# UL 1573

## STANDARD FOR SAFETY

## Stage and Studio Luminaires and Connector Strips

UL Standard for Safety for Stage and Studio Luminaires and Connector Strips, UL 1573

Fourth Edition, Dated May 29, 2003

***Summary of Topics***

***This revision to UL 1573 dated January 22, 2019 includes an Alternate Method for Providing Installation Instructions.***

The revised requirements are substantially in accordance with Proposal(s) on this subject dated December 3, 2018.

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

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# UL 1573

## Standard for Stage and Studio Luminaires and Connector Strips

Prior to the first edition, the requirements for the products covered by this standard were included in the twelfth edition of the Standard for Electric Lighting Fixtures, UL 57.

The first, second, and third editions of this standard were titled Stage and Studio Lighting Units.

First Edition – January, 1985
Second Edition – February, 1994
Third Edition – October, 1996

**Fourth Edition**

**May 29, 2003**

This UL Standard for Safety consists of the Fourth Edition including revisions through January 22, 2019.

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

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## INTRODUCTION

### 1 Scope

1.1 These requirements cover stage and studio luminaires rated 600 volts or less for use in theaters, studios, and similar locations in accordance with Articles 520 and 530 of the National Electrical Code, NFPA 70.

1.2 These requirements cover borderlights, spotlights, floodlights, footlights, professional photographic lights, portable strip lights, and the like, that use incandescent, fluorescent, high-intensity discharge, xenon, and other high-pressure electric discharge lamps, as well as connector strips, drop boxes, and the like, when rigged similarly to borderlights. These requirements do not cover stage and studio luminaires using carbon arc lamps.

1.3 These requirements do not cover miscellaneous special purpose lights, amateur movie lights, or lighting intended for residential use.

### 2 General

#### 2.1 Components

2.1.1 Except as indicated in 2.1.2, 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 used in the products covered by this standard.

2.1.2 A component is not required to comply with a specific requirement that:

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

b) Is superseded by a requirement in this standard.

2.1.3 A component shall be used in accordance with its rating established for the intended conditions of use.

2.1.4 Specific components are 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.

## 2.2 Units of measurement

2.2.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

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

## 2.3 Undated references

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

## 2.4 Product configuration

2.4.1 Unless otherwise indicated in a specific requirement, all product orientations for which the manufacturer intends the product to be suitable shall be evaluated.

## 3 Glossary

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

3.2 ACCESSIBILITY BARRIER – A material provided to limit access to parts that present a risk of electric shock or injury. When determined to comply with applicable additional requirements, all or part of the accessibility barrier is capable of also serving as part of an enclosure or a lamp-containment barrier.

3.3 BACK-UP RESTRAINT DEVICE – A cable, chain, or other device not supporting an object but is provided to help prevent an object from falling to the floor when the normal means used for object securement fails.

3.4 BARN-DOOR – A shutter or flap attached to the front of a luminaire and used to control the shape of a light beam. Barn-doors are typically used in one or two pairs.

3.5 BORDERLIGHT – A striplight placed behind a stage border on rigging.

3.6 CLASS 2 CIRCUIT – A circuit supplied by a Class 2 power source.

3.7 CLASS 2 POWER SOURCE – One of the following power sources:

a) A transformer complying with the construction and performance requirements for Class 2 transformers in 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.

b) A power unit complying with the construction and performance requirements in the Standard for Class 2 Power Units, UL 1310.

c) Another power source confirmed to exhibit limited voltage, current, and power equivalent to that of (a) or (b), such as a limited-voltage/current circuit as described in Limited-Voltage/ Current Circuits, Section 27.

3.8 CLASS 3 CIRCUIT – A circuit supplied by a Class 3 power source.

3.9 CLASS 3 POWER SOURCE – One of the following power sources:

a) A transformer complying with the construction and performance requirements for Class 3 transformers in 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.

b) A power unit complying with the construction and performance requirements for Class 3 Output Circuits in the Standard for Power Units Other Than Class 2, UL 1012.

c) Another power source confirmed to comply with construction and performance requirements equivalent to that of (a) or (b).

3.10 CLEARANCE DISTANCE – The shortest distance measured through air between conductive parts.

3.11 COLD HIGH-PRESSURE LAMP – An electric discharge lamp which exhibits a pressure within the arc envelope exceeding 103.4 kPa (15 psi) while at a temperature of 40°C (104°F) or less.

3.12 CONNECTOR STRIP – A wireway mounted on rigging (a network of lines and chains used for support and manipulation of scenery and equipment) or to the building structure above or adjacent to the luminaires it supplies. Receptacles or drop cords are provided for the connection of spotlights, floodlights, and portable striplights that are capable of being mounted to or suspended from the strip. A connector strip with many portable striplights is equivalent to a borderlight.

3.13 CORD CONNECTOR – A connector device for a flexible cord to which an attachment plug is connected.

3.14 CREEPAGE DISTANCE – The shortest distance measured over the surface of insulation between conductive parts.

3.15 DIFFERENT CIRCUITS – Circuits from different sources such as primary circuits with different branch-circuit overcurrent protective devices, primary and secondary circuits, and secondary circuits from different windings of an isolating transformer.

3.16 DISAPPEARING FOOTLIGHT – A footlight that folds flush with the stage floor when not in use.

3.17 DRIPPING MATERIAL BARRIER – A barrier provided to reduce the risk of molten metal, burning insulation, flaming particles, and the like from falling through an opening in the enclosure.

3.18 DROP BOX – A short connector strip with a temporary means of mounting to pipes on rigging.

3.19 DROP CORD – A length of pendant flexible cord or cable that terminates in a cord connector and that is permanently connected to the supply circuit.

3.20 ENCLOSURE – A material provided to enclose electrical parts and components that present a risk of fire. When determined to comply with applicable additional requirements, all or part of the enclosure is capable of also serving as an accessibility barrier, dripping material barrier, or lamp-containment barrier.

3.21 FLOODLIGHT – A luminaire that produces an intense and broad light beam.

3.22 FOOTLIGHT – A striplight located at foot level along the front of the stage or cyclorama (a stretched cloth across the back of the stage used to form the background).

3.23 GOBO – A perforated plate or disk that is part of, or capable of being added to and supported by, a luminaire for the purpose of projecting images or patterns.

3.24 HAND-SECURED JOINT – A joint that is designed to be tightened or secured by hand and without the use of a tool. Examples of a hand-secured joint include a threaded knob, a twist-type latch, and a deflection-type tab or latch.

3.25 HIGH-PRESSURE LAMP – An electric discharge lamp which exhibits a pressure within the arc envelope exceeding 103.4 kPa (15 psi) at any time. Such lamps include short-arc xenon and other short-arc lamps. A high-pressure sodium lamp is not a high-pressure lamp as defined herein.

3.26 INTERLOCK MECHANISM – A mechanism that de-energizes parts involving a risk of electric shock or that stops moving parts before they become accessible to the user when the enclosure of the part is opened or a cover is removed.

3.27 IRIS – An adjustable arrangement of thin plates that form an opaque area with a variable circular opening in the center of the arrangement. The iris is used to control the size of a light beam, as from a spotlight.

3.28 KNOCKOUT – A precut portion of the wall of an outlet box or enclosure, or a feed connector that can be readily removed at the time of installation in order to provide an open hole for the attachment of a connector or fitting.

3.29 LAMP – A device consisting of a glass or quartz envelope, a filament and filament supports, electric arc electrodes, a base, and the like that is the source of illumination.

3.30 LAMP-CONTAINMENT BARRIER – A barrier intended to limit the emission of:

a) Quartz particles of a ruptured tungsten-halogen lamp or of an electric discharge lamp of other than the fluorescent type or

b) Lamp-envelope particles, lamp metal parts, and other lamp parts that result from the explosion of a high-pressure lamp.

3.31 LIGHT BEAM – The illumination generated by a lamp. The size and shape of the light beam is capable of being changed by barn-doors, shutters, and the like.

3.32 LIMITED-VOLTAGE/CURRENT CIRCUIT – A circuit that complies with the requirements specified in Limited-Voltage/Current Circuits, Section 27, and is supplied from an isolated secondary winding of a transformer.

3.33 LOW-VOLTAGE COMPONENT FAN – A component fan intended to be used in an isolated, secondary circuit, rated a maximum of 30 V rms (42.2 volts peak), or 60 V DC, and complying with the requirements for such fans in the Standard for Electric Fans, UL 507.

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3.34 LUMINAIRE – A complete assembly that includes an enclosure, a lamp, a lampholder, a mounting means, a power supply connection means, and the like. A luminaire is also capable of including other parts such as barn-doors or shutters.

3.35 MOTOR DRIVE CIRCUIT – The circuitry intended to control the operation of a motor. Operation characteristics controlled include motor energization/deenergization and rotor speed, direction, or position.

3.36 NON-STANDARD RECEPTACLE, CORD CONNECTOR, and PLUG – A receptacle, cord connector, or plug that has a slot or blade or pin configuration that has not been assigned a voltage or current rating by a nationally-recognized, standards-developing organization or by the general practice of an industry. Stage-type fittings are categorized as non-standard.

3.37 OPENING – A hole in the wall of a required enclosure. An open hole and a knockout are both openings.

3.38 ORDINARY TOOLS – Flat-blade and cross-head screwdrivers, crescent wrenches, and pliers.

3.39 OVERHEAD PRODUCT – A product provided with a mounting means for mounting the product above the floor to a wall, ceiling, pipe, or other structure.

3.40 POLE LEAST CAPABLE OF STRIKING GROUND – A pole that is referenced to ground or, by virtue of its position, potential, or both, relative to other poles of the device, is least capable of striking ground. Where two or more poles are equally least capable of striking ground, any one of the poles is capable of being categorized as the pole least capable of striking ground.

3.41 PORTABLE STRIPLIGHT – A short length of cord-connected striplight with a means for temporary mounting.

3.42 PROSCENIUM SIDELIGHT – A striplight on or in the proscenium (the wall that frames the stage and separates the stage from the auditorium).

3.43 RECEPTACLE – A connector device permanently connected to the supply circuit to which an attachment plug is connected.

3.44 RISK OF INJURY TO PERSONS – A condition that exists when stationary parts (such as sharp metal edges and projections), moving parts (such as gears, chains, or linkages), falling objects, inadequate mechanical strength of material, or the physical instability of the equipment, are such that a person is capable of being injured.

3.45 SCROLLER – A mechanism with a roll of thin plastic film or other material which is part of, or shall be added to and supported by, a luminaire for the purpose of projecting images or colors. The film scrolls between two cylindrical drums on either side of the involved light aperture.

3.46 SECONDARY CIRCUIT – A circuit that is conductively connected to the secondary winding of a transformer.

3.47 SHUTTER – A mechanical device, similar to an iris, used to control the amount of illumination from a lamp.

3.48 SPOTLIGHT – A luminaire that produces a relatively intense light beam that illuminates only a small area, used especially to center attention on an object.

3.49 STANDARD RECEPTACLE, CORD CONNECTOR, or PLUG – A receptacle, cord connector, or plug that has a slot or blade or pin configuration assigned a voltage and current rating by a nationally-recognized, standards-developing organization or by the general practice of an industry. Examples of standard fittings as defined in this paragraph and used in this standard are:

a) Fittings with a slot, blade, pin, or sleeve configuration as specified in the Standard for Wiring Device Configurations, UL 1681, and other configurations specified in the National Electrical Manufacturers Association (NEMA) publications for wiring devices and

b) Fittings with a pin or sleeve configuration as specified in the Standard for Pin and Sleeve Configurations, UL 1686, or the Standard for Plugs, Receptacles, and Cable Connectors of the Pin and Sleeve Type, UL 1682.

3.50 STILL PHOTOGRAPHY LIGHT – A portable, spring-type clamp-on, or freestanding floodlight or spotlight intended for use in still photography studios, and using incandescent lamps totaling not more than 2000 watts or fluorescent lamps.

3.51 STRIPLIGHT – A continuous row of small floodlights wired in three or four circuits.

3.52 TRIP-FREE – A type of reset mechanism constructed so that, regardless of the position of the actuating handle, button or lever, the contacts cannot be held in the closed position when the unit has tripped.

3.53 WATER-SHIELD – A part other than a gasket that is wetted during the Rain Test, Section 47, and is relied upon to comply with the requirements of the rain test.

## CONSTRUCTION – MECHANICAL

### 4 General

4.1 A luminaire shall be provided with a reflector(s) or other guards to protect the lamps from mechanical damage and inadvertent contact with scenery and other combustible material.

4.2 A freestanding luminaire, a unit that comes attached to a stand, or a unit that has a stand specifically intended for it shall be constructed so it does not tip over when subjected to the Stability Test, Section 35.

4.3 A product shall be provided with a means for mounting or support.

4.4 An overhead product intended to be suitable for use with an accessory shall be provided with means for mounting or support of the accessory.

*Exception: An overhead product intended to be suitable for use with a cardboard color gel frame secured by adhesive tape, or another accessory with an equally low risk of injury when the accessory falls, is not required to be provided with means for mounting or support of the accessory.*

4.5 A connector strip fabricated from sections joined together in the factory or the field shall be provided with a means for mounting or support of each section. A connector strip section having a length exceeding 3 m (10 feet) shall be provided with a means for mounting or support for every 2.4 m (8 feet) or partial 2.4 m of length. Mounting means shall be provided for a terminal box of a hanging connector strip at which a power supply cord terminates.

*Exception: A connector strip section having a length of 0.9 m (3 feet) or less is not required to be provided with a means of mounting or support other than the joint to the adjacent section, when the adjacent section's means of mounting or support is located not more than 0.6 m (2 feet) from the joint.*

## 5 Corrosion Protection

5.1 Iron and steel parts shall be protected against corrosion by painting, enameling, galvanizing, plating, or other equivalent means when the malfunction of such unprotected parts presents a risk of fire, electric shock, or injury to persons.

*Exception No. 1: When the oxidation of iron or steel from exposure of the metal to air and moisture is not appreciable – thickness of metal and temperature also being factors – surfaces of sheet steel and cast-iron parts within an enclosure are not required to be protected against corrosion.*

*Exception No. 2: Bearings, laminations, or minor parts of iron or steel (such as washers, screws, and the like) are not required to be protected against corrosion.*

## 6 Enclosures

6.1 All splices, taps, wires not jacketed with glass fiber sleeving with a wall thickness of at least 0.64 mm (0.025 inch), transformers, current-carrying parts or devices with exposed live metal, and leads or terminals for field connection of supply wires shall be enclosed in material specified in 6.2.

*Exception No. 1: A component device (such as a motor) with an integral outer enclosure that complies with 6.2 is not required to be additionally enclosed.*

*Exception No. 2: Lampholder shells that are connected to the grounded (neutral) conductor and lampholder contacts that are accessible only during relamping are not required to be enclosed.*

6.2 The enclosure required in 6.1 shall be constructed of metal, glass, ceramic, porcelain, or a polymeric material that complies with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

6.3 After assembly, there shall be no openings in an enclosure other than those specified in Openings, Section 8.

## 7 Metal Thickness

### 7.1 Sheet metal

7.1.1 Sheet metal used in the construction of an enclosure or wireway shall be at least as thick as indicated in Table 7.1.

*Exception No. 1: A minimum thickness is not specified for:*

*a) A reflector part that does not form part of the enclosure or*

*b) Any part not required to serve as the enclosure, to provide structural integrity, or to act as support of a wiring device.*

*Exception No. 2: A form of construction that uses metal with a thickness less than required in Table 7.1 is not prohibited from being used when investigated and determined to provide strength and protection equivalent to constructions in compliance with Table 7.1.*

**Table 7.1**
**Minimum thickness of sheet metal**

| Specific construction | | Uncoated steel, mm | Uncoated steel, (inch) | Zinc-coated steel, mm | Zinc-coated steel, (inch) | Copper, brass, or aluminum, mm | Copper, brass, or aluminum, (inch) |
|---|---|---|---|---|---|---|---|
| **At opening for conduit connection[a]** | | 0.81 | 0.032 | 0.86 | 0.034 | 1.02 | 0.040 |
| Length more than 26 inches (660 mm) | Component[b] support | 0.66 | 0.026 | 0.74 | 0.029 | 0.81 | 0.032 |
| | | 0.51[c] | 0.020[c] | 0.58[c] | 0.023[c] | 0.64[c] | 0.025[c] |
| | No component support | 0.51 | 0.020 | 0.58 | 0.023 | 0.64 | 0.025 |
| | | 0.41[c] | 0.016[c] | 0.48[c] | 0.019[c] | 0.51[c] | 0.020[c] |
| Length 26 inches (660 mm) or less | Component[b] support | 0.51 | 0.020 | 0.58 | 0.023 | 0.64 | 0.025 |
| | | 0.41[c] | 0.016[c] | 0.48[c] | 0.019[c] | 0.51 | 0.020 |
| | No component support | 0.41 | 0.016 | 0.48 | 0.019 | 0.51 | 0.020 |
| | | 0.33[c] | 0.013[c] | 0.41[c] | 0.016[c] | 0.41[c] | 0.016[c] |

[a] For an opening in a recessed housing that also serves as an enclosure, the minimum thickness is:

a) 0.66 mm (0.026 inch) when of uncoated steel;

b) 0.74 mm (0.029 inch) when of zinc-coated steel; or

c) 0.81 mm (0.032 inch) when of copper, brass, or aluminum.

[b] In this table, "component" refers to an electrical device, such as a lampholder or switch.

[c] Minimum required thickness for forms of construction that have been determined to provide the physical strength and protection in accordance with 7.1.

7.1.2 A metal striplight or connector-strip trough or wireway containing circuit conductors shall be made of sheet metal not less than 0.79 mm (0.031 inch) thick.

### 7.2 Cast metal

7.2.1 Cast metal thickness shall comply with the requirements in Table 7.2.

**Table 7.2**
**Cast metal thickness**

| Metal | At unreinforced areas exceeding 35 square inches (226 cm$^2$), | | At all other areas, | |
|---|---|---|---|---|
| | mm | (inch) | mm | (inch) |
| Die-cast metal | 2.0 | 5/64 | 1.2 | 3/64 |
| Cast malleable iron or permanent mold cast aluminum | 2.4 | 3/32 | 1.6 | 1/16 |
| Other cast metal | 3.2 | 1/8 | 2.4 | 3/32 |

## 8 Openings

8.1 The requirements in this section apply to permissible openings in the enclosure as described in 6.1.

8.2 An open hole in the enclosure as specified in 6.1 shall not exceed the dimensions specified in Table 8.1.

**Table 8.1**
**Maximum size of miscellaneous open holes**

| Shape of opening | Dimension, | | Maximum area, | |
|---|---|---|---|---|
| | mm | (inch) | cm$^2$ | (inch$^2$) |
| Slot | 9.5 (width) | 3/8 | 9.68 | 1-1/2 |
| Square | 12.7 (side) | 1/2 | – | – |
| Round | 12.7 (diameter) | 1/2 | – | – |
| Irregular | – | – | 9.68 | 1-1/2 |



8.3 The total area of one or more open holes shall not be more than 15 percent of the area of the surface in which it is located. This includes the wiring compartment or integral outlet box compartment.

8.4 The enclosure shall be constructed so that molten metal, burning insulation, flaming particles, or the like do not fall on the surface below.

8.5 The requirement in 8.4 specifies that an opening in an enclosure bottom be provided with a dripping material barrier above or below the opening when the opening is:

a) Under a motor, unless:

1) The structural parts of the motor or of the appliance provide the equivalent of such a barrier;

2) The protection provided with the motor is such that no burning insulation or molten material falls to the surface below the appliance when the motor is energized under each of the following fault conditions:

i) Open main winding,

ii) Open starting winding,

iii) Starting switch short-circuited, and

iv) For a permanent-split-capacitor motor, the capacitor is short-circuited. The short circuit is to be applied before the motor is energized and the rotor is to be blocked.

3) The motor is provided with a thermal motor protector (a protective device that is sensitive to both temperature and current) that prevents the temperature of the motor windings from becoming more than 125°C (257°F) under the maximum load under which the motor runs without causing the protector to cycle, and from becoming more than 150°C (302°F) with the rotor of the motor locked; or

4) The motor complies with the requirements for impedance-protected motors;

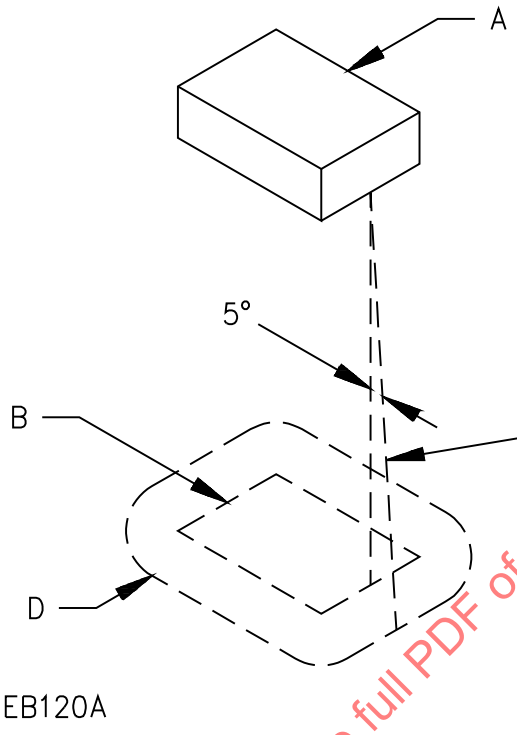
b) Under wiring, unless the wiring complies with the VW-1 (Vertical-Specimen) Flame Test in the Reference Standard for Electrical Wires, Cables, and Flexible Cords, UL 1581;

c) Under an unenclosed switch, transformer, relay, solenoid, and the like, unless it can be shown that malfunction of the component does not result in a fire; or

d) Under field- and factory-made splices and overload and overcurrent protection devices.

*Exception: A dripping material barrier is not required to be provided when the opening is not within the area under the component requiring a barrier as illustrated by Line D in Figure 8.1.*

**Figure 8.1**
**Location and extent of barrier**




8.6 The dripping material barrier specified in 8.5 shall be:

a) Horizontal;

b) Of metal, ceramic, or a material that can be used as an enclosure material in accordance with 6.2;

c) Located as indicated in Figure 8.1; and

d) Shall have an area not less than that described in Figure 8.1.

8.7 The mounting surface of the luminaire enclosure shall have no unused openings.

## 9 Restraint of Overhead Objects

9.1 The structure and all joints of an overhead product and its accessories shall be capable of supporting a static load of not less than six times the actual load supported. The joints to be evaluated include all manufacturer-assembled joints and user-affected joints. Where it is not evident that the materials and dimensions of the parts involved have the specified strength, the parts shall be subjected to the Overhead Product Static Loading Test, Section 37.

*Exception No. 1: The strength of a structural component or a joint is not required to be evaluated when failure of the component or joint does not result in an object falling to the floor.*

*Exception No. 2: The structure and joints supporting a cardboard color gel frame secured by adhesive tape, or other accessory that presents a low risk of injury when it falls to the floor, are not required to be evaluated.*

9.2 A safety cable, safety chain, or other field-installed backup-restraint device intended to "catch" a falling object shall be capable of supporting a static load of not less than six times the intended load. When it is not evident that the backup-restraint device is capable of supporting a weight of six times the marked maximum load weight, the device shall be subjected to the Backup Restraint-Device Loading Test, Section 38.

## 10 Lamp-Containment Barriers and UV Radiation Filters

### 10.1 General

10.1.1 The requirements in this section are supplementary to other applicable requirements in this standard and apply to stage and studio luminaires incorporating tungsten-halogen lamps and electric discharge lamps that are not provided with an integral glass outer envelope and that are of other than the fluorescent type.

### 10.2 Lamp-containment barriers

10.2.1 A luminaire intended for use with one of the following lamp types shall be provided with a lamp-containment barrier as defined in 3.30:

a) A tungsten-halogen lamp.

*Exception: A luminaire intended for use with a non-pressurized, tungsten-halogen lamp for which the lamp manufacturer does not require an enclosure, or a tungsten-halogen lamp with an integral outer envelope, is not required to be provided with a lamp-containment barrier when the marking specified in 58.4 is provided.*

b) An electric discharge lamp that is not provided with an integral glass outer envelope and that is of other than the fluorescent type.

c) A high-pressure lamp as defined in 3.25.

10.2.2 A lamp-containment barrier shall be constructed of:

a) Metal at least 0.41 mm (0.016 inch) thick;

b) Glass, porcelain, or ceramic at least 3.0 mm (1/8 inch) thick for metric trade size glass; or

c) Polymeric material having a relative thermal index with impact at the involved thickness of not less than the temperature encountered on the lamp-containment barrier surface during the Temperature Test, Section 30.

When a lamp-containment barrier also serves as an enclosure, the lamp-containment barrier shall also comply with applicable enclosure thickness and other enclosure requirements.

*Exception: A lamp-containment barrier constructed of glass is not prohibited from being less than 3.0 mm thick [but is to be at least 2.4 mm (3/32 inch) thick] when it is intended for use with other than a high-pressure lamp and a lamp rated less than 100 watts.*

10.2.3 A lamp-containment barrier shall be secured in position by:

a) A mechanical means that produces an interference fit;

b) Physical fit; or

c) Other means determined to be equivalent.

**10.3 Tungsten-halogen lamps**

10.3.1 A lamp-containment barrier shall not have any open holes greater than 3.2 mm (1/8 inch) thick diagonally or in diameter when the openings are line-of-sight between the lamp and any points outside the fixture. [Standard metal-wire mesh having 4 square openings per linear cm (16 square openings per linear inch) has been determined to comply with the requirements in 10.2.2, 10.2.3, and 10.3.1.]

**10.4 Electric discharge lamps other than fluorescent and high-pressure lamps**

10.4.1 A lamp containment barrier shall comply with 10.3.1.

10.4.2 Those surfaces of a lamp-containment barrier on which particles of a ruptured lamp come to rest shall be constructed of:

a) Metal;

b) Heat-resistant glass such as tempered, annealed, or borosilicate glass;

c) Glass material other than tempered, annealed, or borosilicate glass that complies with the Glass Thermal Shock/Containment Test, Section 43; or

d) A polymeric material that complies with the Polymeric Lamp-Containment Barrier Flammability/Containment Test, Section 44.

### 10.5 High-pressure lamps

10.5.1 The lamp-containment barrier shall be constructed so that glass, quartz, or metal fragments resulting from a hot lamp explosion are totally contained.

10.5.2 A lamp containment barrier shall comply with 10.4.2.

10.5.3 A door that serves as part of a lamp-containment barrier for a high-pressure lamp shall be provided with an interlock mechanism.

10.5.4 Removing or opening a door that serves as part of a lamp-containment barrier for a cold high-pressure lamp shall require the use of a key-lock with a removable key. A second and separate fastening means required to be unfastened to obtain final access to the lamp compartment shall also be provided. The construction shall be such that both fasteners are required to be properly secured before the lamp is energized.

### 10.6 UV radiation filter

10.6.1 A luminaire that uses an electric discharge lamp not provided with an integral glass outer envelope and that is of other than the fluorescent type shall be provided with a UV radiation filter as specified in 10.6.2 – 10.6.7.

10.6.2 A UV radiation filter shall be provided for all UV radiation directly emitted from the lamp and for UV radiation that reflects off only one surface after emitting from the lamp.

10.6.3 A UV radiation filter shall be of metal at least 0.41 mm (0.016 inch) thick, glass as specified in 10.6.4, or polymeric material as specified in 10.6.5.

10.6.4 The glass material of the UV radiation filter specified in 10.6.2 shall be:

a) Minimum 4.0-mm (5/32-inch) thick sodalime glass or

b) Minimum 3.2-mm (1/8-inch) thick glass with a transmission characteristic in accordance with Table 10.1.

**Table 10.1**
**Ultraviolet transmission characteristics**

| Wavelength, nanometers | Maximum transmission, percent |
|---|---|
| 350 | 85 |
| 320 | 40 |
| 300 | 8 |
| 290 | 0.5 |
| Less than 280 | 0.1 |

10.6.5 A polymeric material of the UV radiation filter specified in 10.6.2 shall:

a) Be minimum 2.4 mm (3/32 inch) thick;

b) Have the transmission characteristic in accordance with Table 10.1;

c) Be resistant to UV radiation in compliance with the requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C;

d) Be suitable for the temperature encountered;

e) Be rated HB minimum; and

f) When not flat, comply with the mold stress-relief requirements in UL 746C.

10.6.6 Any open holes in the UV radiation filter shall be provided with a baffle or similar feature to prevent emission as specified in 10.6.2.

10.6.7 A door that serves as a UV radiation filter shall be provided with an interlock mechanism; and the luminaire shall be marked in accordance with 58.6.

## 11 Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts

11.1 To reduce the risk of unintentional contact and electric shock from an uninsulated live part or film-coated wire operating at greater than 30 volts (42.4 volts peak) between live parts of opposite polarity or between live parts and ground, or injury to persons from a moving part, an opening in an enclosure shall comply with either (a) or (b).

a) For an opening that has a minor dimension (as defined in 10.5) less than 25.4 mm (1 inch), such a part shall not be contacted by the probe illustrated in Figure 11.1.

b) For an opening that has a minor dimension of 25.4 mm or more, such a part or wire shall be spaced from the opening as specified in Table 11.1.

*Exception No. 1: Lampholder shells connected to the grounded (neutral) conductor and lampholder contacts that are accessible during relamping are not required to comply with this requirement.*

*Exception No. 2: A motor is not required to comply with this requirement when it complies with the requirements in 11.2.*

*Exception No. 3: Wires jacketed with an outer glass-fiber sleeve with a wall thickness of at least 0.64 mm (0.025 inch) are not required to comply with this requirement.*

**Figure 11.1**
**Articulate probe with web stop**

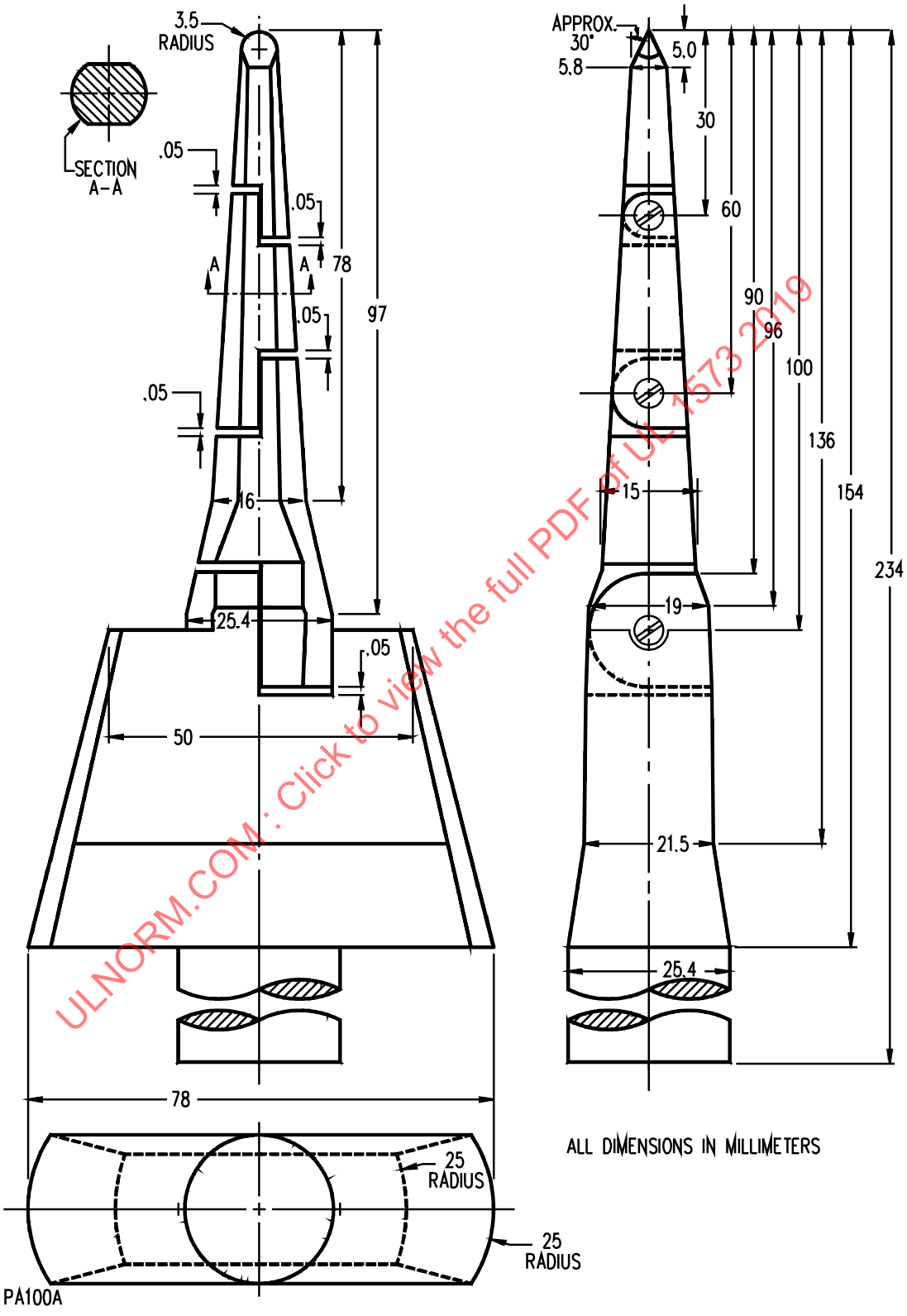


**Table 11.1**
**Minimum distance from an opening to a part that involves a risk of electric shock or injury to persons**

| Minor dimension of opening,[a] | | Minimum distance from opening to part, | |
|---|---|---|---|
| mm | (inches) | mm | (inches) |
| 19.1[b] | 3/4[b] | 114.3 | 4-1/2 |
| 25.4[b] | 1[b] | 165.1 | 6-1/2 |
| 31.8 | 1-1/4 | 190.5 | 7-1/2 |
| 38.1 | 1-1/2 | 317.5 | 12-1/2 |
| 47.6 | 1-7/8 | 393.7 | 15-1/2 |
| 54.0 | 2-1/8 | 444.5 | 17-1/2 |
| 152.4 | 6 | 762.0 | 30 |

NOTE – Interpolation is to be used to determine a value between values specified in the table.

[a] See 11.5.

[b] Any dimension 1 inch (25.4 mm) or less applies to a motor only.

11.2 With regard to a part or wire as specified in 11.1, in an integral enclosure of a motor (as specified in Exception No. 2 to 11.1):

a) An opening that has a minor dimension (as described in 11.5) less than 19.1 mm (3/4 inch) shall be used when:

1) A moving part is not capable of being contacted by the probe illustrated in Figure 11.2;

2) Film-coated wire is not capable of being contacted by the probe illustrated in Figure 11.3;

3) In a directly accessible motor (as described in 11.6), an uninsulated live part is not capable of being contacted by the probe illustrated in Figure 11.4; and

4) In an indirectly accessible motor (as described in 11.6), an uninsulated live part is not capable of being contacted by the probe illustrated in Figure 11.2.

b) An opening that has a minor dimension of 19.1 mm or more is not prohibited from being used when a part or wire is spaced from the opening as specified in Table 11.1.

**Figure 11.2**
**Probe for moving parts and uninsulated live parts**

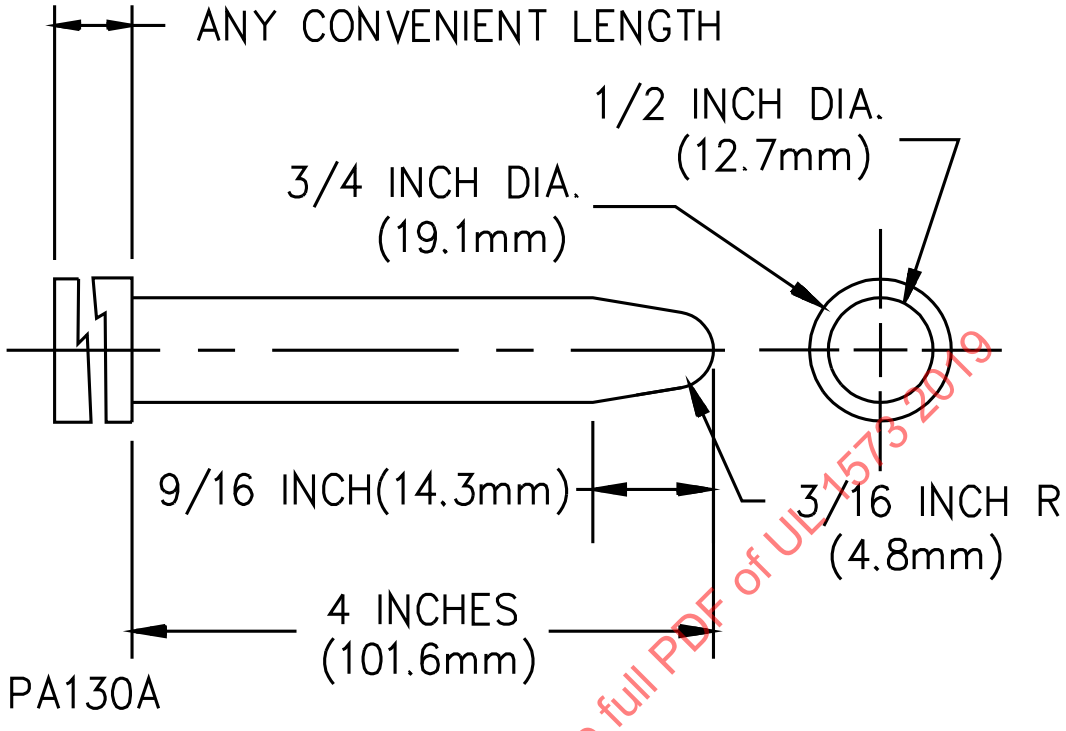





**Figure 11.3**
**Probe for film-coated wire**

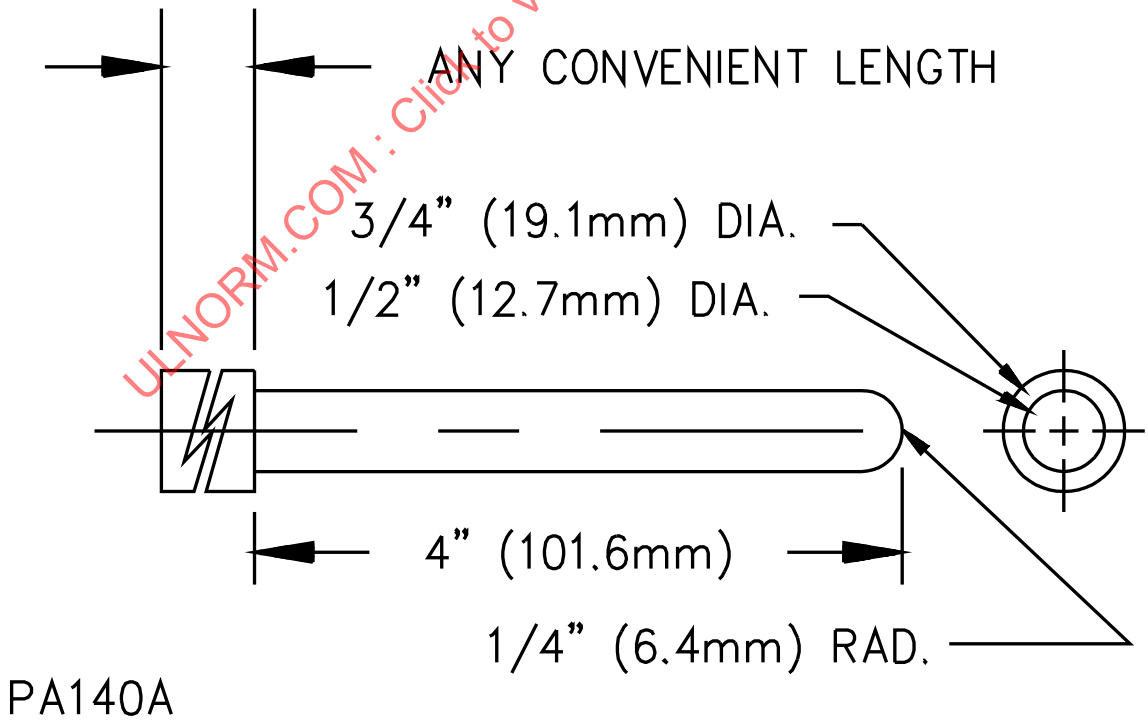
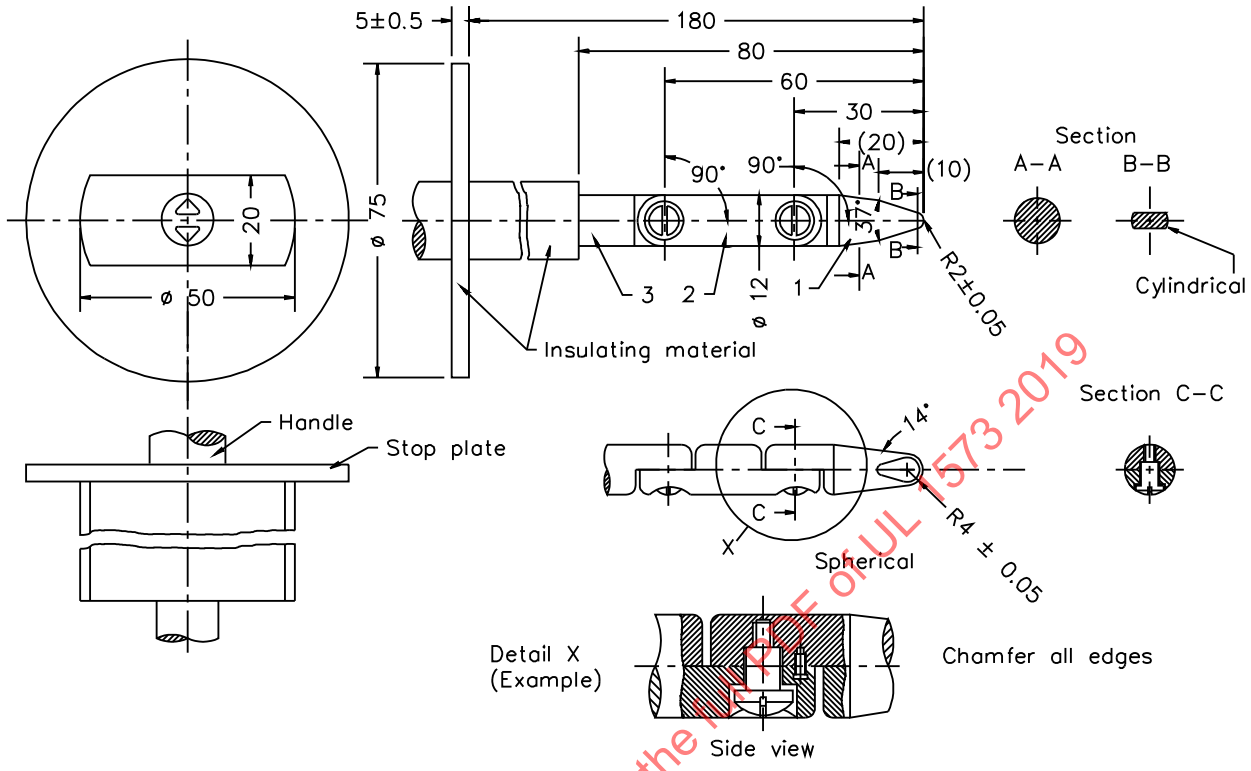


**Figure 11.4**
**Articulate probe**

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11.3 The probes specified in 11.1 and 11.2 and illustrated in Figures 11.1 – 11.4 shall be applied to any depth that the opening permits and shall be rotated or angled before, during, and after insertion through the opening to any position that is required to examine the enclosure. The probes illustrated in Figures 11.1 and 11.4 shall be applied in any possible configuration and, when required, the configuration shall be changed after insertion through the opening.

11.4 The probes specified in 11.3 and 11.5 shall be used as measuring instruments to determine the accessibility provided by an opening, and not as instruments to evaluate the strength of a material. They shall be applied with the minimum force required to determine accessibility.

11.5 With reference to the requirements in 11.1 and 11.2, the minor dimension of an opening is the diameter of the largest cylindrical probe having a hemispherical tip that is capable of being inserted through the opening.

11.6 With reference to the requirements in 11.2, an indirectly accessible motor is a motor:

a) That is accessible only by opening or removing a part of the outer enclosure, such as a guard or panel, that is capable of being opened or removed without using a tool or

b) That is located at such a height or is otherwise guarded or enclosed so it is not contacted.

A directly accessible motor is capable of being contacted without opening or removing any part or is located so as to be accessible to contact by the user.

11.7 During the examination of a product to determine whether it complies with the requirements in 11.1 or 11.2, a part of the enclosure that is capable of being opened or removed by the user without using a tool (for example, to attach an accessory or make an adjustment) is to be opened or removed.

*Exception: A part of the enclosure fastened by use of a thumbscrew or equivalent means that requires a positive and deliberate action by the user to open or remove it is not required to comply with this requirement.*

11.8 With reference to the requirements in 11.1 and 11.2, insulated brush caps are not required to be additionally enclosed.

## 12 Products for Use in Damp Locations

12.1 A product that is marked as indicated in 56.5 as suitable for use in damp locations shall comply with the requirements in 12.2 – 12.9.

12.2 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 on all surfaces.

*Exception No. 1: Removable accessories such as color gel frames, pattern holders, shutters, and irises are not required to be provided with protection against corrosion.*

*Exception No. 2: The surface of a panel not relied upon for compliance with another requirement in this standard is not required to be provided with protection against corrosion. Evaluation of the panel with regard to functioning as an electrical enclosure, lamp-containment barrier, thermal barrier, or heat sink, and support for other parts, shall be given.*

12.3 Punched holes and cut edges in ferrous material are not required to be corrosion protected.

12.4 Hinges, bolts, and fasteners made of ferrous materials shall be protected against corrosion as described in 12.2.

*Exception: Hinge pins are not required to be provided with the corrosion protection required in 12.2.*

12.5 Sheet steel or other metal that is painted to comply with 12.2 and 12.3 shall be properly cleaned of grease and the like prior to painting.

12.6 Welds in iron or steel (other than stainless steel) shall be painted or provided with equivalent protection against corrosion. Copper, aluminum, alloys of copper and aluminum, stainless steel, and similar materials having inherent resistance to atmospheric corrosion are not required to be provided with additional corrosion protection.

12.7 Vitreous enamel shall be used as the only protective coating for sheet steel having a thickness of 0.026 inch (0.66 mm) or more.

12.8 Non-absorptive, electrical insulation shall be used in the construction of electrical components where it is relied upon to provide electrical spacings or sole support of live electrical parts or as electrical insulation. Untreated fiber, asbestos, and the like are examples of materials that shall not be used, while treated cellulose fiber, phenolic, urea, porcelain, and the like are examples of materials that are capable of being used.

12.9 The screw shell in a screw shell-type lampholder shall not be made of unplated aluminum.

## 13 Products for Use in Wet Locations

13.1 A product that is marked as indicated in 56.6 as suitable for use in wet locations shall comply with the requirements in 12.8, 12.9, and 13.2 – 13.13, and Sections 47 – 51.

13.2 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 13.1.

*Exception No. 1: Other finishes are capable of being used, including paints, special metallic finishes, and combinations of the two, when they have been determined to provide equivalent protection by comparative tests with galvanized sheet steel conforming with item A (Type G90) of Table 13.1.*

*Exception No. 2: A metal part, such as a decorative part, that is not required for compliance with this standard is not required to be protected against corrosion.*

*Exception No. 3: Stainless steel is not required to be additionally protected against corrosion.*

*Exception No. 4: Edges, fasteners, and welds complying with 13.3 – 13.6 is not required to be additionally protected against corrosion.*

*Exception No. 5: When the inside surfaces of the product are protected from the elements such that no water enters the product during the rain test, the inside surfaces are capable of being provided with corrosion protection equivalent to that specified in 12.2 – 12.7.*

**Table 13.1**
**Sheet steel coatings**

| Type of coating | Type or thickness,[a] mm | (inch) | 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) | 0.0155[d] | 0.00061[d] | – |
| | 0.0104[d] | 0.00041[d] | with 1 coat of outdoor paint[c] |
| (C) Cadmium coating | 0.0254 | 0.0010 | – |
| | 0.01905 | 0.00075 | with 1 coat of outdoor paint[c] |
| | 0.0127 | 0.0005 | with 2 coats of outdoor paint[c] |
| (D) Vitreous enamel[e] | – | | – |

[a] As determined by the Standard Guide for Measurement of Electrodeposited Metallic Coating Thicknesses by the Dropping Test, ASTM B555.

[b] Conforming with the coating designation G90, G60, or A60 in the Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM A653/A653M-02a, 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 0.00178 mm (0.00007 inch).

[e] Vitreous enamel shall be used on sheet steel at least 0.66 mm (0.026 inch) thick.

13.3 Hinges, bolts, and fasteners made of ferrous materials shall be protected against corrosion as described in 12.2 for damp locations.

*Exception: Hinge pins are not required to be provided with the corrosion protection required in 12.2.*

13.4 The product shall be constructed so that a water-shield prevents 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 ″W″ or ″Water Resistant″; liquid tight flexible metal conduit; outlet boxes marked for use in wet locations; rigid conduit; and the like.

*Exception: For the purposes of this requirement, the outer surface of the glass envelope or integral reflector (such as Type MR 16 lamps) of a lamp are permitted to be wetted.*

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

13.6 A gasket relied upon to comply with the rain test shall be secured so that removal of a lamp or other servicing of the product does not result in loosening of the gasket. An adhesive used to secure a gasket shall comply with the Gasket Adhesion Test, Section 51.

13.7 An opening for the connection of conduit or for an auxiliary part shall be threaded.

*Exception No. 1: When the rain test shows no entrance of water into the product with any opening open, the opening is not required to be threaded.*

*Exception No. 2: The opening is not required to be threaded when a conduit fitting intended for use in wet locations that complies with the requirements in the Standard for Conduit, Tubing and Cable Fittings, UL 514B, is provided.*

13.8 An open drain hole shall be provided on all products to prevent the accumulation of water above a level that results in the wetting of an electrical part or opening for the connection of conduit or for an auxiliary part. The hole shall be as specified in Table 13.2.

*Exception: A product that has been subjected to the Rain Test, Section 47, is not required to be provided with a drain hole when no water enters the product.*

**Table 13.2**
**Size of drain holes**

| Opening shape | Minimum dimension, | | Minimum area, | | Maximum dimension, | | Maximum area, | |
|---|---|---|---|---|---|---|---|---|
| | mm | (inch) | $mm^2$ | ($inch^2$) | mm | (inch) | $mm^2$ | ($inch^2$) |
| Slot | 3.2 (width) | 1/8 | 7.74 | 0.012 | 9.5 (width) | 3/8 | 968 | 1-1/2 |
| Square | 3.2 (side) | 1/8 | – | – | 12.7 (side) | 1/2 | – | – |
| Round | 3.2 (diameter) | 1/8 | – | – | 12.7 (diameter) | 1/2 | – | – |
| Irregular | – | – | 7.74 | 0.012 | – | – | 968 | 1-1/2 |

13.9 Any flexible cord exposed outside of a product shall be marked "W" following the type designation.

13.10 The product shall not have a drop cord.

13.11 All live parts in a ground-supported product shall be located at least 102 mm (4 inches) above ground level.

*Exception: Flexible cord marked "water resistant" is not required to be located at least 102 mm above ground level.*

13.12 A product provided with a receptacle shall be constructed to prevent the entrance of water into the receptacle during the Rain Test, Section 47, with and without an attachment plug in place.

13.13 A receptacle cover or receptacle/attachment plug cover that is relied upon to prevent the entrance of water into the receptacle or attachment plug during the Rain Test, Section 47, shall be attached to the product. A cover shall close automatically when an attachment plug is removed from the receptacle.

## CONSTRUCTION – ELECTRICAL

### 14 General

14.1 A wiring device (a switch, fuseholder, lampholder, or the like) shall be prevented from any turning that applies tension to splices or other wiring connections, damages the wiring, or otherwise adversely affects the assembly.

14.2 A wireway shall be free from burrs and sharp edges and of such construction that a light is capable of being wired without damage to the conductor insulation.

14.3 A luminaire shall be constructed so all lamps can be replaced without damaging any wiring, component, or part.

14.4 A disappearing footlight shall be arranged so that it is automatically disconnected from the supply when the footlight is moved into the recessed position.

14.5 Electrical components and electrical insulating materials, including insulated wire splicing connectors, insulated wire terminals, and insulated conductors, shall have a voltage rating of not less than the voltage involved during intended use.

*Exception: Electrical components and electrical insulation materials only involved with a Class 2 circuit or a limited-voltage/current circuit are not required to have an assigned voltage rating.*

## 15 Switches

15.1 A switch shall be rated for the voltage and current of the circuit it controls and the ampere rating of the switch shall be multiplied by the derating factor as indicated in Table 15.1 when determining whether its current rating is suitable for the current handling capability of the specified load.

**Table 15.1**
**Switch derating factors**

| Switching load | Switch type | | | |
|---|---|---|---|---|
| | AC general use[a] | AC ″L″ or AC-DC ″T″[b] | AC | DC |
| Transformer or motor | none | none | 1/2 | – |
| Receptacle | none | none | 1/6 | 1/10 |
| Incandescent lamp | none | none | 1/6 | 1/10 |

[a] This column applies to general-use AC switches (for mounting in flush-device outlet boxes) and also to switches of the fixture, pendant, and through-cord types rated AC only.

[b] A switch, other than a type specified in note a, that has been investigated for the control of tungsten-filament lamps, is marked with the letter ″T″ or ″L″ in conjunction with the current rating at which the tungsten-filament lamp rating applies; for example, ″1 ampere, 125 volt, T.″

15.2 A switch shall not be connected to the secondary circuit of a ballast unless it is rated for switching the electric discharge lamp load involved.

## 16 Transformers

16.1 A transformer shall comply with the construction requirements in:

a) The Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1, and the Standard for Low Voltage Transformers – Part 2: General Purpose Transformers, UL 5085-2;

b) The Standard for Transformers and Motor Transformers for Use in Audio-, Radio-, and Television-Type Appliances, UL 1411; or

c) 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.

The transformer shall additionally comply with the performance requirements specified in UL 5085-1 and UL 5085-2, UL 1411, UL 5085-1 and UL 5085-3, or the Transformer Overload Test, Section 39.

## 17 Motors and Motor Drive Circuits

### 17.1 General

17.1.1 These requirements cover the motors and motor drive circuits used to move or retract lamp heads, operate cooling fans, shutters, mechanical strobes, gobos, mirrors, and the like.

### 17.2 Motors

17.2.1 Motors in other than limited-voltage/current circuits shall comply with the requirements of 17.2.2 – 17.2.5.

17.2.2 A motor shall comply with the requirements in the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1, and shall be capable of delivering its maximum intended load without introducing a risk of fire, electric shock, or injury to persons. Maximum intended load is the load the motor drives when the luminaire and the motor are operating as intended.

*Exception: A motor that is part of an electric fan complying with the requirements in the Standard for Electric Fans, UL 507, is not required to be further evaluated to the requirements in UL 1004-1.*

17.2.3 A motor shall incorporate overload protection against running-overload and locked-rotor conditions. The required protection shall consist of one of the following:

a) Thermal protection complying with the applicable requirements in the Standard for Overheating Protection for Motors, UL 2111.

*Exception No. 1: Where a fan blade or blower wheel is attached directly to the motor shaft, a motor and its protection is not required to comply with the Running Heating Temperature Test in UL 2111.*

*Exception No. 2: A shaded pole motor having a difference of 1 ampere or less between no-load and locked-rotor currents and having a 2:1 or smaller ratio between locked-rotor and no-load currents are not required to be protected against locked-rotor conditions only.*

b) Impedance protection complying with UL 2111, when the motor is tested as used in the product under locked-rotor conditions.

*Exception: A motor that is part of a low-voltage component fan complying with the requirements for such fans in the Standard for Electric Fans, UL 507, is not required to be further evaluated.*

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

17.2.5 A motor shall drive its maximum intended load during operation of a luminaire or accessory without introducing a risk of fire, electric shock, or injury to persons. Maximum intended load is defined as the load the motor drives when the luminaire and the motor are operating as intended.

### 17.3 Motor drive circuits

17.3.1 A motor drive circuit shall comply with the requirements for Limited-Voltage/Current Circuits, Section 27, or shall comply with the requirements for motor drive circuits as specified in the Standard for Industrial Control Equipment, UL 508.

*Exception: A motor-drive circuit that is part of an electric fan complying with the requirements in the Standard for Electric Fans, UL 507, is not required to be further evaluated.*

17.3.2 There are no specifications for insulating material, spacings, and components in a limited voltage/current motor drive circuit other than those that are required to prevent contact with an uninsulated live part of another circuit.

## 18 Wiring and Conductors

### 18.1 General

18.1.1 A conductor shall be made of copper.

18.1.2 A conductor shall have insulation rated for the voltage and condition of service to which it is subjected under conditions of intended service.

18.1.3 A lamp circuit conductor in a striplight shall be soldered to the lampholder terminal when the terminal is of the screw type.

18.1.4 Wire to a lamp-supported lampholder shall be provided with a strain-relief device at the end that exits the luminaire enclosure. The device shall comply with the test requirement in 34.1 when subjected to the pulling force specified in the Exception to 34.1.

18.1.5 When a conductor passes through an opening or crosses over the edge of sheet metal, it shall be held away from the edges of the metal or shall be protected by a bushing or a grommet, or by rolling the edge of the metal not less than 120 degrees. Sleeving is not to be used as a means of preventing cutting and abrasion of wires.

*Exception: The edges of sheet metal thicker than 1.07 mm (0.042 inch) are only required to be treated to remove burrs, fins, and sharp edges by reaming or an equivalent method.*

18.1.6 A product shall be constructed so that wires can be factory- or field-installed, as involved, without damaging the conductor insulation. A wire enclosure shall be free from burrs, fins, and other sharp edges that come into contact with wires.

18.1.7 Not more than 4.8 mm (3/16 inch) of the threads of sheet metal and self-tapping screws shall be exposed in a wire enclosure.

*Exception: More than 4.8 mm of screw threads may be exposed when wires are held or positioned so that they do not come into contact with the threads.*

18.1.8 A bushing used to comply with 18.1.5 shall be securely held in place, and a bushing constructed of insulating material shall be at least 1.2 mm (3/64 inch) thick. A rubber bushing shall not be used.

*Exception: A bushing less than 1.2 mm thick may be used when an investigation shows that the mechanical properties contemplated are provided.*

**18.2 Ampacity and temperature**

18.2.1 A conductor that supplies a receptacle or cord connector shall comply with (a), (b), or (c):

a) The conductor shall be sized as specified in Tables 18.1 and 18.2 to have an ampacity not less than the load current value determined as specified in 18.3.2;

b) The conductor shall:

1) Be a conductor within a flexible cord or cable that is not part of a drop cord and in which the number of current-carrying conductors exceeds three and

2) Be sized as specified in Tables 18.1 and 18.2 to have an ampacity not less than the value obtained by multiplying the load current value determined as specified in 18.3.2 by the ampacity reduction factor specified in Table 18.3; or

c) The conductor:

1) Shall be other than a conductor within the flexible cord or cable that is part of a drop cord;

2) Shall be sized not less than 0.82 $mm^2$ (18 AWG); and

3) Shall be part of a construction that complies with the requirements described in the Temperature Test, Section 30.

All other conductors shall not be less than 0.82 $mm^2$. Figure 18.1 shows an example of the application of this requirement.

## Table 18.1
## Maximum ampacities of wires and cords used to supply receptacles and cord connectors for wire sized 18 – 10 AWG

| Type of wire, cord, or cable | Ampacity (amperes), 18 AWG[a] | 16 AWG[a] | 14 AWG[a] | 12 AWG[a] | 10 AWG[a] |
|---|---|---|---|---|---|
| Appliance wiring material and thermoplastic-insulated wire with: | | | | | |
| 60°C temperature rating[b] | – (6) | – (8) | 20 (17) | 25 (23) | 30 |
| 75°C temperature rating | – | – | 20 | 25 | 35 |
| 90°C temperature rating | 14 | 18 | 25 | 30 | 40 |
| 150°C temperature rating | – | – | 34 | 43 | 55 |
| 200°C temperature rating | – | – | 36 | 45 | 60 |
| 250°C temperature rating | – | – | 39 | 54 | 73 |
| Fixture wire | 6 | 8 | 17 | 23 | 28 |
| Flexible cord and cable (used as drop cords and supply cords) | | | | | |
| Single-conductor Types PPE, SC, SCE, SCT, and W cable[c] with: | | | | | |
| 60°C temperature rating | – | – | – | – | – |
| 75°C temperature rating | – | – | – | – | – |
| 90°C temperature rating | – | – | – | – | – |
| 2-conductor Types G, PPE, SC, SCE, SCT, and W cable[d] with: | | | | | |
| 60°C temperature rating | – | – | – | – | – |
| 75°C temperature rating | – | – | – | – | – |
| 90°C temperature rating | – | – | – | – | – |
| 3-conductor Types G, PPE, SC, SCE, SCT, and W cable[e] with: | | | | | |
| 60°C temperature rating | – | – | – | – | – |
| 75°C temperature rating | – | – | – | – | – |
| 90°C temperature rating | – | – | – | – | – |
| 2-conductor flexible cord and cable other than Type G, PPE, SC, SCE, SCT, or W[d] | 10 | 13 | 18 | 25 | 30 |
| 3-conductor flexible cord and cable other than Type G, PPE, SC, SCE, SCT, or W[d] with: | | | | | |
| 60°C temperature rating | 7 | 10 | 15 | 20 | 25 |
| 75°C temperature rating | – | – | 24 | 32 | 41 |
| 90°C temperature rating | – | – | 28 | 35 | 47 |

[a] SI equivalent cross-sectional area: 0.82 $mm^2$ (18 AWG), 1.3 $mm^2$ (16 AWG), 2.1 $mm^2$ (14 AWG), 3.3 $mm^2$ (12 AWG), 5.3 $mm^2$ (10 AWG), 8.4 $mm^2$ (8 AWG), 13.3 $mm^2$ (6 AWG), 21.2 $mm^2$ (4 AWG), 26.7 $mm^2$ (3 AWG), 33.6 $mm^2$ (2 AWG), 42.4 $mm^2$ (1 AWG).

[b] The value not enclosed in parentheses applies only to thermoplastic insulated wire; the adjacent value enclosed in parentheses applies only to appliance wiring material. The values for all other entries apply to both appliance wiring material and thermoplastic insulated wire.

[c] These ampacities apply to single-conductor Type PPE, SC, SCE, SCT, or W cable only where the individual conductors are not installed in raceways and are not in physical contact with each other except in lengths not exceeding 610 mm (24 inches) where passing through the wall of an enclosure.

[d] These ampacities apply to 2-conductor flexible cords or cables or other multi-conductor flexible cords or cables connected so that only 2 conductors are current-carrying.

[e] These ampacities apply to 3-conductor flexible cords or cables or other multi-conductor flexible cords or cables connected so that only 3 conductors are current-carrying.

[f] These ampacities apply to flexible cords or cables of the type suitable for extra-hard usage when used to supply borderlights, connector strips, and drop boxes, and when not in direct contact with enclosures containing heat-producing elements.

## Table 18.2
## Maximum ampacities of wires and cords used to supply receptacles and cord connectors for wire sized 8 – 1 AWG

| Type of wire, cord, or cable | Ampacity (amperes), 8 AWG[a] | 6 AWG[a] | 4 AWG[a] | 3 AWG[a] | 2 AWG[a] | 1 AWG[a] |
|---|---|---|---|---|---|---|
| Appliance wiring material and thermoplastic-insulated wire with: | | | | | | |
| 60°C temperature rating | 40 | 55 | 70 | 85 | 95 | 110 |
| 75°C temperature rating | 50 | 65 | 85 | 100 | 115 | 130 |
| 90°C temperature rating | 55 | 75 | 95 | 110 | 130 | 150 |
| 150°C temperature rating | 76 | 96 | 120 | 143 | 160 | 186 |
| 200°C temperature rating | 83 | 110 | 125 | 152 | 171 | 197 |
| 250°C temperature rating | 93 | 117 | 148 | 166 | 191 | 215 |
| Fixture wire | – | – | – | – | – | – |
| Flexible cord and cable (used as drop cords and supply cords) | | | | | | |
| Single-conductor Types PPE, SC, SCE, SCT, and W cable[b] with: | | | | | | |
| 60°C temperature rating | 60 | 80 | 105 | 120 | 140 | 165 |
| 75°C temperature rating | 70 | 95 | 125 | 145 | 170 | 195 |
| 90°C temperature rating | 80 | 105 | 140 | 165 | 190 | 220 |
| 2-conductor Types G, PPE, SC, SCE, SCT, and W cable[c] with: | | | | | | |
| 60°C temperature rating | 55 | 72 | 96 | 113 | 128 | 150 |
| 75°C temperature rating | 65 | 88 | 115 | 135 | 152 | 178 |
| 90°C temperature rating | 74 | 99 | 130 | 152 | 174 | 202 |
| 3-conductor Types G, PPE, SC, SCE, SCT, and W cable[d] with: | | | | | | |
| 60°C temperature rating | 48 | 63 | 84 | 99 | 112 | 131 |
| 75°C temperature rating | 57 | 77 | 101 | 118 | 133 | 156 |
| 90°C temperature rating | 65 | 87 | 114 | 133 | 152 | 177 |
| 2-conductor flexible cord and cable other than Type G, PPE, SC, SCE, SCT, or W[c] | 40 | 55 | 70 | – | 95 | – |
| 3-conductor flexible cord and cable other than Type G, PPE, SC, SCE, SCT, or W[c] with: | | | | | | |
| 60°C temperature rating | 35 | 45 | 60 | – | 80 | – |
| 75°C temperature rating[e] | 57 | 77 | 101 | – | 133 | – |
| 90°C temperature rating[e] | 65 | 87 | 114 | – | 152 | – |

[a] SI equivalent cross-sectional area: 0.82 $mm^2$ (18 AWG), 1.3 $mm^2$ (16 AWG), 2.1 $mm^2$ (14 AWG), 3.3 $mm^2$ (12 AWG), 5.3 $mm^2$ (10 AWG), 8.4 $mm^2$ (8 AWG), 13.3 $mm^2$ (6 AWG), 21.2 $mm^2$ (4 AWG), 26.7 $mm^2$ (3 AWG), 33.6 $mm^2$ (2 AWG), 42.4 $mm^2$ (1 AWG).

[b] These ampacities apply to single-conductor Type PPE, SC, SCE, SCT, or W cable only where the individual conductors are not installed in raceways and are not in physical contact with each other except in lengths not exceeding 610 mm (24 inches) where passing through the wall of an enclosure.

[c] These ampacities apply to 2-conductor flexible cords or cables or other multi-conductor flexible cords or cables connected so that only 2 conductors are current-carrying.

[d] These ampacities apply to 3-conductor flexible cords or cables or other multi-conductor flexible cords or cables connected so that only 3 conductors are current-carrying.

[e] These ampacities apply to flexible cords or cables of the type suitable for extra-hard usage when used to supply borderlights, connector strips, and drop boxes, and when not in direct contact with enclosures containing heat-producing elements.

## Table 18.3
## Ampacity reduction factor for flexible cords and cables with four or more current-carrying conductors

| Number of conductors | Percent of 3-conductor flexible cord and cable ampacities in Tables 18.1 and 18.2 based on temperature rating of cord | |
|---|---|---|
| | 60°C (140°F) | 75°C (167°F) and 90°C (194°F) |
| 4 through 6 | 80 | 80 |
| 7 through 9 | 70 | 70 |
| 10 through 20 | 50 | 70[a] |
| 21 through 24 | 45 | 70[a] |
| 25 through 30 | 45 | 60[a] |
| 31 through 40 | 40 | 60[a] |
| 41 through 42 | 35 | 60[a] |
| 43 and above | 35 | 50[a] |

[a] These ampacity reduction factors apply for flexible cords of the type rated for extra-hard usage when:

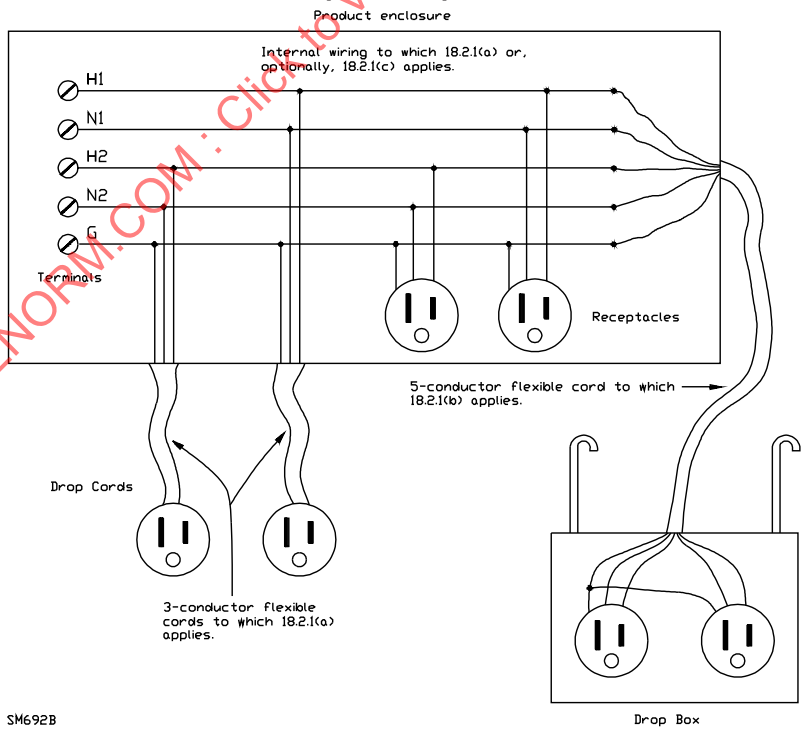
a) Used to supply borderlights, connector strips, or drop boxes;

b) Not in direct contact with enclosures containing heat-producing elements; and

c) The borderlight, connector strip, or drop box is marked as specified in 59.4 to indicate that it is to be operated with a minimum load diversity factor of 50 percent.



## Figure 18.1
## Illustrative example of requirements in 18.2.1



18.2.2 When applying the requirement of 18.2.1 to a conductor of a connector strip that supplies a receptacle or cord connector, the conductor shall be sized using the 60°C ampacities as specified in Tables 18.1 and 18.2 for the type of wire, flexible cord, or cable involved.

*Exception No. 1: It shall be permitted to size a conductor of a connector strip that supplies a receptacle or cord connector using the ampacity of the conductor having the insulation temperature rating specified in the first column of Table 18.4, when the insulation temperature rating of the conductor used exceeds the value specified in the second column of Table 18.4.*

*Exception No. 2: The conductor of a connector strip or drop box power supply cord rated at more than 60°C (140°F) shall be sized using the ampacities assigned for the temperature rating for the conductors.*

**Table 18.4**
**Connector strip conductor ampacity correlation table for Exception No. 1 to 18.2.2**

| Maximum conductor insulation temperature rating whose ampacities shall be used as specified in Tables 18.1 and 18.2 | Minimum temperature rating of appliance wiring material or thermoplastic insulated wire |
|---|---|
| 75°C | 140°C |
| 90°C | 155°C |
| 150°C | 215°C |
| 200°C | 265°C |
| 250°C | 315°C |

18.2.3 A conductor connected to a terminal of an electrical component used in stage and studio lighting equipment shall comply with (a), (b), or (c), as applicable, when:

a) The electrical component is marked to identify both the minimum size and minimum insulation temperature rating of the conductor to be used, the conductor connected to the terminal of the electrical component shall have an insulation temperature rating and size not less than that specified in the marking;

b) The electrical component is marked to identify only the minimum insulation temperature rating of the conductor to be used (and not the conductor size), the conductor connected to the terminal of the electrical component shall be sized as specified in 18.2.4 and shall have an insulation temperature rating not less than that specified in the marking; or

c) The conductor connected to the terminal of an electrical component not marked as specified in (a) or (b) shall be sized as specified in 18.2.4. The conductor of a circuit rated 100 amperes or less shall have an insulation temperature rating of not less than 60°C (140°F). The conductor of a circuit rated more than 100 amperes shall have an insulation temperature rating of not less than 75°C (167°F).

*Exception: A conductor connected to a terminal of an electrical component used in stage and studio luminaire equipment is not prohibited from being smaller than that specified in 18.2.3, or from having an insulation temperature rating less than that specified in 18.2.3, when the materials of the electrical component and conductor insulation do not attain temperatures higher than their ratings when the equipment is tested as indicated in the Temperature Test, Section 30.*

18.2.4 A conductor connected to a terminal of an electrical component not marked as specified in 18.2.3(a) and used in a circuit rated 100 amperes or less shall be sized to have an ampacity not less than the current involved based on connecting a conductor having an insulation temperature rating of 60°C (140°F). A conductor connected to a terminal of an electrical component not marked as specified in 18.2.3(a) and used in a circuit rated more than 100 amperes shall be sized to have an ampacity not less than the current involved based on connecting a conductor having an insulation temperature rating of 75°C (167°F). The ampacities of conductors having an insulation temperature rating of 60°C and 75°C are specified in Table 18.1 for thermoplastic insulated wire.

18.2.5 A wire used in a luminaire shall have insulation rated for the highest temperature to which it is subjected as determined by the Temperature Test, Section 30.

18.2.6 A wire used in a connector strip or striplight shall be provided with insulation with a temperature rating of not less than 125°C (257°F).

*Exception No. 1: The conductor insulation on the end of a drop cord entering a connector strip housing is not prohibited from having a rating of less than 125°C, but shall not be less than 90°C (194°F), when the leads extend a maximum of 152 mm (6 inches) into the connector strip housing for splicing and are positively prevented from contacting any wire in the connector strip other than the leads of the wires to which they are spliced.*

*Exception No. 2: The conductor insulation on the end of the cord or cable described in 26.3 that enters a connector strip housing is not prohibited from having a rating of less than 125°C, but shall not be less than 90°C, when the wires extend a maximum of 457 mm (18 inches) into the connector strip housing for splicing and are positively prevented from contacting any wire in the connector strip other than the leads of the wires to which they are spliced.*

18.2.7 The conductor fill of a connector strip shall not exceed 20 percent. When calculating the connector strip fill, wires of all circuits (not including grounding or bonding conductors) are to be included. The cross-sectional area calculation shall use the cross-sectional area of all wires (metal conductor and insulation) crossing an imaginary plane perpendicular to the long axis of the wireway. For the purpose of this requirement, a wire crossing the imaginary plane more than once is treated as separate wires and the cross-sectional area of a wire having a non-circular cross-section shall be taken as the cross-sectional area of a circular wire having a diameter equal to the maximum width of the wire having the non-circular cross-section.

*Exception: The conductor fill of a connector strip is not prohibited from exceeding 20 percent when the construction complies with the Temperature Test, Section 30.*

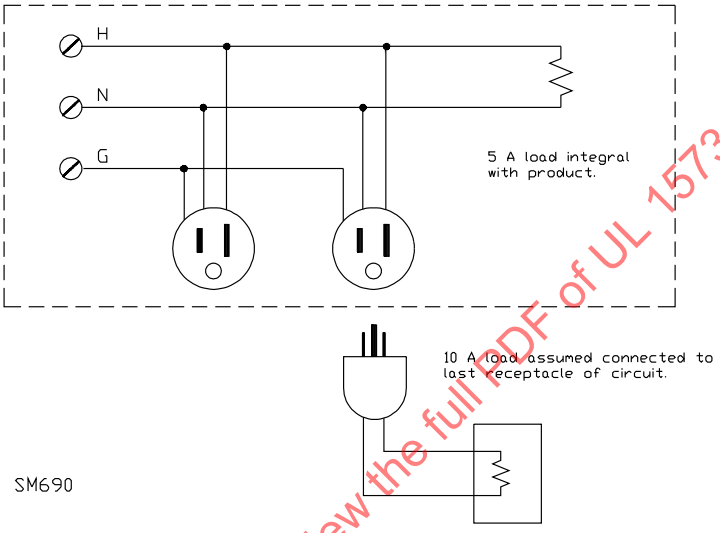
18.2.8 The conductors of a connector strip shall be arranged so as to reduce the risk of unintended heating of surrounding metal by induction. This shall be accomplished by placing all phase conductors and the grounded circuit conductor of a circuit together in the same compartment and raceway.

*Exception: The conductors are not required to be routed together in the same compartment when the construction complies with the Temperature Test, Section 30. During the testing, the temperatures of metal surfaces near conductors shall be monitored and shall not exceed the temperature limits indicated in Table 30.1 for the conductors.*

## 18.3 Load determination

18.3.1 When a circuit supplies two or more receptacles or cord connectors, it shall be assumed that any one or combination of the receptacles or cord connectors is loaded so that the involved conductors and receptacle(s) conduct the maximum current. The intended maximum available current for the receptacles and cord connectors shall be determined as specified in 18.3.2(c). Figures 18.2 and 18.3 show examples of the application of this requirement.

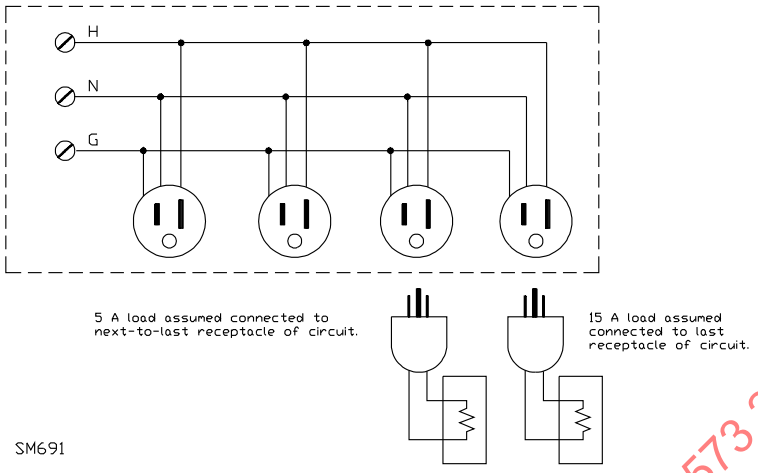
**Figure 18.2**
**Illustrative example of requirements in 18.3.1 and 30.2.3**




Both circuit rating and current rating associated with blade and pin configuration of receptacles are 15 A.

Marking adjacent to set of receptacles: "The combined load connected to all receptacles is not to exceed 10 A."

**Figure 18.3**
**Illustrative example of requirements in 18.3.1 and Exception to 30.2.2**




Circuit rating: 20 A

Current rating associated with blade and pin configuration of receptacles: 15 A

Marking adjacent to set of receptacles: "The combined load connected to all receptacles is not to exceed 20 A."

18.3.2 The total load current value for a conductor that supplies a receptacle or cord connector as specified in 18.2.1 shall be calculated by determining and adding the individual load current values as indicated in (a) – (d) for the loads supplied by the conductor. Figures 18.4 and 18.5 show examples of applications of this requirement.

a) Lampholders – A load current value equal to that calculated by dividing the marked lamp replacement wattage by the lampholder circuit voltage.

b) Motors – A load current value equal to 125 percent of the full load current of the motor.

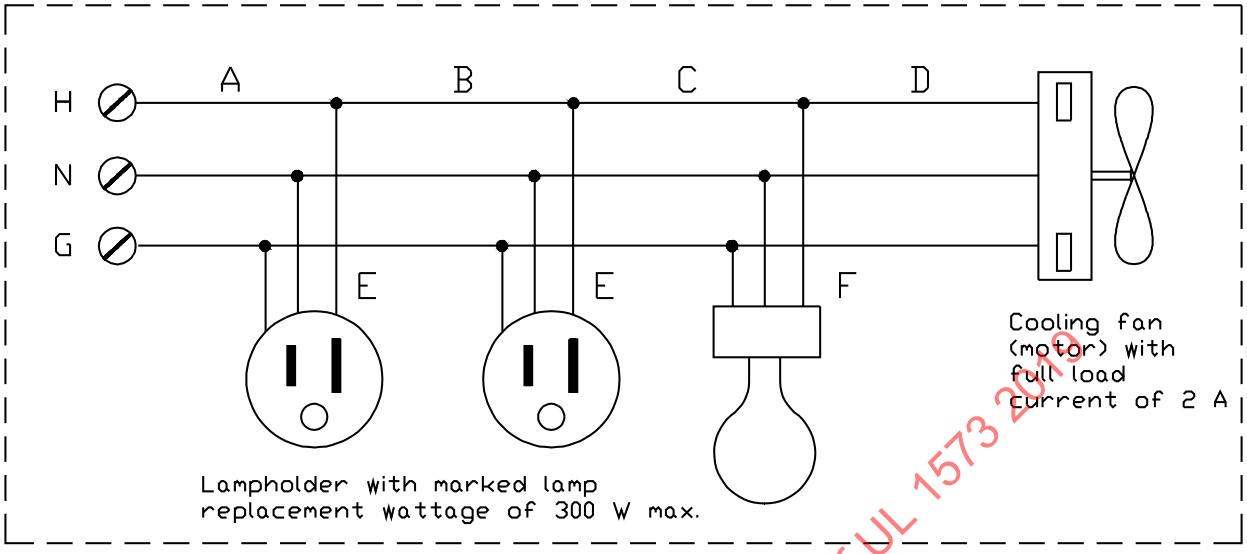
c) Receptacles and Cord Connectors– A load current value calculated as described below in the applicable subitem.

1) The load current value for one or a set of receptacles or cord connectors supplied by the same conductor and that are not marked as specified in 59.2 or 59.3 with an intended maximum available current that is less than the current rating associated with the blade or pin configuration of the receptacle or cord connector shall be the current rating associated with the blade or pin configuration of the receptacle or cord connector.

2) Where a conductor supplies a receptacle or cord connector that is marked as specified in 59.2 or 59.3 with an intended maximum available current, the load current value is to be the maximum current appearing in any of the markings provided.

d) Other loads – A load current value equal to the full load current anticipated shall be assigned.

**Figure 18.4**
**Illustrative example of requirements in 18.3.2**




SM689



Circuit rating: 20 A

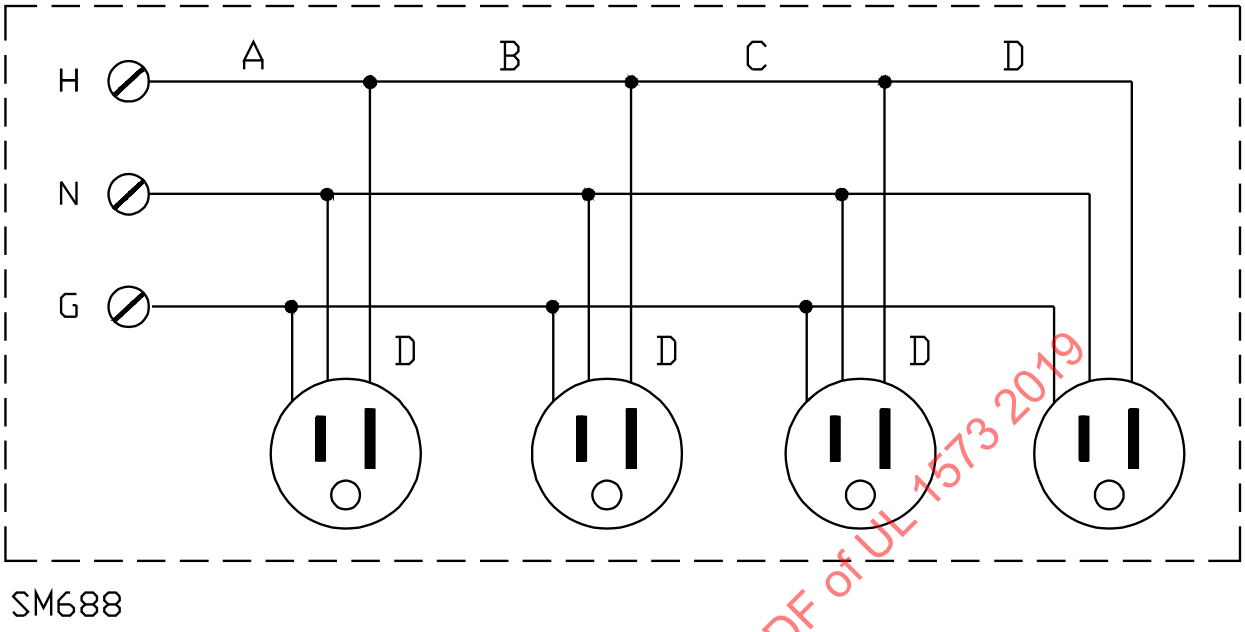
Current rating associated with blade and pin configuration of receptacles: 15 A

Receptacles not provided with the marking in 59.2 or 59.3 indicating an intended maximum available current.

| Load current value assignment | |
|---|---|
| **Component** | **Load current value used** |
| Both receptacles as a set | 15 A |
| Lampholder | 2.5 A |
| Cooling Fan | 2.5 A (125 percent of 2 A) |

| Conductor size determination | | |
|---|---|---|
| **Conductor letter code** | **Load current value** | **Minimum size of conductor without temperature test** |
| A | 20 A | 12 AWG |
| B | 20 A | 12 AWG |
| C | 5 A | 18 AWG |
| D | 2.5 A | 18 AWG |
| E | 15 A | 14 AWG |
| F | 2.5 A | 18 AWG |

**Figure 18.5**
**Illustrative example of requirements in 18.3.2**






Circuit rating: 20 A

Current rating associated with blade and pin configuration of receptacles: 15 A

Receptacles each marked as specified in 59.2 for an intended maximum available current of 5 A.

| Load current value assignment | |
|---|---|
| **Component** | **Load current value used** |
| Each receptacle | 5 A |

| Conductor size determination | | |
|---|---|---|
| **Conductor letter code** | **Load current value** | **Minimum size of conductor without temperature test** |
| A | 20 A | 12 AWG |
| B | 15 A | 14 AWG |
| C | 10 A | 14 AWG |
| D | 5 A | 18 AWG |

## 19 Receptacles, Drop Cords, Cord Connectors, Interconnecting Flexible Cords and Cables, and Overcurrent Protection

19.1 A drop cord shall consist of one of the types of flexible cord or cable identified in 26.3(a) and shall terminate in a cord connector.

19.2 External wiring used to interconnect separated assemblies of a product, such as a luminaire and a remote ballast assembly or remote control assembly, shall be flexible cord or cable of the type identified in 26.3(a), or equivalent.

*Exception: External wiring connected to a Class 2 circuit or a limited-voltage/current circuit is not required to be flexible cord or cable.*

19.3 The slot or pin configuration of a standard receptacle or cord connector shall be that associated with the voltage of the circuit to which the receptacle or cord connector is connected.

19.4 A non-standard receptacle or cord connector shall be supplied by a circuit with a voltage rating not exceeding the voltage rating of the receptacle or cord connector being used.

19.5 All receptacles and cord connectors shall be of a grounding type.

*Exception: A receptacle or cord connector is not required to be of a grounding type when the circuit supplying the receptacle or cord connector is rated 150 volts DC or less and the product is marked as specified in 56.2 to indicate that the product is intended for use only in motion picture and television studios and similar locations.*

19.6 A receptacle or cord connector shall be provided with overcurrent protection that is an integral part of the equipment when the situation described in (a) or (b) applies.

a) The receptacle or cord connector is supplied by the secondary of a transformer that is part of the equipment.

b) A branch circuit to which the equipment is intended to be connected supplies the receptacle or cord connector in the equipment and is provided with overcurrent protection greater than the current rating associated with the slot or pin configuration of the receptacle or cord connector.

The overcurrent protection shall be of the branch-circuit type and shall not be greater than the current rating associated with the blade or pin configuration of the receptacle or cord connector.

*Exception: A 15-ampere receptacle or cord connector supplied by a circuit that is protected by branch-circuit overcurrent protection rated 20 amperes is not required to be provided with additional overcurrent protection.*

19.7 A user-serviceable fuse shall be mounted or guarded so that no live parts are exposed to unintentional contact. The arrangement shall be such that, at any time during replacement, the fuse is not gripped or held by any part of the fuseholder while live parts are exposed.

19.8 A clip for a cartridge fuse shall be mounted securely, resistant to turning, and provided with end stops.

19.9 Where markings or other manufacturer provided information associates a receptacle or connector with the Class 2 circuit classification, the receptacle or connector shall not be connected within the product to other than a circuit of either (a), (b), or (c).

a) A Class 2 circuit as defined in 3.6;

b) A limited-voltage/current circuit as defined in 3.32; or

c) An internal circuit not conductively connected to another source of voltage or current (the voltage or current is received through the receptacle or connector), and the circuit and its components comply with applicable requirements of this standard for separation from other than Class 2 and limited-voltage/current circuits.

For such a receptacle or connector, the marking in 57.7 shall be provided.

19.10 Where markings or other manufacturer provided information associates a receptacle or connector with the Class 3 circuit classification, the receptacle or connector shall not be connected within the product to other than a Class 3 circuit as defined in 3.8. For such a receptacle or connector, the marking in 57.8 shall be provided.

## 20 Polarity

20.1 Equipment containing a receptacle, cord connector, or a screw-shell type lampholder shall be wired such that a wire connected to the shell or to the grounded (neutral) terminal of the receptacle or cord connector is clearly identified for the connection of the grounded conductor of the supply circuit at the point of connection to the supply.

*Exception: The polarity is not required to be marked when:*

*a) The lampholder or receptacle is connected to a circuit electrically-isolated from the supply (such as in the secondary of an isolated secondary transformer);*

*b) The lampholder or receptacle operates at a potential to ground and between conductors of 30 volts (42.4 volts peak) or less; or*

*c) The lampholder has a screw-shell lampholder that does not connect any pole of the supply to the shell until the lamp is nearly fully inserted, and which fully shrouds the metallic screw base of the lamp when contact is made.*

20.2 A switch that de-energizes a lampholder shall disconnect all ungrounded conductors to the lampholder. It is to be assumed both conductors to a lampholder are ungrounded conductors when the equipment is not marked as specified in 55.2 for connection to an alternating current supply only.

*Exception: This requirement does not apply to a switch that de-energizes a lampholder covered by the Exception to 20.1.*

20.3 A terminal intended for the connection of a grounded supply conductor shall be either:

a) Made of or plated with metal that is white in color and shall be readily distinguishable from the other terminal or

b) Identified clearly in some other manner, such as on an attached wiring diagram.

20.4 A lead intended for the connection of a grounded power-supply conductor shall be finished to show a white or gray color and shall be readily distinguishable from the other leads.

20.5 The lead or terminal of a product with a ballast that is intended to be connected to a branch circuit with a grounded circuit conductor (neutral) shall be identified as such in accordance with the applicable requirements of 20.3 and 20.4.

## 21 Ballasts and Capacitors

21.1 A ballast and starter or ignitor, when provided, shall be rated for the operation of the type and size of lamps involved and shall be electrically connected in accordance with the diagram or instructions on or with the ballast.

21.2 A product having a capacitor as a component separate from the ballast shall incorporate means, such as a bleeder resistor or a construction as described in 21.4, for the automatic discharge of the capacitor within one minute after removal of the lamp from the circuit or after opening of the primary circuit, or both. The voltage (V) at the end of one minute across the terminals shall be reduced to a value of 50 volts or less, and the energy stored (J) shall be less than 20 joules as determined by the equation:

$$J = 5 \times 10^{-7} CV^2$$

*in which:*

*C is the capacitor rating in microfarads.*

21.3 To comply with 21.2, the maximum resistance value of a bleeder resistor shall be determined by the equation:

$$R = \frac{K}{C}$$

*in which:*

*R is the resistance value in megohms;*

*K is the resistor factor determined in Table 21.1; and*

*C is the capacitor rating in microfarads.*

**Table 21.1**
**Bleeder resistor factor (k)**

| Voltage, peak | Voltage, (rms)[a] | Factor (k) |
|---|---|---|
| 0 – 100 | 0 – 70 | 85 |
| 101 – 110 | 71 – 78 | 76 |
| 111 – 120 | 79 – 85 | 70 |
| 121 – 130 | 86 – 92 | 63 |
| 131 – 140 | 93 – 99 | 55 |
| 141 – 150 | 100 – 106 | 54 |
| 151 – 170 | 107 – 120 | 50 |
| 171 – 200 | 121 – 141 | 44 |
| 201 – 240 | 142 – 169 | 39 |
| 241 – 280 | 170 – 197 | 35 |
| 281 – 325 | 198 – 230 | 32 |
| 326 – 375 | 231 – 265 | 30 |
| 376 – 450 | 266 – 318 | 27 |
| 451 – 500 | 319 – 353 | 26 |
| 501 – 700 | 354 – 495 | 23 |
| 701 – 1000 | 496 – 707 | 19 |

[a] For a transformer-type ballast, the voltage value to be applied from this table is the rms voltage rating of the capacitor as specified by the ballast.



21.4 Compliance with the requirement in 21.2 is also achieved without the use of a bleeder resistor when the capacitor is located in a closed loop of the circuit and when the loop is not opened by removal of the lamp or by the opening of a switch, fuse, or similar device.

21.5 A capacitor or EMI filter connected across the primary circuit shall comply with the requirements in 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. A capacitor or EMI filter is determined to be across the primary circuit when, in a shorted condition, a current of greater than 1 ampere passes through it when the equipment is in a heated condition. The means used to limit the current to 1 ampere or less shall be a fixed impedance or a protective device rated 1 ampere or less.

21.6 An electrolytic capacitor located in unlimited power circuitry and that is greater than 10 mm (0.4 inch) in diameter shall be provided with a means for relieving internal pressure.

21.7 When an oil-filled capacitor in an electric discharge product is not integral with the ballast, its characteristics and installation shall comply with 21.8 – 21.11.

21.8 The capacitor shall comply with the Standard for Capacitors, UL 810, and shall be rated for the voltage to which it is to be connected. Such capacitors relieve an internal fault condition by movement of the terminal end of the capacitor enclosure to break the circuit internally. Movement is initiated by internal pressure during a fault condition, causing expansion of the capacitor body.

21.9 The capacitor shall be rated not less than the maximum fault current to which it is subjected, as follows:

a) A value of 10,000 amperes when connected across the ballast primary; that is, when the capacitor is in parallel with the ballast input circuit;

b) A value of 200 amperes when connected in series with a ballast coil; or

c) The maximum current available to the capacitor under capacitor short-circuit condition, as determined by an investigation.

21.10 The placement and mounting of a capacitor in a product shall be such that a free air space is provided in front of the capacitor end-terminals to enable the capacitor to expand, without obstruction, under a fault condition. This expansion clearance space shall allow the front enclosure and terminals of the capacitor, with associated wire connectors and supply leads attached, to travel 12.7 mm (1/2 inch) in a direction perpendicular to the mounting surface of the terminals.

*Exception: The expansion clearance space is not prohibited from being less than 12.7 mm when an investigation determines that the space required for a particular capacitor is provided.*

21.11 In addition to the expansion clearance space specified in 21.10, an electrical air spacing between any exposed live part of the capacitor, such as exposed terminals and wire connectors, and any uninsulated live part of opposite polarity or uninsulated, grounded dead-metal parts shall (after expansion) be at least:

a) 1.6 mm (1/16 inch) when the voltage involved does not exceed 300 volts or

b) 3.2 mm (1/8 inch) when the voltage involved exceeds 300 volts.

## 22 Printed-Wiring Boards

22.1 A printed-wiring board containing circuits involving a risk of fire or electric shock or where separation of the bond between the printed-wiring board foil and the base material results in contact with circuits involving a risk of fire or electric shock, shall comply with the Standard for Printed-Wiring Boards, UL 796.

## 23 Electrical Spacings

23.1 An electrical spacing shall comply with the requirements specified in this section.

*Exception No. 1: A spacing is not required to comply with the requirements in this section within snap switches, lampholders, and similar component devices covered by 2.1.1.*

*Exception No. 2: A spacing between uninsulated live parts of snap switches, lampholders, and similar component devices and dead metal that is part of the device (including mounting screws, rivets, yoke, clamp, or the like) is not required to comply with the requirements in this section.*

*Exception No. 3: There are no specifications for spacings in limited-voltage/current circuits or Class 2 circuits. A limited-voltage/current circuit shall comply with Limited-Voltage/Current Circuits, Section 27.*

*Exception No. 4: Motor drive circuits shall comply with the following spacing requirements in the Standard for Industrial Control Equipment, UL 508:*

*a) Spacing requirements for constructions in which transient voltages are known and controlled or*

*b) Alternate spacing requirements under the heading of clearance and creepage distances.*

*Exception No. 5: For other than providing isolation between different circuits, spacings between traces of different potential on a printed-wiring board are not required to comply with the requirements in this section when:*

*a) The printed-wiring board has a flammability rating of V-0;*

*b) The printed-wiring board base material has a minimum Comparative Tracking Index (CTI) of 100 volts; and*

*c) The circuit complies with the Printed-Wiring Board Abnormal Operation Test, Section 40.*

23.2 The electrical spacing through-air and over-surface between lampholder terminals and the metal of a striplight enclosure shall be minimum 12.7 mm (1/2 inch) for voltages up to 600 volts.

23.3 Electrical spacings at field-wiring terminals shall comply with the values specified in Table 23.1.

## Table 23.1
## Minimum electrical spacings at field-wiring terminals

| Potential involved, volts, rms (peak voltages)[a] | Between field-wiring terminals (through-air and over-surface), | | Between field-wiring terminals and other uninsulated parts not always of the same polarity, | | | |
|---|---|---|---|---|---|---|
| | mm | (inch) | mm | (inch) | mm | (inch) |
| 0 – 50 (0 – 71) | 3.2 | 1/8 | 3.2[b] | 1/8[b] | 3.2 | 1/8 |
| 51 – 250 (72 – 354) | 6.4 | 1/4 | 6.4[b] | 1/4[b] | 6.4 | 1/4 |
| 251 – 600 (355 – 850) | 12.7[c] | 1/2[c] | 12.7[b,c] | 1/2[b,c] | 9.5 | 3/8 |

[a] The values in parentheses are peak voltages. When investigating the voltage of a circuit that produces other than essentially sinusoidal waveform, both rms and peak voltages are considered and the requirement for the larger spacing is to be applied.

[b] These spacings apply to the sum of the spacings involved wherever an isolated dead-metal part is interposed.

[c] A spacing of less than 12.7 mm (1/2 inch) is permitted over-surface or through-air at wiring terminals in a wiring compartment or terminal box that is integral with a motor but shall not be less than 9.5 mm (3/8 inch).

23.4 Except as specified in 23.2, and at other than field-wiring terminals, electrical spacings shall comply with the values specified in Table 23.2 for potentials up to 600 volts rms and 850 volts peak.

## Table 23.2
## Minimum electrical spacings other than at field-wiring terminals

| Potential involved, volts, rms (peak voltages)[a] | Over-surface, | | Through-air, | |
|---|---|---|---|---|
| | mm | (inches) | mm | (inches) |
| 51 – 125 (0 – 177) | 1.6[b] | 1/16[b] | 1.6[b] | 1/16[b] |
| 126 – 250 (178 – 354) | 2.4[b] | 3/32[b] | 2.4[b] | 3/32[b] |
| 251 – 600 (355 – 850) | 12.7[c] | 1/2[c] | 9.5[c] | 3/8[c] |

NOTES

1 Film-coated wire is considered an uninsulated live part.

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

[a] The values in parentheses are peak voltages. When investigating the voltage of a circuit that produces other than essentially sinusoidal waveform, both rms and peak voltages are considered and the requirement for the larger spacing is to be applied.

[b] At closed-in points only, such as a screw and washer construction of an insulated stud mounted in metal, a spacing less than as specified above is permitted but shall not be less than 1.2 mm (3/64 inch).

[c] An over-surface and through-air spacing less than as specified above, between a dead-metal part and film-coated wire that is rigidly supported and held in place on a coil, is permitted but shall not be less than 2.4 mm (3/32 inch).

23.5 Electrical spacings between two circuits involving different voltages, such as between a limited-voltage/current circuit and a line voltage circuit, shall not be less than as required for the higher voltage circuit.

## 24 Grounding

24.1 All conductive parts of a product not intended to be electrically live that are accessible to persons (including during maintenance and repair), and are capable of inadvertently becoming energized, shall be grounded by being conductively bonded to a common point that incorporates provision for grounding of the luminaire. A product shall be provided with a grounding means to provide connection to the branch-circuit grounding conductor, as specified in 24.2– 24.8.

*Exception: A product rated 150 volts DC or less, that is marked as specified in 58.2 to indicate that the product is intended for use only in motion-picture and television studios and similar locations, is not required to comply with the requirements in this section.*

24.2 An equipment grounding means shall be:

a) A pigtail lead, pressure terminal connector, or wire-binding screw complying with the requirements of Termination Provisions for Field-Connected Conductors, Section 25, or

b) The grounding pin of an attachment plug or the equivalent.

The equipment grounding means shall be at the same location as the power-supply connection means.

24.3 When insulated, an equipment-grounding conductor, where visible to the installer, shall have a braid of continuous green color with or without a yellow tracer or, when no braid is used, the insulation on the conductor shall be green with or without one or more yellow stripes.

*Exception: A conductor having green insulation and a braid of other than green shall be used when the green insulation is readily visible where connections to the branch-circuit supply wires are made.*

24.4 An equipment-grounding conductor shall not be terminated on the luminaire by a screw, rivet, or equivalent device that is also used to secure another device or part that is removed during replacement of any electrical device or component.

24.5 The cord of a cord-connected luminaire shall contain an equipment-grounding conductor complying with 24.3 and 24.4.

24.6 A wire-binding screw intended for the field connection of an equipment-grounding conductor shall have a green-colored head that is hexagonal-shaped or slotted, or both.

24.7 A pressure-wire terminal for the connection of an equipment-grounding conductor shall be marked as specified in 57.1.

24.8 All parts required to be grounded shall be conductively connected to the ground termination point such that the resistance between any two points is 0.1 ohm or less as determined in the Grounding Continuity Test, Section 36.

24.9 A bonding wire or jumper connector shall not be terminated by a screw, rivet, or equivalent device that is also used to secure another device, part, or the like, that is removed during replacement of any electrical device or component.

## 25 Termination Provisions for Field-Connected Conductors

25.1 The termination means provided for field-connected conductors shall consist of a pigtail lead, a pressure terminal connector, a wire-binding screw, or a stud with nut.

25.2 A wire-binding screw or nut shall be 4.2 mm (No. 8) major diameter or larger and shall be provided with a cupped washer to hold the wire under the head of the screw or nut. A sheet metal screw shall not be used.

*Exception: A means other than a cupped washer is not prohibited from being used to hold the wire when investigated and determined to be equivalent.*

25.3 A wire-binding screw shall not be used to connect a conductor larger than 5.3 $mm^2$ (10 AWG).

25.4 A terminal plate having a tapped hole for a wire-binding screw shall be of metal not less than 0.76 mm (0.030 inch) thick and shall have not fewer than two full threads in the metal.

*Exception: A tapped hole for a screw having a thread pitch of 0.8 mm or less (32 or more threads per inch) is not prohibited from having the metal extruded at the screw hole to provide two full threads.*

25.5 The termination provision shall accommodate a conductor sized in accordance with Tables 18.1 and 18.2 for having an ampacity of not less than the current rating of the equipment and:

a) A 60°C (140°F) temperature rating for equipment rated 100 amperes or less or

b) A 75°C (167°F) rating for equipment rated more than 100 amperes.

*Exception: The termination provision is not prohibited from accommodating a conductor sized less – or having a temperature rating greater – than as specified in this requirement, when the equipment complies with the temperature test requirements with the different conductor used, and is provided with the marking described in 57.5.*

25.6 A pigtail lead shall not be sized less than 4 sizes smaller than the conductor determined in accordance with 25.5 or its exception. For example, a pigtail lead intended for connection with a 3.3 $mm^2$ (12 AWG) conductor shall not be smaller than 1.3 $mm^2$ (16 AWG).

## 26 Power Supply Connections

26.1 Stage luminaires, connector strips, and the like intended for permanent installation shall have provision for the entry of conduit or cable. Means shall be provided to ensure that supply connections and wiring that are added in the field are accessible for inspection.

26.2 Equipment intended for permanent connection shall have termination provisions for field-connected conductors that comply with the requirements of Termination Provisions for Field-Connected Conductors, Section 25.

26.3 A portable stage luminaire shall be provided with a length of flexible cord or cable or special conductor assembly that complies with (a) – (e). A portable connector strip shall be provided with a length of flexible cord or cable that complies with (a) and (c) – (e).

a) A flexible cord shall have a serviceability rating at least equal to extra-hard-usage types such as Type G, S, SE, SEO, SO, ST, STO, or W.

*Exception No. 1: Still photography lights are not prohibited from being provided with a flexible cord having a serviceability rating at least equal to hard-usage types such as Type SJ, SJO, SJT, or equivalent power supply cords.*

*Exception No. 2: Portable stage luminaires are not prohibited from being provided with a flexible cord having a serviceability rating at least equal to hard-usage types such as Type SJ, SJO, SJT, or equivalent power supply cords providing that the supply cord is not greater than 2 m ( 6.6 feet) in length and is rated at not more than 20A.*

b) A special assembly of conductors used in lieu of the flexible cord or cable of portable stage luminaires shall consist of stranded conductors rated minimum 125°C (257°F) and an outer glass fiber sleeve with a wall thickness of at least 0.64 mm (0.025 inch). The conductors and sleeving shall be maximum 1 m (3.3 feet) in length.

*Exception: The special assembly of conductors are not required to include an outer glass fiber sleeve when the conductors are part of an appliance wiring material that includes an overall jacket or outer sleeving and the appliance wiring material is equivalent to the special assembly of conductors described above with regard to resistance to abrasion and conductor insulation damage. For example, appliance wiring material Style 4418 has been determined to be equivalent to the special assembly of conductors.*

c) The flexible cord, cable, or special conductor assembly shall be sized to have an ampacity that corresponds to the electrical rating of the equipment but shall not be smaller than 0.82 $mm^2$(18 AWG) flexible cord, cable, or conductor, as applicable.

d) The flexible cord, cable, or special assembly of conductors shall be terminated by an attachment plug that is of the grounding type.

*Exception No. 1: The length of flexible cord, cable, or special conductor assembly is not required to terminate in an attachment plug when the unit is marked in accordance with 57.2 or 57.3, as applicable.*

*Exception No. 2: The attachment plug is not required to be of the grounding type when the product is rated 150 volts DC or less and is marked as specified in 56.2 to indicate that the product is intended for use only in motion picture and television studios and similar locations.*

e) The flexible cord, cable, or special conductor assembly shall be provided with a strain-relief means that complies with the Strain-Relief Test, Section 34.

26.4 The length of a power supply cord shall not be less than 914 mm (3 feet). The length of the power supply cord is to be measured from the face of the attachment plug to the point where the cord emerges from the enclosure.

*Exception: The length of the power supply cord of a connector strip is not prohibited from being less than 914 mm but shall not be less than 457 mm (18 inches).*

26.5 An adaptor and connector provided for power supply connections shall:

a) Comply with the requirements in Polarity, Section 20;

b) Be rated for the voltage involved; and

c) Have the same current rating as the supply circuit connector to which the adaptor or connector is intended to be connected.

## 27 Limited-Voltage/Current Circuits

27.1 A limited-voltage/current circuit is one that is supplied from an isolated secondary winding of a transformer and that complies with the applicable values specified in Table 27.1. Power limitations of a limited-voltage/current circuit shall be obtained by the use of any of the following configurations:

a) An inherently-limited transformer;

b) A non-inherently-limited transformer coupled with an overcurrent-protected device on the output circuit;

c) A combination transformer and fixed impedance; or

d) An arrangement determined to be equivalent to (a), (b), or (c).

## Table 27.1
## Limited-voltage/current circuits

| Inherently-limited transformer (overcurrent protection not required) | | | |
|---|---|---|---|
| Circuit voltage (volts)[a] | 0 – 20 volts AC or DC | Over 20 volts but not more than 30 volts AC or DC | Over 30 volts but not more than 60 volts DC |
| Power limitation (volt-amperes)[b] | – | – | – |
| Current limitation amperes[c] | 8 | 8 | 150/V[a] |
| Maximum overcurrent protection (amperes) | – | – | – |

| Not inherently-limited transformer (overcurrent protection required) | | | | |
|---|---|---|---|---|
| Circuit voltage (volts)[a] | 0 – 15 volts AC or DC | Over 15 volts but not more than 20 volts AC or DC | Over 20 volts but not more than 30 volts AC or DC | Over 30 volts but not more than 60 volts DC |
| Power limitation (volt-amperes)[b] | 350 | 250 | 250 | 250 |
| Current limitation amperes[c] | 1000/V[a] | 1000/V[a] | 1000/V[a] | 1000/V[a] |
| Maximum overcurrent protection (amperes) | 5 | 5 | 100/V[a] | 100/V[a] |
| NOTE – In all cases the applied primary voltage shall be as indicated in 30.1.8. | | | | |



Table 27.1 Continued on Next Page

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**Table 27.1 Continued**

| Inherently-limited transformer (overcurrent protection not required) |
|---|
| [a] Maximum output voltage, regardless of load, with applied voltage as specified in 30.1.8. |
| [b] Maximum volt-ampere output, regardless of load, and overcurrent protection (when provided) bypassed. |
| [c] Maximum output after 1 minute of operation under any noncapacitive load, including short circuit, and with overcurrent protection (when provided) bypassed. |

27.2 A transformer intended to comply with the requirements in 27.1 shall be subjected to the Test for Limited-Voltage/Current Circuit Transformers, Section 41.

27.3 When an overcurrent-protective device is required to comply with the requirements in 27.1, the secondary of the transformer and the overcurrent-protective device are to be evaluated as part of the line-voltage circuits.

27.4 The overcurrent-protective device specified in 27.1(b) shall not be of the automatically-reset type but shall be trip-free when of the manually-reset type.

## 28 Separation of Circuits

28.1 Conductors of two circuits involving different voltages, such as between a limited-voltage/current circuit and a line voltage circuit, shall be separated from each other by a barrier or segregated as specified in 28.2 unless the conductors of both circuits are insulated for the maximum voltage of either circuit.

28.2 Conductors shall be separated from all uninsulated live parts of a different voltage circuit by a barrier or segregated from the uninsulated live parts as specified in 28.4.

28.3 Where a Class 2 circuit leaves the equipment's electrical enclosure, all conductors of the Class 2 circuit within the electrical enclosure shall be separated from all uninsulated live parts of other than a Class 2 circuit by a barrier or segregated from the uninsulated live parts as specified in 28.4.

28.4 Segregation of a conductor shall be accomplished by clamping, routing, or equivalent means that provides permanent separation from a conductor or an uninsulated live part of a different circuit.

## 29 Isolation Devices

29.1 An optical isolator that is relied upon to provide isolation between primary and secondary circuits as required by this standard shall be constructed in accordance with the Standard for Optical Isolators, UL 1577, and shall withstand for 1 minute, without breakdown, an AC dielectric voltage-withstand potential equal to 1000 V plus twice the rated voltage between the input and output circuits.

*Exception: Optical isolators that comply with the requirements for isolation devices in the Standard for Industrial Control Equipment, UL 508, are not required to comply with this requirement.*

29.2 A power-switching semiconductor device that is relied upon to provide isolation to ground shall be constructed in accordance with the Standard for Electrically Isolated Semiconductor Devices, UL 1557. The dielectric voltage-withstand tests required by UL 1557 shall be conducted at a dielectric potential of 1000 V plus twice the rated voltage for 1 minute.

*Exception: Power-switching semiconductor devices that comply with the requirements for isolation devices in the Standard for Industrial Control Equipment, UL 508, are not required to comply with this requirement.*



## PERFORMANCE

## 30 Temperature Test

### 30.1 General

30.1.1 A luminaire; a connector strip constructed to comply with 18.2.1(c), the Exception to 18.2.3, Exception No. 2 to 18.2.6, or the Exceptions to 18.2.7 and 18.2.8; and a connector strip provided with any heat-generating components (such as a lamp, transformer, or motor) other than wires and receptacles and cord connectors, shall be tested as described in 30.1.2 – 30.3.3. The luminaire or connector strip shall exhibit no temperature rises at specific points greater than as indicated in Table 30.1.

**Table 30.1**
**Maximum temperature rises**

| Thermocouple location | °C | (°F) |
|---|---|---|
| 1. Supply wires and points they contact | 35[a] | 63[a] |
| 2. Lampholder body of thermosetting material (such as phenolic or urea)[b] | 125 | 225 |
| 3. Coil of device other than motor using: | | |
| Class 105 insulation systems: | | |
| Thermocouple method | 65 | 117 |
| Resistance method | 75 | 135 |
| Class 130 insulation systems: | | |
| Thermocouple method | 85 | 153 |
| Resistance method | 95 | 171 |
| Class 155 insulation systems: | | |
| Thermocouple method | 110 | 198 |
| Resistance method | 115 | 207 |
| Class 180 insulation systems: | | |
| Thermocouple method | 125 | 225 |
| Resistance method | 140 | 252 |
| Class 200 insulation systems: | | |
| Thermocouple method | 145 | 261 |

Table 30.1 Continued on Next Page

## Table 30.1 Continued

| Thermocouple location | °C | (°F) |
|---|---|---|
| Resistance method | 160 | 288 |
| Class 220 insulation systems: | | |
| Thermocouple method | 160 | 288 |
| Resistance method | 175 | 315 |
| Class 250 insulation systems: | | |
| Thermocouple method | 190 | 342 |
| Resistance method | 205 | 369 |
| 4. Capacitors[b] | | |
| a) Electrolytic | 40 | 72 |
| b) Other types | 65 | 117 |
| 5. Varnished cloth insulation[b] | 60 | 108 |
| 6. Fuse | 65 | 117 |
| 7. Fiber used as electrical insulation[b] | 65 | 117 |
| 8. Wood | 65 | 117 |
| 9. Copper conductors | | |
| a) Tinned or bare strands having: | | |
| 1) A diameter less than 0.38 mm (0.015 inch) | 125 | 225 |
| 2) A diameter of 0.38 mm or more | 175 | 315 |
| b) Plated with nickel, gold, silver, or a combination of these | 225 | 405 |
| 10. Termination of copper conductor and pressure terminal connectors without a nickel coating or equivalent protection | 125 | 225 |
| 11. Lampholder screw shell, center contact, or other connecting device of aluminum or unplated copper | 175[b] | 315[b] |
| 12. Polymeric material used for enclosure or structural parts | c | c |
| 13. Surface to which a marking or label is attached | d | d |
| 14. Wire or cord | e | e |
| 15. Class 105 insulation systems on coil windings of (1) a direct-current motor and (2) a universal motor | | |
| a) In an open motor: | | |
| Thermocouple method | 65 | 117 |
| Resistance method | 75 | 135 |
| b) In a totally enclosed motor: | | |
| Thermocouple method | 70 | 126 |
| Resistance method | 80 | 144 |
| 16. Class 105 insulation systems on coil windings of an alternating-current motor (not including a universal motor) | | |
| a) In an open motor and on vibrator coils (thermocouple or resistance method) | 75 | 135 |
| b) In a totally enclosed motor (thermocouple or resistance method) | 80 | 144 |
| 17. Class 130 insulation systems on coil windings of (1) a direct-current motor and (2) a universal motor | | |
| a) In an open motor: | | |
| Thermocouple method | 85[b] | 153[b] |
| Resistance method | 95 | 171 |
| 18. Class 130 insulation systems on coil windings of an alternating-current motor (not including a universal motor) and on vibrator coils | | |
| a) In an open motor and on vibrator coils (thermocouple or resistance method) | 95 | 171 |
| b) In a totally enclosed motor (thermocouple or resistance method) | 100 | 180 |
| 19. Exposed enclosure surface | 65[f] | 117[f] |



Table 30.1 Continued on Next Page

**Table 30.1 Continued**

| Thermocouple location | °C | (°F) |
|---|---|---|
| 20. Enclosure of electronic starter for HPS lamp[h] | 65 | 117 |
| WET LOCATION PRODUCTS | | |
| 21. Gaskets of silicon rubber[i] | 175 | 315 |
| 22. Impregnated asbestos gaskets[i] | 175 | 315 |
| 23. Non-thermosetting sealing compound | j | j |
| 24. Rubber gaskets[i] | 35 | 63 |
| 25. Neoprene gaskets[i] | 65 | 117 |
| 26. Gaskets of cork or other fibrous material[i] | 100 | 180 |
| 27. Polymeric material used for water-shield | g | g |

[a] Any temperature rise up to 175°C (315°F) is not prohibited when the unit is marked in accordance with 57.4.

[b] These limitations do not apply to compounds or components that have been investigated and determined to be intended for a higher temperature.

[c] The investigation of a polymeric material is to comply with the requirement in 6.2.

[d] The maximum temperature, when corrected to a 25°C (77°F) ambient temperature, is the temperature rating of a label that is used as specified in 53.3.

[e] The maximum temperature, when corrected to a 25°C (77°F) ambient temperature, is the temperature rating of the wire or cord.

[f] Exposed surface temperature rises in excess of 65°C (117°F) but not more than 250°C (450°F) are not prohibited when the unit is marked in accordance with 56.3.

[g] The investigation of a polymeric material shall comply with the requirements in the Polymeric Water-Shield Conditioning Test, Section 49.

[h] These limitations do not apply to compounds or components that have been investigated and determined for use at a higher temperature.

[i] Applicable only for materials used in wet locations in compliance with Products for Use in Wet Locations, Section 13.

[j] 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 by the Standard Test Methods for Softening Point of Resins Derived from Naval Stores by Ring-and-Ball Apparatus, ASTM E 28.



30.1.2 The values for temperature rise in Table 30.1 are based on an assumed ambient temperature of 25°C (77°F), and tests are to be conducted at an ambient temperature of 25 ±5°C (77 ±9°F). The ambient temperature is to be measured by means of a thermocouple immersed in a bath of 15 milliliters of mineral oil in a glass container. The oil bath is to be placed at the same level as the horizontal plane formed by a line that passes through the fixture halfway down its vertical length, and at least three fixture diameters from the fixture horizontally.

30.1.3 Thermocouples are to consist of wires not larger than 24 AWG (0.21 $mm^2$) and not smaller than 30 AWG (0.05 $mm^2$). It is standard practice to use thermocouples consisting of 30 AWG iron and constantan wires and a potentiometer-type instrument, and such equipment is to be used whenever referee temperature measurements by thermocouple are required. The thermocouple wires are to conform with the requirements specified 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.

30.1.4 The temperature of a coil or winding of a ballast using a Class 130 or higher insulation system is to be measured by means of the change-of-resistance method. For a potted device, it is usually required to have a unit made up with test leads brought out before it is potted, as well as having a thermocouple placed on any capacitor.

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30.1.5 At a point on the surface of a coil of a ballast where the temperature is affected by an external source of heat radiation (for example, a lamp), the temperature rise measured by means of thermocouples mounted on the outside of the coil wrap is permitted to be greater than the indicated maximum when the temperature rise of the coil, as measured by the resistance method, is not greater than specified in Table 30.1. The maximum allowable temperature differential for the thermocouple method is 20°C (36°F).

30.1.6 The capacitance of a capacitor used with a ballast shall be within 5 percent of the capacitance for which the ballast is rated.

30.1.7 A luminaire or connector strip required to be temperature-tested as specified in 30.1.1 shall be supplied and operated as specified in the applicable item:

a) A luminaire with an incandescent lamp is to be connected to a supply circuit of rated frequency, when rated for AC and nominal rated voltage. The supply voltage is to be adjusted to result in the lamp operating at rated wattage. When the luminaire uses a component that must be operated at a specified voltage (such as a transformer), the unit is to be connected to the supply voltage specified in 30.1.8 and fitted with a lamp that operates within 1 percent of rated wattage at the lamp's rated voltage.

b) A luminaire with an electric-discharge lamp type of other than fluorescent is to be connected to a supply circuit of rated frequency, when rated for AC and nominal rated voltage. The supply voltage is to be adjusted to result in the lamp operating within 5 percent of rated wattage after the wattage has stabilized (within 15 minutes).

*Exception: A lamp is not required to operate within 5 percent of its marked rating when operated by a ballast that the ballast manufacturer intends to operate the lamp at other than the lamp's marked wattage rating. Such a construction is to be documented by the ballast manufacturer.*

c) A connector strip and a luminaire with a fluorescent lamp type are to be connected to a supply circuit of rated frequency, when rated for AC, and of the voltage specified in 30.1.8.

30.1.8 Test supply voltage is to be:

a) 120 volts when the marked rating is within the range of 110 – 125 volts or

b) 240 volts when the marked rating is within the range of 220 – 250 volts.

When the voltage rating does not fall within either of the indicated voltage ranges, the unit is to be tested at its rated voltage.

30.1.9 Equipment that is provided with terminals or pigtail leads as the power supply connection means is to be connected to thermoplastic insulated wire supply conductors. For equipment rated 100 amperes or less, the supply conductors are to be the smallest conductors that have an ampacity not less than the current involved based on the use of 60°C (140°F) conductors. For equipment rated more than 100 amperes, the supply conductors are to be the smallest conductors that have an ampacity not less than the current involved based on the use of the 75°C (167°F) conductors. The ampacities of thermoplastic insulated conductors having an insulation temperature rating of 60°C and 75°C are specified in Tables 18.1 and 18.2.

## 30.2 Plug-connected loads and load diversity

30.2.1 In reference to the requirements of 30.2.2 and 30.2.3, conductors and devices supplied by different final overcurrent protection devices are determined to be on separate circuits.

30.2.2 The load for the one or last receptacle or cord connector in a circuit is to be 100 percent of the current associated with the blade or pin configuration of the receptacle or cord connector when each receptacle or cord connector or the set of receptacles and cord connectors is not provided with one of the markings specified in 59.2 or 59.3 to identify the intended maximum available current for each receptacle or cord connector or the set of receptacles or cord connectors. The other receptacles or cord connectors in the circuit are not to be loaded.

*Exception: When the last receptacle or cord connector in a circuit protected by branch-circuit overcurrent protection rated 20 amperes is provided with a 15-ampere blade or pin configuration, the next to the last receptacle or cord connector is also to be loaded as required to result in a total circuit current of 20 amperes. Figure 18.3 shows an example of the application of this requirement.*

30.2.3 The load for the last receptacle or cord connector of a set of receptacles or cord connectors on a circuit is to be 100 percent of the intended maximum available current for the set as specified in the marking in 59.3(b) when:

a) The marking in 59.3(b) is provided and

b) Each receptacle or cord connector or the set of receptacles and cord connectors is not provided with one of the markings specified in 59.2 or 59.3 to identify the intended maximum available current for each receptacle or cord connector.

The other receptacles or cord connectors in the circuit are not to be loaded. Figure 18.2 shows an example of the application of this requirement.

*Exception: When the last receptacle or cord connector in a circuit protected by branch-circuit overcurrent protection rated 20 amperes is provided with a 15-ampere blade or pin configuration, the next to the last receptacle or cord connector is also to be loaded as required to result in a total circuit current of 20 amperes.*

30.2.4 The load for each receptacle or cord connector is to be 100 percent of the current marked on or near the receptacle or cord connector when:

a) The unit has a total of only one or two receptacles or cord connectors,

b) Each receptacle or cord connector is provided with one of the markings specified in 59.2 or 59.3(a) to identify an intended maximum available current for each receptacle or cord connector, and

c) The set of receptacles or cord connectors is not provided with the marking specified in 59.3(b) to identify an intended maximum available current for the set of receptacles or cord connectors.

30.2.5 The load for each receptacle or cord connector is to be as indicated in either (a) or (b) when the unit has a total of three or more receptacles or cord connectors, the receptacles or cord connectors are marked as specified in 59.2 or 59.3(a) with an intended maximum available current for each receptacle or cord connector, and the set of receptacles or cord connectors are not marked as specified in 59.3(b).

a) Based on the total number of receptacles or cord connectors provided in the set, one receptacle or cord connector is to be tested at 100 percent of the maximum current marked as intended to be available from the receptacles for each subset of six or partial subset of six receptacles or cord connectors in the set. When possible, one of each different construction of receptacle or cord connector in the set is to be loaded to the maximum current marked as intended to be available from the construction. When selecting receptacles or cord connectors, the receptacles or cord connectors are to be selected beginning with those having the highest marked current rating and working down in current rating to those having the lower marked current ratings to complete the total number.

b) All receptacles or cord connectors of the set not loaded to comply with (a) are to be loaded at 75 percent of the current marked as intended to be available from the receptacles or cord connectors.

30.2.6 The receptacles and cord connectors identified in 30.2.5 are to be assigned to the set based only on the marking information. Circuit assignment is not evaluated in establishing the set.

30.2.7 When the set of receptacles or cord connectors for a circuit includes receptacles or cord connectors that have different constructions, the unit is to be tested as many times as required so that each receptacle or cord connector construction is assigned the maximum load that is determined using the requirements in 30.2.2 – 30.2.5. Each receptacle and cord connector construction is to be loaded to the maximum current intended to be available from each construction during at least one test to confirm that the receptacle and cord connector materials and the conductors connected to the receptacles and cord connectors do not encounter temperatures exceeding their limits.

*Exception: When agreeable to all concerned, a product is not prohibited from being tested fewer times when, during at least one test, each different construction of receptacle and cord connector is loaded to the maximum current intended to be available from the construction even when this results in a total product loading exceeding that determined using the requirements specified in 30.2.2 – 30.2.5.*

30.2.8 Testing a minimum 2.44-m (8-foot) long section of a connector strip exceeding 2.44 m in length is permitted to represent the complete connector strip. In such a case, the tested section of connector strip is to have the following features:

a) The configuration of receptacles or cord connectors and conductors is to be that configuration creating the highest overall temperatures among all of the various configurations that exist along the length of the complete connector strip. When determining the configuration that creates the highest overall temperatures, the following features are to be verified:

1) The number of receptacles or cord connectors per unit length of the section tested is to be the maximum number per unit length that exists in the complete connector strip.

2) The section tested is to contain the group of receptacles or cord connectors representing the greatest total marked available current per unit length that exists in the complete connector strip.

3) The section tested is to have each size and type of conductor loaded with the maximum current that exists for that size and type of conductor at any point in the complete connector strip.

b) Additional or extensions of existing conductors are to be installed through the tested section of connector strip and loaded as though they are supplying the current for the remaining length of connector strip not present for the test. The amount of current load for the additional or extension conductors is to be determined as indicated in 30.2.1 – 30.2.6.

c) The tested section of connector strip is to include any lamps, motors, or other additional heat-generating devices that exist in the complete connector strip.

The loading of the additional conductors specified in (b) is capable of being accomplished by connecting in series the conductors that are normally connected to different (but identical current rating) branch circuits so as to supply the set of conductors during the test by one suitable rated branch circuit. The series connections are to be made external to the connector strip. When required to obtain a connector strip section that includes each of the features specified in 30.2.8 to represent the complete connector strip, a section shall be specifically prepared.

30.2.9 The load specified in 30.2.2 – 30.2.5 is to be resistive, and connected to each receptacle or cord connector involved using a minimum 0.91-m (3-foot) length of flexible cord or cable that terminates in an assembled-on attachment plug with integral cord grip. The type and size of flexible cord or cable used is to be of the type, size, and temperature rating specified in Table 30.2. The attachment plug is to have a current rating that matches the current rating associated with the blade or pin configuration of the receptacle or cord connector to which it is connected.



**Table 30.2**
**Type, size, and temperature rating of flexible cords or cables used to connect the resistive load to attachment plug and receptacle or cord connector**

| Load current in flexible cord or cable[a] (amperes)[b] | | Flexible cord or cable type and insulation temperature rating | Conductor size[c] |
|---|---|---|---|
| More than | Not more than | | |
| 0 | 10 | Type ST – 60°C | 18 AWG (0.82 mm$^2$) |
| (0) | (7) | | |
| 10 | 13 | Type ST – 60°C | 16 AWG (1.3 mm$^2$) |
| (7) | (10) | | |
| 13 | 18 | Type ST – 60°C | 14 AWG (2.1 mm$^2$) |
| (10) | (15) | | |
| 18 | 25 | Type ST – 60°C | 12 AWG (3.3 mm$^2$) |
| (15) | (20) | | |
| 25 | 30 | Type ST – 60°C | 10 AWG (5.3 mm$^2$) |
| (20) | (25) | | |
| 30 | 40 | Type ST – 60°C | 8 AWG (8.4 mm$^2$) |
| (25) | (35) | | |
| 40 | 55 | Type G – 60°C | 8 AWG (8.4 mm$^2$) |
| (35) | (48) | | |
| 55 | 72 | Type G – 60°C | 6 AWG (13.3 mm$^2$) |
| (48) | (63) | | |
| 72 | 96 | Type G – 60°C | 4 AWG (21.2 mm$^2$) |
| (63) | (84) | | |
| 96 | 100 | Type G – 60°C | 3 AWG (26.7 mm$^2$) |

Table 30.2 Continued on Next Page

**Table 30.2 Continued**

| Load current in flexible cord or cable[a] (amperes)[b] | | Flexible cord or cable type and insulation temperature rating | Conductor size[c] |
|---|---|---|---|
| More than | Not more than | | |
| (84) | (88) | | |
| 100 | 115 | Type G – 75°C | 4 AWG (21.2 mm$^2$) |
| (88) | (101) | | |
| 115 | 135 | Type G – 75°C | 3 AWG (26.7 mm$^2$) |
| (101) | (118) | | |
| 135 | 152 | Type G – 75°C | 2 AWG (33.6 mm$^2$) |
| (118) | (133) | | |
| 152 | 178 | Type G – 75°C | 1 AWG (42.4 mm$^2$) |
| (133) | (156) | | |
| 178 | 207 | Type G – 75°C | 1/0 AWG (53.5 mm$^2$) |
| (156) | (181) | | |

[a] The ampacities without parentheses apply to 2-conductor flexible cords and cables or other multi-conductor flexible cords or cables connected so that only 2 conductors are current-carrying.

[b] The ampacities (in parentheses) apply to 3-conductor flexible cords and cables or other multi-conductor flexible cords or cables connected so that only 3 conductors are current-carrying.

[c] Conductor sizes are SI equivalent cross-sectional areas.



## 30.3 Orientation, adjustments, and motor-driven mechanisms

30.3.1 The luminaire or connector strip is to be installed or supported to simulate intended use. When a luminaire has more than one intended use, it is to be installed in accordance with the following conditions:

a) The luminaire is to be mounted and orientated in the position that results in the highest temperatures. When the luminaire is marked as specified in 56.4 with a restricted range of mounting or adjustment orientations, the luminaire mounting and orientation used for this test is to be within the marked range and is to be the mounting and orientation that results in the highest temperatures.

b) Any device such as a shutter, an iris, or a barn-door that is permanently mounted to or intended to be used with a luminaire and is intended to alter the light beam is to be adjusted so the aperture is uniformly reduced in area by 70 percent. Motor-driven gobos or other image-projecting devices shall be such that the image projected is circular and the area of the image reduced by 70 percent of maximum. Color wheels, when provided, shall be of a single color that results in the maximum heating.

c) A scroller, when provided, shall be a single color which results in the most heating of the luminaire.

30.3.2 Motor-driven mechanisms intended to be operated continuously in normal use such as mechanical strobes, scrollers, and mirrors are to be operated continuously during the temperature test. Motor-driven mirror mechanisms are to be operated continuously through a pattern of travel that results in the maximum power input to the mirror motor. Luminaires with motorized gobo or other image-projecting mechanisms are to be operated as specified in 30.3.1(b) until temperatures in the luminaire stabilize. Following this, the image-rotation mechanism and image changer, when provided, are to be operated until temperatures on and about the luminaire stabilize. The cycle of operation is to be as follows:

a) The pattern rotation mechanism is to cycle through each pattern as fast as the unit can rotate, stopping at each pattern for 2 seconds.

b) When the mechanism arrives at the last pattern of the disk, rotate in a new disk, when provided with such a mechanism.

c) Continue with the rotation of the patterns in (a).

When agreeable to all concerned, the mechanisms are not prohibited from being cycled faster than as specified in (a) – (c).

30.3.3 Where multiple-light, output-varying features are provided, the total light output shall be reduced with the one or more features that create the most adverse heating of the components of concern. The total light output of the luminaire shall not be reduced by more than 70 percent. For example, a test shall be conducted with framing shutters closed to reduce their aperture by 70 percent to increase lamp compartment temperatures. When blocking light at the gobo position increases luminaire temperatures in the area of the motor, another test shall be conducted with motor-driven gobos selected to have a circular light aperture area 70 percent less than the aperture when no gobo is installed. The test shall not be conducted, for example, with the light output through each feature reduced by 70 percent since the total light output of the luminaire is reduced by 91 percent.

## 31 Dielectric Voltage-Withstand Test

31.1 A product shall be subjected to this test while at its maximum normal operating temperature.

*Exception: A luminaire or connector strip that contains only a lampholder, switch, receptacle, or drop cord, and does not contain a printed-wiring board, ballast, transformer, other coil device, or other electrical or electronic component, is not required to be subjected to this test.*

31.2 The insulation and spacings shall withstand, without breakdown, the application of the test potentials shown in Table 31.1 for 1 minute.

*Exception No. 1: The insulation and spacings are not required to be tested when investigation shows that a breakdown of the insulation or arc tracking across or through the insulation does not result in a risk of fire or electric shock.*

*Exception No. 2: The insulation and electrical spacings separating (a) a Class 2 circuit or Limited-Voltage/Current Circuit from (b) non-current carrying metal are not required to be tested.*

**Table 31.1**
**Dielectric voltage-withstand test – potentials and applications**

| Circuit or component | Points of application[a] | Test potentials[b] |
|---|---|---|
| 1. Primary circuits | | |
| Printed-wiring portions | c, d | (2E + 1000) volts DC |
| All parts | c, d | 1000 volts, 60 Hz; or 1400 volts DC |
| 2. Transformers | e | 1000 volts, 60 Hz |
| 3. Circuits supplied by a transformer secondary or power unit: | | |
| Circuits rated maximum 30 VAC or 42.4 V peak | f | 500 volts, 60 Hz; or 710 volts DC |
| All other | f | (2E + 1000) volts DC |
| 4. Load side of rectifier of direct connected supply | d, f | (2E + 1000) volts DC |

[a] Power-dissipating component parts, electronic devices, and electrolytic capacitors located between the circuits under test are to be removed or disconnected so that the spacings and insulations, rather than such component parts, are subjected to the full dielectric voltage-withstand test potential. Switches and other controls, whether accessible or not, are to be set or adjusted so that all conductors and parts intended to be tested are connected to the circuit under test.

[b] E equals the maximum peak potential in volts between the conductor or part to be tested and earth, an accessible conductive part, or other conductive part.

[c] The insulations and spacings are to be tested between primary circuit parts and the following parts all connected together: the grounding terminal; the enclosure, with a conductive foil wrapped around insulating portions of the enclosure; and accessible conductive parts. Care is to be taken to ensure that each capacitor, winding separation, or other separation (such as a spacing between conductors) that isolates accessible conductive parts from the primary circuit are to be tested.

[d] The insulations and spacings between parts of opposite polarity are to be tested.

[e] The insulations and spacings between windings and parts of a transformer conductively connected to a supply circuit are to be tested. The windings and parts to be tested are to include each of the following: primary to shield or guard (when used); primary to core; and primary to each secondary (or all secondaries connected together).

[f] The insulations and spacings between parts of circuits involving the risk of fire or electric shock and each of the following are to be tested: the protective grounding terminal (when provided); the enclosure, with a conductive foil wrapped around insulating portions of the enclosure; accessible conductive parts; and all other circuits.

31.3 A DC test voltage is not to have more than 3 percent ripple.

31.4 The indicated test voltage is to be measured directly across the points of application of the test potential with a high-resistance voltmeter.

31.5 Breakdown is often indicated by an abrupt decrease or nonlinear advance of voltage as the test voltage is increased or by an abrupt increase in current.

31.6 The test equipment is to include a transformer having an essentially sinusoidal output. When the output of the transformer is less than 500 volt-amperes, the equipment is to include a voltmeter in the output circuit to directly indicate the test potential. When the output of the transformer is 500 volt-amperes or larger, the test potential shall be indicated by:

a) A voltmeter in the primary circuit or a tertiary-winding circuit;

b) A selector switch marked to indicate the test potential; or

c) A marking in a readily-visible location to indicate the test potential of equipment having a single test-potential output.

## 32 Abnormal Operation Test

32.1 A luminaire subjected to the Temperature Test, Section 30, while orientated within the range of orientations marked in accordance with 56.4, shall be subjected to the test described in this section when the luminaire pivots or moves into or through an orientation that produces higher temperatures during the temperature test when a hand-secured joint fails.

32.2 To determine when the luminaire pivots or moves into or through an orientation that produces higher temperatures during the temperature test, the steps in (a) and (b) are to be performed.

a) One or more hand-tightened joints are to be loosened so that they offer as little friction as possible without completely disassembling the joint and

b) The luminaire is to be moved or pivoted into the most unbalanced orientation and then released so that it moves or pivots into a balanced and at-rest position.

When the luminaire moves or pivots to or through an orientation that produces temperatures higher than those encountered during the Temperature Test, Section 30, this test is to be conducted.

32.3 The orientation to be selected for this test is the orientation that the luminaire moves or pivots into or through (as determined in 32.2) that produces the highest temperatures. The most adverse orientation is not restricted to that orientation in which the luminaire comes to rest as a result of the steps described in 32.2. When an intermediate orientation through which the luminaire moves or pivots is more adverse, the intermediate orientation is to be used for this test.

32.4 When floor-mounted, the luminaire is to be supported on a tissue paper-covered, knot-free softwood surface. When other than floor-mounted, the luminaire is to be supported with the lowest feature of the lamp compartment 0.9 m (3 feet) above the tissue paper-covered, knot-free softwood surface. The tissue paper is to be untreated white paper, such as that used for gift wrapping.

32.5 The luminaire is to be loosely covered with a single layer of bleached cheesecloth, 914 mm (36 inches) wide, running 26 – 28 $m^2$/kg (14 – 15 square yards per pound) and having a count of 13 by 11; that is, for any square centimeter, 13 threads in one direction and 11 in the other direction (for any square inch, 32 threads in one direction and 28 in the other direction). The cloth is to be loosely draped over the luminaire in order to serve as a flame indicator (presence of ash or burnt holes) but is not to be used as a blanket to trap heat.

32.6 Accessible conductive parts are to be connected to the branch-circuit grounding conductor through a 1-ampere, nontime-delay type fuse. The equipment-grounding conductor is to be disconnected for this test.

32.7 All other test conditions are to be as used during the Temperature Test, Section 30. The temperature on the exposed enclosure surface is to be monitored using thermocouples as indicated in the temperature test. The ″exposed enclosure surface″ temperature limits in item 19 (and footnote f) in Table 30.1 shall apply, and the marking specified in 56.3 shall be provided, when the exposed enclosure surface temperature warrants.

32.8 The luminaire is to be operated until one of the following conditions is encountered or until 7 hours has elapsed with none of the following conditions occurring:

a) Emission of flame or molten metal, burning insulation, flaming particles, or the like;

b) Exposure of a part involving a risk of electric shock; or

c) Rupture of the 1-ampere fuse.

32.9 Immediately following this test and while still hot, the luminaire shall also comply with the Dielectric Voltage-Withstand Test following Abnormal Operation Test, Section 33.

**33 Dielectric Voltage-Withstand Test following Abnormal Operation Test**

33.1 This test is to be conducted on a luminaire subjected to the Abnormal Operation Test, Section 32.

33.2 A luminaire shall withstand, without electrical breakdown, the application of the applicable test potential specified in Table 31.1 applied for 1 minute between:

a) Primary winding, including connected components, and accessible dead-metal parts of a luminaire that become energized, including those parts that are accessible only during relamping and

b) Primary winding and accessible low-voltage – 42.4 volts peak or less – metal parts, including terminals.

33.3 The test equipment is to have the characteristics specified in 31.6.

**34 Strain-Relief Test**

34.1 A strain-relief device is to be tested by the application of a 156 N (35 pound-force) pull on the power supply cord for 1 minute. The pull shall not be transmitted to terminals, splices, or internal wiring.

*Exception: Wire to a lamp-supported lampholder shall be subjected to a pull of 89 N (20 pounds-force).*

34.2 The conductors of the cord are to be severed immediately adjacent to the terminals or splices. The pull is to be applied to the cord or wire in a direction perpendicular to the plane of the entrance to the fixture. There shall not be movement of any conductor more than 1.6 mm (1/16 inch) at the point where it is severed.

## 35 Stability Test

35.1 A freestanding luminaire shall not overturn when resting on a plane inclined at an angle of 8 degrees to the horizontal.

35.2 After being placed on the inclined plane, the luminaire and any adjustable parts (such as barn-doors) permanently mounted to or intended to be used with the luminaire, are to be adjusted to the position resulting in the least stable condition.

## 36 Grounding Continuity Test

36.1 Each luminaire construction provided with a grounding means shall be tested to determine that grounding continuity exists between the grounding means and accessible dead-metal.

36.2 Only a single test is required when the accessible metal selected is conductively connected by construction to all other accessible metal.

36.3 An ohmmeter is permitted to be used to determine whether a luminaire complies with the requirement in 24.8.

36.4 When an indicating device of the type described in 36.3 does not indicate continuity of the grounding circuit, an alternating current or a direct current of at least 25 amperes from a power supply of not more than 12 volts is to be passed from the point of connection of the equipment grounding means to a point in the grounding circuit and the points. The resistance in ohms is then calculated by dividing the drop in potential (in volts) by the current (in amperes). The resistance shall not exceed 0.1 ohm.

## 37 Overhead Product Static Loading Test

37.1 This test is to be used to determine that the structure and joints relied upon to comply with the requirements of 9.1 provide the required strength where it is not evident such strength is provided.

37.2 The product support, adjustment, and accessory configuration used for this test is to be the most adverse configuration from the configurations specified in 2.4.1.

37.3 A structural member or joint subjected to a static load is to be gradually loaded to a total test load of not less than six times the load involved. The additional weight is to be equal to five times the weight of the supported product, component, or accessory. The additional weight is to be distributed proportionally, similar to that of the product, component, or accessory weight distribution. The structural member or joint under test shall bear the test load for 1 hour and shall not show any visible evidence of material failure such as breakage, cracking, stripping of threads, or slipping of pressure joints.

## 38 Backup Restraint-Device Loading Test

38.1 This test is to be used to determine that the structure and joints of a safety chain, safety cable, or other backup-restraint device, and the means provided on the product for attachment of the device, provide the required strength where it is not evident such strength is provided.

38.2 The device is to be secured to a rigid support and to a test load using the method described in the installation instructions marked on the device.

38.3 The attached test load is to have a weight of not less than six times the maximum weight marked on the device.

38.4 Swinging and movement of the test load shall be prevented when the support of the test load is transferred to the backup-restraint device. The backup-restraint device shall continue to support the test load for 1 hour.

38.5 The structural members and joints of the backup-restraint device and attachment fittings shall not show any visible evidence of material failure such as breakage, cracking, stripping of threads, or slipping of pressure joints.

## 39 Transformer Overload Test

39.1 As specified in 16.1, samples of each transformer are to be placed on a tissue paper-covered, knot-free, softwood surface, and covered with a layer of cheesecloth. The cheesecloth is to be in accordance with 32.5.

39.2 The transformer is to be connected to a supply protected by a branch-circuit-type overcurrent device corresponding to that of a branch circuit to which the unit is intended to be connected but not less than 30 amperes.

39.3 The core of each transformer is to be connected to the branch-circuit grounding conductor through a 1-ampere, non-time-delay-type fuse. Any grounding conductor of the transformer is to be disconnected for this test.

39.4 With each secondary conducting the load current involved in the luminaire, one secondary is to be short-circuited. This test procedure is to be applied to three samples for each secondary. Any supplemental overcurrent protective device provided as part of the luminaire in the supply or load circuit of the transformer is also to be used in this test.

39.5 The test procedure described in 39.4 is to be repeated except the load condition is to be at maximum power in the secondary under test.

*Exception: When a supplemental overcurrent protective device is provided as part of the luminaire in the supply or load circuit of the transformer, this device is to be short-circuited and the load on the secondary under test is to be increased to the load that results in a current through the overcurrent protective device of 110 percent of the device's rating when this load is less than maximum power for the secondary under test.*

39.6 Each transformer is to be operated until 7 hours has elapsed or until one of the following conditions occurs:

a) Ignition of the cheesecloth or tissue paper or

b) Rupture of the 1-ampere fuse.

39.7 Following the testing, each transformer shall comply with the requirements of the Dielectric Voltage-Withstand Test, Section 31.

## 40 Printed-Wiring Board Abnormal Operation Test

40.1 Spacings on printed-wiring boards that are less than those specified in Electrical Spacings, Section 23, and that are relied upon to provide operational insulation, are to be tested as described in 40.3 – 40.7. As a result of this test:

a) The overcurrent protection in the branch circuit to which the equipment is connected shall not open.

b) When a wire or a printed-wiring board trace opens, the gap is to be electrically shorted and the test continued until ultimate results occur (this applies to each occurrence).

c) A flame shall not emit from the overall enclosure of the equipment.

d) The cheesecloth or tissue paper shall not glow or flame.

e) The 3-ampere fuse connected in the equipment grounding circuit shall not open.

40.2 Operation of an overcurrent protection device – other than the branch-circuit overcurrent protection device – before any abnormal condition results is permitted to terminate a test. When an overcurrent protective device opens, the marking specified 60.1 shall be provided.

40.3 A sample of the equipment using the printed-wiring board is to be wired as intended to an electrical supply circuit sized and protected to simulate end-use conditions. When the live parts on the printed-wiring board have spacings between them that are less than those specified in Electrical Spacings, Section 23, they are to be short-circuited one at a time.

40.4 A 3-ampere fuse is to be connected between the supply circuit pole least capable of striking ground and the outer enclosure (when provided) and grounded or exposed dead-metal parts.

40.5 During the abnormal test, the equipment is to be placed on a white tissue-paper-covered, softwood surface. A single layer of cheesecloth is to be draped loosely over the entire enclosure. Open equipment is to be tested in an enclosure representative of that encountered in service. When agreeable to all concerned, tests shall be conducted without an enclosure and evaluated as representative of tests conducted using an enclosure. When tests are to be conducted without an enclosure, cheesecloth is to be placed on a wire cage, surrounding (and in close proximity to) the equipment under test to simulate the intended enclosure.