UL 2388

STANDARD FOR SAFETY

Flexible Lighting Products

UL Standard for Safety for Flexible Lighting Products, UL 2388

Second Edition, Dated May 3, 2017

Summary of Topics

This revision to ANSI/UL 2388 dated August 7, 2023 is being issued to incorporate the following requirements:

– Addition of UL 969A, the Standard for Marking and Labeling Systems – Flag Labels, Flag Tags, Wrap-Around Labels and Related Products, as an Option into UL 2388; 47.1

– Addition of the reference to the Standard for Marking and Labeling Systems, UL 969, for clarification; 47.1

– Editorial revisions to test conditions for cord tags; 40.2.5, 40.2.7, 40.3.1

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

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated April 28, 2023.

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UL 2388

Standard for Flexible Lighting Products

First Edition – July, 2002

Second Edition

May 3, 2017

This ANSI/UL Standard for Safety consists of the Second Edition including revisions through August 7, 2023.

The most recent designation of ANSI/UL 2388 as an American National Standard (ANSI) occurred on August 7, 2023. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

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INTRODUCTION

1 Scope

1.1 This standard covers portable flexible lighting products with a maximum input voltage rating of 120 volts to be used in accordance with the National Electrical Code, ANSI/NFPA 70. These products are provided with a power supply cord and are intended for outline and decorative lighting use.

1.2 These requirements cover lighting products incorporating non-replaceable series and series/parallel connected lamps enclosed within a flexible polymeric tube or extrusion.

1.3 These requirements also cover flexible lighting products used in light sculptures.

1.4 These requirements do not cover lighting products with replaceable lamps.

1.5 These requirements do not cover the temporary-use, seasonal decorative-lighting products and accessories with a maximum input voltage rating of 120 V that are covered by the Standard for Seasonal and Holiday Decorative Products, UL 588.

1.6 These requirements do not cover flexible lighting products that are intended for use as a sign, such as self-contained product, usually with advertising or other words, numbers, or symbols, intended for use in a nonresidential environment to convey information or attract attention. These products shall be covered under the Standard for Electric Signs, UL 48.

2 Components

2.1 Except as indicated in 2.2, 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.

2.2 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.

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

2.4 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.

3 Units of Measurement

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

4 Undated References

4.1 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.

5 Glossary

5.1 For the purpose of this standard, the following definitions apply.

5.2 EXTENSION SEGMENT – A flexible lighting product intended to be connected to a connector of another flexible lighting product and not provided with a means to independently connect to a 120 V supply circuit.

5.3 INTERNAL LAMP SHUNT – A device that provides a current path when the filament of a lamp opens so that the remaining lamps in a series-connected circuit remain illuminated.

5.4 LIGHT SCULPTURE – A polymeric or metallic rigid frame to which a flexible light is attached. The flexible light provides outline illumination of the figure or object created by the frame.

5.5 NON-EXTENDABLE FLEXIBLE LIGHT – A flexible light product that is not provided with any means to add an extension segment.

CONSTRUCTION

6 Assembly and Packaging

6.1 A flexible lighting product shall be completely wired with each electrical component mounted in place and with each splice and connection completed.

6.2 Detachable power-supply cords and extension segments that comply with Section 17, Interconnecting Means, need not be connected.

6.3 The package for a flexible lighting product designed to be connected to its source of supply by means of a detachable power-supply cord shall include the detachable power-supply cord.

7 Enclosures

7.1 The enclosure shall withstand the abuses that it is subjected to without total or partial collapse of the enclosure, reduction of spacing, loosening or displacement of parts, or other defects that increase the risk of fire, electric shock, or injury to persons.

7.2 A polymeric material used to enclose or provide structural support for electrical current carrying parts shall:

a) Have a minimum flammability rating of V-0; and

b) Have a minimum HWI (hot-wire resistance to ignition) Performance Level Category (PLC) of 3, a minimum HAI (high-current arc resistance to ignition) PLC of 3, and a minimum CTI PLC of 4, if marked for indoor use, or a minimum PLC of 3, if marked for outdoor use.

Exception No. 1: The minimum flame rating shall be HB when the flexible lighting product is located in a Class 2 circuit.

Exception No. 2: A flexible lighting product whose enclosure is extruded of an insulation compound that is rated 105°C, and also complies with the requirements of the VW-1 flame test, and 720 hour weatherometer test, need not comply with 7.2(a) and (b) when the ropelight body complies with the VW-1 flame test as described in the Reference Standard for Electrical Wires, Cables, and Flexible Cords, UL 1581, and when intended for outdoor use, complies with the VW-1 flame test and crush test after being subjected to the Ultraviolet (UV) Light Exposure and Water Immersion Tests described in Section 31.

7.3 The polymeric tube or extrusion section of the flexible light enclosure that is used to enclose the lamps shall comply with the:

a) Crush Test, Section 30;

b) Flexing Test, Section 33; and

c) Oven Conditioning Test, Section 34.

7.4 There shall be a minimum of 3/64 inch (1.2 mm) of insulating material between uninsulated current carrying parts of the series or series/parallel circuit and the outer surface of the ropelight body.

Exception: A ropelight located in a Class 2 circuit need not comply with this requirement.

7.5 A polymeric enclosure for a controller or other accessory used with a flexible light shall comply with the:

a) Crush Test, Section 30;

b) Ball Impact Test, Section 32; and

c) Oven Conditioning Test, Section 34.

7.6 The flammability rating specified in 7.2(a) is to be determined by the applicable tests in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

7.7 As an alternative to 7.2(a), the polymeric material is able to comply with the 3/4 inch or 12 mm flame test of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. At the conclusion of the test there shall not be openings large enough to enable a 1/4 inch (6.4 mm) diameter rod to penetrate the enclosure and there shall not be ignition of the cotton indicator. The indicator is to be absorbent, 100 percent cotton thinned to approximately 2 by 2 inches (50 by 50 mm) and a maximum thickness of 0.24 inches (6 mm). The cotton is to be placed horizontally 11.8 ±0.39 inches (300 ±10 mm) below the component material.

7.8 With regard to consideration of thermal endurance in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, the material shall possess a mechanical temperature index, with impact, as a result of long term aging or a generic temperature index of at least the measured temperature in the Normal Temperature Test, Section 26.

7.9 The temperature index specified in 7.8 shall include temperatures measured on polymeric materials closest to or in direct contact with any lamp.

7.10 An enclosure formed of polymeric material and marked for outdoor use in accordance with Section 48, Outdoor Use Markings, shall comply with:

a) The UV resistance and water exposure requirements from the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C;

b) The Rain Test, Section 39; and

c) For an enclosure of a flexible light, the Cold Bend Test, Section 35.

7.11 As an alternative to 7.10(a), a polymeric material may be employed as an enclosure of a flexible lighting product marked for outdoor use provided it complies with the flammability rating evaluation of 7.6 or 7.7 as applicable, the Crush Test, Section 30, and the Ball Impact Test, Section 32, after being subjected to the Ultraviolet (UV) Light Exposure and Water Immersion Tests described in Section 31. The

end-product test force and impact values shall be reduced by 30 percent after the UV light exposure test, and reduced by 50 percent after the water immersion test. At the conclusion of the conditioning and end-product tests, the flammability rating shall not be reduced and the samples shall comply with the requirements of 30.3 and 32.6. The ball impact test is only applicable to a controller or other accessory used with a flexible light.

7.12 If a flexible light enclosure consists of multiple layers of polymeric materials, all layers shall comply with 7.2 and only the outermost layer needs to comply with the UV resistance and water exposure requirements of 7.10(a), providing that the material used for the outermost layer is suitable for the purpose and complies with the minimum thickness of 7.4.

8 Decorative Parts

8.1 A material used as a decorative part that is near any component that generates heat shall:

a) Be installed on the unit when it is temperature tested;

b) Have a minimum flammability rating of HB; and

c) Not melt or deform in any way that interferes with the normal operation of the flexible lighting product or causes a risk of fire or electric shock during the Normal Temperature Test, Section 26.

9 Light Sculptures

9.1 The frame of a light sculpture shall be:

a) Metal that is free of sharp edges or burrs that are able to cut or abrade conductors or the insulation; or

b) A polymeric material that complies with the Oven Conditioning Test, Section 34, such that stress is not placed on electrical connections or wire as a result of the test.

Exception: A light sculpture supplied by a Class 2 circuit is not required to comply with 9.1.

9.2 If the light sculpture folds, such as for storage, it shall have sufficient free length of wire to avoid pinching, cutting, or abrading of the conductors or insulation.

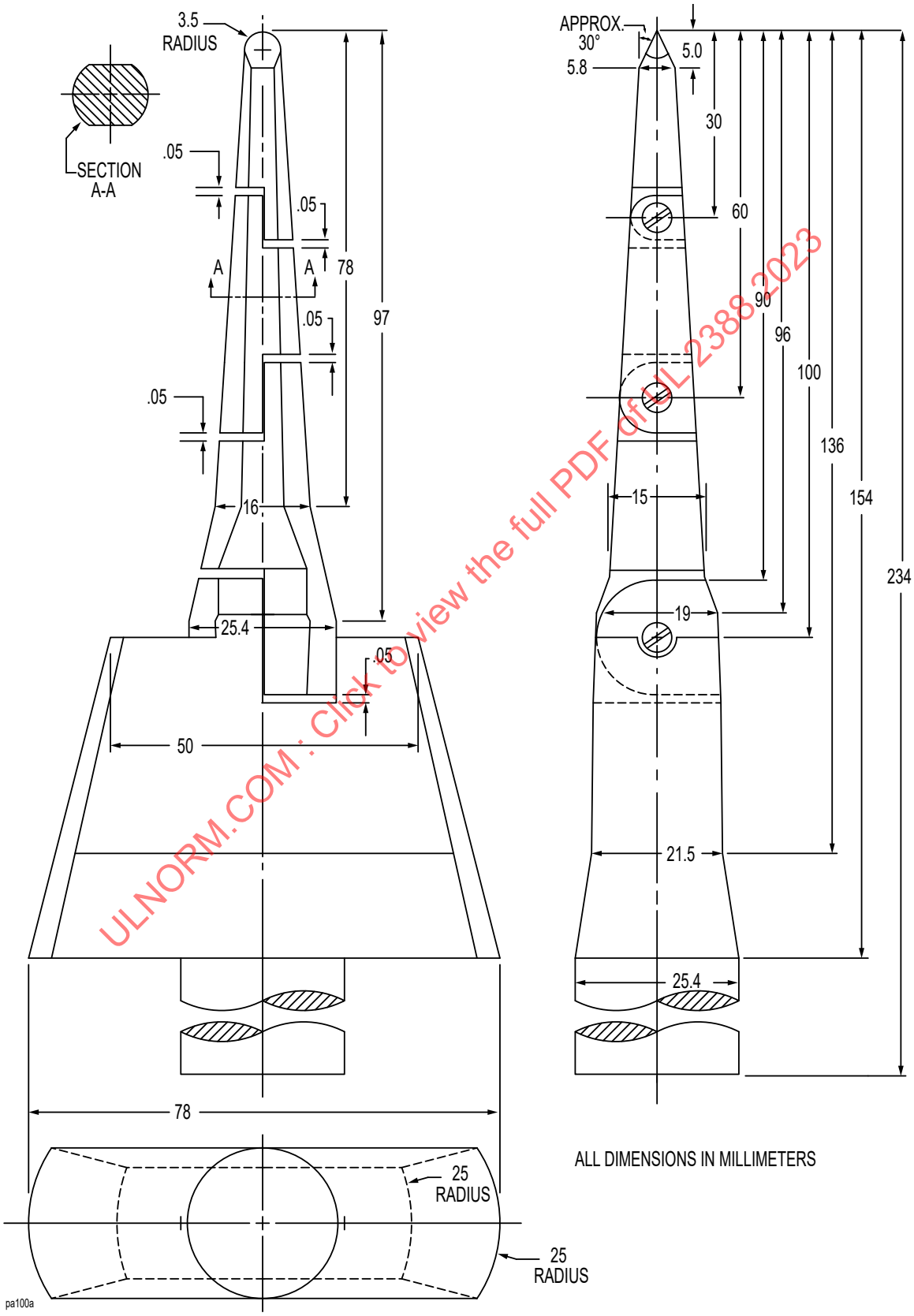
10 Accessibility of Current Carrying Parts

10.1 An uninsulated current carrying part involving a risk of shock shall be enclosed so that it is not accessible to unintentional contact by persons during normal use.

10.2 A current carrying part is considered inaccessible when the UL articulated accessibility probe, shown in Figure 10.1, is unable to be manipulated to touch it. The probe shall be applied to any depth that the opening will permit; and shall be rotated or angled, before, during, and after insertion through the opening, to any position that is necessary to try and contact the current carrying part.

Figure 10.1

Articulate probe with web stop



10.3 An end cap provided to prevent contact with uninsulated current carrying parts shall be secured in place and comply with the End Cap Pull Test, Section 38.

11 Insulating Materials

11.1 A polymeric material used as an electrical insulator, or as direct or indirect support of a current carrying part, shall comply with the requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

12 Electrical Spacing

12.1 Except as noted in 12.2, the electrical spacing between uninsulated current carrying parts of opposite polarity, and between uninsulated current carrying parts and accessible metal that is capable of being grounded shall be minimum 1/16 inch (1.6 mm) through air or over surface.

12.2 The electrical spacing between uninsulated current carrying parts of opposite polarity in the series lamp circuit shall be minimum 1/32 inch (0.8 mm) through air or over surface.

12.3 Film-coated wire is considered to be an uninsulated current carrying part in determining compliance of a product with the spacing requirements.

13 Lamps

13.1 Lamps used in flexible lighting products shall not be user replaceable or provided with an internal shunt device.

14 Conductors

14.1 Conductors shall be made of annealed copper in compliance with the Standard Specification for Soft or Annealed Copper Wire, ASTM B3 or annealed coated copper in compliance with the Standard Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes, ASTM B33.

14.2 All conductors, other than integral lamp leads and series connection type, shall be stranded size as shown in Table 14.1. The size of the individual strands shall be a minimum of 0.0049 in (0.125 mm) and a maximum of 0.010 in (0.260 mm). For ropelights employing flexible printed circuits, the traces used as conductors are not required to be stranded and shall be of a size equivalent to that shown in Table 14.2.

Table 14.1
Maximum normal current for internal conductors, flexible cord, and interconnecting cord

Wire gauge, AWG (mm^2)	Maximum Fuse rating, Amps	Maximum conductor current, Amps
22 (0.32)	3	1.8
20 (0.52)	5	3.5
18 (0.82)	8	8
16 (1.3)	10	10

Table 14.2
Maximum resistance and minimum cross-sectional area of conductors

Wire gauge, AWG (mm^2)	Maximum resistance, Ohms per 1000 ft at 20°C	Maximum resistance, Ohms per 1000 m at 20°C	Cross-sectional area	
			circular mils	mm^2
22 (0.32)	18.2	59.7	621	0.314
20 (0.52)	11.5	37.6	989	0.503
18 (0.824)	7.20	23.6	1570	0.796
16 (1.31)	4.54	14.9	2500	1.27

14.3 The maximum normal current for internal conductors, flexible cord, and interconnecting cord shall not exceed the value specified in Table 14.1.

14.4 The conductor size shall be determined by either:

a) The cross-sectional area complying with the minimum values given in Table 14.2 when determined in accordance with the method specified in the Reference Standard for Electrical Wires, Cables, and Flexible Cords, UL 1581, Sections 200 or 210; or

b) The maximum dc resistance complying with the values in Table 14.2. In case of dispute, dc resistance shall be the referee method.

15 Splices and Connections

15.1 Each splice shall be soldered, welded, or otherwise effectively assembled by means of a connector.

Exception: Splices located in a series-circuit are permitted to be twisted.

15.2 A soldered joint shall be made mechanically secure before soldering. One of the following methods shall be used:

a) The conductor shall be wrapped at least one revolution around the terminal, or

b) The conductor shall be passed through an eyelet or opening with at least one right angle bend, or

c) Twisted with other conductors.

Exception: When mechanical security of a soldered joint has been demonstrated to be impossible, it is acceptable to make a joint without mechanical security before soldering, provided both sides of the joint are secured in such a way that stress on the connection, either during or after manufacturing process, has been shown to be unlikely.

15.3 Field connections shall be limited to detachable power supply cords and interconnection of extension segments.

15.4 The field connections in 15.3 shall not permit accessibility to uninsulated current carrying parts during installation. For example, the supply side end shall have a female configuration and the mating load side shall have a male configuration.

16 Attachment Plugs

16.1 An attachment plug shall be a standard NEMA type 1-15 (15 A, 120 V) or 1-20 (20 A, 120 V) configuration. For flexible lighting products that are extendable or provided with a detachable power supply cord, the attachment plug shall be fused and polarized.

16.2 Attachment plugs shall comply with the applicable requirements of the Standard for Attachment Plugs and Receptacles, UL 498 or the Standard for Cord Sets and Power-Supply Cords, UL 817.

16.3 Attachment plugs, cord connectors, current taps and other wiring devices that comply with the applicable requirements in the Standard for Seasonal and Holiday Decorative Products, UL 588 are permitted to be employed in products covered under this standard.

17 Interconnecting Means

17.1 Connectors shall comply with the applicable requirements of the Standard for Attachment Plugs and Receptacles, UL 498 or the Standard for Cord Sets and Power-Supply Cords, UL 817 and shall be suitable for making and breaking under load with respect to the Overload, Temperature, and Resistance to Arcing Tests described in the Standard for Attachment Plugs and Receptacles, UL 498.

17.2 Crimp connections made between internal wiring and a connector shall comply with the Crimp Connection Secureness Test, Section 37.

17.3 The interconnecting means shall consist of connector parts where the means of maintaining polarity, strain relief, and maintaining electrical connections are inherent in the construction of the interconnecting parts.

17.4 An interconnecting means shall not require any assembly by the user other than the connection of mating male and female connectors.

18 Switches, Fuses, and Controllers

18.1 A switch or controller shall have a voltage and current rating suitable for the maximum load it controls. For ropelights that are extendable, these components shall have a minimum rating that is equivalent to the fuse rating.

18.2 A controller shall comply with the Standard for Industrial Control Equipment, UL 508, or the Standard for Seasonal and Holiday Decorative Products, UL 588.

18.3 A flexible lighting product is not required to be provided with a switch or controller.

18.4 A switch, fuse or other protective device shall be connected to the ungrounded supply conductor.

18.5 The current rating of the fuse employed shall be in accordance with Table 14.1.

18.6 Fuses required for compliance with 18.5 shall be replaceable. The assembly or packaging shall include minimum of one spare fuse for each rating.

18.7 A flexible lighting product that is non-extendable with a non-detachable power supply cord is not required to be provided with a fuse.

18.8 A switch employed in a flexible lighting product shall be tungsten-rated.

19 Power Supply Cord and Interconnecting Cords

19.1 A power-supply cord and any interconnecting cord shall be:

a) Not smaller than 18 AWG (0.82 mm^2);

b) At least equal to SPT-2;

c) Rated VW-1; and

d) The maximum normal current shall not exceed the value specified in Table 14.1.

19.2 Products marked for outdoor use shall have a jacketed power supply cord at least equal to SJT (junior hard service cord type) with a “W” suffix.

20 Strain Relief

20.1 Strain relief shall be provided for all power-supply cord and interconnecting cord terminations. The strain relief shall comply with the Strain Relief Test, Section 36.

21 Mounting Means

21.1 A flexible lighting product shall be provided with a means for mounting.

21.2 The mounting means shall not pinch or otherwise damage the insulation of the flexible light.

21.3 The mounting means shall be designed to prohibit permanently securing the flexible lighting to a building, permanent fixtures, or other similar structures. This does not preclude the provision of clips or separable mounting brackets, that are designed to be permanently attached to a building structure.

21.4 A flexible lighting product shall not require tools to remove it from the mounting clips or brackets.

22 Outdoor Use Products

22.1 When an interconnection means is provided with a gasket or similar sealing device to seal out moisture the device shall comply with the requirements for wet locations in the Standard for Gaskets and Seals, UL 157, or the Gasket Test, Section 41, in addition to the requirements in 22.2.

22.2 A gasket employed in a product intended for outdoor use shall be constructed of a material that meets the requirements in 22.1. Polychloroprene (Neoprene) rubber has been found to be suitable for a 60°C (140°F) service temperature and silicone has been found to be suitable for a 105°C (221°F) maximum service temperature and do not need to comply with the gasket test.

23 Class 2 Circuits

23.1 A Class 2 circuit shall be derived from the output of:

a) A Class 2 transformer that complies with the applicable requirements 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; or

b) A Class 2 power unit which complies with the applicable requirements in the Standard for Class 2 Power Units, UL 1310; or

c) A power unit which complies with the applicable requirements for a limited power source in the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1.

23.2 A flexible lighting product that is in the secondary of a Class 2 circuit shall comply with the following:

a) The polymeric material used to enclose electrical current carrying parts shall be a minimum of HB;

b) Overcurrent protection would not be required;

c) There is no minimum wire size for the internal conductors and the acceptability would be determined by the normal temperature test;

d) The minimum spacings described in Section 12 would not be required;

e) Instructions concerning flexible lighting products being cut in the field will be considered acceptable provided the product complies with the requirements;

f) The enclosure of the power supply must meet the requirements in UL 2388. Through cord devices must also comply with the rain test if intended for Outdoor Use, and the flexible cord for the input of the supply must be in accordance with UL 2388.

24 Battery Operated Products

24.1 When a flexible lighting product utilizes the number and type of batteries shown in Table 24.1, the product shall comply with all the requirements in this standard for Class 2 circuits having more than a 15 W output.

Table 24.1
Output capabilities of common sizes and types of batteries[c]

Battery				8 A output at 1 minute (batteries in parallel)[b]
Type	Size	Designation[a]	Rated voltage	
Carbon-zinc	N	N	1.5	NA
	AAA	AAA	1.5	NA
	AA	AA	1.5	6
	C	C	1.5	5
	D	D	1.5	3
	F	–	1.5	2
	G	–	1.5	1
	6	6	6.0	1
	9-V transistor	1604	9.0	NA
Alkaline-manganese dioxide	N	L20	1.5	NA
	AAA	L30	1.5	NA
	AA	L40	1.5	2
	C	L70	1.5	2
	D	L90	1.5	1
	9-V transistor	1604A	9.0	2
Nickel-cadmium	N	KR115/XXX	1.2	NA

Table 24.1 Continued on Next Page

Table 24.1 Continued

Battery				8 A output at 1 minute (batteries in parallel)[b]
Type	Size	Designation[a]	Rated voltage	
	AAA	–	1.2	NA
	AA	KR142/XXX	1.2	1
	C	KR257/XXX	1.2	1
	D	KR334/XXX	1.2	1
	9-V transistor	–	8.4	NA

[a] This designation corresponds to that in the Standard for Portable Primary Cells and Batteries with Aqueous Electrolyte – General and Specifications, ANSI/NEMA C18.1M, Part 1.

[b] Denotes minimum number of batteries capable of delivering 8 A DC or more to external resistive load for minimum 1 minute.

[c] The measured power output of a battery not included in the table shall be less than 15 watts as determined by the Power Measurement Test.

24.2 When a flexible lighting product utilizes fewer than the number of batteries shown in Table 24.1, the product shall be evaluated using the requirements for Class 2 circuits having less than a 15 W output. In addition, each of the products described above shall comply with the marking requirements in Sections 49 and 50.

PERFORMANCE

25 Input Test

25.1 The input current to the flexible light shall not exceed the marked rating by more than 10 percent when connected to a 120 V, 60 Hz source of supply.

25.2 When measuring the input current for extendible flexible lighting products, either the maximum number of extension segments or flexible light lengths permitted by the installation instructions shall be connected to the flexible light during this test or a representative length of flexible lighting be used and the overall rating be calculated based on the results.

26 Normal Temperature Test

26.1 The temperature rises measured on the flexible light, when mounted as described in 26.3 and connected to a 120 V, 60 Hz source of supply, shall not exceed the values specified in Table 26.1. There shall be no melting, deformation, or discoloration of any polymeric materials involving a risk of fire or shock.

Table 26.1
Maximum acceptable temperature rises

Materials and component parts of the unit	Temperature rises	
	°C	°F
1. Polymeric enclosure	a	a
2. External surfaces that can be contacted by persons or may come in contact with combustible material during normal use	65	117
3. Supporting surfaces	65	117
4. Insulating materials		
a) Polymeric	a	a
b) Fiber	65	117
c) Wood and similar material	65	117
d) Phenolic composition[b]	125	225
5. Gasketing materials for outdoor use		
a) Polymeric	a	a
b) Neoprene rubber	65	117
c) Ordinary rubber	45	81
d) Silicone rubber	205	369
e) Fiber	65	117
6. Softening point of any sealing compound	c	c
7. Fuses	65[b]	117[b]
8. Insulated conductors	35[b]	63[b]
9. Flexible cords	35[b]	63[b]

[a] The maximum temperature of a polymeric material, when corrected to 77°F (25°C) ambient temperature, shall not exceed the temperature index.

[b] Does not apply if investigated and accepted for a higher temperature.

[c] The maximum sealing compound temperature, when corrected to 77°F (25°C) ambient temperature, is 27°F (15°C) less than the softening point of the compound as determined by the Standard Test Methods for Softening Point of Resins Derived from Pine Chemicals and Hydrocarbons, by Ring-and-Ball Apparatus, ASTM E28.

26.2 Tests are to be conducted at an ambient temperature of 77 ±9°F (25 ±5°C).

26.3 A representative section of the flexible light shall be mounted and tested for each of the following installations:

Method A – Ceiling Mount – The flexible light shall be mounted on an insulated test ceiling in accordance with the Standard for Luminaires, UL 1598, and arranged so that there are 10 parallel lengths, with a 0.2 inch (5 mm) spacing between lengths. For products whose construction of the product does not allow this spacing then the spacing shall be the minimum that the construction allows; and

Method B – Mounting On Pole – The flexible light shall be tightly coiled for 10 turns around a 6 ±0.25 inch (152 ±6.35 mm) diameter wooden pole to form a single layer of adjacent turns. The temperatures shall be measured in the middle of the coil; or

Method C – For Flexible Lights with Decorative Parts – The flexible light with the decorative parts shall be tested as mounted in the intended manner. The temperatures shall be measured on the parts most likely to produce the highest temperatures.

26.4 An extendible flexible lighting unit shall be provided with a suitable load to represent the total maximum length specified by the manufacturer.

26.5 Temperature measurements are to be made with 30 AWG iron Constantan thermocouple wires and an appropriate measurement instrument. The unit is to be operated until constant temperatures are obtained, where constant temperatures are indicated by the test running for at least 3 hours and where three successive readings at thirty minute intervals are within 1.8°F (1°C) of one another and not still rising.

26.6 Temperature measurements of the flexible light housing shall be made by thermocouples in contact with the inner surface of the tube as close as possible to a light (heat) source. This may be accomplished by slitting or drilling through the enclosure to an appropriate depth, taking care not to otherwise damage the sample or create additional openings that would permit heat dissipation not representative of an otherwise intact specimen.

27 Abnormal Operation Test

27.1 The flexible light of maximum rated length shall be tightly coiled around a 6 inch (152.4 mm) diameter mandrel to form a single layer of 10 adjacent turns. Alternatively, a shorter length may be used with a suitable load to represent the maximum length of the flexible light, provided that the flexible light is of sufficient length for the 10 turns around the mandrel as specified. Four pieces of string, distributed equidistantly around the coil at 90 degree increments, are to be used to secure the coil in this configuration. The mandrel shall then be removed, and the sample placed on a tissue paper covered soft wood board and then in turn covered with a single layer of tissue paper.

27.2 The sample shall be connected to a 120 volt, 60 Hz source of supply, protected by a 20A slow blow fuse, and operated until constant temperatures are obtained, but not less than 7.5 hours.

27.3 The results are acceptable if there is no glowing, flaming or charring of the tissue paper nor any melting, charring, cracking or deformation of the polymeric materials that allows accessibility to current carrying parts as determined by applying the accessibility probe as described in 10.2. Opening of the line fuse or the attachment plug fuse is an acceptable result.

28 Insulation Resistance Test

28.1 The insulation resistance of a flexible light shall not be less than 100 megohms when measured between:

a) Current carrying parts and dead metal parts that are exposed to contact by persons or that may be grounded in service; and

b) Current carrying parts and any external surface of the light enclosure and cords.

28.2 The insulation resistance is to be measured by a magneto megohmmeter that has an open-circuit output of 500 volts, or by equivalent equipment.

28.3 When measuring insulation resistance between current carrying parts and the surface of a flexible light enclosure, a section consisting of a minimum of one complete series circuit is to be completely immersed in stainless steel ball bearings with an approximate diameter of 0.10 inch (2.5 mm). The shot is to be connected to one terminal of the insulation resistance measurement equipment, and the current carrying parts of the flexible light are to be connected to the other terminal of the equipment.

28.4 A flexible light intended for outdoor use shall additionally be tested by immersing the flexible light for a period of 24 hours in a salt solution consisting of 8 grams of NaCl per liter of distilled water prior to conducting the insulation resistance test. A metal tub shall be used as a container for the salt solution, and serve as the external electrode for the insulation resistance measurement equipment test terminal. The flexible light shall be positioned in the solution so that no part of a separable connector is immersed in the solution.

29 Dielectric Voltage Withstand Test

29.1 The flexible light shall be capable of withstanding without breakdown for a period of 1 minute, the application of a 60 Hz potential of 1250 volts between:

a) Current carrying parts of opposite polarity of detachable power-supply cords and interconnecting cords; and

b) Current carrying parts and any surface of insulating material that is exposed to contact by persons or that may be in contact with ground in service.

29.2 For the test in 29.1(b), the potential is to be applied between the input leads connected together and a sample of the flexible light sample and foil wrapped tightly around the light enclosure, all connectors and the outer surface of all cords. The length of the foil should be sufficient to wrap a complete section of the ropelight, at least one connector for an extension segment, and the connector and outer surface of the power-supply cord.

29.3 A flexible light marked for outdoor use shall additionally be tested following immersing the unit for a period of 24 hours in a salt solution, as described in 28.4.

29.4 The test potential is to be supplied from a 500 VA or larger capacity testing transformer whose output potential is essentially sinusoidal and can be varied. The applied potential is to be increased from zero until the required test voltage is reached, and held at that voltage for 1 minute. The increase in the applied potential is to be at a substantially uniform rate and as rapid as is consistent with its value being correctly indicated by a voltmeter.

30 Crush Test

30.1 One sample of the flexible light, including connectors, is to be plugged into a 120 volt supply and stretched out flat on a hardwood surface to form a straight line and operated for a minimum of 1 hour. A piece of 1/2 inch (12.7 mm) thick plywood measuring 3 by 3 inch (76.2 by 76.2 mm) is placed on top of a representative section of the flexible light enclosure along its longitudinal and a load of 200 pound (90.9 kg) is to be gradually applied to the top of the plywood and allowed to remain in this condition for a period of one minute. The test may need to be repeated along the length of the flexible light to ensure that all representative sections, including connectors and end caps, are tested.

30.2 For flexible lighting products intended for outdoor use, the above test shall be repeated following the Ultraviolet (UV) Light Exposure and Water Immersion Tests specified in Section 31 as required by 7.11.

30.3 There shall be no:

a) Accessibility of uninsulated current carrying parts as determined by applying the accessibility probe specified in 10.2;

b) Reduction of spacing to values below minimum acceptable values specified in 12.1;

c) Reduction in the effectiveness of strain relief as determined by conducting the Strain Relief Test, Section 36, except the oven conditioning is not required;

d) Dielectric breakdown as determined by conducting the Dielectric Voltage Withstand Test, Section 29, except the immersion in the salt solution is not required; or

e) Cracking or other damage to an outdoor flexible light enclosure that allows water to contact current carrying parts not inherently corrosion resistant, as determined by conducting the Rain Test, Section 39, except the Dielectric Voltage Withstand Test is not repeated following the Rain Test.

31 Ultraviolet (UV) Light Exposure and Water Immersion Tests

31.1 General

31.1.1 After being tested as described in 31.2.1 – 31.3.1, the polymeric material employed as an enclosure of uninsulated live parts for a flexible lighting product intended for outdoor use shall comply with both of the following:

a) The flammability classification of the unconditioned material shall not be reduced as a result of the UV conditioning or water immersion described in 31.2.1 – 31.3.1. The flammability classification is to be determined according to the flammability requirements for polymeric enclosures contained in 7.2. The portion of the material having the thinnest wall thickness is to be tested. All colors under consideration are to be tested; and

b) The product shall be subjected to the Crush Test, Section 30 and the Ball Impact Test, Section 32, as applicable.

Exception: A decorative part need not be subjected to these tests.

31.1.2 After the UV conditioning, the end-product test force and impact values shall be reduced by 30 percent.

31.2 UV conditioning

31.2.1 Each unit is to be exposed to ultraviolet light and water spray by using either of the following apparatus:

a) Twin enclosed carbon-arc, Type D, in accordance with the Standard Practice for Operating Light-Exposure Apparatus (Carbon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials, ASTM G23. Exposure Method 1, continuous exposure to light and intermittent exposure to water spray, with a programmed cycle of 20 minutes consisting of a 17 minute light exposure and a 3 minute exposure to water spray with light, is to be used. The apparatus is to operate with a black-panel temperature of 63 ±3°C (145.4 ±5.4°F), or

b) Xenon-arc, Type B, in accordance with the Standard Practice for Operating Light-Exposure Apparatus (Xenon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials, ASTM G26. Exposure Method 1, continuous exposure to light and intermittent exposure to water spray, with a programmed cycle of 120 minutes consisting of a 102 minute light exposure and an 18 minute exposure to water spray with light, is to be used. The apparatus is to operate with a 6500 W, water-cooled xenon-arc lamp, borosilicate glass inner and outer optical filters, a spectral irradiance of 0.35 W/m^2 nm at 340 nm and a black-panel temperature of 63 ±3°C (145.4 ±5.4°F).

31.2.2 The units are to be mounted vertically on the inside of the cylinder in the ultraviolet-light apparatus, with the width of the unit facing the arcs so that they do not touch each other.

31.2.3 One set of units is to be exposed. For twin enclosed carbon-arc, one set is to be exposed for a total of 720 hours. For xenon-arc, one set is to be exposed for a total of 1000 hours. After the test exposure, the units are to be removed from the test apparatus, examined for signs of deterioration such as crazing or cracking, and retained under conditions of ambient room temperature and atmospheric pressure for not less than 16, nor more than 96 hours, before being subjected to the flammability and physical tests described in 31.1.1. For comparative purposes, units that have not been exposed to ultraviolet light and water are to be subjected to these tests at the same time that the final exposed units are tested.

31.2.4 When a material is to be considered in a range of colors, units representing these ranges are also to be provided. Units in the natural (when used in this color) and in the most heavily pigmented light and dark colors are to be provided and considered representative of the color range, when the test results are essentially the same. An additional set of units is to be provided in the heaviest organic pigment loading, unless the most heavily pigmented light and dark colors include the highest organic pigment level. When certain color pigments (for example, red, yellow, or similar colors) are known to have particularly critical effects, they are also to be provided.

31.3 Water immersion

31.3.1 Using standard test procedures, property values for the material are to be determined both before and after conditioning. Units of the material shall be immersed in distilled or deionized water at 70.0 ±1.0°C (158.0 ±1.8°F) for 7 days. A complete change of water is to be made on each of the first 5 days. Following the water conditioning, the units which are to be subjected to tests described in 31.1.1(b) are to be immersed in distilled or deionized water at 23.0 ±2.0°C (73.4 ±3.6°F) for 1/2 hour immediately prior to testing. Following the immersions, the units to be subjected to flammability tests are to be conditioned in air at 23.0 ±2.0°C (73.4 ±3.6°F) and 50 ±5 percent relative humidity for 2 weeks.

31.3.2 After the water immersion conditioning, the end-product test force and impact values shall be reduced by 50 percent.

32 Ball Impact Test

32.1 Three samples of the polymeric enclosures for a controller or other accessory used with flexible lights are to be tested. Each is to be subjected to a single impact. Each of the impacts is to be made in a different location on the sample.

32.2 For products that are marked for use in outdoor locations, the samples are to be cooled to a temperature of -31 ±2°F (-35 ±1.1°C) and maintained at that temperature for 3 hours, prior to conducting the ball impact tests. The impact is to be applied to the samples within 1 minute upon removal from the cooling chamber.

32.3 A product that is marked for indoor use only is to be tested at room temperature, 77 ±9°F (25 ±5°C).

32.4 Each sample is to be placed on a concrete surface in the positions most likely to produce adverse results. The impact force is obtained using a solid smooth steel sphere 2 inches (50.8 mm) in diameter and weighing 1.18 pounds (0.53 kg). The sphere is to be allowed to fall freely from rest through the distance required to strike the test sample with an energy of 5 foot-pounds (6.78 N·m).

32.5 The above test shall be repeated following the Ultraviolet (UV) Light Exposure and Water Immersion Tests specified in Section 31 as required by 7.11.

32.6 There shall be no:

a) Accessibility of uninsulated current carrying parts as determined by applying the accessibility probe specified in 10.2;

b) Reduction of spacing to values below minimum acceptable values specified in 12.1;

c) Reduction in the effectiveness of strain relief as determined by conducting the Strain Relief Test, Section 36, except the oven conditioning is not required;

d) Dielectric breakdown as determined by conducting the Dielectric Voltage Withstand Test, Section 29, except the immersion in the salt solution is not required; or

e) Cracking or other damage to an outdoor enclosure that allows water to contact current carrying parts not inherently corrosion resistant, as determined by conducting the Rain Test, Section 39, except the Dielectric Voltage Withstand Test is not repeated following the Rain Test.

33 Flexing Test

33.1 Flexible lights with detachable power-supply cords and connectors for extension segments are to be subjected to this test.

33.2 Six samples of the flexible light attached to its supply connector shall be subjected to 750 cycles of 180 degree flexing. If the flexible light is also provided with a load connector for interconnecting extension segments, three additional samples shall be tested with the supply connector and three additional samples shall be tested with the load connector.

33.3 Each sample shall consist of a connector secured as intended to a section of the flexible light body. The length of the flexible light used for this test shall be not less than 20 inches (508 mm) long and contain at least one complete series circuit.

33.4 Each sample is to be secured to the flexing apparatus described in the Flexing Test-Services Employing Parallel Cords of Integral or Nonintegral Construction, in the Standard for Cord Sets and Power-Supply Cords, UL 817, so that the flexible light assumes the natural bend permitted by the construction.

33.5 Each connector is to be secured in the jaws of the flexing machine so that the point of flexible light body exit is at the center of rotation. The rotating jaws are to be adjusted to rotate to an angle of 90 degrees to each side of the centered position. At the centered position, the flexible light body is to hang vertically and a test weight shall be attached to the flexible light body approximately 12 inches (305 mm) from the point of rotation. See Table 33.1 for the test weights.

Table 33.1
Test weight based on internal conductors

Conductor size	Test weight
18 AWG or larger	10 ounces (284 g)
Smaller than 18 AWG	4 ounces (113 g)

33.6 Each sample is to be subjected to the flexing of 33.5 until 750 cycles are completed or a conductor opens as determined by a suitable current detection device. A flexing cycle consists of rotation of the jaws from the vertical (centered) position until 90 degrees to one side, back past the vertical position until 90 degrees to the other side, and back to the vertical (centered) position. The rate of testing shall be 10 cycles per minute.

33.7 There shall be no:

a) Bus conductor opening within 750 flexible cycles. Opening of the series circuit conductor shall be disregarded;

b) Accessibility of uninsulated current carrying parts as determined by applying the accessibility probe specified in 10.2;

c) Reduction of spacing to values below minimum acceptable values specified in 12.1;

d) Reduction in the effectiveness of strain relief as determined by conducting the Strain Relief Test, Section 36;

e) Dielectric breakdown as determined by conducting the Dielectric Voltage Withstand Test, Section 29; or

f) Cracking or other damage to an outdoor flexible light enclosure that allows water to contact current carrying parts not inherently corrosion resistant, as determined by conducting the Rain Test, Section 39.

34 Oven Conditioning Test

34.1 The flexible light is to be placed in a full-draft circulating-air oven for seven hours. The oven is to be maintained at a uniform temperature of 18°F (10°C) higher than that measured on the polymeric material during the temperature test, but no less than 158°F (70°C). After removal from the oven, the sample is to be permitted to cool to room temperature and then inspected.

34.2 The results are acceptable if there is no softening, cracking or warping, or other signs of deterioration in the light jacket or connectors that would tend to expose uninsulated current carrying parts or reduce electrical spacing.

35 Cold Bend Test

35.1 A sample of the flexible light intended for outdoor use and a 3 inch (76.2 mm) diameter metal mandrel are to be placed in a cold chamber maintained at minus 4 ±3.6°F (minus 20 ±2°C) for a period of 4 hours. Immediately upon removal from the chamber, the flexible light is to be tightly wound around the mandrel for six complete turns. This winding operation is to be completed within 30 seconds of the time that the cold chamber is opened.

35.2 There shall be no cracking or other damage that exposes uninsulated current carrying parts or reduces electrical spacings.

36 Strain Relief Test

36.1 A sample of the flexible light shall withstand a 35 pound (16 kg) force without damage to the insulation or parts and without strain being transmitted to internal conductors or terminals of a conductor.

36.2 The force is to be gradually applied to the cord in parallel with the direction the cord normally enters the flexible light or connector. The force is to be maintained for one minute.

36.3 If the flexible light employs a molded thermoplastic strain relief, an additional sample is to be conditioned in a hot air circulating oven for a period of seven hours. The oven temperature is to be maintained at 18°F (10°C) higher than that measured on the plastic during the temperature test but no less than 158°F (70°C). The Strain Relief Test is to be conducted after the sample has cooled to room temperature.

37 Crimp Connection Secureness Test

37.1 Six samples of the individual crimp connections used to make electrical connection to the flexible light conductors or connectors are to be subjected to this test. Samples are to be tested before the crimped connections have been assembled or molded into its final application. Each terminal is to be held rigidly and a force applied to the conductor in a direction normal to the longitudinal axis of the terminal and conductor. See Table 37.1 for the test weights. The force is then to be gradually applied to the conductor to hang freely suspended and maintained for one minute.

Table 37.1
Test weight based on internal conductors

Conductor size	Test weight
18 AWG or larger	20 pound (9.1 kg)
Smaller than 18 AWG	8 pound (3.6 kg)

37.2 The conductors shall remain securely attached to the crimp connectors at the completion of this test.

38 End Cap Pull Test

38.1 Three samples of the flexible light are to be held rigidly secured, and the force required to completely remove the end cap from each sample in a direction parallel to the longitudinal centerline of the flexible light is to be measured. The force shall be applied in a straight line without torque.

38.2 This test is to be repeated with three additional samples that have been conditioned in a hot air circulating oven for a period of seven hours. The oven temperature is to be maintained at 18°F (10°C) higher than that measured in the area of the end cap during the temperature test but not less than 158°F (70°C).

38.3 The minimum average force required to remove the end cap from each of the sets of three samples of flexible lights for each condition shall not be less than 20 pounds (9.1 kg), and the force to remove any one end cap shall be not less than 15 pounds (6.8 kg).

39 Rain Test

39.1 A sample of the flexible light intended for outdoor use shall be positioned on a flat surface and energized as indicated in the following table. The test is to be conducted using the rain apparatus as described in the Standard for Luminaires, UL 1598. The unit shall be positioned in the focal area of the spray in order to cause maximum wetting of gaskets, joints and openings. If the flexible light is extendible, the test is to be conducted with an additional unit is to be plugged into the extension connector. The water flow gauges are to be adjusted to yield a 5 psi (34.5 kPa) water spray to simulate a beating rain for sequence in Table 39.1.

Table 39.1
Test parameters

Duration (hrs)	Lamp	Water
1	On	Off
1/2	Off	On
2	On	On
1/2	Off	On

39.2 Following the last application of the water spray, the sample shall be subjected to the Dielectric Voltage Withstand Test, Section 29.

39.3 For the Dielectric Voltage Withstand Test, Section 29, the dielectric trip current is to be set for 300 mA maximum.

39.4 No water shall contact uninsulated current carrying parts and there shall be no dielectric breakdown.

Exception: Water is allowed to enter the interior of a fused attachment plug when the device complies with the applicable requirements of the Standard for Seasonal and Holiday Decorative Products, UL 588, and is rated for outdoor use.

40 Test for Permanence of Cord Tag

40.1 General

40.1.1 When tested as described in 40.2.1 and 40.3.2, a cord tag containing the markings specified in Sections 47 – 48 shall comply with all of the following:

a) The tag shall resist tearing longer than 1/16 inch (1.6 mm) at any point;

b) The tag shall not separate from the cord;

c) There shall not be permanent shrinkage, deformation, cracking, or any other condition that may render the marking of the tag illegible; and

d) The overlamination shall remain in place and shall not be torn or otherwise damaged. The printing shall remain legible.

40.2 Test conditions

40.2.1 Each of nine cord tags is to be applied to a cord and conditioned as described in 40.2.2 – 40.2.4, as indicated, before being tested as described in 40.3.1 and 40.3.2. If the tag is applied by an adhesive, the conditioning is to be conducted at least 24 hours after the application of the tag.

40.2.2 Each of three cord tags is to be tested in the as-received condition.

40.2.3 Each of three cord tags is to be placed in a 60 ±1°C (140 ±1.8°F) circulating-air oven for 240 hours. The cord tags are then to be conditioned at a room temperature of 23 ±2°C (73.4 ±3.6°F) and 50 ±5 percent relative humidity for 30 minutes.

40.2.4 Each of three cord tags is to be tested within 1 minute of being exposed to a humidity of 85 ±5 percent at 32 ±2°C (89.6 ±3.6°F) for 72 hours.

40.2.5 In addition to the conditioning described in 40.2.2 – 40.2.4, if the tag is intended to be applied to the cord of a product intended for outdoor use, nine additional cord tags are each to be applied to a cord and conditioned as described in 40.2.6 – 40.2.9, as indicated, before being tested as described in 40.3.1 and 40.3.2.

40.2.6 Each of three tags is to be tested after 24 hours of exposure conditioning at 23 ±2°C (73.4 ±3.6°F) and 50 ±5 percent relative humidity, followed by 48 hours of immersion to a depth of not less than 1/8 inch (3.2 mm) in demineralized water at a temperature of 23°C (73.4°F). Testing in accordance with 40.3.1 and 40.3.2 shall be performed within 1 minute of the conditioning.

40.2.7 *Deleted*

40.2.8 Each of three tags is to be tested after 24 hours of exposure conditioning at 23.0 ±2.0°C (73.4 ±3.6°F) and 50 ±5 percent relative humidity, followed by 7 hours of exposure in a cold box at a temperature of -10 ±2°C (14.0 ±3.6°F). Testing in accordance with 40.3.1 and 40.3.2 shall be performed within 1 minute of the conditioning.

40.2.9 Each of three tags is to be tested after 24 hours of exposure conditioning at 23.0 ±2.0°C (73.4 ±3.6°F) and 50 ±5 percent relative humidity, followed by exposure to water and ultraviolet light using either of the following methods:

a) Twin enclosed carbon-arc Type D or DH, in accordance with the Standard for Practice for Operating Light-Exposure Apparatus (Carbon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials, ASTM G23. The tags are to be exposed for 720 hours. The operating cycle is to be 20 minutes consisting of 17 minutes of light exposure only and three minutes of water spray and light, or

b) Xenon-arc, Type B, in accordance with the Standard Practice for Operating Light-Exposure Apparatus (Xenon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials, ASTM G26. The tags are to be exposed for 1000 hours. The operating cycle is to be 120 minutes consisting of 102 minutes of light exposure only and 18 minutes of exposure to water spray and light.

Testing in accordance with 40.3.1 and 40.3.2 shall be performed after 24 hours of exposure at 25 ±5°C (77 ±9°F).

40.3 Test method

40.3.1 The tag is to be tested with each cord size to which it is intended to be applied. The cord, with the attachment plug or current tap pointing up, is to be held tautly in a vertical plane. A force of 5 lbs (22.2 N) is to be applied for 1 minute to the uppermost corner of the tag farthest from the cord, within 1/4 inch (6.4 mm) of the vertical edge of the tag. The force is to be applied vertically downward in a direction parallel to the major axis of the cord. In determining compliance with 40.1.1(c), manipulation, such as straightening of the tag by hand, is permissible.

40.3.2 To determine compliance with 40.1.1(d), each cord tag assembly is to be scraped 10 times across printed areas and edges, with a force of approximately 2 lbs (8.9 N), using the edge of a 5/64 inch (2.0 mm) thick steel blade held at a right angle to the test surface. The portion of the blade contacting the test surface shall have a radius of curvature of 1.00 inch (25.4 mm) and the edges of the blade shall be rounded to a radius of approximately 1/64 inch (0.4 mm).

41 Gasket Test

41.1 After the conditioning described in 41.2, a gasket intended to provide a water seal shall have a tensile strength of not less than 60 percent and an elongation of not less than 75 percent of the values determined before conditioning.

41.2 A total of 12 gaskets is needed for this test. Each of three gaskets is to be tested for elongation in the as-received condition and each of three is to be tested for tensile strength in the as-received condition. Each of six is to be placed in a circulating-air oven at a temperature 20°C (36°F) above the temperature measured on the gasket during the Normal Temperature Test, Section 26, for 168 hours. Three of the conditioned gaskets are to be tested for elongation and the other three are to be tested for tensile strength. The test methods and apparatus are described in the Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension, ASTM D412.

42 Gasket Adhesion Test

42.1 When tested as described in 42.2 – 42.4, a gasket secured by adhesive and intended to provide a water seal shall have an adhesion force of not less than 60 percent of the value determined before conditioning.

42.2 A total of 9 representative gaskets is to be tested.

42.3 Three gaskets are to be tested in the as-received condition. Six gaskets are to be placed in a circulating-air oven at a temperature 20°C (36°F) above the temperature measured on the gasket during the Normal Temperature Test, Section 26, for 168 hours.

42.4 The force required to remove the gasket from its mounting surface is the adhesion force and is to be measured by pulling the gasket strip from the test panel at an angle of approximately 90 degrees and a crosshead speed of 0.5 inches/minute (12.7 mm/minute). Three are to be tested in the as-received condition, three are to be tested 1/2 hour after removal from the oven, and three are to be tested 24 hours after removal from the oven.

MANUFACTURING AND PRODUCTION TESTS

43 Production-Line Spark Test

43.1 A spark tester shall include a voltage source, electrode, voltmeter, fault-signal device or system, and the appropriate electrical connections. The ability of the equipment to comply with the requirements in 43.1 – 43.17 shall be certified a minimum of once a year by an accredited independent calibration service or its equivalent, such as checking the test potential with a voltmeter whose calibration is traceable. Calibration shall be traceable to a National Institute of Standards and Technology (USA) standard or to other national physical measures recognized as equivalent by NIST.

43.2 The voltage source of a spark tester shall maintain a minimum test potential of 6000 volts RMS under all normal conditions of leakage current. The core of a transformer and one end of its secondary winding shall be solidly connected to earth ground. A voltage source shall not be connected to more than one electrode.

43.3 The electrode shall be of the link- or bead-chain type and shall make intimate contact throughout its entire length with the surface of the flexible light enclosure being tested.

43.4 The bottom of the metal electrode enclosure shall be U- or V-shaped, the chains shall have a length appreciably greater than the depth of the enclosure, and the width of the trough shall be (typically 1-1/2 inches or 40 mm) greater than the diameter of the flexible light enclosure that is tested.

43.5 For a bead-chain electrode, the longitudinal and transverse spacings of the chains and the diameter of each bead shall comply with Table 43.1. The vertical spacing between beads in each chain shall not exceed the diameter of a bead.

Table 43.1
Maximum center-to-center spacings of bead chains

Diameter of a bead[a]		Longitudinal spacing within each row[a]		Transverse spacing between rows[a]			
				Chains staggered		Chains not staggered	
Inch	(mm)	Inch	(mm)	Inch	(mm)	Inch	(mm)
3/16	(5.0)	1/2	(13)	1/2	(13)	3/8	(10)
3/32	(2.5)	b	b	b	b	b	b

[a] A diameter and spacings other than indicated comply where investigation shows that the chains contact an equal or greater area of the outer surface of the wire.
[b] The chains shall be staggered and shall touch one another in the longitudinal and transverse directions.

43.6 The electrode shall have an earth-grounded metal screen or an equivalent guard that protects operating personnel against electric shock from the electrode and associated current carrying parts.

43.7 The voltmeter shall be connected in the circuit to indicate the actual test potential at all times.

43.8 The equipment shall include a light, counter, or other device or system that gives a signal in the event of a fault. When a fault is detected, the signal shall be maintained until the indicator is reset manually.

43.9 The spark test shall be conducted as the flexible light enclosure is being cut just prior to storage in or shipping from the factory in which the flexible light enclosure is made. The insulation at points of repair shall be re-sparked.

43.10 A flexible light enclosure that has been spark-tested in compliance with 43.9 need not be re-sparked if it is subsequently re-cut into lengths shorter than 200 feet (60 m).

43.11 The length of the electrode is not specified. However, the rate of speed at which the wire travels through the electrode shall keep any point on the wire in contact with the electrode for not less than a total of 18 positive and negative crests of the supply voltage (the equivalent of 9 full cycles of the supply voltage). The maximum speed of the flexible light enclosure is to be determined by means of whichever of the following formulas is applicable.

Feet per minute = (5/9) × Frequency (hertz) × Electrode length (inches)

or

Meters per minute = (1/150) × Frequency (hertz) × Electrode length (mm)

For convenience, Table 43.2 shows the formulas for several frequencies.

Table 43.2
Formula for maximum speed of the flexible light enclosure in terms of electrode length L

Nominal supply (Frequency in hertz)	Feet per minute (L in inches)	Meters per minute (L in millimeters)
50	$27.8L_{in}$	$0.333L_{mm}$
60	$33.3L_{in}$	$0.400L_{mm}$
100	$55.6L_{in}$	$0.667L_{mm}$
400	$222L_{in}$	$2.67L_{mm}$
1000	$556L_{in}$	$6.67L_{mm}$
3000	$1667L_{in}$	$20.0L_{mm}$
4000	$2222L_{in}$	$26.7L_{mm}$

43.12 The conductor of the flexible light enclosure shall be earth-grounded during the spark test. Where the conductor coming from the pay-off reel is bare, the conductor shall be earth-grounded at the pay-off reel or at another point at which continuous contact with the bare conductor, prior to the insulating process, is maintained. Where the conductor coming from the pay-off reel is insulated, an earth-ground connection shall be made at both the pay-off and the take-up reels. In any case, each earth-ground connection shall be bonded directly to the earth ground in the spark tester.

43.13 To determine whether or not a flexible light enclosure is continuous, the conductor is to be connected in series with a lamp, buzzer, bell, or other indicator and a power supply. The conductor is continuous from end-to-end of the finished wire where the lamp lights, the bell or buzzer sounds, or another indicator signal is given.

43.14 For the factory production continuity testing of a flexible light enclosure, it is the manufacturer's choice whether to substitute either of the following for the test in 43.13 a:

a) Continuous eddy-current procedure complying with 43.15 and 43.16; or

b) Continuous differential capacitive-current procedure complying with 43.17.

43.15 The eddy-current test arrangement shall include equipment that complies with each of the following:

a) The equipment is to apply current at one or several frequencies in the range of 1 – 125 kHz to a test coil for the purpose of inducing eddy currents in the conductor moving through the coil at production speed;

b) The equipment is to detect the variation in impedance of the test coil caused by each break in the conductor;

c) The equipment is to provide a visual indication to the operator.

43.16 The longitudinal axis of the conductor is to be coincident with the electrical center of the test coil. The flexible light enclosure is to have little or no vibration as it passes through the test coil and is to clear the coil by a distance that is not greater than 1/2 inch (13 mm). Variations in the speed of the flexible light enclosure through the test coil are to be limited to plus 50 percent and minus whatever percentage (50 percent maximum) keeps the signal amplitude from falling below the level at which a break can be detected. Calibration without any wire in the test coil is to be made at least daily to check whether the equipment is functioning. The temperature along the length of the flexible light enclosure being tested is not to vary from the temperature at which the equipment was calibrated, balanced, and so forth unless the variations are gradual and are without hot or cold spots that cause false signals.

43.17 The differential capacitive-current procedure shall include equipment that complies with each of the following:

a) The equipment is to be used in conjunction with a 1 – 3 kHz or higher-frequency spark tester;

b) Two pickup electrodes are to be located in tandem either along the portion of the conductor being tested that is moving from the grounded pay-off reel toward the spark electrode, or along the portion of the conductor being tested that is moving toward the grounded take-up reel from the spark electrode;

c) As each break in the conductor is passing from the first pickup electrode toward the second, the equipment is to detect the difference between the voltage capacitively coupled from the conductor under test to the pickup electrode nearest the spark electrode and the lower voltage coupled to the pickup electrode nearest the grounded reel; and

d) The equipment is to show a visual indication to the operator.

44 Operational Test

44.1 Each flexible light shall be tested by the manufacturer. Inability of any lamp to light is to be considered unacceptable. The manufacturer may use a means other than lamping that produces results equal to actual lamping.

45 Polarization Continuity Test

45.1 As a routine production-line verification, each flexible light provided with a 2-wire polarized attachment plug shall be tested for electrical continuity between the grounded (neutral) circuit supply