

**LIGHT EMITTING DIODE (LED) EQUIPMENT FOR USE IN
LIGHTING PRODUCTS**

Underwriters Laboratories of Canada (ULC) was established in 1920 by letters patent issued by the Canadian Government. It maintains and operates laboratories and certification services for the examination, testing and certification of appliances, equipment, materials, constructions and systems to determine their relation to life, fire and property hazards as well providing inspection services.

Underwriters Laboratories of Canada is accredited by the Standards Council of Canada as a Certification Organization, a Testing Organization, and an Inspection Body under the National Standards System of Canada.

ULC Standards develops and publishes standards and other related publications for building construction, security and burglar protection, environmental safety, electrical equipment, fire protection equipment, gas and oil equipment, thermal insulation products, materials and systems, energy use in the built environment and electrical utility safety.

ULC Standards is a not-for-profit organization and is accredited by the Standards Council of Canada as a Standards Development Organization.

Other Recognized Documents (ORD) developed by Underwriters Laboratories of Canada are developed in accordance with the procedure outlined in the documents CAN-P-3, "General Requirements for Bodies Operating Product Certification Systems"; and CAN-P-1500, "Additional Requirements for Accreditation of Certification Bodies", published by the Standards Council of Canada.

ULC is represented across Canada as well as many countries worldwide. For further information on ULC services, please contact:

CORPORATE HEADQUARTERS

Underwriters Laboratories of Canada
7 Underwriters Road
Toronto, Ontario M1R 3A9
Telephone: (416) 757-3611
Fax: (416) 757-9540
Customer Service: 1-866-937-3852

The Standards Council of Canada (SCC) is the coordinating body of the National Standards System, a coalition of independent, autonomous organizations working towards the further development and improvement of voluntary standardization in the national interest.

The principal objects of the SCC are to foster and promote voluntary standardization as a means of advancing the national economy, benefiting the health, safety and welfare of the public, assisting and protecting the consumer, facilitating domestic and international trade, and furthering international cooperation in the field of standards.

The National Standards System of Canada accepts the use of Other Recognized Documents (ORD) as defined in CAN-P-3, "General Requirements for Bodies Operating Product Certification Systems"; and CAN-P-1500, "Additional Requirements for Accreditation of Certification Bodies", published by the Standards Council of Canada.

The Standards Council of Canada is located at:

270 Albert Street
Suite 200
Ottawa, Ontario K1P 6N7
Telephone: (613) 238-3222

REGIONAL OFFICES

EASTERN OFFICE

6505, Rte Transcanadienne, Suite 330
St-Laurent, Québec H4T 1S3
Telephone: (514) 363-5941
Fax: (514) 363-7014
Customer Service: 1-866-937-3852

PACIFIC OFFICE

13775 Commerce Parkway, Suite 130
Richmond, British Columbia V6V 2V4
Telephone: (604) 214-9555
Fax: (604) 214-9550
Customer Service: 1-866-937-3852

For further information on ULC standards, please contact:

ULC STANDARDS

440 Laurier Avenue West, Suite 200
Ottawa, Ontario K1R 7X6
Telephone: (613) 755-2729
Fax: (613) 231-5977
Customer Service: 1-866-937-3852

E-mail: customerservice@ulc.ca
Web site: www.ulc.ca

The intended primary application of this Other Recognized Document is stated in its scope. It is important to note that it remains the responsibility of the user of the Other Recognized Document to judge its suitability for this particular application.

Copies of this Other Recognized Document may be ordered from ULC Standards.

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

ICS 29.140 ; 29.140.40 ; 31.080.10

Prepared and Published by
UNDERWRITERS LABORATORIES OF CANADA



FIRST EDITION AUGUST 2011

Copyright © 2011

Underwriters Laboratories of Canada

No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without prior permission.

AVADocuments

TABLE OF CONTENTS

FOREWORD	i
PREFACE	ii
1. SCOPE	1
2. REFERENCE PUBLICATIONS	1
3. GLOSSARY	3
4. GENERAL	5
4.1 COMPONENTS	5
4.2 UNITS OF MEASUREMENT	6
5. POWER SUPPLIES, LED DRIVERS, AND TRANSFORMERS	6
6. ENVIRONMENTAL CONSIDERATIONS	6
7. MECHANICAL CONSTRUCTION	7
7.1 GENERAL	7
7.2 METAL THICKNESS	7
7.3 POLYMERIC MATERIALS FOR ENCLOSURES AND ELECTRICAL INSULATION	8
7.4 ENCLOSURE OPENINGS	9
7.5 CONDUCTOR PROTECTION	10
7.6 STRAIN RELIEF	10
7.7 POTTING COMPOUND	10
8. ELECTRICAL CONSTRUCTION	10
8.1 GENERAL	10
8.2 ACCESSIBILITY	11
8.3 INTERNAL WIRING	11
8.4 SUPPLY AND LOAD CONNECTIONS	13
8.4.1 General	13
8.4.2 Permanently-connected units	14
8.4.2.1 Conduit connection	14
8.4.2.2 Field-wiring leads	16
8.4.2.3 Field-wiring terminals	16
8.4.2.4 Push-in terminals	17
8.4.3 Cord-connected and direct plug-in units	17
8.4.4 Leads, terminals, and connectors for other than branch <i>circuit</i> connections	19
8.4.4.1 General	19
8.4.4.2 Leads	19
8.4.4.3 Output connectors	20
8.4.4.4 Insulation-piercing connections	20
8.5 SEPARATION OF CIRCUITS	20
8.6 INSULATING MATERIALS	20
8.7 PRINTED WIRING BOARDS	21

8.8 ELECTRICAL SPACINGS	23
8.9 CIRCUIT COMPONENTS	25
8.10 PROTECTIVE DEVICES	25
8.11 COIL INSULATION	26
8.11.1 General	26
8.11.2 Insulation for transformers	26
8.12 CLASS 2 OUTPUT CIRCUITS	29
9. PERFORMANCE TESTS	29
9.1 GENERAL	29
9.2 INPUT TEST	29
9.3 TEMPERATURE TEST	29
9.4 DIELECTRIC VOLTAGE WITHSTAND TEST	33
9.5 ABNORMAL TESTS	33
9.5.1 General	33
9.5.2 Component failure test	34
9.5.3 Output loading test	34
9.5.4 Output loading – alternate method	35
9.6 50-WATT POINT POWER MEASUREMENT TEST	36
9.7 LEAKAGE CURRENT MEASUREMENT TEST	37
9.8 CORD STRAIN AND PUSH-BACK RELIEF TEST	39
9.9 SECURITY OF OUTPUT TERMINALS	39
9.10 INSULATION-PIERCING CONNECTION THERMAL CYCLING TEST	40
9.11 ADHESIVE SUPPORT TEST	40
9.12 ENVIRONMENTAL TESTS	41
9.12.1 Humidity exposure	41
9.12.2 Water exposure	41
9.13 MECHANICAL STRENGTH TESTS FOR METAL ENCLOSURES	45
9.14 DETERMINATION OF LOW-VOLTAGE, LIMITED-ENERGY CIRCUIT STATUS	45
10. MARKINGS	46
10.1 GENERAL	46
10.2 IDENTIFICATION AND RATINGS	46
10.3 CONSTRUCTION-RELATED MARKINGS	47
 ANNEX A –FRENCH MARKING TEXT (NORMATIVE)	
 ANNEX B – RESERVED (NORMATIVE)	
 ANNEX C – COATINGS (NORMATIVE)	
 ANNEX D – PRINTED WIRING BOARD REQUIREMENTS (NORMATIVE)	
 ANNEX E – COMPONENT STANDARDS (INFORMATIVE)	

FOREWORD

Certification organizations are periodically requested to promptly provide certification services for devices, constructions, materials and systems where Canadian recognized Standards do not currently exist or are not entirely applicable. Accordingly, the certification organization utilizes its experience, existing specifications and requirements in related areas, together with assistance from its advisory councils to develop and prepare Other Recognized Documents (ORDs) for use in conducting the necessary tests and evaluation investigation.

Underwriters Laboratories of Canada has prepared many ORDs in response to requests from, and in conjunction with, industry, code writing bodies, regulatory agencies and others prior to promulgating a certification program. In many instances such documents have become published ULC Standards and subsequently National Standards of Canada. It is the intention of Underwriters Laboratories of Canada to continue this practice, as appropriate.

Comments on the content of this ORD should be directed to the Head Office of Underwriters Laboratories of Canada, 7 Underwriters Road, Toronto, Ontario, CANADA, M1R 3A9.

NOTE: These Other Recognized Documents are accepted under the National Standards System of Canada. Reference may be made to the Document CAN-P-3, "General Requirements for Bodies Operating Product Certification Systems"; and CAN-P-1500, "Additional Requirements for Accreditation of Certification Bodies", published by the Standards Council of Canada located at 270 Albert Street, Suite 200, Ottawa, Ontario, CANADA, K1P 6N7.

ULC/ORD-C420-11

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

PREFACE

This is the First Edition of ULC/ORD-C420, Light Emitting Diode (LED) Equipment for Use in Lighting Products.

Only metric SI units of measurement are used in this ORD. If a value for measurement is followed by a value in other units in parentheses, the second value may be approximate. The first stated value is the requirement.

In Canada, there are two official languages, French and English. The safety markings required by this ORD shall be in English and French. Attention is drawn to the fact that some Canadian authorities may require additional markings and/or instructions to be in either or both official languages.

Requests for interpretation of this ORD should be sent to the ULC Mark Program Owner of Underwriters Laboratories of Canada. The requests should be worded in such a manner as to permit a “yes” or “no” answer based on the literal text of the requirement concerned.

This ORD is intended to be used for conformity assessment.

ULC/ORD-C420-11

1. SCOPE

1.1 These requirements cover *LED* equipment that is an integral part of a luminaire or other lighting equipment and which operates in the visible light spectrum between 400 – 700 nm. These requirements also cover the component parts of light emitting diode (*LED*) equipment, including *LED* drivers, controllers, arrays, modules, and packages as defined within this ORD.

1.2 These lighting products are intended for installation on branch circuits of 600 V nominal or less in accordance with the CSA C22.1, Canadian Electrical Code, Part 1, Safety Standard for Electrical Installations, and for connection to isolated (non-utility connected) power sources such as generators, batteries, fuel cells, solar cells, and the like.

1.3 *LED* equipment is utilized in lighting products that comply with the end-product standards listed below. The requirements in this ORD are intended to supplement those in other end-product standards. Included are:

- A CAN/CSA C22.2 No. 207, Portable and Stationary Electric Signs and Displays
- B CSA C22.2 No. 12, Portable Luminaires
- C CSA C22.2 No. 89, Swimming-Pool Luminaires, Submersible Luminaires and Accessories
- D CSA C22.2 No. 141, Emergency Lighting Equipment
- E CSA C22.2 No. 166, Stage and Studio Luminaires
- F CAN/CSA C22.2 No. 9.0, Track Lighting Systems
- G CSA C22.2 No. 250.0, Luminaires and Low Voltage Lighting Systems
- H CSA C22.2 No. 256, Direct Plug-In Night lights
- I CSA C22.2 No. 250.7, Extra Low-Voltage Landscape Lighting Systems
- J CSA C22.2 No. 1993, Self-Ballasted Lamps and Lamp Adapters
- K CSA C22.2 No. 9.0, Cabinet and Undercabinet Luminaires

2. REFERENCE PUBLICATIONS

The documents shown below are referenced in the text of this ULC Other Recognized Document (ORD). Unless otherwise stated elsewhere in this ORD, such reference shall be considered to indicate the edition and/or revisions of the documents available at the date on which this ULC ORD is published.

Documents Published by the American Society for Testing and Materials (ASTM)
100 Barr Harbour Drive, PO Box C700, West Conshohocken, PA 19428-2959 U.S.A.
Telephone: (610) 832-9585
www.astm.org

- ASTM E 28-09, Standard Test Methods for Softening Point of Resins Derived from Naval Stores by Ring-and-Ball Apparatus
- ASTM D 3359-09e2, Standard Test Methods for Measuring Adhesion by Tape Test

- ASTM D 1000-09, Standard Test Methods for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications

Standards Published by CSA Standards
5060 Spectrum Way, Mississauga, ON L4W 5N6 Canada
Telephone: (416) 747-4000 or 1-800-469-6727
www.csa.ca

- CSA C22.2 No. 42-10, General Use Receptacles, Attachment Plugs, and Similar Wiring Devices
- CAN/CSA E60384-1-03, Fixed capacitors for use in electronic equipment Part 1: Generic specification
- CAN/CSA E60384-14-03, Fixed capacitors for use in electronic equipment Part 14: Sectional specification: Fixed capacitors for electromagnetic interference suppression and connection to the supply mains
- CSA C22.1-09, Canadian Electrical Code, Part 1, Safety Standard for Electrical Installations
- CSA C22.2 No. 35-09, Extra-low-voltage control circuit cable, low-energy control cable, and extra-low-voltage control cable
- CSA C22.2 No. 21-95, Cord Sets and Power Supply Cords
- CAN/CSA C22.2 No. 60950-1-07, Information Technology Equipment Safety Part 1: General Requirements
- CSA C22.2 No. 0.2-93, Insulation Coordination - General Instruction No 1
- CAN/CSA C22.2 No. 248.14-00 (R 2010), Low-Voltage Fuses - Part 14: Supplemental Fuses
- CSA C22.2 No. 66.1-06, Low Voltage Transformers – Part 1: General Requirements
- CSA C22.2 No. 66.2-06, Low Voltage Transformers – Part 2: General Purpose Transformers
- CSA C22.2 No. 66.3-06, Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers
- CSA C22.2 No. 0.15-01, Adhesive Labels
- CAN/CSA C22.2 No. 0.17-00 (R2009), Evaluation of Properties of Polymeric Materials
- CSA 22.2 No. 107.1-01 (R 2006), General Use Power Supplies
- CAN/CSA C22.2 No. 223-09, Power Supplies with Extra-Low-Voltage Class 2 Outputs
- CAN/CSA E60691-08, Thermal-links – Requirements and application guide
- CAN/CSA C22.2 No. 47-M90 (R 2007), Air-Cooled Transformers (Dry Type)
- CSA C22.2 No. 60065, Audio, Video and Similar Electronic Apparatus – Safety Requirements

Document Published by the International Electrotechnical Commission (IEC)
Available from Information Handling Services Canada, 1 Antares Drive, Suite 200,

Ottawa, ON, Canada, K2E 8C4
Telephone: 1-800-267-8220
www.ihscanada.ca

- IEC 60417, Database on Graphical Symbols for Use on Equipment

Document Published by Underwriters Laboratories, Inc.
333 Pfingsten Road, Northbrook, IL 60062-2096 U.S.A.
Telephone: +1-847-272-8800
www.ul.com

- UL 2353, Standard for Single- and Multi-Layer Insulated Winding Wire.

3. GLOSSARY

Note: Terms used in this ORD that are in *italic* print are defined as follows:

BARRIER — A part of the unit intended to physically limit access to parts that pose a *risk of electric shock*.

CIRCUIT, CLASS 2 — A *circuit* supplied by an isolating source that complies with the requirements of the CAN/CSA C22.2 No. 223, Standard for Power Supplies with Extra-Low-Voltage *Class 2* Output, or both the

CSA C22.2 No. 66.1, Standard for Low Voltage Transformers – Part 1: General Requirements, and

CSA C22.2 No. 66.3, Standard for Low Voltage Transformers – Part 3: *Class 2* Transformers,

CIRCUIT, ISOLATED LOW VOLTAGE LIMITED ENERGY (LVLE) — A *circuit* supplied by a source with no direct electrical connection between input and output, such as provided by a transformer or optical isolator, and with output parameters as follows: source with a maximum output voltage of 42.4 V peak ac (30 V rms) or 42.4 V dc; and a maximum output current limited to:

A maximum 8 amps for 0 – 42.4 V peak ac, or 0 – 30 V dc, or

B 150/V amps, for a voltage between 30 – 42.4 V dc.

Measurements for determining LVLE *circuit* status shall be per the requirements in Determination of Low-Voltage, Limited-Energy Circuit Status of 9.14.

ENCLOSURE, ELECTRICAL — A part of the equipment intended to limit access to parts that are operating at voltage levels in excess of *Class 2* or LVLE.

ENCLOSURE, FIRE — A part of the equipment that is intended to minimize the spread of fire or flames from within a product.

ENVIRONMENTAL LOCATIONS — A part of the unit intended to physically limit access to parts that pose a *risk of electric shock*.

- A **DRY LOCATION** — A location not normally subject to dampness, but may include a location subject to temporary dampness, as in the case of a building under construction, provided ventilation is adequate to prevent an accumulation of moisture.

B DAMP LOCATION — An exterior or interior location that is normally or periodically subject to condensation of moisture in, on, or adjacent to, electrical equipment, and includes partially protected locations.

C WET LOCATION — A location in which water can drip, splash, or flow on or against electrical equipment.

INSULATION-PIERCING TERMINAL — A terminal having a contact pin that punctures the conductor insulation and penetrates between the conductor strands.

ISOLATED OUTPUT — A *circuit* with only magnetic, capacitive, or optical connection to any ground-referenced supply source. A low voltage *circuit* derived by a dropping resistor is not isolated.

LED (LIGHT EMITTING DIODE) — A solid-state component embodying a p-n junction, emitting optical radiation when excited by an electric current.

LED ARRAY (LED MODULE) — An assembly of one or more *LED* discrete electronic components on a printed wiring board, typically with optics and additional thermal, mechanical, and electrical interfaces.

LED CONTROL MODULE (LED CONTROLLER) — Electronic *circuitry* interposed between the power source and an *LED array* to 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*.

LED DRIVER — A power source that adjusts the voltage or current to *LEDs*, ranging in complexity from a resistor to a constant voltage or constant current power supply. Also referred to as Lamp Control Gear. (See also Power Source).

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

MEASUREMENT INDICATION UNIT (MIU) — The rms equivalent value of a 60 Hz sinusoidal leakage current in milliamperes (mA), adjusted to compensate as necessary for leakage currents composed of complex waveforms or frequencies other than 50 or 60 Hz. It is determined by dividing the output voltage (V3) in millivolts (mV) rms by 500 (the value in ohms of the resistance in parallel with V2) in the measurement instrument *circuit* in Figure 9.3.

PART, DEAD CONDUCTIVE (DEAD) — The current-carrying parts of electrical equipment are free from any electrical connection to a source of voltage and from electrical charge and do not have a voltage different from that of earth.

PART, HAZARDOUS LIVE — A part located in a *circuit* that is operating in excess of the *risk of electric shock* or risk of fire limits.

PART, LIVE (LIVE) — Electrically connected to a source of voltage difference, or electrically charged to have a voltage different from that of the earth; the term may be used in place of the term “current-carrying”, where the intent is clear, to avoid repetition of the longer term.

PLC (PERFORMANCE LEVEL CHARACTERISTIC) VALUE — An integer that defines a range of test values for a given electrical/mechanical property test for polymeric (plastic) materials as defined in the CAN/CSA C22.2 No. 0.17, Standard for Evaluation of Properties of Polymeric Materials.

POWER LIMITED CIRCUIT — Refers to a Class 2 circuit in accordance with Section 16 of CSA C22.1, Canadian Electrical Code, Part I, Safety Standard for Electrical Installations.

POWER SOURCE, CLASS 2 — An electrical source, such as a transformer or power supply that complies with the requirements of the CAN/CSA C22.2 No. 223, Standard for Power Supplies with Extra-Low-Voltage Class 2 Outputs, or both the CSA C22.2 No. 66.1, Standard for Low Voltage Transformers – Part 1: General Requirements and the CSA C22.2 No. 66.3, Standard for Low Voltage Transformers – Part 3: Class 2 Transformers

POWER SOURCE, ISOLATED LOW VOLTAGE LIMITED ENERGY (LVLE) — A source as defined by *Circuit, Isolated Low Voltage Limited Energy (LVLE)*.

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

RISK OF ELECTRIC SHOCK — A *risk of electric shock* exists between any two conductive parts or between a conductive part and earth ground if the open *circuit* potential is higher than 42.4 V peak ac (30 V rms) or 42.4 V dc, and the available current that flows between them exceeds 0.5 mA as determined by the Leakage Current Measurement Test, Section 9.7.

RISK OF FIRE — A risk of fire exists in all electrical *circuits* except:

- A A Class 2 circuit, or
- B An LVLE circuit.

UNIT — A generic term meaning any discrete device, subassembly, or assembly.

UNIT, FIXED — A unit intended to be permanently connected electrically to the wiring system.

UNIT, PORTABLE — A unit that is easily carried or conveyed by hand, and is provided with a power-supply cord for connection to the supply *circuit*.

UNIT, STATIONARY — A unit that is intended to be fastened in place or located in a dedicated space, and is provided with a power-supply cord for connection to the supply *circuit*.

4. GENERAL

4.1 COMPONENTS

4.1.1 Except as indicated in this clause, a component of a product covered by this ORD shall comply with the requirements for that component. See the Standards for Components Annex E for a list of standards covering components generally used in the products covered by this ORD.

4.1.2 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 ORD, or
- B Is superseded by a requirement in this ORD.

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

4.1.4 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.

4.2 UNITS OF MEASUREMENT

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

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

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

5. POWER SUPPLIES, LED DRIVERS, AND TRANSFORMERS

5.1 A power supply or *LED* driver that complies with any one of the following standards is considered to meet the intent of the requirements of this ORD:

- A CAN/CSA C22.2 No. 223, The Standard for Power Supplies with Extra-Low-Voltage Class 2 Outputs
- B CAN/CSA C22.2 No. 60950-1, The Standard for Information Technology Equipment - Safety - Part 1: General Requirements
- C CSA C22.2 No. 107.1, The Standard for Power Supplies

5.2 A transformer for use with *LED* units that complies with any one of the following is considered to meet the intent of the requirements of this ORD:

- A CSA C22.2 No. 66.1, The Standard for Low Voltage Transformers – Part 1: General Requirements; and
CSA C22.2 No. 66.3, Standard for Low Voltage Transformers – Part 3: Class 2 Transformers
- B CSA C22.2 No. 60065, Standard for Audio, Video and Similar Electronic Apparatus – Safety Requirements
- C CSA C22.2 No. 66.2, The Standard for Low Voltage Transformers – Part 2: General Purpose Transformers
- D CAN/CSA C22.2 No. 47, The Standard for Air-Cooler Transformers (Dry Type)

5.3 A power supply, *LED* driver, or transformer shall be used within its rated input, output, and environmental ratings.

6. ENVIRONMENTAL CONSIDERATIONS

6.1 A unit intended for *dry locations* only shall be so identified and shall not be provided with any information such as markings, instructions, or illustrations that implies or depicts damp or wet use.

6.2 A unit intended for *damp locations* shall be:

- A Subjected to the environmental tests of 9.12 unless all *live parts* and traces on the printed wiring board are potted (see 7.7) or conformal coated (see 8.7.2), and
- B Eligible to be marked as suitable for *damp locations*, and not be provided with any information such as markings, instructions, or illustrations that implies or depicts wet use.

6.3 A unit intended for use in wet locations shall:

- A Be subjected to the environmental tests of 9.12 unless all *live parts* and traces on the printed wiring board are potted (see 7.7) or conformal coated (see 8.7.2), and
- B If provided with a polymeric enclosure, comply with the Weatherometer Test of the CAN/CSA C22.2 No. 0.17, Standard for Evaluation of Properties of Polymeric Materials, and
- C If provided with a polymeric enclosure, three samples shall comply with the Physical Abuse Test of the CAN/CSA C22.2 No. 0.17, Standard for Evaluation of Properties of Polymeric Materials, immediately after a 3 h conditioning in a minus 35 ± 2.0 °C ambient, and
- D Be eligible to be marked as suitable for wet locations.

7. MECHANICAL CONSTRUCTION

7.1 GENERAL

7.1.1 A unit intended to be used in an application identified by one of the standards specified in 11.1.3 shall comply with the mechanical construction requirements of that standard. If an end-use application is not specified or identified, or if a particular construction feature is not covered by the identified standard, the unit shall comply with the mechanical construction requirements of this section.

7.1.2 An enclosure of a unit shall prevent contact with uninsulated parts that represent a *risk of electric shock*, contain any fire initiated within the unit, and prevent mechanical damage to internal parts.

7.1.3 *Circuits* that represent a *risk of electric shock* or risk of fire shall be provided with an enclosure that complies with 7.2 or 7.3.

7.1.4 *Circuits* that do not involve a *risk of electric shock* or risk of fire shall not be required to be provided within an enclosure. *Circuits* operating within *Class 2* or *LVLE* levels need not be enclosed.

7.1.5 An adhesive used to secure the enclosure of a product that poses a *risk of electric shock* or risk of fire shall comply with the adhesive support test of 9.11. Fusion techniques, such as solvent cementing, ultrasonic welding, electromagnetic induction, and thermal welding are permitted without test.

7.2 METAL THICKNESS

7.2.1 The thickness of a metal enclosure shall be in accordance with Table 7.1.

Exception: A part of an enclosure that complies with the mechanical strength tests for metal enclosures of 9.13 need not comply with the thickness specified in Table 7.1.

**TABLE 7.1
MINIMUM THICKNESS OF METAL ENCLOSURES**

Metal	At small, flat, unreinforced surfaces and at surfaces of a shape or size to provide adequate mechanical strength		At surfaces to which a wiring system is to be connected in the field		At relatively large unreinforced flat surfaces	
	mm	(in)	mm	(in)	mm	(in)
Die-cast	1.2	(3/64)	—	—	2.0	(5/64)
Cast malleable iron	1.6	(1/16)	—	—	2.4	(3/32)
Other cast metal	2.4	(3/32)	—	—	3.2	(1/8)
Uncoated sheet steel	0.66	(0.026)	0.81	(0.032)	0.66	(0.026)
Galvanized sheet steel	0.74	(0.029)	0.86	(0.034)	0.74	(0.029)
Nonferrous sheet metal other than copper	0.91	(0.036)	1.14	(0.045)	0.91	(0.036)

7.2.2 All ferrous metal parts, including hinges, bolts, and fasteners, exposed after assembly shall be protected against corrosion by painting, coating, or plating, except for edges, punched holes, and spot welds in prefinished steel, enclosed steel pipe, and hanger locations for painting or plating. Copper, aluminum, alloys of copper and aluminum, stainless steel, and similar materials having inherent resistance to atmospheric corrosion are not required to have additional corrosion protection.

7.2.3 A protective coating need not be applied to steel enclosure parts when:

- A The interior of an enclosure is completely filled with potting compound,
- B Flat metal surfaces are tightly clamped together, or
- C Where not practical due to bearings, sliding surfaces of a hinge or shaft, hinge pins, and similar parts.

7.3 POLYMERIC MATERIALS FOR ENCLOSURES AND ELECTRICAL INSULATION

7.3.1 A polymeric material shall have an electrical, mechanical with impact and mechanical with strength relative thermal index (RTI), or a generic thermal index as specified in the CAN/CSA C22.2 No. 0.17, Standard for Evaluation of Properties of Polymeric Materials, that is equal to or greater than the temperature measured during the temperature test of 9.3.

7.3.2 A polymeric material used as an enclosure shall comply with the material characteristic requirements identified in Table 7.2 based on the specific application.

TABLE 7.2
POLYMERIC ENCLOSURE REQUIREMENTS

performance characteristic	Power source		
	Class 2 & LVLE	Isolated non-Class 2	Direct connected
Enclosure Type Needed	None	Fire	Fire and Electrical
Relative Temperature Index (RTI)	No	Yes	Yes
Physical Abuse – Sphere Impact	No	Yes ^a	Yes ^a
Physical Abuse – Drop Test	No	Yes ^b	Yes ^b
Physical Abuse – Sphere Impact with pre-conditioning ^c	No	Yes ^c	Yes ^c
Weatherometer (UV Resistance)	No	Yes ^d	Yes ^d
Flammability	No	5VA ^{e, f}	5VA ^{e, f}
Mould Stress	No	Yes	Yes
Comparative Tracking Index (CTI)	No	No	PLC of 4 ^g
Hot Wire Ignition, (HWI)	No	No	PLC of 3 ^g
High Ampere Arc (HAI)	No	No	PLC of 2 ^g
^a Sphere (6.8J) impact for dry or damp location, fixed or stationary units ^b Drop test (1 m) impact for portable units ^c For damp or wet location, fixed units, to be conducted on three samples after cold conditioning in accordance with CAN/CSA C22.2 No. 0.17, Standard for Evaluation of Properties of Polymeric Materials, (immediately after conditioning for 3 h in either a 0 ± 2.0 °C ambient (for <i>damp location</i> units) or minus 35 ± 2.0 °C (for wet location units) ambient. ^d For wet location units ^e V2 for portable units and Track Lighting Luminaires ^f V1 for the lens (optic) of an <i>LED package</i> ^g Not required when all <i>live parts</i> are spaced at least 0.8 mm from the material			

7.3.3 A conductive coating applied to a surface such as the inside surface of a cover, enclosure, and the like shall comply with the appropriate requirements for metallized parts in Annex C of this ORD, unless it can be determined that flaking or peeling of the coating does not result in a reduction of spacing of electrical parts or the bridging of *live parts* that may result in a risk of fire or electric shock.

7.3.4 The lens (optic) of an *LED package* connected in a *circuit* that represents a *risk of electric shock* need not be provided within an enclosure if made of:

- A Glass, or
- B A polymeric material that complies with the dielectric voltage withstand test of 9.4 when a 500-V potential is applied between the electrical connections to the *LED* and the lens surface.

7.3.5 The lens (optic) of an *LED package* connected in a *circuit* that represents a risk of fire need not be provided within an enclosure if made of a material having a flammability rating as noted in footnote f of Table 7.2.

7.4 ENCLOSURE OPENINGS

7.4.1 Other than for supply connections, open holes shall not be permitted in any surface of a fire or *electrical enclosure*.

Exception: An open hole is permitted in an enclosure intended for installation on or over an outlet box when the outlet box will serve to complete the enclosure.

7.4.2 Open holes shall be permitted for units not intended for installation in a concealed space. Line of sight to open core and coil components shall be louvered or baffled.

7.5 CONDUCTOR PROTECTION

7.5.1 Conductors that pass over edges or through openings in metal shall be secured from contacting the edges or be protected from cutting and abrasion. For sheet metal less than 1.1 mm (0.042 in) thick, protection shall be provided by one of the following methods:

- A Rolling the edge of the metal not less than 120°,
- B A bushing or grommet of a material other than rubber at least 1.2 mm (0.047 in) thick, or
- C Glass sleeving at least 0.25 mm (0.010 in) thick.

7.6 STRAIN RELIEF

7.6.1 For any accessible conductor operating above *Class 2* or *LVLE* limits, a strain relief and cord push back means shall be provided that complies with the cord strain pushback relief test requirements of 9.8, where cord or lead wire displacement could result in:

- A Subjecting the supply cord or lead to mechanical damage,
- B Exposing the supply cord or lead to a temperature higher than that for which it is rated,
- C Reducing spacing (such as to a metal strain-relief clamp) below the minimum required values, or
- D Damage to internal connections or components.

Exception: A conductor embedded in an epoxy potting compound inside the enclosure at the cord entrance is considered to be provided with the necessary strain relief.

7.7 POTTING COMPOUND

7.7.1 Potting compound shall not leak, drip, or be released from a unit while under condition of testing, and shall not exceed its Relative Thermal Index (RTI) during the temperature test of 9.3.

7.7.2 Asphalt potting compound shall remain at least 15 °C (27 °F) below its softening point as determined by the Standard Test Methods for Softening Point of Resins Derived from Naval Stores by Ring-and-Ball Apparatus, ASTM E28.

8. ELECTRICAL CONSTRUCTION

8.1 GENERAL

8.1.1 A unit intended to be used in an application identified by one of the standards specified in 11.1.3 shall comply with the electrical construction requirements of that standard. If an end-use application is not specified or identified, or if a particular construction feature is not covered by the identified standard, the unit shall comply with the electrical construction requirements of this section.

8.1.2 A current-carrying part shall be silver, copper, a copper alloy, plated iron or steel, stainless steel, or other corrosion-resistant alloys acceptable for the application.

8.1.3 An uninsulated *live part* shall be secured so that it does not turn or shift in position if such motion results in a reduction of spacings below the minimum acceptable values.

8.1.4 Friction between surfaces is not acceptable as a means to prevent shifting or turning of a *live part* but a lock washer is acceptable.

8.2 ACCESSIBILITY

8.2.1 A *live part* that is a *risk of electric shock* shall be located so it is inaccessible to contact using the articulate probe shown in Figure 8.1, applying a force not exceeding 4.45 N (1 lbf).

8.2.2 A part that can be removed without using a tool is to be removed when determining accessibility to the probe.

8.2.3 An insulating *barrier* used to prevent access to *live parts* shall not be less than 0.71 mm (0.028 in) thick.

8.2.4 An insulating *barrier* used in conjunction with not less than half the required spacing through air is permitted to be less than 0.71 mm (0.028 in) thick, but not less than 0.33 mm (0.013 in) thick if the *barrier* or liner is of insulating material that is:

- A Resistant to moisture,
- B Of acceptable mechanical strength if exposed or otherwise likely to be subjected to mechanical damage,
- C Reliably held in place, and
- D Located so that it is not adversely affected by operation of the device – particularly arcing.

8.2.5 An insulating *barrier* in the secondary *circuit* where the potential is not more than 50 V is permitted to be less than 0.71 mm (0.028 in) thick but not less than 0.25 mm (0.010 in) thick if it is:

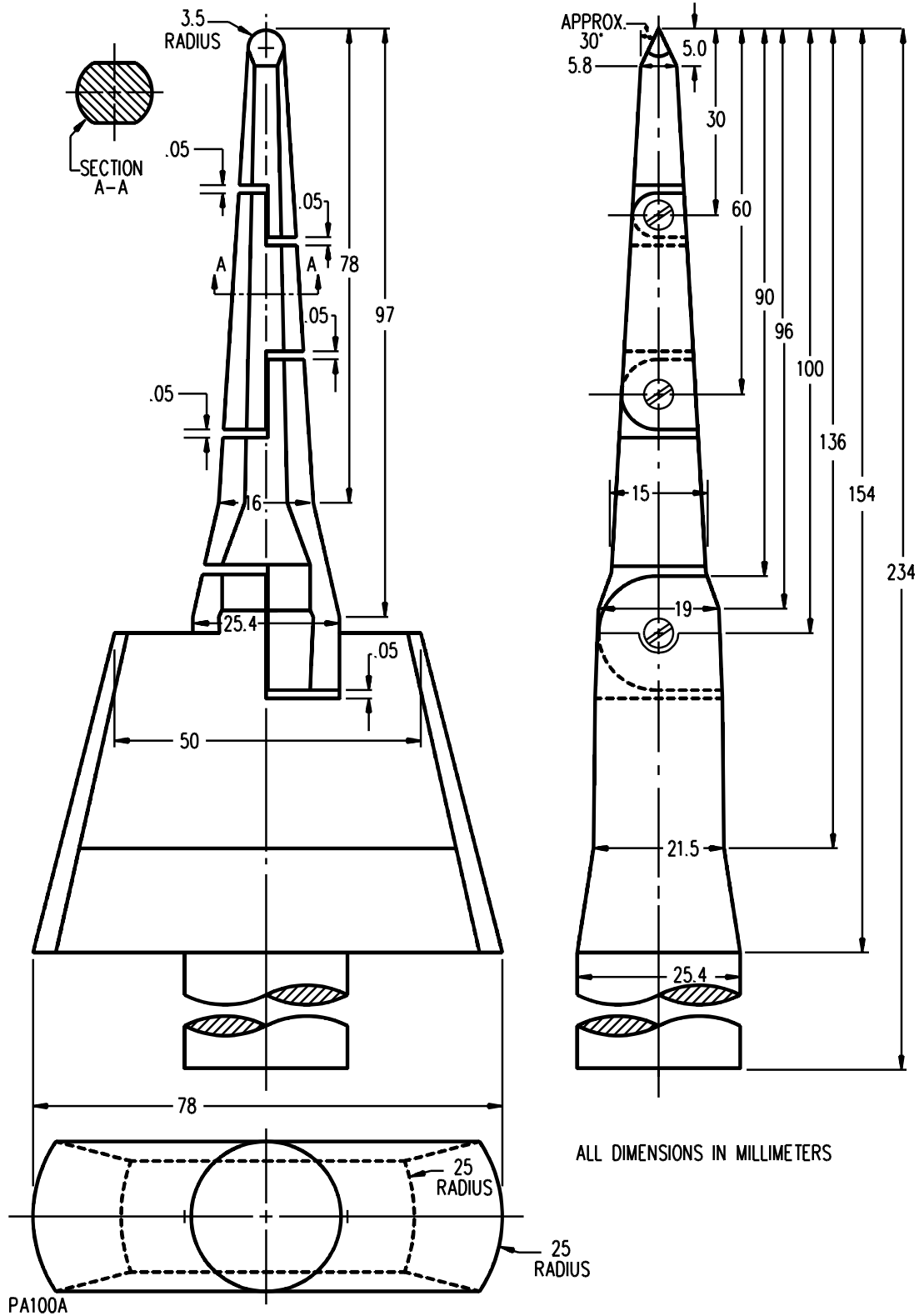
- A Resistant to moisture,
- B Of acceptable mechanical strength if exposed or otherwise likely to be subjected to mechanical damage, and
- C Reliably held in place.

8.2.6 An insulating *barrier* is permitted to have a thickness less than 0.71 mm (0.028 in) thick if separately evaluated as an internal *barrier*, and found to have insulating characteristics equivalent to 0.71 mm (0.028 in) thick vulcanized fiber.

8.3 INTERNAL WIRING

8.3.1 Internal wiring shall consist of insulated conductors having the mechanical strength, dielectric voltage withstand properties and ampacity for the application.

FIGURE 8.1
ARTICULATE PROBE WITH WEB STOP



8.3.2 Each splice and connection shall be mechanically secured, shall provide reliable electrical contact, and shall be provided with insulation at least equivalent to that of the voltage involved unless acceptable permanent spacing is maintained between the splice and all other uninsulated current-carrying parts at different potentials and non-current-carrying metal parts.

8.3.3 The electrical and mechanical connection between a conductor and any *circuitry* operating above *Class 2* or *LVLE* limits shall be contained within an enclosure and be inaccessible in accordance with 8.2.

8.3.4 Soldered connections shall be mechanically secured before soldering.

Exception No. 1: A wave-solder connection to a metal-clad printed-circuit board is considered acceptable without any further mechanical security.

Exception No. 2: A solder connection that is covered after soldering with two-part epoxy is considered to be mechanically secure.

Exception No. 3: A conductor passed through a hole on the board and soldered on the opposite side is considered mechanically secure.

Exception No. 4: Surface Mount Device (SMD) components and small components without integral leads do not need to be mechanically secured to the printed wiring board before soldering. Surface mounted connector receptacles and associated connectors with leads are acceptable without being mechanically secure in applications where the lead wires are not subject to movement after assembly.

Exception No. 5: The connection of a wire held rigidly in place without the use of solder so as to preclude any movement at the point of electrical connection is considered mechanically secure.

Exception No. 6: A soldered connection supplied by a Class 2 or LVLE source does not require additional mechanical securement if detachment will not reduce spacings to non-Class 2 or non-LVLE circuits below the applicable required spacings of 8.8.

8.3.5 Conductors shall be minimum 18 AWG (0.82 mm²), except as specified in 8.3.6 and 8.3.7, and shall be rated for the voltage, current, temperature, and conditions of service for normal operation.

8.3.6 Conductors of a size smaller than 18 AWG (0.82 mm²) but no smaller than 24 AWG (0.21 mm²) are permitted under the following conditions:

- A Where completely enclosed,
- B Where not subject to movement under normal use, and
- C In the secondary of a transformer or in a *circuit* containing solid-state devices.

8.3.7 Conductors of a size smaller than 24 AWG (0.21 mm²) are permitted when the conductors are in *Class 2* or *isolated LVLE circuits* only and are physically separated from all other *non-Class 2* or *non-isolated LVLE circuits*, such as by a *barrier* or reliably fixed spacing of minimum 6.4 mm (0.25 in).

8.4 SUPPLY AND LOAD CONNECTIONS

8.4.1 General

8.4.1.1 Input and output wiring shall comply with the requirements for internal wiring as specified in 8.3 in addition to the applicable requirements in this section.

8.4.1.2 Power limited circuit wiring that is intended to be external to a unit and intended to be routed within a building structure shall be of a type, suitable for the application (e.g. LVT, CMP, CMR, CMG, CM, CMX, CMH, or CMUC) as indicated in Table 19 of the Canadian Electrical Code - Part I, and in accordance with the requirements of the Standard for Communication Cables, CSA C22.2 No. 214 or the Standard for Extra-low-voltage Control Circuit Cable, Low-energy Control Cable, and Extra-low-voltage Control Cable, CSA C22.2 No. 35. The minimum conductor size shall be:

- A No. 19 AWG for a cable with two or more conductors,
- B No. 22 AWG for a cable with four or more conductors,
- C No. 24 AWG for a cable with six or more conductors, and
- D No. 26 AWG for a cable with ten or more conductors.

8.4.2 Permanently-connected units

8.4.2.1 Conduit connection

8.4.2.1.1 A unit intended to be connected to a branch *circuit* in accordance with the CSA C22.1, Canadian Electrical Code, Part 1, Safety Standard for Electrical Installations, shall be provided with either field-wiring leads complying with 8.4.2.2 or field-wiring terminals complying with 8.4.2.3.

8.4.2.1.2 Connection to a permanent wiring system shall be by providing a means for conduit connection.

8.4.2.1.3 Unthreaded openings for conduit and the area surrounding the opening shall comply with the requirements in Table 8.1.

TABLE 8.1
DIMENSIONS OF UNTHREADED OPENING FOR CONDUIT AND DIAMETER OF THE AREA
SURROUNDING THE OPENING

Nominal trade size of conduit	Unthreaded opening diameter ^a		On interior of component, minimum unobstructed diameter of flat surface surrounding conduit opening	
	mm	(in)	mm	(in)
1/2	22.2	(0.875)	28.09	(1.11)
3/4	28.2	(1.109)	34.04	(1.34)
1	34.9	(1.375)	42.85	(1.69)
1-1/4	44.0	(1.734)	55.07	(7.10)

^a A plus tolerance of 0.81 mm (0.032 in) and a minus tolerance of 0.38 mm (0.015 in) applies to the knockout diameter. Knockout diameters are to be measured other than at points where a tab attaches the knockout.

8.4.2.1.4 A threaded opening for conduit shall comply with Table 8.2. When tapped all the way through, the opening shall have at least 3.5 but no more than 5 threads and comply with the minimum unobstructed diameter of flat surface in Table 8.1 to accommodate the conduit bushing. When not tapped all the way through, the opening shall have at least 5 threads.