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SUBJECT 8750

OUTLINE OF INVESTIGATION

FOR

LIGHT EMITTING DIODE (LED) LIGHT SOURCES FOR USE IN LIGHTING PRODUCTS

Issue Number: 1

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Summary of Topics

This is the first issue of the Outline of Investigation for Light Emitting Diode (LED) Light Sources For Use In Lighting Products. The outline covers the component parts of a light emitting diode (LED) light source such as LED modules, LED Arrays, power sources and control circuitry. It covers LED light sources that are produced by the end use product manufacturer, and that are an integral part of the end use product, or discrete component parts of an LED light source produced by one manufacturer for use in another manufacturer's lighting product.

The UL Foreword is no longer located within the UL Outline of Investigation. For information concerning the use and application of the requirements contained in this Outline of Investigation, the current version of the UL Foreword is located on ULStandardsInfoNet at: <http://ulstandardsinfo.net/ul/foreword.html>

The text included in paragraphs 3.14.1, 3.14.2, and 3.14.2, and Tables 3.1 and 3.2 are based on material in Information Technology Equipment – Safety – Part 1: General Requirements, IEC 60950-1, First edition copyright 1999-01. This material is used in this Standard with the consent of the IEC and the American National Standards Institute (ANSI). The IEC copyrighted material has been reproduced with permission from ANSI. ANSI should be contacted regarding the reproduction of any portion of the IEC material. Copies of the IEC Publication 60950-1 may be purchased from ANSI, 11 West 42nd Street, New York, New York, 10036, (212)642-4900.

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INTRODUCTION

1 Scope

1.1 These requirements specify the minimum safety requirements for the component parts of a light emitting diode (LED) light source that serves as the source of illumination in any of the lighting products listed in 1.3.

1.2 An LED light source consists of one or more of the following component parts:

- a) LED or LED array – that provide illumination,
- b) Power source that supplies the proper voltage and current to operate the LEDs,
- c) Control circuitry that may switch, dim or otherwise control the electrical energy to the LEDs.

1.3 LED light sources complying with these specifications are utilized as the source of illumination in lighting products that comply with the appropriate end product standard as listed below. These lighting products are intended for installation on branch circuits of 600 V nominal or less in non-hazardous locations in accordance with the National Electrical Code (NEC), ANSI/NFPA 70. These requirements also apply to LED light sources connected to isolated (non-utility connected) power sources such as batteries, fuel cells, and the like. Included are:

- a) Luminaires, UL 1598;
- b) Portable luminaires, UL 153;
- c) Stage and studio luminaires, UL 1573;
- d) Submersible luminaires, UL 676;
- e) Swimming pool luminaires, UL 676;
- f) Track lighting systems, UL 1574 ;
- g) Signs, UL 48;
- h) Emergency lighting and exit signs, UL 924;
- i) Self-ballasted lamps, UL 1993;
- j) Luminous Egress Path Marking Systems, UL 1994;
- k) Nightlights, UL 1786;
- l) Flexible lighting, UL 2388;
- m) Low Voltage Lighting Systems, UL 2108;
- n) Lampholder Fittings, UL 496; and
- o) Landscape Lighting, UL 1838.

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1.4 Applications incorporating LED light sources such as lighting products for use in hazardous locations, health care, emergency lighting or marine lighting have additional requirements not described in this outline of investigation.

2 General

2.1 Components

2.1.1 Except as indicated in 2.1.2, a component of a product covered by this outline 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 outline.

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 outline, or
- b) Is superseded by a requirement in this outline.

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 Except for conductor size, values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

2.2.2 All values of voltage and current are true root mean square (rms) values unless otherwise indicated.

2.2.3 For customary purposes wire sizes are in American Wire Gauge (AWG).

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2.3 Reference publications

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

3 Definitions

3.1 For the purpose of these requirements, the following definitions apply.

3.2 CONDITIONS OF USE – Parameters and specifications that identify the proper use of a component according to the requirements to which it has been determined to comply, and limitations of the use of the component in an LED module or control gear.

3.3 ENCLOSURE, ELECTRICAL – A part of the equipment intended to limit access to parts that are operating at voltage levels exceeding a Class 2, SELV or a limited power source.

3.4 ENCLOSURE, FIRE – A part of the equipment that limits access to hazardous live parts and is intended to minimize the spread of fire or flames from within.

3.5 ENCLOSURE, MECHANICAL – A part of the equipment intended to reduce the risk of injury due to mechanical and other physical hazards.

3.6 LAMP – A generic term for a man-made source of light. By extension, the term is also used to denote sources that radiate in regions of the spectrum adjacent to the visible. In lighting parlance, the lamp is the replaceable light-generating component of a luminaire, usually a standardized element with a standard base, such as a screw base, pin base, or bayonet base, for mechanical and electrical coupling.

3.6.1 LED LAMP, INTEGRATED – An LED device with an integrated driver and an ANSI standardized base that is designed to connect to the branch circuit via an ANSI standardized lampholder.

Note: In North America, “a standardized base” refers to an ANSI standard base. In the U.S. “branch circuit” is used to describe the “mains voltage” in IEC documents.

3.6.2 LED LAMP, NON-INTEGRATED – An LED device with no integral power source and with an ANSI standardized base designed for connection to a LED luminaire.

3.7 LED LUMINAIRE – A complete lighting unit consisting of a LED light source and power source together with parts to distribute light, to position and protect the light source, and to connect the light source to a branch circuit. The LED light source may be an LED array, an LED module or an LED lamp. The LED luminaire is intended to connect directly to a branch circuit.

3.8 LIGHT EMITTING DIODE (LED) – A pn junction semiconductor device that emits incoherent optical radiation when biased in the forward direction.

3.8.1 LED ARRAY – An assembly of LED packages on a printed circuit board, possibly with optical elements and additional thermal, mechanical, and electrical interfaces. The device does not contain a power source and is not connected directly to the branch circuit.

3.8.2 LED MODULE – A component part of an LED light source that includes one or more LEDs that are connected to the load side of LED power source or LED driver. Electrical, electronic, optical, and mechanical components may also be part of an LED module. The device does not contain a POWER SOURCE and is not connected directly to the branch circuit.

3.8.3 LED PACKAGE – An assembly of one or more LED die that contains wire bond connections, possibly with an optical element and thermal, mechanical, and electrical interfaces. The device does not include a power source and is not connected directly to the branch circuit.

3.9 LIGHTING UNIT, FIXED – A power source or LED luminaire that is intended to be permanently connected electrically to a branch circuit supply and fastened in place.

3.10 LIGHTING UNIT, PORTABLE – A power source or LED luminaire with a flexible cord and attachment plug to connect it to the supply circuit, that has no provision for attaching it to a supporting surface and is easily carried or conveyed by hand.

3.11 LIGHTING UNIT, STATIONARY – A power source or LED luminaire that is intended to be fastened in place or located in a dedicated space, and is provided with a flexible cord and attachment plug to connect it to a branch circuit supply.

3.12 LIVE PART – A conductive part that has an electrical difference of potential with respect to earth ground or any other conductive part and no basic insulation. A part connected to a grounded supply (neutral) conductor is considered to be a live part.

3.12.1 DEAD CONDUCTIVE PART – A conductive part with no basic insulation that, under normal operating conditions, carries no electrical current. A grounded dead conductive part may carry leakage current.

3.13 POLLUTION DEGREES – The level of pollution present at the location on or in a product where the clearance and creepage distance measurement is made, and can be controlled by design of the product.

a) **POLLUTION DEGREE 2** – Normally only non-conductive pollution; however, temporary conductivity is capable of being caused by condensation.

b) **POLLUTION DEGREE 3** – Conductive pollution, or dry, non-conductive pollution that becomes conductive due to condensation.

3.14 POWER SOURCE – A transformer, power supply, or battery capable of controlling current, voltage or power within its design limits.

3.14.1 CIRCUIT, EXTRA-LOW VOLTAGE – A secondary circuit with voltages between any two conductors of the circuit, and between any one such conductor and earth ground, not exceeding 42.4 V peak, or 60 V dc, under normal operating conditions, which is separated from hazardous voltage by basic insulation, and which neither meets all of the requirements for an SELV circuit nor meets all of the requirements for a limited current circuit.

3.14.2 CIRCUIT, LIMITED CURRENT – A circuit that is so designed and protected that, under both normal operating conditions and single fault conditions, the current, which can be drawn, is not hazardous (does not exceed Class 2 limits.)

3.14.3 CIRCUIT, SAFETY EXTRA-LOW VOLTAGE (SELV) – A secondary circuit that is so designed and protected that under normal operating conditions and single fault conditions, its voltages are less than 30 V rms (42.4 V peak) or 60 V DC.

3.14.4 LED CONTROL MODULE – Electronic circuitry interposed between the power source and an LED array to limit voltage and current, dim, switch or otherwise control the electrical energy to the LED array. The device does not contain a power source and is not connected directly to the branch circuit.

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3.14.5 LED DRIVER – A power source with integral control circuitry designed to meet the specific requirements of a LED lamp or a LED array.

3.14.6 LED DRIVER, CLASS 2 – A LED driver that operates within Class 2 limits.

3.14.7 POWER SUPPLY – An electronic device capable of controlling current, voltage, or power within its design limits.

3.14.8 POWER SOURCE, CLASS 2 – An electrical source, such as a transformer, power supply, or battery, having an open-circuit voltage that is less than 30 V rms (42.4 V peak) or 60 V DC and having limited energy available in the circuit under load conditions, including short-circuit and extremely low resistance. A Class 2 supply source can be either inherently limited or non-inherently limited.

a) INHERENTLY LIMITED POWER SOURCE – A transformer, power supply or battery having no discrete protective device that is relied upon to limit the output energy available from the supply. A power supply or battery with internal current and energy limiting circuitry shown to be reliable is eligible to be identified as inherently limited. Transformers, power supplies and batteries may be provided with protective devices as long as they are not relied upon to limit the output.

b) NON-INHERENTLY LIMITED POWER SOURCE – A transformer, power supply or battery having a discrete protective device that automatically interrupts the output when the current and energy output reaches a prescribed limit.

3.14.9 POWER SOURCE, LIMITED POWER SOURCE (LPS) – A power source identified as "LPS" where the output is limited as specified in Tables 3.1 and 3.2. The output of an LPS is considered equivalent to power supplies with Class 2 outputs.

Table 3.1
Limits for inherently limited power sources

Output voltage ¹⁾ (U_{oc})		Output current ²⁾ (I_{sc}) A	Apparent power ³⁾ (S) VA
V a.c.	V d.c.		
≤ 20	≤ 20	≤ 8.0	$\leq 5 \times U_{oc}$
$20 < U_{oc} \leq 30$	$20 < U_{oc} \leq 30$	≤ 8.0	≤ 100
–	$30 < U_{oc} \leq 60$	$\leq 150 / U_{oc}$	≤ 100

¹⁾ U_{oc} : Output voltage measured in accordance with 10.1 with all load circuits disconnected. Voltages are for substantially sinusoidal a.c. and ripple free d.c. For non-sinusoidal a.c. and for d.c. with ripple greater than 10% of the peak, the peak voltage shall not exceed 42.4 V.

²⁾ I_{sc} : Maximum output current with any non-capacitive load, including a short circuit, measured 60 S after application of the load.

³⁾ S (VA): Maximum output VA with any non-capacitive load measured 60 s after application of the load.

Table 3.2
Limits for power sources not inherently limited (overcurrent protective device required)

Output voltage ¹⁾ (U_{oc})		Output current ²⁾ (I_{sc}) A	Apparent power ³⁾ (S) VA	Current rating of overcurrent protective device ⁴⁾ A
V a.c.	V d.c.			
≤ 20	≤ 20	$\leq 1\,000/U_{oc}$	≤ 250	≤ 5.0
$20 < U_{oc} \leq 30$	$20 < U_{oc} \leq 30$			$\leq 100/U_{oc}$
–	$30 < U_{oc} \leq 60$			$\leq 100/U_{oc}$

¹⁾ U_{oc} : Output voltage measured in accordance with 10.1 with all load circuits disconnected. Voltages are for substantially sinusoidal a.c. and ripple free d.c. For non-sinusoidal a.c. and for d.c. with ripple greater than 10% of the peak, the peak voltage shall not exceed 42.4 V.

²⁾ I_{sc} : Maximum output current with any non-capacitive load, including a short circuit, measured 60 s after application of the load. Current limiting impedances in the equipment remain in the circuit during measurement, but overcurrent protective devices are bypassed.

³⁾ S (VA): Maximum output VA with any non-capacitive load measured 60 s after application of the load. Current limiting impedances in equipment remain in the circuit during measurement, but overcurrent protective devices are bypassed.

NOTE The reason for making measurements with overcurrent protective devices bypassed is to determine the amount of energy that is available to cause possible overheating during the operating time of the overcurrent protective devices.

⁴⁾ The current ratings of overcurrent protective devices are based on fuses and circuit breakers that break the circuit within 120 s with a current equal to 210% of the current rating specified in the table.

3.15 RATED MAXIMUM TEMPERATURE, T_c – A temperature limit assigned by the manufacturer to a specified location marked on the outer surface of the LED module that is not to be exceeded (under normal operating conditions in the end product). The assigned T_c is related to the product's reliable operation, and is not necessarily a safety limit.

3.16 RISK OF ELECTRIC SHOCK – A risk of electric shock exists between any two conductive parts with no basic insulation or between a conductive part with no basic insulation and earth ground if the continuous current flow through a 1500 Ω resistor in parallel with a 0.15 μ F capacitor connected between the two points exceeds 5 mA rms (7 mA peak) and if the open circuit voltage exceeds 30 V rms (42.4 V peak) ac or 60 V DC for dry or damp locations or 15 V (21.2 V peak) AC or 30 V DC for wet locations.

3.17 RISK OF FIRE – A risk of fire exists between two conductive parts with no basic insulation if I_{max} or VA_{max} exceeds Class 2 circuit limitations as defined in Section 725 of the National Electrical Code (NEC).

3.18 UNIT – A generic term meaning a power source, control module or LED module.

4 General Requirements And Use Of This Outline of Investigation

4.1 General

4.1.1 This document has a dual purpose of providing requirements for the evaluation of components of a LED light source either has a discrete component or as integrated (power supply and LED lamp on a single circuit board) into various lighting products that would additionally be evaluated with additional end-product standards described in the scope. When components are evaluated with additional end product standards, the requirements of the end product standard supersede these requirements.

4.1.2 Sections 5 through 7, and 12 give common requirements for any of the components of a LED light source. Section 8 contains supplementary requirements that pertain to LED power source components, while Section 9 contains supplementary requirements that pertain to LED and control module components.

4.1.3 To use this outline, a product's function and intended environmental uses would first be determined along by either review of product markings or discussion with the manufacturer.

4.1.4 Units, which are marked "Double Insulated," or marked with the symbol for double insulation, shall comply with the requirements of be investigated to the Reference Standard for Double Insulation Systems for Use in Electronic Equipment, UL 2097.

4.2 LED modules

4.2.1 Integral modules not having their own enclosure shall be treated as integral components of the end product luminaire and comply with the component requirements specified in the end product standard. They shall be tested as far as applicable in accordance with this outline.

4.2.2 Independent modules shall comply, in addition to this outline, with the requirements of relevant clauses of the end product standard, where these requirements are not already covered in this outline.

4.2.3 If the module is a factory sealed unit, it shall not be opened for any tests. In the case of doubt based on the inspection of the module and the examination of the circuit diagram, and in agreement with the manufacturer or responsible vendor, such specially prepared modules shall be submitted for testing so that a fault condition can be simulated.

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CONSTRUCTION

5 Environmental Considerations

5.1 A unit not subjected to additional construction features or testing for environmental conditions is intended for use only in dry locations and is to be marked as such. The unit shall not be provided with any information such as markings, instructions, or illustrations either on the carton or with the device that implies or depicts a damp or wet location use.

5.2 A unit intended for use in damp locations, such as within an enclosed outdoor luminaire, shall be:

- a) Subjected to the Humidity Test in the Standard for Fluorescent-Lamp Ballasts, UL 935, Section 23;
- b) Have spacing of electrical parts meeting damp or wet location requirements, or Pollution Degree 2 as specified in Spacing of Electrical Parts, Section 7.10; and
- c) Be marked as specified in 12.2.5.

5.3 A unit intended for use in wet locations shall be:

- a) Subjected to the Humidity Test in the Standard for Fluorescent-Lamp Ballasts, UL 935, Section 23;
- b) Have spacing of electrical parts meeting damp or wet location requirements, or Pollution Degree 3 as specified in Spacing of Electrical Parts, Section 7.10;
- c) Have polymeric enclosures comply with the UV rating described in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, Section 57;
- d) Subjected to the Water Spray Test in the Standard for Luminaires UL 1598, Section 16.5.2;
- e) Have polymeric enclosures be subjected to the Cold Impact Test in UL 746C, Section 56; and
- f) Be marked as specified in 12.2.5.

5.4 A unit intended for use in constant contact with water, (e.g. installed on the bottom of a sign body or the enclosure of the outdoor portion of an outdoor sign or a submersible wet locations) shall be:

- a) Subjected to the Humidity Test in the Standard for Fluorescent-Lamp Ballasts, UL 935, Section 23;
- b) Have spacing of electrical parts meeting damp or wet location requirements, or Pollution Degree 3 as specified in Spacing of Electrical Parts, Section 7.10;
- c) Have polymeric enclosures comply with the UV rating described in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, Section 57;
- d) Subjected to the Water Exposure and Immersion Test in UL 746C;
- e) Have polymeric enclosures be subjected to the Cold Impact Test in UL 746C, Section 56; and

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- f) Be marked as specified in 12.2.5.

6 Mechanical Construction

6.1 General

6.1.1 Enclosures shall have the strength and rigidity required to resist the abuses expected to be encountered in use without increasing the risk of fire, electric shock or injury to persons due to a reduction in required spacing between live parts or live parts and dead parts or the loosening or displacement of such parts. The requirements in Section 6 shall be used in conjunction with the applicable supplementary requirements in this outline.

6.1.2 All parts operating above Class 2 or LPS limits shall be enclosed within a qualifying material.

Note: The parts that are required to be enclosed are all parts connected to an electrical circuit that is NOT designated Class 2 or LPS and the live parts are not otherwise intended to be enclosed in the end product

6.1.3 The enclosure shall be designed to reduce the risk of electric shock and mechanical damage to component parts, and contain fire within it.

6.1.4 Components with integral electrical enclosures that comply with the enclosure requirements for the component are considered to comply.

6.1.5 Components where the electrical enclosure is provided as part of the end product are not required to have an integral electrical enclosure.

6.2 Metal enclosures

6.2.1 Sheet metal and cast enclosures shall have a minimum thickness in accordance with Table 8.1 in the Standard for Class 2 Power Supplies, UL 1310.

6.2.2 An enclosure constructed of iron or steel shall be protected against corrosion by plating, painting, or the equivalent. Both inside and outside surfaces of an enclosure shall be protected against corrosion.

6.2.3 A protective coating need not be applied to:

- a) The interior of an enclosure that is completely filled with potting compound; or
- b) Flat metal surfaces that are tightly clamped together.