

**OTHER
RECOGNIZED
DOCUMENT**

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(Including amendment 1)

FLAT-PLATE PHOTOVOLTAIC MODULES AND PANELS



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FLAT-PLATE PHOTOVOLTAIC MODULES AND PANELS

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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.

FLAT-PLATE PHOTOVOLTAIC MODULES AND PANELS

PREFACE

This is the (Reaffirmed) First Edition of ULC/ORD-C1703, entitled "Flat-Plate Photovoltaic Modules and Panels".

A product that complies with these requirements will not necessarily be acceptable if, when examined and tested, it is found to have features not covered by this Document which may impair the result contemplated by these requirements.

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, English and French. All safety warnings must be in French and English. Attention is drawn to the possibility that some Canadian authorities may require additional markings and/or installation instructions to be in 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.

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 CSA Group
178 Rexdale Boulevard, Toronto, ON Canada M9W 1R3
Telephone: 416-747-4044

- CAN/CSA C22.2 No. 18-98, Outlet Boxes, Conduit Boxes, Fittings and Associated Hardware
- CAN/CSA C22.2 No. 94-M91, Special Purpose Enclosures
- CSA C22.1 1998, Safety Standard for Electrical Installations, Canadian Electrical Code, Part I
- CSA C22.2 No. 0.15-95, Adhesive Labels
- CSA C22.2 No. 0.17-00, Evaluation of Properties of Polymeric Materials
- CSA C22.2 No. 65-93, Wire Connectors

Code published by the National Research Council of Canada
Publication Sales M20, National Research Council of Canada,
Institute for Research in Construction, Ottawa, ON Canada K1A 0R6
Telephone: 613-993-2463; Canada 1-800-672-7990

- National Building Code of Canada 1995

Document Published by the Underwriters Laboratories of Canada, 7 Underwriters Road, Toronto, Ontario M1R 3A9 fax: (613) 757-3611 ext. 61744, (ULC Website) publications@ca.ul.com

- CAN/ULC-S107-M87, Fire Tests of Roof Coverings

Document published by Underwriters Laboratories Inc.
Available from COMM 2000, Inc.
1418 Brook Drive, Downers Grove, IL 60515, U.S.A.
Telephone: 1-888-853-3512

- UL 1439-1998, Tests for Sharpness of Edges on Equipment

Documents published by the American National Standards Institute
11 West 42nd Street, New York, NY 10036, U.S.A.
Telephone: (212) 642-4900

- ANSI Z97.1-1984, Safety Glazing Materials Used in Buildings-Safety Performance Specifications and Methods of Test

- ANSI/ISA MC96.1-1982, Temperature Measurement Thermocouples

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 A653/A653M-00 , Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
- ASTM A90/A90M-1995 , Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings
- ASTM B117-94, Method for Salt Spray (Fog) Testing
- ASTM D395-1998, Standard Test Methods for Rubber Property-Compression Set
- ASTM D412-1998, Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension
- ASTM D638M-1996, Standard Test Method for Tensile Properties of Plastics
- ASTM D2240-2000, Standard Test Method for Rubber Property-Durometer Hardness
- ASTM D2303-97 , Standard Test Methods for Liquid-Contaminant, Inclined-Plane Tracking and Erosion of Insulating Materials
- ASTM E28-99, Standard Test Methods for Softening Point of Resins Derived from Naval Stores by Ring-and-Ball Apparatus
- ASTM E162-98 , Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source
- ASTM E927-91, Standard Specifications for Solar Simulation for Terrestrial Photovoltaic Testing
- ASTM E1036M-96, Standard Test Methods of Testing Electrical Performance of Nonconcentrator Terrestrial Photovoltaic Modules and Arrays Using Reference Cells
- ASTM G159-98, Standard Tables for References Solar Spectral Irradiance at Air Mass 1.5: Direct Normal and Hemispherical for 37 Degree Tilted Surface,

Documents published by the International Electrotechnical Commission
Available from IHS Canada/Micromedia
240 Catherine Street, Suite 305, Ottawa ON Canada K2P 2G8
Telephone: (613) 237-4250

- IEC 60891-87, Procedures for Temperature Irradiance Corrections to Measure I-V Characteristics of Crystalline Silicon Photovoltaic Devices
- IEC 60904-1 (1987), Photovoltaic Devices, Part 1: Measurement of Photovoltaic Current-Voltage Characteristics

- IEC 60904-3 (1989), Photovoltaic Devices, Part 3: Measurement Principles for Terrestrial Photovoltaic (PV) Solar Devices With Spectral Irradiance Data
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1 SCOPE

1.1 These requirements cover flat-plate photovoltaic *modules* and *panels* intended for installation on or integral with buildings, or to be free-standing (that is, not attached to buildings), in accordance with CSA C22.1, Safety Standard for Electrical Installations, Canadian Electrical Code, Part 1, and the National Building Code of Canada.

1.2 These requirements cover *modules* and *panels* intended for use in systems with a maximum system voltage of 1000 V or less.

1.3 These requirements also cover components intended to provide electrical connection to and mounting facilities for flat-plate photovoltaic *modules* and *panels*.

1.4 These requirements do not cover:

- A Equipment intended to accept the electrical output from the *array*, such as power conditioning units (inverters) and batteries;
- B Any tracking mechanism;
- C *Cell* assemblies intended to operate under concentrated sunlight;
- D Optical concentrators; or
- E Combination photovoltaic-thermal *modules* or *panels*.

1.5 A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this Document, and that involves a risk of fire or of *electric shock* or injury to persons shall be evaluated using appropriate additional component and end-product requirements to maintain the level of safety as originally anticipated by the intent of this Document. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this Document does not comply with this Document. Revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this Document.

2. GLOSSARY

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

AIR MASS (AM) — A dimensionless quantity, the ratio of:

- A The actual path length of radiation through the atmosphere to
- B The vertical path length of radiation through the atmosphere to sea level. At sea level, for all but very high zenith angles (Θ_z) (the angle subtended by the zenith and the line of sight to the sun),

($AM = \sec \Theta_z$)

ARRAY — A mechanically integrated assembly of *modules* or *panels* with a support structure and foundation, tracking, and other components, if used, to form a power-producing unit.

BLOCKING DIODE — A diode used to block *reverse current* into a photovoltaic-source circuit.

BYPASS DIODE — A diode connected across one or more *cells, modules, or panels* in the forward current direction to allow current to bypass such *cells, modules, or panels*.

CELL — The basic photovoltaic device that generates electricity when exposed to light.

ELECTRIC SHOCK — A risk of electric shock is considered to exist at a part if the potential between the part and earth ground or any other accessible part is more than 30 volts dc and the leakage current exceeds the values specified in Table 1.

ENCAPSULANT — Transparent insulating material enclosing the *cells* and *cell interconnects*.

INTERCONNECT — A conductor within a *module* that provides a mechanism for conducting electricity between *cells*.

MAXIMUM POWER (P_{max}) — The point on the current-versus-voltage curve of a *module*, at *standard test conditions*, where the product of current and voltage is maximum.

MAXIMUM SYSTEM VOLTAGE — The sum of the maximum open-circuit voltages of the maximum number of *modules* or *panels* to be connected in series in a system.

METALLIZATION — An electrically conductive metal coating on the surface of a *cell*.

MODULE (FLAT-PLATE) — The smallest complete environmentally protected assembly of interconnected solar *cells*.

The equilibrium *cell* junction temperature corresponding to nominal *module* service operating conditions in a reference environment of 80 mW/cm² irradiance, 20°C ambient air temperature, 1 m/s wind across the *module* from side to side, an electrically open circuit, and a mounting method in accordance with Clause 5.2.6 and Clause 5.2.7

PANEL (FLAT-PLATE) — An assembly of *modules* mechanically fastened together and pre-wired to form a self-contained unit.

RATED OPERATING VOLTAGE — The voltage, $\pm 10\%$, at which *maximum power* is available from the *module* or *panel* under *standard test conditions*.

RATED OPEN-CIRCUIT VOLTAGE (V_{oc}) — The no-load voltage available at the output terminals of the *module* at *standard test conditions*.

REVERSE CURRENT — Current flowing in a reverse direction to the normal direction resulting from a normally illuminated PV *module*.

STANDARD TEST CONDITIONS (STC) — Test conditions consisting of:

- A 100 mW/cm² irradiance;
- B AM 1.5 spectrum; and
- C 25°C *cell* temperature

UNCONDITIONED MODULES OR SPECIMENS — *Modules* or specimens that have not been previously subjected to tests or environmental exposures.

3. COMPONENTS

3.1 Except as indicated in Subsection 3.2, a component of a product covered by this Document shall comply with the requirements for that component. See Reference Publications for a list of documents covering components generally used in the products covered by this Other Recognized Document.

3.2 A component need not comply with a specific requirement that:

- A Involves a feature or characteristic not needed in the application of the component covered by this Document; or
- B Is superseded by a requirement in this Document.

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

3.4 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. CONSTRUCTION

4.1 GENERAL

4.1.1 A *module* shall be completely assembled when shipped from the factory. A *panel* may be completely assembled when shipped from the factory, or may be provided in subassemblies, provided assembly of the *panel* does not involve any action that is likely to affect compliance with the requirements of this Document.

EXCEPTION: An assembly part need not be affixed to the *module* at the factory.

4.1.2 A *module* or *panel* assembly bolt, screw, or other part shall not be intended for securing the complete device to the supporting surface or frame.

4.1.3 Incorporation of a *module* or *panel* into the final assembly shall not require any alteration of the *module* or *panel* unless specific details describing necessary modification(s) for alternate installation(s) are provided in the installation instructions. If a *module* or *panel* must bear a definite relationship to another for the intended installation and operation of the *array* (for example, to allow connectors to mate), it shall be constructed to permit it to be incorporated into the *array* in the correct relationship without the need for alteration.

4.1.4 The construction of a product shall be such that during installation it will not be necessary to alter or remove any cover, baffle, insulation, or shield that is required to reduce the likelihood of:

- A Excessive temperatures; or
- B Unintentional contact with a part that may involve a risk of *electric shock*.

EXCEPTION: A cover of a wiring compartment providing access to a connection means that may involve a risk of *electric shock* may be removable to allow for the making of electrical connections.

4.1.5 Parts shall be prevented from loosening or turning if such loosening or turning may result in a risk of fire, *electric shock*, or injury to persons.

4.1.6 Friction between surfaces is not acceptable as the sole means to inhibit the turning or loosening of a part, but a lock washer properly applied is acceptable for this purpose.

4.1.7 An adjustable or movable structural part shall be provided with a locking device to reduce the likelihood of unintentional shifting, if any such shifting may result in a risk of fire, *electric shock*, or injury to persons.

4.1.8 Metals used in locations that may be wet or moist shall not be employed in combinations that could result in deterioration of either metal such that the product would not comply with the requirements in this Document.

4.1.9 Edges, projections, and corners of photovoltaic *modules* and *panels* shall be such as to reduce the risk of injury to persons.

4.1.10 Whenever a referee measurement is necessary to determine that a part as mentioned in Clause 4.1.9 is not sufficiently sharp to constitute a risk of injury to persons, the method described in the requirements in the Standard for Tests for Sharpness of Edges on Equipment, UL 1439, is to be employed.

4.2 POLYMERIC MATERIALS

4.2.1 A polymeric material system serving as the enclosure of a part involving a risk of fire or *electric shock* shall comply with the applicable requirements in CSA C22.2 No. 0.17, Evaluation of Properties of Polymeric Materials, concerning:

- A Flammability,
- B Ultraviolet light exposure,
- C Water exposure and immersion, and
- D Hot-wire ignition (HWI).

EXCEPTION: The flammability tests prescribed in CSA C22.2 No. 0.17 do not apply to the superstrate, encapsulation, and substrate. These materials shall comply with Clause 4.2.4.

4.2.2 A polymeric material system serving as the support or insulation of a part involving a risk of fire or *electric shock* shall:

- A Have a flammability classification of HB, V-2, V-1, or V-0 determined in accordance with CSA C22.2 No. 0.17, Evaluation of Properties of Polymeric Materials;
- B Have a minimum High-Current Arc Ignition performance level category (PLC) in accordance with the following:

Flammability Classification	High-Current Arc Ignition, PLC
HB	1
V-2	2
V-1	2
V-0	3

- C Have a Comparative Tracking Index performance level category (PLC) of 2 or better, when the system voltage rating is 600 V or less, as determined in accordance with CSA C22.2 No. 0.17, Evaluation of Properties of Polymeric Materials;
- D Have an Inclined Plane Tracking (ASTM D2303, Standard Test Method for Liquid-Contaminant, Incline-Plane Tracking and Erosion of Insulating Materials) rating of 1 h using the time to track method at 2.5 kV when the system voltage rating is in the range 601 – 1000 V; and
- E Comply with the requirements for exposure to ultraviolet light as determined in accordance with CSA C22.2 No. 0.17, Evaluation of Properties of Polymeric Materials, when exposed to light during normal operation of the product. Polymeric materials that are exposed to sunlight and are protected by glass, or other transparent medium, shall be tested with an equivalent layer of that medium attenuating the ultraviolet light exposure during the test.

EXCEPTION: *encapsulant* materials between the substrate and the superstrate are not required to comply with this requirement.

4.2.3 A polymeric substrate or superstrate shall have a thermal index, both electrical and mechanical, as determined in accordance with CSA C22.2 No. 0.17, Evaluation of Properties of Polymeric Materials, not less than 90°C. In addition, the thermal index shall not be less than 20°C above the measured operating temperature of the material. All other polymeric materials shall have a thermal index (electrical and mechanical) 20°C above the measured operating temperature. The measured operating temperature is the temperature measured during the open-circuit mode for Temperature Test, Subsection 4.2, or the temperature during the short-circuit mode, whichever is greater.

4.2.4 A polymeric material that serves as the outer enclosure for a *module* or *panel* that:

- A Is intended to be installed in a multi-*module* or multi-*panel* system; or
- B Has an exposed surface area greater than 0.93 m² or a single dimension larger than 1.83 m.

shall have a flame spread index of 100 or less as determined under the Standard Test Method of Test for Surface Flammability of Materials Using a Radiant Heat Energy Source, ASTM E162.

EXCEPTION No. 1: A material that serves as the outer enclosure for a small cover or box used for electrical connections is not required to have an index of 100 or less.

EXCEPTION No. 2: A material that serves as the outer enclosure for a *module* or *panel* complying with Subsection 4.11, Fire Resistance, meets the intent of this requirement.

4.2.5 A barrier or liner of polymeric insulating material providing the sole insulation between a live part and an accessible metal part or between uninsulated live parts not of the same potential shall be of adequate thickness and of a material appropriate for the application. The barrier or liner shall be held in place and shall not be adversely affected to the extent that its necessary properties may fall below the minimum acceptable values for the application.

4.3 CURRENT-CARRYING PARTS AND INTERNAL WIRING

4.3.1 A current-carrying part and wiring shall have the mechanical strength and ampacity necessary for the service.

4.3.2 A current-carrying part shall be of silver, a copper-base alloy, stainless steel, aluminum, or other material appropriate for the application.

4.3.3 Wiring used in a *module* or *panel* shall be insulated and acceptable for the purpose, when considered with respect to temperature, voltage, and the conditions of service to which the wiring is likely to be subjected within the equipment.

4.3.4 A splice shall be provided with insulation equivalent to that required for the wires involved.

4.3.5 A joint or connection shall be mechanically secure and shall provide electrical contact without strain on connections and terminals. Soldered connections between *interconnects* and *metallizations* are considered mechanically secure when held by encapsulation systems.

4.3.6 An uninsulated live part, including a terminal, shall be secured to its supporting surface by a method other than friction between surfaces so that it will be prevented from turning or shifting in position if such motion may result in reduction of spacings to less than required in Table 2 and Table 3.

4.3.7 Strain relief shall be provided so that stress on a lead intended for field connection, or otherwise likely to be handled in the field, including a flexible cord, is not transmitted to the connection inside the *module* or *panel*.

4.3.8 The wiring of a *module* or *panel* shall be located so that after installation of the product in the intended manner it will not be exposed to the degrading effects of direct sunlight.

EXCEPTION: Wiring rated sunlight resistant need not be so located.

4.4 WIREWAYS

4.4.1 An enclosure for wire shall be smooth and free from sharp edges, burrs, or the like that may damage insulation or conductors.

4.5 CONNECTION MEANS

4.5.1 In Clauses 4.5.2 through 4.5.10, connection means are considered to be those to which field-installed wiring is connected when the product is installed. Connection means may be within a wiring compartment, may be connectors outside of a wiring compartment, or may be another means acceptable for the application.

4.5.2 A *module* or *panel* shall be capable of accommodating at least one of the acceptable wiring systems described in CSA C22.1, Safety Standard for Electrical Installations, Canadian Electrical Code, Part I.

4.5.3 A *module* or *panel* shall be provided with wiring terminals, connectors, or leads to accommodate current-carrying conductors of the load circuit.

4.5.4 The connection means for a *module* or *panel* shall be so located that after installation of the product in the intended manner they will not be exposed to the degrading effects of direct sunlight.

EXCEPTION: Connection means rated for use in direct sunlight need not be so located.

4.5.5 A lead that is intended to be spliced in the field to a circuit conductor shall not be smaller than 0.82 mm² (No. 18 AWG) and the insulation shall not be less than 0.8 mm thick.

4.5.6 The free length of a lead for field connection shall be at least 152 mm.

4.5.7 A wire-binding screw or stud- and nut-type terminal used to terminate conductors not larger than 5.3 mm² (No. 10 AWG) shall comply with the following:

- A A threaded screw or stud shall be of non-ferrous metal, stainless steel, or plated steel appropriate for the application, shall not have more than 32 threads per inch, and shall not be smaller than No. 8 when used to terminate 5.3 or 3.3 mm² (No. 10 or 12 AWG) wire; and not smaller than No. 6 when used to terminate 2.1 mm² (No. 14 AWG) and smaller wire. A wire-binding screw or stud- and nut-type terminal shall be provided with upturned lugs, a cupped washer, a barrier, or other equivalent means to retain the wire in position. The head of a wire-binding screw used to terminate No. 12 AWG or smaller wire shall have a minimum diameter of 7.0 mm and the head of a screw used to terminate No. 10 AWG wire shall have a minimum diameter of 8.3 mm; and
- B A tapped terminal plate shall:
 - i) Be of non-ferrous metal,
 - ii) Not have less than two full screw threads, and
 - iii) Be of metal not less than 1.27 mm thick when used to terminate No. 10 or 12 AWG wire and not less than 0.76 mm thick when used to terminate a No. 14 AWG or smaller wire. Unextruded metal for screw threads obtained by extruding a hole shall have a thickness not less than the pitch of the screw thread.

4.5.8 A wire connector intended to accommodate conductors shall comply with CSA C22.2 No. 65, Wire Connectors.

4.5.9 A separable multipole connector shall be polarized. If two or more separable connectors are provided, they shall be configured or arranged so that the mating connector for one will not be accepted by the other, and vice-versa, if such is an improper connection.

4.5.10 For a connector incorporating a grounding member, the grounding member shall be the first to make and the last to break contact with the mating connector.

4.6 BONDING AND GROUNDING

4.6.1 A *module* or *panel* shall have a means for grounding all accessible conductive parts. The grounding means shall comply with the applicable requirements in Subsection 4.5, Connection Means. The grounding means shall be bonded to each conductive part of the *module* or *panel* that is accessible during normal use. The grounding means shall be described in detail in the installation manual. See Installation and Assembly Instructions, Subsection 7.2.

EXCEPTION: When the grounding means is a *module* or *panel* mounting member intended to contact an *array* structural member, the *module* or *panel* grounding means are not required to comply with the requirements for Connection Means, Subsection 4.5.

4.6.2 Routine maintenance of a *module* or *panel* shall not involve breaking or disturbing the bonding path. A bolt, screw, or other part used for bonding purposes within a *module* or *panel* shall not be intended for securing the complete device to the supporting surface or frame.

4.6.3 Bonding shall be by a positive means, such as clamping, riveting, bolted or screwed connections, or welding, soldering (see Clause 4.6.5) or brazing. The bonding connection shall penetrate non-conductive coatings, such as paint or vitreous enamel.

4.6.4 A bolted or screwed connection that incorporates a star washer under the screwhead or a serrated screwhead may be acceptable for penetrating non-conductive coatings. If the bonding means depends upon screw threads, two or more screws or two full threads of a single screw shall engage the metal.

4.6.5 All joints in the bonding path shall be mechanically secure independent of any soldering.

4.6.6 A separate bonding conductor or strap shall:

- A Be of copper, copper alloy, or other material acceptable for use as an electrical conductor;
- B Be protected from mechanical damage; and
- C Not be secured by a removable fastener used for any purpose other than bonding, unless the bonding conductor is unlikely to be omitted after removal and replacement of the fastener.

4.6.7 A ferrous metal part in the grounding path shall be protected against corrosion by metallic or non-metallic coatings, such as painting, galvanizing, or plating. Stainless steel is acceptable without additional coating.

4.6.8 A metal-to-metal multiple-bearing pin-type hinge is considered to be an acceptable means for bonding.

4.6.9 A terminal of a *module* or *panel* (for example, a wire-binding screw, a pressure wire connector, or a nut-on-stud) intended to accommodate an equipment bonding conductor shall be identified by being marked "G" or "⊕", or shall have a green-coloured part. No other terminal shall be so identified.

4.6.10 If a marking is used to identify an equipment-bonding terminal, it shall be located on or adjacent to the terminal, or on a wiring diagram affixed to the *module* or *panel* near the terminal.

4.6.11 If a green-coloured part is used to identify the equipment-bonding terminal, it shall be readily visible during and after installation of the equipment-grounding conductor and the portion of the terminal that is green shall not be readily removable from the remainder of the terminal.

4.6.12 The surface of a lead of a *module* or *panel* intended for the connection of an equipment-bonding conductor shall be identified by insulation coloured green, or green with yellow stripe(s). No other lead shall be so identified.

4.7 SPACINGS

4.7.1 The spacings between uninsulated live parts not of the same potential and between a live part and an accessible metal part, shall not be less than the values specified in Tables 2 and 3.

EXCEPTION: These spacing requirements do not apply to the inherent spacings of a component; such spacings shall comply with the requirements for the component in question.

4.7.2 The spacings at a field-wiring terminal are to be measured with and without wire connected to the terminal. The wire is to be connected, as it would be in actual use. If the terminal will properly accommodate it, and if the product is not marked to restrict its use, the wire is to be one size larger than that required; otherwise, the wire is to be the size required.

4.7.3 Surfaces separated by a gap of 0.33 mm or less are considered to be in contact with each other for the purpose of judging over surface spacings.

4.7.4 In Tables 2 and 3, the potential involved is the maximum voltage that may exist between parts during any anticipated use of the *module* or *panel*.

4.7.5 A barrier or liner of electrical grade fibre providing the sole insulation between a live part and an accessible metal part or between uninsulated live parts not of the same potential shall not be less than 0.71 mm thick. The barrier or liner shall be held in place and shall not be adversely affected to the extent that its necessary properties may fall below the minimum values required for the application.

4.8 WIRING COMPONENTS

4.8.1 GENERAL

4.8.1.1 A wiring compartment shall comply with the requirements specified in Clauses 4.8.1.2 through 4.8.1.6; and Clause 4.8.2 (Metallic Wiring Compartments), and Clauses 4.8.3.1 through 4.8.3.4.

4.8.1.2 The internal volume of the wiring compartment shall be in accordance with Table 4. The volume shall be calculated for each conductor intended to be installed, including integral conductors of the *module* or *panel*. In the space being evaluated for the minimum required volume, no enclosure dimension shall be less than 19.1 mm. The internal volume shall be determined using water as prescribed for the volume measurement test in CAN/CSA C22.2 No. 18, Outlet Boxes, Conduit Boxes, Fittings and Associated Hardware.

4.8.1.3 A wiring compartment shall have provision for accommodating a wiring system employing a raceway or cable.

4.8.1.4 A wiring compartment shall have no more than one opening when the *module* or *panel* is shipped from the factory. Tapped holes with screwed-in plugs and knockouts are not considered openings.

4.8.1.5 Gaskets and seals shall not deteriorate beyond limits during accelerated ageing, and shall not be used where they may be subject to flexing during normal operation. See Accelerated Ageing Test, Subsection 5.16.

4.8.1.6 A wiring compartment that is secured to a substrate by means of an adhesive shall comply with Wiring Compartment Securement Test, Subsection 5.24.

4.8.2 Metallic Wiring Compartments

4.8.2.1 A wiring compartment of sheet steel shall have a wall thickness of not less than 1.35 mm if uncoated, or 1.42 mm if zinc coated.

4.8.2.2 A wiring compartment of sheet aluminum shall have a wall thickness of not less than 1.59 mm.

4.8.2.3 A wiring compartment of cast iron, aluminum, brass, or bronze shall have a wall thickness of not less than 2.4 mm.

4.8.2.4 A threaded hole in a metal wiring compartment intended for the connection of rigid metal conduit shall be reinforced to provide metal not less than 6.4 mm thick, and shall be tapered unless a conduit end stop is provided.

4.8.2.5 If threads for the connection of conduit are tapped all the way through a hole in a compartment wall, or if an equivalent construction is employed, there shall not be less than 3-1/2 nor more than five threads in the metal and the construction shall be such that a conduit bushing can be attached as intended.

4.8.2.6 If threads for the connection of conduit are not tapped all the way through a hole in a compartment wall, there shall not be less than five full threads in the metal and there shall be a smooth, rounded inlet hole for the conductors which shall afford protection to the conductors equivalent to that provided by a standard conduit bushing. The throat diameter of an inlet hole shall be within the limits specified in CAN/CSA C22.2 No. 18, Outlet Boxes, Conduit Boxes, Fittings and Associated Hardware.

4.8.2.7 For a non-threaded opening in a metal wiring compartment intended to accommodate rigid metallic conduit, a flat surface of sufficient area as described in CAN/CSA C22.2 No. 18, Outlet Boxes, Conduit Boxes, Fittings and Associated Hardware, shall be provided around the opening to accept the bearing surfaces of the bushing and lock washer.

4.8.3 Non-Metallic Wiring Compartments

4.8.3.1 The considerations mentioned in Clause 4.2.1 concerning polymeric materials serving as the enclosure apply to non-metallic wiring compartments.

4.8.3.2 A non-metallic wiring compartment intended to accommodate non-metallic conduit shall have:

- A One or more unthreaded conduit-connection sockets integral with the compartment that comply with the requirements in CAN/CSA C22.2 No. 18, Outlet Boxes, Conduit Boxes, Fittings and Associated Hardware;
- B One or more threaded or unthreaded openings for a conduit-connection socket; or
- C One or more knockouts that comply with CAN/CSA C22.2 No. 18, Outlet Boxes, Conduit Boxes, Fittings and Associated Hardware.

4.8.3.3 With reference to Clause 4.8.3.2(B), a *module* or *panel* provided with a non-metallic wiring compartment having a threaded opening shall be marked in accordance with Clause 7.1.7.

4.8.3.4 In a non-metallic compartment, a socket for the connection of non-metallic conduit shall provide a positive end stop for the conduit; and the socket diameters, the throat diameter at the entrance to the box, the socket depths, and the wall thickness of the socket shall be within the limits specified in CAN/CSA C22.2 No. 18, Outlet Boxes, Conduit Boxes, Fittings and Associated Hardware.

4.8.3.5 A knockout or opening in a non-metallic wiring compartment intended to accommodate rigid non-metallic conduit shall comply with the requirements of CAN/CSA C22.2 No. 18, Outlet Boxes, Conduit Boxes, Fittings and Associated Hardware.

- A A Hot-dipped mill galvanized sheet steel conforming with the coating designation G60 or A60 in the Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM A653/A653M, with not less than 40% of the zinc on any side, based on the minimum single spot-test requirement in this ASTM specification. The weight of zinc coating may be determined by any method; however, in case of question, the weight of coating shall be established in accordance with the Standard Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings, ASTM A90/A90M;