CSA STANDARDS

C22.2 No. 271-11
(reaffirmed 2016)

Photovoltaic cables

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CANADIAN STANDARDS ASSOCIATION

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C22.2 No. 271-11
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Title: *Photovoltaic cables* — originally published May 2011

The following revisions have been formally approved and are marked by the symbol delta (Δ) in the margin on the attached replacement pages:

Revised	Clauses 5.2, 5.7.2.2, 6.13, 6.19, and Table 4
New	None
Deleted	Clause 6.17

- Update your copy by inserting these revised pages.
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C22.2 No. 271-11
Photovoltaic cables

1 Scope

1.1
This Standard specifies requirements for photovoltaic single-conductor and multi-conductor thermoset-insulated wires and cables that are rated 600, 1000, or 2000 V, suitable for ac and dc systems, and intended for installation in accordance with the *Canadian Electrical Code, Part I*.

Notes:

(1) *See Table 1 for the wire and cable types covered by this Standard.*

(2) *See Table 2 for voltage and maximum conductor temperature ratings for the wire and cable types covered by this Standard.*

1.2
In CSA standards, "shall" is used to express a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard; "should" is used to express a recommendation or that which is advised but not required; and "may" is used to express an option or that which is permissible within the limits of the standard.

Notes accompanying clauses do not include requirements or alternative requirements; the purpose of a note accompanying a clause is to separate from the text explanatory or informative material.

Notes to tables and figures are considered part of the table or figure and may be written as requirements.

Annexes are designated normative (mandatory) or informative (nonmandatory) to define their application.

1.3
The values given in SI units are the units of record for the purposes of this Standard. The values given in parentheses are for information and comparison only.

2 Reference publications
This Standard refers to the following publications, and where such reference is made, it shall be to the edition listed below, including all amendments published thereto.

CSA (Canadian Standards Association)

C22.1-09
Canadian Electrical Code, Part I

C22.2 No. 0-10
General requirements — Canadian Electrical Code, Part II

C22.2 No. 38-10
Thermoset-insulated wires and cables

CAN/CSA-C22.2 No. 2556-07
Wire and cable test methods

3 Definitions

The following definitions shall apply in this Standard:

CP — a thermoset compound whose characteristic constituent is chlorosulfonated polyethylene.

CPE — a thermoset compound or a thermoplastic compound whose characteristic constituent is chlorinated polyethylene.

EP — a thermoset compound whose characteristic constituent is a copolymer of ethylene and propylene; a terpolymer of ethylene, propylene, and a small amount of non-conjugated diene; or a blend of both.

EPCV — a thermoset compound whose characteristic constituent is a co-vulcanizate of ethylene and propylene with polyethylene.

NBR/PVC — a thermoset compound whose characteristic constituents are acrylonitrile butadiene rubber and polyvinyl chloride.

PVC — a thermoplastic compound whose characteristic constituent is polyvinyl chloride.

RPV — thermoset photovoltaic cable.

RPVU — thermoset photovoltaic cable suitable for direct burial.

XL — a thermoset compound whose characteristic constituents are cross-linked polyethylene and cross-linked ethylene copolymers, or blends thereof.

4 General requirements

General requirements applicable to this Standard are given in CSA C22.2 No. 0.

5 Construction

5.1 General

The construction of photovoltaic cables shall comply with the RW90 or RWU90 requirements specified in CSA C22.2 No. 38 and with the requirements of this Standard.

Δ 5.2 Conductors

Circuit conductors shall be stranded aluminum conductor material (ACM) or stranded copper conductors in accordance with CSA C22.2 No. 38. Separate bonding conductors may be solid or stranded ACM or copper.

5.3 Insulation

5.3.1

EP, EPCV, and XL may be used as insulation material for photovoltaic cables.

5.3.2

The physical properties of insulation shall meet the requirements of Table 3 when determined in accordance with the physical properties (ultimate elongation and tensile strength) test specified in CAN/CSA-CSA C22.2 No. 2556.

5.3.3
The insulation thickness of 600, 1000, and 2000 V RPV cables shall be the same as the insulation thickness of 600, 1000, and 2000 V RW90 cables, respectively, specified in CSA C22.2 No. 38. The insulation thickness of 1000 and 2000 V RPVU cables shall be the same as the insulation thickness of RWU90 1000 V cables specified in CSA C22.2 No. 38.

5.3.4
Insulation shall meet the weather (sunlight) resistance test requirements specified in Clause 6.15.

5.4 Conductor identification

5.4.1 Polarity identification for dc applications
Polarity identification shall be optional for single-conductor cables. When used, it shall follow the requirements for multi-conductor cables specified in this Clause.

In a multi-conductor cable with an overall jacket or multi-conductor assembly, the polarity of the conductors shall be identified by one of the following means:

(a) printing ("+/–", "pos/neg", or "positive/negative") on the insulation or the jacket over single-insulated conductors, where applicable, repeated at a maximum of 300 mm (12 in) intervals;
(b) a solid colour (red for positive, black for negative) for the insulation or the jacket over single-insulated conductors, where applicable; or
(c) a coloured stripe over the outermost layer of single-insulated conductors, where applicable. The coloured stripe* shall be weather (sunlight) resistant.

When a bonding conductor is included in the assembly, it shall be green or green with one or more yellow stripes. In the case of a multi-conductor cable with an overall jacket, the bonding conductor may be uninsulated or, if insulated, shall be green or green with one or more yellow stripes. The bonding conductor shall meet the size requirements specified in Table 25 of CSA C22.2 No. 38.

**Red for positive, black for negative.*

5.4.2 Phase identification for ac applications
Phase identification shall be in accordance with CSA C22.2 No. 38.

5.4.3 Separate (single) bonding conductor identification
Single-conductor cables used as separate bonding conductors shall be identified as follows:

(a) green or green with yellow stripe(s) for sizes 2 AWG and smaller; and
(b) as specified by the *Canadian Electrical Code, Part I*, for sizes larger than 2 AWG.

5.5 Fillers
When used, fillers shall meet the requirements of CSA C22.2 No. 38.

5.6 Jacket separators
Jacket separators shall meet the requirements of CSA C22.2 No. 38.

5.7 Jackets

5.7.1 Jackets over single-insulated conductors

5.7.1.1
CP, CPE, NBR/PVC, neoprene, and XL may be used as jacket or covering material.

Note: *Depending on their composition (e.g., plasticizers), CP, CPE, and NBR/PVC might not be appropriate for single-conductor cables.*

5.7.1.2
A single-conductor cable may be unjacketed or have a jacket applied over the outer surface of the insulation in accordance with Table 1. The temperature rating of the jacket shall be the same as that of the insulated conductor. The physical properties of jackets shall meet the requirements of Table 4 when determined in accordance with the physical properties (ultimate elongation and tensile strength) test specified in CAN/CSA-C22.2 No. 2556.

5.7.1.3
Jackets shall meet the thickness requirements specified in CSA C22.2 No. 38.

5.7.1.4
Jackets shall meet the weather (sunlight) resistance test requirements specified in Clause 6.15.

5.7.2 Jackets over multi-conductor cables

5.7.2.1
CP, CPE, NBR/PVC, neoprene, PVC, and XL may be used as jacket or covering material.

Δ #### 5.7.2.2
A multiple-conductor cable shall have a jacket, where applicable, applied over the cabled conductors in accordance with Tables 1 and 5. When a thermoplastic or thermoset jacket is required or applied, the jacket shall fit tightly. The physical properties of jackets shall meet the requirements of Table 4 when determined in accordance with the physical properties (ultimate elongation and tensile strength) test specified in CAN/CSA-C22.2 No. 2556.

5.7.2.3
Jackets shall meet the thickness requirements specified in CSA C22.2 No. 38.

5.7.2.4
Jackets shall meet the weather (sunlight) resistance test requirements specified in Clause 6.15.

5.8 Assemblies that include single-insulated conductors
Assemblies that include single-insulated and single-insulated/jacketed conductors shall meet the requirements of CSA C22.2 No. 38.

6 Tests

6.1 General
Every length of finished RPV or RPVU cable shall meet the applicable requirements of Clauses 6.2 to 6.23.

6.2 Conductor resistance
Compliance shall be determined in accordance with the conductor resistance test specified in CSA C22.2 No. 38.

6.3 Aluminum conductors
Compliance shall be determined in accordance with the tests of aluminum conductors specified in CSA C22.2 No. 38. The high-current heat cycling test shall not apply to stranded conductors.

6.4 Long-term insulation resistance in water

Compliance shall be determined in accordance with the long-term insulation resistance in water test specified in CSA C22.2 No. 38.

6.5 Long-term insulation resistance in air for 105 °C and higher-rated conductors

Compliance shall be determined in accordance with the long-term insulation resistance in air for 90 °C rated conductors test specified in CSA C22.2 No. 38, except that the test shall be carried out at the rated temperature of the cable.

6.6 Capacitance and relative permittivity

Compliance shall be determined in accordance with the capacitance and relative permittivity test specified in CSA C22.2 No. 38.

6.7 Conductor corrosion

Compliance shall be determined in accordance with the conductor corrosion test specified in CSA C22.2 No. 38, except that the test shall be performed at the applicable aging temperature specified in Table 3.

6.8 Insulation fall-in

Compliance shall be determined in accordance with the insulation fall-in test specified in CSA C22.2 No. 38.

6.9 Heat shock of thermoplastic jacket

Compliance shall be determined in accordance with the heat shock of thermoplastic jacket test specified in CSA C22.2 No. 38, except that the test shall be performed at the applicable aging temperature specified in Table 4.

6.10 Flexibility of separator under a thermoplastic jacket

Compliance shall be determined in accordance with the flexibility of separator under a thermoplastic jacket test specified in CSA C22.2 No. 38.

6.11 Cold bend and cold impact

Compliance shall be determined in accordance with the cold bend and cold impact test specified in CSA C22.2 No. 38, except that the test shall be performed at –40 °C.

6.12 Deformation (XL only)

Compliance shall be determined in accordance with the deformation test specified in CAN/CSA-C22.2 No. 2556, except that the test specimens shall be unconditioned. The test shall be performed with the loads specified in Table 6 and at the aging temperature specified in Table 3, with a 50% maximum decrease.

Δ 6.13 Hot-creep elongation and hot-creep set

Compliance shall be determined in accordance with the hot-creep elongation and hot-creep set (EP and EPCV only) test specified in CSA C22.2 No. 38, except that for 125 °C and 150 °C rated cable the oven conditioning temperature shall be 200 °C.

6.14 Flame and smoke

Compliance shall be determined in accordance with the following flame and smoke tests specified in CSA C22.2 No. 38, based on conditions of use:

(a) burning particles (mandatory);
(b) FT1 (optional);

(c) FT4 vertical tray (optional); and
(d) ST1 limited smoke (optional).

6.15 Weather (sunlight) resistance (mandatory)
Compliance shall be determined in accordance with the weather (sunlight) resistance test specified in CSA C22.2 No. 38.

6.16 Oil resistance (optional)
Compliance shall be determined in accordance with the oil resistance test specified in CSA C22.2 No. 38.

Δ **6.17 — Deleted**

6.18 Durability of ink printing
Compliance shall be determined in accordance with the durability of ink printing test specified in CSA C22.2 No. 38.

Δ **6.19 Shrinkback (XL only)**
Compliance shall be determined in accordance with the shrinkback test specified in CSA C22.2 No. 38.
Note: *Note: Applies only to solid conductors #14-10AWG.*

6.20 AC spark test
Compliance shall be determined in accordance with the ac spark test specified in CSA C22.2 No. 38.

6.21 Dielectric voltage-withstand in water
Compliance shall be determined in accordance with the dielectric voltage-withstand in water test specified in CSA C22.2 No. 38.

6.22 Insulation resistance in water at 15 °C
Compliance shall be determined in accordance with the insulation resistance in water at 15 °C test specified in CSA C22.2 No. 38.

6.23 Electrical continuity
Compliance shall be determined in accordance with the electrical continuity test specified in CSA C22.2 No. 38.

7 Markings

7.1 Markings on product

7.1.1 General

7.1.1.1
All markings on the finished product shall be visible, legible, and durable. Surface printing, indent printing, or embossed marking shall be considered to meet this requirement. The process shall not result in an insulation thickness less than the minimum specified (see Clause 5.3.3).

Table 3
Physical properties of RPV and RPVU insulation
(See Clauses 5.3.2, 6.7, and 6.12.)

Condition	Test	Insulation material		
		EP	EPCV	XLPO
Before aging	Tensile strength, minimum	4.8 MPa (700 lbf/in^2)	8.3 MPa (1200 lbf/in^2)	10.3 MPa (1500 lbf/in^2)
	Elongation, minimum	250%	200%	150%
After air oven accelerated aging for 90 °C rated insulation		121 ± 1 °C for 7 d	121 ± 1 °C for 7 d	121 ± 1 °C for 7 d
	Tensile strength, minimum	75% of unaged value	75% of unaged value	70% of unaged value
	Elongation, minimum	75% of unaged value	75% of unaged value	70% of unaged value
After air oven accelerated aging for 105 °C rated insulation		136 ± 1 °C for 7 d	136 ± 1 °C for 7 d	136 ± 1 °C for 7 d
	Tensile strength, minimum	45% of unaged value	45% of unaged value	45% of unaged value
	Elongation, minimum	70% of unaged value	70% of unaged value	70% of unaged value
After air oven accelerated aging for 125 °C rated insulation		158 ± 1 °C for 7 d	158 ± 1 °C for 7 d	158 ± 1 °C for 7 d
	Tensile strength, minimum	70% of unaged value	70% of unaged value	80% of unaged value
	Elongation, minimum	80% of unaged value	80% of unaged value	80% of unaged value
After air oven accelerated aging for 150 °C rated insulation		180 ± 1 °C for 7 d	180 ± 1 °C for 7 d	180 ± 1 °C for 7 d
	Tensile strength, minimum	80% of unaged value	80% of unaged value	80% of unaged value
	Elongation, minimum	80% of unaged value	80% of unaged value	80% of unaged value

Δ

Table 4
Physical properties of RPV and RPVU jackets

(See Clauses 5.7.1.2, 5.7.2.2, and 6.9.)

		Jacket material						
Condition	Test	CP*	CPE thermo-plastic	CPE thermo-set*	NBR/ PVC*	Neoprene	PVC†	XL
Before aging	Tensile strength, minimum	10.3 MPa (1500 lbf/in^2)	9.65 MPa (1400 lbf/in^2)	10.3 MPa (1500 lbf/in^2)	4.8 MPa (700 lbf/in^2)	12.4 MPa (1800 lbf/in^2)	10.3 MPa (1500 lbf/in^2)	8.3 MPa (1200 lbf/in^2)
	Elongation, minimum	300%	150%	250%	250%	300%	150%	225%
After air oven accelerated aging for 90 °C rated jackets		121 ± 1 °C for 7 d	121 ± 1 °C for 7 d	121 ± 1 °C for 7 d	121 ± 1 °C for 7 d	121 ± 1 °C for 10 d	121 ± 1 °C for 7 d	121 ± 1 °C for 7 d
	Tensile strength, minimum	70% of unaged value	50% of unaged value	60% of unaged value	75% of unaged value	6.2 MPa (900 lbf/in^2)	70% of unaged value	75% of unaged value
	Elongation, minimum	70% of unaged value	50% of unaged value	85% of unaged value	75% of unaged value	50% of unaged value	70% of unaged value	75% of unaged value
After air oven accelerated aging for 105 °C rated jackets		136 ± 1 °C for 7 d	—	136 ± 1 °C for 7 d	—	—	136 ± 1 °C for 7 d	136 ± 1 °C for 7 d
	Tensile strength, minimum	8.3 MPa (1200 lbf/in^2)	—	10.3 MPa (1500 lbf/in^2)	—	—	45% of unaged value	45% of unaged value
	Elongation, minimum	100% of unaged value	—	200% of unaged value	—	—	70% of unaged value	70% of unaged value
After air oven accelerated aging for 125 °C rated jackets		—	—	—	—	—	—	158 ± 1 °C for 7 d
	Tensile strength, minimum	—	—	—	—	—	—	70% of unaged value
	Elongation, minimum	—	—	—	—	—	—	80% of unaged value
After air oven accelerated aging for 150 °C rated jackets		—	—	—	—	—	—	180 ± 1 °C for 7 d
	Tensile strength, minimum	—	—	—	—	—	—	80% of unaged value
	Elongation, minimum	—	—	—	—	—	—	80% of unaged value

**Depending on its composition, e.g., plasticizers, this compound might not be appropriate for single-conductor cables.*
†Not appropriate for single-conductor cables.

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Photovoltaic cables

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Preface

This is the first edition of CSA C22.2 No. 271, *Photovoltaic cables,* one of a series of Standards issued by the Canadian Standards Association under Part II of the *Canadian Electrical Code*.

For general information on the Standards of the *Canadian Electrical Code, Part II*, see the preface of CSA C22.2 No. 0, *General Requirements — Canadian Electrical Code, Part II*.

This Standard is considered suitable for use for conformity assessment within the stated scope of the Standard.

This Standard was prepared by the Integrated Committee on Fixed Installation Wires and Cables, under the jurisdiction of the Technical Committee on Wiring Products and the Strategic Steering Committee on Requirements for Electrical Safety, and has been formally approved by the Technical Committee.

Interpretations: The Strategic Steering Committee on Requirements for Electrical Safety has provided the following direction for the interpretation of standards under its jurisdiction: "The literal text shall be used in judging compliance of products with the safety requirements of this Standard. When the literal text cannot be applied to the product, such as for new materials or construction, and when a relevant committee interpretation has not already been published, CSA's procedures for interpretation shall be followed to determine the intended safety principle".

May 2011

Notes:

(1) *Use of the singular does not exclude the plural (and vice versa) when the sense allows.*

(2) *Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.*

(3) *This publication was developed by consensus, which is defined by* CSA Policy governing standardization — Code of good practice for standardization *as "substantial agreement. Consensus implies much more than a simple majority, but not necessarily unanimity". It is consistent with this definition that a member may be included in the Technical Committee list and yet not be in full agreement with all clauses of this publication.*

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(c) where possible, phrase the request in such a way that a specific "yes" or "no" answer will address the issue.
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(5) *CSA Standards are subject to periodic review, and suggestions for their improvement will be referred to the appropriate committee. To submit a proposal for change to CSA Standards, please send the following information to* ***inquiries@csa.ca*** *and include "Proposal for change" in the subject line:*
(a) Standard designation (number);
(b) relevant clause, table, and/or figure number;
(c) wording of the proposed change; and
(d) rationale for the change.

C22.2 No. 271-11
Photovoltaic cables

1 Scope

1.1
This Standard specifies requirements for photovoltaic single-conductor and multi-conductor thermoset-insulated wires and cables that are rated 600, 1000, or 2000 V, suitable for ac and dc systems, and intended for installation in accordance with the *Canadian Electrical Code, Part I*.

Notes:

(1) *See Table 1 for the wire and cable types covered by this Standard.*

(2) *See Table 2 for voltage and maximum conductor temperature ratings for the wire and cable types covered by this Standard.*

1.2
In CSA standards, "shall" is used to express a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard; "should" is used to express a recommendation or that which is advised but not required; and "may" is used to express an option or that which is permissible within the limits of the standard.

Notes accompanying clauses do not include requirements or alternative requirements; the purpose of a note accompanying a clause is to separate from the text explanatory or informative material.

Notes to tables and figures are considered part of the table or figure and may be written as requirements.

Annexes are designated normative (mandatory) or informative (nonmandatory) to define their application.

1.3
The values given in SI units are the units of record for the purposes of this Standard. The values given in parentheses are for information and comparison only.

2 Reference publications
This Standard refers to the following publications, and where such reference is made, it shall be to the edition listed below, including all amendments published thereto.

CSA (Canadian Standards Association)

C22.1-09
Canadian Electrical Code, Part I

C22.2 No. 0-10
General requirements — Canadian Electrical Code, Part II

C22.2 No. 38-10
Thermoset-insulated wires and cables

CAN/CSA-C22.2 No. 2556-07
Wire and cable test methods

3 Definitions

The following definitions shall apply in this Standard:

CP — a thermoset compound whose characteristic constituent is chlorosulfonated polyethylene.

CPE — a thermoset compound or a thermoplastic compound whose characteristic constituent is chlorinated polyethylene.

EP — a thermoset compound whose characteristic constituent is a copolymer of ethylene and propylene; a terpolymer of ethylene, propylene, and a small amount of non-conjugated diene; or a blend of both.

EPCV — a thermoset compound whose characteristic constituent is a co-vulcanizate of ethylene and propylene with polyethylene.

NBR/PVC — a thermoset compound whose characteristic constituents are acrylonitrile butadiene rubber and polyvinyl chloride.

PVC — a thermoplastic compound whose characteristic constituent is polyvinyl chloride.

RPV — thermoset photovoltaic cable.

RPVU — thermoset photovoltaic cable suitable for direct burial.

XL — a thermoset compound whose characteristic constituents are cross-linked polyethylene and cross-linked ethylene copolymers, or blends thereof.

4 General requirements

General requirements applicable to this Standard are given in CSA C22.2 No. 0.

5 Construction

5.1 General

The construction of photovoltaic cables shall comply with the RW90 or RWU90 requirements specified in CSA C22.2 No. 38 and with the requirements of this Standard.

5.2 Conductors

Circuit conductors shall be stranded aluminum conductor material (ACM) or copper in accordance with CSA C22.2 No. 38. Separate bonding conductors may be solid or stranded ACM or copper.

5.3 Insulation

5.3.1

EP, EPCV, and XL may be used as insulation material for photovoltaic cables.

5.3.2

The physical properties of insulation shall meet the requirements of Table 3 when determined in accordance with the physical properties (ultimate elongation and tensile strength) test specified in CAN/CSA-CSA C22.2 No. 2556.

5.3.3
The insulation thickness of 600, 1000, and 2000 V RPV cables shall be the same as the insulation thickness of 600, 1000, and 2000 V RW90 cables, respectively, specified in CSA C22.2 No. 38. The insulation thickness of 1000 and 2000 V RPVU cables shall be the same as the insulation thickness of RWU90 1000 V cables specified in CSA C22.2 No. 38.

5.3.4
Insulation shall meet the weather (sunlight) resistance test requirements specified in Clause 6.15.

5.4 Conductor identification

5.4.1 Polarity identification for dc applications
Polarity identification shall be optional for single-conductor cables. When used, it shall follow the requirements for multi-conductor cables specified in this Clause.

In a multi-conductor cable with an overall jacket or multi-conductor assembly, the polarity of the conductors shall be identified by one of the following means:

(a) printing ("+/–", "pos/neg", or "positive/negative") on the insulation or the jacket over single-insulated conductors, where applicable, repeated at a maximum of 300 mm (12 in) intervals;
(b) a solid colour (red for positive, black for negative) for the insulation or the jacket over single-insulated conductors, where applicable; or
(c) a coloured stripe over the outermost layer of single-insulated conductors, where applicable. The coloured stripe* shall be weather (sunlight) resistant.

When a bonding conductor is included in the assembly, it shall be green or green with one or more yellow stripes. In the case of a multi-conductor cable with an overall jacket, the bonding conductor may be uninsulated or, if insulated, shall be green or green with one or more yellow stripes. The bonding conductor shall meet the size requirements specified in Table 25 of CSA C22.2 No. 38.

**Red for positive, black for negative.*

5.4.2 Phase identification for ac applications
Phase identification shall be in accordance with CSA C22.2 No. 38.

5.4.3 Separate (single) bonding conductor identification
Single-conductor cables used as separate bonding conductors shall be identified as follows:

(a) green or green with yellow stripe(s) for sizes 2 AWG and smaller; and
(b) as specified by the *Canadian Electrical Code, Part I*, for sizes larger than 2 AWG.

5.5 Fillers
When used, fillers shall meet the requirements of CSA C22.2 No. 38.

5.6 Jacket separators
Jacket separators shall meet the requirements of CSA C22.2 No. 38.

5.7 Jackets

5.7.1 Jackets over single-insulated conductors

5.7.1.1
CP, CPE, NBR/PVC, neoprene, and XL may be used as jacket or covering material.

Note: *Depending on their composition (e.g., plasticizers), CP, CPE, and NBR/PVC might not be appropriate for single-conductor cables.*

5.7.1.2
A single-conductor cable may be unjacketed or have a jacket applied over the outer surface of the insulation in accordance with Table 1. The temperature rating of the jacket shall be the same as that of the insulated conductor. The physical properties of jackets shall meet the requirements of Table 4 when determined in accordance with the physical properties (ultimate elongation and tensile strength) test specified in CAN/CSA-C22.2 No. 2556.

5.7.1.3
Jackets shall meet the thickness requirements specified in CSA C22.2 No. 38.

5.7.1.4
Jackets shall meet the weather (sunlight) resistance test requirements specified in Clause 6.15.

5.7.2 Jackets over multi-conductor cables

5.7.2.1
CP, CPE, NBR/PVC, neoprene, PVC, and XL may be used as jacket or covering material.

5.7.2.2
A multiple-conductor cable shall have a jacket applied over the cabled conductors in accordance with Tables 1 and 5. When a thermoplastic or thermoset jacket is required or applied, the jacket shall fit tightly. The physical properties of jackets shall meet the requirements of Table 4 when determined in accordance with the physical properties (ultimate elongation and tensile strength) test specified in CAN/CSA-C22.2 No. 2556.

5.7.2.3
Jackets shall meet the thickness requirements specified in CSA C22.2 No. 38.

5.7.2.4
Jackets shall meet the weather (sunlight) resistance test requirements specified in Clause 6.15.

5.8 Assemblies that include single-insulated conductors
Assemblies that include single-insulated and single-insulated/jacketed conductors shall meet the requirements of CSA C22.2 No. 38.

6 Tests

6.1 General
Every length of finished RPV or RPVU cable shall meet the applicable requirements of Clauses 6.2 to 6.23.

6.2 Conductor resistance
Compliance shall be determined in accordance with the conductor resistance test specified in CSA C22.2 No. 38.

6.3 Aluminum conductors
Compliance shall be determined in accordance with the tests of aluminum conductors specified in CSA C22.2 No. 38. The high-current heat cycling test shall not apply to stranded conductors.

6.4 Long-term insulation resistance in water

Compliance shall be determined in accordance with the long-term insulation resistance in water test specified in CSA C22.2 No. 38.

6.5 Long-term insulation resistance in air for 105 °C and higher-rated conductors

Compliance shall be determined in accordance with the long-term insulation resistance in air for 90 °C rated conductors test specified in CSA C22.2 No. 38, except that the test shall be carried out at the rated temperature of the cable.

6.6 Capacitance and relative permittivity

Compliance shall be determined in accordance with the capacitance and relative permittivity test specified in CSA C22.2 No. 38.

6.7 Conductor corrosion

Compliance shall be determined in accordance with the conductor corrosion test specified in CSA C22.2 No. 38, except that the test shall be performed at the applicable aging temperature specified in Table 3.

6.8 Insulation fall-in

Compliance shall be determined in accordance with the insulation fall-in test specified in CSA C22.2 No. 38.

6.9 Heat shock of thermoplastic jacket

Compliance shall be determined in accordance with the heat shock of thermoplastic jacket test specified in CSA C22.2 No. 38, except that the test shall be performed at the applicable aging temperature specified in Table 4.

6.10 Flexibility of separator under a thermoplastic jacket

Compliance shall be determined in accordance with the flexibility of separator under a thermoplastic jacket test specified in CSA C22.2 No. 38.

6.11 Cold bend and cold impact

Compliance shall be determined in accordance with the cold bend and cold impact test specified in CSA C22.2 No. 38, except that the test shall be performed at –40 °C.

6.12 Deformation (XL only)

Compliance shall be determined in accordance with the deformation test specified in CAN/CSA-C22.2 No. 2556, except that the test specimens shall be unconditioned. The test shall be performed with the loads specified in Table 6 and at the aging temperature specified in Table 3, with a 50% maximum decrease.

6.13 Hot-creep elongation and hot-creep set

Compliance shall be determined in accordance with the hot-creep elongation and hot-creep set test specified in CSA C22.2 No. 38, except that for 125 °C and 150 °C rated cable the oven conditioning temperature shall be 200 °C.

6.14 Flame and smoke

Compliance shall be determined in accordance with the following flame and smoke tests specified in CSA C22.2 No. 38, based on conditions of use:

(a) burning particles (mandatory);
(b) FT1 (optional);

(c) FT4 vertical tray (optional); and
(d) ST1 limited smoke (optional).

6.15 Weather (sunlight) resistance (mandatory)
Compliance shall be determined in accordance with the weather (sunlight) resistance test specified in CSA C22.2 No. 38.

6.16 Oil resistance (optional)
Compliance shall be determined in accordance with the oil resistance test specified in CSA C22.2 No. 38.

6.17 Crushing resistance
Compliance shall be determined in accordance with the crushing resistance test specified in CSA C22.2 No. 38.

6.18 Durability of ink printing
Compliance shall be determined in accordance with the durability of ink printing test specified in CSA C22.2 No. 38.

6.19 Shrinkback
Compliance shall be determined in accordance with the shrinkback test specified in CSA C22.2 No. 38.

6.20 AC spark test
Compliance shall be determined in accordance with the ac spark test specified in CSA C22.2 No. 38.

6.21 Dielectric voltage-withstand in water
Compliance shall be determined in accordance with the dielectric voltage-withstand in water test specified in CSA C22.2 No. 38.

6.22 Insulation resistance in water at 15 °C
Compliance shall be determined in accordance with the insulation resistance in water at 15 °C test specified in CSA C22.2 No. 38.

6.23 Electrical continuity
Compliance shall be determined in accordance with the electrical continuity test specified in CSA C22.2 No. 38.

7 Markings

7.1 Markings on product

7.1.1 General

7.1.1.1
All markings on the finished product shall be visible, legible, and durable. Surface printing, indent printing, or embossed marking shall be considered to meet this requirement. The process shall not result in an insulation thickness less than the minimum specified (see Clause 5.3.3).

7.1.1.2
Markings shall be repeated at intervals not exceeding 1.0 m (40 in), except for conductor size markings on single-conductor cables, which shall be repeated on the conductor or marker tape at intervals not exceeding 610 mm (24 in).
Note: *See also Clause 5.4.1(a).*

7.1.2 Manufacturer's identification
Finished wires and cables shall have a distinctive marking throughout their entire length by which the organization responsible for the product is readily identifiable.

7.1.3 Type designation and maximum operating dry temperature rating of insulation
The product shall be marked "RPV90", "RPV105", "RPV125", "RPV150", "RPVU90", "RPVU105", "RPVU125", or "RPVU150", as applicable. The RPVU may also be marked "DIR BUR" or "DIRECT BURIAL".

7.1.4 Conductor size
Conductor size shall be marked on the product in one of the following forms:
(a) mm^2 (AWG);
(b) AWG (mm^2);
(c) mm^2 (kcmil); or
(d) kcmil (mm^2).
A comma or period shall be used to signify a decimal. For printing on products "mm2" may be used in place of "mm^2".

7.1.5 Aluminum conductors
AA 8000 conductors shall be marked "AL". The additional marking "ACM" or "AA 8000" may also be used.

7.1.6 Polarity identification
If printing is used, polarity shall be identified in accordance with Clause 5.4.1.

7.1.7 Voltage marking
Wires and cables shall be marked with their voltage rating, using "V", "VOLTS", or "volts".

7.1.8 Insulating material designation
Wires and cables shall be marked with their insulating material designation, i.e., "EP", "EPCV", "XL", or "XLPE", as applicable.

7.1.9 Low-temperature marking
Wires and cables shall be marked "(–40C)".

7.1.10 Flame test marking
If applicable (see Clause 6.14), insulated conductors shall be marked "FT1", "FT4", or "ST1".

7.1.11 Weather (sunlight) resistance marking
The outermost surface of wires and cables shall be marked "SR", "SUN RES", or "SUNLIGHT RESISTANT".

7.1.12 Oil resistance marking
Wires and cables complying with the oil resistance at 60 °C test requirements specified in CSA C22.2 No. 38 may be marked "PR I". Wires and cables complying with the oil resistance at 75 °C test requirements specified in CSA C22.2 No. 38 may be marked "PR II".

7.2 Markings on package

Each package of wire or cable shall be legibly tagged or marked to indicate the following:

(a) manufacturer's identification;
(b) month and year of manufacture (a code shall be considered acceptable). Alternatively, the month and year of manufacture may be marked on the finished product as specified in Clause 7.1.1 (a code shall be considered acceptable);
(c) type designation;
(d) conductor size and ASTM class of stranding;
(e) voltage rating;
(f) maximum dry and wet operating temperature rating of the insulation; and
(g) conductor size and ASTM class of stranding followed by "AA 8000", "ACM" or "AA 8000" if an aluminum conductor is used.

Table 1
Photovoltaic cable construction types
(See Clauses 1.1, 5.7.1.2, and 5.7.2.2.)

		Jacket	
Type I	nsulation	Over single conductors	Over parallel or twisted conductors
RPV	EP	Required	Required
	XL or EPCV	Optional	Required
RPVU	EP or EPCV	Required	Optional
	XL	Optional	Optional

Table 2
Voltage and maximum conductor temperature ratings for photovoltaic cables
(See Clause 1.1.)

Type	Voltage rating, V	Temperature rating, °C
RPV	600, 1000, or 2000	90, 105, 125, or 150
RPVU	1000 or 2000	90, 105, 125, or 150

Table 3
Physical properties of RPV and RPVU insulation
(See Clauses 5.3.2, 6.7, and 6.12.)

Condition	Test	Insulation material		
		EP	EPCV	XLPE
Before aging	Tensile strength, minimum	4.8 MPa (700 lbf/in^2)	8.3 MPa (1200 lbf/in^2)	10.3 MPa (1500 lbf/in^2)
	Elongation, minimum	250%	200%	150%
After air oven accelerated aging for 90 °C rated insulation		121 ± 1 °C for 7 d	121 ± 1 °C for 7 d	121 ± 1 °C for 7 d
	Tensile strength, minimum	75% of unaged value	75% of unaged value	70% of unaged value
	Elongation, minimum	75% of unaged value	75% of unaged value	70% of unaged value
After air oven accelerated aging for 105 °C rated insulation		136 ± 1 °C for 7 d	136 ± 1 °C for 7 d	136 ± 1 °C for 7 d
	Tensile strength, minimum	45% of unaged value	45% of unaged value	45% of unaged value
	Elongation, minimum	70% of unaged value	70% of unaged value	70% of unaged value
After air oven accelerated aging for 125 °C rated insulation		158 ± 1 °C for 7 d	158 ± 1 °C for 7 d	158 ± 1 °C for 7 d
	Tensile strength, minimum	70% of unaged value	70% of unaged value	80% of unaged value
	Elongation, minimum	80% of unaged value	80% of unaged value	80% of unaged value
After air oven accelerated aging for 150 °C rated insulation		180 ± 1 °C for 7 d	180 ± 1 °C for 7 d	180 ± 1 °C for 7 d
	Tensile strength, minimum	80% of unaged value	80% of unaged value	80% of unaged value
	Elongation, minimum	80% of unaged value	80% of unaged value	80% of unaged value

Table 4
Physical properties of RPV and RPVU jackets
(See Clauses 5.7.1.2, 5.7.2.2, and 6.9.)

		Jacket material						
Condition	Test	CP*	CPE thermo-plastic	CPE thermo-set*	NBR/ PVC*	Neoprene	PVC†	XL
Before aging	Tensile strength, minimum	8.3 MPa (1200 lbf/in^2)	9.65 MPa (1400 lbf/in^2)	8.3 MPa (1200 lbf/in^2)	8.3 MPa (1200 lbf/in^2)	8.3 MPa (1200 lbf/in^2)	10.3 MPa (1500 lbf/in^2)	10.3 MPa (1500 lbf/in^2)
	Elongation, minimum	200%	150%	200%	200%	200%	100%	150%
After air oven accelerated aging for 90 °C rated jackets		110 ± 1 °C for 10 d	121 ± 1 °C for 7 d	110 ± 1 °C for 10 d	110 ± 1 °C for 10 d	110 ± 1 °C for 10 d	121 ± 1 °C for 7 d	110 ± 1 °C for 10 d
	Tensile strength, minimum	50% of unaged value	85% of unaged value	50% of unaged value	50% of unaged value	50% of unaged value	85% of unaged value	75% of unaged value
	Elongation, minimum	50% of unaged value	50% of unaged value	50% of unaged value	50% of unaged value	50% of unaged value	45% of unaged value	75% of unaged value
After air oven accelerated aging for 105 °C rated jackets		136 ± 1 °C for 7 d	—	136 ± 1 °C for 7 d	—	—	136 ± 1 °C for 7 d	136 ± 1 °C for 7 d
	Tensile strength, minimum	8.3 MPa (1200 lbf/in^2)	—	10.3 MPa (1500 lbf/in^2)	—	—	45% of unaged value	45% of unaged value
	Elongation, minimum	100% of unaged value	—	200% of unaged value	—	—	70% of unaged value	70% of unaged value
After air oven accelerated aging for 125 °C rated jackets		—	—	—	—	—	—	158 ± 1 °C for 7 d
	Tensile strength, minimum	—	—	—	—	—	—	70% of unaged value
	Elongation, minimum	—	—	—	—	—	—	80% of unaged value
After air oven accelerated aging for 150 °C rated jackets		—	—	—	—	—	—	180 ± 1 °C for 7 d
	Tensile strength, minimum	—	—	—	—	—	—	80% of unaged value
	Elongation, minimum	—	—	—	—	—	—	80% of unaged value

*Depending on its composition, e.g., plasticizers, this compound might not be appropriate for single-conductor cables.
†Not appropriate for single-conductor cables.

Table 5
Insulation and overall jacket temperature ratings in multi-conductor cables, °C
(See Clause 5.7.2.2.)

Conductor insulation temperature rating	Minimum jacket temperature rating
90	90
105	90
125	105
150	125

Table 6
Deformation load requirements
(See Clause 6.12.)

Size of conductor, mm^2 (AWG or kcmil)	Load exerted on a specimen by the foot of the rod, N (gf)
2.08–8.37 (14–8)	4.90 (500)
13.3–42.4 (6–1)	7.35 (750)
53.5–107 (1/0–4/0)	9.81 (1000)
127–1010 (250–2000)	19.61 (2000)

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