamp starting, lamp operation, operation without a lamp, and operation with a deactivated lamp. For a multi-lamp inverter, separate measurements are to be taken with each lamp in succession removed and then replaced. A 500-ohm resistor is then to be connected in turn between each lampholder terminal or output lead and ground or exposed dead-metal parts of the inverter, with the lamp removed, and the current through the resistor measured.

77.2.6 revised May 30, 2008

77.3 Abnormal conditions test

77.3.1 There shall be no risk of fire or electric shock when an inverter is operated at thermal equilibrium under intended conditions as described in 43.2, and the following abnormal conditions are introduced, one at a time, but not necessarily in the order indicated, and applied throughout each complete test:

a) The output leads are to be short-circuited.

b) The inverter is to be operated into a deactivated lamp as specified in 77.3.5.

c) Solid-state components are to be opened or short-circuited to produce worst-case conditions.

d) Polarity of the input supply leads is to be reversed if the polarity protection is not provided, or if provided, the polarity protection can be easily defeated.

During the tests, the sample is to be placed on a softwood surface covered with white tissue paper, and a single layer of cheesecloth as specified in 65.2.1 is to be draped loosely over the entire enclosure. Exposed dead-metal parts are to be connected to earth ground through a 3-ampere, nontime-delay fuse. The test is to be continued for 7 hours or until:

e) A risk of fire or electric shock develops;

f) The inverter's protective device opens;

g) Any other circuit component opens;

h) Operation for the minimum marked rated operating time elapses, circuit conditions stabilize, and there is no further evidence of overheating of parts; or

i) 7 hours of operation elapse, except the duration of the test may be limited by the maximum capacity of the batteries provided to supply the inverter when installed in complete emergency equipment.

77.3.1 revised May 30, 2008

77.3.2 With regard to 77.3.1(e), a risk of fire or electric shock is considered to exist if there is:

a) Glowing, charring, or flaming of the cheesecloth or tissue paper;

b) Opening of the 3-ampere fuse; or

c) Emission of flame, sparks, molten metal, or compound from the inverter enclosure.

77.3.3 With regard to 77.3.1(g), if the test is terminated by the opening of a circuit component, other than an acceptable, circuit-protective device, the test is to be conducted two more times using new samples or new components for each test.

77.3.4 With regard to 77.3.1(h), overheating of parts may be detected by an indicator such as odor, smoke, discoloration, cracking of materials, charring, flaming, glowing, arcing, changes in circuit current through the applied fault, or similar phenomenon.

77.3.5 For the requirements in this standard, a deactivated lamp is simulated by using two double-ended lamps with a lampholder connected to one end of each lamp; for an instant starter circuit utilizing a circuit-interrupting lampholder, the lamp is to be removed and the lampholder contacts are to be shorted together. For a compact fluorescent lamp having two contacts, two lamps are to be used and the supply and ballast connections are to be made to one contact of each lamp. For a compact fluorescent lamp having four contacts, two lamps are to be used and the ballast output connections are to be made to one filament of each lamp.

78 Marking

78.1 An inverter that delivers a current greater than specified in Table 77.1 and that has a voltage to ground greater than 300 volts rms shall be marked with one of the following to indicate the intended use:

a) For use with circuit-interrupting lampholders;

b) For use only with a circular lamp or lamps that require no more than a single lampholder per lamp; or

c) For use only with a recessed-double-contact lamp or lamps.

78.1 revised May 30, 2008

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SUPPLEMENT SA - ALTERNATIVE TEST PROGRAM FOR BATTERY RECOGNITION

Supplement SA deleted May 30, 2008

No Text on This Page

SUPPLEMENT SB - RETROFIT FLUORESCENT FIXTURE INVERTER/CHARGER PACKS

SB1 General

SB1.1 Inverter/charger packs intended for installation within or adjacent to fluorescent luminaires shall comply with applicable requirements elsewhere in this Standard and with the requirements in Sections SB2 – SB6.

SB1.1 revised May 30, 2008

SB2 Mounting and Installation

SB2.1 Inverter/charger packs shall have a means for permanent mounting.

SB2.1 revised May 30, 2008

SB2.2 Installation of an inverter/charger pack in accordance with the installation instructions shall result in an assembly that complies with this Standard.

SB2.2 added May 30, 2008

SB3 Retrofit Trial Installation

SB3 deleted May 30, 2008

SB4 Performance

SB4.1 Inverter/charger packs intended for installation within a luminaire enclosure or above a ceiling shall be subject to the Battery Discharge, Section 46, Temperature, Section 50, and Undervoltage Recharge Capability, Section 52A, Tests in a 55°C (131°F) ambient, or higher if so rated.

SB4.1 revised May 30, 2008

SB4.2 Inverter/charger packs rated for use in ambients below 20°C (68°F) shall be subject to the Battery Discharge, Section 46, and Undervoltage Recharge Capability, Section 52A, Tests under the appropriate ambient conditions as noted in those Sections.

SB4.2 revised May 30, 2008

SB4.3 Inverter/charger packs intended for use in damp or wet locations shall be evaluated in accordance with the applicable requirements of Emergency Lighting and Power Equipment for Use in Damp Locations, Supplement SC, and/or Emergency Lighting and Power Equipment for Use in Wet Locations, Supplement SD.

SB4.3 revised May 30, 2008

SB4.4 Inverter/charger packs intended for use in air handling luminaires shall be evaluated in accordance with the applicable requirements of the Standard for Luminaires, UL 1598.

SB4.4 added May 30, 2008

SB5 Marking and Instructions

SB5.1 An inverter/charger pack shall be marked or provided with instructions to indicate whether it has or has not been investigated for use with electronic and/or magnetic ballasts.

SB5.1 revised May 30, 2008

SB5.2 Deleted May 30, 2008

SB5.3 An inverter/charger pack shall be marked and provided with instructions to indicate whether it has or has not been investigated for use in an air-handling fixture, and whether it is suitable or not in a heated air outlet.

SB5.3 revised May 30, 2008

SB5.4 Deleted May 30, 2008

SB5.5 An inverter/charger pack evaluated and found suitable for use in damp or wet location fixtures shall be marked in accordance with Emergency Lighting and Power Equipment for Use in Damp Locations, Supplement SC, or Emergency Lighting and Power Equipment for Use in Wet Locations, Supplement SD, as applicable.

SB5.5 revised May 30, 2008

SB5.5.1 An inverter/charger pack evaluated and found suitable for use at other than 25°C (77°F), in accordance with SB4.1 and/or SB4.2, shall be marked with its lowest and highest ambient temperature rating.

SB5.5.1 added May 30, 2008

SB5.6 A fluorescent fixture inverter/charger pack that has been investigated and found to comply with the Battery Compartment Ventilation Test, Section 47, is permitted to be marked ″Suitable for installation in sealed or gasketed compartments″, or the equivalent.

SB6 Instruction Manual

SB6.1 The instruction manual for an inverter/charger pack shall include all instructions necessary to install the pack as intended.

SB6.1 revised May 30, 2008

SB6.2 The instruction manual shall specify that the derangement signal (per Section 28) be located such that it is visible after installation from the room (occupied space) side and without the need to move or remove any parts of the equipment.

SB6.2 revised May 30, 2008

SB6.3 Deleted May 30, 2008

SB6.4 Deleted May 30, 2008

SB6.5 Deleted May 30, 2008

SB6.6 Deleted May 30, 2008

SB6.7 Deleted May 30, 2008

No Text on This Page

SUPPLEMENT SC - EMERGENCY LIGHTING AND POWER EQUIPMENT FOR USE IN DAMP LOCATIONS

SC1 General

SC1.1 Emergency lighting and power equipment intended for use in damp locations shall comply with the applicable requirements elsewhere in this standard and with the requirements in Sections SC2 – SC6.

SC1.1 revised May 30, 2008

SC2 Construction – Mechanical

SC2.1 All inside and outside surfaces of sheet steel or other mechanical parts of iron or steel shall be zinc-coated, cadmium-plated, enameled, painted, or provided with equivalent protection against corrosion.

Exception No. 1: Copper, aluminum, alloys of copper and aluminum, stainless steel, and similar materials having inherent resistance to atmosphere corrosion need not be provided with additional corrosion protection.

Exception No. 2: Punched holes and cut edges in ferrous material need not have corrosion protection.

SC2.2 Hinges, bolts, and fasteners made of ferrous materials shall be protected against corrosion as described in SC2.1.

Exception: Hinge pins need not be provided with the corrosion protection described in SC2.1.

SC2.3 Sheet steel or other metal that is painted to comply with SC2.1 shall be properly cleaned of grease and the like prior to painting.

SC2.4 Welds in iron or steel shall be painted or provided with equivalent protection against corrosion.

SC2.5 Vitreous enamel may be used as the only protective coating for sheet steel having a thickness of not less than 0.026 inch (0.66 mm).

SC3 Construction – Electrical

SC3.1 Non-moisture-absorptive electrical insulation shall be used in the construction of electrical components where it is relied upon to provide electrical spacings or direct or indirect support of uninsulated live electrical parts. Untreated fiber is an example of a material that shall not be used; vulcanized fiber, phenolic, urea, porcelain, and the like, are examples of acceptable materials.

SC3.2 The screw shell in a screw shell-type lampholder shall not be made of unplated aluminum.

SC3.3 Single-pin or recessed double-contact lampholders shall be of the weatherproof type or of a type acceptable for use in outdoor enclosed signs.

SC3.4 A ballast shall be of the outdoor or weatherproof type.

SC3.5 A printed-wiring board (PWB) shall be tested per SC3.7, or it shall be completely and uniformly coated on both sides and tested per the Conformal Coating Test Program I, Section 56, or Conformal Coating Test Program II, Section 57.

Exception: PWBs in unvented enclosures sealed by gaskets or the like (such as type 4 or 4X) need not be coated or tested in accordance with SC3.7.

SC3.5 revised May 30, 2008

SC3.6 Deleted May 30, 2008

SC3.7 A sample of the printed-wiring board with components and leads attached shall be placed in an environmental chamber having a relative humidity of 88 ± 2 percent and a temperature of 5°C (9°F) higher than the equipment's rated upper ambient temperature. The sample shall remain in the environmental chamber under these conditions for 1000 hours. At the conclusion of the 1000 hour conditioning and while still in the environmental chamber, the printed-wiring board sample shall be subjected to the Dielectric Voltage-Withstand Test, Section 55, without breakdown as applied between primary and secondary, input connections, output connections, and between primary and any ground traces. Following the Dielectric Voltage Withstand Test, the PWB is to be visually examined for separation of the laminates or other signs of deterioration as a result of the humidity conditioning.

SC3.7 revised May 30, 2008

SC4 Performance

SC4.1 Humidity conditioning

SC4.1.1 For 24 hours prior to, and during, the Temperature Test, Section 50, Dielectric Voltage-Withstand Test, Section 55, and Battery Discharge Test, Section 46, if applicable, equipment shall be placed in a chamber maintained at 88 ±2 percent relative humidity and 5°C (9°F) above the equipment's maximum rated ambient temperature. For equipment rated for both low and high temperature ambients, the humidity conditioning need only occur associated with the high temperature ambient test.

SC4.1.1 revised May 30, 2008

Table SC4.1
Tests after environmental conditioning on damp- location equipment provided with batteries

Table SC4.1 deleted May 30, 2008

SC4.1.2 Deleted May 30, 2008

SC4.1.3 Deleted May 30, 2008

SC4.1.4 Deleted May 30, 2008

SC4.1.5 Deleted May 30, 2008

SC4.2 Tests after low-temperature conditioning on damp-location equipment not provided with batteries using fluorescent or electroluminescent lamps

SC4.2.1 Deleted May 30, 2008

SC5 Rating

SC5 deleted May 30, 2008

SC6 Markings

SC6.1 Equipment that complies with this supplement is permitted to be marked ″Suitable for damp locations.″ The marking shall be visible after installation.

SC6.1 revised May 30, 2008

SC6.2 Deleted May 30, 2008

No Text on This Page

SUPPLEMENT SD - EMERGENCY LIGHTING AND POWER EQUIPMENT FOR USE IN WET LOCATIONS

SD1 General

SD1.1 Emergency lighting and power equipment for use in wet locations shall comply with the applicable requirements elsewhere in this standard and with the requirements specified in this Supplement.

SD1.1 revised May 30, 2008

SD2 Construction – Mechanical

SD2.1 Corrosion protection

SD2.1.1 The inside and outside surfaces of cast ferrous metal, sheet steel, or ferrous tubing shall be protected against corrosion by one of the coatings described in Table SD2.1.

Exception No. 1: Other finishes including paints, special metallic finishes and combinations of the two that have been shown, by comparative tests with galvanized sheet-steel conforming with Type G90, in (A) of Table SD2.1 to provide equivalent protection, may be used.

Exception No. 2: A metal part, such as a decorative part, that is not required for compliance with this standard need not be protected against corrosion.

Exception No. 3: Stainless steel need not be additionally protected against corrosion.

Exception No. 4: Edges, fasteners, and welds complying with SD2.1.2 – SD2.1.5 need not be additionally protected against corrosion.

Exception No. 5: If the equipment is constructed such that no water enters the equipment, or contacts the outside surfaces that are protected from the elements when installed in accordance with the installation instructions (such as the recessed housing of a recessed emergency lighting fixture) during the Rain or Sprinkler Test, the inside surfaces and the outside surfaces so protected may be provided with corrosion protection equivalent to that specified in SC2.1 – SC2.5.

Table SD2.1
Sheet steel coatings

Type of coating	Type or thickness,[a] inch	(mm)	Description
(A) Hot-dipped, mill-galvanized steel	G90[b]		–
	G60[b]		with 1 coat of outdoor paint[c]
	A60[b]		with 1 coat of outdoor paint[c]
(B) Zinc coating other than type (A)	0.00061	(0.0155)[d]	–
	0.00041	(0.0104)[d]	with 1 coat of outdoor paint[c]
(C) Cadmium coating	0.0010	(0.0254)	–
	0.00075	(0.01905)	with 1 coat of outdoor paint[c]
	0.0005	(0.0127)	with 2 coats of outdoor paint[c]
(D) Vitreous enamel[e]	–	–	–

[a] As determined by the Guidelines for Measurement of Electrodeposited Metallic Coating Thicknesses by the Dropping Test, ASTM Method B555-1975.

[b] Conforming with the coating designation G90, G60, or A60 in Table 1 of the Specification for Sheet Steel, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM A653/A653M–94, with not less than 40 percent of the zinc on any side based on the Minimum Single Spot Test requirement in this ASTM standard.

[c] Identified as outdoor paint by paint manufacturer.

[d] Average thickness with a spot minus tolerance of 0.00007 inch (0.00178 mm).

[e] Acceptable on sheet-steel at least 0.026 inch (0.66 mm) thick.

SD2.1.2 Hinges, bolts, and fasteners made of ferrous materials shall be protected against corrosion as described in SC2.1 for damp locations.

Exception: Hinge pins need not be provided with the corrosion protection required in SC2.1.

SD2.1.3 The acceptability of a coating on hinges, bolts, and fasteners may be determined by visual inspection.

SD2.1.4 Punched holes and cut edges in ferrous material need not be corrosion protected.

SD2.1.5 Welds in iron or steel (other than stainless steel) shall be painted with one coat of outdoor paint of a type as specified in Table SD2.1.

Exception: One coat of any indoor paint is acceptable over a spot weld on galvanized steel.

SD2.2 Enclosures

SD2.2.1 An enclosure shall be constructed to prevent the wetting of live parts or electrical components or wiring not identified for use in contact with water, and to reduce the risk of electric shock due to weather exposure. Parts identified for use in contact with water include flexible cords marked with a ″W″, liquid-tight flexible metal conduit, outlet boxes marked for use in wet locations, rigid conduit, and waterproof ballasts. See also 8.5.1 in regards to ventilation of battery compartments.

Exception: For the purposes of this requirement, the outer surface of the glass envelope of a lamp may be wetted.

SD2.2.2 Wall-mounted recessed equipment shall be constructed so it prevents the entrance of any water into the enclosure. The enclosure shall be intended for permanent connection to watertight supply connection fittings.

Exception: If a drain hole as described in SD2.4.2 is provided to drain water from the front of the equipment, water may enter the equipment if there is no wetting of live parts, electrical components, or wiring not identified for use in contact with water, as described in SD2.2.1.

SD2.2.3 To determine compliance with SD2.2.1 and SD2.2.2, a complete assembly is to be subjected to the Rain or Sprinkler test as specified in Performance, Section SD4.

SD2.3 Gaskets and bushings

SD2.3.1 A gasket or bushing used to comply with the requirements for wet locations shall comply with the requirements of the Thermal conditioning test described in SD4.7.2.

Exception: Gaskets or bushings tested while installed in the equipment as described in SD4.7.3 need not be subjected to the test described in SD4.7.2.

SD2.3.2 A gasket shall be secured so that removal of a lamp or opening of glassware or a frame for relamping will not cause the gasket to loosen. Clips or a clamping ring are acceptable means of securement. An adhesive or other means shall be investigated to determine acceptability.

SD2.3.3 If an adhesive is used to secure a gasket as described in SD2.3.2, the gasket assembly shall comply with the Gasket adhesion test described in SD4.8.1.

SD2.4 Openings

SD2.4.1 An opening for the connection of conduit or for an auxiliary part shall be threaded.

Exception No. 1: If the Rain and Sprinkler tests as described in Performance, Section SD4, show no entrance of water into the fixture with the opening or openings open, the opening or openings need not be threaded.

Exception No. 2: If a conduit fitting intended for use in wet locations is provided that complies with the requirements in the Standard for Fittings for Cable and Conduit, UL 514B, the opening or openings need not be threaded.

SD2.4.2 An open drain hole shall be provided on all equipment to prevent the accumulation of water above a level that would result in the wetting of an electrical part or an opening for the connection of conduit or for an auxiliary part. The hole shall be as specified in Table SD2.2 and located such that water will not drain into the building when the equipment is installed as intended. However, drainage onto an exterior building surface is acceptable.

Exception No. 1: Equipment that has been subjected to the Rain or Sprinkler Test as required in SD4.2.1 – SD4.2.3 need not be provided with a drain hole if no water enters the fixture.

Exception No. 2: A drain hole is not required on wall-mounted recessed equipment as described in SD2.2.2.

Exception No. 3: A drain hole is not required in a fluorescent fixture inverter/charger pack intended to be installed inside fixtures.

Table SD2.2
Size of drain holes

Opening shape	Minimum dimension,		Minimum area,		Maximum dimension,		Maximum area,	
	inch	(mm)	inch^2	(mm^2)	inch	(mm)	inches^2	(cm^2)
Slot	1/8 (width)	3.2	0.012	7.74	3/8 (width)	9.5	1-1/2	9.68
Square	1/8 (side)	3.2	–	–	1/2 (side)	12.7	–	–
Round	1/8 (diameter)	3.2	–	–	1/2 (diameter)	12.7	–	–
Irregular	–	–	0.012	7.74	–	–	1-1/2	9.68

SD2.5 Polymeric water shields

SD2.5.1 A polymeric material used as a water shield, whether provided as a lens, diffuser, or opaque part, shall:

a) Be classified at least HB in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, and

b) Comply with the exposure to the Ultraviolet Light Test in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception: Equipment marked suitable for Indoor Wet Locations and not subjected to ultraviolet radiation from integral fluorescent lamps need not be tested for exposure to ultraviolet light.

SD3 Construction – Electrical

SD3.1 Wet-location equipment shall comply with the requirements in SC3.1 – SC3.7.

SD3.1 revised May 30, 2008

SD3.2 Any cord exposed outside of a surface-mount equipment shall be marked with a ″W″ following the type designation.

SD3.3 A switch shall be enclosed.

Exception: The operating button of a momentary-contact test switch as specified in the Test Switch, Section 29, or the key-operated actuator of a disconnect switch as specified in Disconnect Switches and Fuses, Section 31, may protrude outside the enclosure.

SD3.4 Equipment provided with a receptacle shall be constructed to prevent the entrance of water into the receptacle with or without any provided cover in place and with or without an attachment plug in place.

Exception: If water is not excluded during the Rain Test with the receptacle cover open, the cover shall close automatically when not in use.

SD4 Performance

SD4.1 General

SD4.1.1 The requirements specified in SD4.2.1 – SD4.9 apply to all wet-location emergency lighting and power equipment.

SD4.1.1 revised May 30, 2008

SD4.2 Tests required

SD4.2.1 Wet-location equipment shall be subjected to the appropriate Rain and Sprinkler Tests as required in SD4.2.2 and SD4.2.3 and described in SD4.3.1 – SD4.6.3. A summary of the tests required is provided in Table SD4.1.

Table SD4.1
Required tests for wet-location equipment

Type of equipment	Rain	Sprinkler
Surface-mounted ceiling	Yes[a]	Yes[b]
Recessed ceiling	Yes[a]	Yes
Surface-mounted wall	Yes	No
Recessed wall	Yes	No

[a] Test not required if the equipment is marked for covered ceiling installation only as specified in SD4.2.3.
[b] Test not required if the Rain Test is conducted as described in Exception No. 3 to SD4.2.3.

SD4.2.2 Wall-mounted surface equipment and wall-mounted recessed equipment shall be subjected to the Rain Test.

Exception: The Rain Test is not required if the construction is such that it is readily apparent that water will not enter the equipment when installed in the intended manner.

SD4.2.3 Ceiling-mounted equipment shall be subjected to the Rain and Sprinkler Tests.

Exception No. 1: Recessed- or surface-mounted-ceiling equipment need not be subjected to the Rain Test if it is marked "For covered ceiling installation only" in accordance with SD6.3.

Exception No. 2: The Rain and Sprinkler Tests are not required if the construction is such that it is readily apparent that water will not enter the equipment when it is installed in the intended manner.

Exception No. 3: Equipment subjected to the Rain Test with no ceiling above the equipment during the Rain Test need not be subjected to the Sprinkler Test.

SD4.3 General – test conditions

SD4.3.1 Before the Rain or Sprinkler Test is conducted, an enclosure containing an opening for supply connections is to be fitted with the intended supply connection means. However, surface-mounted, outlet box-connected equipment is to be mounted to the wall or ceiling as intended, and the open hole provided for the connection of the power supply is to be sealed with plastic, tape, or the like to simulate a watertight seal between the fixture and a building structure. All sections, fittings, and the like are to be assembled as intended.

SD4.3.2 Equipment marked in accordance with SD6.2 to indicate a limited angle of mounting shall be mounted during a test in the most adverse position permitted by the marking.

SD4.3.3 Equipment intended to be mounted on either a wall or a ceiling shall be treated as both wall-mounted and ceiling-mounted equipment.

Exception: Equipment marked as specified in SD6.3 may be treated as only wall- or ceiling-mounted equipment.

SD4.3.4 The Rain or Sprinkler Test is to be conducted in the following operating sequence:

Duration in hours	Equipment operating?	Water
1/2	Yes	Off
2	No (charging)	On
1	Yes	On
1/2	No (charging)	On

SD4.4 General – test results

SD4.4.1 Test results are acceptable if, after completion of the Water Shield Impact Test (if applicable) and the Rain Test or Sprinkler Test, no water has entered the fixture.

Exception: Water may enter recessed ceiling-, recessed wall-, and surface-mounted equipment if the water does not cause wetting of any wiring devices such as lampholders, wiring, or other electrical parts that are not inherently waterproof and if the equipment is provided with a drain hole as required in SD2.4.2.

SD4.5 Sprinkler test

SD4.5.1 Equipment required to be subjected to the Sprinkler Test shall comply with the requirements in SD4.5.2.

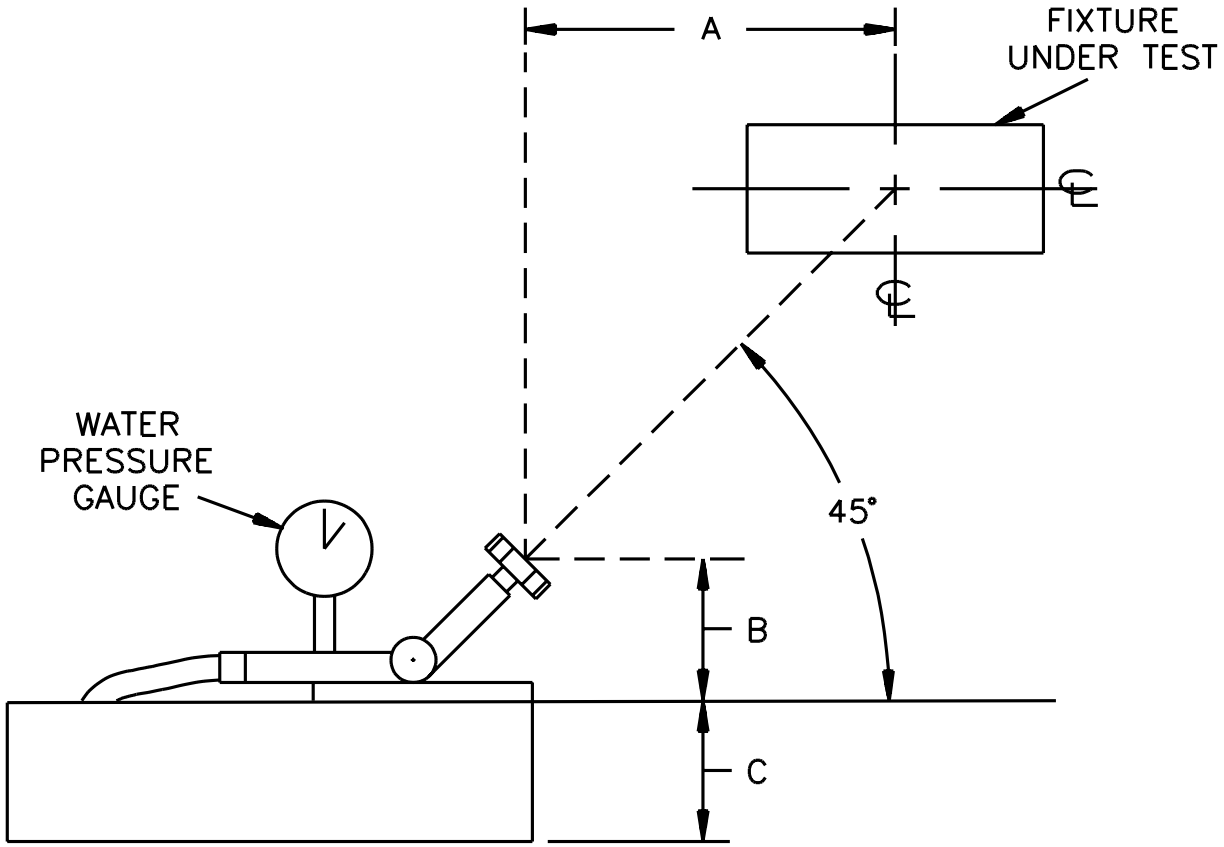
SD4.5.2 The equipment is to be positioned as shown in Figure SD4.1 in front of a standard water spray head of the type shown in Figure SD4.2, to which the water pressure is maintained at a gage pressure of 20 pounds per square inch (138 kPa).

SD4.6 Rain test

SD4.6.1 Equipment required to be subjected to the Rain Test shall comply with the requirements in SD4.6.2 and SD4.6.3.

SD4.6.2 The water spray test apparatus is to consist of three spray heads mounted in a water supply pipe rack as shown in Figure SD4.3. Spray heads are to be constructed in accordance with the details shown in Figure SD4.2. The sample is to be arranged as in a normal installation with conduit connections – without pipe compound – if so intended. The enclosure is to be positioned in the focal area of the spray heads so that the greatest quantity of water is likely to enter the enclosure. The water pressure is to be maintained at 5 pounds per square inch (34.5 kPa) at each spray head.

Figure SD4.1
Representative sprinkler test setup



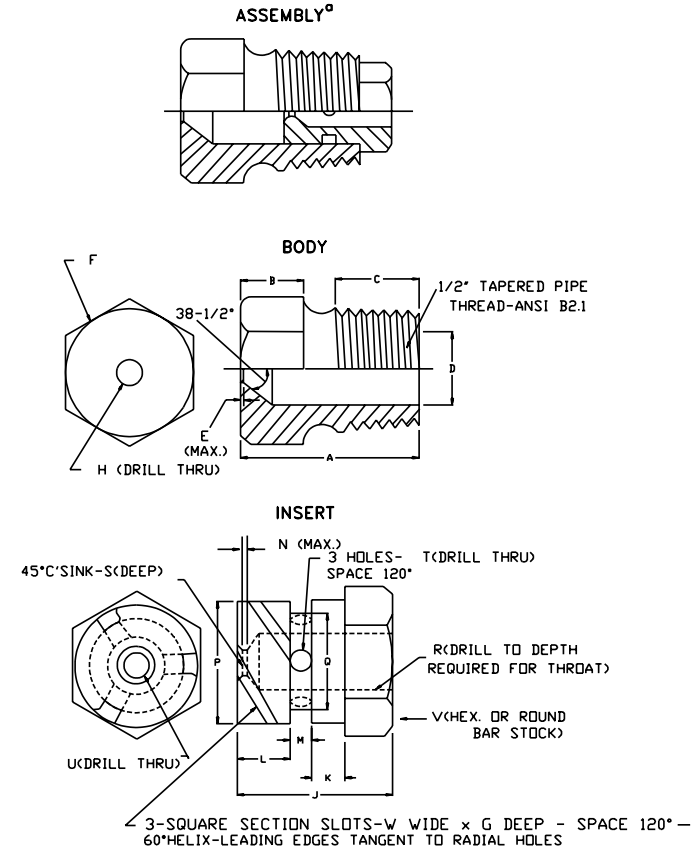
NOTES:

A: 36 inches (914.4 mm)

B: 3 – 6 inches (76.2 – 152.4 mm)

C: Height necessary for the equipment to be mounted as intended with the dimensional center of the equipment on a line projected from the centerline of the nozzle head.

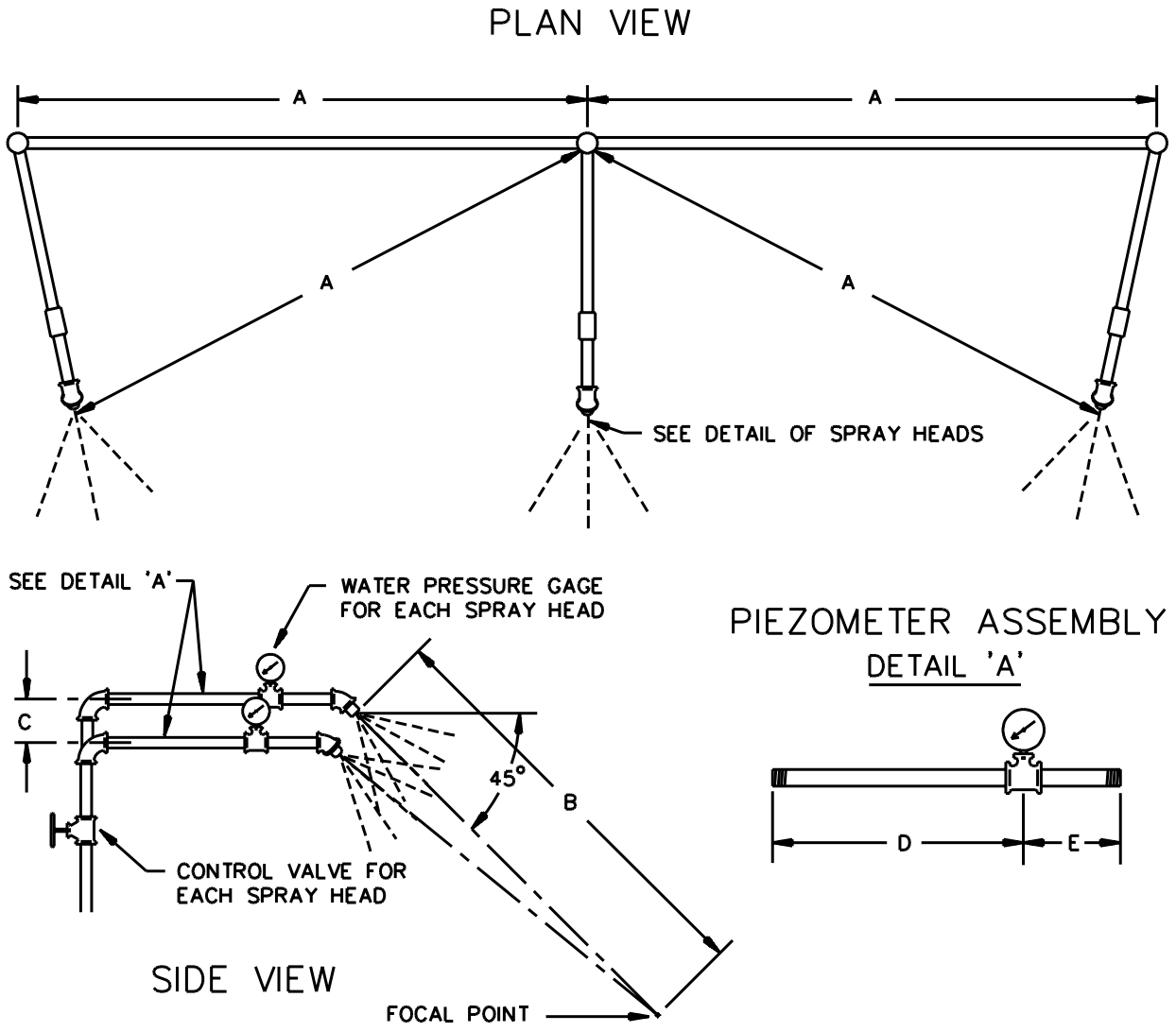
Figure SD4.2
Spray head



Item	inches	(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		.576	14.63
D	.578	14.68	Q	.453	11.51
	.580	14.73		.454	11.53
E	1/64	0.40	R	1/4	6.35
F	c	c	S	1/32	0.80
G	.06	1.52	T	(No. 35)[b]	2.80
H	(No. 9)[b]	5.0	U	(No. 40)[b]	2.50
J	23/32	18.3	V	5/8	16.0
K	5/32	3.97	W	0.06	1.52
L	1/4	6.35			
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.

Figure SD4.3
Spray head piping



Item	inches	(mm)
A	28	710
B	55	1400
C	2-1/4	55
D	9	230
E	3	75

SD4.6.3 Gasketed equipment shall be tested after the Temperature Test or after operation for 1/2 hour, followed by removal and reinstallation of rings, frames, lamps, or other replaceable parts serving to compress the gasket.

SD4.7 Thermal conditioning

SD4.7.1 A polymeric material used as a water shield that is subjected to an operating temperature in excess of 65°C (149°F) as determined by the Temperature Test shall retain its original dimensions and shape after exposure for 1000 hours to a temperature in accordance with Table SD4.2. Exposure time may be reduced by one-half for each increase in oven temperature of 10°C (18°F). If the sample is too large for the test oven, the sample may be cut to fit.

Exception No. 1: A polymeric water shield that also serves as an enclosure and complies with the requirements specified in Polymeric Enclosures, Section 10, need not be tested.

Exception No. 2: A material that possesses a mechanical temperature index, with impact, as a generic rating or as a result of long term aging, of at least the temperature to which it is subjected, need not be tested.

Table SD4.2
1000-hour exposure temperature

Normal temperature on polymeric diffuser or lens material				Oven test temperature,	
Higher than,		No higher than,			
°C	(°F)	°C	(°F)	°C	(°F)
65	149	75	167	85	185
75	167	85	185	95	203
85	185	95	203	105	221

SD4.7.2 A gasket or bushing used to comply with the requirements for wet locations shall, after conditioning for 168 hours in a circulating air oven at a temperature 20°C (36°F) above the temperature measured on the gasket or bushing during the Temperature Test, have a tensile strength of not less than 60 percent and an elongation of not less than 75 percent of the values determined before conditioning.

Exception No. 1: This test need not be conducted if a gasket or bushing is tested while installed in the fixture as described in SD4.7.3.

Exception No. 2: Neoprene rubber is acceptable for 60°C (140°F) and silicone rubber is acceptable for 105°C (221°F) without being subjected to the test.

SD4.7.3 As an alternative to the test described in SD4.7.2, a gasket or bushing used to comply with the requirements for wet locations shall be tested as follows. With the gasket(s) or bushing(s) in place, the equipment is to be conditioned in a circulating air oven for 240 hours at 20°C (36°F) above the temperature measured during the Temperature Test. After the conditioning, any panels that depend upon the gasket or bushing for sealing are to be opened. The results are acceptable if a visual inspection shows no damage to the gasket and the gasket has remained in place. The panels are then to be closed and the equipment subjected to the Rain Test or Sprinkler Test, as appropriate.

SD4.7.4 With regard to SD4.7.3, if more than one gasket is provided and the temperature rise measured on the gasket material during the Temperature Test is not the same for all gaskets, the test described in SD4.7.3 may be conducted at the accelerated aging condition corresponding to the highest temperature rise for the gaskets. Otherwise, a separate sample will need to be tested at each measured temperature rise on the gaskets.

SD4.8 Gasket adhesion test

SD4.8.1 In accordance with SD2.3.3, a gasket secured by an adhesive shall be tested as follows. The force required to remove the gasket from its mounting surface is to be measured while pulling on the edge of the gasket in a plane perpendicular to the surface on which the gasket is mounted. Six samples of the gasket assembly are then to be subjected to the gasket conditioning described in SD4.7.2. The force required to remove the gaskets from the mounting surface is to be measured within 1/2 hour after completion of the conditioning for three of the samples, and 24 hours after the conditioning for the remaining three samples. The results are acceptable if the force necessary to remove the gasket from its mounting surface is at least 60 percent of the value measured prior to the conditioning.

SD4.8.1 revised May 30, 2008

SD4.9 Humidity conditioning

SD4.9.1 For 24 hours prior to, and during, the Temperature Test, Section 50, Dielectric Voltage-Withstand Test, Section 55, and Battery Discharge Test, Section 46, if applicable, equipment shall be placed in a chamber maintained at 88 ±2 percent relative humidity and 5°C (9°F) above the equipment's maximum rated ambient temperature. For equipment rated for both low and high temperature ambients, the humidity conditioning need only occur associated with the high temperature ambient test.

SD4.9.1 revised May 30, 2008

Table SD4.3
Tests after environmental conditioning on wet- location equipment provided with batteries

Table SD4.3 deleted May 30, 2008

SD4.9.2 Deleted May 30, 2008

SD4.9.3 Deleted May 30, 2008

SD4.9.4 Deleted May 30, 2008

SD4.9.5 Deleted May 30, 2008

SD4.10 Tests after low-temperature conditioning on wet-location equipment not provided with batteries and using electric discharge or electroluminescent lamps

SD4.10.1 Deleted May 30, 2008

SD5 Rating

SD5 deleted May 30, 2008

SD6 Markings

SD6.1 Equipment that complies with this supplement is permitted to be marked ″Suitable for wet locations.″

SD6.1 revised May 30, 2008

No Text on This Page

SD6.2 Equipment with adjustable mounting or possible alternative mounting positions shall be marked to indicate the limits of adjustment or mounting position necessary to comply with the test requirements.

SD6.3 Equipment not intended for exposure to rain on the back surface shall be marked:

a) ″For side wall installation only″;

b) ″For ceiling installation only″; or

c) ″For covered ceiling installation only″.

The marking may combine either (a) and (b) or (a) and (c), if the equipment is intended for such use.

SD6.4 The markings specified in SD6.1 – SD6.3 shall be visible after installation.

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SUPPLEMENT SE - ALTERNATIVE REQUIREMENTS FOR TRANSFORMERS

INTRODUCTION

SE1 Scope

SE1.1 These requirements cover transformers used in equipment evaluated for compliance with this Standard. Transformers and their related circuitry shall comply with the applicable requirements of the Standard in addition to those in this Supplement.

SE1.2 This Supplement only addresses the construction and performance requirements for transformers. Products employing a transformer complying with this Supplement shall also comply with the basic requirements contained in this Standard applicable to the type of product.

CONSTRUCTION

SE2 General

SE2.1 A transformer required to provide an isolated secondary circuit shall have an insulation system as described in Table SE2.1.

Exception: A transformer that complies with the construction requirements of UL 506, UL 1310, UL 1411, UL 1585 or UL 5085-1 in combination with either UL 5085-2 or UL 5085-3, as applicable, shall be considered in compliance with Table SE2.1.

SE2.1 revised May 30, 2008

SE2.2 A 2-flange, concentrically wound bobbin relying on sheet or tape insulation between the primary and secondary windings, per items A or C of Table SE2.1, shall provide a continuous minimum 1/32 inch (0.8 mm) wide edge against each bobbin flange.

Table SE2.1
Transformer insulation

Insulation required	Type of insulation
1. Insulation between the primary wires of opposite polarity and between secondary wires of opposite polarity	A, B, C, or D
2. Insulation between the primary and any secondary winding	A, B, C, or D
3. Insulation between any winding or lead connections and dead-metal parts	B, C, D, E, F, or G
4. Insulation between the crossover leads and the turns of a different winding, the metal enclosure of a unit, or the core	A, D, E, G, or H

A – Electrical grade paper that is waxed or otherwise treated to retard the absorption of moisture and that has a total thickness of no less than 0.028 inch (0.71 mm); polyethylene terephthalate film no less than 0.007 inch (0.178 mm) thick; or aromid paper no less than 0.0085 inch (0.216 mm) thick.

B – A thermoplastic or thermoset coil form no less than 0.028 inch thick having a generic or relative electrical thermal index of 105°C (221°F) or higher for class 105 insulation systems.

C – A material having a thickness less than 0.028 inch may be used if it is equivalent to A or B and the material has a minimum dielectric breakdown strength of 5000 volts for the thickness used as determined by the test described in the Test on Transformer Insulating Materials, Section SE7.

D – Spacings specified in Table 37.1 may be used in place of the specified insulation.

Table SE2.1 Continued on Next Page

Table SE2.1 Continued

Insulation required	Type of insulation
E – Electrical grade paper, waxed or otherwise treated to resist the absorption of moisture, having a total thickness of no less than 0.013 inch (0.33 mm) if used in conjunction with an air spacing of one-half that specified in D. F – Electrical grade paper, waxed or otherwise treated to resist the absorption of moisture, having a total thickness of no less than 0.028 inch if the insulation is in contact with the enclosure. G – A material having a thickness less than that specified in E and F may be used if it is equivalent to E and F and the material has a minimum dielectric breakdown strength of 2500 volts for the thickness used for E and 5000 volts for the thickness used for F as determined by the test described in the Test on Transformer Insulating Materials, Section SE7. H – Any type and thickness of insulation in addition to the magnet wire coating, or a through-air spacing less than that specified in Table 37.1 may be used between a crossover lead and the winding to which it is connected if the construction complies with either of the following: 1. The coil withstands the appropriate dielectric withstand potential described in the Dielectric Voltage-Withstand Test, Section SE4. The potential is to be applied between the coil leads with the crossover lead cut at the point where it enters the inner layer. 2. The coil withstands the induced potential described in the Induced Potential Test, Section SE5. *Exception: The insulation is not specified between the crossover lead in the secondary winding of a low-voltage, limited-energy transformer described in Determination of Low-Voltage, Limited-Energy Circuit Status, Section 49, and the following:* *a) The winding to which the crossover lead is connected and* *b) The core.*	

PERFORMANCE

SE3 General

SE3.1 Transformers and associated circuitry shall be tested for compliance with Sections SE4 – SE6. When tested within the end product, the end product shall be connected to a supply circuit of rated voltage and frequency. When tested independently of the end product, the transformer (and related circuitry) shall be connected to a supply circuit of voltage and frequency simulating its intended use within the end product.

Exception No. 1: A transformer need not be tested per SE6.2 when it has been found to comply with the:

a) Abnormal Operation Test of theStandard for Transformers and Motor Transformers for Use in Audio-, Radio-, and Television-Type Appliances, UL 1411, or

b) Abnormal (Burnout) Test of the Standard for Class 2 Power Units, UL 1310.

Exception No. 2: An isolating transformer used in a low frequency inverter need not be tested per SE6.3 when it has been found to comply with the Overload Test of:

a) The Standard for Specialty Transformers, UL 506;

b) The Standard for Class 2 and Class 3 Transformers, UL 1585; or

c) The Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1, and either the Standard for Low Voltage Transformers – Part 2: General Purpose Transformers, UL 5085-2, or the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3, as applicable.

Exception No. 3: A transformer need not be tested per Section SE4 when it has been found to comply with the Dielectric Withstand Test of UL 506, UL 1310, UL 1411, UL 1585, or UL 5085-1 in combination with either UL 5085-2 or UL 5085-3, as applicable.

SE3.1 revised May 30, 2008

SE4 Dielectric Voltage-Withstand Test

SE4.1 The test method described in Dielectric Voltage-Withstand Test, Section 55, shall be performed between:

a) All windings intended to be isolated from one another, and

b) Between each winding and the core or any metal to which the core is conductively connected.

Exception: Test (b) need not be conducted for an encapsulated or electrically insulated (non-accessible) core.

SE5 Induced Potential Test

SE5.1 A transformer constructed per SE2.2, or with crossover lead insulation in accordance with item H of Table SE2.1, shall not exhibit insulation breakdown when subjected to the Induced Potential Test, SE5.2 – SE5.4.

Exception: A transformer that operates above 800 Hz need not be subjected to this test.

SE5.2 The primary winding of the transformer, while in a heated condition from operation as in the Temperature Test or conditioned in an oven to obtain the temperature reached in the Temperature Test, is to be subjected to an alternating potential of twice the rated voltage with the ends of all other windings opened. The potential is to be applied for 7200 cycles or for 60 seconds, whichever is less. An essentially sinusoidal source is to be used, and the frequency of the test is to be in the range of 120 – 1000 hertz.

SE5.3 A 3-phase transformer may be tested with a single-phase voltage. The voltage specified in SE5.2 is to be applied successively across each primary winding.

SE5.4 The test voltage specified in SE5.2 is to be initiated at one-fourth or less of the full value and brought up gradually to the full value in no more than 15 seconds. After being held for the time specified, the voltage is to be reduced slowly, but within 5 seconds, to one-fourth of the maximum value or less, and the circuit opened.

SE6 Abnormal Tests

SE6.1 General

SE6.1.1 A transformer shall not become a risk of fire or electric shock when subjected to the tests specified in SE6.2 – SE6.3 where applicable. Separate representative devices may be used for conducting these tests.

SE6.1.2 Following each test, the Dielectric Voltage-Withstand Test specified in Section SE4, is to be conducted.

Exception: More than one Abnormal Test may be conducted on a representative device, and the Dielectric Voltage-Withstand Test may be conducted after completion of all Abnormal Tests.

SE6.1.3 A risk of fire or electric shock is considered to exist if:

a) There is ignition, glowing, or charring of the cheesecloth or tissue paper or

b) The insulation breaks down when tested in accordance with SE6.1.2.

SE6.1.4 During these tests, the product containing a transformer is to be placed on a softwood surface covered with white tissue paper A single layer of cheesecloth is to be draped loosely over the product.

Exception: The tests may be performed on the transformer not mounted in the product if agreeable to those concerned.

SE6.1.5 The supply circuit is to have branch circuit overcurrent protection, the size of which equals 125 percent of the input current rating of the equipment in which the transformer is intended to be used (20 ampere minimum). When this value does not correspond with the standard rating of a fuse or circuit breaker, the next higher standard device rating shall be used. The test voltage and frequency are to be adjusted to the values specified in SE3.1.

SE6.1.6 Only those primary or secondary protective devices integral to the product complying with the requirements applicable to such devices and to any applicable requirements in this Standard may be connected in the circuit for these tests.

SE6.1.7 Each test is to be continued until further change as a result of the test condition is not likely. If an automatically reset protector functions during a test, the test is to be continued for 7 hours. If a manual reset protector functions during a test, the test is to be continued until the protector operates for 10 cycles using the minimum resetting time, but not at a faster rate than 10 cycles of operation per minute. The following are considered as an acceptable termination of the test:

a) Opening of the intended branch-circuit, overcurrent-protection device described in SE6.1.5.

b) Opening of a protective device indicated in SE6.1.6.

SE6.2 Transformer burnout test

SE6.2.1 An adjustable resistive load is to be connected directly to the secondary winding of each transformer and adjusted to result in the load condition described in (a), (b), or (c) below.

a) For a transformer having a single isolated secondary winding, the load is to be adjusted to result in maximum volt-ampere output but not resulting in more than three times the maximum normal alternating current to flow in the primary winding.

b) For a transformer having multiple isolated secondary windings, each secondary winding is to be tested separately. The winding under test is to be loaded with an alternating current equal to three times the rms value of the secondary current flowing through that winding during maximum normal operation of the unit. Each of the other isolated windings are to be loaded with an alternating current equal to the rms value of the secondary current flowing through their respective windings during maximum normal operation.

c) For an autotransformer, the conditions specified in (a) are to be used with the supply voltage connected to the outer input legs and the load resistor connected to the outer output legs.

Exception No. 1: A transformer supplied from either an inverter circuit or other means limiting the current to the transformer to less than three times rated current is to be loaded to a condition resulting in maximum obtainable input current.

Exception No. 2: A transformer used in a high frequency inverter or converter shall be subjected to the overload test described in SE6.3.4 in lieu of the Transformer Burnout Test.

Exception No. 3: A transformer used in a low-frequency inverter shall be subjected to the overload test in SE6.3.2 and SE6.3.3 in lieu of the Transformer Burnout Test.

Exception No. 4: A transformer that serves as an isolating, low-voltage limited-energy source shall be tested with the secondary winding(s) short-circuited.

Exception No. 5: A ferro-resonant transformer is to be tested with the secondary winding loaded to obtain the maximum input current. The transformer is to be operated continuously until ultimate conditions are observed.

SE6.3 Transformer overload test

SE6.3.1 A transformer used in a low frequency inverter shall be tested per SE6.3.2 and SE6.3.3. A transformer used in a high frequency inverter or converter shall be tested per SE6.3.4.

SE6.3.2 A resistive load is to be connected directly to each transformer secondary winding and adjusted to a value allowing each secondary winding to carry 50 percent of rated load until temperatures of the transformer core become stabilized. The load is then to be increased to 200 percent of the rated value and no further adjustment of the overload current is to be made. The duration of the overload is to be 30 minutes. The short-circuit method as described in the Test Code for Dry-Type Distribution and Power Transformers, ANSI/IEEE C57.12.01-1979, may be used to obtain the 200 percent of rated load current. If the Short-Circuit Test method is used, all secondary windings are to be shorted and the voltage applied to the primary windings is to be adjusted to result in rated current flowing in the secondary windings.

SE6.3.3 Within 1 hour following the Overload Test, the transformer is to be tested for compliance with the following:

a) The Dielectric Voltage-Withstand Test described in Section SE4, except that the test value is to be at 65 percent of the value specified in SE4.1 and

b) The Induced Potential Test, Section SE5.

SE6.3.4 For a high-frequency transformer tested in accordance with Exception No. 2 to SE6.2.1, the power circuit output supplied by the transformer is to be connected to a resistive load that will draw maximum obtainable output power without causing operation of internal overcurrent protection devices or a protection circuit or resulting in opening of a circuit component such as a resistor, solid state device, or the like. This condition is to be held in this position immediately before circuit regulation feedback. Other test conditions and requirements are as specified in SE6.1.2 – SE6.1.7.

SE7 Test on Transformer Insulating Materials

SE7.1 If required by C or G of Table SE2.1, the transformer insulating material shall be subjected to the test described in SE7.2.

SE7.2 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 moveable electrode is to weigh 50±2 grams to exert sufficient pressure on the specimen to provide 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.

SUPPLEMENT SF - EXIT SIGN RETROFIT KITS

INTRODUCTION

SF1 Scope

SF1.1 These requirements cover retrofit kits intended for installation in existing exit fixtures and exit lights to convert the light source from one type to another, for example, from incandescent to fluorescent. A retrofit kit may also convert the light source to a source of different wattage, longer life, or the like.

SF1.2 These requirements cover exit light retrofit kits intended for installation only in existing exit lights energized by an ac power source in the normal mode and by an internal or external dc power source in the emergency mode.

SF1.3 Retrofit kits identified as Type EFI and Type ELI are intended for use in single and double faced panel exit signs with interior dimensions as specified in the manufacturer's installation instructions. Retrofit kits identified as Type EFG and Type ELG are intended for use in single and double faced stencil exit signs having a legend not exceeding 6 inches (152 mm) in height and conforming to a description in the manufacturer's installation instructions. Retrofit kits identified as Type EFS and Type ELS are intended for use with specific models of exit signs.

SF1.4 These requirements cover exit sign retrofit kits that may or may not be intended for permanent connection to the supply circuit.

SF1.5 Exit sign retrofit kits shall comply with the applicable requirements elsewhere in this standard except as modified by the following requirements.

SF1.6 These requirements do not cover exit fixture to exit light conversions.

SF2 Glossary

SF2.1 For the purpose of this standard the following definitions apply.

SF2.2 TYPE EFG (EXIT FIXTURE GENERAL) – An exit fixture retrofit kit intended for use in single and double stencil faced exit fixtures having a legend not exceeding 6 inches (152 mm) in height and conforming to a specific size and description in the manufacturer's installation instructions and provided with replacement diffusers. The visibility of a Type EFG retrofit kit shall be independent of specific exit fixture construction parameters as covered by the performance section of this supplement.

SF2.3 TYPE EFI (EXIT FIXTURE INDEPENDENT) – A self-contained assembly of the light source, light reflecting media, enclosure, diffuser, and legend, (with or without two directional indicators). The kit shall be independent of the exit fixture construction for visibility, and shall only depend upon the existing exit fixture for mechanical support and electrical supply, and not for the physical location of any of its integral components.

SF2.4 TYPE EFS (EXIT FIXTURE SPECIFIC) – An exit fixture retrofit kit intended for use with specific models of exit fixtures. The visibility of a Type EFS kit is permitted to be dependent on the construction of the exit fixture.

SF2.5 TYPE ELG (EXIT LIGHT GENERAL) – An exit light retrofit kit intended for use in single and double stencil faced exit lights having a legend not exceeding 6 inches (152 mm) in height and conforming to a specific size and description in the manufacturer's installation instructions and provided

with replacement diffusers. The visibility of a Type EFG retrofit kit shall be independent of specific exit fixture construction parameters as covered by the performance section of this supplement. A Type ELG kit shall have the emergency input permanently connected by means other than an adapter. See also SF3.1.2.

SF2.6 TYPE ELI (EXIT LIGHT INDEPENDENT) – A self-contained assembly of the light source, light reflecting media, enclosure, diffuser, and legend, (with or without two directional indicators). The kit shall be independent of the exit fixture construction for visibility, and shall only depend upon the existing exit fixture for mechanical support and electrical supply, and not for the physical location of any of its integral components. See also SF3.1.2.

SF2.7 TYPE ELS (EXIT LIGHT SPECIFIC) – An exit light retrofit kit intended for use with specific models of exit lights. The visibility of a Type EFS kit is permitted to be dependent on the construction of the exit fixture. See also SF3.1.3.

SF3 Construction

SF3.1 General

SF3.1.1 For the purpose of this supplement, unless a requirement refers to a specific Type of retrofit kit, the requirement applies to all Types of kits covered by this supplement.

SF3.1.2 A Type ELI or Type ELG exit light retrofit kit shall consume a maximum DC power input of 4 watts if the kit is powered from the battery of the original exit light. If the kit uses the same illumination source for both normal and emergency illumination, the kit shall also be provided with a transfer function to allow for testing of the emergency system when the test switch on the exit light or remote source is depressed. The transfer function shall disconnect or isolate the normal input from the emergency input.

SF3.1.3 A Type ELS retrofit kit that employs the existing emergency illumination source shall comply with the performance section of this standard while using the existing emergency illumination source. A type ELS retrofit kit that includes its own emergency illumination source shall not exceed the emergency illumination source wattage of the original exit light. If the normal and emergency illumination source are the same, the kit shall be provided with a transfer function to allow for testing of the emergency system when the test switch on the exit light or remote source is depressed. The transfer function shall disconnect or isolate the normal input from the emergency input.

SF3.2 Frame and enclosure

SF3.2.1 A Type EFI, Type EFG, Type ELI or Type ELG retrofit kit shall be provided with a frame and enclosure in accordance with the requirements in Frame and Enclosure, Section 8. A Type EFS or Type ELS retrofit kit shall be enclosed to the degree necessary to comply with the requirements in Frame and Enclosure, Section 8, after installation in the intended exit sign.

Exception: The following items need not be enclosed:

a) A lampholder and

b) A component device, such as a ballast, that has an integral outer enclosure in compliance with the requirements for the component.

SF3.3 Mounting

SF3.3.1 A retrofit kit shall have a means for permanent mounting to the exit sign. The mounting means shall not require the drilling of holes into a wireway or splice compartment of the exit sign.

Exception No. 1: Kits that employ screw-type lamps as the replacement light source, without additional electrical components, need not comply with this requirement.

Exception No. 2: Holes may be drilled into a wireway or a splice compartment for a Type EFS or Type ELS retrofit kit intended for permanent connection to the supply circuit.

SF3.3.2 An adhesive used for the mounting of a retrofit kit or diffuser shall be acceptable for the application with regard to the surface material and finish involved, temperature, and other conditions of use. The adhesive shall be investigated in accordance with the requirements for adhesives in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, for application to aluminum, galvanized steel, cadmium plated steel, zinc, and the following types of coatings (paints): acrylic, alkyd, epoxy, and polyester. An adhesive used for the mounting of a retrofit kit or diffuser to an exit sign employing a polymeric enclosure shall additionally be investigated for application to Acrylonitrile Butadiene Styrene (ABS), Polycarbonate (PC), Polyvinyl Chloride (PVC), Polyphenylene, and Polystyrene.

Exception: An adhesive used for the mounting of a Type EFS or Type ELS kit need only be investigated for application to the surface material or finish of the intended exit sign specified on the retrofit kit.

SF3.4 Wiring and connections

SF3.4.1 Conductors and splices shall comply with Installation – Wiring Connections, Section 17, Internal Wiring, Section 19, and Accessibility of Insulated Current-Carrying Parts, Section 39. For the purpose of this requirement, a splice is any point where a wire is connected to another wire. A single wire terminating in a wire connector, or at a wire-binding screw, is not considered to be a splice.

SF3.4.2 An insulated plug and connector assembly may be used without an additional enclosure if it complies with all of the following:

a) It is rated for the maximum temperature, voltage, and current involved;

b) The connector is acceptable for disconnection under load;

c) The plug and connector are inhibited from being inadvertently disconnected by a positive means, such as a latching mechanism for the mated parts;

d) No live parts are exposed when the male and female parts are disconnected as determined in accordance with 8.2.1; and

e) The secureness of the leads at each end is as specified in 19.5.1.

SF3.4.3 A Type EFS or Type ELS retrofit kit intended for permanent connection to the supply circuit shall be provided with supply leads that are 6 inches (152 mm) longer than the distance from the point of exit from the exit sign to the center of the outlet box. A Type EFI, Type EFG, Type ELI, or Type ELG retrofit kit shall be provided with at least 22 inches (559 mm) of supply leads as measured from the point of exit from the retrofit enclosure.

Exception: A kit that is provided with its own enclosure for splices or is intended for use in a specific exit sign that has been investigated as an enclosure need not comply with this requirement.

SF3.5 Assembly

SF3.5.1 A retrofit kit shall be constructed with all electrical components mounted in place and completely wired with all splices and connections made, including the connection of the ballast to the lampholder.

Exception: Connections intended to be made in the field with a keyed insulated plug and connector assembly need not comply with this requirement.

SF3.5.2 A retrofit kit shall be provided with all the parts and components necessary for installation, including input connections.

Exception: A readily available fluorescent lamp found in a lamp manufacturer's catalog need not be provided as part of a kit.

SF3.5.3 When a retrofit kit is installed in the exit sign intended to be retrofitted, as specified in the manufacturer's installation instructions or on the product, the entire assembly shall comply with all of the requirements applicable to exit signs.

SF3.5.4 A retrofit kit shall be constructed so that, after installation in the intended exit sign, in accordance with the manufacturer's instructions or on the product, there will not be any wiring or other components between the light source and the exit legend. This may necessitate provision of wire positioning devices and instructions for routing and securing wires along the contour of the exit sign frame.

SF3.6 Grounding

SF3.6.1 A retrofit kit shall be provided with a means and instructions for bonding all dead-metal parts likely to become energized and that are exposed to contact during routine maintenance, including during lamp or starter replacement, to the exit sign grounding means in accordance with the requirements in Bonding of Internal Parts, Section 21.

SF3.7 Adapter

SF3.7.1 A retrofit kit not intended for permanent connection to the supply circuit shall be provided with an adapter intended to be fitted into a lampholder in an exit sign to provide power for the kit. Such an adapter shall be of the medium, intermediate, candelabra, or bayonet base size and shall comply with the applicable requirements in the Standard for Lampholders, UL 496. If an adhesive secures the screw or bayonet base to the adapter, the construction shall be investigated for compliance with the Base Securement Test described in SF4.9.1.

Exception: A Type ELI, or Type ELS kit may employ a wedge base adapter for emergency input that complies with the applicable requirements in UL 496.

SF3.7.2 The assembly of an adapter and its leads shall withstand a pull of 20 lbf (89 N) when tested in accordance with 19.5.1. If the adapter leads terminate in a connector at the other end, the leads at the connector shall also comply with the requirement in 19.5.1.

SF3.7.3 A Type EFG, Type EFS, Type ELG, or Type ELS kit constructed in the form of a lamp shall additionally comply with the applicable requirements in the Standard for Lampholders, UL 496. If an adhesive secures the lamp or adapter base to the envelope or insulator, the construction shall be investigated for compliance with the Base Securement Test described in SF4.9.1.

SF3.7.4 The overall base height of a lamp or adapter shall not exceed the limit specified in Table SF3.1 for a lamp or other appliance or combination thereof, as measured axially from the bottom of the center contact (including solder) to the upper rim of the bayonet or screw base, including solder or any conducting material.

Table SF3.1
Maximum height of adapter or lamp metal base

Base size	Height,	
	inch	(mm)
Medium	1.0	25.4
Intermediate	0.844	21.44
Candelabra	0.687	17.44
Bayonet	0.793	20.14

SF3.7.5 The screw-base of an adapter or lamp shall comply with the thread specifications contained in Electrical Lamp Bases, ANSI C81.61-1990. Compliance shall be determined by the Lamp Base Conformity Test, Section SF4.10.

SF3.7.6 A filament lead in a screw-base adapter or lamp shall not protrude more than 0.04 inch (1 mm) through the center contact solder on the base. The side solder or side filament lead shall not extend more than 0.04 inch (1 mm) from the side of the screw shell. A filament lead on a bayonet-base adapter or lamp shall not protrude more than 0.04 inch (1 mm) through the double contact solder on the base of the adapter or lamp.

SF3.8 Diffuser

SF3.8.1 A Type EFI or Type ELI kit shall be provided with a minimum of one integral diffuser. A Type EFG or ELG shall be provided with a minimum of two diffusers of the same color.

SF3.8.2 A diffuser shall not be white in color or transparent (clear or with color) and shall comply with the performance requirements of this supplement.

Exception: A Type EFI or Type ELI kit may be provided with a transparent diffuser.

SF3.8.3 The legally required legend and directional indicator, if provided, shall be visible when the illumination source is not energized. A Type EFG or Type ELG retrofit kit is to be installed in an exit sign having a black, white, or silver stencil background. Compliance with this requirement is to be determined in accordance with the Non-Energized Contrast Measurement Test, 41.4.

SF3.8.4 A Type EFI, Type EFS, Type ELI, or Type ELS retrofit kit shall comply with the Non-Energized Contrast Measurement Test, 41.4, when the illumination source is not energized.

SF3.8.5 A retrofit kit provided with a diffuser shall be provided with a means to mount the diffuser to the exit sign.

SF4 Performance

SF4.1 Trial installation test

SF4.1.1 For a Type EFG or Type ELG retrofit kit, the trial installation is to be performed in accordance with the manufacturer's installation instructions in all representative exit signs specified in Tables SF4.1A and SF4.1B. The exit signs are to have their interiors painted flat black (0 percent reflectance) and are to have 6 inch (152 mm) legends and two directional indicators. The diffusers provided with the kit are to replace the original exit sign diffusers.

SF4.1.2 For a type EFI or Type ELI retrofit kit, the trial installation is to be performed in accordance with the manufacturer's installation instructions in exit signs of the smallest and largest interior dimensions as specified with the kit. The sign interiors are to be painted flat black (0 percent reflectance).

SF4.1.3 For a Type EFS or Type ELS retrofit kit, the trial installation is to be performed in accordance with the manufacturer's installation instructions in the exit sign or signs specified on the retrofit kit.

SF4.1.4 Installation is considered acceptable if:

a) The installer is able to complete the installation as intended with the components and instructions provided with the unit (see SF3.5.2);

b) The unit operates as intended;

c) There is no wiring or other component between the light source and the legend and if provided, the directional indicator (see SF3.5.4); and

d) The unit complies with the requirements contained in the Performance Section of this Supplement.

Table SF4.1
Representative exit sign dimensions

Table SF4.1 separated into Tables SF4.1A and SF4.1B May 30, 2008

Sign no.	Exterior dimensions[a]								Distance from exterior side to centerline of lampholder,	
	Width,		Height,		Maximum depth,		Minimum depth,			
	inches	(mm)	inches	(mm)	inches	(mm)	inches	(mm)	inches	(mm)
1	10-1/2	267	7-1/2	191	1-11/16	42.9	–	–	2	50.8
2[d]	10-17/32	268	7-3/4	197	2-11/32	59.5	2-1/16	52.4	3	76.2
3	12	305	8-1/4	210	2-1/4	57.2	–	–	2-1/2	63.5
4[d]	12	305	8-5/16	204	1-9/16	39.7	–	–	3-5/8	92.1
5	12-1/8	308	7-1/2	191	2-1/16	52.4	–	–	4-3/4	121
6	11-1/2	292	7-3/4	197	2-1/2	63.5	–	–	2-3/4	69.9
7[d]	13-5/8	346	8-1/4	210	1-7/8	47.6	–	–	3-3/4	95.3
8[d]	13	330	9	229	3-9/16	90.5	–	–	4-3/4	121

[a] Maximum and minimum dimensions apply to exit signs with tapering frames or with obstruction within the frame.

[b] Largest interior dimension excluding any obstructions.

[c] Smallest interior dimension measured either from the frame of the sign to any obstruction or between any two obstructions excluding a lampholder or lampholders.

[d] Single face exit sign.

Table SF4.1B
Representative exit sign dimensions

Table SF4.1 separated into Tables SF4.1A and SF4.1B May 30, 2008

Sign no.	Interior dimensions[a]											
	Maximum[b]						Minimum[c]					
	Width,		Height,		Depth,		Width,		Height,		Depth,	
	inches	(mm)	inches	(mm)	inches	(mm)	inches	(mm)	inches	(mm)	inches	(mm)
1	10-1/16	256	6-1/4	159	1-9/32	32.5	–	–	–	–	1	25.4
2[d]	10-1/4	260	7-1/2	191	1-7/8	47.6	9-1/2	241	6-1/2	165	1-3/4	44.5
3	11-1/2	292	8	203	2	50.8	–	–	7-1/8	181	–	–
4[d]	11-7/8	302	8-3/16	208	1-7/16	36.5	9-7/8	251	7	178	15/16	23.8
5	12	305	7-7/16	189	1-3/4	44.5	–	–	6-3/4	172	–	–
6	11-3/8	289	7-5/8	194	2-3/8	60.3	–	–	–	–	–	–
7[d]	13-7/16	341	8-1/16	205	1-1/2	38.1	10-1/4	260	6-7/8	175	7/8	22.2
8[d]	12-7/8	327	8-7/8	225	3-1/4	82.6	12-1/8	308	7-7/8	181	–	–

[a] Maximum and minimum dimensions apply to exit signs with tapering frames or with obstruction within the frame.

[b] Largest interior dimension excluding any obstructions.

[c] Smallest interior dimension measured either from the frame of the sign to any obstruction or between any two obstructions excluding a lampholder or lampholders.

[d] Single face exit sign.

SF4.2 Input test

SF4.2.1 The input current and wattage of a retrofit kit shall not exceed the marked rating by more than 10 percent when the unit is operated under the conditions of intended use and connected to a supply circuit of the voltage and frequency specified in 43.2.

SF4.2.2 For a Type EFS or Type ELS retrofit kit, the input current of the kit also shall not exceed the input current of the original illumination source or sources.

SF4.2.3 The emergency input wattage for a Type ELI, Type ELG, or Type ELS kit shall be measured at rated DC voltage or through the rated DC voltage range. The emergency input wattage for a Type ELI or Type ELG kit shall not exceed 4 watts at any rated voltage. The emergency input wattage for a Type ELS kit shall not exceed the DC illumination source wattage for the original exit light.

Exception: A retrofit kit provided with its own illumination source, battery, and charger, need not comply with this requirement.

SF4.3 Temperature test

SF4.3.1 A Type EFG or Type ELG retrofit kit shall comply with the Temperature Test, Section 50, when installed in sign No. 1 specified in Tables SF4.1A and SF4.1B. A Type EFI or Type ELI kit shall be tested when installed in a sign of the smallest interior dimensions as specified with the kit. A Type EFS or Type ELS kit shall be tested in the representative exit sign specified in the manufacturer's installation instructions. A Type ELI, Type ELG, or Type ELS kit provided with emergency illumination sources shall have the temperature measurements taken during normal and emergency modes of operation.

Exception: A Type EFI, Type EFG, or Type EFS fluorescent retrofit kit need not be tested when all the following conditions are met:

a) The wire temperature rating is a minimum of 90°C (194°F);

b) The physical spacing between two or more ballasts is not less than 1 inch (25.4 mm) end-to-end between lamination and 4 inches (102 mm) side-to-side between end bells; and

c) The rating of the insulation system of the ballasts is not greater than 105 or Class A.

SF4.4 Conductor secureness test

SF4.4.1 Supply leads and leads subject to handling during installation and routine maintenance, such as those described in SF3.4.3 and SF3.7.2, shall comply with the requirement in 19.5.1.

SF4.5 Visibility test

SF4.5.1 A Type EFG or Type ELG kit shall be tested in all representative exit signs used for the Trial Installation Test. A Type EFI or Type ELI kit shall be tested in a sign of the largest interior dimensions as specified with the kit. A Type EFS or Type ELS kit shall be tested in the exit sign or signs specified on the retrofit kit.

SF4.5.2 A Type EFI or Type ELI kit shall comply with the Observation Visibility Test, 41.2, or the Luminance Measurement Test, 41.3, when installed in the representative exit sign.

SF4.5.3 A Type EFG kit shall comply with the Luminance Measurement Test, 41.3, conducted on all representative exit signs except that the minimum luminance shall be 6.00 fL (20.56 cd/m^2).

SF4.5.4 A Type EFS kit shall comply with the Luminance Measurement Test, 41.3, conducted on all representative exit signs except that the minimum luminance shall be 4.00 fL (13.70 cd/m^2).

SF4.5.5 A Type ELG kit shall comply with the Luminance Measurement Test, 41.3, conducted on all representative exit signs except that the minimum luminance shall be:

a) 6.00 fL (20.56 cd/m^2) at the rated normal input voltage;

b) 6.00 fL (20.56 cd/m^2) at the rated emergency input voltage, where rated emergency input voltage is defined as nominal battery voltage in increments of 2 volts or 1.2 volts; and

c) 3.60 fL (12.33 cd/m^2) at 87.5 percent of the rated emergency input voltage.

SF4.5.6 A Type ELS kit shall comply with the Luminance Measurement Test, 41.3, conducted on all representative exit signs except that the minimum luminance shall be:

a) 4.00 fL (13.70 cd/m^2) at the rated normal input voltage;

b) 4.00 fL (13.70 cd/m^2) at the rated emergency input voltage, where rated emergency input voltage is defined as nominal battery voltage in increments of 2 volts or 1.2 volts; and

c) 2.40 fL (8.22 cd/m^2) at 87.5 percent of the rated emergency input voltage.

SF4.6 Normal operation test

SF4.6.1 A Type ELI, Type ELG, or Type ELS retrofit kit shall comply with the Normal Operation Test, Section 45, when installed in a representative exit sign with regard to the operation of the transfer function for operation from normal and emergency sources.

Exception: A kit that employs the original emergency illumination source need not comply with this requirement.

SF4.6.2 A Type ELI, Type ELG, or Type ELS kit shall be tested with normal AC voltage supplying the kit and then the rated DC voltage shall be applied to the emergency input of the kit. Verification of operation shall be made such that the illumination source is only operating from the DC supply while AC is still applied.

SF4.7 Voltage surge test

SF4.7.1 A retrofit kit employing solid state components including solid state lamps shall comply with the Voltage Surge Test, Section 54.

SF4.8 Component breakdown test

SF4.8.1 A retrofit kit employing solid state components including solid state lamps shall comply with the Component Breakdown Test, Section 65.

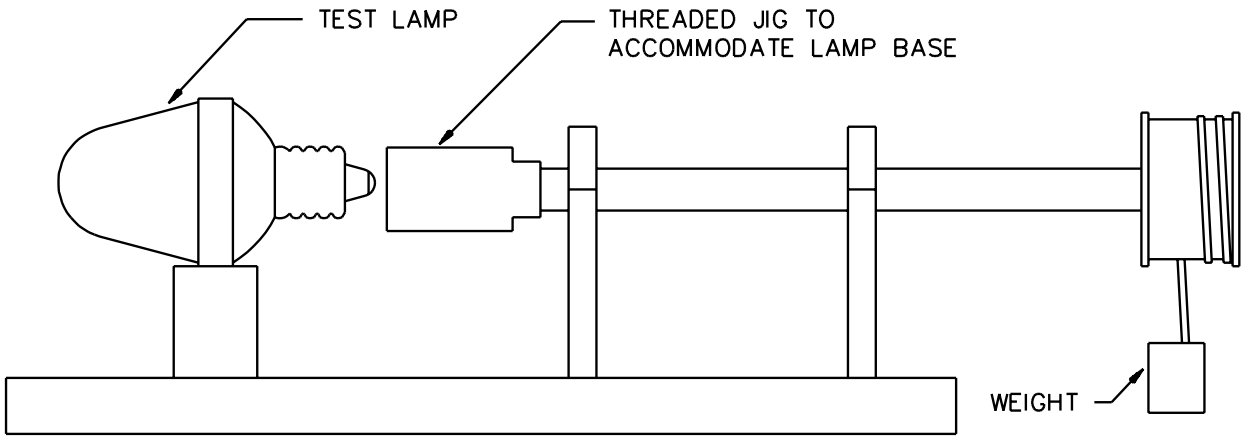
SF4.9 Base securement test

SF4.9.1 The base of a lamp or adapter shall be secured to its envelope or insulator so that the assembly can withstand for 5 seconds a torque as specified in Table SF4.2 without any indication of separation of the envelope or insulator from its base. Six previously untested adapter or lamp bases shall be subjected to this test. Compliance with this requirement may be determined through the use of a test jig as illustrated in Figure SF4.1.

Table SF4.2
Base securement torque

Base size	Torque,	
	lbf·in	(N·m)
Medium	20	2.26
Intermediate	7	0.79
Candelabra	5	0.57
Bayonet	5	0.57

Figure SF4.1
Test jig for base securement torque test



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SF4.10 Base conformity test

SF4.10.1 A bayonet or screw-base adapter or lamp shall comply with the ″Go″ and ″Not-Go″ gauges shown in Table SF4.3. The gauges shall be made and the lamp or adapter shall be tested in accordance with the specifications for Gauges for Electric Lamp Bases and Lampholders, ANSI C81.63-1991. The acceptability of the base shall be determined using the specifications under ″Gauging″ for the ″Go″ and ″Not Go″ gauges for each base type in the Standard for Electric Lamp Bases, ANSI C81.61-1990.

Table SF4.3
Base conformity gauges

Base type	Gauge name	Gauge (standard sheet number)
Candelabra	Threaded ″Go″ Gauge for E12 Candelabra Screw Based Lamps	3-130-1
	″Not-Go″ Ring Gauge for E12 Candelabra Screw Based Lamps	3-132-1
Intermediate	Threaded ″Go″ Gauge for E17 Intermediate Screw Based Lamps	3-144-1
	″Not-Go″ Ring Gauge for E17 Intermediate Screw Based Lamps	3-145-1
Medium	Threaded ″Go″ Gauge for E26 Medium Screw Based Lamps	3-156-1
	″Not-Go″ Ring Gauge for E26 Medium Screw Based Lamps	3-158-1
Bayonet	Threaded ″Go″ Gauge for BA15 Candelabra-Bayonet Based Lamps	3-20-1

Table SF4.3 Continued on Next Page

Table SF4.3 Continued

Base type	Gauge name	Gauge (standard sheet number)
	″Not-Go″ Ring Gauge for BA15 Candelabra-Bayonet Based Lamps	3-21-1

SF4.10.2 Each of the tests in SF4.10.1 shall be performed on six previously untested adapter or lamp bases for each base type.

SF5 Marking

SF5.1 A retrofit kit shall be marked as specified in 70.1.1 (a), (b), and (d). All markings shall be permanent in accordance with 70.1.2. If provided on a label, all markings shall be in black letters on a white background.

SF5.2 A retrofit kit shall be marked with the following or equivalent, ″TYPE ____″. The blank is to be filled in with the Type designation EFI, EFG, EFS, ELI, ELG, or ELS. There shall be only one Type designation on each retrofit kit.

SF5.3 A retrofit kit shall be marked with the rated input voltage, frequency, input current, and input wattage. A Type ELI, Type ELG, or Type ELS kit that is provided with a means for connection to the emergency input for the emergency circuit shall additionally be marked with the DC input voltage and wattage.

SF5.4 A Type EFI, Type EFG, or Type EFS retrofit kit shall be marked, where readily visible during installation, to state that it is not to be used for retrofitting exit lights containing batteries, or exit fixtures connected to a DC source of supply, or exit lights connected to more than one source of supply.

SF5.5 A Type EFG or Type ELG retrofit kit shall be marked with the following or equivalent statement, ″For use only with the exit ____ parameters specified in the installation instructions″. The blank is to be filled in with the word ″fixture″ for a Type EFG retrofit kit, or the word ″light″ for a Type ELG retrofit kit.

SF5.6 A Type EFG retrofit kit shall be marked with the following statement, ″For use in exit fixtures with interior enclosure dimensions of 6-1/4″ H x 9-1/2″ W x 7/8″ D minimum and 8-7/8″ H x 13-7/16″ W x 3-1/4″ D maximum, including all obstructions″.

SF5.7 A Type ELG retrofit kit shall be marked with the following statement, ″For use in exit lights with interior enclosure dimensions of 6-1/4″ H x 9-1/2″ W x 7/8″ D minimum and 8-7/8″ H x 13-7/16″ W x 3-1/4″ D maximum, including all obstructions″.

SF5.8 A Type EFS or Type ELS retrofit kit shall be marked with the manufacturer's name and model number of either the exit fixture or fixtures or the exit light or lights in which it is intended to be used. The model number shall not consist of the series designation only.

SF5.9 A Type EFG or Type ELG retrofit kit shall be marked with the following statement, ″For use in stencil faced exit ____ only. Existing diffuser(s) are to be replaced with supplied diffuser(s).″ The blank is to be filled in with the word ″fixtures″ for a Type EFG retrofit kit, or the word ″lights″ for a Type ELG retrofit kit.

SF5.10 A Type EFI or Type ELI retrofit kit shall be marked with the following statement: ″For use in exit ____ with interior dimensions of ___″ H x ____″ W x ____″ D minimum and ____″ H x _____″ W x ____ ″ D maximum.″ The blank is to be filed in with the word ″fixture″ for Type EFI or the word ″light″ for Type ELI.

SF5.11 A retrofit kit shall be marked with the following:

a) Type EFG or Type ELG only: ″For use with an EXIT legend not exceeding 6 inches (152 mm) in height″;

b) ″Not for use in damp or wet locations″;

Exception: The marking need not be provided for a retrofit kit that has been investigated and found acceptable for use in damp or wet locations.

c) ″For use in metal enclosures only″;

Exception: The marking need not be provided for a retrofit kit that:

1) Complies with the requirement in SF3.3.2;

2) Has components that do not exceed a 25°C temperature rise as measured during the Temperature Test, SF4.3; and

3) Either:

i) Has been investigated for use in exit signs having a polymeric enclosure and found to comply with the applicable requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, or

ii) Is not provided with a transformer or ballast.

d) ″Not for use in recessed enclosures″;

Exception: The marking need not be provided for a retrofit kit that has been investigated and found acceptable for use in recessed exit signs.

e) For kits employing electroluminescent or fluorescent lamps: ″Not for use in temperatures below 20°C (50°F)″;

Exception: The marking may indicate a lower temperature in 5°C increments for a retrofit kit that has been investigated and found acceptable for use at a lower temperature

f) ″The current rating of the kit multiplied by the voltage rating of the kit shall not exceed the total wattage of the lamps replaced″; and

Exception: The marking need not be provided for a Type EFS or Type ELS kit.

g) ″Remove all original lamps before installing.″

Exception: The marking of a Type ELS kit shall indicate which of the original lamps are to be removed.

SF5.12 A retrofit kit shall be marked with the lamp replacement markings specified in 42.3, 42.4, and 42.7. Retrofit kits that do not provide enough space for these markings on the product shall include a user-installed lamp replacement label in accordance with 70.1.2(c) and with instructions for placement and surface preparation. Lamp replacement markings shall be visible during lamp replacement. See also SF6.1(h)(5).

SF5.13 If the retrofit kit construction does not allow space for the markings specified in SF5.6 – SF5.11 on the product, the markings shall be located on a tag in accordance with SF5.17. The markings shall be in black letters on a white background and shall not be less than 1/16 inch (1.6 mm) in height. In addition, the following statements shall be at the top of the tag in letters not less than 1/8 inch (3.2 mm) in height and in the following order, ″DO NOT REMOVE THIS LABEL UNTIL READY FOR INSTALLATION. IMPORTANT SAFEGUARDS – READ AND FOLLOW THESE INSTRUCTIONS BEFORE INSTALLING″.

SF5.14 A retrofit kit intended to be permanently connected to the supply circuit shall be marked with the following or equivalent statement, ″CAUTION – See instruction manual for installation, operation, and maintenance instructions″.

SF5.15 A Type ELG kit shall be marked with the following or equivalent statement, ″Remove DC lampholders from exit light prior to installation″.

SF5.16 A Type EFS or Type ELS retrofit kit shall be marked on a separate tag in accordance with SF5.17 with the following, ″DO NOT REMOVE THIS LABEL UNTIL READY FOR INSTALLATION″. The marking shall be in red letters on a white background and shall not be less than 1/8 inch (3.2 mm) in height. The following shall be located a minimum of 1/2 inch (12.7 mm) below the first marking, ″CAUTION – THIS RETROFIT KIT IS INTENDED FOR INSTALLATION IN A SPECIFIC EXIT SIGN WHOSE MODEL NUMBER AND MANUFACTURER'S NAME APPEAR ON THIS PRODUCT. DO NOT INSTALL IN ANY EXIT SIGN UNLESS THE INFORMATION MATCHES EXACTLY. IF INCORRECTLY INSTALLED, THIS PRODUCT MAY NOT COMPLY WITH LOCAL AND NATIONAL CODES WITH REGARD TO A LIFE SAFETY DEVICE (EXIT SIGN) AND MAY ADDITIONALLY CREATE A RISK OF FIRE″.

SF5.17 The tag markings in SF5.13 and SF5.16 shall be field removable, located within 2 inches of the input connection and shall be one of the following forms:

a) A flat tag having a hole large enough to accommodate the adapter base for a lampholder or a lamp base, but neither so large nor so positioned that the tag can be removed without effort from the adapter or lamp base during handling or transit. The tag is not to be slit from the hole. The same markings are to be located on both sides of the tag;

b) A flag-type tag with an adhesive back. The tag is to be wrapped tightly once around and adhere to the input leads. The ends of the tag are to adhere to each other and project as a flag. The same markings on the tag are to appear on each side, so as not to wrap around the flag-type tag; or

c) A tie-on tag with the same markings located on both sides, where the tie-on tag can be secured to the installation leads without damage to the insulation during installation or removal.

SF6 Instruction Manual

SF6.1 Each retrofit kit shall be provided with an instruction manual. The instructions shall be in black letters on a white background and shall be in letters not less than 1/16 in (1.6 mm) in height. The statement ″READ AND FOLLOW THESE INSTRUCTIONS″ shall precede the list of instructions, and the statement ″DO NOT USE IF PRODUCT AND ITS USE DO NOT COMPLY WITH THE ABOVE″ shall follow the list. These statements shall be in upper-case letters not less than 3/16 inch (4.8 mm) in height. The instructions shall include the following:

a) A warning to make sure power is off before attempting installation.

b) A statement that a retrofit kit intended to be permanently connected to the supply circuit is to:

1) Be installed by qualified personnel in accordance with the applicable codes;

2) Be subject to inspection by the authorities having jurisdiction; and

3) Contain supply connections intended to be made outside the exit sign housing and within the outlet box to which the exit sign is connected.

Exception: A kit that is provided with its own enclosure for splices or is intended for use in a specific exit sign that has been investigated as an enclosure need not comply with the requirement in (3).

c) A statement that the retrofit installation shall be done with consideration to the requirements of the applicable codes, particularly with regard to retrofitting a two-lamp exit sign with a one-lamp retrofit kit, or when the kit interferes with transmission of light through the bottom opening which may affect the illumination level on the floor.

d) A statement that the retrofit kit is for installation in an exit sign that:

1) For a Type EFI, Type EFG, or Type EFS kit: Is supplied by only one source of power that is neither batteries or a DC power supply;

2) For a Type EFI, Type EFG, or Type EFS kit: Contains no batteries or DC lamps;

3) Is not of the edge-lit construction;

4) Is not of the flashing type or connected to a flasher control;

Exception: This item is not required for a retrofit kit that uses light sources other than fluorescent lamps.

5) For a Type EFG or Type ELG kit: Has a stencil faced design only;

6) For a Type EFG or Type ELG kit: Has interior enclosure dimensions of 6-1/4″ H x 9-1/2″ W x 7/8″ D minimum and 8-7/8″ H x 13-7/16″ W x 3-1/4″ D maximum, including all obstructions;

7) For a Type EFI or Type ELI kit: Has interior dimensions of ____″ H x _____″ W x _____″ D minimum and _____″ H x _____″ W x _____″ D maximum.

8) For a Type EFG or ELG kit: Has an EXIT legend not exceeding 6 inches (152 mm) in height;

9) Has a metal enclosure;

Exception: This item may be omitted for a retrofit kit that:

a) Complies with the requirement in SF3.3.2;

b) Has components that do not exceed a 25°C temperature rise as measured during the Temperature Test, SF4.3; and

c) Either:

1) Has been investigated for use in exit signs having a polymeric enclosure and found to comply with the applicable requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C; or

2) Is not provided with a transformer or ballast.

10) Is not installed in a damp or wet location;

Exception: This item may be omitted for a retrofit kit that has been investigated and found acceptable for use in damp or wet locations.

11) Is not recessed mounted; and

Exception: This item may be omitted for a retrofit kit that has been investigated and found acceptable for use in recessed exit signs.

12) Is not for use in temperatures below 20°C (50°F) if the kit uses electroluminescent or fluorescent lamps.

Exception: This item may indicate a lower temperature in 10°C increments for a retrofit kit that has been investigated and found acceptable for use at a lower temperature.

e) An instruction that:

1) The wattage rating of the kit shall not exceed the total wattage of the lamps replaced;

Exception: The instruction manual of a Type EFS or Type ELS kit need not contain this instruction.

2) The current rating of the kit multiplied by the voltage rating of the kit should not exceed the total wattage of the lamps replaced; and

Exception: The instruction manual of a Type EFS or Type ELS kit need not contain this instruction.

3) The current rating of the kit multiplied by the total number of kits installed in exit signs on a branch circuit shall not exceed 80 percent of the rating of the branch circuit protective device.

f) An instruction that all original lamps are to be removed.

Exception: The instruction manual of a Type ELS kit shall indicate which of the original lamps are to be removed.

g) For a retrofit kit intended for permanent connection that is provided with two or more lamps required to be connected in parallel and are provided with separate field wiring input leads: An instruction that the retrofit kit is for connection to a single source of supply such that all lamps are simultaneously illuminated.

Exception: If the retrofit kit is marked with the above statement on the product, this instruction may be omitted from the instruction manual.

h) Detailed instructions for the installation of the kit, including illustrations. These shall include, but not be limited to, the following:

1) Instructions for positioning of the kit and orientation of the lamps. The instruction shall warn against positioning the kit so as to obstruct any vent openings;

2) Instructions for securement of the kit assembly, routing and securement of wiring, connection of bonding means for grounding, and the like. When an adhesive is used for mounting the kit assembly, the instructions shall provide details of surface preparation and application method;

3) Instructions for a retrofit kit intended for permanent connection to the supply circuit regarding:

i) Dismounting of the exit sign to access the supply connections, and disconnection and removal of the leads and any components that are required to be removed in order to successfully retrofit the exit sign.

ii) Routing of the leads of the retrofit kit through an opening in the exit sign housing intended for the purpose (for example, one that is provided with smooth or rounded edges) to the supply connection point in the junction box to which the sign was connected;

4) Instructions for a kit provided with a diffuser to indicate:

i) That the existing diffusers are to be replaced with the supplied diffusers;

ii) How to prepare the supplied diffusers for use in the exit sign intended to be retrofitted; and

iii) How to mount the diffusers.

5) For a kit provided with user-installed lamp replacement labels in accordance with SF5.11: Instructions to secure the lamp replacement marking to the enclosure in a location that will be visible during relamping.

i) For a Type ELI or Type ELG kit: Instructions to indicate that if the exit light intended to be retrofitted is not marked with the DC output voltage rating or DC lamp voltage replacement marking, the installer should operate the exit light in the emergency mode for one minute with the original lamps and measure the voltage under load to determine the output voltage and the suitability of the retrofit kit with the exit sign. The voltage should be in multiples of 1.2 or 2.0 volts (for example, 3.6, 4.8 or 4.0, 6.0 volts).

j) For a Type ELG kit: Instructions to indicate that the DC lampholders are to be removed prior to installation.

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SUPPLEMENT SG - PHOTOLUMINESCENT EXIT SIGNS

SG1 General

SG1.1 Photoluminescent signs with a legally required legend such as ″EXIT″, with or without directional indicators, shall comply with the requirements elsewhere in this Standard as supplemented or modified by this Supplement.

SG1.2 Photoluminescent signs evaluated in accordance with this Standard are complete assembled units ready for installation. Adhesively secured directional indicators are permitted to be field installed, as permitted by 40.11(c), when the installation location of the indicators is integrally identified on the sign and the sign is tested with the indicators installed in accordance with the Supplement. All other decals, pigments, markings, etc., must be applied by the manufacturer and are not eligible for field installation or modification.

SG1.3 Photoluminescent signs evaluated in accordance with this Supplement are for indoor dry or damp locations where not exposed to direct unfiltered sunlight, liquids, or temperatures outside the range of 10 – 40°C (50 – 104°F).

Exception: Signs that have been tested in accordance with SG4.1.3 are considered suitable for wet locations and are permitted to be marked accordingly.

SG1.3 revised May 30, 2008

SG2 Mechanical Construction

SG2.1 A photoluminescent sign shall be provided with a rigid structure or mounting means so that the sign remains flat when mounted as intended.

SG2.2 Photoluminescent pigments shall be applied uniformly across the legend and any directional indicators, or across the sign background, in the minimum coating thickness and/or pigment density evaluated for compliance with the Visibility Tests of SG4.2.

SG2.3 A photoluminescent sign shall be provided with a means to securely fasten the sign to a mounting surface so it cannot be removed or repositioned without the use of a tool. Adhesive shall not be provided as the sole means for mounting.

SG2.3 revised May 30, 2008

SG3 Legend dimensions

SG3.1 A photoluminescent sign shall comply with the dimension and location requirements for the legend and directional indicators, if applicable, per Exit Sign Visibility, General, Section 40.

SG4 Performance

SG4.1 Sample conditioning

SG4.1.1 Mold Stress Relief

SG4.1.1.1 Prior to any other conditioning or testing, photoluminescent signs with a polymeric structure are to be conditioned for 7 hours in an oven maintained at 70° C (158° F). Upon removal from the oven, the samples shall be examined for damage, distortion, or warping that could affect the legibility of the sign. The samples are then to be stored in a dark environment of standard atmosphere and room temperature for minimum 24 hours prior to any further conditioning or testing.

SG4.1.1.1 revised May 30, 2008

SG4.1.2 Humidity Exposure

SG4.1.2.1 All photoluminescent exit signs are to be exposed for 72 hours in a chamber maintained at 32°C (90°F), 85 percent R.H.

SG4.1.2.2 Upon removal from the humidity chamber, the samples are to be stored in a dark environment of standard atmosphere and room temperature for minimum 24 hours prior to initiation of the Visibility Tests.

SG4.1.2.2 revised May 30, 2008

SG4.1.3 UV Exposure

SG4.1.3.1 Photoluminescent exit signs intended for outdoor wet locations shall be subjected to the ultraviolet light exposure test conditions of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, instead of the Humidity Exposure of SG4.1.2.1.

SG4.1.3.1 added May 30, 2008

SG4.1.3.2 Upon removal from the UV exposure chamber, the samples are to be stored in a dark environment of standard atmosphere and room temperature for minimum 24 hours prior to initiation of the Observation Visibility Test (41.2).

SG4.1.3.2 added May 30, 2008

SG4.2 Visibility tests

SG4.2.1 Light Exposure

SG4.2.1.1 Signs that have been conditioned per SG4.1 shall be subjected to the applicable exposure conditions of SG4.2.1.2. Each sample set shall be exposed to only one type of illumination source. The number of samples per set shall be determined by the particular visibility test conducted per SG4.2.2 or SG4.2.3.

SG4.2.1.2 A sample set shall be exposed for 60 minutes to one or more of the following light sources, as appropriate for the product markings required by SG5:

a) An incandescent lamp at 1 ft-c illuminance;

b) An incandescent lamp at 5 ft-c illuminance with the sign marked in accordance with SG5.2;

c) A fluorescent lamp at 5 ft-c illuminance with the sign marked in accordance with SG5.3;

d) Any other light source type at 5 ft-c illuminance with the sign marked in accordance with SG5.4.

SG4.2.1.3 Illuminance levels noted in SG4.2.1.2 are to be measured on the face of the sign and shall be uniform within ±10 percent across the sign face. Lamps used for exposures SG4.2.1.2(a) and SG4.2.1.2(b) shall be as specified in Table SG4.1. Light sources used for exposure SG4.2.1.2(d) shall be as specified in the product marking in accordance with SG5.4.

SG4.2.1.3 revised May 30, 2008

Table SG4.1
Lamp parameters for sign exposure

Table SG4.1 added May 30, 2008

Lamp type	Description	Color temperature
Incandescent	Soft white, seasoned minimum 45 minutes	2700 – 3000 K
Fluorescent	Straight tube, T8 or T12, seasoned minimum 100 hours	4000 – 4500 K
Metal Halide	Seasoned minimum 100 hours	4000 – 4500 K
Mercury Vapor	Seasoned minimum 100 hours	3500 – 4000 K
High Pressure Sodium	Seasoned minimum 100 hours	2000 – 2500 K

SG4.2.1.4 Photoluminescent signs shall comply with Section 41 (Performance) as modified in this section. All samples are to be conditioned per SG4.1 and exposed to light as specified in SG4.2.1.2.

SG4.2.1.5 Photoluminescent signs subjected to the Luminance Measurement Tests shall be evaluated in accordance with SG4.2.2. Photoluminescent signs subjected to the Observation Visibility Tests shall be evaluated in accordance with SG4.2.3.

SG4.2.2 Luminance Measurements

SG4.2.2.1 Luminance measurements shall be in accordance with Luminance Measurement Test, Section 41.3, and Non-Energized Contrast Measurement Test, Section 41.4, for ″EXIT″ text legends and directional indicators, measurements shall be taken at the following points:

a) Figure 41.1 – Legend points 7, 12, 16, 19 and background points 2, 7, 9, 15, 17, and 22;

b) Figure 41.6 – Direction indicator points D1, D3, D5 and background points B1, B3, B5, and B7.

Luminance measurement sets are to begin at 1 minute and again at 90 minutes after removal from the light source, or longer if the sign is marked with a rated operating time greater than 90 minutes. The time (relative to removal from the light source) is to be recorded for each measurement. After the last point of a measurement on a sign is recorded, the first point of that set is to be re-measured. All measurements within a measurement set on a single sample shall be completed within 10 minutes. A linear luminance decay rate for a measurement set is to be calculated by subtracting the final measurement from the first measurement and dividing by the time that transpired between the measurements. The luminance levels of all other points measured on that sign are to be adjusted (upwards) in accordance with this decay rate. These recalculated luminance levels shall be used to determine compliance with Section 41.3.

SG4.2.2.1 revised May 30, 2008

SG4.2.3 Observation Visibility Tests

SG4.2.3.1 Observation of each candidate sign shall begin 90 minutes after removal from the light source, or longer if the sign is marked with a rated operating time greater than 90 minutes. The sign shall be kept in complete darkness until the observations begin.

SG4.2.3.2 Photoluminescent signs subjected to the Observation Visibility tests shall also comply with the visibility requirements of the Non-Energized Contrast Measurement Test, Section 41.4.

SG5 Markings and Installation Instructions

SG5.1 Photoluminescent exit signs tested in accordance with exposure conditions (b), (c), or (d) of SG4.2.1.2 shall be permanently marked to specify the required light type and minimum illuminance level in accordance with SG5.2, SG5.3, and/or SG5.4. Markings shall be visible after installation (for example, on the sign face or an exposed frame member). The letters shall be a minimum 1/16 inch (1.6 mm) high. The markings shall be paint-stencilled, die-stamped, indelible lettering, or on a label system suitable for the surface that complies with the Standard for Marking and Labeling Systems, UL 969. All lettering shall be of a color that contrasts with the background.

SG5.1 revised May 30, 2008

SG5.2 Photoluminescent exit signs tested in accordance with exposure condition (b) of SG4.2.1.2 shall be marked ″Min 5 fc external light on sign face at all times of building occupancy.″

SG5.2 revised May 30, 2008

SG5.3 Photoluminescent exit signs tested in accordance with exposure condition (c) of SG4.2.1.2 shall be marked ″Min 5 fc fluorescent light on sign face at all times of building occupancy.″

SG5.3 revised May 30, 2008

SG5.4 Photoluminescent exit signs tested in accordance with exposure condition (d) of SG4.2.1.2 shall be marked ″Min 5 fc _____ light on sign face at all times of building occupancy.″ The blank shall specify the manufacturer, catalog number, and type of lighting source used for testing.

Exception: A photoluminescent exit sign tested in accordance with both exposure conditions (c) and (d) of SG4.2.1.2 may be marked with a single statement combining the information from SG5.3 and SG5.4.

SG5.4 revised May 30, 2008

SG5.5 All photoluminescent exit signs shall be provided with installation instructions that include the following two statements verbatim:

″CAUTION: EXTERNAL ILLUMINATION SOURCE REQUIRED″

and

″SAVE THESE INSTRUCTIONS FOR FIRE SAFETY INSPECTIONS″.

Additionally, the instructions shall include the following information in any convenient format:

a) Identification of the minimum required external illumination charging source in accordance with the testing conducted under SG4.2.1.2;

b) Instructions to select or install an external illumination source that is deemed reliable and is supplied by a circuit not controlled by automatic timers or sensors that turn off the charging light when the building is occupied, and whose controls are accessible only to authorized personnel;

c) Instructions that the external illumination source is to be energized at all times during building occupancy;

d) Instructions that lighting levels on the sign are to be reassessed after any changes in external lighting types or levels to determine that the sign is still being illuminated in accordance with its Listing;

e) Instructions to periodically clean the sign face with a damp cloth or as otherwise recommended by the manufacturer;

f) Instructions to conduct periodic visibility tests in accordance with the applicable installation code (such as NFPA 101); and

g) If applicable, instructions to install the sign indoors only, where not exposed to direct unfiltered sunlight, liquid spray, or temperatures outside of the range 10° – 40°C.

SG5.5 revised May 30, 2008

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SUPPLEMENT SH - MINIMUM LIGHT OUTPUT FOR EMERGENCY LIGHTING EQUIPMENT

SH1 Introduction

SH1.1 The Life Safety Code, NFPA 101, and the Uniform Fire Code, require an initial average 1 ft-candle lighting level along the identified means-of-egress. This lighting is typically provided by unit equipment or other luminaires connected to an emergency power source and/or by luminaires with an integral (battery) emergency supply. Equipment intended to serve this purpose shall comply with the minimum light output performance criteria of this section so that when properly selected, installed, and maintained, facility conformance with the applicable means-of-egress lighting levels can be obtained.

SH1.2 These requirements are supplementary to all other applicable requirements of this Standard. Degradation of light output due to battery discharge, light source deterioration, or other factors is not considered under this section. These factors are covered elsewhere or are beyond the scope of this Standard.

SH2 Construction

SH2 deleted May 30, 2008

SH3 Performance

SH3.1 Individual luminaires shall provide a minimum 1.0 ft-candle of illuminance measured at each of two points no less than one foot apart on the floor, when tested in accordance with SH3.3 – SH3.4.

SH3.1 revised May 30, 2008

SH3.2 Photometric data from a suitably equipped and accredited laboratory* may be used to demonstrate conformance to the minimum floor light levels specified in SH3.1, without further tests. The photometric data shall be adjusted, as needed, to be determined as equivalent to or more severe than the mounting, wall reflectance, and orientation test conditions of SH3.3.

*NVLAP accredited for LM-41 (IES approved method for photometric testing of indoor fluorescent luminaires) or LM-46 (Photometric testing of indoor luminaires using high intensity discharge or incandescent filament lamps), as applicable.

SH3.3 The test chamber shall be of any convenient size sufficient for this test, with all interior surfaces painted flat black and an interior ambient light level of 0.01 ft-candle (0.108 lux) or less. The luminaire under test shall be mounted in the chamber with no part of the luminaire less than 7.17 feet (2.2 m) above the floor, centered along a wall or on the ceiling, in accordance with its intended use. If adjustable, a lamphead is to be oriented to provide maximum illuminance on the floor. Inverter packs are to be connected to or installed within a luminaire in accordance with the manufacturer's instructions.

Exception: The luminaire under test may be mounted at a lesser height if it has a horizontal projection from the wall surface of 4 inches (101.6 mm) or less when mounted as intended. The test height shall be in accordance with the maximum mounting height marked on the product, per SH4.1.

SH3.4 A luminaire powered by an integral battery shall be tested using an external power supply set at the DC voltage level measured one minute into the Battery Discharge Test, Section 46. A luminaire powered by an external supply is to be operated at rated input voltage. Incandescent luminaires shall be new; fluorescent luminaires shall be conditioned for 100 hours prior to testing. Other lighting technologies are to be ″seasoned″ only to the extent necessary for light output stability.

SH3.5 A luminaire tested at a height of four feet or lower, as permitted by the Exception to SH3.3, shall also comply with the Impact Test, Section 67.

SH4 Marking

SH4.1 A luminaire tested at a lesser mounting height per the Exception to SH3.3 shall be marked ″Max. mounting height: ____ ft″ or the equivalent. This marking shall be on the packaging, in the installation instructions, and on the product in a location visible during installation. It is not prohibited that a luminaire tested at a greater height than required by SH3.3 be marked as suitable for the height at which it was tested.

APPENDIX A

Standards for Components

Standards under which components of the products covered by this standard are evaluated include the following:

Title of Standard − UL Standard Designation

Attachment Plugs and Receptacles – UL 498
Ballasts, Fluorescent-Lamp – UL 935
Cables, Nonmetallic-Sheathed – UL 719
Capacitors – UL 810
Circuit Breakers, Molded-Case, Molded-Case Switches, and Circuit-Breaker Enclosures – UL 489
Control Panels, Industrial – UL 508A
Cord Sets and Power-Supply Cords – UL 817
Equipment, Industrial Control – UL 508
Equipment, Transfer Switch – UL 1008
Flexible Cords and Cables – UL 62
Lampholders – UL 496
Lamp Starters, Fluorescent – UL 542
Luminaires – UL 1598
Marking and Labeling Systems – UL 969
Metallic Tubing, Electrical – UL 797
Motors, Electric – UL 1004
Outlet Boxes, Metallic – UL 514A
Polymeric Materials – Long Term Property Evaluations – UL 746B
Polymeric Materials – Short Term Property Evaluations – UL 746A
Polymeric Materials – Use in Electrical Equipment Evaluations – UL 746C
Power Systems, Uninterruptible – UL 1778
Printed-Wiring Boards – UL 796
Raceways and Fittings, Surface Metal – UL 5
Switches, Snap, General-Use – UL 20
Switches, Special-Use – UL 1054
Tape, Polyvinyl Chloride, Polyethylene, and Rubber Insulating – UL 510
Terminal Blocks – UL 1059
Terminals, Quick-Connect, Electrical – UL 310
Tubing, Extruded Insulating – UL 224
Wire Connectors – UL 486A-486B
Wires and Cables, Thermoplastic Insulated – UL 83
Wires and Cables, Thermoset-Insulated – UL 44

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