UL 924

STANDARD FOR SAFETY

Emergency Lighting and Power Equipment

UL Standard for Safety for Emergency Lighting and Power Equipment, UL 924

Tenth Edition, Dated May 9, 2016

Summary of Topics

This revision of ANSI/UL 924 dated February 12, 2025 includes the following changes:

– Scope updates; 1.1

– Direct current output; 74.1A and 76.7

– Additional battery options; 22.2.1

– ELCF Test; 47.5

– Battery discharge test; 48.1, 48.3, 48.3A, and 48.6

– Temperature test; 52.11.1

– Emergency equipment with AC and DC input ratings; 73A.2.1

– Emergency battery pack replacement marking; 73A.4.15

– Instructions for directly controlled emergency luminaires; 74.11, 74.12, and B1

– Editorial updates; 11.1, 22.2.1, 22.2.2, and 48B.1

– Area of Refuge Signs; Supplement SH

– Functional Safety Evaluations; 23.1, 23.3, and Appendix A

Text that has been changed in any manner or impacted by ULSE's electronic publishing system is marked with a vertical line in the margin.

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated September 6, 2024 and December 6, 2024.

Users of the electronic versions of UL's Standards for Safety agree to defend, indemnify, and hold ULSE harmless from and against any loss, expense, liability, damage, claim, or judgment (including reasonable attorney's fees) resulting from any error or deviation introduced while purchaser is storing an electronic Standard on the purchaser's computer system.

MAY 9, 2016
(Title Page Reprinted: February 12, 2025)

1

UL 924

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, 2006

Tenth Edition

May 9, 2016

This ANSI/UL Standard for Safety consists of the Tenth Edition including revisions through February 12, 2025.

The most recent designation of ANSI/UL 924 as an American National Standard (ANSI) occurred on February 12, 2025. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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.

Comments or proposals for revisions on any part of the Standard may be submitted to ULSE at any time. Proposals should be submitted via a Proposal Request in the Collaborative Standards Development System (CSDS) at https://csds.ul.com.

No Text on This Page

CONTENTS

INTRODUCTION

1 Scope 9
2 References 10
3 Resistance to Environmental Conditions 10
4 Glossary 10
5 Components 16
6 Units of Measurement 17
7 Radioactive Energy Sources 17

CONSTRUCTION

8 Frame and Enclosure 17
8.1 General 17
8.2 Uninsulated live parts 17
8.3 Metallic enclosures 19
8.4 Nonmetallic enclosures 21
8.5 Enclosure openings 22
8.6 Enclosure covers 23
9 Environmental Rating 24
10 Polymeric Materials 24
10.1 General 24
10.2 Enclosures 25
10.3 Mechanical support 25
10.4 Barriers 25
10.5 Grounding or bonding means 26
10.6 Structural support 26
11 Mounting Means 26
12 Corrosion Resistance 26
13 Insulation Material 27
14 Mounting of Parts 27
15 Operating Mechanisms 28
16 Current-Carrying Parts 28
17 Installation – Wiring Connections 28
17.1 General 28
17.2 Wiring terminals 28
17.3 Field-wiring leads 29
17.4 Polarity identification 29
17.5 Termination of wiring systems 30
17.6 Knockouts 30
18 Cord-Connected Unit Equipment and Luminaires 31
18.1 General 31
18.2 Flexible cord 31
18.3 Alternative connection 32
18.4 Attachment plug 32
18.5 Grounding 32
18.6 Strain relief 32
18.7 Push-in prevention 32
18.8 Bushings 33
19 Internal Wiring 33
19.1 Wires 33
19.2 Wireways 34
19.3 Electrical connections 35

19.4 Separation of circuits 35
19.5 Conductor secureness 36
20 Grounding 36
21 Bonding of Internal Parts 37
22 Batteries 39
23 Electronic Circuits 41
24 Capacitors 41
25 Lampholders 41
26 Overcurrent (Overload) Protection 41
27 Coil Windings 42
28 Derangement Signals 42
29 Test Switch 43
29A Emergency Lighting Control Devices 43
30 Self-Testing/Self-Diagnostic Equipment 43
31 Disconnect Switches and Fuses 44
32 Transformers 44
33 Impedance Networks 44
34 Printed-Wiring Board 44
35 Motors 45
36 Equipment Using Simple Reactance Ballasts and Lamps Having Integral Starters 45
37 Spacings 45
37.1 General 45
37.2 Barriers 47
37.3 Insulating barriers 47
38 Field-Wiring Space 48
38.1 General 48
38.2 Wire-bending space 48
39 Accessibility of Insulated Current-Carrying Parts 50
39.1 General 50
39.2 Accessibility determination 50
39.3 Insulated parts 51
39.4 Accessibility barriers 52

EXIT SIGN VISIBILITY

40 Exit Sign Construction – General 52
41 Text-Based Exit Signs – Construction 53
42 Graphical Symbol Exit Signs – Construction 57
43 Performance 60
43.1 General 60
43.2 Observation visibility test 61
43.3 Luminance measurement test 63
43.4 Non-energized contrast measurement test 71
43.5 Flashing rate and duration between successive light pulse measurements 71
44 Markings 72

PERFORMANCE

45 General 72
46 Leakage Current Test 72
47 Emergency Lighting Control Functionality (ELCF) Test 75
48 Battery Discharge Test 76
48A Lithium Battery Charge Rate Measurement 78
48B Lithium Battery Charging Circuit Abnormal Tests 78
49 Input Test 79

50 Determination of Low-Voltage, Limited-Energy Circuit Status 79
51 Determination of Limiting Impedance Circuit Status 80
52 Temperature Test 80
53 Overvoltage Withstand Test 85
54 Undervoltage Recharge Capability Test 85
55 Voltage Surge Test 85
56 Dielectric Voltage-Withstand Test 89
57 Conformal Coating Test Program I 89
57.1 General 89
57.2 Coating on printed-wiring board in lieu of spacings 90
58 Conformal Coating Test Program II 90
58.1 General 90
58.2 Samples 90
58.3 Room ambient conditioning 90
58.4 Thermal conditioning 90
58.5 Dielectric voltage-withstand test for conformal coating 92
59 Strain Relief Test 92
59.1 General 92
59.2 Strain 92
60 Conductor Secureness Test 92
61 Overtinned Wire Flexibility Test 92
62 Bonding Conductor Test 92
63 Grounding Continuity Test 93
64 Security of Knockout Test 94
65 Swivel Torsion and Pull Test 94
66 Component Breakdown Test 94
66.1 General 94
66.2 General test conditions 95
67 Humidity Conditioning Test 96
68 Impact Test 96
69 Mechanical Support Static Load Test 97
70 Barrier Strength Test 97
70A Mounting Means Test 98

RATINGS

71 General 98
72 Standby Operation 98

MARKINGS

73 General 98
73A Markings 98
73A.1 General 98
73A.2 Ratings 99
73A.3 Installation 101
73A.4 Operation and maintenance 102

INSTRUCTION MANUAL

74 General 104
75 Safety Instructions 106
76 Other Instructions 107

LOW-FREQUENCY INVERTERS

77 General 108
78 Performance 108
78.1 Output load power factor test 108
78.2 Battery discharge test 108
78.3 Output voltage and frequency test 108

HIGH-FREQUENCY INVERTERS

79 General 108
80 Performance 109
80.1 General 109
80.2 Output voltage and current test 109
80.3 Abnormal conditions test 110
81 Marking 111

SUPPLEMENT SA – FIELD INSTALLED LUMINAIRE EMERGENCY BATTERY PACKS

SA1 General 113
SA2 Mounting and Installation 113
SA3 Performance 113
SA4 Marking and Instructions 113
SA5 Instruction Manual 114

SUPPLEMENT SB – EMERGENCY LIGHTING AND POWER EQUIPMENT FOR USE IN DAMP LOCATIONS

SB1 General 115
SB2 Construction – Mechanical 115
SB3 Construction – Electrical 115
SB4 Performance – Humidity Conditioning 116
SB5 Markings 116

SUPPLEMENT SC – EMERGENCY LIGHTING AND POWER EQUIPMENT FOR USE IN WET LOCATIONS

SC1 General 117
SC2 Construction – Mechanical 117
SC2.1 Corrosion protection 117
SC2.2 Enclosures 118
SC2.3 Gaskets and bushings 118
SC2.4 Openings 119
SC2.5 Polymeric water shields 120
SC3 Construction – Electrical 120
SC4 Performance 120
SC4.1 General 120
SC4.2 Tests required 120
SC4.3 General – test conditions 121
SC4.4 General – test results 122
SC4.5 Sprinkler test 122
SC4.6 Rain test 124
SC4.7 Thermal conditioning 125
SC4.8 Gasket adhesion test 126
SC4.9 Humidity conditioning 126

SC5 Markings 126

SUPPLEMENT SD – ALTERNATIVE REQUIREMENTS FOR TRANSFORMERS

INTRODUCTION

SD1 Scope 127

CONSTRUCTION

SD2 General 127

PERFORMANCE

SD3 General 128
SD4 Dielectric Voltage-Withstand Test 128
SD5 Induced Potential Test 129
SD6 Abnormal Tests 129
SD6.1 General 129
SD6.2 Transformer burnout test 130
SD6.3 Transformer overload test 130
SD7 Test on Transformer Insulating Materials 131

SUPPLEMENT SE – EXIT SIGN RETROFIT KITS

INTRODUCTION

SE1 Scope 133
SE2 Glossary 133
SE3 Construction 134
SE3.1 General 134
SE3.2 Frame and enclosure 134
SE3.3 Mounting 134
SE3.4 Wiring and connections 135
SE3.5 Assembly 135
SE3.6 Grounding 136
SE3.7 Adapter 136
SE3.8 Diffuser 137
SE4 Performance 137
SE4.1 Trial installation test 137
SE4.2 Input test 138
SE4.3 Temperature test 139
SE4.4 Conductor secureness test 139
SE4.5 Visibility test 139
SE4.6 ELCF test 140
SE4.7 Voltage surge test 140
SE4.8 Component breakdown test 140
SE4.9 Base securement test 140
SE4.10 Base conformity test 141
SE5 Marking 141
SE6 Instruction Manual 144

SUPPLEMENT SF – PHOTOLUMINESCENT EXIT SIGNS

SF1 General 147

SF2 Mechanical Construction 147
SF3 Legend dimensions 147
SF4 Performance 147
SF4.1 Sample conditioning 147
SF4.2 Visibility tests 148
SF5 Markings and Installation Instructions 149

SUPPLEMENT SG – MINIMUM LIGHT OUTPUT FOR EMERGENCY LIGHTING EQUIPMENT

SG1 Introduction 151
SG2 Performance 151
SG3 Marking 151

SUPPLEMENT SH – AREA OF REFUGE SIGNS

SH1 Scope 153
SH2 General 153
SH3 Legend Design for Area of Refuge Signs 153
SH4 Luminance Performance of Area of Refuge Signs 154
SH5 Markings and Instructions 154

APPENDIX A

Standards for Components 155

APPENDIX B (informative)

B1 Evaluation of Emergency Lighting Control Functionality (ELCF) 156

Appendix C (Informative) Emergency Systems

C1 Purpose 158
C2 System Components 158
C3 Construction 159
C4 Performance 159
C5 Markings and Instructions 159

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. This Standard also applies to photoluminescent and self-luminous exit signs that do not connect to a branch circuit. 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, the Fire Code, NFPA 1, the International Building Code, IBC, and the International Fire Code, IFC.

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

Emergency Lighting Control Devices (e.g., Automatic Load Control Relays, Derangement Signals)

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 The basic requirements for protection against risk of fire, electric shock, and injury for some equipment within the scope of this standard are addressed in other standards. The primary role of UL 924 in these cases is to validate compliance with emergency system functionality and performance expectations. The investigation of such equipment for UL 924 compliance shall, to the extent practical, adhere to 5.1 and 5.2 (typically applied to Components). Examples of equipment and their respective safety standards that exhibit this relationship include, but are not limited to, the following:

Luminaires, UL 1598

Low Voltage Lighting Systems, UL 2108

Electric Signs, UL 48

Uninterruptible Power Systems, UL 1778

Energy Storage Systems and Equipment, UL 9540

Branch Circuit Emergency Lighting Transfer Switches, UL 1008

(PoE) Power Source Equipment, UL 60950-1 or UL 62368-1

1.5 Emergency lighting and power equipment intended for installation in Classified (hazardous) Locations, as defined in NFPA 70, shall comply with additional or alternative requirement outside the scope of this standard.

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 – An Emergency Lighting Control Device (ELCD) that switches dimmed or off emergency luminaires to full illumination output when the normal supply fails, and returns the luminaires to the previous 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.

4.4 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.

4.7 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 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, or the Limited Power Source Test of the Standard for Household and Commercial Batteries, UL 2054.

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 – A letter 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.

4.13.1 DIRECTLY CONTROLLED EMERGENCY LUMINAIRE – A luminaire with ALCR functionality to automatically override any control setting (such as dim or “off”) and restore full (or some other pre-set) illumination level upon loss of normal power. The ALCR functionality can be integral to the luminaire or through a control signal input from a remote ELCD.

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 BALLAST – An assembly with batteries, a charger, high frequency inverter, and ELCD (or ELCF circuit) intended to provide emergency power to one or more fluorescent lamps upon loss of normal power.

4.17 EMERGENCY BATTERY PACK – A term used within this standard to refer to both an emergency ballast and an emergency LED driver.

4.18 EMERGENCY LED DRIVER – An assembly with batteries, a charger, LED driver, and ELCD (or ELCF circuit) intended to provide emergency power to one or more LED lamps or arrays upon loss of normal power.

4.18.1 EMERGENCY LIGHTING CONTROL DEVICE (ELCD) – A separate or integral device intended to perform one or more EMERGENCY LIGHTING CONTROL FUNCTIONS. Upon loss of normal power, an ELCD defaults to a position that does not disrupt the flow of emergency power to any controlled emergency load.

4.18.2 EMERGENCY LIGHTING CONTROL FUNCTION (ELCF) – An activity related to the performance of an emergency lighting system, including but not necessarily limited to one or more of the following:

a) Sensing normal power status and transmitting a normal power status signal to a separate or integral device;

b) Interpreting a normal power status signal (receiving and translating to some other type of signal);

c) Controlling the lighting output level (e.g., changing “off” to “on”; “dim” to “full”);

d) Distributing emergency power or control signals among connected devices;

e) Simulating a loss of normal power (for manual testing or self-test/self-diagnostic purposes).

Each function is subject to performance validation in accordance with the Emergency Lighting Control Functionality (ELCF) Test, Section 47.

4.19 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),

b) One or more lamps and an integral ELCD, or

c) An emergency battery pack.

4.20 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 text or graphical symbol legend.

4.21 EXIT LIGHT – A complete, enclosed unit assembly arranged for permanent connection, with one or more lamps that illuminate an integral text or graphical symbol 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.

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

4.23 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.

4.24 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.

4.25 FULL-SIZE ILLUMINATED LEGEND – A text-based legend whose dimensions conform to Table 41.2, or a graphical symbol legend whose dimensions conform to Figure 42.2 and Figure 42.3.

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

4.27 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.

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

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

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

4.31 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.

4.32 LAMP – A light source of any configuration (e.g., bulb, tube, LED array or module, etc.), replaceable or not, intended to illuminate portions of the equipment (such as a lamp inside an exit sign that illuminates the legend) or to illuminate the environment where the equipment is located (such as the lamps on unit equipment).

4.33 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.

4.34 LEGEND – Text (in English or other languages as appropriate for the installation site) or graphical symbols intended to transmit a specific message associated with life safety, in accordance with an adopted building or fire code.

4.35 LIMITING IMPEDANCE CIRCUIT – A circuit supplied by an impedance that, under any load condition including 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 under any single fault condition unless it consists of a single resistor, or of a single capacitor that complies with the Standard for Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384-14. See Determination of Limiting Impedance Circuit Status, Section 51.

4.36 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.

4.37 LOW-VOLTAGE, LIMITED-ENERGY CIRCUIT – A circuit supplied by a source of open circuit potential below the risk of electric shock and maximum 8 A, or 150/V amps for circuits operating between 30 – 60 Vdc, measured after one minute of operation. See Section 50.

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

4.39 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.

4.40 NON-CONTINUOUS ILLUMINATED LETTER OR DIRECTIONAL INDICATOR – A letter or 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.

4.40.1 OPEN TYPE DEVICE – A component or subassembly with instructions that limit installation to within enclosures of metal or nonmetallic materials suitable for fire containment and that limits user access to parts representing a risk of electric shock. See 74.9.

4.41 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).

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

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

4.44 REDUCED-SIZE ILLUMINATED LEGEND – A legend having full size letters in accordance with 41.1, 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.

4.45 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.

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

4.47 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 as shown in Table 4.1, and the available current that would flow between the parts, through a 1500-ohm resistance, is more than 5 mA.

Table 4.1
Voltage limits for risk of electric shock

Waveform type[a]	Maximum voltage	
	Dry and damp locations	Wet locations
Sinusoidal ac	30 V_{rms}	15 V_{rms}
Non-sinusoidal ac	42.4 V_{peak}	21.2 V_{peak}
dc [b,c]	60 V	30 V

[a] For a combined ac + dc waveform, the wet location voltage limit shall be the non-sinusoidal ac limit where the dc voltage is no more than 10.4 V, and shall be (16 + 0.45*dc voltage) V where the dc voltage is between 10.4 V and 30 V. The dry and damp location voltage limit shall be twice these amounts.

[b] If the peak-to-peak ripple voltage on a dc waveform exceeds 10 percent of the dc voltage, the waveform shall be considered a combined waveform per footnote a above.

[c] DC waveforms interrupted at frequencies between 10 – 200 Hz shall be limited to 24.8 V in dry and damp locations, and 12.4 V in wet locations.

4.48 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.

4.49 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 73A.4.9.

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

4.51 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.

4.52 SELF-LUMINOUS EXIT SIGN – A sign with an integral 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.

4.52.1 SELF-DIAGNOSTIC ONLY EQUIPMENT – Equipment that automatically performs tests not related to its readiness to provide emergency lighting functionality.

4.52.2 SELF-TESTING/SELF-DIAGNOSTIC EQUIPMENT – Equipment that automatically performs tests, and provides visual (or other) reporting on those tests, related to its readiness to provide emergency lighting functionality in accordance with this Standard.

4.53 SERVICE – Tasks intended to be performed on-site by qualified personnel and that requires either a tool to access any compartment or specialized knowledge for performance of the task.

4.54 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.

4.55 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.

4.56 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 an ELCD (or ELCF circuit) to energize the lamps automatically upon failure of the normal supply. Terminals or leads are provided for the connection of remote lamps.

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

4.58 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.

5.4 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

[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.

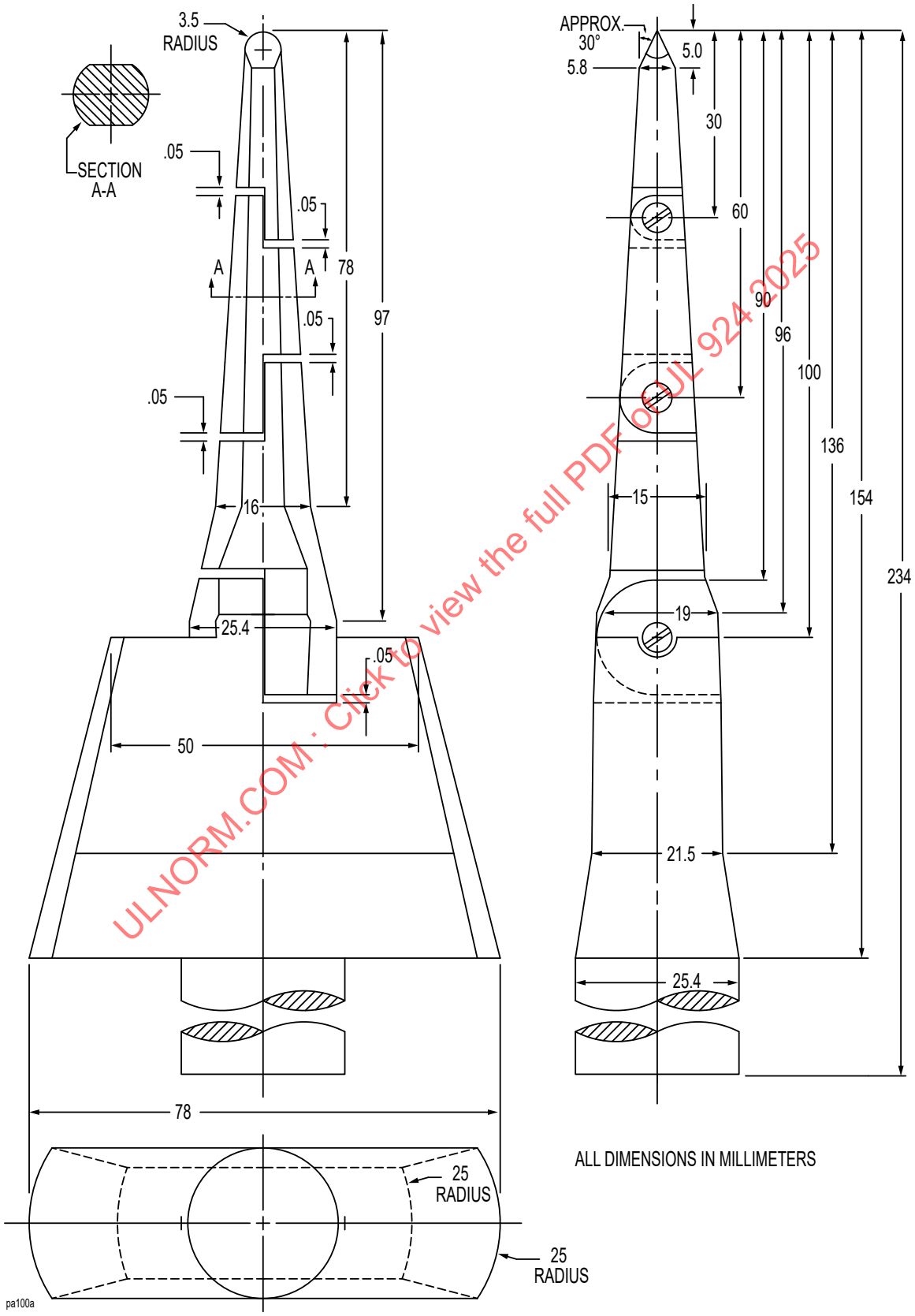
8.2 Uninsulated live parts

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.

Exception: Open type devices (see 4.40.1).

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.

8.3 Metallic enclosures

8.3.1 The thickness of a sheet metal enclosure shall be as indicated in Table 8.1 or Table 8.2. These Tables 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.

Exception No. 1: The enclosure thickness for unit equipment exit signs and luminaires is permitted to be in accordance with the Standard for Luminaires, UL 1598.

Exception No. 2: Lesser thicknesses may be used if the construction is shown by investigation to provide equivalent mechanical strength.

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[d]	(0.51[d])	0.023[d]	(0.58[d])
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)
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)

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]		Maximum length,[c]		Maximum width,[b]		Maximum length,		Uncoated,		Zinc coated,	
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	inches	(mm)	inches	(mm)
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.

[d] At point of connection for wiring systems, minimum 0.026 inch (0.66 mm) for uncoated and minimum 0.029 inch (0.74 mm) for zinc coated.

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]		Maximum length,[c]		Maximum width,[b]		Maximum length,			
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	inch	(mm)
3.0	(7.6)	Not limited		7.0	(17.8)	Not limited		0.023[d]	(0.58[d])
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[d]	(0.74[d])
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)		
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)		

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]		Maximum length,[c]		Maximum width,[b]		Maximum length,			
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	inch	(mm)
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.

[d] At point of connection for wiring systems, minimum 0.036 inch (0.91 mm).

8.3.2 The thickness of a cast metal 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.

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.

8.4 Nonmetallic enclosures

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

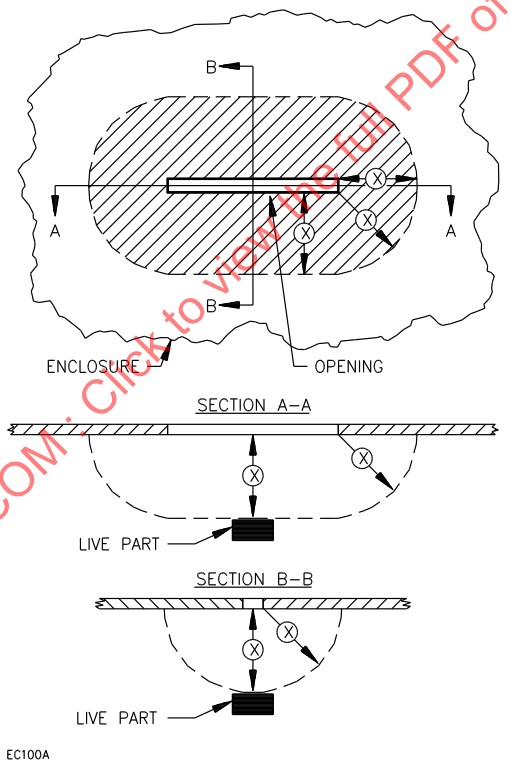
8.5 Enclosure openings

8.5.1 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.

8.5.2 An opening of a type as described in 8.5.1 that has a minor dimension of 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).

Figure 8.2

Opening in enclosure



8.5.3 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).

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 8.5.3.				

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 8.5.3.			

8.5.4 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.

8.5.5 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.

8.5.6 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 Enclosure covers

8.6.1 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.

8.6.2 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.

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 SB or SC, as applicable.

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 the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

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 the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. Equipment marked for use in ambients of 0°C (32°F) or below are subject to the cold conditioning prior to impact at 5°C below the marked low ambient temperature. Equipment marked for use in ambients no less than 5°C are subject to the cold conditioning prior to impact at their lowest rated ambient temperature;

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.

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.

10.2.3 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 76.5.

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 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 A polymeric part used to suspend another part that weighs more than 2 lbs (0.9 kg) shall comply with the Mechanical Support Static Load Test, Section 69.

10.4 Barriers

10.4.1 A polymeric material used as a barrier 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 the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C when molded or constructed of formed thermoplastic; and

c) Comply with the Barrier Strength Test, Section 70.

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

b) Comply with the Mold Stress-Relief Distortion requirements of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C followed by the Grounding Continuity Test of Section 63 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 the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, 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 Equipment that weighs less than 100 lbs (45 kg), and not intended to be placed at grade level or on a rack (or shelf), shall be provided with mounting means that requires the use of tools for relocation. Keyhole slots for mounting screws comply if there is at least one round hole or all screwheads will be accessible for tightening during installation.

11.2 Wall or ceiling-mounted equipment (surface or recessed) that weighs more than 50 lbs (22.5 kg) shall be provided with special mounting hardware and comply with the Mounting Means Test of Section 70A.

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.

13.3 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 shall be determined by 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.

14.3 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 65.

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.

15.3 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 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.

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

17 Installation – Wiring Connections

17.1 General

17.1.1 Emergency lighting equipment shall be provided with either lead wires or wiring terminals.

Exception No. 1: See 18.1.3.

Exception No. 2: Equipment supplied by communication cables with RJ45 fittings (i.e., PoE) and whose installation instructions declare it to be installed where access to the supply connection is restricted to authorized personnel is permitted to use appropriately configured ports to serve as the supply wire terminals.

17.1.2 *Deleted*

17.1.3 Equipment shall have provision for the connection of one of the wiring systems required for the equipment. Field drilling of the enclosure for connection of a raceway is permitted if the instructions specifically identify an area suitable for drilling.

17.1.4 Field wiring connections for emergency circuits shall be physically separated, either by location or by barriers, from connections for normal power circuits. If no barrier is provided, separation shall be minimum 1/2 inch (12.7 mm). If a barrier is relied upon, it shall be of metal or a polymeric material that complies with 10.4.

17.2 Wiring terminals

17.2.1 Wiring terminals shall provide a secure connection and be prevented from turning. Soldering lugs or solderless (pressure) wire connectors shall be used for larger than 10 AWG (5.3 mm^2) wire. Smaller

wires are permitted to use a clamp or a binding screw with a terminal plate having upturned lugs, or the equivalent.

17.2.2 Supply wiring terminals shall be sized to accommodate 60°C (140°F) rated wire, corresponding to the amperage ratings of the equipment. Wiring terminals intended for the connection of remote loads, other than class 2, shall be marked to indicate the required wire size or be sized to accommodate at least one size larger than required for the amperage.

17.2.3 A wire-binding screw to which field-wiring connections are made shall be no smaller than no. 6 (3.5 mm major diameter) for 14 AWG (2.1 mm^2) or smaller wire, and no smaller than No. 8 (4.2 mm major diameter) for larger than 14 AWG wire.

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:

a) No less than 6 inches (152 mm) free length,

b) No smaller than 18 AWG (0.82 mm^2), and

c) Rated for the current, voltage, temperature, and conditions of use (dry, damp, or wet locations) to which they will be subjected.

17.3.2 *Deleted*

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 *Deleted*

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 64.

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			
				Overall diameter,		Height,	
Nominal size, inches	Outside diameter, (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	(2.2)	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)

Table 17.1 Continued on Next Page

Table 17.1 Continued

Trade size of conduit		Knockout or hole diameter,		Bushing dimensions			
				Overall diameter,		Height,	
Nominal size, inches	Outside diameter, (mm)	inches	(mm)	inches	(mm)	inches	(mm)
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 and Luminaires

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 74.8.

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

18.1.3 Flexible cord for connection to the supply circuit is permitted on pendant, high bay, or other luminaires where the intended application is specifically identified as a permitted use of flexible cord in accordance with Subsections 400.10 and 410.62 of the National Electrical Code, NFPA 70-2020.

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 for unit equipment 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.

Exception: An attachment plug is permitted but not required for pendant and high bay luminaires.

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.

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, and the equipment shall be marked per 73A.3.6. If required to be of the grounding type per 18.2.1, the attachment plug shall be of the 3-blade, grounding type. The attachment plug is permitted to 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 59.

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

Table 19.1 Continued on Next Page

Table 19.1 Continued

Types of insulation	Nominal thickness of insulation[a]	
	600-volt applications, inch (mm)	300-volt applications, inch (mm)
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 61. 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.

19.4.4 *Deleted*

19.5 Conductor secureness

19.5.1 Internal wiring that involves a risk of electric shock, fire, or required performance per this standard, and is subject to handling during installation or routine maintenance shall be evaluated for compliance with the Conductor Secureness Test, Section 60.

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

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.

Exception: Where the dead metal conductive parts that can become energized are accessible only during service, marking the cover to be removed in accordance with 73A.4.9 is permitted in lieu of provisions for grounding.

20.2 The following constitute effective means for grounding of equipment:

a) Equipment intended to be connected only by a metal-enclosed wiring system – a knockout or equivalent opening in the metal enclosure. Such equipment shall be marked in accordance with 73A.3.2.

b) Equipment 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 50, 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; and

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.

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 63.

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 62.

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 66.2.3 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 Batteries that serve as an emergency power source shall be rechargeable and shall comply with this Section.

22.2 Batteries that are replaceable shall include a protective housing (casing) that allows them to be handled without risk of damage to the cells contained within.

22.2.1 Secondary cells and batteries shall comply with the applicable requirements of one (or more) of the following standards:

a) UL 1642, Lithium Batteries

b) UL 2054, Household and Commercial Batteries

c) UL 62133-1, Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes – Safety Requirements for Portable Sealed Secondary Cells, and for Batteries Made from Them, for Use in Portable Applications – Part 1: Nickel Systems

d) UL 62133-2, Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes – Safety Requirements for Portable Sealed Secondary Cells, and for Batteries Made from Them, for Use in Portable Applications – Part 2: Lithium Systems.

e) UL 1973, Batteries for Use in Stationary and Motive Auxiliary Power Applications

f) UL 1989, Valve Regulated or Vented Batteries with Aqueous Electrolytes

g) UL/ULC 2580, Batteries for Use in Electric Vehicles

22.2.1.1 *Deleted*

22.2.1.2 *Deleted*

22.2.2 Batteries shall be located and mounted in a manner that, during replacement or use, prevents misalignment, reverse polarity, damage to connections, loose connections, or access to uninsulated parts that represent a risk of electric shock.

22.2.3 The charging circuitry for lithium batteries shall comply with the Lithium Battery Charge Rate Measurement Test, Section 48A, and the Lithium Battery Charging Circuit Abnormal Test, Section 48B.

22.3 Unless marked or specified otherwise by the manufacturer, the rated battery voltage is to be calculated on the following basis:

Battery type	Volts per cell
Lead acid	2.0
Nickel cadmium	1.2
Nickel metal Hydride	1.2
Lithium nickel manganese cobalt oxide (NMC)	3.7
Lithium iron phosphate (LFP)	3.3

22.4 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 in jars of conductive material shall be installed in trays of nonconductive material.

22.5 A battery whose maintenance requires the addition of water, electrolyte, or other liquids shall have transparent or translucent jars.

22.6 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.

22.7 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.

22.8 Battery packs consisting of more than one battery or cell shall not permit individual batteries or cells to be replaced, in order to avoid mixing new and old batteries that can create voltage imbalances within the cells.

22.9 Equipment with batteries connected in a manner capable of producing 60 Vdc or greater shall be provided with Backfeed Protection in accordance with Annex FF (normative) and Annex GG (informative) of the fourth edition of the Standard for Uninterruptible Power Systems, UL 1778.

22.10 Central station and unit equipment is permitted to be shipped without the batteries it has been evaluated for use with when marked per 73A.4.11 and provided with instructions per 74.6.

22.11 Equipment with batteries shall be marked with battery replacement information per 73A.4.11.

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 66.

NOTE: Applicable standards for safety-related electronic circuits include UL 60730-1 Annex H and UL 8750 Supplement SA.

23.2 Equipment containing solid-state components conductively connected to a branch circuit shall be subject to the Voltage Surge Test, Section 55.

23.3 Electronic circuits that activate emergency lighting in response to an external signal (loss of normal power, fire alarm, motion sensor or the like), including loss of a signal, shall be subject to the ELCF Test, Section 47, and shall operate in accordance with 47.2 or issue a derangement signal appropriate for the condition in accordance with 47.7. If these circuits rely upon programmable devices they shall be additional evaluated for compliance with UL 60730-1, Annex H.

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. The overcurrent device amperage rating shall be no less than 125% of the load rating for the connected remote equipment, to limit the risk of nuisance tripping.

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 batteries and battery-charging means shall provide audible or illuminated visible indicator(s) that change status and are detectable to facility maintenance personnel without the need to adjust or remove any equipment covers or parts. The indicators are permitted to be located directly on the equipment itself, or may be remotely located and triggered to activate by a wired or wireless control signal issued by the equipment.

28.2 Derangement signal activation shall occur under each of the following conditions, if applicable to the equipment under test:

a) Disconnection of the battery power source;

Exception: Disconnection of the battery need not be considered for equipment with batteries not intended for replacement, maintenance or service, such as an emergency battery pack or equipment marked in accordance with 73A.4.8.

b) The battery is actively supplying a remote (but not concurrently a local) load while normal power remains available;

c) The battery charger is not receiving its intended charging voltage or has experienced an internal failure that inhibits its ability to provide the intended charging current to the battery; or

d) For self-testing / self-diagnostic equipment, detection of a non-functional feature during a self-testing/self-diagnostic routine, in accordance with 30.1.

e) *Deleted*

28.3 Compliance with 28.2 shall be determined through testing per the Emergency Lighting Control Functionality (ELCF) Test, Section 47. Compliance with Section 47 does not require a prescribed level of brightness or sound for any required indicator. The type of indicator response need only be appropriate for the indicator's location (i.e., sufficiently bright or loud if intended to be detected in a large space, versus a text or graphical message if sent to a remote display or handheld device).

28.4 When tested per the Emergency Lighting Control Functionality (ELCF) Test, Section 47, derangement signal activation is not required to occur immediately or automatically upon initiation of the applicable conditions from 28.2. A derangement signal that activates when the test switch (see 29.1) is operated subsequent to imposing the condition from 28.2 is also considered compliant with this requirement.

29 Test Switch

29.1 Equipment provided with an ELCF shall have means for periodic testing, such as an integral or remote (wired or wireless) switch , to simulate the conditions under which the ELCF is intended to operate (such as loss of the normal supply). The test switch shall be evaluated per Emergency Lighting Control Functionality (ELCF), Section 47.

Exception: Equipment that has self-test/self-diagnostic capabilities in accordance with Self-Testing/Self-Diagnostic Equipment, Section 30, need not be provided with a manually operable test switch.

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.

29.3 A test switch of the momentary-break type, that returns the equipment to normal status when released, shall be accessible to maintenance personnel (see 4.49, routine maintenance) without the need for tools to remove a panel or barrier.

29A Emergency Lighting Control Devices

29A.1 An ELCD that has control functionality (“on”, “off”, “dim”, etc.) subject to testing under 47.2(c) shall have means to monitor the input signal referred to in 47.2(c) for the branch circuit associated with its controlled loads. This input signal monitoring feature, which can be wired or wireless, shall be continuously functional and independent of the emergency power feeding through the ELCD to the load

29A.2 An ELCD that has functionality related to facility conditions beyond the status of normal power availability requires evaluation as part of the system it is designed to work within, for that facility and as approved by an authority having jurisdiction. Such additional functionalities, which may consider real-time conditions and hazards, and that may involve software algorithms to make real-time facility infrastructure adjustments, are beyond the scope of this Standard.

30 Self-Testing/Self-Diagnostic Equipment

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

a) ELCF operation;

b) Battery charger system functionality;

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

d) Availability and functionality of connected loads. Based on preset or recalibrated levels indicating load availability, a derangement signal shall occur when the levels deviate by more than 50 percent for exit signs, more than 25 percent for unit equipment and emergency battery packs, and more than 10 percent for central station battery systems. The means to determine the availability of connected loads shall be appropriate for the equipment technology, such as a measurement of impedance (for incandescent loads) or drive current (for LED loads).

NOTE: The load percentages reflect a number of discrete load devices typically associated with each equipment type – two lamps or light sources within an exit sign, 2 integral plus 2 remote lamps for unit equipment and emergency battery packs, and multiple separate loads for central station battery systems. Where the equipment under test has fewer discrete light sources, the percentage of load loss for detection purposes can be adjusted accordingly. For example, unit equipment with two lamps but no means for connection of remote lamps would be required to detect only a 50% loss of load rather than a 25% loss.

The equipment shall be tested in accordance with 47.7 and 47.8, and be provided with user instruction manual content per 74.4.

30.1.1 Equipment with a range of output levels and subject to loads being added or removed after initial installation shall be marked in accordance with 73A.4.13.

30.2 A self-testing function that discharges more than 30 minutes of the total capacity of a system battery that supplies more than one lighting unit shall have provision, such as a programmable or random clock generator, to reduce the risk that the battery will be excessively discharged as a result of simultaneous or consecutive self-tests.

30.3 Equipment that is self-diagnostic only shall be marked in accordance with 73A.4.14.

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 Equipment with batteries and having provision for connection of remote equipment shall have means (switches, fuses, wiring device connectors, 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 If a disconnect switch handle is operated vertically rather than rotationally or horizontally, the up position of the handle shall be the "ON" position.

31.3 Equipment shall be provided with means, accessible only to service personnel, to disable the battery circuit of an emergency battery pack during installation and servicing of the equipment.

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 73A.4.8.

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

33 Impedance Networks

33.1 Battery-charging circuits provided by an impedance networkshall provide the same level of output under reverse polarity input, unless means that are not easily defeated are provided to prevent reverse polarity input. Where needed, compliance is verified using the method of Section 48A.

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 52, when tested with the intended lamp types and wattages indicated in the lamp replacement marking.

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: Other than at field wiring terminals or to the enclosure, clearances and creepage distances between parts that are rigidly held in place are permitted to 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	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)

Table 37.1 Continued on Next Page

Table 37.1 Continued

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)
parts other than the enclosure, or exposed dead-metal parts that are isolated									
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

RMS voltage[a]	Minimum spacings,[b] inch	(mm)	Coating program section[c, g]
0 – 30[d]	1/64	(0.4)	57 or 58
0 – 50[e,f]	1/32	(0.8)	57 or 58
51 – 600	1/32	(0.8)	57
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 57, 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 50.

[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 Enclosures for Electrical Equipment, 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 57 or 58.

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 52, with any lamps operating.

37.1.6 Film-coated wire is considered to be an uninsulated 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 52;

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	–

Table 38.1 Continued on Next Page

Table 38.1 Continued

Wire size,		Wires per terminal (pole),	
AWG or kcmil	(mm^2)	1	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.

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.

38.2.3 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.

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 equipment 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 4.47) or fire (see 4.48).

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 39.4.1, if it complies with Barrier Strength Test, Section 70.

EXIT SIGN VISIBILITY

40 Exit Sign Construction – General

40.1 These requirements apply to exit signs, 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 43, when the protective device operates.

40.3 *Deleted*

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 4.49) and the compartment containing the light source is marked per 73A.4.9, or the unit is sealed and marked per 73A.4.8.

40.5 An exit sign is permitted to flash in response to a fire alarm activation signal. The flashing rate shall be between 12 and 120 cycles per minute and the “off” time between flashes shall not exceed 250 milliseconds per cycle as determined in accordance with 43.5.1. A Flashing exit sign shall be marked per 73A.4.3.

40.6 *Deleted*

40.7 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 40.1

Light pulse duration

Figure deleted

40.8 The requirements of Section 41 apply to text based exit signs using English alphabet letters, regardless of language. Text-based signs using other character sets would not necessarily be expected to conform to the letter height, width, and spacing requirements established for English letters; however, reductions from these dimensional values could result in reduced viewing distances. The viewing distance rating for any text-based sign of letter dimensions less than those required for English letters can instead be determined using the Observation Visibility Test.

41 Text-Based Exit Signs – Construction

41.1 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 41.1. 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.

Table 41.1
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"

41.2 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.

41.3 Dimensions of the illuminated letters shall be as specified in Table 41.2. 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 41.2
Illuminated legend minimum dimensions

	Letter height,		Stroke width,		Letter width,[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 41.1.

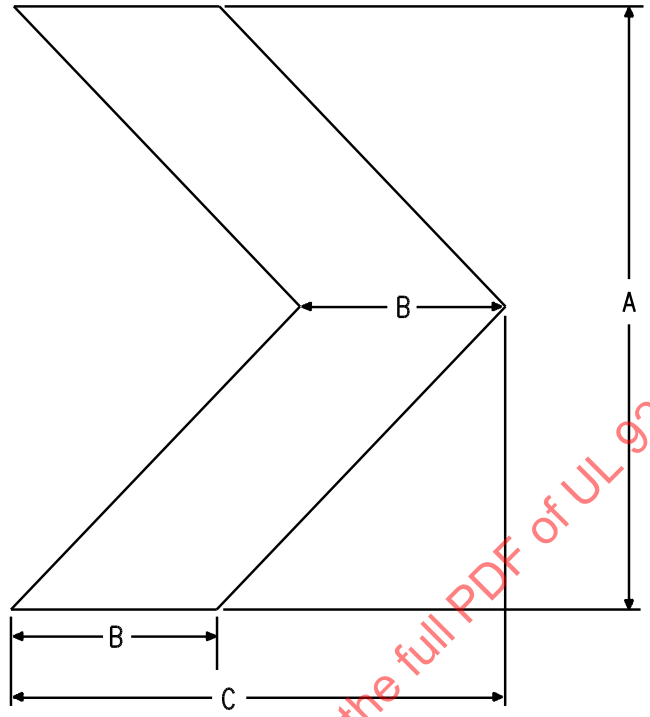
[c] Letters of the minimum dimensions specified for a full size legend shall be present on the face of the sign upon which reduced size illuminated letters are to be centered.

41.4 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.

41.5 A directional indicator shall be as shown in Figure 41.1. Measurement of the overall dimensions is to include any illuminated borders. 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 41.7(a).

Figure 41.1

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 stroke width	3 : 1 maximum

NOTE – Illuminated borders are to be included.

41.6 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 43.2.

41.7 A directional indicator shall be:

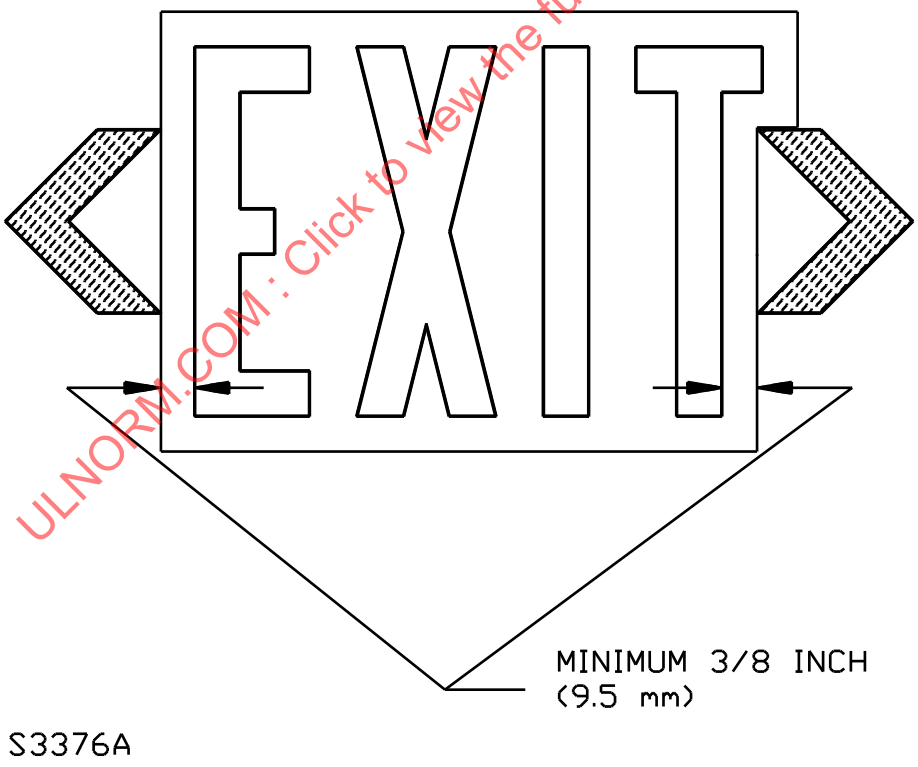
a) Located outside of the legend and no less than 3/8 inch (9.5 mm) from any letter as shown in Figure 41.2;

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 and shall be evaluated in accordance with 41.8 or 41.9, as applicable. 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 41.2

Minimum distance between directional indicator and legend



41.8 A directional indicator of flexible material that is secured by adhesive shall comply with the Adhesion Test of the Standard for Marking and Labeling Systems, UL 969.

41.9 A directional indicator of rigid material that is secured by adhesive shall be tested per (a) and (b) below. The average shear strength shall be no less than four times the weight of the directional indicator.

a) Three test specimen sets shall be created, consisting of the directional indicator and the panel to which it is to be secured, cut to conform to the size and shape identified in the Standard Test Method for Apparent Shear Strength of Single-Lap-Joint Adhesively Bonded Metal Specimens by Tension Loading (Metal-to-Metal), ASTM D1002 (to the extent practical and sufficient for representative testing). The three adhered specimen sets shall be subjected to the exposure conditions of Standard for Marking and Labeling Systems, UL 969, in accordance with the intended conditions of use for the exit sign under evaluation.

b) After the conditioning, the shear strength of each specimen set bond shall be measured, per the method of Standard Test Method for Apparent Shear Strength of Single-Lap-Joint Adhesively Bonded Metal Specimens by Tension Loading (Metal-to-Metal), ASTM D1002.

41.10 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 43.3 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.

41.11 The legend and directional indicator shall be visible as determined by compliance with Performance, Section 43.

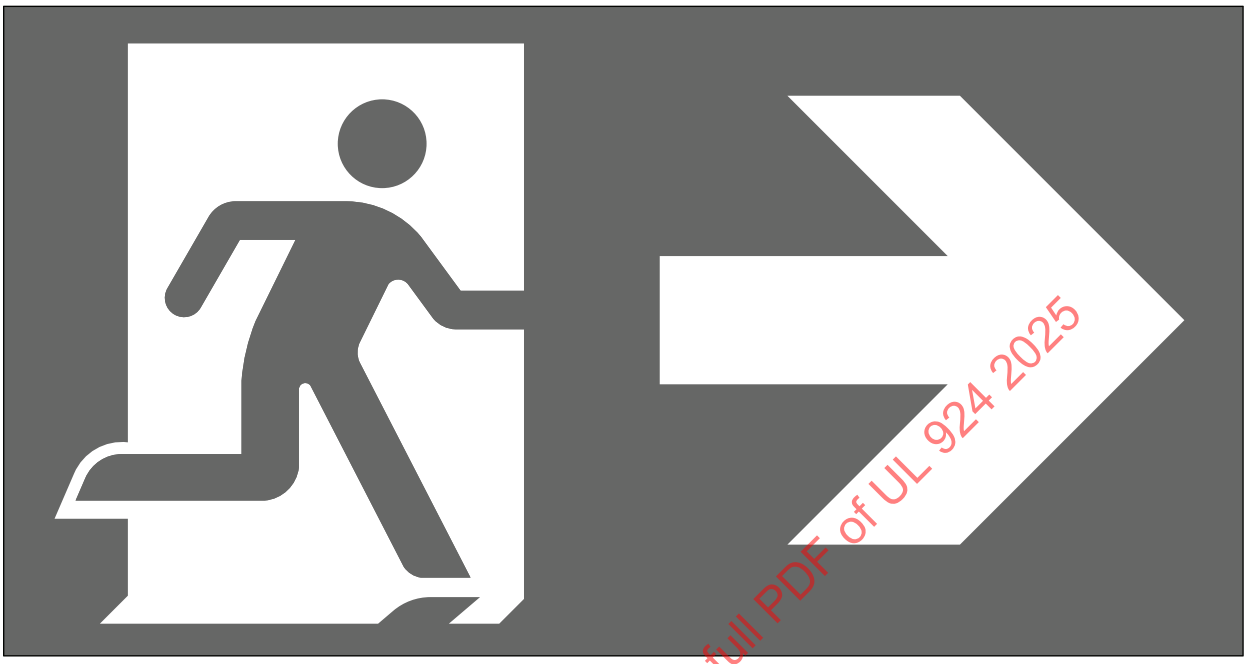
42 Graphical Symbol Exit Signs – Construction

42.1 A graphical symbol exit sign shall include the running man symbol and arrow, such as shown in Figure 42.1. The arrow shall be located on the side of the sign toward which the running man is facing (i.e., for a running man facing towards the right, the arrow shall be to the right of the running man).

Exception: A second arrow is permitted on the opposite side of the running man, pointing in the opposite direction.

Figure 42.1

Running man symbol and arrow



su1161a

42.2 The arrow shall be oriented up, down, horizontally pointing away from the running man, or 45 degrees from horizontal pointing away-and-up or away-and-down from the running man.

42.3 Additional text or symbols that provide supplemental evacuation information (such as a wheelchair symbol, indicating an accessible means of egress) is permitted on the side of the sign opposite to that of the arrow. No content that detracts from the visibility of either the arrow or the running man symbol is permitted.

42.4 Figure 42.2 and Figure 42.3 specify minimum dimensions for specific elements of the running man and arrow based on a minimum required sign height of 6 inches (152 mm). All other elements shall retain proportionality to the elements whose dimensions are specified. For larger signs, all dimensions shall be increased proportionately.

Figure 42.2

Minimum dimensions for specific elements of the running man

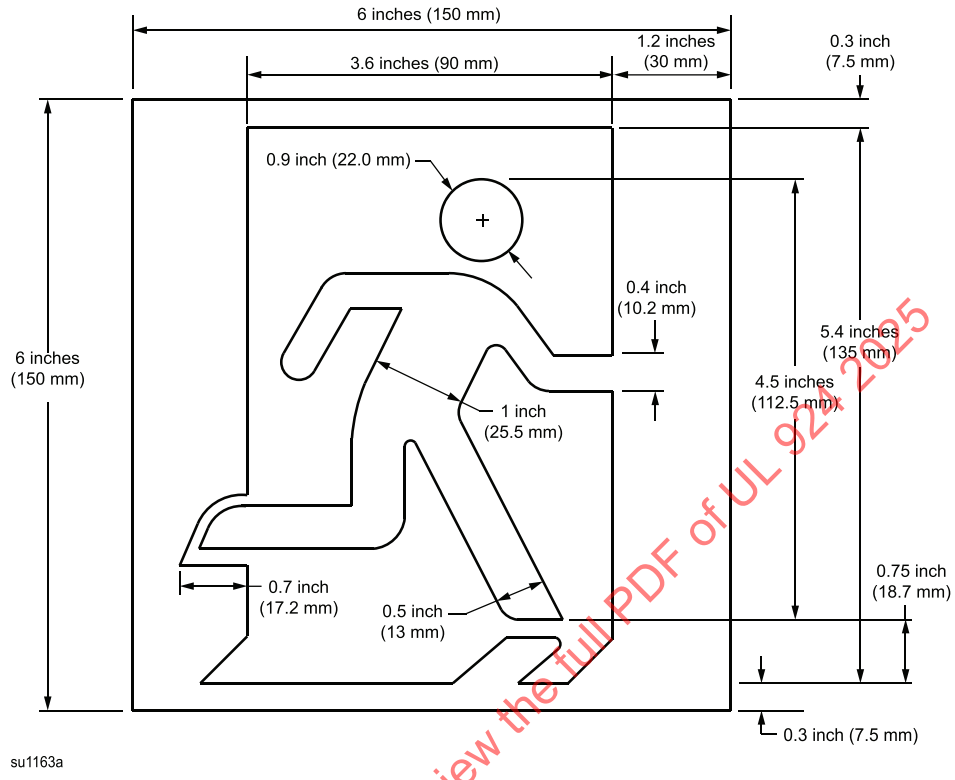
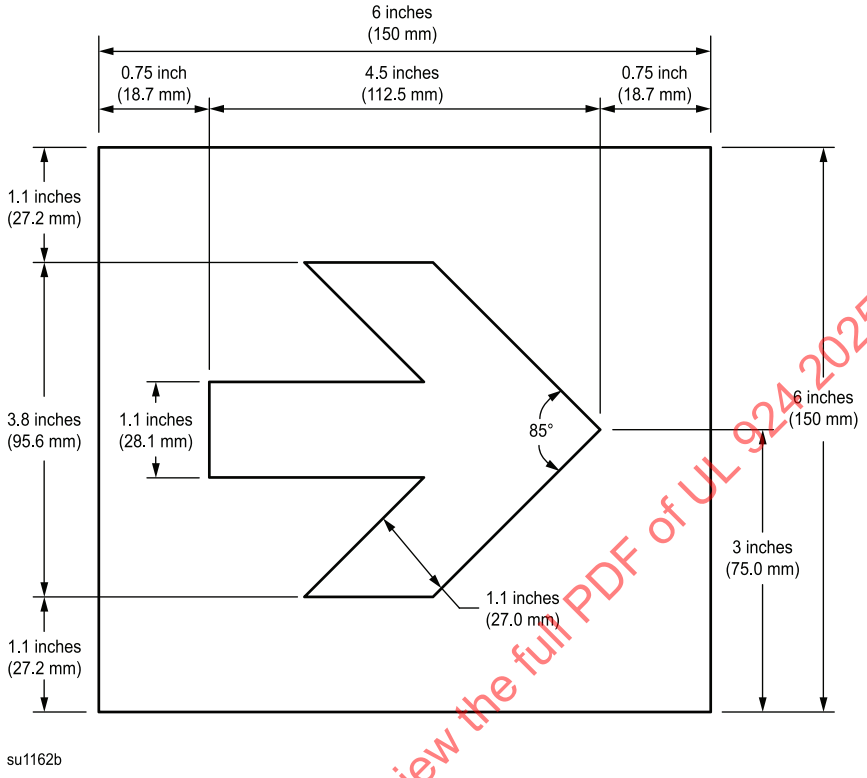


Figure 42.3

Minimum dimensions for specific elements of the arrow



42.5 The contrasting color space between the arrow and the inside of the running man symbol door frame shall be no less than 1 inch (25.4 mm) measured at the closest point.

42.6 The brightness (luminance) of the background space between the running man and the door frame shall be comparable to that of the arrow, as determined by the Luminance Measurement Test of 43.3.

43 Performance

43.1 General

43.1.1 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.

43.1.2 A full size, continuously illuminated exit sign shall be subject to either the Observation Visibility Test, 43.2, or the Luminance Measurement Test, 43.3. A reduced size or non-continuously illuminated exit sign shall be subject to the Observation Visibility Test.

43.1.3 A graphical symbol exit sign evaluated in accordance with the Observation Visibility Test of 43.2 shall additionally be subject to luminance measurements on the arrow and on the background space between the running man and the door frame. These measurements shall be made in accordance with 43.3.3 and the results shall comply with the luminance uniformity requirement of 43.3.6.

43.1.4 All exit signs shall be subject to the Non-Energized Contrast Measurement Test, 43.4.

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

a) Have an accuracy of ±5 percent and

b) Be cosine corrected.

43.1.6 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.

43.1.7 An exit sign intended for connection to an electrical utility source shall be subject to the Observation Visibility Test, 43.2, or the Luminance Measurement Test, 43.3, while supplied at rated input voltage. See also 43.1.8 and 43.1.9.

43.1.8 An exit sign intended for connection to a remote battery-powered emergency source shall be subject to the Observation Visibility Test, 43.2, or the Luminance Measurement Test, 43.3, while supplied at 87.5 percent of the rated emergency input voltage. If applicable, this test is in addition to the test of 43.1.7.

43.1.9 An exit sign provided with integral batteries serving as an emergency source of power shall be subject to the Observation Visibility Test, 43.2, or the Luminance Measurement Test, 43.3, while supplied by a constant-voltage power supply set at the minimum battery voltage measured during the Battery Discharge Test, Section 48. If applicable, this test is in addition to the test of 43.1.7.

43.1.10 A self-luminous exit sign shall be subject to the Observation Visibility Test, 43.2, or the Luminance Measurement Test, 43.3, while in a condition representative of that expected at its marked replacement date.

43.1.11 A photoluminescent exit sign shall be subject to the Observation Visibility Test, 43.2, or the Luminance Measurement Test, 43.3, in accordance with the procedures described in Supplement SF, Photoluminescent Exit Signs.

43.1.12 A flashing sign shall be subject to the Luminance Measurement Test, 43.3, with the flashing circuit or device defeated so that the sign is continuously illuminated.

43.2 Observation visibility test

43.2.1 When the Observation Visibility Test is to be used as indicated in 43.1.2 the test shall be conducted as described in this Section.

43.2.2 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 43.1.1 shall make the observations as required in 43.2.6.

43.2.3 Text-based exit signs shall be tested as follows:

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", masking the lower horizontal element of the "E" and the lower right portion of the "X" (so that the letters appear similar to "F" and "Y") is considered to meet this objective. For other text legends, visual elements of comparable size and significance shall be altered to distinguish between the two sample sets.

43.2.4 Graphical symbol exit signs shall be tested as follows, with each of the following sets consisting of two identical signs:

a) Set 1 – arrow on the right, pointing right.

b) Set 2 – arrow on the right, pointing up.

c) Set 3 – arrow on the right, pointing 45 degrees up and to the right.

d) Set 4 – arrow on the right, pointing 45 degrees down and to the right.

43.2.5 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 of a text-based legend, 40 feet (12.2 m);

b) For a text-based legend or the arrow of a graphical symbol sign, either the viewing distance marked in accordance with 73A.3.9 or 100 feet (30.5 m), whichever is less.

43.2.6 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' would consist of either eight graphical symbol signs with arrows, eight text-based signs with directional indicators, or six text-based signs with legends only). 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 arrow, or the altered and/or non-altered element of a text-based 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.

43.2.7 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.

43.2.8 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 is 80 percent or more. See 43.2.9 for illustrative examples and sample calculations.

$$(1)\ \text{Mean, PC} = \frac{\Sigma pc(i)s}{n}$$

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

$$(3)\ \text{Lower Cutoff Limit, LCL} = PC - 0.896S$$

in which:

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

n is the number of observers.

43.2.9 For the purpose of illustration, consider the following example. The Observation Visibility Test data obtained on an exit sign directional indicator is recorded in Table 43.1. Since the means is less than 6.4, the Standard deviation (S) and the lower cutoff limit (LCL) are calculated using formulas (2) and (3) given in 43.2.8. The data for observer Nos. 2 and 3 are below the LCL, so they are discarded and a revised means calculated. Since the revised means is more than 6.4, the results are considered acceptable.

Table 43.1
Example of visibility test data analysis and calculations

Observer no.	Number of correct responses
1	7
2	4
3	4
4	6
5	6
6	7
7	6
8	7
Mean (PC)	5.875
Standard deviations (S)	1.25
Lower cutoff limit (LCL)	4.76
Observer nos. omitted	2 and 3
Revised mean	6.5

43.3 Luminance measurement test

43.3.1 When the Luminance Measurement Test is to be used as indicated in 43.1.2, the test shall be conducted as described in this Section.

43.3.2 The luminance of the legend, directional indicators, graphical symbols, and background shall be measured on a candidate sign operating under each condition specified in 43.1.7 – 43.1.9, 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 Figure 43.1 – Figure 43.5. 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.

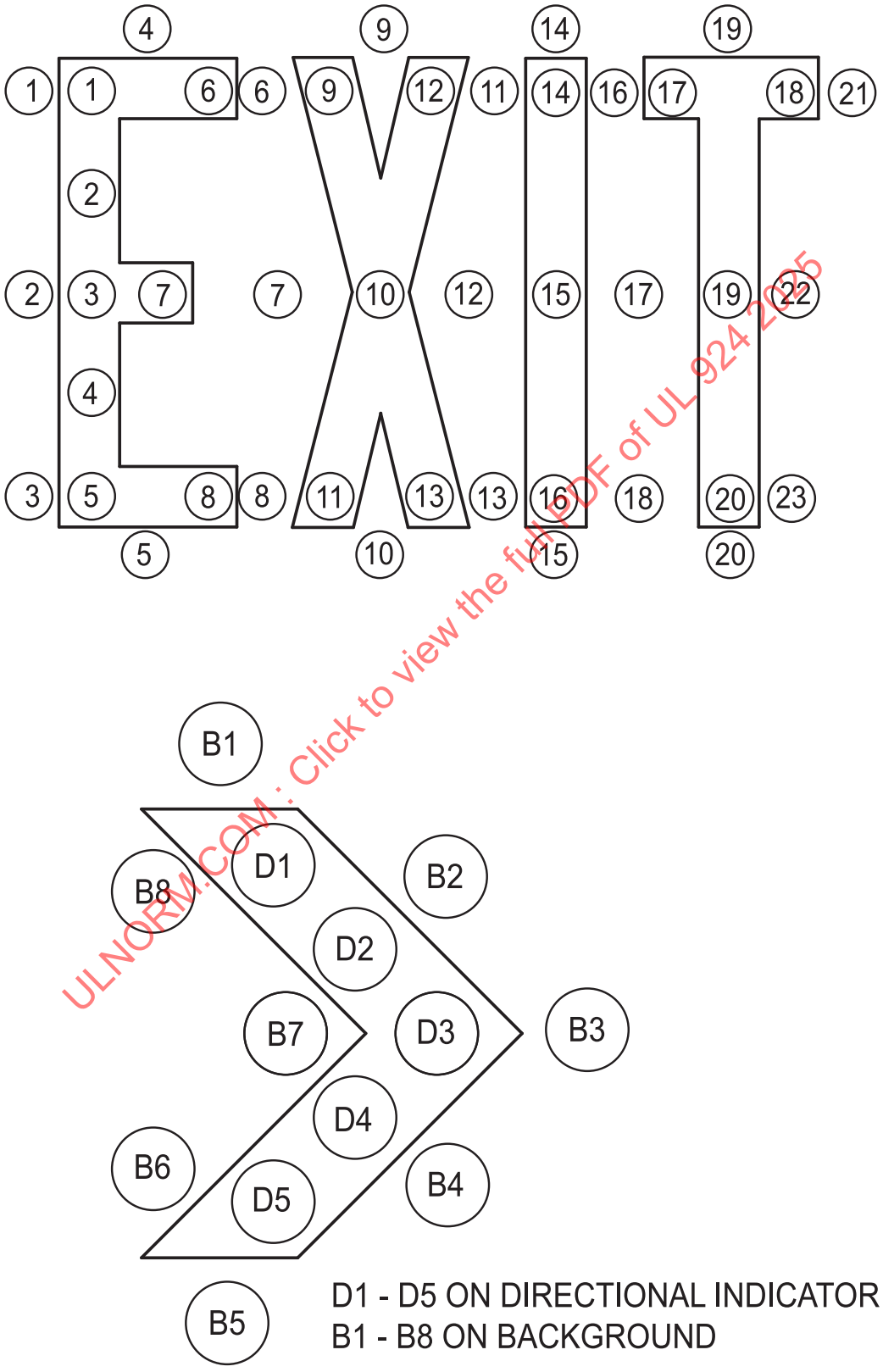
b) Measurements on the background of a panel face or edgelit sign shall be within 1 inch (25.4 mm) of the outer edge of any letters, directional indicators, or graphical symbols.

c) Measurement of the combined luminance of letters and borders (points 1 – 33 of Figure 43.3 and points LB1 – LB21 of Figure 43.4) 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.

43.3.3 For exit sign designs not represented by Figure 43.1 – Figure 43.5, 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.

Figure 43.1

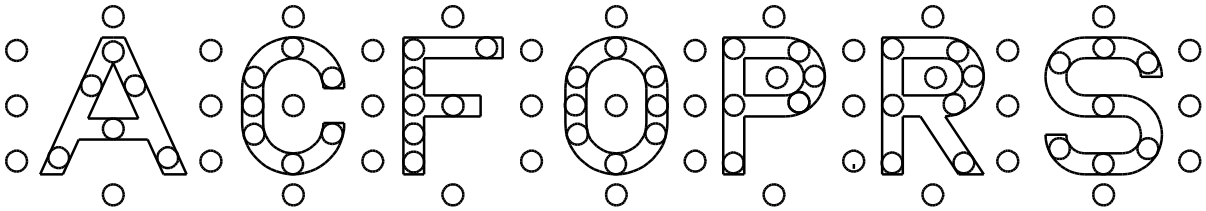
Luminance measurement points



su0337

Figure 43.2

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 43.3

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

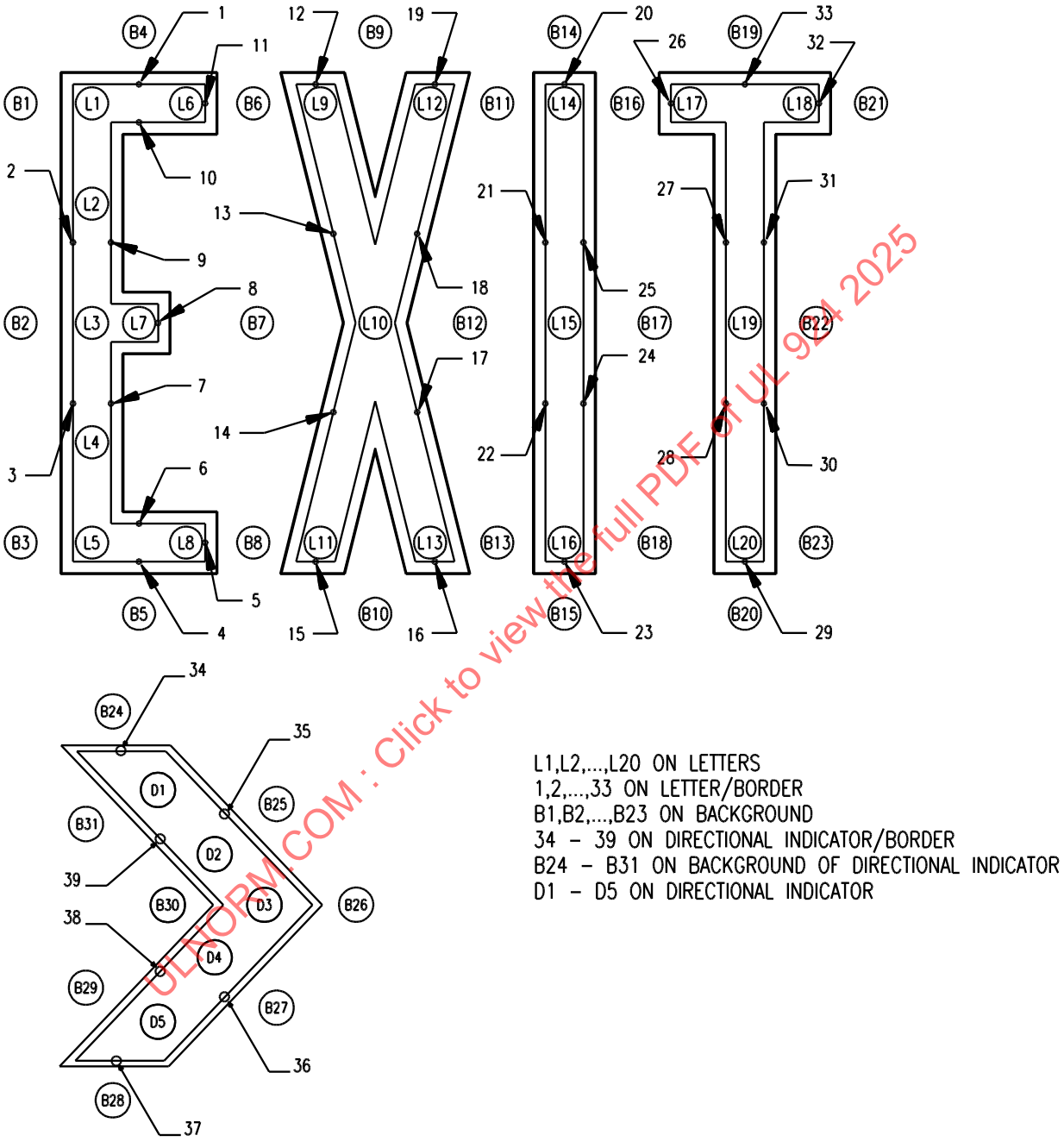


Figure 43.4

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

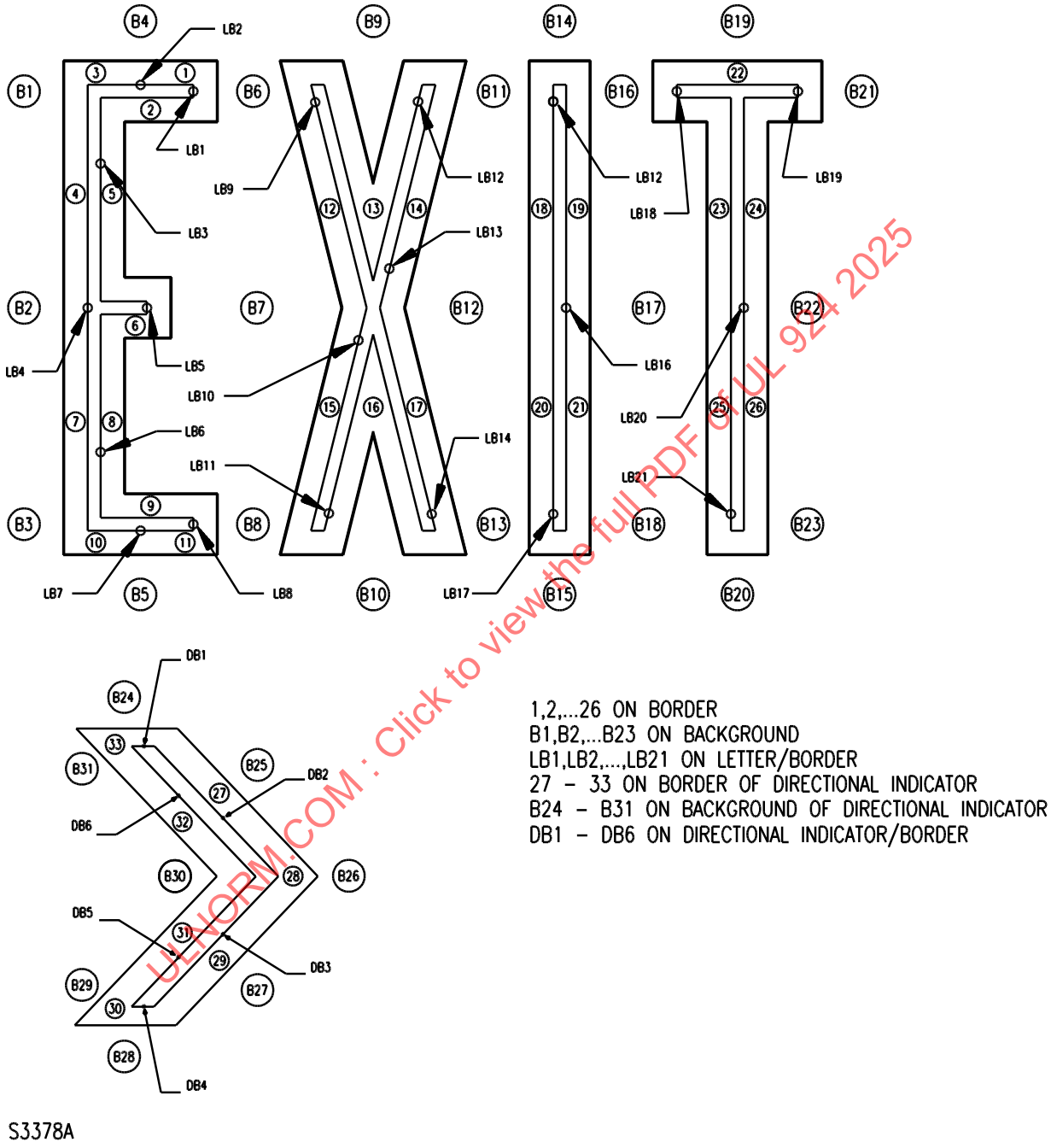
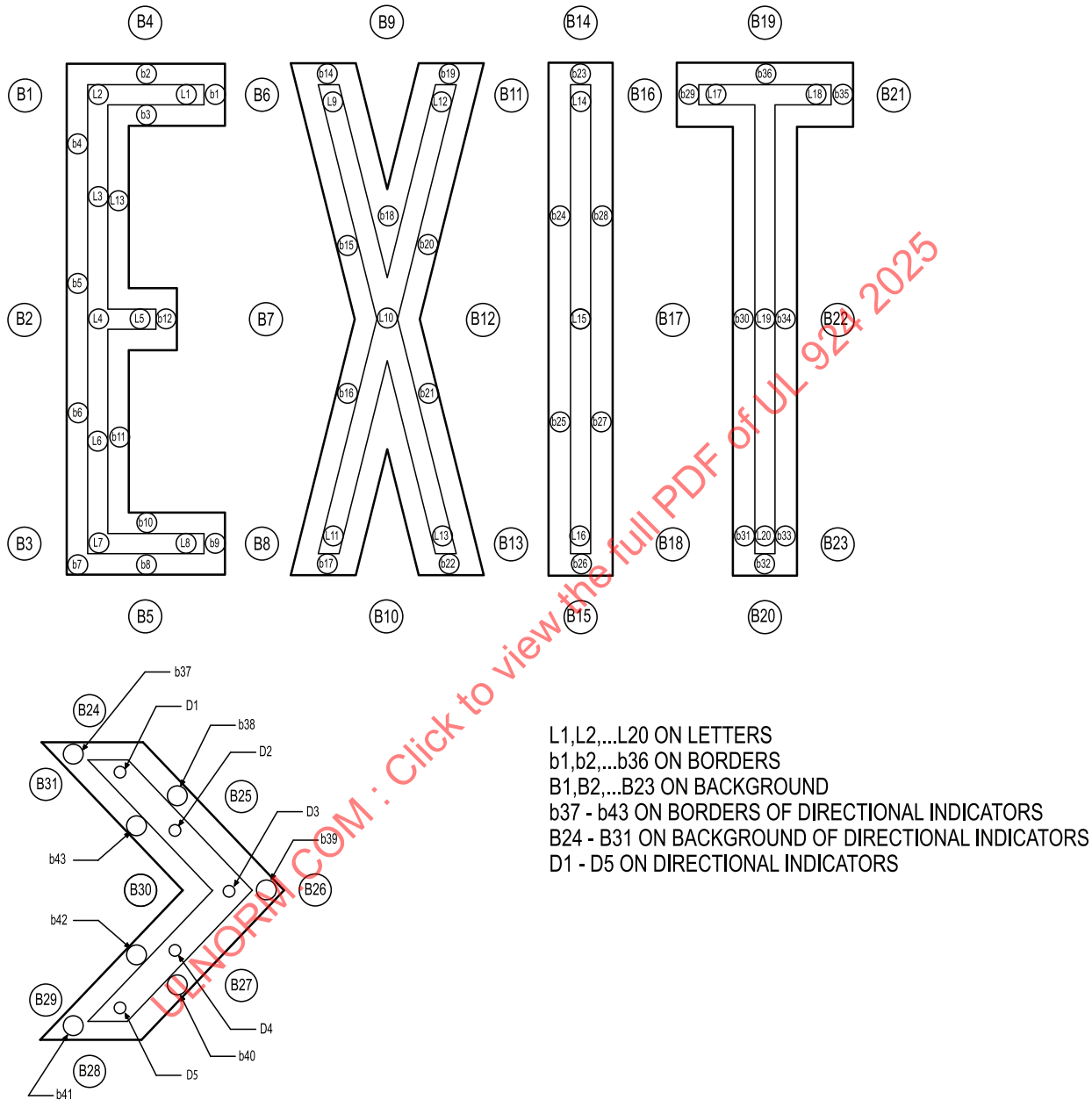


Figure 43.5

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

su1506

43.3.4 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 43.2 and Table 43.3.

Table 43.2
Contrast ratios for exit signs with letters having illuminated borders

Contrast ratio	Measurement points		
	Figure 43.3	Figure 43.4	Figure 43.5
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

Table 43.3
Contrast ratios for directional indicators having illuminated borders

Contrast ratio	Measurement points		
	Figure 43.3	Figure 43.4	Figure 43.5
C1	D1 – D5 and B24 – B31	27 – 33 and B24 – B31	B1 – B5 and B24 – B31
C2	34 – 39 and B24 – B31	DB1 – DB6 and B24 – B31	b37 – b43 and B24 – B43

43.3.5 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 43.1.7) and 1.50 foot-lamberts (5.14 cd/m^2) under emergency conditions representative of its end of rated time (in accordance with 43.1.8 – 43.1.11, 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.

43.3.6 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.

43.4 Non-energized contrast measurement test

43.4.1 Exit signs shall have distinctively contrasting colors (i.e., light versus dark) between the legend (and directional indicators or arrows) and background, to ensure a minimum level of functionality where intended maintenance has not occurred (such as replacement of dysfunctional light or emergency power sources). Where such contrast is not evident, an exit sign shall be evaluated in accordance with either 43.4.2 or 43.4.4.

43.4.2 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.

43.4.3 The measurement of 43.4.2 shall be used to determine compliance with 43.3.4.

43.4.4 As an alternative to the measurement test of 43.4.2, the Observation Visibility Test of 43.2 shall be conducted, modified as follows:

a) The observers shall be as stated in 43.2.2, except that four observers, regardless of age group, shall be used.

b) Evaluation shall be as stated in 43.2.3, except that, where the color scheme of the directional indicators is identical to that of the legend, only the legend shall be evaluated.

c) The test setup is to be as stated in 43.2.5, except that the test area shall maintain reasonably uniform, nominal 30 fc (323 lux), ambient light conditions between the observers and the exit signs.

d) The test shall be conducted as stated in 43.2.6, except that the observers require no eye acclimation time prior to the test.

e) In lieu of the calculations of 43.2.8, 100% of the observations shall be correct.

43.5 Flashing rate and duration between successive light pulse measurements

43.5.1 To determine the flashing rate and duty cycle as specified in 40.5, 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 45.2.1, 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 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. A minimum of ten full successive pulses of light shall be recorded.

Figure 43.6

Flashing rate duration between successive light pulses

Figure deleted

44 Markings

Section 44 deleted

PERFORMANCE

45 General

45.1 The performance of equipment shall be investigated by testing in accordance with the applicable provisions of Sections 46 – 68.

45.2 All tests are to be conducted with the product connected to a supply circuit of rated frequency.

45.2.1 For equipment designed for connection directly to a branch circuit supply source, or to a supply source that provides a constant voltage, 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).

45.2.2 For equipment designed for connection to a supply source that provides a constant current or wattage, the amperage or wattage of the supply circuit is to be as marked per 73A.2.1(a).

Note: Equipment designed for constant current (or wattage) input does not self-manage its power consumption. It is to be marked with an input voltage rating, per 73A.2.1, but this voltage only serves to allow current to flow; the amount of current is managed exclusively by the power source and not by the equipment under test. Equipment designed for constant voltage input generally uses its own internal impedance to regulate and limit current (and wattage).

45.3 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 73A.3.5.

45.4 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 48.6(h).

45.5 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).

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

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

46 Leakage Current Test

46.1 The leakage current of a cord-connected unit, when measured in accordance with 46.2 – 46.7, shall not exceed 0.75 milliampere.

46.2 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.

46.3 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.

46.4 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.

46.5 The measurement circuit for leakage current is to be as illustrated in Figure 46.1. 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:

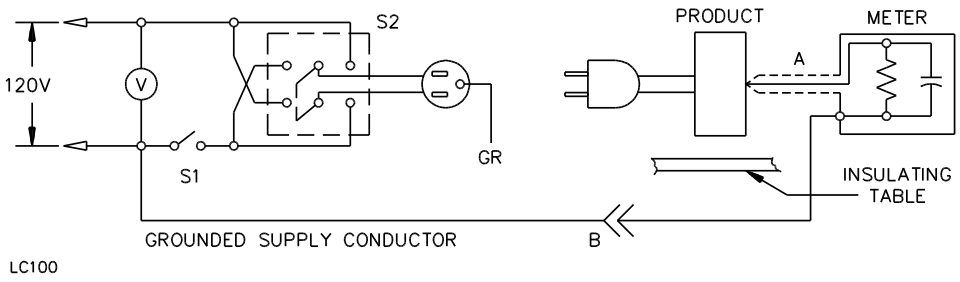
a) The meter is to have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.15 microfarad;

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.

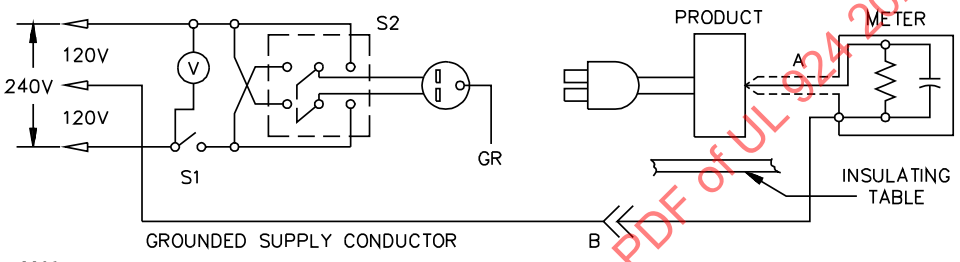
Figure 46.1

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.

46.6 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.

46.7 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 46.1 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.

47 Emergency Lighting Control Functionality (ELCF) Test

47.1 Equipment with ELCF or with self-testing/self-diagnostic circuitry intended to assess equipment status, shall operate as intended in accordance with this Section.

47.2 An ELCD, whether a separate device or as an electronic function integral to the equipment, shall be connected as specified in its installation instructions to its supply source(s) and controlled load(s). Signal inputs for emergency lighting functionality per (a) – (e) below shall be individually transmitted to the ELCD. The tests can be performed in any sequence and shall be performed in every sequence that represents a unique combination of conditions. Consideration shall be given to different power and signal inputs, the different sequence of equipment activation, and all permutations that may render different performance. Multiple functions can be assessed by a single test. ELCDs with functions (a), (c), and/or (d) shall complete all required activity within 10 seconds.

a) Sensing – Each current carrying (hot and neutral) supply source line being monitored shall be individually interrupted. The ELCD shall detect each changed condition and emit an appropriate signal.

b) Interpreting - An input signal indicating normal power status shall be provided, and then switched to indicate loss of normal power. The output shall be assessed in both conditions to validate accuracy.

c) Control – The ELCD shall be provided with an input signal indicating the presence of normal power. A controlled load shall be turned “off”. The input signal shall then be changed to indicate that normal power has been disrupted. The controlled load shall be monitored to validate that the ELCD has overridden the “off” position and directed the controlled load to shift to an appropriate state of activation[1]. For an ELCD identified as suitable for use with dimmable or otherwise adjustable luminaires, this test shall be repeated with a controlled load initially set (under normal power conditions) over a range of control inputs representative of any illumination inhibitory states.

[1] Activation when normal power is lost can be full output illumination, or some other setting less than full illumination where the ELCD instructions identify how to set this level for compliance with the applicable Codes (e.g., NFPA 101).

d) Distributing – The ELCD shall be connected and energized under conditions representative of normal power availability. The conditions shall then be changed to represent disruption of normal power. The distribution of power and control signals under both normal and emergency power conditions shall be validated as appropriate.

e) Simulating – The ‘test’ function of the ELCD shall be actuated[2]. The ELCD output shall be monitored to validate that emergency power is transmitted to the controlled load(s).

[2] Actuation shall be manual, whether by a mechanical switch or radio (or similar) signal. For self-test equipment, see 30.1.

47.3 *Deleted*

47.4 *Deleted*

47.5 Equipment rated for use below 20°C (68°F) shall be tested in accordance with 47.2 while maintained in an ambient 5°C (9°F) lower than that rating. Equipment rated for use above 30°C (86°F) shall be tested while maintained at an ambient 5°C higher than that rating. Equipment rated for use in an ambient from 20 – 30°C (68 – 86°F) shall be tested in a 25°C (77°F) ambient.

Exception No. 1: Equipment operating below the risk of electric shock voltage limit (see 4.47) and not incorporating rechargeable batteries intended to supply emergency power need only be subjected to the extended ambient range testing of this requirement when rated for use below 0°C (32°F) or above 55°C (131°F).

Exception No. 2: Extended ambient testing is not required for equipment without rechargeable batteries or other parts whose functionality is known to be unaffected by temperatures within the range of this requirement.

47.6 *Deleted*

47.7 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.

47.8 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, emergency signal inputs, and relevant individual component or system failures. A timing acceleration device is permitted to be used to verify the minimum 30-day cycle time of the self-testing/self-diagnostic system. The duration of the self-testing/self-diagnostic routine shall be as specified in the manufacturer's literature and instructions, but in no case less than 30 seconds.

48 Battery Discharge Test

48.1 Equipment storage batteries shall retain sufficient energy capacity when tested in accordance with this section. The rated load shall be as marked per 73A.2.2(1) or 73A.2.2(2), as applicable. Compliance shall be determined per method (a), (b), or (c):

a) Battery terminal voltage shall be no less than 87.5% of nominal after the sequence described in 48.6; or

b) Lumen output shall be no less than 60% of the initial lumen output level after the sequence described in 48.6, as described in 48.3; or

c) Power output shall be no less than 90% of the initial output power after the sequence described in 48.6, as described in 48.3A.

Note: Option (b) may be a preferred option for equipment with an integral light source, and option (c) a preferred option for equipment intended to supply a remote light source.

48.2 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.

48.3 Lumen output measurements per 48.1(b) 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 located in a plane that is perpendicular to the light source, and at the same distance from the light source for the measurements after steps (c) and (j) of 48.6.

Exception: For an LED luminaire or LED unit equipment, the current supplied to the LED array can be used as an alternative to the light output measurement of 48.6(j), as follows:

a) The current associated with the initial light level (48.6(c)) is measured.

b) Calculate the 60% light output level.

c) Using an adjustable current source, record the minimum current needed to achieve 60% light output (measuring at the same location and distance as in step (a) of this exception).

d) Measure the current supplied to the LEDs after step (48.6(j)). Current equal to or greater than that recorded in step (c) of this exception is considered a compliant result.

48.3A Power output measurements per 48.1(c) are to be made after steps (c) and (j) of 48.6 for equipment without an integral light load and with an electrical output designed for constant power delivery.

48.4 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.

48.5 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.

48.6 The equipment shall be subject to the following test sequence.

a) The battery is to be charged as specified in 48.7. 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 or power output measurements, a 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).

e) Recharge the battery as specified in 48.7, but for not more than 24 hours.

f) Discharge the battery at maximum rated load for 1 hour.

g) Recharge the battery as specified in 48.7, 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 48.7, 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, lumen output, or power output, as applicable.

48.7 With regard to 48.6 (a), (e), (g) and (i), battery charging shall automatically commence and continue upon connection to or restoration of normal power, without any other manual intervention. 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, per 73A.2.6. 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).

48A Lithium Battery Charge Rate Measurement

48A.1 The battery(ies) shall be installed in the equipment and fully discharged by any convenient means. The charging cycle shall then be initiated. Current flow from the charging circuit into the battery shall be monitored during the charge cycle to determine the maximum rate. The test shall be continued only until it is clear that the rate of charging is steady or decreasing, but not less than 3 hours. The maximum rate shall not exceed the battery manufacturer's recommendation.

48B Lithium Battery Charging Circuit Abnormal Tests

48B.1 The tests of 48B.2 and 48B.3 shall not result in any of the following:

a) Chemical leaks caused by cracking, rupturing or bursting of the battery jacket;

b) Spillage of liquid from any pressure relief device in the battery;

c) Explosion of the battery; or

d) Emission of flame or expulsion of molten material outside of the equipment enclosure.

The measured charging voltage shall not exceed the manufacturer's recommended maximum for the battery or cells, and the current shall not exceed three times the manufacturer's recommendation for the battery or cells. For equipment otherwise required to comply with the Dielectric Voltage-Withstand Test (Section 56), that test shall be repeated after this test program. If the equipment becomes inoperable as a result of a test, a new sample may be used to continue the test program.

48B.2 Single fault conditions that may increase the charging voltage or current shall be imposed, one at a time, on components within the charging circuitry. A fully discharged battery(ies) shall be charged under these conditions for 7 hours. The test may be discontinued prior to 7 hours if temperatures on the battery reach and remain at ambient (±2 C) for no less than 30 minutes.

Exception: Components whose reliability against fault conditions has been demonstrated through compliance with applicable requirements, such as those of UL 60730-1, are not subject to the fault conditions of 48B.2.

48B.3 Single fault conditions that may permit reverse charging within a multi-cell battery shall be imposed, one at a time, on components within the charging circuitry that are not known to be reliable. Component faults shall be chosen to cause the highest reverse charging current. A fully discharged battery shall be charged under these conditions for 7 hours. The test may be discontinued prior to 7 hours if temperatures on the battery reach and remain at ambient (±2 C) for no less than 30 minutes.

NOTE: Where equipment includes multiple identical multi-cell batteries, this fault condition test is only required to be performed on a single battery.

49 Input Test

49.1 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.

Exception: This test is not applicable to equipment designed for constant current or wattage input. See the note in 45.2.2.

49.2 The input to a unit incorporating a battery charger is to be determined after the battery has been discharged no less than 24 hours. A dual-rate charger is to be operated at the higher rate.

49.3 Equipment marked per 73A.2.4 with a standby electrical rating is to be charged for no less than 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.

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

50.1 When evaluated per 50.2 – 50.4, a circuit may be considered low-voltage, limited-energy when the maximum open circuit voltage potential of its supply source does not exceed the limit for risk of electric shock, and the maximum available current does not exceed 8 A, or 150/V amps for circuits operating between 30 – 60 Vdc, measured after one minute of operation.

50.2 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, or 150/V amps for circuits operating between 30 – 60 Vdc, can be obtained and sustained for one minute of operation. If this level of current cannot be sustained for one minute under any condition of load, the test shall be discontinued.

50.3 When a secondary fuse or similar device is used to limit the output current, it shall be rated as indicated in Table 50.1. 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 73A.4.12.

50.4 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 50.1
Output limiting secondary fuse

Open circuit potential, V_{peak} or DC	Maximum fuse rating, amps
0 – 20	5.0
>20 – 60	$100/V_{peak}$ or DC

51 Determination of Limiting Impedance Circuit Status

51.1 When evaluated per 51.2 – 51.4, a circuit is considered a limiting impedance when the maximum power able to be delivered from the circuit does not exceed 15 W under any condition of load, including short circuit, measured after one minute of operation.

51.2 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, or minimally loaded if required for circuit operation. The variable resistance load on the output under test shall then be adjusted from open circuit to short circuit to determine if available power output above 15 W can be obtained and sustained for one minute of operation. If 15W cannot be sustained for one minute under any condition of load, the test shall be discontinued. No circuit components are permitted to fail (open or short) during this test.

51.3 If the circuit consists of other than a single resistor or a capacitor known to comply with the Standard for Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384-14, the test shall be repeated under any single component fault condition within the circuit likely to result in greater output power availability, in accordance with 51.4 and 51.5. The fault condition shall first be applied, and then the variable resistance load shall be adjusted from open to short circuit as described in 51.2.

51.4 During the single fault condition test of 51.3, the opening of a circuit fuse (or a similar limiting component intended to open under fault conditions) is permitted. If the test is disrupted by the opening of a component whose primary function is not to open under fault conditions, the test shall be repeated two additional times, with a new sample under the same fault condition. Test disruption by opening of the same, or a different, component during these repeated tests is permitted.

51.5 If there is any indication of overheating during the single fault test of 51.3 and 51.4 (such as odor, smoke, discoloration, glowing, cracking, melting, or changes in circuit current through the fault), the same component shall be subject to the Component Breakdown Test, Section 66.

52 Temperature Test

52.1 Equipment shall exhibit no visual indication of combustion and shall comply with the Dielectric Voltage-Withstand Test, Section 56 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.

52.2 Equipment subject to the Temperature Test shall exhibit no temperature greater than that indicated in Table 52.1.

52.3 Tests are to be conducted at an ambient temperature of 25 ±5°C (77 ±9°F) except equipment marked for use above 30°C (86°F) ambient shall be tested at 5°C (9°F) above its maximum rated ambient.

An emergency battery pack or open type device shall be tested in a 55°C (131°F) ambient, or higher if so rated.

52.4 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.

52.5 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.

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

52.7 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 Tolerances thermocouples as listed in the Tolerances on Initial Values of EMF versus Temperature tables in the Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M.

Table 52.1
Maximum temperature

Materials and component parts	°C	(°F)
1. Rubber or thermoplastic insulation	60[a]	(140[a])
2. Any point on a selenium rectifier	75[a]	(167[a])
3. A silicon rectifier	100[a]	(212[a])
4. Field-wiring terminals[b]	75	(167)
5. Supply wire connections	60[f]	(140[f])
6. Varnished-cloth insulation	85	(185)
7. Surfaces adjacent to or upon which the unit may be mounted in service	90	(194)
8. Fuse clips with dummy fuse installed	55	(131)
9. Fuse clip with rated fuse installed	110	(230)
10. Fiber used as electrical insulation	90	(194)
11. Wood or other combustible material	90	(194)
12. Class 105 insulation systems on windings of relays, solenoids, and the like	90[c]	(194[c])
13. Transformer enclosure	90	(194)
14. Contacts	90	(194)
15. Connecting straps	90	(194)
16. Class 130 insulation systems on windings of relays, solenoids, and the like	110[c]	(230[c])
17. Phenolic composition used as electrical insulation	150[a]	(302[a])
18. On the embedding material of resistors	325	(617)
19. On bare resistor material	400	(752)

Table 52.1 Continued on Next Page

Table 52.1 Continued

Materials and component parts	°C	(°F)
20. Capacitors	Rated temperature limit	
21. Sealing compound	d	(d)
22. Polymeric material used for enclosure or structural parts	e	(e)
23. Other components	g	(g)

[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.

[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] 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.

[e] The maximum temperature of a polymeric material, when corrected to a 25°C ambient temperature, shall not exceed the temperature index specified in 10.2.1(b).

[f] Unless the equipment is marked for use with 75°C or 90°C supply wire.

[g] See.5.3 and 5.4.

52.8 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.

52.9 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.

52.10 To determine if a unit complies with the requirements in 52.1, it is to be connected to a supply circuit of rated voltage (and, if 45.2.2 is applicable, rated current / wattage) and frequency and operated continuously, under representative intended service conditions that are likely to produce the highest temperature, until constant temperatures are attained. Conditions of operation are indicated in 52.11 – 52.17 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.

52.11 Battery charging equipment and a unit provided with storage batteries and a battery charger are to be tested with discharged batteries as described in 45.4 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 48.6(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 52.8 is to be measured with the coil at its peak temperature. The maximum (peak) temperature is not to exceed the values specified in Table 52.1.

Exception: The maximum (peak) temperature may exceed the values specified in Table 52.1 if the equivalent continuous normal use temperature determined in accordance with 52.12 does not exceed the values specified in Table 52.1.

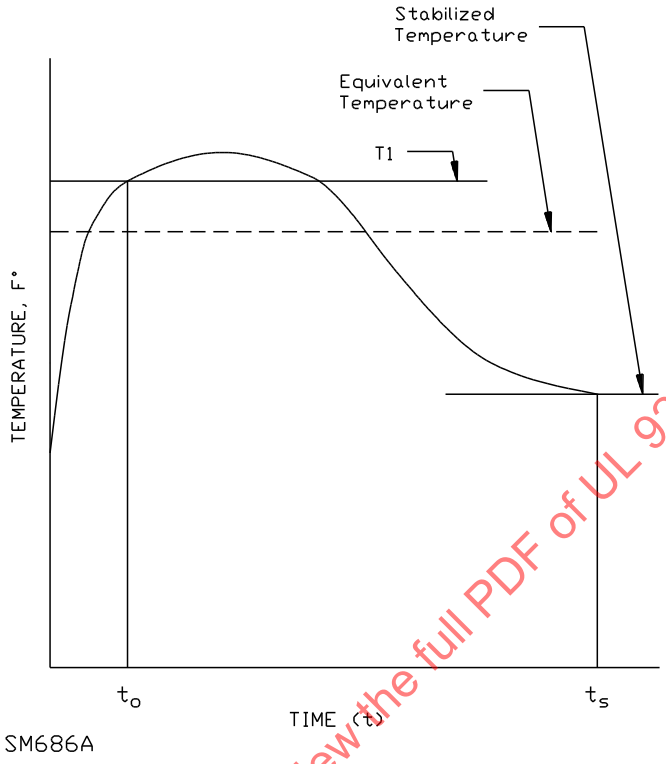
52.11.1 An integral or separate battery management system that de-activates lithium battery charging during this test to avoid exceeding the battery manufacturer's charging temperature limit is permitted to remain operable when shown to comply with the safety-related electronic circuit (SREC) requirements of UL 8750 Supplement SA, or a comparable reliability program. A battery management system not known to comply with the UL 8750 SREC (or comparable) requirements is to be bypassed when determining compliance with 52.11.

Note: UL 8750 SREC compliance is not required when the battery management system halts charging due to the battery reaching fully charged status.

52.12 With regard to the Exception to 52.11, 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 52.1 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 52.1

Determination of the equivalent, continuous, normal-use temperature



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

52.14 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.

52.15 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 52.1.

52.16 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.

52.17 Exit signs and luminaires intended for installation wholly or partially recessed into the mounting surface shall be tested in accordance with the applicable Type IC or Type non-IC normal temperature test of UL 1598. The abnormal temperature test is not required. Such equipment shall also be marked per 73A.3.12.

53 Overvoltage Withstand Test

53.1 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.

53.2 To determine if the normal supply voltage sensing circuit and the charging circuit of equipment complies with the requirement in 53.1, 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 52.4.

54 Undervoltage Recharge Capability Test

54.1 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 73A.2.1(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 48.6(c).

54.2 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.

55 Voltage Surge Test

55.1 Equipment conductively connected to a branch circuit and 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 55.2 and

b) Ten random applications of a 6-kilovolt surge impulse at 60-second intervals as described in 55.2.

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 measured limiting voltage or voltage protection rating not higher than the voltage rating of the solid-state components, need not be tested.

55.2 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 55.1 (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.

55.3 With regard to 55.1, 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 56.

55.4 The surge generator is to have a surge impedance of 50 ohms. Figure 55.1 and Figure 55.2 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:

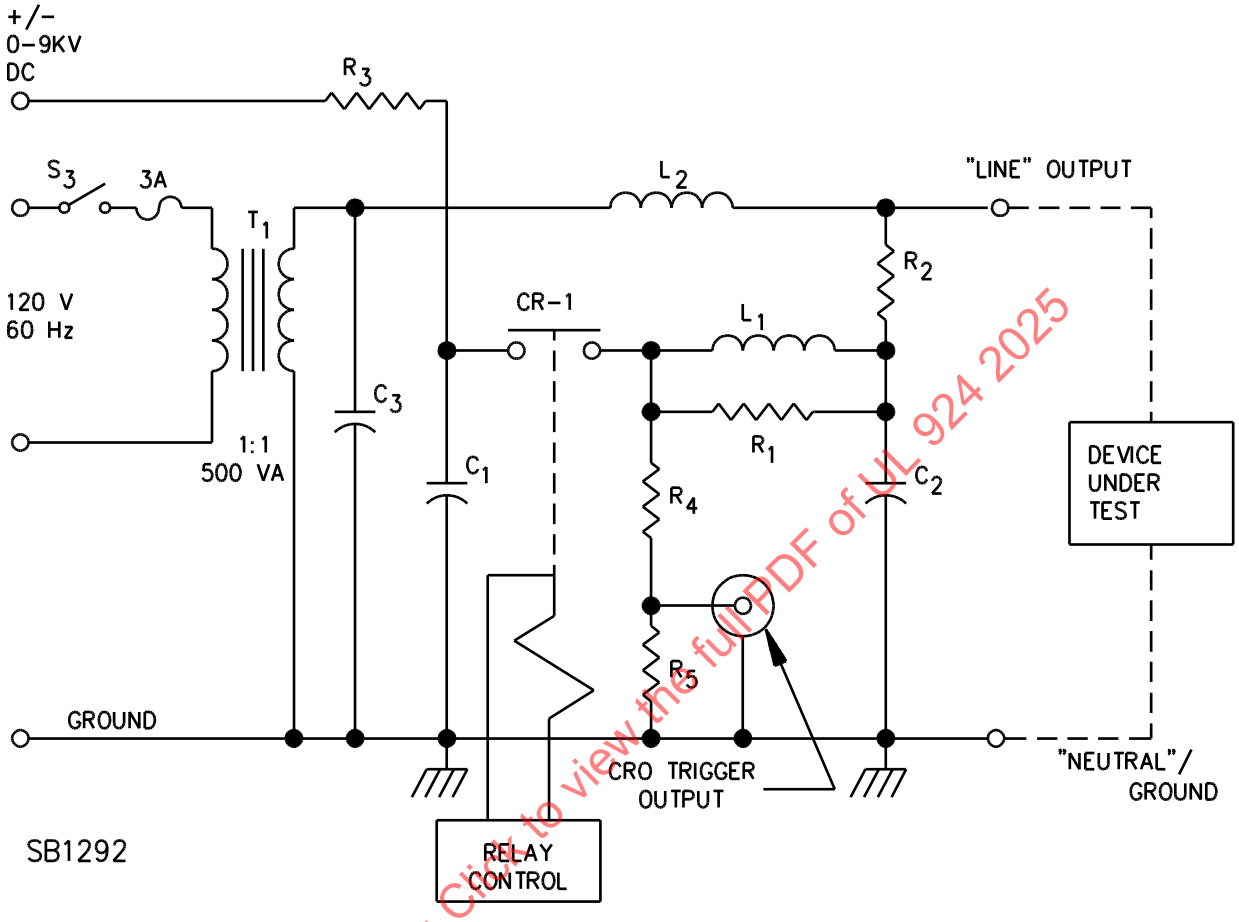
a) Initial rise time, 0.5 microsecond between 10 percent and 90 percent of peak amplitude;

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

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

Figure 55.1

Surge generator circuit



C_1 = 0.025 µF, 10kV

C_2 = 0.02 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)

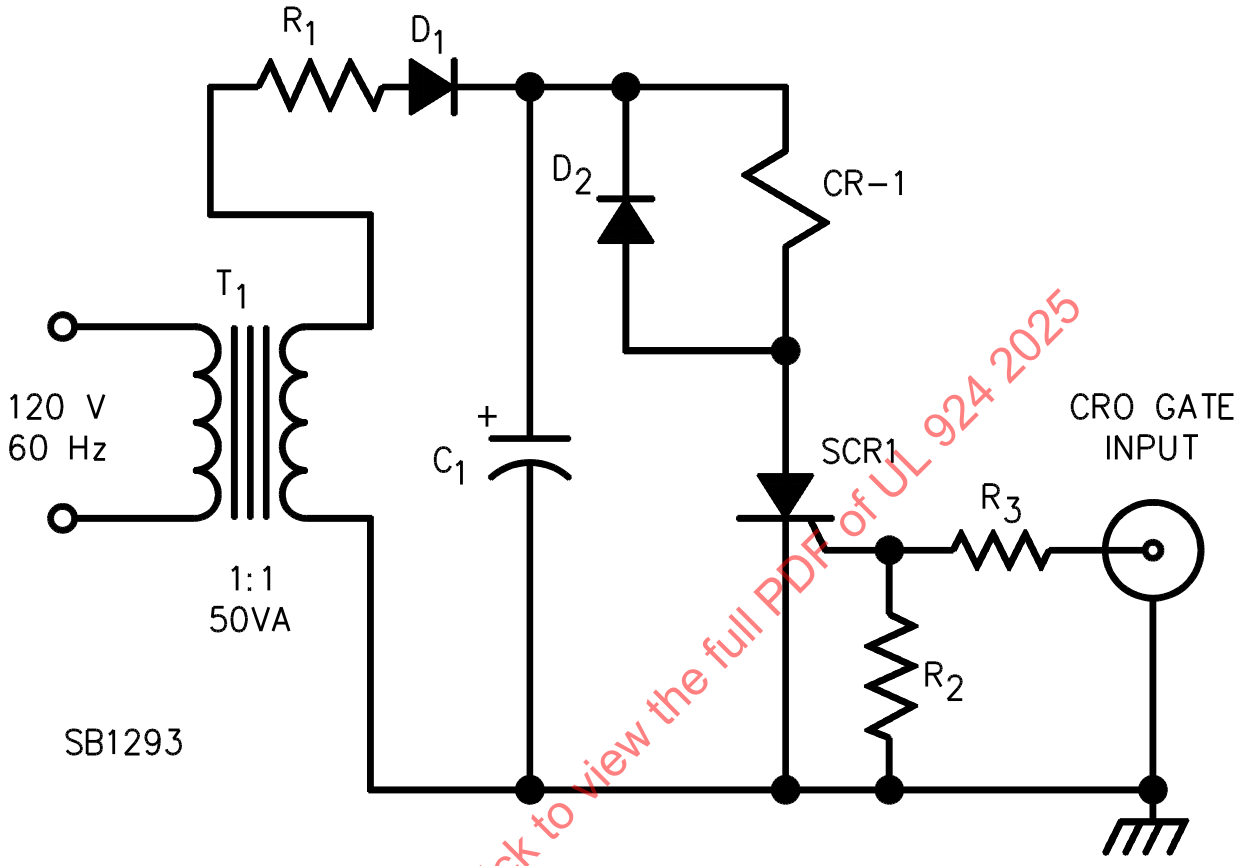
R_4 = 47K ohms (10 × 4.7K ohms, 1/2 W)

CR-1 = Relay

R_5 = 200 ohms, 1/2 W

Figure 55.2

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

56 Dielectric Voltage-Withstand Test

56.1 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 isolated 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 RMS or less, and 1000 volts plus twice the maximum voltage for circuits operating at more than 50 volts RMS. In (c), the test potential shall be the value determined by the higher voltage of the different circuits. For an inverter, the test potential between the output circuit and dead metal shall be based on the highest voltage measured per 78.3 (for a low frequency inverter) or 80.2.3 (for a high frequency inverter). 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.

56.2 With regard to 56.1 (d) and (e), the test is not required for a capacitor complying with either the Standard for Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384-14, or the Standard for Electromagnetic Interference Filters, UL 1283.

56.3 To comply with 56.1, it may be necessary to disconnect solid state components interconnecting the two circuits.

56.4 To determine if equipment complies with the requirements in 56.1 the equipment is to be operated under full load conditions until stabilized temperatures are achieved. Equipment that has previously been subjected to the Temperature Test, or equivalent operation, is considered to have met this conditioning criteria. The equipment need not be at operating temperatures for this test. The equipment 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.

57 Conformal Coating Test Program I

57.1 General

57.1.1 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.

57.2 Coating on printed-wiring board in lieu of spacings

57.2.1 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.

58 Conformal Coating Test Program II

58.1 General

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

58.2 Samples

58.2.1 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 58.3.1 – 58.5.2. Test leads are to be attached to the printed wiring so as to allow for convenient application of specified test potential.

58.3 Room ambient conditioning

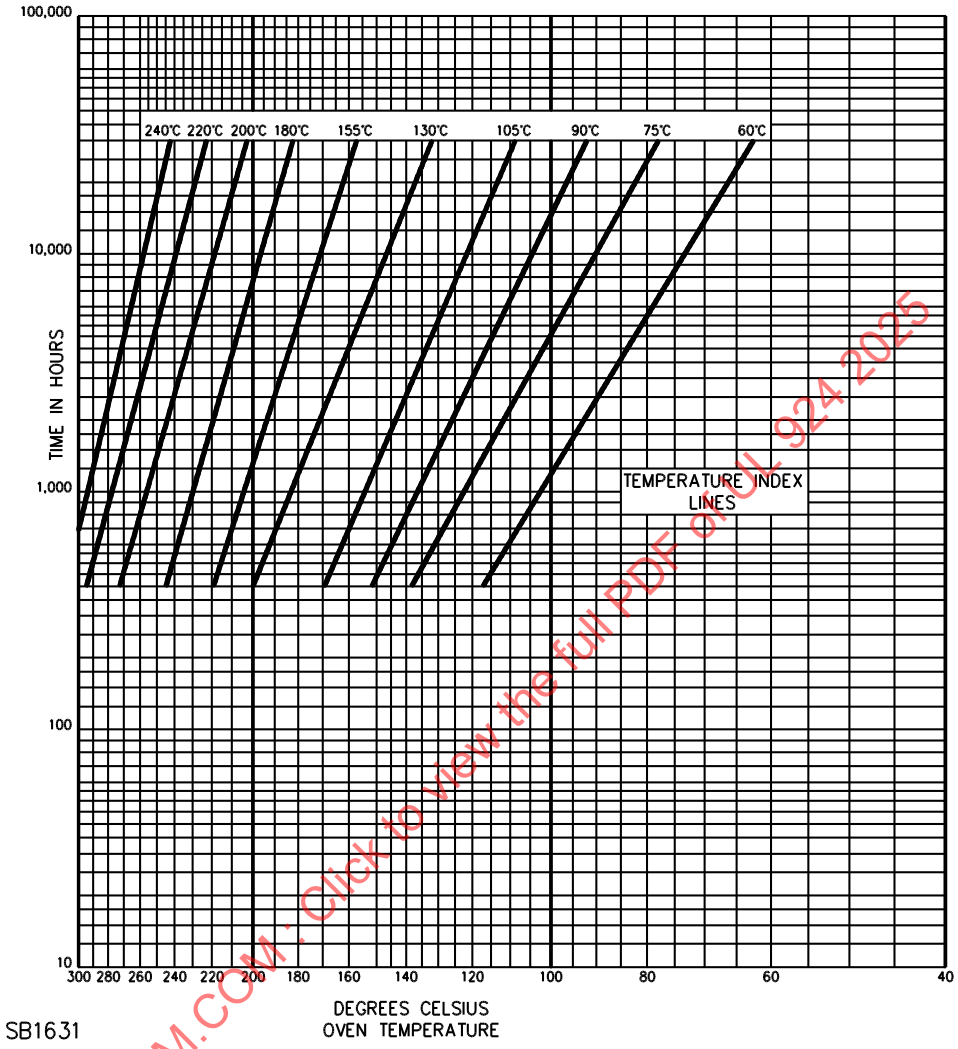
58.3.1 Four specimens shall be exposed to ambient air at a temperature of 25 ±5°C (77 ±9°F) and 50 ±5 percent relative humidity for no less than 24 hours. Following room ambient conditioning, four samples shall be subjected to the dielectric voltage-withstand test described in 58.5.1. All specimens shall 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.

58.4 Thermal conditioning

58.4.1 Four samples shall be exposed to ambient air at a temperature selected from the applicable curve shown in Figure 58.1, 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 58.1

Aging time versus aging temperature



58.5 Dielectric voltage-withstand test for conformal coating

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

58.5.2 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.

59 Strain Relief Test

59.1 General

59.1.1 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 59.2.1. 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.

59.2 Strain

59.2.1 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.

60 Conductor Secureness Test

60.1 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.

61 Overtinned Wire Flexibility Test

61.1 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 61.2. Following the mechanical cycling, there shall be no insulation breakdown when a dielectric withstand test (as described in 56.1) is conducted between adjacent conductors and between the conductors and any adjacent conductive surfaces.

61.2 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.

62 Bonding Conductor Test

62.1 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 62.1 and

b) Three samples are subjected to the Limited-Short-Circuit Test using a test current as specified in Table 62.2 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 62.1
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 62.2
Circuit capacity for bonding conductor short-circuit test

Rating of unit, volt-amperes			
Single-phase	3-phase	Volts	Capacity of test circuit, amperes
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

63 Grounding Continuity Test

63.1 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.

63.2 Any indicating instrument may be used to determine compliance with 63.1. 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.

64 Security of Knockout Test

64.1 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 64.3 when tested as described in 64.2.

64.2 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.

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

65 Swivel Torsion and Pull Test

65.1 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.

66 Component Breakdown Test

66.1 General

66.1.1 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.

66.1.2 With reference to the requirement in 66.1.3, 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 66.2.1;

b) Opening of the 3-ampere fuse specified in 66.2.2;

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.

66.1.3 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.

66.1.4 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.

66.1.5 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 secured with a positive means of latching, as described in 8.6.2.

66.2 General test conditions

66.2.1 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 the device or over all ventilating openings.

Exception: For an open type device, the cheesecloth is permitted to be draped over a wire cage sized to represent any installation spacing specified in the installation instructions. See 74.9. The wire can be of any convenient diameter provided that the opening between parallel wires is no less than twice the wire diameter.

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

66.2.3 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 45.2.

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.

66.2.4 A fuse that may be replaced during routine maintenance is to be effectively defeated unless marked in accordance with 73A.4.12. 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 73A.4.12, and any other overcurrent protective device not subject to replacement during routine maintenance may be left in the circuit.

66.2.5 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 66.1.2.

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.

66.2.6 The overheating of parts referred to in 66.2.5(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.

66.2.7 If a fault condition is terminated by opening of a circuit component as specified in 66.2.5(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 66.1.2, the results for that component fault are considered acceptable.

67 Humidity Conditioning Test

67.1 After conditioning as described in 67.2, 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 47, 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 56, conducted between all live parts and exposed dead-metal parts as described in 56.1 – 56.4.

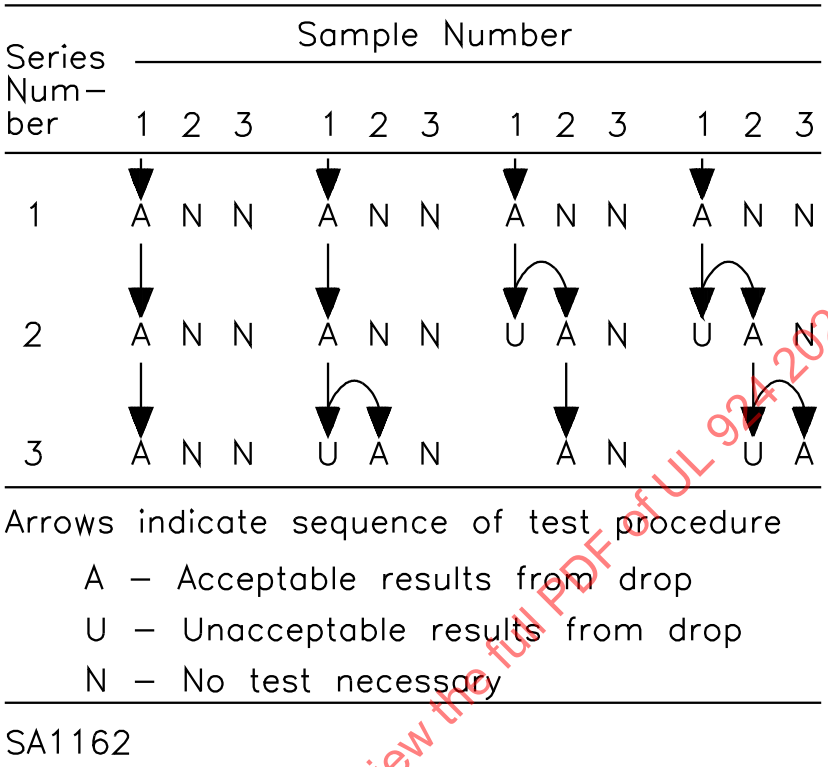
67.2 Two samples are to be tested. One sample is to be conditioned unenergized and the other is to be conditioned while energized at rated voltage. The samples are to be conditioned for 240 hours at 95 to 100 percent relative humidity at 65.0 ±2.0°C (149 ±3.6°F). An exit light sample that is to be conditioned 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.

68 Impact Test

68.1 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 68.1. 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 68.1

Procedure for impact test



69 Mechanical Support Static Load Test

69.1 A polymeric part relied upon to suspend a part weighing more than 2 lbs (0.9 kg), in accordance with 10.3.2 shall be installed as intended on or in the equipment. The equipment shall be placed in a chamber maintained at 10°C above the maximum temperature measured on the supporting part during the normal temperature test. The part shall be allowed to acclimate to the temperature in the chamber for one hour. A weight equal to four times the weight of the suspended part shall then be gradually applied to the supporting part, distributed evenly and in the same direction as the actual suspended part. The full weight shall be maintained for one minute. The weight shall then be removed, the equipment allowed to cool, and the supporting part examined for signs of distortion. The part shall exhibit no visual evidence of distortion.

70 Barrier Strength Test

70.1 A barrier employed for compliance with 10.4.1(c) or 39.4.2 shall be subjected to a steady pushing force of 10 lbs (44.5 N) for one minute, evenly applied over an area of 1 square inch (6.45 cm^2). The force shall be applied from any direction in which the part serves as a barrier, and at the location(s) most likely to result in breaking, cracking, or displacement of the barrier. If more than one location or direction requires testing, a separate sample shall be used unless all parties agree to performing the tests on a single sample.

70.2 The test of 70.1 shall 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.

70A Mounting Means Test

70A.1 To determine compliance with 11.2, the equipment is to be mounted in accordance with the instructions, using the hardware provided, and adjusted (if adjustable) to the position that results in the most severe test. A weight of three times the weight of the equipment is to be gradually applied at a location placing the maximum stress on the mounting means and hardware, and maintained for 1 h. Neither the equipment nor any of the mounting hardware shall be pulled from the mounting surface.

RATINGS

71 General

Section 71 deleted

72 Standby Operation

72.1 *Deleted*

MARKINGS

73 General

Section 73 deleted

73A Markings

73A.1 General

73A.1.1 Equipment shall be 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; and

d) The date or other dating period of manufacture not exceeding any three consecutive months. 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 does not repeat in less than 20 years and does not require reference to the production records of the manufacturer to determine when the unit was manufactured.

73A.1.2 With regards to 73A.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.

73A.1.3 Markings are to be visible after installation unless specified as not on the equipment or specified as visible during installation. A marking that becomes visible when a cover or similar part is opened or removed, without disassembling or removing a component or device, is considered visible after installation.

73A.1.4 Unless a larger size is specified, all required markings shall be in letters not less than 1/16 inch (1.6 mm) in height. The word "CAUTION", where required, shall be in letters not less than 1/8 inch (3.2 mm) in height.

73A.1.5 Markings in quotations (“ “) are to be used verbatim; for other markings, text that provides for equivalent meaning and clarity is permitted.

73A.1.6 Boxes and enclosures of emergency equipment shall be identified as a component of the emergency system. The marking shall state EMERGENCY CIRCUITS 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. The marking is permitted to be supplied as a separate, field-installable label when instructions are provided in accordance with 76.6. When provided as a separate label, the label shall comply with 73A.1.2(c).

Note: This marking is to facilitate equipment approval in accordance with NEC Article 700 requirements for emergency system wiring identification. It does not apply to equipment that is clearly understood as integral to the emergency lighting or power system, such as emergency luminaires, exit signs, emergency battery packs, remote lamp assemblies, and unit equipment.

73A.1.7 Product markings, instruction manuals, or other media shall not claim that the product can be used in any way that conflicts with the markings and instructions specified in this standard.

73A.1.8 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.

73A.1.9 A directly controlled emergency luminaire evaluated and found to comply with the applicable requirements of this standard is permitted to be marked “directly controlled emergency luminaire” on the equipment, packaging, or literature.

73A.2 Ratings

73A.2.1 For each input supply circuit, the following electrical ratings shall be marked:

1) Input voltage;

2) Frequency (Hz) or DC, or both (see Note);

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).

Note: Equipment with both AC and DC input ratings is permitted a single combined marking when the amperage (or wattage) is identical – for example, “120 Vac, 60 hz or 170 Vdc; 3 A.” If the amperage (or wattage) is different, the markings shall be separate – for example, “120 Vac, 60 hz, 2A; or 170 Vdc, 3A.”

Exception: Incandescent lamp luminaires and exit signs directly connected to the supply source, without a transformer or a step down circuit, need only be rated for voltage.

73A.2.2 For each output circuit, the following electrical ratings shall be marked. Equipment with multiple identically-rated outputs is permitted to use a single marking such as “Each output rated ___ A, ___ V”, or similar and as required by (1) or (2) below, with the marking located where readily understood to apply to all output terminals or connections.

1) Direct Current Output Circuits:

i) The maximum output current or wattage;

ii) The nominal system voltage and "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 and frequency (Hz);

iii) The permissible load power factor range expressed in both lead and lag;

Exception: The permissible specific load types (tungsten, ballast, motor) shall be marked for automatic load control relays and ELCDs supplying remote loads.

iv) The number of phases or wires (if other than single phase).

NOTE 1: Output circuits limited to class 2 levels (see 4.8) are permitted to be identified as class 2, to facilitate acceptance of class 2 wiring methods. The maximum voltage and current of these outputs, along with their AC or DC designation, is still required to be marked.

NOTE 2: Relays intended to control LED drivers and similar electronic power supplies are most closely characterized by the ballast load type. See UL 508 (Standard for Industrial Control Equipment), Table 48.1, footnote k.

73A.2.3 Equipment marked for an extended ambient per 73A.2.5 is permitted to be marked with separate output current or wattage ratings for ambient temperatures below and above 25°C (i.e., xx – 25 C and 25 C – yy), where 'xx' and 'yy' are the lowest and highest marked temperatures.

73A.2.4 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. The standby power consumption marking shall be separated from the electrical ratings of 73A.2.1 by a blank line or the equivalent. See also 76.4.

73A.2.5 Equipment subjected to the ELCF Test, Section 47, Battery Discharge Test, Section 48, Temperature Test, Section 52, and Undervoltage Recharge Capability Test, Section 54, 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).

73A.2.6 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 48.7. Equipment marked for an extended ambient per 73A.2.5 and marked with separate output ratings based on ambient temperature, per 73A.2.3, shall also be marked with separate minimum charge times for ambient temperatures below and above 25°C (i.e., xx – 25 C and 25 C – yy), where 'xx' and 'yy' are the lowest and highest marked temperatures.

Exception: This requirement does not apply to auxiliary equipment.

73A.3 Installation

73A.3.1 Unless the intended wiring connections are evident, installation wiring terminals or leads shall be marked, where visible during installation, to indicate the intended connections.

73A.3.2 Unless unit equipment is provided with an equipment grounding terminal or lead as described in 20.2, it shall be marked, where visible during installation, to limit it to use with a metal enclosed wiring system.

73A.3.3 Emergency equipment with battery circuit output wiring terminals shall be marked to indicate the minimum wire size required for the purpose.

73A.3.4 Field wiring terminals restricted to copper wire use only, due to available wiring bending space or other issues, shall be marked “CU only” or “Copper wire only” in minimum 3/32 in. (2.4 mm) high letters. The marking shall be located on or adjacent to the affected terminal(s), or at an alternative location (visible after installation) with the affected terminal(s) identified.

73A.3.5 Unless the correct mounting position is obvious, equipment that must be mounted in a specific position to function properly shall be marked, where visible during installation, to indicate the correct mounting position.

73A.3.6 Equipment with an attachment plug 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 markings 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.

This marking is permitted to be visible when viewing the applicable internal connections.

73A.3.7 Low-frequency equipment that produces other than an essentially sinusoidal output wave form shall be marked for use only with specific loads with which it has been tested, or shall be marked "Loads connected to this equipment should be evaluated together with this equipment to determine reliable operation of the combination."

73A.3.8 An emergency luminaire intended for installation as an air-handling register for cool or return air only shall be marked "Suitable for use as an air-handling emergency luminaire. Not for use as a Heated-Air Outlet" or the equivalent. An emergency luminaire intended for installation as an air-handling register and that has been investigated for use in a 55 C environment is permitted to be marked “Suitable for use as an air-handling emergency luminaire” or the equivalent.

73A.3.9 Exit signs subjected to the Observation Visibility Test, 43.2, at a viewing distance of less than 100 feet shall be marked, in letters of minimum 1/8 inch (3.2 mm) height, with the following or an equivalent statement: "Notice – Rated 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.

73A.3.10 An exit sign investigated in accordance with the Impact Test, Section 68, for installation near the floor is permitted to be marked with the following or equivalent wording: "Suitable for floor proximity installation."

73A.3.11 A directly controlled emergency luminaire whose emergency operation responds to a control signal input more specific than zero (no input) or non-zero (any input) shall identify the control signal

generating device(s) with which it has been found suitable. This shall be accomplished with a marking, such as “For use only with _____” (where the blank is to include the manufacturer and model number(s) of the qualified equipment) or “See (insert URL here) for compatible control equipment”.

73A.3.12 Exit signs and luminaires intended for installation wholly or partially recessed into the mounting surface, and tested per 52.17, shall be marked “Type IC” or “Type non-IC”, as applicable. The marking shall be visible during installation.

73A.4 Operation and maintenance

73A.4.1 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.

73A.4.2 Exposed components such as meters, pilot lights, and switches shall be identified as to their function. Test switches shall be marked to indicate how to use or activate the switch, if not obvious.

73A.4.3 An exit sign that flashes, produces an audible signal, or both shall be provided with a marking to specify such features. A flashing exit sign shall additionally be marked to specify the flash rate and duty cycle of operation.

73A.4.4 Equipment with an input power factor of 0.85 or greater is permitted to be marked "Power Factor Corrected" or the equivalent. Equipment with an input power factor of 0.9 or greater is permitted to be marked "High Power Factor" or "HPF", or the equivalent.

73A.4.5 Equipment with integral loads and provision for connection of remote loads shall be marked with the word "CAUTION" and one of the following or equivalent:

a) "Total connected load (integral and remote) 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 73A.2.2.

Exception: This marking is not required when the equipment remote load outputs are marked class 2.

73A.4.6 Equipment having more than one power input source that might present a risk of electric shock (see 4.47) shall be marked "CAUTION" and the following or equivalent: "Disconnect both the branch circuit-breakers or fuses and emergency power supplies before servicing."

73A.4.7 Equipment having more than one power source that might present a risk of electric shock (see 4.47), and having provisions for connection of remote loads, shall be marked where readily visible during any approach to service "CAUTION" and the following or equivalent: "Disconnect both normal and emergency sources within this unit before servicing this or any connected equipment."

73A.4.8 A sealed unit shall be marked: "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.

73A.4.9 If required per the exceptions to 20.1 or 40.4, 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.

73A.4.10 Equipment with a replaceable light source (lamp) shall be marked with one of the following, as applicable. The marking shall be visible during relamping.

(a) Luminaires and unit equipment – " ____ W, ____ type lamp only." When more than one lamp type is eligible, other eligible replacement lamp types are permitted to be identified on a manufacturer-controlled website when the website address is also permanently marked in the same location, with text such as “For additional lamp options, see abc.com/lamps”.

(b) Exit signs:

(1) Incandescent – “ ____ W ____ type ____ volt lamp only" or “____ lamp assembly only." 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.

(2) Fluorescent – “____ W ____ type lamps" or " ____ lamp assembly only." 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.

(3) LED – " ____ lamp assembly only." The blank space is to be filled in with the manufacturer's identity and lamp type designation or part number.

73A.4.11 Equipment incorporating or intended to incorporate batteries shall be marked "CAUTION: Install only _____ battery." The blank is to be filled in with the battery manufacturer identification and catalog designation. This information is to be in a location visible during battery replacement. Markings that appear only on the battery are not considered in compliance with this marking requirement.

Exception No. 1: This marking is not required for sealed units marked per with 73A.4.8.

Exception No. 2: The marking is permitted to additionally state “See (specific URL inserted here) for other eligible batteries" or alternatively state “CAUTION: Install only batteries identified at (specific URL inserted here)". The manufacturer shall maintain this website without restrictions (such as password or registration requirements).

73A.4.12 A fuse replacement marking shall be located where readily visible during fuse replacement, either adjacent to the fuse or fuseholder or in another location provided that it is obvious to which fuseholder the marking applies. The marking shall specify the ampere rating, and the voltage rating if higher than 125 V. Where fuses with special characteristics (such as time delay) are necessary, the fuse 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."

73A.4.13 Self-testing/self-diagnostic equipment with variable outputs, per 30.1.1, shall be marked, on a surface visible during service, "CAUTION: See instructions for derangement signal calibration" Examples include constant power output LED emergency battery packs which provide reduced current in proportion to higher voltage loads being connected. See 74.5.

73A.4.14 Self-diagnostic (only) equipment shall be marked in color-contrasting, minimum 1/16-inch (1.6-mm) high lettering, "NOT SELF-TESTING PER ANSI/NFPA 101", or the equivalent. See also 74.10. 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.

73A.4.15 An emergency luminaire with an integral emergency battery pack is permitted to be marked "CAUTION: Replace only with _____ emergency battery pack." The blank is to be filled in with either:

a) The emergency battery pack manufacturer identification and catalog designation, or

b) “UL 924-compliant emergency battery pack with output rated _____.” The blank shall specify either the output voltage and current, matching that of the original emergency battery pack, or the output power of the original (if of constant power design).

The marking shall be located where visible during emergency battery pack replacement but not on the original emergency battery pack itself. The marking is permitted to additionally state “See (specific URL inserted here) for other eligible emergency battery packs." The manufacturer shall maintain this website without restrictions (such as password or registration requirements).

Exception: This marking is not required for sealed units marked per with 73A.4.8.

INSTRUCTION MANUAL

74 General

74.1 Instructions necessary for the intended installation, operation, and maintenance of equipment shall be provided with all equipment. The instructions are permitted to be separately provided on a publicly accessible web site if the equipment is permanently marked (see 73A.1.2) with a QR code or "See (specific URL inserted here) for installation, operation, and maintenance instructions." As an alternative to a product marking, the QR code or website address can be provided on a stuffer sheet packaged with the 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.

74.1A Instructions shall not include content that conflicts with the markings required by Section 73A (For example, instructions for equipment marked with a DC output shall not recommend connection to a load rated only for AC input).

74.2 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. This information can alternative be marked on the equipment.

74.3 The instruction manual for equipment with ELCF capability shall describe the operational mode(s) of the ELCF and describe the appropriate testing and diagnostic procedures. Where ELCF capability is dependent on signals or power received from or transmitted to other equipment, the instructions shall include identification of the other equipment, any constraints on the installation of or means of interaction with that equipment, and a description of procedures to verify that the intended interoperability is established.

74.4 Per 30.1 and specifically 30.1(d), the user manual for self-testing/self-diagnostic equipment shall include guidance for installation, calibration, and diagnostic report analysis. The instructions should address conditions that could result in false positives (indicating failure when no failure exists) or

undetected equipment failures that may be due to the effect of other equipment installed between the emergency power source and the connected load (for example, an ELCD that allows a connected emergency load to be “off”).

74.5 Per 30.1.1, equipment with self-test/self-diagnostic capability and a range of output levels shall include derangement signal calibration instructions preceded by the following, or equivalent: “CAUTION: This equipment provides reduced current levels when higher voltage loads are connected. The derangement signal requires calibration to ensure proper operation.”

74.6 The instructions for central station and unit equipment shipped without batteries, as permitted by 22.10, shall identify the intended batteries by manufacturer and part number.

74.7 The installation instructions for an exit sign with a transparent background shall include the following statement, or equivalent: "This sign shall be installed only where there is adequate color contrast between the sign legend and the interior wall finish behind the sign, to provide for sufficient visibility."

74.8 Installation instructions for cord-connected unit equipment shall state 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.

74.9 Installation instructions provided with an open type device shall include the statement “Intended for installation within the enclosure of equipment Listed for permanent installation” or similar. The instructions shall identify:

a) The minimum spacing requirements, if required per the Exception to 66.2.1, between the device and any combustible materials or enclosure openings,

b) Any orientation constraints applicable per 52.10,

c) Any equipment compatibility limits or constraints related to emergency control functionality, such as load ratings or specific manufacturers / model numbers, and

d) other information that may be relevant to establish a Code-compliant installation, including reference to NEC 700.24 for an ELCD intended for installation within a directly controlled luminaire.

74.10 The product literature and instruction sheets for self-diagnostic (only) equipment shall 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.

74.11 The installation instructions for a directly controlled emergency luminaire whose control signal input control is intended to be bypassed under emergency power conditions shall include the following text, or equivalent: “CAUTION: When this luminaire is designated as part of a facility emergency lighting system and supplied by a remote emergency power source, the control input to the luminaire must be disconnected upon loss of normal facility power. Loss of power to the control input will set the luminaire to either full output or a pre-set illumination level complying with the applicable codes and approved by the authority having jurisdiction.”

74.12 The installation instructions for a directly controlled emergency luminaire whose control signal input control is intended to be actively controlled under emergency power conditions shall include the following text, or equivalent: “CAUTION: When this luminaire is designated as part of a facility emergency lighting system and supplied by a remote emergency power source, the control input must be supplied from a listed ELCD that will set the luminaire output to an illumination level complying with the applicable codes and approved by the authority having jurisdiction.

75 Safety Instructions

75.1 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).

75.2 The safety instructions shall include instructions or illustrations to identify important safety features, in addition to the important safeguards listed in 75.5.

75.3 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.

75.4 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.

75.5 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

76 Other Instructions

76.1 The instruction manual shall include instructions for installation, operation, and maintenance recommended by the manufacturer. The instructions shall state that installation and servicing should be performed by qualified personnel.

76.2 *Deleted*

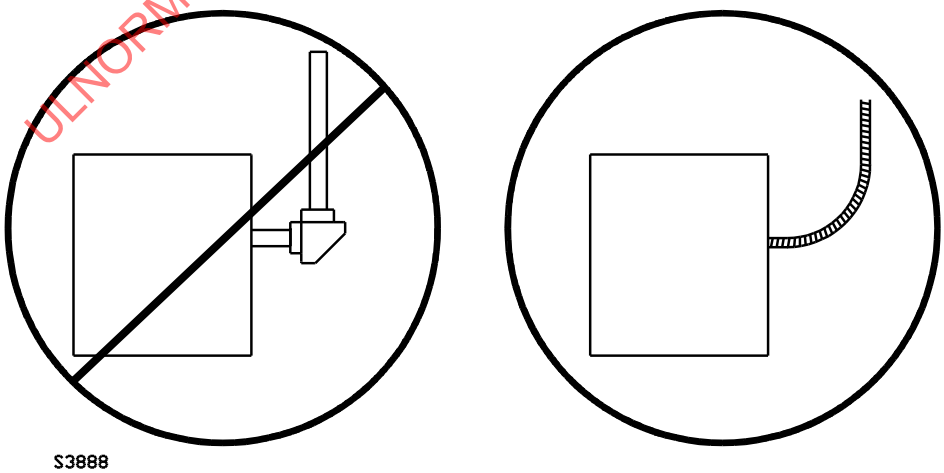
76.3 An exit light or exit fixture that flashes or produces an audible signal or both shall be provided with instructions to specify that such features are incorporated in the construction and that such equipment is intended for installation in locations permitted by local codes. For flashing exit lights 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.

76.4 Equipment marked with a standby electrical input rating in accordance with 73A.2.4 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.

76.5 When equipment with polymeric enclosures is intended for connection only to a non-rigid wiring system, per 10.2.5, the installation instructions shall state, adjacent to the respective diagrams shown in Figure 76.1, 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 76.1

Flexible conduit marking



76.6 A field-installable label provided in accordance with 73A.1.6 shall be accompanied with instructions that declare it for application only to equipment connected to circuits designated for emergency power, in

accordance with NEC Article 700 or an equivalent applicable installation code. The instructions shall also specify that the label is to be applied to an equipment location that will be visible after installation.

76.7 Installation instructions for equipment with direct current output circuits shall state “Connect only DC rated electrical loads. Do not connect electrical loads that are rated for AC input only.”

LOW-FREQUENCY INVERTERS

77 General

77.1 Low-frequency inverters (50 – 800 hertz) shall comply with requirements elsewhere in this standard and with the requirements in Performance, Section 78.

78 Performance

78.1 Output load power factor test

78.1.1 To determine that low-frequency inverters comply with the requirements in 73A.2.1(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.

78.2 Battery discharge test

78.2.1 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. Lumen output (48.3) or current output (Exception to 48.3) measurements are permitted as alternatives to measuring battery voltage.

78.2.2 To determine if low-frequency inverters comply with the requirement in 78.2.1, the unit shall be tested per 48.6 at unity power factor load or at the rated power factor load which draws the maximum battery current.

78.3 Output voltage and frequency test

78.3.1 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".

78.3.2 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 78.3.1.

HIGH-FREQUENCY INVERTERS

79 General

79.1 High-frequency inverters (greater than 800 hertz and intended to operate electric discharge lamps), as defined in 4.27, shall comply with the appropriate requirements elsewhere in this standard and with the requirements in Performance, Section 80, and Marking, Section 81.

80 Performance

80.1 General

80.1.1 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 80.2 and 80.3.

80.2 Output voltage and current test

80.2.1 The voltage to ground or on exposed, dead-metal parts of the inverter shall be measured in accordance with 80.2.3. If the measured voltage exceeds 300 volts rms and the current through the 500 ohm resistor exceeds the values shown in Table 80.1, the inverter shall be marked in accordance with 81.1.

Table 80.1
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.

80.2.2 The accessible voltage on an inverter required by 80.2.1 to be marked per 81.1 shall not exceed the voltage versus capacitance values outlined in Table 80.2.

Table 80.2
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

Table 80.2 Continued on Next Page

Table 80.2 Continued

Voltage across capacitor prior to discharge	Capacitance,[a] microfarads
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.

80.2.3 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.

80.3 Abnormal conditions test

80.3.1 There shall be no risk of fire or electric shock when an inverter is operated at thermal equilibrium under intended conditions as described in 45.2, 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 80.3.5.

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 66.2.1 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.

80.3.2 With regard to 80.3.1(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.

80.3.3 With regard to 80.3.1(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.

80.3.4 With regard to 80.3.1(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.

80.3.5 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.

81 Marking

81.1 An inverter that delivers a current greater than specified in Table 80.1 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.

No Text on This Page

SUPPLEMENT SA – FIELD INSTALLED LUMINAIRE EMERGENCY BATTERY PACKS

SA1 General

SA1.1 Emergency ballasts intended for field installation within or adjacent to previously installed fluorescent luminaires, and emergency LED drivers intended for field installation within or adjacent to previously installed LED luminaires, shall comply with applicable requirements elsewhere in this Standard and with the requirements in Sections SA2 – SA5. Unless otherwise noted, requirements in this section that refer to “emergency battery packs” apply to both types of products.

SA2 Mounting and Installation

SA2.1 Emergency battery packs shall have a means for permanent mounting.

SA2.2 Installation of an emergency battery pack in accordance with the installation instructions shall result in an assembly that complies with this Standard.

SA3 Performance

SA3.1 Emergency battery packs intended for installation within a luminaire enclosure or above a ceiling shall be subject to the Battery Discharge Test, Section 48, Temperature Test, Section 52, and Undervoltage Recharge Capability Test, Section 54, in a 55°C (131°F) ambient, or higher if so rated.

SA3.2 Emergency battery packs rated for use in ambients below 20°C (68°F) shall be subject to the Battery Discharge Test, Section 48, and Undervoltage Recharge Capability Test, Section 54, under the appropriate ambient conditions as noted in those Sections.

SA3.3 Emergency battery 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 SB, and/or Emergency Lighting and Power Equipment for Use in Wet Locations, Supplement SC.

SA3.4 Emergency battery packs intended for use in air handling luminaires shall be evaluated in accordance with the applicable requirements of the Standard for Luminaires, UL 1598.

SA3.5 Emergency battery packs shall comply with Supplement SG for the lamp type(s) and wattage(s) it is marked for use with, per SA4.5. Testing per SG2 shall be performed using a down-facing luminaire suitable for the designated lamp(s). The down-facing luminaire surface shall have a flat white painted (non-glossy) surface coating and no diffuser or lens between the lamp and the floor.

SA4 Marking and Instructions

SA4.1 An emergency ballast 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.

SA4.2 An emergency battery 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. See 73A.3.8.

SA4.3 An emergency battery 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 SB, or Emergency Lighting and Power Equipment for Use in Wet Locations, Supplement SC, as applicable.

SA4.4 An emergency battery pack evaluated and found suitable for use at other than 25°C (77°F), in accordance with SA3.1 and/or SA3.2, shall be marked with its lowest and highest ambient temperature rating.

SA4.5 An emergency battery pack shall be marked to identify the intended lamp type(s) and wattage(s). For a pack that is suitable for use with more than one lamp type, the additional lamp types are permitted to be identified on a manufacturer-controlled website when the website address is also permanently marked in the same location, with text such as “For additional lamp options, see abc.com/lamps”.

SA4.6 An emergency battery pack tested in accordance with SG2.2 shall be marked to indicate the maximum mounting height of the connected luminaire, in accordance with SG3.2. If the battery pack is suitable for use with more than one luminaire or luminaire configuration whose maximum mounting height differs, the pack shall be marked to refer to the installation instructions where the maximum mounting height for each configuration shall be noted, as indicated in SG3.2.

SA5 Instruction Manual

SA5.1 The instruction manual for an emergency battery pack shall include all instructions necessary to install the pack as intended.

SA5.2 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.

SA5.3 The instruction manual shall include the word "CAUTION" and the following statement or equivalent "Verify that all replacement lamp types marked on the installed luminaire are also identified as suitable for use with this emergency battery pack."

SUPPLEMENT SB – EMERGENCY LIGHTING AND POWER EQUIPMENT FOR USE IN DAMP LOCATIONS

SB1 General

SB1.1 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 SB2 – SB5.

SB2 Construction – Mechanical

SB2.1 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.

SB2.2 Hinges, bolts, and fasteners made of ferrous materials shall be protected against corrosion as described in SB2.1.

Exception: Hinge pins need not be provided with the corrosion protection described in SB2.1.

SB2.3 Sheet steel or other metal that is painted to comply with SB2.1 shall be properly cleaned of grease and the like prior to painting.

SB2.4 Welds in iron or steel shall be painted or provided with equivalent protection against corrosion.

SB2.5 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).

SB3 Construction – Electrical

SB3.1 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.

SB3.2 The screw shell in a screw shell-type lampholder shall be made from:

a) Copper, or a copper alloy with a minimum 80 percent copper;

b) Nickel alloy; or

c) Stainless steel.

SB3.3 Single-pin or recessed double-contact lampholders shall be of the weatherproof type or of a type acceptable for use in outdoor enclosed signs.

SB3.4 A ballast shall be of the outdoor or weatherproof type.

SB3.5 A printed-wiring board (PWB) shall be tested per SB3.6, or it shall be completely and uniformly coated on both sides and tested per the Conformal Coating Test Program I, Section 57, or Conformal Coating Test Program II, Section 58.

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 SB3.6.

SB3.6 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 ±5 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 56, 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.

SB4 Performance – Humidity Conditioning

SB4.1 For 24 hours prior to the Dielectric Voltage-Withstand Test, Section 56, equipment shall be placed in a chamber maintained at 88 ±5 percent relative humidity and 5°C (9°F) above the equipment's maximum rated ambient temperature.

SB5 Markings

SB5.1 Equipment that complies with this supplement is permitted to be marked "Suitable for damp locations." The marking shall be visible after installation.

SUPPLEMENT SC – EMERGENCY LIGHTING AND POWER EQUIPMENT FOR USE IN WET LOCATIONS

SC1 General

SC1.1 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.

SC2 Construction – Mechanical

SC2.1 Corrosion protection

SC2.1.1 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 SC2.1.

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 SC2.1 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 SC2.1.2 – SC2.1.5 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 SB2.1 – SB2.5.

Table SC2.1
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]

Table SC2.1 Continued on Next Page

Table SC2.1 Continued

Type of coating	Type or thickness,[a] inch	(mm)	Description
(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.

SC2.1.2 Hinges, bolts, and fasteners made of ferrous materials shall be protected against corrosion as described in SB2.1 for damp locations.

Exception: Hinge pins need not be provided with the corrosion protection required in SB2.1.

SC2.1.3 The acceptability of a coating on hinges, bolts, and fasteners may be determined by visual inspection.

SC2.1.4 Punched holes and cut edges in ferrous material need not be corrosion protected.

SC2.1.5 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 SC2.1.

Exception: One coat of any indoor paint is acceptable over a spot weld on galvanized steel.

SC2.2 Enclosures

SC2.2.1 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.

Exception: For the purposes of this requirement, the outer surface of the glass envelope of a lamp may be wetted.

SC2.2.2 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 SC2.4.2 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 SC2.2.1.

SC2.2.3 To determine compliance with SC2.2.1 and SC2.2.2, a complete assembly is to be subjected to the Rain or Sprinkler test as specified in Performance, Section SC4.

SC2.3 Gaskets and bushings

SC2.3.1 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 SC4.7.2.

Exception: Gaskets or bushings tested while installed in the equipment as described in SC4.7.3 need not be subjected to the test described in SC4.7.2.

SC2.3.2 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.

SC2.3.3 If an adhesive is used to secure a gasket as described in SC2.3.2, the gasket assembly shall comply with the Gasket adhesion test described in SC4.8.1.

SC2.4 Openings

SC2.4.1 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 SC4, 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 the installation instructions specify the use of a conduit fitting that complies with the wet location requirements in the Standard for Conduit, Tubing, and Cable Fittings, UL 514B, the opening or openings need not be threaded.

SC2.4.2 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 SC2.2 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 SC4.2.1 – SC4.2.3 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 SC2.2.2.

Exception No. 3: A drain hole is not required in an emergency battery pack intended to be installed inside fixtures.

Table SC2.2
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)

SC2.5 Polymeric water shields

SC2.5.1 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.

SC3 Construction – Electrical

SC3.1 Wet-location equipment shall comply with the requirements in SB3.1 – SB3.6.

SC3.2 Any cord exposed outside of a surface-mount equipment shall be marked with a "W" following the type designation.

SC3.3 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.

SC3.4 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.

SC4 Performance

SC4.1 General

SC4.1.1 The requirements specified in SC4.2.1 – SC4.9 apply to all wet-location emergency lighting and power equipment.

SC4.2 Tests required

SC4.2.1 Wet-location equipment shall be subjected to the appropriate Rain and Sprinkler Tests as required in SC4.2.2 and SC4.2.3 and described in SC4.3.1 – SC4.6.3. A summary of the tests required is provided in Table SC4.1.

Table SC4.1
Required tests for wet-location equipment

Type of equipment	Rain	Sprinkler
Surface-mounted ceiling	Yes[a]	Yes[b]
Recessed ceiling	Yes[a]	Yes

Table SC4.1 Continued on Next Page

Table SC4.1 Continued

Type of equipment	Rain	Sprinkler
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 SC4.2.3.

[b] Test not required if the Rain Test is conducted as described in Exception No. 3 to SC4.2.3.

SC4.2.2 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.

SC4.2.3 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 SC5.3.

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.

SC4.3 General – test conditions

SC4.3.1 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.

SC4.3.2 Equipment marked in accordance with SC5.2 to indicate a limited angle of mounting shall be mounted during a test in the most adverse position permitted by the marking.

SC4.3.3 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 SC5.3 may be treated as only wall- or ceiling-mounted equipment.

SC4.3.4 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

SC4.4 General – test results

SC4.4.1 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 SC2.4.2.

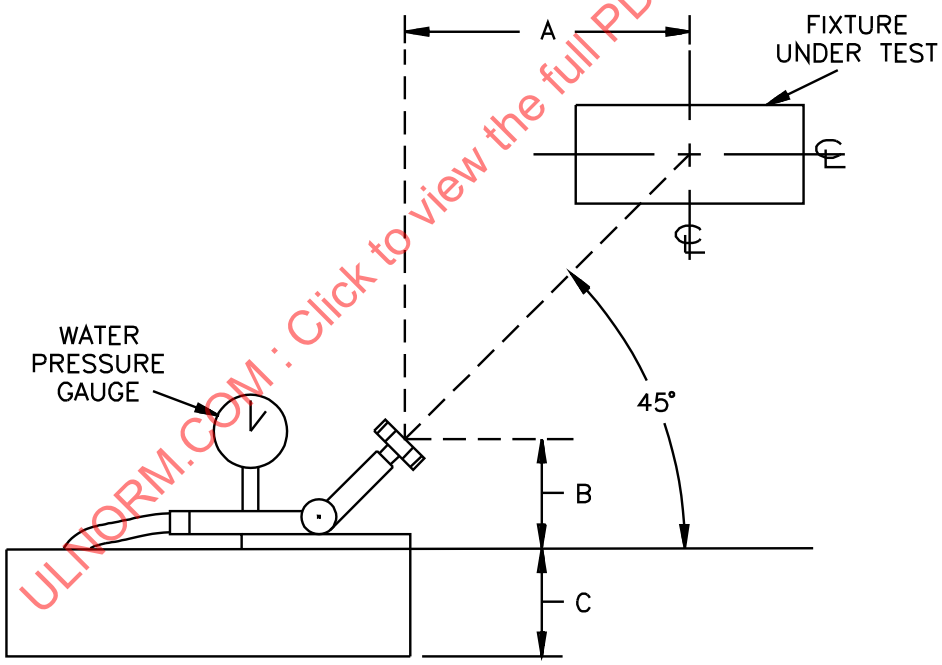
SC4.5 Sprinkler test

SC4.5.1 Equipment required to be subjected to the Sprinkler Test shall comply with the requirements in SC4.5.2.

SC4.5.2 The equipment is to be positioned as shown in Figure SC4.1 in front of a standard water spray head of the type shown in Figure SC4.2, to which the water pressure is maintained at a gage pressure of 20 pounds per square inch (138 kPa).

Figure SC4.1

Representative sprinkler test setup



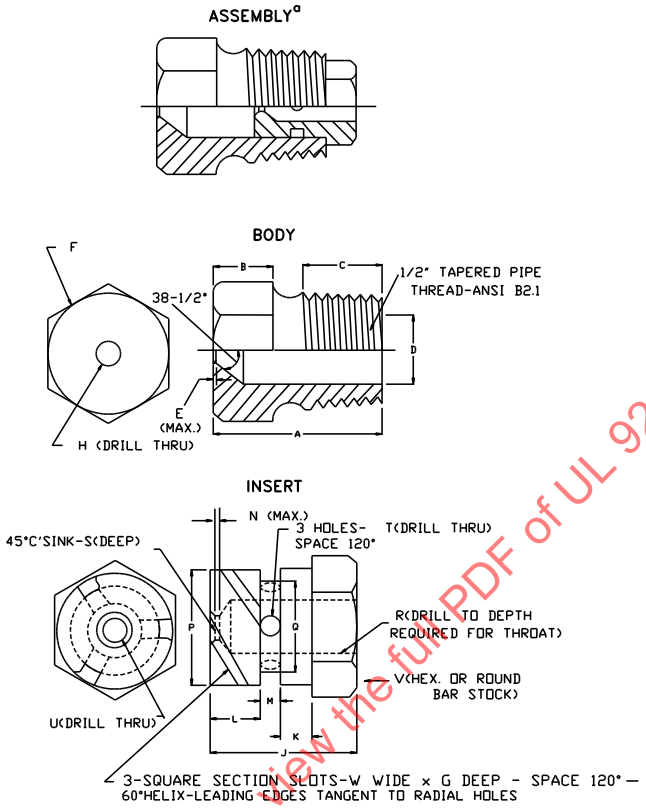
NOTES:

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 SC4.2
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.

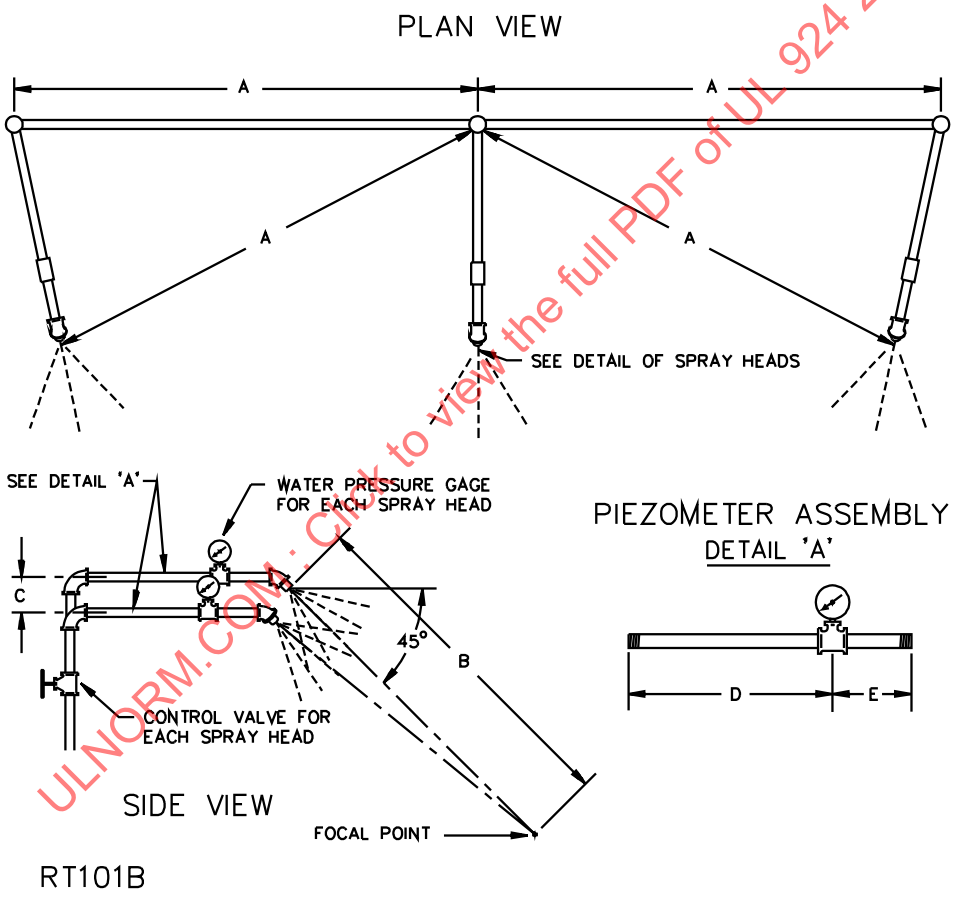
SC4.6 Rain test

SC4.6.1 Equipment required to be subjected to the Rain Test shall comply with the requirements in SC4.6.2 and SC4.6.3.

SC4.6.2 The water spray test apparatus is to consist of three spray heads mounted in a water supply pipe rack as shown in Figure SC4.3. Spray heads are to be constructed in accordance with the details shown in Figure SC4.2. 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 SC4.3

Spray head piping



RT101B

Item	inches	(mm)
A	28	(710)
B	55	(1400)
C	2-1/4	(55)
D	9	(230)
E	3	(75)

SC4.6.3 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.

SC4.7 Thermal conditioning

SC4.7.1 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 SC4.2. 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 SC4.2
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)

SC4.7.2 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 SC4.7.3.

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.

SC4.7.3 As an alternative to the test described in SC4.7.2, 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.

SC4.7.4 With regard to SC4.7.3, 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 SC4.7.3 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.

SC4.8 Gasket adhesion test

SC4.8.1 In accordance with SC2.3.3, 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 SC4.7.2. 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.

SC4.9 Humidity conditioning

SC4.9.1 For 24 hours prior to the Dielectric Voltage-Withstand Test, Section 56, equipment shall be placed in a chamber maintained at 88 ±5 percent relative humidity and 5°C (9°F) above the equipment's maximum rated ambient temperature.

SC5 Markings

SC5.1 Equipment that complies with this supplement is permitted to be marked "Suitable for wet locations" or, if appropriate per the Exception to SC2.5.1, “Suitable for indoor wet locations.”

SC5.2 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.

SC5.3 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.

SC5.4 The markings specified in SC5.1 – SC5.3 shall be visible after installation.

SUPPLEMENT SD – ALTERNATIVE REQUIREMENTS FOR TRANSFORMERS

INTRODUCTION

SD1 Scope

SD1.1 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.

SD1.2 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

SD2 General

SD2.1 A transformer required to provide an isolated secondary circuit shall have an insulation system as described in Table SD2.1.

Exception: A transformer that complies with the construction requirements of UL 506, UL 1310, UL 1411, UL 5085-1 in combination with either UL 5085-2 or UL 5085-3, as applicable, shall be considered in compliance with Table SD2.1.

SD2.2 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 SD2.1, shall provide a continuous minimum 1/32 inch (0.8 mm) wide edge against each bobbin flange.

Table SD2.1
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 aramid 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 SD7.

D – Spacings specified in Table 37.1 may be used in place of the specified 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.

Table SD2.1 Continued on Next Page

Table SD2.1 Continued

Insulation required	Type of insulation
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 SD7. 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 SD4. 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 SD5. *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 50, and the following:* *a) The winding to which the crossover lead is connected and* *b) The core.*	

PERFORMANCE

SD3 General

SD3.1 Transformers and associated circuitry shall be tested for compliance with Sections SD4 – SD6. 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 SD6.2 when it has been found to comply with the:

a) Abnormal Operation Test of the Standard 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 SD6.3 when it has been found to comply with the Overload Test of:

a) The Standard for Specialty Transformers, UL 506;

b) The Standard for 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 SD4 when it has been found to comply with the Dielectric Withstand Test of UL 506, UL 1310, UL 1411, UL 5085-1 in combination with either UL 5085-2 or UL 5085-3, as applicable.

SD4 Dielectric Voltage-Withstand Test

SD4.1 The test method described in Dielectric Voltage-Withstand Test, Section 56, shall be performed between: