Standards Update Notice (SUN)

Issued: July 28, 2017

Standard Information

Standard Number: CSA C22.2 No. 107.1
Standard Name: Power conversion equipment
Standard Edition and Issue Date: 4th Edition Dated June 2016
Date of Issue: June 2016
Date of Previous Revision of Standard: 3rd Edition Reaffirmed 2011

Effective Date of New/Revised Requirements

Effective Date:

(1) After **January 1st 2018**, products for evaluation and revisions will be evaluated to the requirements of CSA C22.2 No.107.1-16.

(2) Power conversion equipment (PCE) manufactured and certified to CSA C22.2 107.1-01 will continue to be listed until **January 1, 2022**. To ensure continued certification of previously certified products, an application for testing must be received no later than April 1, 2021.

(3) The combiner portion of PCE with an integral PV combiner shall comply with CSA C22.2 No. 290-15. Certified PCE with a combiner portion must be reevaluated and tested on its combiner portion. You must respond no later than November 29th 2017 in order to guarantee the update to your certification is completed by **May 29, 2018**.

Impact, Overview, and Action Required

Impact Statement: A review of all Listing Reports is necessary to determine which products comply with new/revised requirements and which products will require re-evaluation. **NOTE:** Effective immediately, this revised standard will be exclusively used for evaluation of new products unless the Applicant requests in writing that current requirements be used along with their understanding that their listings will be withdrawn on Effective Date noted above, unless the product is found to comply with new/revised requirements.

Overview of Changes: This edition has been extensively rewritten to accommodate new technologies. Specific details of new/revised requirements are found in table below.

If the applicable requirements noted in the table are not described in your report(s), these requirements will need to be confirmed as met and added to your report(s) such as markings, instructions, test results, etc. (as required).

Client Action Required:

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Information – To assist our Engineer with review of your Listing Reports, please submit technical information in response to the new/revised paragraphs noted in the attached or explain why these new/revised requirements do not apply to your product (s).

Current Listings Not Active? – Please immediately identify any current Listing Reports or products that are no longer active and should be removed from our records. We will do this at no charge as long as Intertek is notified in writing prior to the review of your reports.

Description of New/Revised Technical Requirements

Clause	Verdict	Comment
		Additions to existing requirements are underlined and deletions are shown ~~lined out~~ below.
1	Info	Scope
1.1		This Standard applies to ac and dc type power ~~supplies, including rack-mounted and modular units,~~ conversion equipment (PCE) that a) ~~are~~ is of dry or liquid-filled construction; b) ~~have~~ has a rated voltage not exceeding ~~600~~ 1500 V; and c) ~~are~~ is for commercial, industrial, and residential indoor and outdoor use in nonhazardous locations in accordance with the Rules of the *Canadian Electrical Code, Part I.* **~~Note:~~** ~~*These power supplies may include battery-charging functions.*~~
1.2		Clauses ~~2~~ 1 to 6 are general, and apply, unless otherwise noted, to ~~the power supplies covered by~~ all PCE. Clauses 7 to ~~17, as follows:~~ 19 are specific to particular applications or types of PCE, apply to PCE or portions of PCE that include the aspects within the scope of the specific Clause, and supplement or amend the applicable requirements in all other Clauses. ~~(a) Clause 7 – industrial dc power supplies;~~ ~~(b) Clause 8 – power converters for recreational vehicles;~~ ~~(c) Clause 9 – static transfer switches;~~ ~~(d) Clause 10 – inverters;~~ ~~(e) Clause 11 – uninterruptible ac power supplies (UPS);~~ ~~(f) Clause 12 – telecommunication equipment power supplies;~~ ~~(g) Clause 13 – CATV power supplies;~~ ~~(h) Clause 14 – power conversion equipment for use in photovoltaic (PV) systems;~~ ~~(i) Clause 15 – utility-interconnected inverters;~~ ~~(j) Clause 16 – dc charge controllers; and~~ ~~(k) Clause 17 – electric vehicle chargers.~~
1.3		This Standard does not apply to

Clause	Verdict	Comment
		a) automotive and nonautomotive chargers as covered by CAN/CSA ~~Standard -~~C22.2 No. 107.2; b) power supplies intended to supply extra-low-voltage for the operation of household electronic equipment, telecommunication equipment, and motor-operated equipment as covered by CSA ~~Standard CAN/CSA-~~C22.2 No. 223; c) "built-in" component type power supplies forming an integral part of end use equipment such as telecommunication equipment, electronic data processing equipment, and office machines as covered by ~~CSA Standard~~ CAN/CSA-C22.2 No. 60950~~; and -~~1; d) rotating type ~~rectifiers.~~ generators or converters; e) uninterruptible ac power supplies (UPS) as covered by CSA C22.2 No. 107.3; and f) non-photovoltaic motor drives as covered by CSA C22.2 No. 14.
1.4		In this Standard, "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 (non-mandatory) to define their application.
4.1.4		Fuses used to limit current levels to those specified in Clause 4.1.3 a) ii) shall be of a type that is nonreplaceable without the use of tools ~~(eg, soldered-in type)~~ if the circuits protected by the fuses extend beyond the ~~power supply~~ PCE enclosure. If there are no circuits extending beyond the enclosure, the fuses may be of a readily replaceable type.
4.1.6		Components that meet the requirements of ~~CSA Standard~~ CAN/CSA-C22.2 No. 60950-1 may be used as component parts of a ~~power supply~~ PCE without further investigation if the ~~power supply~~ PCE is intended for use in a controlled environment and is marked in accordance with Clause 5.12 and if the overvoltage category rating of the component is suitable for the conditions of use in the PCE.
4.1.7		In PCE or part of the PCE that has a higher voltage rating to ground than the pole-to-pole voltage rating, electrical components connected between live parts and ground shall be rated for the voltage to ground. **Note:** *This situation can arise where PCE are rated for series connection with other PCE, for example where dc power supplies are rated to be "stacked" or with PV power optimizers rated to be connected into strings.*
4.1.8		Disconnect switches, circuit breakers, and other devices that are connected between two sources shall be rated for being energized from both sides and, where applicable, for tripping due to current in either direction.
4.2	Info	Enclosures

Clause	Verdict	Comment
4.2.1	Info	General
4.2.1.1		~~Power supplies~~ PCE shall have enclosures that enclose all live parts. Rack-mounted ~~assemblies (eg, component types) may have exposed parts where enclosed by the rack enclosure.~~ that are a shock hazard, energy hazard, or are in circuits that exceed the limits for a Class 2 circuit. PCE provided with an otherwise complete enclosure may have exposed input and/or output terminals that are a shock hazard, energy hazard, or are in circuits that exceed the limits for a Class 2 circuit, if the PCE is intended only for installation in an outer enclosure or rack and is marked and provided with installation instructions in accordance with Clause 5.43.
4.2.5	Info	**Openings in enclosures**
4.2.5.1		The enclosure shall have no openings through which the articulated probe (see Figure 1) can be inserted so as to touch moving parts (e.g., fan blades) or any uninsulated live parts (including filmcoated wire) operating at a voltage of more than 42.4 V peak to any other part or to ground or at an energy level exceeding the requirement in Clause 6.19. See also Clause 4.2.6.1.
4.2.5.2		The probe of Figure 1 shall be inserted to any depth that the opening will permit, using an applied force of not greater than 4.4 N. The probe shall be rotated or angled before, during, and after insertion through the opening to any necessary position, using any possible configuration. If necessary, the configuration shall be changed after insertion through the opening. During the probe test, doors, covers, connectors, or other accessible parts that can be opened without the use of a tool, shall be open or partially open, whichever is the worst case.
4.2.5.7		If a barrier is provided to comply with Clause 4.2.5.5, the barrier shall comply with all of the following: a) be made of metal or nonmetallic material complying with the flame test of Clause 6.11; b) not contain perforations or openings except as specified in Items d) and e); c) be so located and be of such extent as to conform to Figure 5 and the ~~legend~~ notes appended thereto; d) have one of the following constructions, if made of perforated metal: i) a metal screen, or the equivalent, that has a mesh* not greater than 2 × 2 mm (14 × 14 mesh per inch) and wire with a minimum diameter of 0.46 mm; ii) a perforated metal panel in accordance with Table 4; or iii) a perforated metal panel that complies with the flaming oil test of Clause 6.14; and e) be permitted to have openings not larger than 6.4 mm2 if the barrier is located under areas containing only materials classified, at least V-1 in accordance with CAN/CSA ~~Standard~~ C22.2 No. 0.17. Openings that are not square ~~can~~ may be provided if they do not have an area greater than 40 mm2 (see also Clause 4.15.4). * *A mesh or screen described in ~~Clause 4.2.5.7~~ Item d) i) cannot be used to form the side of an enclosure.*

Clause	Verdict	Comment
4.2.5.8		The diameter of the wires of a metal screen used for other than the bottom of an enclosure shall be not less than a) 1.2 mm when the screen openings are 320 mm2 or less in area; and b) 2 mm for screen openings larger than 320 mm2.
4.2.5.9		Sheet metal employed for expanded metal mesh and perforated sheet metal used for other than the bottom of an enclosure shall have an uncoated thickness of not less than a) 1.2 mm if the mesh openings or perforations are 320 mm2 or less in area; and b) 2 mm for openings larger than 320 mm2.
4.2.5.11		Material, other than glass or metal, employed as a sole covering over an opening ~~that forms~~ forming part of the enclosure and relied upon to prevent contact with bare live parts shall be of adequate mechanical strength and shall comply with the requirements of the flame test specified in Clause 6.11 and the impact test specified in Clause 6.12.2.
4.2.6.3		When a hinged door is required by Clause 4.2.6.2, means (operable with or without a tool) shall be provided to keep the door closed.
4.2.6.5		A component that ~~may~~ might require examination, resetting, adjustment, servicing, or maintenance while energized shall be so located and mounted with respect to other components and with respect to ~~grounded~~ bonded metal parts that it is accessible for electrical service functions without subjecting service personnel to a possible shock or energy hazard or to injury by adjacent moving parts. Access to a component shall not be impeded by other components including wiring.
4.2.6.7		A live heat sink ~~for a solid-state component (eg, one mounted on a printed circuit board), a~~, live relay frame, ~~and the like,~~ or similar part that ~~may~~ can pose a shock or energy hazard ~~or~~ and might be mistaken for an unenergized part shall be guarded to reduce the risk of unintentional contact by service personnel or be marked in accordance with Clause 5.14.
4.2.7		Special-purpose enclosures
4.2.7.1		Special-purpose enclosures for nonhazardous locations shall comply with the requirements of CSA ~~Standard CAN/CSA~~ C22.2 No. 94.1 and, if applicable, CSA C22.2 No. 94.2. Enclosures for use outdoors shall be a type intended for outdoor use in accordance with CSA C22.2 No. 94.2 and shall comply with the requirements of that standard when mounted and connected as intended in use.
4.2.7.2		When a supplementary housing is used to comply with Clause 4.2.7.1, the temperature ~~rise of the enclosed equipment~~ testing required in this Standard shall be ~~investigated~~ performed with the supplementary housing in place.
4.2.9	Info	**PCE mounting means**
4.2.9.1		PCE intended to be fastened in place shall be provided with mounting means and the installation instructions shall include the information found in Clause 5.26 and, if applicable, Clauses 5.11, 5.12, and 5.43.

Clause	Verdict	Comment
4.2.9.2		PCE intended for mounting in a manner in which the weight is borne by a wall, pole, rack, or other structure, rather than the floor or ground, shall comply with the vertical loading test in Clause 6.22, except for liquid-filled PCE as required by Clause 4.24.7.
4.4		**Supply connections**
4.4.1		**Permanently connected ~~Power Supplies~~ PCE**
4.4.1.1		~~Power supplies~~ PCE intended to be secured to a structure (e.g., a wall) shall be supplied with means for permanent connection of input and output power wiring and shall have provision for the connection of armoured cable or conduit as required by ~~CSA Standard~~ CAN/CSA-C22.2 No. 0~~; except that.~~ In addition, a supply cord and plug may be provided, ~~subject to acceptance by the authority having jurisdiction~~, if the ~~power supply~~ PCE is marked in accordance with Clause 5.15 ~~and an area that will accommodate conduit connections in accordance with CSA Standard CAN/CSAC22.2 No. 0 is available on the enclosure.~~
4.4.1.3		If leads are provided instead of terminals for connection to the ~~supply~~ input or output power circuit conductors, they shall be of approved wire no smaller than No. 18 AWG and at least 150 mm long.
4.4.2		**Cord-connected ~~Power Supplies~~ PCE**
4.4.2.1		~~Power supplies~~ PCE intended to be cord-connected shall be provided with a suitable length of cord ~~having an additional conductor for grounding non-current-carrying conductive parts~~. The cord shall have an ampacity at least equal to the marked ~~input~~ circuit current in amperes (see Clause 5.1 ~~(f)~~) and shall be of the hard-usage type except
4.4.2.2		~~The~~ An ac input supply cord intended for connection to a standard ac distribution system receptacle shall terminate in a suitable attachment plug that a) conforms to CSA ~~Standard~~ C22.2 No. 42 and has a has voltage rating suitable for the voltage marked on the equipment; and b) has a current rating of not less than i) 125% of the marked input current; or ii) 100% of the marked input current if the input current ~~decreases to~~ averaged over any 3 h period of normal operation is 80% of the marked value ~~after the first 3 h of operation starting with a discharged battery~~ or less.
4.4.2.4		Strain relief shall be provided ~~so that~~ to protect the terminations of cords against stress ~~on a supply~~ due to pushing, pulling, or twisting of the cord, as determined by the test specified in Clause 6.~~18, or twisting of the cord will not be transmitted to the connections inside the power supply.~~
4.4.2.5		At the point at which a ~~supply~~ cord passes through an opening in a wall, barrier, or the overall enclosure, there shall be a bushing or the equivalent that is secured in place and that has a smooth, well-rounded surface against which the cord may can bear.

Clause	Verdict	Comment
4.4.2.7		~~A~~ Cord-connected ~~power supply~~ PCE having ~~a~~ an ac input rating of 208 V, single phase, may be provided with an attachment plug for a supply cord or cord connector for an output cord rated 250 V, provided that a) there is no evidence of a shock or fire hazard when the ~~power supply~~ PCE is tested at 240 V in accordance with Clause 6.6.10; b) the supply cord is marked in accordance with Clause 5.28; and c) an output receptacle or cord connector is marked in accordance with Clause 5.29.
4.4.2.8		Notwithstanding Clause 4.4.2.7 b), no marking is required on the supply cord if a) the ~~power supply~~ PCE complies with the requirements of the leakage current test (Clause 6.4), the rating test (Clause 6.2~~.3 or 11.3.1, as applicable~~), the temperature test (Clause 6.3 or 17.3.9, as applicable), and the backfeed protection test (Clause 9.4.1); and b) the output voltage of the ~~power supply~~ PCE does not exceed its output voltage rating by more than 10% while energized from a 240 V source of supply.
4.4.2.9		Cord(s) provided as part of PCE shall be a type suitable for the application in accordance with the *Canadian Electrical Code, Part I.*
4.5	Info	**Terminal parts and leads**
4.5.3		~~A~~ Field wiring ~~terminal~~ provisions for PCE intended for field connection of ~~a~~ conductors larger than No. ~~8~~10 AWG ~~or larger conductor~~ need not ~~be provided with a pressure terminal connector at the time of shipment of the power supply~~ include wiring terminals, provided that a) the ~~power supply and terminal assembly packages are marked~~ PCE is provided with instructions in accordance with Clause 5.13; ~~(a) and~~ b) a fastening device such as a stud, nut, bolt, spring, or flat washer, or the like, as required for an effective installation, is provided ~~as part of the terminal assembly~~ or is specified in the installation instructions; c) the installation of the terminal assembly does not involve the loosening or disassembly of parts other than the cover or other part giving access to the terminal location; d) the means for securing the terminal connectors is readily accessible for tightening before and after the installation of the field conductors; and e) after installation of the terminal in the intended manner, the PCE complies with the requirements of this Standard.
4.5.4		If the ~~pressure~~ terminal connector provided in or specified for use with a terminal assembly requires the use of a special tool for securing the conductor, necessary instructions for using the tool ~~are~~ shall be included ~~in the assembly package or~~ with the ~~power supply~~ PCE in accordance with Clause 5.41. ~~and after installation of the pressure terminal in the intended manner, the power supply complies with the requirements of this Standard.~~
4.6	Info	**Current-carrying parts**

Clause	Verdict	Comment
4.6.2		Bare live parts (including conductors) shall be secured to their bases or mounting surfaces so that they will be prevented from turning or shifting so as to reduce the spacings required by Clause 4.16. Friction between surfaces ~~is~~ shall not ~~an acceptable~~ be used as a means of preventing the turning of live parts, but a suitable lockwasher ~~will~~ may be ~~acceptable~~ used if properly applied.
4.8		**Electrical insulation**
4.8.2		Insulating material relied on for compliance with this Standard and that ~~may~~ can be subject to the influence of the arc formed by the opening of a set of contacts shall be suitable for the particular application with regards to resistance to arcing.
4.9	Info	**Transformers**
4.9.1		Transformers shall comply with the requirements of CSA ~~Standard~~ C22.2 No. 66.1, CSA C22.2 No. 66.2, and/or CSA C22.2 No. 66.3, so far as they apply.
4.10	Info	**Motors**
4.10.2		Fan motors, other than those connected in secondary circuits that operate at extra-low-voltage and are supplied by Class 2 circuits, shall be provided with either of the following: a) inherent overheating protection complying with the requirements of CSA ~~Standard~~ C22.2 No. 77; or b) overload protection rated or set at not more than 125% of the motor full load current rating.
4.11	Info	**Capacitors**
4.11.3		Electrolytic or other special types of capacitors and capacitors intended for connection directly across the line shall be approved for the application or shall be made the subject of investigation.
4.11.4		Provision shall be made for the safe discharge of the energy stored in capacitors if the safety of an area to which a service worker has access for routine maintenance is dependent upon deenergization of the ~~power supply~~ PCE, unless a) the covers by which access is gained require the use of tools for removal; and b) the ~~power supply~~ PCE is marked with clear instruction specifying the time required for a safe discharge (see Clauses 5.42 and 6.19). In cord-connected ~~power supplies~~ PCE, the pins of the attachment plug shall be considered as bare live parts unless there is an isolating transformer between the supply cord and the capacitors. ~~(see Clause 6.20).~~
~~4.12~~		~~**Suppressors**~~
4.12	Info	**Fuses and fuseholders**

Clause	Verdict	Comment
4.12.4		When fuseholders are accessible to the operator, ~~either a caution in accordance with Clause 5.7 shall be provided or~~ the design shall be such that bare live parts of a fuse or fuseholder that ~~may~~ might be a shock hazard cannot be contacted by the probe shown in Figure 1 when the fuse is completely inserted or when the fuse is tilted at any angle during insertion or removal, or has been completely removed, except for a plug fuse in accordance with Clauses 4.12.1 and 4.12.2. Where a plug fuse is accessible to the operator, the warning marking of Clause 5.7 shall be provided. ~~**Note:** *Accessibility is not to be considered with the fuse completely removed.*~~
4.13	Info	**Overload relays**
~~4.14.1~~		~~Overload relays shall be so designed and connected as to ensure reliable and positive electrical and mechanical performance for their intended purpose under all conditions of operation.~~ Automatic tripping of overload relays shall be independent of manipulation of the handle.
~~4.14.3~~		~~Adjustable overload relays shall be provided with instructions for such adjustment.~~
4.14	Info	**Switches and controllers**
4.14.1		~~Switches shall comply with the requirements of CSA Standards C22.2 No. 14, C22.2 No. 55, and C22.2 No. 111 so far as they apply.~~ A switch or other control device shall have a current and voltage rating not less than that of the circuit that it controls when the equipment is operated under any condition of normal service.
4.16	Info	Spacings
4.16.1.1		Spacings shall comply with the requirements in Clauses 4.16.2 to 4.16.14 or, as an alternative, the spacings requirements in Clause 4.17 may be used. The requirements in Clause 4.17 shall be used for PCE or portions of PCE operating at voltages higher than those covered by the requirements in Clause 4.16.2 to 4.16.14.
4.16.1.2		Unless stated otherwise, spacings shall be based on the maximum voltages involved under the worst case normal conditions within the PCE ratings.
4.16.1.3		When the PCE or part of a PCE has a higher voltage rating to ground than the pole-to-pole voltage rating, spacings to ground and to accessible conductive parts shall be based on the maximum rated voltage to ground. **Note:** *This situation can arise where PCE are rated for series connection with other PCE, for example where dc power supplies are rated to be "stacked" or with PV power optimizers rated to be connected into strings.*

Clause	Verdict	Comment
4.16.8		Where the "transients limited" spacings of Table 7 or 8 are applied, and transient reduction is by means of metal oxide varistors (MOVs): a) failure of the MOV overvoltage protection shall be automatically detected; b) the protected circuit shall be automatically de-energized upon failure of the protection; c) the PCE shall provide external indication of the failure; and d) if the PCE is for permanent installation, the MOV may be provided by the installer and external to the PCE, in which case the information in Clause 5.34 a) shall be provided.
4.16.11		Bare current-carrying parts connected to different circuits shall be spaced from each other as though they were parts of opposite polarity~~, in accordance with the requirements of Clause 4.17.1,~~ and shall be judged on the basis of the highest voltage involved.
4.17		**Alternative approach to spacings**
4.17.1		**General** For this alternate approach to spacings, in accordance with Clause 4.16.1, the construction and test requirements of C22.2 No. 0.2 apply, along with the following:
4.17.2		**Overvoltage category (OVC)**
4.17.2.1		The overvoltage category shall be selected as follows: a) OVC IV applies to circuits connected to utility ac at or ahead of the service entrance; b) OVC III applies to circuits connected to utility ac downstream of the service entrance; c) OVC II applies to circuits connected to utility ac downstream of the OVC III distribution level (e.g., circuits connected to socket outlets), and to circuits isolated from the utility or separately derived but not transient free (e.g., PV array circuits); or d) OVC I applies to transient free secondary circuits isolated from the utility (e.g., battery inputs isolated from other circuits).
4.17.2.2		If the Clearance B (controlled overvoltages) approach from CSA C22.2 No. 0.2 is used and the overvoltage protective devices or systems are MOVs that are integral to the PCE, then a) failure of the MOV overvoltage protection shall be automatically detected; b) the protected circuit shall be automatically de-energized upon failure of the protection; c) the PCE shall provide external indication of the failure; and d) if the PCE is for permanent installation, the MOV may be provided by the installer and external to the PCE, in which case the information in Clause 5.34 a) shall be provided.

Clause	Verdict	Comment
4.17.3		**Pollution degree (PD)** The PD shall be selected in accordance with CSA C22.2 No. 0.2. Portions of the PCE may have a different PD than the external environment, if measures are taken to reduce condensation, contamination, or both, in accordance with CSA C22.2 No. 0.2. If PCE is intended for use in an external environment that is PD4, measures shall be taken to control entry of contamination into the PCE enclosure to reduce the PD to PD3 or better. Coatings including solder mask used to reduce the PD shall comply with the coatings test requirements in CSA C22.2 No. 0.2.
4.17.4		**Installation instructions** Installation instructions provided with the PCE shall specify the PD and overvoltage categories applied, in accordance with Clause 5.34 b).
~~4.17.7~~		~~The spacings within components such as lampholders and special use switches shall comply with the applicable Standard of the *Canadian Electrical Code, Part II*.~~
4.18	Info	**Separation of circuits**
4.18.1		Factory-and field-installed insulated conductors (internal wiring, including wires in a terminal box or compartment) that operate at different voltages shall comply with at least one of the following: a) be segregated by internal barriers; b) be physically separated from each other; c) be segregated by ~~grounded~~ bonded shielding; d) have all conductors insulated for the highest voltage; or e) have either conductor (or the group of conductors for that voltage) insulated for twice the highest voltage.
4.18.2		Insulated conductors shall be separated from bare live parts at a voltage higher than that for which the conductors are insulated, by either internal barriers or ~~shall be segregated~~ by physical separation.
4.18.3		~~Segregation or~~ Physical separation ~~of insulated conductors~~ may be accomplished by clamping, routing, or an equivalent means that ensures permanent separation.
~~4.18.12~~		~~Grounded shielding, when used, shall be subject to investigation to determine compliance with CSA Standard C22.2 No. 0.4.~~
4.19		**Overcurrent protection** ~~**Protection of Control, Battery, and Output Power Circuits**~~
4.19.1		**Circuits external to the PCE**

Clause	Verdict	Comment
4.19.1.1		Overcurrent protection shall be provided for a) control circuits that extend from the ~~power supply~~ PCE to a remote control panel or the like, unless such circuits are Class 2 in accordance with the *Canadian Electrical Code Part I*; and b) an ac or dc output circuit **Note:** *Overcurrent protection for PCE input circuit conductors is provided in the installation.* ~~(b) battery supply circuits (see Table 9); and an ac output~~ Overcurrent protection for external circuits ~~except for a UPS~~ need not be provided in PCE having provision for permanent wiring connection of the ac output circuit and provided with an instruction manual specifying that overcurrent protection shall be provided at the time of installation ~~(see Clause 5.27).~~ and specifying the ratings and type of overcurrent protection to be provided in accordance with Clause 5.27. ~~**Note:** *Equivalent protection may be achieved by electronic means.*~~
4.19.1.3		~~**Note:**~~ The protective devices may be circuit breakers or fuses acceptable for use as branch circuit protection or supplementary protectors ~~*as covered by CSA Standard CAN/CSA-C22.2 No. 235 (see also Table 9)*~~. If a supplementary protector is used to comply with Clause 4.19.1.1 b), it shall comply with CSA C22.2 No. 235 and meet all of the following: a) have a short-circuit application code of U3; b) have a tripping current application code of TC3; c) have an overload code of OL0 or OL1. The inverter shall be marked with the corresponding OL rating in accordance with Clause 5.38. The instructions for use shall identify the OL rating and shall explain its meaning in accordance with Clause 5.39; d) be an overcurrent type or a shunt trip overcurrent type; e) have a short circuit current rating not less than the maximum available fault current under all PCE operating modes; and f) be of a type appropriate for the PCE intended use application (industrial, commercial, or household).
4.19.1.4		Notwithstanding Clause 4.19.1.3, equivalent electronic overcurrent protection may be provided. The electronic means shall a) be assigned a nominal rating that is published in the installation instructions and marked on the PCE in accordance with Clause 5.40; b) limit the current to not more than 135% of the nominal rating for 1 h and not more than 200% of the nominal rating for 2 min; c) have a current vs. time characteristic that is below and to the left of an exponential curve passing through the points in Item b) as shown in Figure 12; and d) not trip at currents of 110% of the nominal rating or less.

Clause	Verdict	Comment
4.19.1.5		For PCE intended for parallel connection to other PCE of the same type, the installation instructions shall specify the maximum number of units that can be paralleled before overcurrent protection must be provided, and the location and maximum rating or setting of the overcurrent protection, in accordance with Clause 5.27.
4.19.2		If overcurrent protection of internal circuits is needed to comply with Clause 6.6, then the protection device shall be located between the source and any component that may short circuit due to failure of the component, and shall be capable of interrupting the short-circuit current of the circuit in which they are used. The circuit protection need not be provided in PCE having provision for permanent wiring connection of the circuit and provided with an instruction manual specifying that overcurrent protection shall be provided at the time of installation (see Clause 5.27) and specifying the ratings and type of overcurrent protection to be provided.
4.19.3		**Battery circuits** For battery ~~cabinets~~ circuits, the protective device required by Clause 4.19.1.1 b) ~~for battery supply circuits shall be located between the battery and any component that may short-circuit due to failure of the component, such as a capacitor or solid state device, and shall comply with the overcurrent protection test of Clause 6.7.~~ or 4.19.2 shall have an interrupting rating not less than the battery short circuit current or shall comply with the short circuit test in the relevant CSA C22.2 Standard when tested with the highest capacity battery used in or with the PCE.
4.20		**Disconnecting means** **Note:** *Additional requirements for disconnecting means for high voltage circuits are in Cause 4.25 and for PV circuits are in Clause 14.*
4.20.1		Disconnecting means shall be provided for the input or output ac and dc power circuits of ~~power supplies~~ the PCE not having either a cord and plug or receptacle for connection of the input or output ac or dc circuit~~; and~~. ~~(b) a dc supply circuit for remote batteries and batteries located in cabinets.~~
4.20.2		The disconnecting means shall be an integral part of the ~~power supply,~~ PCE or the instruction manual shall specify that it is to be provided at the time of installation in accordance with Clause 5.35.
4.20.3		If disconnecting means for an input power circuit is provided in the PCE then parts that remain energized with the disconnecting means in the off position shall be guarded against inadvertent contact by service personnel.
4.20.4		If provided, a disconnect device shall a) open all ungrounded conductors of the circuit to which it is connected; b) consist of a manually operated switch or a circuit breaker; and c) be load break rated.

Clause	Verdict	Comment
4.20.6		Where the PCE is supplied by two or more different transformers or other different sources of voltage, then the disconnecting means shall comply with one of the following: a) a single disconnecting means is provided integral to the PCE for all sources connected to the PCE; b) more than one disconnecting means are provided that together provide isolation for all sources connected to the PCE and the marking of Clause 5.16.2 appears adjacent to each disconnect device; or c) no disconnecting means is provided in the PCE, or not all source circuits are provided with disconnecting means, in which case the installation instructions shall contain the information in Clause 5.35.
4.20.7		Disconnecting means need not be provided for control circuits originating beyond the PCE and not exceeding 150 volts-to-ground, provided that all associated bare live parts in the PCE are protected against inadvertent contact by means of barriers.
4.20.8.1		Means shall be provided integral to or adjacent to fuse holders, to disconnect fuses from all sources of energy and allow for safe servicing of the fuses, if the fuses are located in input or output power circuits.
4.20.8.2		The disconnecting means integral to or adjacent to fuse holders in Clause 4.20.8.1 is not required if a) internal current limiting or equivalent protection in the PCE will prevent the fuse from opening due to external faults or overloads and complies with the requirements in Clause 4.19.1.4; **Note:** *In such circumstances, the fuse is unlikely to open and to require replacement so the disconnecting means for the PCE, required by Clause 4.20, is adequate and a disconnecting means integral or adjacent to the fuseholders is not needed.* b) disconnecting means is provided in accordance with Clauses 4.20.1 to 4.20.7; or c) isolating means is provided and the system incorporates a means to ensure no load current is flowing in the isolating means during its opening and closing; the isolating means shall be marked in accordance with Clause 5.25. **Note:** *Isolating means are not load break rated, whereas disconnecting means are load break rated. The intent of Item c) is to allow non-load break rated switches, finger-safe fuseholders, suitably located connectors, etc., as isolating means for fuses, as long as means is provided for the service person to shut off the PCE or other loads so that no current is flowing.*
4.20.8.3		The disconnecting means in Clause 4.20.8.1 is not required to be integral to the PCE if the instruction manual specifies that it is to be provided at the time of installation in accordance with Clause 5.35 and that it is to be located adjacent to the PCE.

Clause	Verdict	Comment
4.21		**Protection of receptacles** An output receptacle shall be protected by an overcurrent device rated or set at not more than the rating of the receptacle unless a) the circuit is not capable of delivering current in excess of the rating of the receptacle under any conditions of loading; or b) electronic protection is provided that ~~cannot be defeated by a single fault~~ complies with Clause 4.19.1.4.
4.22	Info	Battery supplies
4.22.3		~~When no batteries~~ For PCE that are not supplied ~~as permitted by Clause 4.22.2~~ with batteries, or that contain replaceable batteries, the instruction manual ~~for a power supply having an integral battery compartment or a battery cabinet that is not provided with batteries shall specify the manufacturer's name and the catalogue number~~ relevant parameters of the batteries that may be used (~~see~~ in accordance with Clause 5.23 e).
4.22.8		Vented wet cell batteries may be integral with the ~~power supply~~ PCE provided ~~that~~ all the following conditions are met: a) the enclosure or compartment housing the batteries is vented; b) arcing parts such as the contacts of switches, circuit breakers, and relays are not located in the battery compartment; and c) the battery compartment does not vent into compartments with enclosed spaces that contain arcing parts. **Note:** *The requirements of this Clause ~~4.22.8~~ do not apply to sealed cell or valve regulated batteries.*
4.22.9		If vented wet cell batteries are housed in an enclosure or compartment, the ventilation shall provide a minimum of four changes of air per hour and the ~~power supply~~ PCE shall be marked in accordance with Clause 5.18.
4.22.13		If transformer isolation is not provided between the ac input circuit of the ~~power supply~~ PCE and the battery circuit a) the batteries shall be located in a compartment that cannot be accessed without the use of a tool; b) the battery terminals shall be guarded to reduce the likelihood of unintentional contact with the battery terminals by service personnel; and c) the marking specified in Clause 5.21 shall appear adjacent to the batteries where visible before removing the guard; the warning shall not be located on the guard.

Clause	Verdict	Comment
4.22.14		If the battery voltage under any normal condition including charging exceeds 42.4 V, a battery cabinet for external connection to ~~a UPS~~ PCE shall a) be ~~grounded~~ bonded to ground or to the frame of the ~~UPS~~ bonded PCE or be double-insulated in accordance with CSA C22.2 No. 0.1; b) if the battery circuit is cord-connected, have all external plug and receptacle connectors i) provided with a guard to prevent accidental contact with bare live parts of such connectors including any not required for operation of the ~~power supply~~ PCE, unless a tool is required for their separation; and ii) marked in accordance with Clause 5.25; and c) if for nonpermanent connection, have interconnecting wiring not more than 2 m long, if unjacketed conductors are used.
4.25		**Equipment with high voltage input or output circuits**
4.25.1		**General** The requirements of Clause 4.25 apply to PCE with input or output circuits operating at high voltage, as defined by the *Canadian Electrical Code, Part I*. **Note:** *In the 2015 edition of the* Canadian Electrical Code, Part I*, high voltage is defined as exceeding 750 V (ac or dc). That definition can change in a future revisions of the* Canadian Electrical Code, Part I. *This Standard uses whatever the most current definition is in the* Canadian Electrical Code, Part I. *Also, other sections, for example Section 64 of the* Canadian Electrical Code, Part I*, contain provisions, and can be further revised in future, to make certain requirements apply only to systems above a certain voltage.*
4.25.2		**Disconnecting means** Disconnecting means used in a circuit operating at high voltage shall be of the draw-out type, or shall provide visible isolation where required by the *Canadian Electrical Code, Part I*. **Note:** *These requirements are in addition to the requirements in Clause 4.20.*
4.25.3		**Fuse access and interlocking** Compartments containing fuses in high voltage circuits shall have the cover (or door) interlocked with the isolating or disconnecting means where required by the *Canadian Electrical Code Part I*, so that a) there is no access to the fuses unless the isolating or disconnecting means between the fuses and each source of voltage is in the de-energized position; and b) the isolating or disconnecting means cannot be placed in the closed position until the fuse compartment has been closed.
4.25.4		**Installation instructions** The installation instructions for PCE rated for connection to high voltage circuits shall contain the information in Clause 5.36.
4.26	Info	**External signal, control and communication circuits**

Clause	Verdict	Comment
4.26.1		Signal, control, communication, and similar circuits complying with either Clauses 4.26.2 to 4.26.4 or with Clause 4.26.5 may leave the PCE enclosure without the need for subsequently being enclosed in the final installation.
4.26.2		The circuits shall be secondary circuits.
4.26.3		The circuits shall be supplied only from sources complying with the requirements for Class 2 power sources in CSA C22.2 No. 66.3 or CSA C22.2 No. 223.
4.26.4		If an overcurrent protective device is used to comply with the Class 2 limits in Clause 4.26.3, the device shall not be interchangeable with a device having a higher rating, or it shall not be accessible except to service personnel after use of a tool.
4.26.5		As an alternative to Clauses 4.26.2 to 4.26.4, the circuits shall comply with the requirements in CAN/CSA-C22.2 No. 60950-1 for SELV or PELV circuits and for limited power sources.
5		**Markings** **Note:** ~~*In Canada, there are two official languages; therefore, it is necessary to have caution*~~ *See Annex C for equivalent French markings.* ~~*in both English and French. Appendix B gives acceptable French translations of markings specified in this Standard. When a product is not intended for use in Canada, cautionary markings may be provided in English only.*~~
5.1		The equipment shall be plainly marked, in a permanent manner, in a place where the details will be readily visible after installation without the use of a tool, with the following: a) manufacturer's name, trademark, trade name, or other recognized symbol of identification; b) catalogue, style, model, or other type designation; c) rated input voltage(s) including the maximum rated voltage to ground if that exceeds the input voltage; d) an indication whether the equipment is rated for ac or dc, or both, and, when necessary, the input and output frequency; e) number of phases, except for equipment obviously intended for single-phase use only; f) input in amperes*, volt-amperes, or kilovolt-amperes; g) rated output voltage; h) rated maximum continuous output in amperes, volt-amperes, or watts; i) output power factor, if less than unity, unless output is expressed in watts and volt-amperes, or watts and amperes; j) the month and year of manufacture (date coding, serial numbers, or the equivalent may be used); k) the maximum and minimum rated ambient operating temperatures; ~~k) for equipment that is intended for operation in ambient temperatures higher than 25°C, the maximum ambient temperature; and~~ l) for liquid-filled equipment, identification of the dielectric liquid used and quantity in litres;

Clause	Verdict	Comment
		m) for disconnect switches identification of the circuit controlled by the switch and the words "ON" and "OFF" or their symbols ("I" and "O", respectively) to indicate the "ON" and "OFF" positions; and n) where relevant for safety, the functions and positions of other switches and controls. * *Including the neutral current of a 3-phase, 4-wire power supply if larger than the phase current.* Where PCE is intended for connection to a voltage source that normally operates across a range in excess of 10% above or below the nominal voltage, the marking in Item c) shall be the range of operating voltage for which it is intended. Otherwise, marking the nominal voltage is acceptable. **Note:** *For example, a PCE rated for connection to a battery source whose voltage normally varies from 10 V dc to 15 V dc across various states of charge, the PCE marking would state that full range. For a PCE connected to a 120 V ac utility grid where the normal range of operation is not in excess of 10% (108 V ac — 125 V ac based on 120 V ac nominal is –10%, +4% per CSA CAN3-C235) the PCE voltage rating may state simply 120 V ac.*
5.2		Markings shall comply with the requirements of ~~CSA Standard~~ CAN/CSA-C22.2 No. 0, including requirements for language of markings. Where CAN/CSA-C22.2 No. 0 or this Standard requires a safety marking or wording in the documentation, and a flag word ("Warning", "Caution", etc.) is required, the flag word may be replaced as follows: a) "Caution" may be replaced by "Warning" or "Danger"; and **Note:** *In French, "Attention" may be replaced with "Avertissement" or "Danger".* b) "Warning" may be replaced by "Danger". **Note:** *In French, "Avertissement" may be replaced with "Danger".* **Note:** *The intent of the above is to allow users of this Standard to also comply with other safety message standards that use a different hierarchy of flag words* The polarity of ~~the output leads~~ any dc field-wiring provisions shall be plainly marked on or adjacent to the provisions, unless the ~~power supply~~ PCE is provided with a polarized termination.
5.3		The polarity of ~~the output leads~~ any dc field-wiring provisions shall be plainly marked on or adjacent to the provisions, unless the ~~power supply~~ PCE is provided with a polarized termination.
5.4		Unless the proper wiring connections are plainly evident, wiring terminals shall be marked, or the ~~device~~ markings or installation instructions shall ~~be provided with~~ include a suitable wiring diagram to indicate the proper connections. If additional information is necessary for the proper ~~operation~~ use of the ~~device, it shall be provided with~~ wiring terminals, the ~~device (eg,~~ information shall be provided in ~~an accompanying booklet).~~the installation instructions.

Clause	Verdict	Comment
5.5		Markings and instructions relating to conductor insulation temperature and the temperature used for ampacity calculations shall be in accordance with the following: a) Conductor insulation temperature marking: The following ~~caution~~ wording, or the equivalent, shall be ~~shown~~ marked at or near the point where the field connections will be made if the temperatures ~~in the~~ at any point on or within a supply terminal box or ~~compartment intended for the~~ on the supply conductors or field ~~connections~~ wiring terminals exceeds ~~60°C in~~ the ~~normal temperature test~~ limits of Table 9. (See Clause 6.3 and Table 9): WARNING: USE ~~WIRES SUITABLE~~ CONDUCTORS WITH INSULATION RATED FOR AT LEAST °C. The value of temperature to be marked in the caution shall be i) 75 °C for temperatures in the range of over 60 to 75 °C; and ii) 90 °C for temperatures in the range of over 75 to 90 °C. b) Conductor termination temperature marking: The following marking or equivalent wording shall appear adjacent to field wiring terminals: BASE THE CONDUCTOR AMPACITY ON A MAXIMUM TERMINATION TEMPERATURE OF °C The temperature to be used in the marking shall not exceed the temperature the ampacity was based on in determining conductor sizes during temperature testing in accordance with Clause 6.3.1. This marking can be combined with the marking in Item a). c) Conductor temperature rating installation instructions: The installation instructions for the PCE shall specify the criteria for selection of field wiring with respect to insulation temperature rating and termination temperatures. Regarding termination temperatures, the installation instructions shall require the installer to consider the maximum termination temperature at both ends of the conductor and to base the ampacity on the lower value.
5.6		For all fuses, the required voltage and current ratings and type of fuse shall be marked, along with the wording: WARNING: REPLACE ONLY WITH THE SAME RATINGS AND TYPE OF FUSE. The ratings, type, and warning wording shall be located adjacent to each fuse or group of fuses, or may be located in a single location where they will be visible to personnel replacing the fuse(s). ~~The required voltage and current rating of customer replaceable fuses and other fuses, as specified in Clause 4.1.3(a)(ii), that provide current limitation for compliance with this Standard, shall be marked in the vicinity of the fuse.~~
5.7		When required by Clause 4.12.4, the following marking or its equivalent shall be provided: ~~CAUTION~~ WARNING: DISCONNECT SUPPLY BEFORE CHANGING FUSE.

Clause	Verdict	Comment
5.9		When required by Clause 4.23.3, the equipment shall be marked with the following or equivalent: ~~CAUTION~~ WARNING: ONDING BETWEEN CONDUIT CONNECTIONS IS NOT AUTOMATIC AND MUST BE PROVIDED AS A PART OF THE INSTALLATION or alternatively ~~CAUTION~~ WARNING: NONMETALLIC ENCLOSURE DOES NOT PROVIDE ~~GROUNDING~~ BONDING BETWEEN CONDUIT CONNECTIONS. USE GROUNDING TYPE BUSHINGS AND JUMPER WIRES. This marking may be on a paper tag, or equivalent, inside the equipment.
5.13		If ~~pressure wire connectors~~ terminals for the connection of field conductors are not provided with the ~~power supply at the time of shipment~~ PCE, as permitted by Clause 4.5.3, the ~~power supply shall be marked to indicate which pressure terminal connectors or component terminal assembly packages shall be used with the power supply. This marking may appear on a tag attached to the power supply~~; PCE installation instructions shall include guidance for the proper selection of suitable terminals, including information such as material compatibility, matching terminals to the size and stranding of the field wiring used, termination temperature considerations, proper mounting to the PCE with regards to secureness and contact surface area, and other necessary considerations depending on the type of field wiring provisions in the PCE. ~~(b) the terminal assembly packages shall be marked with an identifying marking, wire size, and the name, trademark, or other recognized symbol of identification of the manufacturer; and~~
5.14		When required by Clause 4.2.6.7, the live part such as a heat sink or relay frame shall be identified. The following or equivalent caution shall be located on or near the live part and shall be readily visible: ~~CAUTION~~ WARNING: IS LIVE. RISK OF ELECTRIC SHOCK. DISCONNECT POWER BEFORE SERVICING. **Note:** *Space for insertion of the name of the part that is live ("heat sink", "relay frame", etc).* **Note:** *One label may suffice to identify a number of such live parts if all are in close proximity to the label.*
5.15		A ~~power supply~~ PCE that is intended to be permanently secured to a structure and is provided with a supply cord in accordance with Clause 4.4.1.1 shall be marked with the following or equivalent: THE SUITABILITY OF THE USE OF FLEXIBLE CORD PER ~~CEC~~ THE *CANADIAN ELECTRICAL CODE, PART I*, ~~RULE 4-010,~~ IS TO BE DETERMINED BY THE LOCAL INSPECTION AUTHORITY HAVING JURISDICTION.

Clause	Verdict	Comment
5.16.1		~~A power supply~~ PCE that is energized from more than one ~~circuit and that does not have means for disconnecting all ungrounded conductors within a single enclosure or compartment~~ shall be permanently marked on the outside with the following or equivalent wording: WARNING: DISCONNECT ALL SOURCES OF SUPPLY BEFORE SERVICING or WARNING: MORE THAN ONE LIVE CIRCUIT — SEE DIAGRAM.
5.16.2		If the marking refers to a diagram, the installation instructions for the PCE shall include a diagram showing all sources that may be energizing the PCE, or shall require the installer to provide such a diagram. Where multiple disconnecting means are provided as in Clause 4.20.6 b), wording shall be placed on or adjacent to each disconnecting means indicating that all of the disconnecting means must be opened to ensure complete de-energization of the equipment.
5.16.3		If switches or disconnecting means are integral to the PCE and are energized on both sides, the PCE shall be marked adjacent to the device with a warning notice that contacts on either side of the device may be energized. **Note:** *Clause 5.16 does not apply to circuits at extra-low-voltage ~~as defined in the Canadian Electrical Code, Part I.~~*
5.18		When required by Clause 4.22.9, the following marking or equivalent shall appear on the cabinet or compartment housing the batteries: ~~CAUTION~~ WARNING: THIS CABINET (COMPARTMENT) CONTAINS VENTED WET CELL BATTERIES. VENTILATION OF THE ROOM IN ACCORDANCE WITH THE RULES OF THE *CANADIAN ELECTRICAL CODE, PART I*, IS REQUIRED.
5.19		A remote battery supply/cabinet assembly shall be marked to show the nominal dc circuit rating (volts and amperes). ~~The nominal dc ampere rating for a UPS shall be the value of battery current measured during the reserve mode of operation (see Clause 11.3.1.1(b)) when the output voltage of the battery supply equals the nominal voltage rating of the battery or the value calculated from the following formula:~~  ~~(Deleted)~~ ~~where~~ ~~I = nominal dc battery current in amperes~~ ~~W = battery power rating in watts~~ ~~N = total number of battery cells in a series string~~ ~~V = nominal voltage rating of battery cells (= 2 V and 1.2 V for lead-acid and alkali batteries, respectively)~~

Clause	Verdict	Comment
5.20		When required by Clause 4.23.5 b), the following marking or equivalent shall appear on the ~~power supply~~ PCE: WARNING: NEUTRAL FLOATING.
5.21		When required by Clause 4.22.13, the following marking or equivalent shall be provided adjacent to the batteries: ~~CAUTION~~ WARNING: RISK OF ELECTRIC SHOCK. BATTERY CIRCUIT IS NOT ISOLATED FROM AC INPUT. HAZARDOUS VOLTAGE MAY EXIST BETWEEN BATTERY TERMINALS AND GROUND. TEST BEFORE TOUCHING.
5.22		Explicit battery safety instructions (see Clause 5.23) shall be provided for a a) ~~power supply~~ PCE having internal batteries; b) remote battery supply investigated under the requirements of this Standard; and c) ~~power supply~~ PCE intended for use with ~~batteries to be located in a remote battery room when the batteries are furnished with the power supply.~~ external batteries **Note:** *These instructions may appear on the ~~power supply~~ PCE or in an instruction manual accompanying the ~~power supply~~ PCE.*
5.23		The safety instructions for batteries that are required by Clause 5.22 shall include ~~those~~ the items on the following list. The statement "IMPORTANT SAFETY INSTRUCTIONS" shall precede the list. Equivalent wording of the listed instructions is acceptable.: a) SAVE THESE INSTRUCTIONS — THIS MANUAL CONTAINS IMPORTANT SAFETY INSTRUCTIONS. b) ~~CAUTION~~ WARNING: A BATTERY CAN PRESENT A RISK OF ELECTRICAL SHOCK, BURN FROM HIGH SHORT-CIRCUIT CURRENT, FIRE OR EXPLOSION FROM VENTED GASES*. OBSERVE PROPER PRECAUTIONS. * *Cautionary statement regarding fire or explosion from vented gases is not required for valve-regulated (sealed-cell) batteries.* c) WHEN REPLACING BATTERIES USE THE SAME NUMBER AND THE FOLLOWING TYPE BATTERIES†. †*Identifying battery type such as sealed-cell lead acid, vented lead acid, nickel cadmium, or other equally* *definitive term describing the batteries used.* d) PROPER DISPOSAL OF BATTERIES IS REQUIRED. REFER TO YOUR LOCAL CODES FOR DISPOSAL REQUIREMENTS.~~ and~~ e) The safety relevant battery parameters shall be specified, such as battery type and chemistry, voltage, Ah rating, form factor, maximum short circuit current contribution, etc. f) For batteries that require the addition of water, instructions for determining the electrolyte level, for determining the proper level when full, and for adding water, shall be provided.

Clause	Verdict	Comment
		g) For PCE in which the batteries are external to the PCE, the installation instructions shall specify that the battery installation must be done in accordance with the storage battery rules of the *Canadian Electrical Code, Part I*. ~~(e) the manufacturer's name and the catalogue number of the batteries that may be used when batteries are not supplied as permitted by Clause 4.22.3.~~
5.25		When required by Clause 4.20.8.2 c) or 4.22.14, the following marking or equivalent shall appear on or adjacent to the external battery connector or isolating means: WARNING: DO NOT DISCONNECT UNDER LOAD.
5.26		The installation instructions shall include all information (cooling, mounting, etc.) necessary for the proper installation and function of the ~~power supply~~ PCE, and shall state that the installation shall be in accordance with the *Canadian Electrical Code, Part I*.
5.27		When required by Clause 4.19, 9.3.2.2, 10.3.1, or 13.5.2.5, the instruction manual shall specify that overcurrent protection ~~for the ac output circuit~~ is to be provided at the time of installation, shall specify that coordination of conductor sizes with overcurrent protection shall be in accordance with the *Canadian Electrical Code, Part I*, and shall specify the required ratings of the overcurrent devices where particular values are required to adequately protect the PCE or its components. Where required by Clause 4.19.1.5, for PCE intended for parallel connection to other PCE of the same type, these installation instructions shall include the maximum number of units that can be paralleled before overcurrent protection must be provided, and the location and maximum rating or setting of the overcurrent protection.
5.28		When required by Clause 4.4.2.7 b), the supply cord of a ~~power supply~~ PCE having a rating of 208 V, single-phase, and an attachment plug rated at 250 V shall be provided with a permanently attached tag bearing the following or equivalent marking: ~~CAUTION~~ WARNING: RISK OF ELECTRIC SHOCK AND FIRE. CONNECT TO A RECEPTACLE WIRED FOR 208 V AC.
5.30		A ~~power supply~~ PCE having an internal battery supply shall be marked with the following or equivalent caution on the outside of the ~~power supply~~ PCE unless it is prominently visible with any cover or panel opened: ~~CAUTION~~ WARNING: RISK OF ELECTRIC SHOCK. HAZARDOUS LIVE PARTS INSIDE THIS POWER SUPPLY ARE ENERGIZED FROM THE BATTERY SUPPLY EVEN WHEN THE INPUT AC POWER IS DISCONNECTED.
5.31		When required by Clause 4.23.6, the following shall be marked on the unit or in the accompanying instructions: WARNING: PROVIDE GROUND DETECTION DEVICE DURING INSTALLATION.

Clause	Verdict	Comment
5.34		Where the alternative approach to spacings in Clause 4.17 is used for any portion of the PCE, the installation instructions shall include the following as applicable: a) a specification of any overvoltage protective devices that must be provided as part of the installation in order to comply with the Clearance B approach in Clause 4.17.2; for MOVs, these instructions shall include any information needed by the installer to implement the required automatic de-energization and external failure indication; and b) a specification of the external PD and overvoltage categories that the PCE is rated for.
5.35		Where one or more disconnecting means for external sources is not provided integral to the PCE, as allowed by Clauses 4.20 and 4.25, the installation instructions shall state that the disconnecting means must be provided as part of the installation, and shall provide the necessary electrical ratings for the selection of the disconnecting means, the circuit location(s) for the disconnecting means, and the physical location if that is specified elsewhere in this Standard. **Note:** *Physical location may need to be specified where, for example, there are requirements in this standard or in the* Canadian Electrical Code, Part I *that a disconnecting means must be adjacent to or within sight of equipment.*
5.36		The installation instructions for PCE rated for connection to high voltage circuits shall require the installer to mark the PCE with the following wording or equivalent, located on or adjacent to each wiring compartment giving access to high voltage circuits, only if actually connected to high voltage in the installation: DANGER — HIGH VOLTAGE or DANGER XXX V where XXX is replaced by the rated voltage.
5.37		For PCE in which one or more circuits has a higher voltage rating to ground than the pole-to-pole voltage ratings, the installation instructions shall include the maximum voltage rating to ground and any related installation requirements such as the maximum number of PCE allowed to be connected in series, the voltage rating to be used for field wiring and associated equipment, etc.
5.38		When required by Clause 4.19.1.3, the OL rating of the supplemental protector shall be marked adjacent to the protector.
5.39		When required by Clause 4.19.1.3, the installation instructions shall specify the OL rating of the supplemental protector, and shall explain the overload test multiplier corresponding to the applicable OL rating. These multipliers are a) for OL0: 1.5 times the ampere rating for general use; or b) for OL1: 6 times the ac current rating or 10 times the dc current rating for motor starting applications.

Clause	Verdict	Comment
5.40		When electronic overcurrent protection for external circuits is provided in the PCE in accordance with Clause 4.19.1.4, the installation instructions for the PCE shall specify the nominal current rating and can specify the current vs. time characteristic of the electronic overcurrent protection. The PCE shall be marked with the following: [name of circuit] IS PROVIDED WITH INHERENT OVERCURRENT PROTECTION SET AT XX A. where XX is the nominal current rating of the electronic overcurrent protection in amperes.
5.41		~~if~~ Where required by Clause 4.5.4, for a terminal connector that requires the use of a special tool to secure the conductor, necessary instructions for using the tool shall be provided. These instructions shall appear in the installation manual for the PCE or marked in a readily visible location, such as on the connector, on a wiring diagram, on a tag secured to the connector, or in an assembly package provided with the ~~power supply.~~ PCE.
5.42		When required by Clause 4.11.4, the PCE shall be marked with the following or equivalent wording: WARNING: RISK OF ELECTRIC SHOCK FROM STORED ENERGY. WAIT MIN AFTER DISCONNECTING ALL SOURCES OF SUPPLY BEFORE ACCESSING. As an alternative, the symbols in Figure 18 may be used, and shall be accompanied by the following wording or equivalent: WARNING: STORED ENERGY. ALLOW S FOR DISCHARGE.
5.42		Where required by Clause 4.2.1.1, a PCE with exposed terminals shall be marked with the following or equivalent: WARNING: SHOCK HAZARD. ONLY FOR MOUNTING IN A RACK OR ENCLOSURE FULLY ENCLOSING ALL LIVE PARTS. The installation instructions shall indicate which parts require enclosing in the end application.
5.44		The installation instructions shall specify the full range of output voltage(s) and current(s) under normal conditions for each output of the PCE, if the values vary by more than ± 10% of the rated values marked in accordance with Clause 5.1.
5.45		The installation instructions shall specify any remote control or communications systems necessary for the safe operation of the system.
5.46		Where required by Clause 6.3.8, a hot accessible surface shall be marked with the following or equivalent wording: WARNING: HOT SURFACE. As an alternative, IEC 60417 symbol number 5041 may be used. **Note:** *For convenience, IEC 60417 symbol number 5041 is reproduced here:*

Clause	Verdict	Comment
		 (New)
5.46		The installation instructions shall include an explanation of any symbols used in the markings on the PCE required by this Standard.
6	Info	**Tests**
6.1	Info	**Test conditions**
6.1.1		**General** In general, unless otherwise stated below, and only where the test results could be affected, the test conditions with regards to PCE operating modes, input electrical parameters, output loading parameters, physical orientation, etc., shall be those conditions within the manufacturer's ratings, installation instructions, etc. that result in worst case conditions for the particular test under consideration. For a particular test, it might be necessary to perform the test under more than one set of conditions in order to determine complete worst case test results. **Note:** *For example, when performing fault tests, using a source with less than the maximum short circuit current available might be worst-case, if it results in a longer test duration.*
6.1.2		**Voltage**
6.1.2.1		Except as specifically noted, ~~power supplies~~ PCE having an input or output intended for connection to an ac utility supply system, and having a voltage rating between 110 and 120 V ac, between ~~190~~ 194 and 208 V ac, between 220 and 240 V ac, between 254 and 277 V~~, or~~ ac, between 318 and 347 Vac, between 440 and 480 V ac, or between 550 and 600 V ac shall be tested at 120, 208, 240, 277, 347, 480, or 600 V~~,~~ ac, respectively.
6.1.2.2		~~Multivoltage power supplies~~ Where PCE is required by Clause 5.1 to be marked with a range of voltages, or is rated to be operated at more than 1 nominal voltage, the PCE shall be tested at the voltage(s) that produce the ~~highest temperatures~~ worst case test results. Where Clause 5.1 allows marking of the nominal voltage only, the PCE shall be tested at the nominal value.
6.1.4	Info	**Other test conditions**
6.1.4.2		~~Output~~ Current measurements shall be made using an rms meter for ac currents and dc currents with superimposed ac components. An average-reading meter may be used for dc currents with an RMS ac component less than 5% of the mean dc value.

Clause	Verdict	Comment
6.1.4.3		Sources used to supply power to PCE during testing shall be the intended source (e.g., a utility ac supply, a battery, or a PV array) or a simulated source whose characteristics match the characteristics of the intended source in any aspects that affect the outcome of the test being performed. Where the characteristic of the source will not affect the test results, any convenient source may be used.
6.1.4.4		Unless otherwise stated below, during testing the PCE shall be connected in accordance with the applicable requirements of the *Canadian Electrical, Code Part I* or the installation instructions provided with the PCE, whichever results in the worst case conditions for the particular test under consideration, with respect to field wiring conductor sizes, external overcurrent protection, grounding, etc.
6.1.4.5		For PCE intended for series or parallel connection to other PCE of the same type, all system configurations within the manufacturer's specifications shall be considered in determining the worst case test conditions for the single PCE under test. **Note:** *The intent of the above is to ensure testing conditions take into consideration system conditions, for example:* a) *series connection of PCE resulting in a high voltage with respect to ground in some units; or* b) *parallel connection of PCE resulting in current from other units passing through the unit under test.*
6.2	Info	**Ratings** When operated under normal conditions in accordance with Clause 6.1, selecting the conditions that cause the highest normal continuous input current, the PCE input and output currents shall be measured and shall not exceed 110% of the marked value or the calculated value when the output rating is not expressed in amperes. The test shall be performed when the PCE has been operating for sufficient time to be thermally stable. Ambient temperature for the test shall be taken into account, for example where additional current may be drawn by heaters in cold temperatures.
~~6.2.3~~		~~**Rating (Input)**~~ ~~The load to be used for the rating (input) and temperature tests shall be the marked output amperes or the calculated value when the output rating is not expressed in amperes.~~
~~6.2.3.2~~		~~The average input current in amperes shall be measured when temperatures on electrical components have become constant and shall not exceed 110% of the marked value.~~
6.3	Info	**Temperature (normal)**

Clause	Verdict	Comment
6.3.1		The equipment shall be operated ~~at rated output, at the test voltage and frequency~~ under the conditions specified in Clause 6.1, under conditions of loading that result in maximum operating temperatures, until thermal equilibrium is reached. Notwithstanding Clause 6.1.4.4, the ampacity used to select conductor sizes for temperature testing shall be based on the higher of a) the termination temperature rating of the device(s) the field wiring connects to in the PCE; or b) the termination temperature specified by the PCE manufacturer.
6.3.2		Dry-type equipment shall be considered to comply with the requirements if a) temperatures at specified points do not exceed the ~~values~~ limits specified in Tables 9 and 10; b) there is no evidence of fire hazard or ~~injury~~ damage to materials in the equipment; and c) any overheating or overload protective devices in the equipment do not operate during the normal temperature test.
6.3.3		The temperature limits specified in Tables 9 and 10 are based on an ambient temperature of 25 °C and apply to equipment intended for use in ambient temperatures that are not usually higher than 25 °C but may be as high as 40 °C occasionally and for brief periods. Tests ~~of equipment for service in such ambient temperatures~~ may be conducted at any ambient temperature between 10 and 40 °C in which case the variation below or above 25 °C is to be respectively subtracted from or added to the allowable temperatures specified in Tables 9 and 10.
6.3.4		~~Power supplies~~ PCE rated specifically for use in prevailing ambient temperatures constantly more than 25 °C shall be tested at the higher rated ambient temperature; ~~except that, with the agreement of the testing agency.~~ As an alternative, the test may be conducted at a lower ambient temperature in which case the ~~allowable temperatures specified in Table 10~~ resulting temperature measurements shall be ~~reduced~~ adjusted upward by the amount ~~that~~ by which the ~~higher~~ rated ambient exceeds the test ambient temperature, for comparison to the allowable temperature limits specified in Tables 9 and 10.
6.3.5		Temperatures shall be determined by thermocouples. For windings, temperatures may alternatively or additionally be determined by the rise-of-resistance method ~~in accordance with CSA Standard CAN/CSA-C22.2 No. 0, except that, in special cases, one method may be specified by the testing agency~~. A temperature shall be considered constant when three successive readings taken at ~~5~~ 15 min intervals indicate no significant change. $T = \frac{R}{r}(234.5 + t) - (234.5)$ (New) For the rise-of-resistance method, the following formula shall be used: where

Clause	Verdict	Comment
		T = calculated total temperature, °C *R* = resistance in ohms at temperature *T* (i.e., while hot) *r* = resistance in ohms at temperature *t* *t* = reference room temperature, °C For aluminum conductors of 62% volume conductivity, substitute "225" for "234.5" in the above formula; for aluminum conductors of 61% volume conductivity, substitute "228".
6.3.6		The temperature rise of the field wiring terminals ~~shall be investigated for equipment used in ambient temperatures exceeding 25°C~~ and parts and surfaces which field wiring conductors may contact shall not exceed the limits of Table 9. Where required by Table 9, the PCE shall be marked in accordance with Clause 5.5 a). ~~The test method shall be as specified in Clause 6.3.4.~~
6.3.7		For liquid-filled equipment, total temperatures, ~~rises above ambient~~ under conditions of continuous operation, shall be in accordance with the following: a) The average temperature ~~rise~~ of any winding ~~above ambient temperature~~ shall not exceed ~~65 K~~ 105 °C, except that a temperature ~~rise~~ of ~~70 K~~ 110 °C shall be permitted in the case of a winding that is cooled by forced-directed oil. Where there are two or more windings arranged such that the cooling liquid flows through the windings in series, then the average temperature rise shall be the average of all these windings. b) Transformers shall be so designed that the hottest spot conductor temperature rise of any winding shall not exceed ~~80 K.~~ 120 °C. c) Metallic parts in contact with or adjacent to conductor insulation or other electrically stressed insulation shall not attain a temperature in excess of that allowed for the hottest spot of the winding adjacent to that insulation. d) Internal metallic parts other than those covered in Item c) that are immersed in oil shall not attain a temperature ~~rise~~ in excess of ~~100 K~~ 140 °C. e) The temperature ~~rise~~ of the dielectric liquid, measured near the top of the ~~power supply~~ PCE tank, shall not exceed ~~65 K.~~ 105 °C.
6.3.8		For accessible surfaces subject only to casual contact, the temperature may exceed the limits in Table 10 but shall not exceed 100 °C, and the hot surface shall be marked in accordance with Clause 5.46.
6.4	Info	**Leakage current**
6.4.1		Except as permitted by Clause 6.4.2, the leakage current from accessible parts of a cord-and-plug-connected ~~power supply~~ PCE, rated 250 V or less, when tested in accordance with Clauses 6.4.3 to 6.4.9 shall be not more than a) 0.5 mA for portable ~~supplies~~ equipment; or b) 0.75 mA for stationary ~~supplies~~ equipment.

Clause	Verdict	Comment
6.4.2		Notwithstanding Clause 6.4.1, a cord-connected ~~power supply~~ PCE that is required to have primary circuit filtering and meet the electromagnetic compatibility regulations may have higher leakage current levels at accessible parts subject to all of the following conditions: a) the leakage current does not exceed i) 5 mA for ~~power supply~~ PCE having a nonlocking type attachment plug; or ii) 5% of the input current measured during the rating test for ~~power supplies~~ PCE having a locking type attachment plug; b) the ~~power supply~~ PCE complies with the ~~grounding~~ bonding requirements of Clause 4.23; c) provision is made for connecting together and ~~(earth) grounding~~ bonding of all metal frames of the ~~power supply~~ PCE in the system; and d) suitable installation instructions are provided.
6.5	Info	**Dielectric strength**
6.5.1		While at normal operating temperature, the ~~power supply~~ PCE shall withstand for 1 min without breakdown the application of a ~~60 Hz ac~~ dielectric strength test voltage ~~of 1000 V plus twice rated voltage, between~~ as follows: a) ~~the primary~~ between non-extra low voltage (ELV) circuits and exposed non-current-carrying metal parts; b) ~~the primary~~ between non-ELV circuits and ~~secondary~~ ELV circuits that are operator accessible in the PCE or in the end application or that are not isolated from other circuits that are accessible; c) between non-ELV circuits and other non-ELV circuits that are isolated from each other; and ~~(c) a secondary circuit operating at more than 30 V rms (42.4 V peak or dc) and exposed noncurrent-carrying metal parts*;~~ ~~(d) secondary circuits operating at more than 30 V rms (42.4 V peak or dc) and all other secondary circuits that are isolated from each other; and~~ d) the terminals of a capacitor connected across the line in ~~primary~~ ac supply circuits if not protected by a transient suppression device. Tests in Items b) and c) do not apply between two different circuits that are not required to be isolated from each other. **Note:** *The above applies for example in a non-isolated inverter where there is no isolation between the PV input circuit and the ac output circuit* The test in Item d) is waived for capacitors that are approved or are subjected to an equivalent test in production. The value of the dielectric strength test voltage for ac circuits shall be either • 1000 V ac plus twice the maximum rated RMS voltage of the circuit for an ac test; or • the above value multiplied by 1.414 for a dc test. The value of the dielectric strength test voltage for dc circuits shall be either • 1414 V dc plus twice the max rated dc voltage of the circuit for a dc test; or

Clause	Verdict	Comment
		• the above value divided by 1.414 for an ac test. For ac tests, the frequency of the test voltage shall be 50 or 60 Hz. For the tests between different circuits in Item b), the rated voltage to be used in calculating the test voltage is the rated voltage of the circuit with the highest rated ac peak or dc voltage. For the tests in Items a) to c) the test voltage shall be based on the line-to-neutral or the line-to ground voltage. For the test in Item d) the test voltage shall be based on the voltage across the capacitor under worst case rated conditions. When the PCE or part of a PCE has a higher voltage rating to ground than the pole-to-pole voltage rating, the dielectric strength test voltage related to that portion of the PCE shall be based on the maximum rated voltage to ground. **Note:** *This situation can arise where PCE are rated for series connection with other PCE, for example where dc power supplies are rated to be "stacked" or with PV power optimizers rated to be connected into strings.* ~~**If the secondary circuit is grounded, the ground connection must be removed for this test.*~~
6.5.2		A transformer, if provided, shall withstand for 1 min without breakdown the application of an ac voltage of 1000 V plus twice the maximum voltage of the winding applied between each winding and all other windings, the core, and the enclosure, except that if the maximum ~~low~~ voltage does not exceed 30 V rms, the test voltage may be reduced to 500 V. Unbonded metallic shields are to be treated as windings when performing this test. Where it is more convenient to do so, the dielectric strength test may be made by applying a dc voltage instead of an ac voltage, provided that the voltage used is 1.414 times the values specified.
6.6	Info	**Abnormal operation**
6.6.1		~~A power supply~~ PCE shall not become a shock hazard, or a fire hazard because of electrical failure, when operated under each of the following conditions. Operation shall be without regard to temperatures attained on any part of the ~~power supply~~ PCE: a) 7 h* with the each output of the ~~power supply~~ PCE short circuited one at a time; b) 7 h* with the rotor of each blower motor locked, one at a time†, with the ~~power supply~~ PCE delivering rated load, when forced ventilation is provided; c) 7 h* with ventilations openings blocked;
6.6.2		~~If a protective device opens the circuit during tests in Items (a) to (d) or (f) of Clause 6.6.1, the~~ Unless otherwise noted, abnormal tests shall be a) terminated, if a nonresettable, non-automatic-reset protector ("one shot") functions; b) continued for 7 h, if an automatic-reset protector functions; c) continued for 10 cycles using the minimum resetting time (but not faster than 10 operations per min), if a manual-reset protective device other than a moulded case circuit breaker functions; d) continued for 3 cycles if the manual-reset protective device is a moulded case

Clause	Verdict	Comment
		circuit breaker complying with CSA ~~Standard CAN/CSA-~~C22.2 No. 5~~.1~~; or e) continued as long as necessary to establish steady-state conditions, or up to the point of interruption of the circuit due to failure of the component or to other consequences of the simulated fault condition, whichever is the shorter, if no protective device operates to interrupt the fault condition.
6.6.4		The abnormal operation test specified in Clause 6.6.1 shall be made ~~at the primary voltage specified in~~ under the conditions in Clause 6.1, and the enclosure shall be ~~grounded~~ bonded as described in Clause 6.7.3.
6.6.5		If overcurrent protective devices are not provided as part of the equipment and ~~fuses~~ are specified by the manufacturer as an installation requirement, or if the ~~power supply~~ PCE is intended for use on a branch circuit, such fuses overcurrent protective devices shall be in place during the test.
6.6.6		Any protective devices provided in the PCE that ~~have~~ are not ~~been~~ separately approved shall be ~~the subject of investigation as to their reliability.~~ either a) investigated for compliance with the relevant CSA C22.2 Part II standard; or b) bypassed during the testing
6.6.8		The following test procedure shall be used to determine compliance with Clause 6.6.7: a) Only one fault at a time shall be introduced. b) The equipment shall be set up as ~~for the normal temperature test~~ in Clause 6.1 except that the enclosure shall be connected to ground through a 3 A fuse~~; and~~. c) The test duration shall be in accordance with Clause 6.6.2. ~~(ii) supply circuit shall be fused at not less than 400% of the ampacity of the supply circuit conductors unless otherwise specified by the manufacturer; and~~
~~6.7~~	Info	~~**Protection (Battery Supply Circuits)**~~
6.7	Info	**Overload (control devices)**
6.7.1		~~Except as permitted by Clause 6.8.6~~ Unless approved or investigated to the relevant CSA Group standard for the component involved, under conditions equivalent to the duty of the device in the PCE, a switch or relay supplied as part of the equipment shall be capable of making and breaking, for 50 cycles of operation at intervals of 10 s, a current equal to 150% of the maximum load current the device is used at in the PCE, at the actual power factor involved. The test in Clause 6.7.6 may be used as an alternative.
6.8	Info	**Endurance (control devices)**
6.8.1		Unless approved or investigated to the relevant CSA Group standard for the component involved, under conditions equivalent to the duty of the device in the PCE, a switch or other control device supplied as part of the equipment shall be capable of making and breaking, for 6000 cycles of operation at intervals of 10 s, a current equal to the maximum load current at the actual power factor involved. There shall be no electrical or mechanical failure of the switch nor undue pitting, burning, or welding of the contacts.
6.9	Info	**Compression (metal enclosures)**

Clause	Verdict	Comment
6.9.1		When required by Clause 4.2.2.3, an enclosure constructed of metal that is thinner than that specified in Table 1 or 2 as applicable, shall be ~~reinforced~~ constructed so that its deflection for a given force is not more than that of a reference sheet-metal enclosure of the maximum length and width constructed of the minimum required sheet metal thickness in accordance to these Tables.
6.9.2		The enclosure shall rest on a flat, unyielding, horizontal surface. A vertical force shall be applied at any point on the surfaces of the enclosure ~~except for the door or cover~~, along the axis of a rod having a diameter of 13 mm. ~~Force shall be applied to the end, side, and rear walls of each enclosure.~~ The value of force and limit of deflection, both of which shall be measured and recorded, are not specified, but the force on each wall of both the test and reference enclosures shall be sufficient to result in a measurable deflection on the test enclosure.
6.10	Info	**Deflection (metal enclosures)**
6.10.1		When required by Clause 4.2.2.3, and as an alternative to Clause 6.9, an enclosure constructed of metal that is thinner than that specified in Table 1 or 2, as applicable, shall be subjected to a deflection test using a force of 445 N. There shall be a) no deflection of the enclosure to an extent that would reduce spacings below the values required in Clause 4.16, during or at the conclusion of the test, including damage to or displacement of barriers; and b) no damage to the enclosure that makes hazardous live or moving parts accessible.
6.10.2		The force shall be applied along the axis of a rod having either a flat circular face with a diameter of 13 mm or a flat square face with 12.7 mm sides.
6.10.3		~~The test shall be conducted with the door or cover mounted on the enclosure in the intended manner.~~ The enclosure shall rest on its back on a flat, unyielding, horizontal surface ~~with the door closed and the front or cover secured as intended~~ and the force shall be applied in a direction perpendicular to the surface under test.
6.10.4		The force may be gradually increased to the test value of 445 N and shall be held at the test value for a duration of 5 s.
6.12	Info	**Resistance to impact**
6.12.1	Info	**Polymeric enclosures**
6.12.1.1	Info	**General** Samples of the equipment shall be subjected to the impact tests described in Clause 6.12.1.2 ~~and~~ after the preconditioning in Clause 6.12.1.3. The impact shall not a) reduce spacings below the minimum acceptable values; b) make any bare live parts or internal wiring accessible to contact; c) have an undue adverse effect on the insulation; or d) produce any other condition that might increase the equipment's risk of shock, fire, or casualty.

Clause	Verdict	Comment
6.12.1.2		**Impact test** Each of the three samples of the equipment shall be subjected to an impact on any surface that would be exposed to a blow during normal use or during installation. The impact shall not cause any of the conditions specified in Clause 6.12.1.1 to occur. Tests may be conducted at ~~any~~ an ambient temperature ~~within the range of~~ 10 of 40 °C ~~as follows:~~ or less. a) For an enclosure having no surface area exceeding 25 800 mm2, the impact shall be 7 ± 0.2 J, produced by dropping a steel sphere 50 ± 1 mm in diameter and having a mass of 0.53 kg from a height of 1300 mm. b) For an enclosure having any surface area of more than 25 800 mm2, the impact shall be 13 ± 0.4 J, produced by dropping a steel sphere 50 ± 1 mm in diameter and having a mass of 0.53 kg from a height of 2600 mm.
6.12.1.3		**Preconditioning** ~~Each of~~ The three samples used for the testing of ~~the equipment~~ Clause 6.12.1.2 shall be cooled to 0 °C or the lowest temperature for which the equipment is rated, whichever is lower, and maintained at that temperature for 3 h. ~~Immediately following removal from the cold chamber,~~ The samples shall be subjected to the impact test described in Clause 6.12.1.2, after removal from the cold chamber, and within a time that ensures that the polymeric part under test is still within 5 °C of the preconditioning temperature.
6.12.2		**Covers over openings in enclosure**
6.12.2.1		When required by Clauses 4.2.5.10 and 4.2.5.11, covers over openings in enclosures shall be subjected to the test specified in Clauses 6.12.2.2 ~~and~~ to 6.12.2.5. The test shall be conducted on a single sample at ~~any~~ an ambient temperature ~~in the range of 10~~ of 40 °C or less. For polymeric covers, the sample shall be preconditioned in accordance with Clause 6.12.1.3.
6.13	Info	**Conduit connections (polymeric enclosures)**
6.13.2		**Pullout** ~~The enclosure shall be suspended by~~ A length of ~~rigid~~ conduit shall be installed in ~~one wall of~~ the intended manner. The enclosure shall be rigidly held in place and a direct pull of ~~90 kg~~ 890 N shall be applied for 5 min to ~~a length of~~ the conduit ~~installed in the opposite wall.~~
6.13.4	Info	**Bending**
6.13.4.1		A suitable length of conduit, at least 300 mm long, of a proper size shall be installed: a) in the centre of the largest unreinforced surface; or b) in a hub or an opening if provided as part of the enclosure. **Note:** *"Proper" sized conduit refers to a trade size selected based on the maximum conduit size specified for use with the PCE or, if conduit size is not specified, based on the conduit that would be required for the largest conductor required to be used based on the input current rating of the PCE and in accordance with the* Canadian Electrical Code, Part I. The enclosure shall be securely mounted as intended in service, but so positioned

Clause	Verdict	Comment
		that the installed conduit extends in a horizontal plane. The weight necessary to produce the desired bending moment when suspended from the end of the conduit shall be determined from the following formula: $$W = \frac{0.102\,M - 0.5\,CL}{L}$$ where *W* = weight to be hung at the end of the conduit, ~~in~~ kg *M* = bending moment required, ~~in newton metres suspended, in metres~~ N•m C = weight of the conduit, kg *L* = length of the conduit from the wall of the enclosure to the point at which the weight is suspended, m
6.17		**Strain relief** The strain relief means required by Clause 4.4.2.4 shall be subjected to a steady pull of 156 N and a push of 45 N, each applied for 1 min. PCE wired with cord of round cross-section shall be so constructed that the assembly is capable of withstanding a torque of 0.34 N•m (3 lbf-in) applied for 1 min. There shall be no evidence of any stress being imposed on the wiring terminals, splices, or internal wiring.
6.19		**Capacitor discharge (energy and shock hazards)**
6.19.1		If the charge stored in capacitors is accessible in an operator access area ~~and the safety of the operator is assured by an interlock actuated by a door or cover~~, or by disconnecting a connector (or attachment plug), then the energy stored as determined from the following formula shall be discharged to a safe level not exceeding 42.4 V peak or dc and it shall not exceed 20 J at 2 s after opening ~~of this~~ interlock the door, cover, or connector or disconnection of the connector:
6.21		~~**Bonding Continuity**~~
6.21		Mounting bracket vertical loading test — Liquid filled equipment ~~A power supply~~ When required by Clause 4.24.6, a PCE unit with brackets affixed and with its tank empty of liquid shall be mounted on a vertically positioned rigid steel plate. The location of point A1, as shown in Figure 8, shall be established. The tank shall then be loaded vertically. The applied load shall be such that, combined with the weight of the tank and brackets, the final load will be 1.5 times the weight of the complete ~~power supply~~ PCE (including insulation liquid). The final load shall in no instance be less than the weight of the complete ~~power supply~~ PCE (including liquid) plus 115 kg. The tank shall then be unloaded. Displacement of point A1, in the direction of the load, shall not exceed 2 mm.

Clause	Verdict	Comment
6.22		**Mounting means vertical loading test — Other than liquid filled equipment** When required by Clause 4.2.9.2, a PCE shall be mounted in accordance with the installation instructions, on vertical rigid mounting surface. The PCE shall then be loaded vertically with a weight equal to 3 times the weight of the PCE. The weight shall be increased gradually so that the target weight is reached in 5 to 10 s and maintained for a duration of 60 s. There shall be no permanent dislocation and no permanent damage (cracking, breakage, etc.) to the PCE or its mounting hardware.
7	Info	**Industrial dc ~~Power Supplies~~ PCE**
7.1		Scope Clause 7 applies to industrial dc ~~power supplies~~ output PCE for plating and electrolytic processes, cathodic protection, magnetic chucks and brakes, motion picture arc supply, and similar applications that are intended for either permanent or cord-connection to a single or polyphase 600 V nominal (or less) ac supply.
~~7.1.2~~		~~The requirements of Clause 7 supplement and amend the requirements of Clauses 2 to 6.~~
7.3	Info	**Tests — Temperature (normal)** ~~The measured input in amperes shall not exceed the marked rating by more than 10% when the power supply is tested under normal operating conditions. The test voltage and frequency shall be as specified in Clauses 6.2.1 and 6.2.2.~~ Temperatures shall not exceed the values specified in Tables 9 and 10 when the ~~power supply~~ PCE is tested at rated load in an ambient temperature of 40 °C ~~(see~~ or the maximum ambient temperature for which the PCE is rated, whichever is higher, except the actual ambient temperature during testing may be less if the measurements are adjusted in accordance with Clause 6.3.4 ~~for testing at ambient temperatures other than 40°C).~~
8	Info	**~~Power Converters~~ PCE for use in recreational vehicles**
8.1	Info	**Scope**
8.1.1		Clause 8 applies to ~~power converters with a 12 V or 24 V ac or dc output for use~~ PCE for permanent or cord connection in recreational vehicles ~~that~~ (RV). Converters covered in this Clause are intended to supply 12 V, 24 V, or 48 V load circuits in the RV and are intended for ~~permanent or cord~~ connection to a nominal 120 V or 240 V, single-phase, ac supply. Inverters covered in this Clause are intended to supply ac loads in the RV and are intended for supply from batteries having nominal voltage of 48 V dc or less. Battery charging and other modes of operation may also be incorporated.
8.2	Info	**Construction**
8.2.1.3		Openings in enclosures shall not be directly below arcing parts, in any rated mounting orientation, unless they are suitably baffled or screened as described in Clause 4.2.5.7 to prevent molten metal or burning material escaping from the enclosure.

Clause	Verdict	Comment
8.2.1.4		Openings in enclosures shall be of such size or shape as to prevent the entrance of a straight rod of circular cross-section, 19 mm in diameter. ~~; and~~ **Note:** *This is in addition to the requirements in Clause 4.2.5.* ~~(b) the articulated probe of Figure 1 from touching any uninsulated live parts (including film-coated wire) operating at a voltage of more than 42.4 V peak to any other part or to ground (see Clause 4.2.5.3).~~
8.2.3		**Transfer switches** A transfer switch or a relay provided to ~~change from generator to line power switch the load between two or more ac sources~~ shall ~~disconnect~~ transfer both the grounded and ungrounded circuit conductors, and ~~the rating of the transfer mechanism and its associated wiring shall be suitable for the maximum load that it is required to switch~~ comply with Clause 9.
8.2.5		~~**Grounding and**~~ **Bonding to ground** ~~Converters and combination converter/panelboards~~ PCE shall have an external bonding ~~lug that complies with the requirements of CSA Standard C22.2 No. 65, and is~~ means suitable for connection of a min. No. 8 AWG copper conductor.
8.3	Info	**Marking**
8.3.1		For an input that powers both internal conversion circuits and external load circuits, the rating ~~of combination converter/panelboards~~ shall include both the a) total input amperes; and b) converter input amperes.
8.3.2		~~Converters~~ PCE provided with integral overload protection shall be marked as follows: CAUTION: PROVIDED WITH INTEGRAL PROTECTION AGAINST OVERLOADS.
8.3.3		~~Converters~~ PCE that are not intended for “zero clearance” mounting shall be marked as follows: CAUTION: DO NOT MOUNT IN ZERO CLEARANCE COMPARTMENT. DO NOT COVER OR OBSTRUCT VENTILATING OPENINGS. OVERHEATING ~~MAY~~ CAN RESULT.
8.3.4		Installation instructions shall include the rated mounting orientation(s) of the ~~converter when mounted~~ PCE.
8.3.5		~~A dc converter~~ PCE incorporating a battery charging circuit shall ~~indicate~~ be marked with the charger output amperes as well as total output* amperes, ~~except that this requirement shall not apply to a converter designed for a floating battery system~~ unless the two quantities are identical. * *Total output amperes include battery charging amperes and output amperes intended for dc loads.*
8.3.6		~~A~~ PCE with a dc ~~converter~~ output not designed for charging a battery shall be either marked with the following ~~caution~~ wording or this ~~caution~~ wording shall be included in the instruction manual: WARNING: NOT SUITABLE FOR BATTERY CHARGING.

Clause	Verdict	Comment
8.4	Info	**Tests**
8.4.1		**General**
8.4.1.2		At the conclusion of the tests all protective devices shall be operative with the exception of fuses, which are allowed to open during abnormal tests.
8.4.1.6		Unless specified otherwise, temperatures shall not exceed a) the values specified in Tables 9 and 10 when the ~~converter~~ PCE is tested in an ambient temperature of 25 °C (see Clause 6.3.4 for testing in ambient temperature other than 25 °C); b) 90 °C based on an ambient temperature of 25 °C measured on any surface upon which the ~~converter~~ PCE may be mounted in service and on a surface that may be adjacent to the ~~converter~~ PCE when so mounted; **Note:** *Fins and standoffs are permitted in the construction of the* ~~converter~~ PCE *in order that proper surface temperatures can be maintained on surrounding combustible material.* c) 60 °C based on an ambient of 25 °C at any point on or within a terminal box or compartment of the ~~converter~~ PCE, on which field conductors may rest (including such conductors themselves); except that the temperature may exceed 60 °C but not 90 °C, if the ~~converter~~ PCE is marked in accordance with Clause 5.5; d) the values specified in Table 13 on surfaces of converters PCE intended for flush wall mounting; and e) the values specified in CSA ~~Standard~~ C22.2 No. 29 for the panelboard portion of a combination ~~converter~~ PCE / panelboard.
8.4.1.8		The mounting orientation of the ~~converter~~ PCE for the specified tests shall be in accordance with the manufacturer's installation instructions (see Clause 8.3.4). Where more than one mounting orientation is specified, the worst case orientation(s) for the particular test being performed shall be used.
8.4.3		**Output voltage** The output voltage of a ~~secondary~~ dc output circuit intended for connection to ~~a resistive load~~ dc loads other than battery charging shall be within the values specified in Table 14 when tested with resistive loads.
8.4.4.2.6		Temperatures shall not exceed the limits specified in Clause 8.4.1.6 except that a) the surface temperatures of flush wall mounted ~~converter~~ PCE shall not exceed the limits specified in Table 13; and b) temperatures of ~~converter~~ PCE marked in accordance with Clause 8.3.3 may be 20 ~~K~~ °C higher.
8.4.5.2.3		Temperatures shall not exceed the limits specified in Clause 8.4.1.6 by more than 20 ~~K~~ °C, except that surface temperatures of flush wall mounted ~~converter~~ PCE shall not exceed the limits specified in Table 13.
8.4.6.5	Info	**Reverse polarity**

Clause	Verdict	Comment
8.4.6.5.1		A ~~converter,~~ PCE input or output intended for connection to a ~~floating~~ battery ~~system or for charging a battery~~, shall be subjected to an open bench and zero clearance reverse polarity test applied to ~~the charging~~ that circuit with all other loads disconnected (except the battery).
8.4.6.5.3		The battery used for this test shall be a fully charged ~~lead-acid~~ battery of ~~at least~~ the type and maximum size specified in the installation instructions in accordance with Clause 5.23 e). ~~(a) 72 A•h capacity; or~~ ~~(b) 445 A zero-cranking performance and 135 min reserve capacity as defined by Battery Council International terminology.~~
8.4.7		**Vibration test** PCE shall be subjected to a vibration test with a duration of 1 h, frequency of 12.5Hz, and a displacement of 6.4 mm in a vertical plane, with the PCE mounted in the orientation described in the installation instructions for the PCE. If more than one orientation is described, the test shall be repeated on separate samples in each orientation. The PCE shall withstand the vibration test without structural damage to the mounting means or the enclosure, or loosening of parts that might result in a) an increase in the risk of fire, electric shock, or injury to persons; b) a reduction of spacings to a value less than the minimum specified in Clause 4.16; or c) exposure of a live part. The intended operation of the PCE shall not be impaired. At the conclusion of the test, the PCE shall comply with the dielectric strength test in Clause 6.5.
9	Info	**~~Static~~ Transfer switches**
9.1	Info	**Scope**
9.1.1		Clause 9 applies to ~~static~~ transfer switches ~~intended for incorporation in uninterruptible ac power supplies (UPS), as covered in Clause 11.~~ integral to PCE.
9.1.2		As an alternative to the requirements in Clause 9, transfer switches integral to PCE may be investigated to the requirements of CSA C22.2 No. 178.1, unless the transfer switch implements a closed transition transfer, in which case the requirements of CSA C22.2 No. 178.1 shall be used. **Notes:** **1)** *Stand-alone transfer switches (not part of PCE) are covered by CSA C22.2 No. 178.1.* **2)** *PCE with a closed transition transfer switch that only parallels momentarily with the utility or other source is not classified as interactive with respect to the definition in Clause 3 or the requirements in Clause 14.*
9.2	Info	**Backfeed protection**

Clause	Verdict	Comment
9.2.1		A single fault anywhere in PCE with an integrated transfer switch shall not result in a shock hazard due to energy transfer from the PCE to the bypass source when measured at the PCE bypass source input terminals for longer than 2 s if the PCE is cord connected or for 15 s if the PCE permanently connected from the moment of de-energization of the bypass source or occurrence of the fault, when tested in accordance with Clause 9.4.1. PCE intended for permanent connection in an assembly, vehicle, or other application that is itself cord- connected to the bypass source shall be considered to be cord-connected. **Note:** *For example, PCE for use in an RV is often permanently connected, but the RV connects to utility power at the RV park using a cord and plug.*
9.2.2		Failure analysis shall be performed to determine the impact of single faults in the PCE, the transfer switch components, power supplies, control circuits, etc. The results of the failure analysis shall be considered in determining the test conditions and faults to be applied during the backfeed testing in Clause 9.4.1.
9.2.3		Where the transfer switching device is electro-mechanical, welding of the contacts in either the normally open or normally closed position does not need to be considered as a failure mode, if the ratings of the switching device are such that a) the continuous current carrying, making, and breaking ratings of the switching device are at least equal to the maximum current through the contacts under the worst case rated conditions and operating modes of the PCE; and b) the current used during overload testing of the switching device is at least 600% of the maximum current through the contacts under worst case rated conditions and operating modes of the PCE.
9.2.4		For a static transfer switch, the failure analysis and testing shall include failure of one solid-state transfer device in addition to the single faults on other devices required by Clause 9.2.2. **Note:** *The intent of this Clause is to prevent voltage from appearing on the bypass source upon failure of a solid- state power-switching component and another solid state or mechanical component.*
9.3	Info	**Construction**
9.3.1		**General** Electro-mechanical switching devices used in the transfer switch shall comply with the requirements of CSA C22.2 No. 178.1 or shall be evaluated in conjunction with the PCE and shall comply with a) the load transfer test in Clause 9.4.2; and b) the requirements for switches given in CSA C22.2 No. 14 and CSA C22.2 No. 55 or other appropriate CSA Group Standards.
9.3.2		**Static transfer switches**
9.3.2.1		Solid-state switching devices used in the static transfer switch shall comply with a) the load transfer test in Clause 9.4.2 and the applicable requirements of this Standard; or b) CSA C22.2 No. 178.1.

Clause	Verdict	Comment
9.3.2.2		Overcurrent protection shall be provided for each static switch source in each ungrounded line. If the ~~overcurrent~~ devices are not integral with the ~~uninterruptible power supply, they~~ PCE, the installation instructions provided with the PCE shall ~~be specified on a label~~ include the information in Clause 5.27.
9.4.1		**Backfeed protection test**
9.4.1.1		The PCE shall be operated under the conditions in Clause 6.1, in whichever mode(s) of operation involve a risk of backfeed from the PCE to the bypass source. For a mode of operation in which the bypass source is normally energized, the fault is applied and then the bypass source is de-energized. For a mode of operation in which the bypass source is normally de-energized, the bypass source shall be de-energized and then the fault applied. In each case, the PCE shall be operating in the initial mode of operation before the fault is applied, with the PCE load conditions most likely to result in backfeed.
9.4.1.2		Faults shall be applied to components as required by Clause 9.2, with faults placed on the component in a manner that simulates the normal failure mode(s) of that component (e.g., cathode to anode short on SCR, emitter to collector short or open circuit on a transistor, welding of a relay contact, etc.). Faults are to be applied one at a time, except as required by Clause 9.2.4.
9.4.1.3		The voltage on the bypass source input terminals shall be monitored during the test. None of the tests shall result in a shock hazard as defined in Clause 3, on the bypass source input terminals, after the time specified in Clause 9.2.1. The time is measured from the moment of de-energization of the bypass source or the application of the fault, whichever occurs last.
9.4.1.4		If a voltage exceeding the limits in the definition of shock hazard in Clause 3 remains on the terminals for longer than the time specified in Clause 9.2.1, further investigation shall be conducted to determine if the current available also exceeds the shock hazard limit in Clause 3.
9.4.2		**Load transfer test**
9.4.2.1		~~The~~ Where required by Clause 9.3.1 or 9.3.2, the PCE with integrated transfer switch shall be subjected to one operation of switching the load from the output of the ~~UPS~~ PCE to ~~a~~ the bypass ~~ac~~ source with the load adjusted to draw maximum rated ac power. The chassis of the PCE shall be grounded through a fuse as in Clause 6.7.3. The test conditions shall be as in Clause 6.1 except that before the switching operation, the phase angle of the bypass source shall be displaced from the phase angle of the output of the PCE by a) 120 electrical degrees for a three-phase supply; or b) 180 electrical degrees for a single-phase supply. At the conclusion of the test, there shall be no electrical or mechanical malfunction of the transfer switch, no emission of flame or molten material, the ground fuse shall be intact, and the PCE shall comply with the applicable dielectric strength tests.

Clause	Verdict	Comment
9.4.2.2		For a transfer switch having a control to prevent switching between out-of-phase sources, the test shall be conducted with single faults applied, if such fault conditions can result in an out-of-phase transfer between sources. The faults placed on the components shall simulate the normal failure modes of the components and shall be applied one at a time.
9.4.3		**Dielectric strength tests**
9.4.3.1		For PCE with an integral transfer switch, the dielectric strength tests required in this Standard shall be performed with the transfer switch in the position(s) that allow the test voltage to be applied as intended by the relevant dielectric strength testing Clauses. **Note:** *Since this testing is performed with the PCE de-energized, this may require additional arrangements to ensure the transfer switch is in the desired position(s).*
9.4.3.2		For the dielectric strength tests on PCE containing a static transfer switch, the solid state devices or assemblies normally connected between the sources may be disconnected.
9.5		**Markings — Transfer switch transition type** For PCE with an integral transfer switch, the installation instructions shall specify whether the transfer switch implements an open or closed transition.
10		**Inverters**
10.1		**Scope** Clause 10 applies to inverters ~~for operation on a battery supply (which may be integral~~ and to PCE with ~~the inverter).~~ an inverting function.
~~10.1.2~~		~~Clause 10 applies to inverters rated 600 V and less dc input, 600 V and less, single-phase and polyphase ac output, for commercial and industrial use.~~
~~10.1.3~~		~~The requirements of Clause 10 supplement and amend the requirements of Clauses 2 to 6.~~
10.2	Info	**Performance characteristics**
10.2.1		The output of an inverter in stand-alone mode shall be essentially a sine wave under all conditions of loading, from open circuit to rated load except as permitted in Clause 10.5.2.
10.2.2		The output voltage of ~~the~~ an inverter in stand-alone mode shall be in accordance with Table 2 of CSA ~~Standard~~ CAN3-C235, as follows: a) the output voltage (from no load to rated load) shall be within the “normal operating conditions” with ~~a fully charged battery; and~~ the ~~output~~ dc input voltage at its nominal value; and b) the output voltage (from no load to rated load) shall be within the “extreme operating conditions” ~~when the battery discharges~~ with the dc input voltage at the low and high end of the rated dc input voltage range.
10.3	Info	**Construction**

Clause	Verdict	Comment
10.3.1		**DC input overcurrent protection** Overcurrent protection shall be provided for the dc input circuit and shall be integral with the inverter. The overcurrent protection need not be provided in PCE having provision for permanent wiring connection of the dc input circuit and provided with an instruction manual specifying that overcurrent protection shall be provided at the time of installation (see Clause 5.27) and specifying the ratings and type of overcurrent protection to be provided.
10.3.2		**~~Isolation from~~ injection onto the ~~Load~~ AC output** An inverter shall be provided with means to limit the direct current flowing from its ac output to 0.5% of the ~~load~~ full rated ac output current of the inverter, when tested in accordance with ~~the test in~~ Clause 10.5.3. ~~Devices, such as an isolation transformer, a blocking capacitor, or a direct current sensor with high-speed disconnect switch, may be employed.~~ The test of Clause 10.5.3 is not required for an inverter a) with galvanic isolation between the dc input and ac output, located such that injection of dc on the ac output side of the galvanic isolation is not possible; or b) that must be used with an external isolation transformer between the inverter and the utility or load, and marked as in Clause 10.4.4.
10.4		**Marking**
10.4.1		When required by Clauses 10.5.2.2 or 10.5.2.4, the following marking or equivalent shall appear on the inverter: ~~NOTICE~~ CAUTION: THE OUTPUT OF THIS DEVICE IS NOT SINUSOIDAL. IT HAS A TOTAL HARMONIC DISTORTION OF ____ PER CENT AND MAXIMUM SINGLE HARMONIC OF ____ PER CENT. The blank spaces in the above marking shall be replaced by the THD and maximum single harmonic amplitude from the tests in Clause 10.5.2. When required by Clause 10.5.2.3 or 10.5.2.4, the following marking or equivalent shall appear on the inverter: CAUTION: FOR USE WITH ____ LOADS ONLY. where the blank space is replaced by the specific make and model of load equipment, where required by Clause 10.5.2.3, or by the type of load (computer equipment, lighting equipment, etc.) where required by Clause 10.5.2.4.
10.4.3		An inverter shall be marked to identify whether or not galvanic isolation is present between the dc input and ac output, as follows: a) "WARNING: DC INPUT ISOLATED FROM AC OUTPUT" or equivalent, when the inverter contains galvanic isolation between the dc input and the ac output and the isolation complies with the requirements in this Standard for spacings and dielectric strength, and the isolating components comply with the relevant component standards. b) "WARNING: DC INPUT NON-ISOLATED FROM AC OUTPUT" or equivalent, when the inverter does not comply with the requirements in Item a), except an inverter that must be used with an external isolation transformer shall be marked in

Clause	Verdict	Comment
		accordance with Clause 10.4.4 instead. When the PCE is an inverter only, with no ports other than the dc input and ac output, Items a) and b) may be simplified to "ISOLATED" and "NON-ISOLATED", respectively.
10.4.4		Where required by Clause 10.3.2, the inverter shall be marked: WARNING: MUST BE USED WITH AN EXTERNAL ISOLATION TRANSFORMER.
10.4.5		The stand-alone inverter short circuit current contribution as determined in Clause 10.5.5 shall be provided in the installation instructions and shall be specified by stating the peak current, the duration of the peak, and the 3-cycle RMS value.
10.5		**Tests**
10.5.2		**~~General~~ AC output voltage for stand-alone inverters** To determine compliance with Clause 10.2.2, ~~the~~ PCE with a stand-alone invert mode shall have its ac output voltage ~~shall be~~ monitored ~~while the battery discharges. The test shall be~~ conducted under the dc input voltage conditions below, at no load and full rated load ~~and~~ : a) at the nominal dc input voltage, or for a battery inverter, with the battery ~~shall be~~ fully charged; b) at the ~~beginning of~~ lowest dc input voltage at which the ~~test~~ inverter will operate; and c) at the highest dc input voltage at which the inverter will operate.
10.5.2.1		When measured under the test conditions specified in Clause 10.5.2.6 ~~and, except as specified in Clauses 10.5.2.2 to 10.5.2.5,~~ a) the total rms value of the harmonic output voltages (excluding the fundamental) of an inverter shall not exceed 10% of the fundamental rms output voltage rating; and b) the rms voltage of any single harmonic shall not exceed 6% of the fundamental rms output voltage, except as specified in Clauses 10.5.2.2 to 10.5.2.5.
10.5.2.2		Notwithstanding Clause 10.5.2.1, the output voltage distortion is not specified if an inverter complies with all of the following requirements: ~~(a) the inverter is of the off-line type;~~ a) the electrical output rating is 1000 V•A or less; b) the inverter is not capable of providing rated output for more than 30 min with fully charged batteries; c) there is no provision for powering the inverter from external batteries~~; and~~ or any other external source capable of providing rated output for more than 30 min; and d) the inverter is marked in accordance with Clause 10.4.1.
10.5.2.3		The output voltage distortion is not specified if the inverter is intended for use with a specific load device and is ~~so~~ marked~~.~~ in accordance with Clause 10.4.2. The temperature test shall be performed using the specified load. The temperature on the load shall not exceed the allowable limits specified in the applicable product Standard.

Clause	Verdict	Comment
10.5.2.4		The output voltage distortion is not specified if the inverter is intended for use with a specific type of equipment and is marked in accordance with Clauses 10.4.1 and 10.4.2. Temperature tests shall be performed on representative samples of the end use products using a sinusoidal waveform and the nonsinusoidal waveform of the ~~power supply~~ PCE. The temperatures measured using the nonsinusoidal waveform shall not exceed the temperatures measured using the sinusoidal waveform by more than 5 ~~K,~~°C and, in no case, shall exceed the allowable temperatures specified in the applicable Standard for the load device.
10.5.2.5		The output voltage distortion is not specified if the temperatures measured on loads supplied by the nonsinusoidal waveform do not exceed the temperatures measured using a sinusoidal waveform by more than 5 ~~K~~°C and, in no case, exceed the allowable temperatures specified in the applicable Standard for the load device. The following types of load shall be used for the tests:
10.5.2.6		The harmonic distortion test shall be conducted by connecting an inverter ~~with fully charged batteries~~ to a linear load. ~~The distortion measurement shall be made with the inverter delivering a load~~ drawing between 25 and 100% of full rated output, while supplied at the nominal dc input voltage, or for a battery inverter, with the battery fully charged.
10.5.3		~~The output~~ When required by Clause 10.3.2, an inverter shall be tested at 33%, 66%, and 100% of rated load, using a resistive load, and the ~~unit~~ dc component of the ac output current shall be measured. The dc component shall not ~~inject a dc current greater~~ than exceed 0.5% of the unit full rated output current ~~after a period of six cycles under normal or single fault tests~~ of the inverter.
10.5.4		**Frequency** The output frequency of a stand-alone inverter shall be within ±1 Hz of the rated output frequency when tested at no load and full rated load, at the maximum and minimum ends of the dc input operating voltage range.
10.5.5		**Stand-alone inverter dc output short-circuit current contribution** For stand-alone inverter outputs, during the output short circuit test in Clause 6.6.1, the maximum output fault current of the unit shall be measured immediately after the short is applied. The measurement shall include the peak current, the duration of the peak, and the 3-cycle RMS value (based on the nominal ac output frequency). The values marked on the product in accordance with Clause 13.5.1.2 d) shall not be less than the measured values. See Clause 14.3.9 and 14.4.2.4 for grid-tie inverter output short circuit current contribution requirements.
11	Info	**Telecommunication equipment ~~Power Supplies~~ PCE**
11.3		**Markings**

Clause	Verdict	Comment
11.3.1		When required by Clause 11.2.1.1, the following marking or equivalent shall appear on the ~~power supply~~ PCE: CAUTION: THIS POWER SUPPLY IS FOR USE WITH TELEPHONE EQUIPMENT IN ACCORDANCE WITH SECTION 60 OF THE *CANADIAN ELECTRICAL CODE, PART I*~~,~~ AND IS SUBJECT TO INSPECTION BY AN INSPECTOR.
11.3.2		~~Power supplies~~ PCE equipped with telephone-type plugs or jacks as output connectors that are intended for use with designated end-use equipment shall be marked with the following or equivalent: CAUTION: FOR USE WITH MODEL ____ ONLY.
11.3.3		~~Power supplies~~ PCE equipped with plugs or jacks as output connectors that are intended for general purpose telecommunication equipment shall be marked with the following or equivalent: CAUTION: FOR USE IN TELECOMMUNICATION APPLICATIONS ONLY.
12	Info	**Cable TV PCE ~~TV Power Supplies~~**
12.1	Info	**Scope**
12.1.1		Clause 12 applies to cable TV ~~equipment power supplies~~ (CATV) PCE intended for direct connection to overhead or underground power lines.
12.3	Info	**Marking**
12.3.1		The following marking shall appear on all CATV ~~power supplies~~ PCE: CAUTION: THIS UNIT IS INTENDED FOR CONNECTION TO POLE-MOUNTED OR UNDERGROUND AMPLIFIERS.
12.3.1		CATV ~~power supplies~~ PCE that are not provided with a service switch or circuit breaker as referenced in Clause 12.2.2.1 shall be marked with the following or equivalent: WARNING: IN ORDER TO COMPLY WITH THE *CANADIAN ELECTRICAL CODE, PART I*~~,~~ THIS POWER SUPPLY MUST RECEIVE POWER FROM A DISCONNECT MARKED SUITABLE FOR USE AS SERVICE EQUIPMENT.
13	Info	**~~Power Conversion Equipment~~ PCE for use in photovoltaic (PV) systems**
13.1.2		PV combiners and the combiner portion of PCE with an integral PV combiner shall comply with the requirements of CSA C22.2 No. 290.
13.2		**General** PV PCE shall be rated for operation with grounded arrays, or ungrounded arrays, or both, shall be marked as in Clause 13.5.1.2 d) and shall operate as intended in all systems for which the PCE is rated. The installation manual shall contain the information required in Clause 13.5.2.2. PV PCE that grounds or ungrounds the array in different normal operating modes, shall comply with the applicable requirements for both grounded and ungrounded systems. **Note:** *Intentionally temporarily ungrounding the array for array insulation resistance monitoring or in response to a ground fault is not considered to be a normal operating mode in which the array is ungrounded.* ~~A unit intended to operate at rated voltages of 50 V dc or less shall operate as intended in both grounded and ungrounded dc systems.~~

Clause	Verdict	Comment
13.3		**Construction**
13.3.1		**Bipolar PV systems**
13.3.1.1		The PCE shall be designed so that either a) electrical equipment in the PV source and output circuits cannot be subjected to excessive voltage as defined by the test requirements in Clause 13.4.4, under any normal or single fault condition in the PCE or in the system in which the PCE is installed; or b) electrical equipment in the PV source and output circuits shall be rated for the combined voltage of the two monopoles. PCE complying with Item a) shall comply with the test in Clause 13.4.4, shall be marked in accordance with Clause 13.5.1.6, and the installation instructions shall contain the information in Clauses 13.5.2.8 a) and 13.5.2.9. PCE complying with Item b) shall be marked in accordance with Clause 13.5.1.7 and the installation instructions shall contain the information in Clause 13.5.2.8 b).
13.3.1.2		If required to comply with Clause 13.3.1.1 a), the PCE shall contain an automatic series control means that acts to separate the monopoles from each other. **Note:** *An example of such a system is shown in Figure 11.*
13.3.1.3		The automatic series control means shall a) be permitted to be used as part of the automatic disconnecting means required in Clause 14.2.3 in which case it shall meet the requirements for both purposes; and b) provide galvanic isolation between the PV monopoles and/or between the PV monopoles and the PCE, and/or between the PV monopoles and ground, as necessary to comply with Clause 13.3.1.1.
13.3.1.4		If the automatic series control means opens in response to, or to prevent, a fault condition, then the PCE shall indicate a fault.
13.3.1.5		The galvanic isolation provided by the automatic series control means shall be rated for the maximum voltage across the isolation under any normal or single fault condition with the automatic series control means open (i.e., separating the monopoles), and shall comply with the spacings requirements in Clause 4.16 and the dielectric strength requirements in Clause 6.5, or with the relevant CSA C22.2 Part II standard. **Note:** *CSA C22.2 No. 0.2 provides a method for using testing in order to allow reduced clearances.*

Clause	Verdict	Comment
13.3.1.6		Bipolar PCE complying with Clause 13.3.1.1 a) shall maintain segregation of the two monopoles in accordance with the following, unless an automatic series control means is provided: a) The terminal connections and field wiring from each monopole shall be segregated from the other monopole by internal barriers which are either non-conductive or are bonded. b) Internal factory wiring and devices for each monopole shall be segregated from the other monopole, up to the connection point where the two monopoles are connected to each other, by either i) internal barriers which are either non-conductive or are bonded; or ii) means complying with the separation of circuits requirements in Clause 4.18. If applying Item ii) and if the factory wiring of one monopole can contact the factory wiring of the other monopole, then the voltage rating of all conductors shall be rated for the combined voltage.
13.3.1.7		Spacings, insulation requirements, and dielectric strength test requirements from bipolar PV circuits to ground and to other circuits shall be based on a) the max PV voltage of one monopole for bipolar PCE complying with Clause 13.3.1.1 a); and b) the sum of the max PV voltages of the two monopoles for bipolar PCE complying with Clause 13.3.1.1 b). The spacings and insulation requirements within the combined bipolar PV circuit shall be based on the sum of the max PV voltages of the two monopoles.
13.3.2		**Manual disconnecting means for PV circuits** **Note:** *In this context, "manual" refers to operation by a person and is not meant to exclude motor-operated devices with push-button controls for example. The word "manual" is used to differentiate this section from the automatic means required for non-isolated PCE in Clause 14.2.3.*
13.3.2.1		If provided as part of the PCE, a manual disconnect device located in a PV circuit shall comply with Clause 4.20, Clause 4.25 if applicable, and with the following: The disconnect device shall be rated a) for the max rated PV open circuit voltage of the PCE; b) to carry the max rated PV short circuit current of the PCE; c) for making and breaking the max rated PV short circuit current of the PCE; and d) to carry the continuous backfeed current (if any) of Clause 14.3.7. The value of the max rated PV short circuit current to be used is the value marked in accordance with Clause 13.5.1.2 c).

Clause	Verdict	Comment
13.3.2.2		As an alternative, a connector may be used as isolating means for the PCE if the connector complies with Clause 13.3.2.1 a), b), and d) and the following: a) it shall be rated for disconnection under load or be marked "do not disconnect under load"; and b) if the connector does not make or break all poles simultaneously and is used in a circuit with a max rated voltage exceeding 30 V, it shall require the use of a tool to disconnect the connector.
13.3.3		**~~DC~~ PV input overcurrent protection** Where a unit is intended to be connected to a PV source without a battery in the circuit, ~~the~~ and does not rely on overcurrent protection to comply with the requirements of this Standard, overcurrent protection does not need to be supplied if the installation instructions in Clause 13.5.2.4 are provided.
13.3.4		**PV array ground fault detection and interruption (GFDI)**
13.3.4.1		**General** If PCE for use in PV systems is provided with array ground fault detection (GFD) or ground fault detection and interruption (GFDI), then the system shall comply with both the array insulation resistance requirements in Clause 13.3.4.1 and, when required, the ground fault current detection/interruption requirements in Clause 13.3.4.2. If any of the required detection or interruption functions are not provided in the PCE, then the installation instructions for the PCE shall provide the information required in Clause 13.5.2.7. For PV PCE with more than one PV input where the inputs are galvanically isolated from each other, the GFD/I requirements shall apply to each individual input. The power rating to be used in Clauses 13.3.4.2 and 13.3.4.3 to determine the specific limits shall be the rating of each input, not the overall total rating of the PCE. Where the PV inputs are not galvanically isolated from each other, the GFD/I requirements shall apply to the overall PCE and the inputs shall be treated as a single input. The power rating to be used in Clauses 13.3.4.2 and 13.3.4.3 shall be the total rating of the PCE.
13.3.4.2		**Array to ground insulation resistance (RISO) measurement**
13.3.4.2.1		Before commencing or recommencing operation, and at least once every 24 h, the PCE shall measure the insulation resistance from the array to ground and take the actions in Clause 13.3.4.2.3 if the value is less than given in Table 19. The values in Table 19 are the lowest values that may be set at the factory. The RISO setpoint may be adjustable if the adjustment means is accessible only to qualified personnel (e.g., by password protection).

Clause	Verdict	Comment
13.3.4.2.2		For PCE for grounded or resistively grounded arrays, RISO measurement shall have means to automatically temporarily disconnect the array from ground during the measurement period using a relay or other appropriate means, in accordance with Clause 13.3.5. **Note:** *The period of time for which the RISO system intentionally ungrounds the array for array insulation resistance measurement purposes, should be kept to a minimum time that allows proper measurement.*
13.3.4.2.2		If the insulation resistance from the array to ground is less than the required value in Table 19, the ground fault protection system shall a) disconnect all grounded and ungrounded conductors of the array or the faulted portion of the array from the rest of the system; b) for a normally grounded or normally resistively grounded array, not connect the array or the faulted portion of the array to ground; and c) indicate a fault in accordance with Clause 13.3.6. **Note:** *If it is possible to disconnect only the faulted portion of the array, then the above would allow the PCE to continue or resume operation, connected only to the remaining un-faulted portion of the array, while indicating a fault.* In a normally grounded or normally resistively grounded array in which only the faulted portion of the array has been disconnected in order to resume operation with the remaining unfaulted portion of the array, the grounding or resistive grounding of the unfaulted portion of the array shall be reestablished before resuming operation. If the insulation resistance of the array or faulty portion of the array recovers to a value higher than the minimum threshold above, the PCE may reconnect the array or portion of the array, and resume normal operation. The array to ground insulation resistance measurement system shall comply with the tests in Clause 13.4.3.2.
13.3.4.3		**Ground fault current detection and interruption**
13.3.4.3.1		The GFD/I system shall include a ground fault current detection and interruption function where required by Table 25.
13.3.4.3.2		The ground fault current detection function shall have a rating or setting in accordance with Table 20 and shall detect the total ground fault current. The values in Table 20 are the highest values that shall be set as the factory default setting. The current detection setpoint may be adjustable if the adjustment means is accessible only to qualified personnel (for example by password protection).
13.3.4.3.3		If a fuse or circuit breaker is used as the GFDI device, the rating of the fuse or the rating or setting of the circuit breaker shall not exceed the appropriate setting from Table 20. If a device other than a fuse or circuit breaker is used (e.g., electronic sensing as the detector and a contactor as the interrupter), the GFDI function shall trip in less than a) 1 h for ground fault currents of 135% of the setting from Table 20 or higher; and b) 2 min for ground fault currents of 200% of the setting from Table 20 or higher.

Clause	Verdict	Comment
		Note: *These required current vs. time points are aligned with the minimum requirements for fuses and circuit breakers and will therefore provide protection that is no slower than those devices are allowed to be.*
13.3.4.3.4		For PCE for grounded arrays, the ground fault current interruption means may open the connection between the array and ground. When the ground fault current detection and interruption system trips, it shall a) interrupt the ground fault current; b) indicate a fault in accordance with Clause 13.3.6; and c) either i) disconnect all grounded and ungrounded conductors of the array or of the faulted portion of the array from the rest of the system; or ii) cause the PCE to stop supplying power to output circuits, and to open any automatic disconnecting means provided between the PV array and the ac output. For non-isolated grid-tied PCE, the automatic disconnecting means shall disconnect all grounded and ungrounded conductors between the PV array or the faulty portion of the array and the utility in accordance with Clause 14.2.3. **Note:** *In some topologies, the means of interrupting the ground fault current may be the disconnecting means by which the PCE automatically disconnects from the array or the grid.*
13.3.4.3.5		For PCE provided with a GFD/I system that is able to automatically reset, the PCE may automatically resume normal operation if the ground fault current returns to a value less than the trip threshold above and the RISO measurement returns to a value required in Clause 13.3.4.2. A GFD/I system that is only manually resettable or can be set for either automatic or manual restart is also acceptable.
13.3.4.3.6		If the GFD/I system is set to automatically restart, and trips four times in any 24 h period, the PCE shall not automatically restart, and shall trip in a manner requiring a manual restart. The number of trips with automatic restart in any 24 h period may be adjustable up to a maximum of 10 if the adjustment means is accessible only to qualified personnel (for example by password protection) and the factory default setting is 4.
13.3.4.3.7		The GFD/I system shall comply with the tests of Clause 13.4.3.3.
13.3.5	Info	**PV array system grounding**
13.3.5.1		If the PCE intentionally grounds or resistively grounds one of the conductors of the PV system, a grounded or resistively grounded array shall be created, then the requirements in Clauses 13.3.5.2 to 13.3.5.5 shall apply.
13.3.5.2		In all modes of operation, the PV system shall be grounded or resistively grounded in one location only.
13.3.5.3		The size of the conductor or busbar that grounds the PV system shall comply with the requirements of the *Canadian Electrical Code, Part I*. **Note:** *In the 2015 edition of the* Canadian Electrical Code, Part I*, rules 64-068, 10-810, 10-812, and 10-814 contain relevant requirements. Other rules of Part I might apply.*

Clause	Verdict	Comment
13.3.5.4		A relay, contactor, or other switching device that forms part of the PV system grounding path and is provided as part of the PCE shall meet the following requirements: a) the device shall only open to allow measurement of the insulation resistance of the array to ground (RISO measurement) or as part of the response of the GFDI system to a ground fault, unless the PCE is intended only for bipolar arrays and complies with Clause 13.3.1.2; b) the dc voltage rating of the device shall be no less than the maximum PV open circuit voltage rating of the PCE; c) the continuous current carrying ability of the device shall be not less than the continuous current that the GFD/I system or ground resistor will allow to flow through the device; and d) either i) for PCE in which the device must carry ground fault current, but does not have to interrupt the ground fault current: 1) the device shall be rated to carry or withstand at least 10 occurrences of a current not less than the maximum PV short circuit current rating of the PCE except for resistively grounded systems, the current is reduced to a value equal to the maximum open circuit array voltage for which the PCE is rated divided by the value of the grounding resistance; or 2) the device and associated assembly shall comply with the test in Clause 13.4.3.4; and ii) for PCE in which the device must interrupt the ground fault current: 1) the device shall be rated to interrupt at least 10 operations of a current not less than the maximum PV short circuit current rating of the PCE. For resistively grounded systems, the max open circuit array voltage for which the PCE is rated shall be divided by the value of the grounding resistance; or 2) the device and associated assembly shall comply with the test in Clause 13.4.3.4.
13.3.5.5		In a resistively grounded PCE in which the ground resistance is high enough to be relied upon to limit the ground fault current, as permitted by Clause 13.3.4.3, the resistor(s) shall comply with one of the following: a) the “Test for resistors serving as safeguard” in CAN/CSA-C22.2 No. 62368-1, Annex G.10.3; b) consist of two or more resistors with values selected such that the resistance value is not less than the value required to limit the current to the required value from Table 20, even with open-circuit or short-circuit failure of any one resistor, or the expected value change over the service life of the resistors; or c) other design that provides equivalent levels of safety.

Clause	Verdict	Comment
13.3.6		**Fault indication for ground fault detection/interruption systems** Where required to indicate a fault by the GFD/I requirements in Clause 13.3.4, the PCE shall provide the following: a) indication integral to the PCE: audible or visual indication detectable from outside the PCE. For PCE intended to be mounted in a location where the visual indication is not detectable, an indication integral to the PCE is not required when a means for external indication is provided and is capable of identifying the specific PCE reporting the fault; and **Note:** *The reason for the external indication above is to ensure that the fault indication is detectable by personnel on site. However, for some types of systems, for example where the PCE is mounted out of sight between the roof and the PV module, the integral indicator cannot be detected by personnel on site.* b) remote indication: an electrical or electronic means that the installer may use to allow fault indication to be remotely received. **Note:** *The intent of Item b) is for the ground fault indication to be received by a person in a different location than the PV system, since many PV systems are in remote locations. The means is not defined, but could be implemented as a message sent over a communication system, closure of a pair of contacts, etc.*
13.4		**Tests**
13.4.1		**Test conditions**
13.4.1.1		A unit intended to be energized directly from a photovoltaic source shall be energized from a supply that simulates ~~the~~ those current-voltage characteristics ~~and time response~~ of a photovoltaic array~~.~~ if that could affect the outcome of the test under consideration. The tests shall be conducted at the input voltage that will produce the most unfavourable conditions ~~and the~~ . The short-circuit current available from the source shall be ~~limited~~ at least equal to ~~1.5 times~~ the ~~rated photovoltaic~~ max. PV input ~~short circuit~~ current~~, except when specified otherwise by~~ rating of the ~~test requirements~~ PCE in accordance with Clause 13.5.1.2 c), unless specified otherwise by the test requirements. Where the characteristic of the source will not affect the test results, any convenient source may be used.
13.4.1.3		~~During testing,~~ If the dc input overcurrent protection is installed, it shall be ~~installed or not,~~ in accordance with the manufacturer's instructions (see Clause 13.3.3).
13.4.1.4		A unit intended for use in a photovoltaic module wiring compartment shall be installed in the smallest sized compartment in which it can be installed. Prior to testing, the unit shall be subjected to 20 cycles of the thermal cycling test procedure of ~~CSA Standard~~ CAN/CSA-C61215. ~~In the performance of~~ When performing the tests, the unit, without an electrical enclosure, shall be in an ambient of 60 °C minimum or higher if rated by the manufacturer. Requirements of ~~this section~~ Clause 13 shall also apply to general tests.

Clause	Verdict	Comment
13.4.2		**DC input reverse polarity test** For a unit intended for connection to a photovoltaic source, the photovoltaic source input of the unit shall be connected as ~~specified~~ in Clause 13.4.1.1, except with reverse polarity. The unit shall not become a shock hazard or a fire hazard as the result of this test. For a unit for connection to a battery, the battery reverse polarity test in Clause 6.6.1 d) shall also apply.
13.4.3	Info	**Array ground fault detection/interruption tests**
13.4.3.1		**General** PCE provided with PV array GFD/I protection in accordance with Clause 13.3.4 shall comply with Clauses 13.4.3.2 to 13.4.3.4.
13.4.3.2		**Array to ground insulation resistance (RISO) measurement test**
13.4.3.2.1		The test in Clauses 13.4.3.2.2 and 13.4.3.2.3 shall apply to PCE provided with an RISO measurement function in accordance with Clause 13.3.4.2. The test shall be performed on each PV input terminal of the PCE, unless analysis of the design indicates that one or more terminals can be expected to have the same result, for example where multiple PV string inputs are in parallel.
13.4.3.2.2		Connect a resistance with a value of 90% of the limit in Clause 13.3.4.2 between ground and each PV input terminal of the PCE, in turn. Connect the PCE PV input to a dc source set for a voltage lower than the PCE minimum start-up voltage. Raise the PV input voltage to a value higher than the PCE minimum start-up voltage. The PCE shall take the actions specified in Clause 13.3.4.2 and shall indicate a fault in accordance with Clause 13.3.6. **Note:** *Any resistance to ground in the dc power supply used during the above test may influence the value of external resistance to be applied.*
13.4.3.2.3		Remove the resistance applied in Clause 13.4.3.2.2, and connect a short-circuit between ground and each PV input terminal of the PCE, in turn. Connect the PCE PV input to a dc source set lower than the PCE minimum start-up voltage. Raise the PV input voltage to a value higher than the PCE minimum start-up voltage. The PCE shall take the actions specified in Clause 13.3.4.2 and shall indicate a fault in accordance with Clause 13.3.6.
13.4.3.2.4		For PCE with adjustable RISO thresholds, the tests in Clauses 13.4.3.2.2 and 13.4.3.2.3 shall be performed at both the lowest setting and the highest setting.
13.4.3.3		**Ground fault current detection test**
13.4.3.3.1		The tests in Clauses 13.4.3.3.2 to 13.4.3.3.5 shall apply to PCE provided with a GFD/I system in accordance with Clause 13.3.4.3. The tests shall be performed on each PV input terminal of the PCE, unless analysis of the design indicates that one or more terminals can be expected to have the same result, for example where multiple PV string inputs are in parallel.

Clause	Verdict	Comment
13.4.3.3.2		Connect a resistor between ground and one of the PCE PV input terminals, with an initial value high enough that the test current through the resistor is approximately 10% lower than the ground fault current detection setting in Clause 13.3.4.3. Measure the current through the resistor with an RMS meter having a bandwidth of minimum 2kHz. Connect a second resistor through a switch, such that when the switch is closed, the total resistance from the PV input to ground is lowered by an amount that will cause a current equal to 135% of the required ground fault current detection setting to flow. Connect the PCE PV input to a dc source within the PCE operating range so that the PCE begins normal operation. Close the switch connecting the second resistor to the PCE and record the resulting ground fault current and the time from the moment the switch is closed until the ground fault current detection/interruption function trips. The trip time shall be less than or equal to 1 h and the PCE shall take the actions specified in Clause 13.3.4.3 and shall indicate a fault in accordance with Clause 13.3.6.
13.4.3.3.3		**Current detection/interruption test for 200% of setting** Connect a resistor between ground and one of the PCE PV input terminals, with an initial value high enough that the test current through the resistor is approximately 10% lower than the ground fault current detection setting in Clause 13.3.4.3. Measure the current through the resistor with an RMS meter having a bandwidth of minimum 2 kHz. Connect a second resistor through a switch, such that when the switch is closed, the total resistance from the PV input to ground is lowered by an amount that will cause a current equal to 200% of the required ground fault current detection setting to flow. Connect the PCE PV input to a dc source within the PCE operating range so that the PCE begins normal operation. Close the switch connecting the second resistor the PCE, and record the resulting ground fault current and the time from the moment the switch is closed until the GFD/I system trips. The trip time shall be less than or equal to 2 min, and the PCE shall take the actions specified in Clause 13.3.4.3 and shall indicate a fault in accordance with Clause 13.3.6.
13.4.3.3.4		**Current detection/interruption test for a short circuit to ground** Connect a resistor between ground and one of the PCE PV input terminals, with an initial value high enough that the test current through the resistor is approximately 10% lower than the ground fault current detection setting in Clause 13.3.4.3. Measure the current through the resistor with an RMS meter having a bandwidth of minimum 2 kHz. Connect a switch in parallel with the resistor from the PV input to ground, such that when the switch is closed, that PV input terminal is short-circuited to ground. The current making and carrying capacity of the switch shall be adequate to not affect the results of the test. Connect the PCE PV input to a dc source within the PCE

Clause	Verdict	Comment
		operating range so that the PCE begins normal operation. Close the switch shorting the PV input to ground, and record the resulting ground fault current and the time from the moment the switch is closed until the GFD/I system trips. The trip time shall be less than or equal to 2 min and the PCE shall take the actions specified in Clause 13.3.4.3 and shall indicate a fault in accordance with Clause 13.3.6.
13.4.3.3.5		**Adjustable setpoints** For PCE with adjustable current detection settings, the tests of Clauses 13.4.3.3.2 to 13.4.3.3.4 shall be performed at both the highest setting and at the lowest setting at which the PCE will operate, in the initial condition before switching in the second test resistor or the short circuit (in Clause 13.4.3.3.4).
13.4.3.4	Info	**Array grounding switching device current withstand test**
13.4.3.4.1		If required by Clause 13.3.5.4, the PCE and the array grounding device (relay, contactor, etc.) shall comply with Clauses 13.4.3.4.2 to 13.4.3.4.4.
13.4.3.4.2		The dc source used for this test shall be capable of delivering the maximum PV open circuit voltage when the source is not loaded and the maximum PV short circuit current rating of the PCE when the source is under load. For resistively grounded systems, the current is reduced to a value equal to the max open circuit array voltage the PCE is rated for divided by the value of the grounding resistance.
13.4.3.4.3		During the test, the array grounding switching device (relay, contactor, etc.) shall be either a) installed in the PCE so that the magnitude and duration of fault current through the device is determined by the response of the PV ground fault protection system; or b) removed from the PCE with the test set up such that the magnitude and duration of fault current through the device is not less than it would be if the device was installed in the PCE. **Note:** *It might be necessary to perform the first cycle of the test in the PCE in order to determine the magnitude and duration of fault current through the device*
13.4.3.4.3		A short circuiting device shall be connected to ground from the ungrounded PV conductor, such that when the shorting device is closed, the dc source will apply the rated maximum PV short circuit current through the array grounding device under test. For resistively grounded systems, a current equal to the max open circuit array voltage that the PCE is rated for, divided by the value of the grounding resistance simulating a ground fault shall be used. For each cycle of the test, the shorting device shall be closed to introduce the ground fault current, and either a) opened after the fault current duration as determined in Clause 13.4.3.4.3; or b) opened after the ground fault protection system interrupts the current. After each cycle, a fuse or circuit breaker that operated to interrupt the fault current shall be replaced, if a fuse is used, or reset, if a breaker is used. The next test cycle shall be started after the PCE restart delay period, which shall be set to its

Clause	Verdict	Comment
		minimum setting. The application of the fault current shall be repeated nine more times for a total of 10 cycles. During each of the 10 cycles, the array grounding switching device shall be able to open and close as in normal operation, and there shall be no emission of flame or molten materials. After the 10th cycle, it is not required that the array grounding switching device or PCE be operating normally. If, during the first three cycles the current through the grounding device under test does not exceed the overload rating of the device, the test may be stopped.
13.4.4		**Bipolar PCE tests** Where required by Clause 13.3.1.1 a) for bipolar PCE, the following testing under normal and single fault conditions shall be performed. Fault conditions to be considered include, but are not limited to, ground faults on the PV array, opening of an upstream overcurrent protective device, component faults in the PCE including in the automatic series control means if provided, faults on the output circuit of the PCE, etc. Normal conditions to be considered include, but are not limited to, normal operation, start-up and shut-down modes, opening of upstream disconnecting means, etc. During the testing, voltages shall be monitored where necessary to show compliance with Clause 13.3.1.1 a), for example across open switch contacts or across other equipment connected in each monopole, and from equipment or circuits to ground, in the PCE and external to the PCE. In all cases, the testing shall not result in a voltage that exceeds any of the following: a) the max open circuit voltage rating of one monopole, either line to line within either monopole, or from any line to ground, without a limitation in time; b) the combined open circuit voltages of the two monopoles, either line to line within either monopole, or from any line to ground, for more than 2 s; or c) the max open circuit voltage rating of one monopole across the contacts of a switch or breaker that is opening, or across a fuse that is opening For a particular condition, testing is not required if analysis of schematics, system diagrams, etc. can be used to verify compliance.
13.5		**Markings**
13.5.1		**Product markings**
13.5.1.11		The markings in Clause 13.5.1 shall be plainly and permanently marked, where readily visible after installation, unless otherwise stated.
13.5.1.2		For a unit intended to be energized directly from a photovoltaic source ~~shall be plainly and permanently marked where it is readily visible after installation with the following information~~: a) maximum (open circuit) photovoltaic ~~source~~ input voltage under any condition*; b) range of operating photovoltaic ~~source~~ input voltage; c) maximum photovoltaic ~~source~~ input short-circuit current under any condition*; and d) intended array configuration(s): ungrounded; grounded or resistively grounded

Clause	Verdict	Comment
		and if so which polarities are to be grounded; and "bipolar" if applicable. * *PV modules are marked with open circuit voltage and short circuit current ratings based on standard test conditions (STC). Those STC voltage and short circuit current ratings are required by the* Canadian Electrical Code, Part I *to be adjusted for cold temperatures (if applicable) and for excess irradiance. The PCE markings in Items a) and c) reflect the maximum adjusted ratings that may be connected to the PCE, not the ratings at STC.* ~~(d) maximum output fault current.~~ ~~**Exception:** A unit integrated to a photovoltaic module (eg, ac module inverter) that does not permit access to the input circuit shall not be required to have the markings in Items (a) to (c) of this Clause.~~
13.5.1.3		If disconnecting means for the PV input is provided, the marking of Clause 5.1 m) shall include the designation "PV" or equivalent, on or near the device.
13.5.1.4		For PCE equipped with PV ground fault protection for grounded arrays, the following wording or equivalent shall be marked on the PCE where visible after installation: WARNING: WHEN A GROUND FAULT IS INDICATED, NORMALLY GROUNDED CONDUCTORS MAY BE UNGROUNDED AND ENERGIZED OR NORMALLY UNGROUNDED CONDUCTORS MAY BE GROUNDED. For PCE rated only for use with ungrounded arrays, the following marking may be used as an alternative to the above: WARNING: WHEN A GROUND FAULT IS INDICATED, NORMALLY UNGROUNDED CONDUCTORS MAY BE GROUNDED.
13.5.1.5		PV PCE that cause the array to be grounded or ungrounded in different normal operating modes shall be marked with the following or equivalent wording: WARNING: PV ARRAY IS GROUNDED DURING AND UNGROUNDED DURING REFER TO MANUAL. DISCONNECT AND TEST BEFORE SERVICING THE INVERTER OR THE ARRAY. The blanks shall name the operating modes in which each condition applies. The installation instructions shall comply with Clause 13.5.2.2 b).
13.5.1.6		Where required by Clause 13.3.1.1 a), bipolar PCE shall be marked with the following wording or equivalent: WARNING: ALL ELECTRICAL EQUIPMENT CONNECTED TO THE PV INPUT SHALL BE RATED FOR MIN. V DC. The voltage to be used is the maximum open circuit voltage rating of one monopole.
13.5.1.7		Where required by Clause 13.3.1.1 b), bipolar PCE shall be marked with the following wording or equivalent: WARNING: ALL ELECTRICAL EQUIPMENT CONNECTED TO THE PV INPUT SHALL BE RATED FOR MIN. V DC. The voltage to be used is the sum of the maximum open circuit voltage ratings of the two monopoles.

Clause	Verdict	Comment
13.5.2.2		The operating and installation instructions shall explicitly a) explain all markings in Clause 13.5.1.2; b) describe the interconnection with the photovoltaic array including the intended array grounding configuration(s) - ungrounded, or grounded and if so which polarities is are to be grounded, and information regarding any operating modes in which the array grounding state changes (for example temporarily ungrounding a normally grounded array during array insulation resistance measurement), and whether or not array grounding is integral to the PCE and what actions (e.g., grounding, not grounding) the installer is required to take outside the PCE; and c) describe the interconnection to auxiliary equipment (if applicable).
13.5.2.3		The installation instructions shall indicate that the ~~wiring methods used~~ installation shall be in accordance with the *Canadian Electrical Code, Part I*.
13.5.2.4		Where overcurrent protection for the PV input is not provided integral to the unit, in accordance with Clause 13.3.2, the installation instructions shall indicate that the ~~unit~~ PV input of the PCE is not intended for connection to a battery or any other type of dc source except a PV array.
13.5.2.5		Where overcurrent protection is not provided integral to a unit intended for use with a battery, in accordance with Clause 10.3.1 the installation instructions shall ~~indicate that the overcurrent protection shall be installed at the battery, as part of the installation~~, include the information required in accordance with ~~the *Canadian Electrical Code, Part I*, and shall specify the type and ratings of the overcurrent protection to be provided~~ Clause 5.27.
13.5.2.7.1		Instructions relating to PV GFDI shall be as specified in Clauses 13.5.2.7.2 to 13.5.2.7.6.
13.5.2.7.2		The installation instructions shall indicate whether or not the PCE is provided with a PV GFD/I system, and shall provide information regarding the functioning and settings of the protection functions provided. If any PV GFD/I functions or equipment required by Clause 13.3.4 are not provided in the PCE, the installation manual shall indicate that it is the installer's responsibility to ensure compliance with the requirements of the applicable installation codes regarding PV GFD/I and shall list all specific functions or equipment that are not provided integral to the PCE.
13.5.2.7.3		For PCE including the GFD/I system, the operating instructions shall include instructions for what actions to take in response to a ground fault. Such instructions shall be identified as intended for qualified personnel only, except for tasks that non-qualified personnel can do without exposure to hazards, such as operating a switch to silence an alarm.
13.5.2.7.4		For PCE equipped with PV GFD/I for grounded arrays, the following wording or equivalent shall be in the installation and operation instructions: WARNING: WHEN A GROUND FAULT IS INDICATED, NORMALLY GROUNDED CONDUCTORS MAY BE UNGROUNDED AND ENERGIZED OR NORMALLY UNGROUNDED CONDUCTORS MAY BE GROUNDED.

Clause	Verdict	Comment
		For PCE rated only for use with ungrounded arrays, the following wording may be used as an alternative to the above: WARNING: WHEN A GROUND FAULT IS INDICATED, NORMALLY UNGROUNDED CONDUCTORS MAY BE GROUNDED.
13.5.2.7.5		For PV GFD/I systems with password protected adjustable settings, including the number of trips for which automatic restart is allowed, the instructions shall not provide the password.
13.5.2.7.6		Where required by Clause 13.3.6, the installation instructions shall include information regarding how to make connections to, and use, the remote fault indicating means.
13.5.2.8		Bipolar PCE shall be provided with installation instructions that specify the minimum system voltage rating of the electrical equipment to be used in the PCE input circuits (i.e., the PV source and output circuits). The voltage specified shall be a) for bipolar PCE in accordance with Clause 13.3.1.1 a), the maximum open circuit voltage rating of one monopole; or b) bipolar PCE in accordance with Clause 13.3.1.1 b), the sum of the maximum PV open circuit voltage ratings of the two monopoles.
13.5.2.9		For bipolar PCE in accordance with Clause 13.5.1.2 a), the installation instructions shall specify that a) the electrical equipment in the PV source and output circuits of the two monopoles shall be physically and electrically separated up to the point where they are electrically connected to each other; and b) the PV source and output circuit conductors of the two monopoles shall be installed in separate raceways up to the point where they are electrically connected to each other.
14		~~**Utility Interconnected**~~ **Interactive inverters and PCE** **Note:** *See also Annex B.*
14.1		**Scope** Clause 14 applies to interactive PCE as defined in Clause 3, regardless of whether the input to the PCE is ac or dc (an interactive inverter).
14.2		**Construction**
14.2.1		**Output provisions**
14.2.1.1		The ac output circuit shall not be bonded to the enclosure, and the ~~markings and~~ installation instructions shall comply with Clause ~~5.20 and Clause~~ 14.4.2.3.
14.2.1.2		A general-use ac output receptacle shall not be provided on ~~a utility interconnected~~ an interactive inverter or PCE unless it is internal to the unit and accessible for service personnel use only.
14.2.2		**Utility disconnect functions and islanding protection**
14.2.2.1		The ~~unit~~ interactive inverter or PCE shall be provided with a means to automatically cease ~~to deliver~~ delivering ac power to the utility under abnormal voltage or frequency conditions or islanding conditions, in accordance with the tests in Clauses 14.3.4 and 14.3.5.

Clause	Verdict	Comment
14.2.2.2		The utility disconnect function setpoints (voltage and frequency thresholds, clearing times, and reconnect delays) on interactive inverters or PCE with rated output of 30 kW and less, may be field adjustable. The utility disconnect function setpoints on interactive inverters or PCE with rated output exceeding 30 kW shall be adjustable. The installation instructions shall contain the information required by Clause 14.4.2.2 regarding setpoints. For both adjustable and fixed setpoints, the factory setting may be different than given in Tables 16 and 17 but if different than the values in these Tables, the factory setting shall be closer to the nominal value (for thresholds) or shorter (for clearing times). **Note:** *For example, for the V < 88% setting, a factory setting of 90% for low voltage is allowed but a factory setting of 85% is not allowed. The range of adjustability, however, may extend both above and below the values in the tables.* The factory setting for reconnect delay for interactive inverters or PCE that automatically reconnect shall be either a) fixed, with a value of 5 min; or b) adjustable, with a range having an upper limit of at least 5 min. ~~A utility-interconnected inverter provided with field adjustable trip points for specific utility requirements shall comply with the test of Clause 15.3.4.4 and the marking of Clause 15.4.2.2~~.
14.2.2.3		For ~~a unit~~ interactive inverters or PCE with field adjustable ~~islanding trip points~~ setpoints, the controls shall be accessible to authorized personnel only. **Note:** *A password is considered an acceptable means of restricting access.*
14.2.2.4		Interactive inverters or PCE with field adjustable trip points shall have a means to indicate the active setpoints. T he means may be integral to the inverter or PCE, or may require the use of external equipment. **Note:** *For example, the external equipment may be a computer or handheld display that connects to the PCE.*
14.2.2.5		Three-phase interactive inverters or PCE shall a) be tested to determine the max current imbalance on the ac output under normal conditions, in accordance with the test in Clause 14.3.10; b) have the worst-case current unbalance from the test in Item a) specified in the installation instructions, in accordance with Clause 14.4.2.8; and c) cease to deliver power to all ungrounded phases of supply authority system upon loss of voltage in one or more of the supply authority system's phases, as shown by the testing of Clause 14.3.4. The information required by Clause 14.4.2.7 shall be provided in the installation instructions. **Note:** *The intent of these requirements is to provide the current unbalance information needed to assess the impact of the interactive installation on the voltage unbalance at the point of common coupling. Also note that the test requirement of Clause 14.3.4 requires 3-phase inverters to disconnect when one phase is outside the limits of Table 16.*

Clause	Verdict	Comment
14.2.3		**Automatic disconnecting means for non-isolated interactive inverters** Unless required to be used with an external isolation transformer and marked in accordance with Clause 14.4.1.3, nonisolated interactive inverters operating from an input source or sources exceeding extra low voltage (ELV) shall be provided with means to automatically disconnect all grounded and ungrounded conductors to isolate the utility from the non-ELV input source(s). The automatic disconnecting means shall provide galvanic isolation between the non-ELV input source(s) and the utility, under both normal and single-fault conditions. The automatic disconnecting means shall open when the inverter ceases to deliver power as required by the voltage and frequency disconnect testing in Clause 14.3.4 and the anti-islanding testing in Clause 14.3.5, and if required by Clause 13.3.4.3, in response to a ground fault. **Note:** *The automatic disconnecting means may also open under other conditions if desired.* The PCE shall automatically check the operation of the automatic disconnecting means each time before starting to deliver power, and at least once every 24 h. If any one or more of the disconnecting means devices is not functioning properly with regards to providing galvanic isolation, the PCE shall a) leave the remaining devices in the open position; b) not start operating; and c) indicate a fault. The galvanic isolation provided by the automatic disconnecting means shall comply with the dielectric strength requirements in Clause 6.5, based on the max input voltage, under normal and single fault conditions. **Note:** *These requirements are in addition to the device(s) being required to be rated for the conditions present in the circuit they are installed in, under normal conditions.* The automatic disconnecting means shall comply with the tests in Clause 14.3.8.
14.3	Info	**Tests**
14.3.1	Info	**Test conditions**
14.3.1.3		The total harmonic distortion (THD) of the voltage of the utility source shall be less than 1% without the ~~utility-interconnected~~ interactive inverter or PCE operating.
14.3.1.4		The ~~dc~~ input of the unit shall be connected to a ~~dc~~ source that has the same current-voltage characteristic as the source from which it is intended to be energized. Where the characteristic of the source will not affect the test results, any convenient source may be used.
14.3.2	Info	**Output ratings**
14.3.2.1		**Output power factor** The output of the unit shall have a power factor of 0.85 or higher when the unit is connected to the rated ~~dc~~ input and operated at 25, 50, and 100% of the rated output, with the factory default settings. PCE may have provisions for field adjustment of output power factor in accordance with Clause 14.2.2.3.

Clause	Verdict	Comment
14.3.2.2		**Output current** The unit shall not exceed its rated output current by more than 10% when connected at its rated ~~dc~~ input voltage and to the utility source, and supplied by an ~~dc~~ input source capable of delivering twice the unit's rated input current.
14.3.3		**Harmonic current distortion** The ~~total harmonic distortion (~~THD~~)~~ of the output current shall be less than 5% of the fundamental ~~at~~ frequency rated full load output current. Individual harmonics shall not exceed the limits in Table 15 which are expressed as a percentage of the fundamental frequency rated full load output current. The measurements shall be made with the ~~utility-interconnected~~ interactive inverter or PCE delivering 33%, 66%, and 100% of its rated output power to the utility source. **Note:** *Defined in this way, relative to the full rated output current regardless of the percentage of rated power at which the test is performed, the distortion is often referred to as "total demand distortion".*
14.3.4	Info	**Utility voltage and frequency variation test**
14.3.4.1		The unit shall cease to deliver power to the utility source within the times specified in Tables 16 and 17, after the output voltage ~~and~~ or frequency of the utility source are adjusted to each applicable condition specified in the Tables ~~16~~. Each condition shall be ~~repeated 10~~ performed five times to verify compliance. The ~~utility-interconnected~~ interactive inverter or PCE is not required to run at full rated output power for this test.
14.3.4.2		For the tests described in Clause 14.3.4.1, ~~a three-phase utility-interconnected~~ an interactive inverter or PCE with a multi-phase or single-phase 3-wire output shall cease to deliver power on all ~~three phases~~ conductors when ~~any individual phase~~ the voltage goes outside the range specified in Table 16, on each ungrounded conductor individually, and on all ungrounded conductors simultaneously.
14.3.4.3		At least once during the tests for over-voltage, under-voltage, over-frequency, and under-frequency, the reconnect delay shall be tested as follows: a) Following ~~each~~ disconnection in response to the test, the utility source's voltage and frequency shall be restored to the rated output voltage and frequency for the unit. b) ~~A utility-interconnected~~ An interactive inverter or PCE provided with manual reset control shall not resume delivering power to the utility source. c) A ~~utility-interconnected~~ interactive inverter or PCE with an automatic reset control shall resume delivering power to the utility source only after the voltage and frequency have been restored for at least 5 min or, if adjustable, for at least the factory setting of the reconnect delay set point. During the other repetitions of the tests, the inverter may be set for a shorter reconnect delay to reduce the test duration.

Clause	Verdict	Comment
14.3.4.4		For units with field adjustable trip points, in accordance with Clause 14.2.2.2, the PCE shall be tested with each adjustable voltage, frequency ~~trip point shall be set and tested in accordance with Table 16. In addition, the adjustable trip points shall be~~ , and trip time setpoint set at the low and high ends of the ranges, one at a time, and ~~tested for the voltage and frequency range and~~ at the factory default setting, as specified ~~trip time as detailed~~ in the manufacturer's installation instructions.
14.3.5		**Anti-islanding test**
14.3.5.1		Utility interactive inverters shall comply with either a) the test in Clauses 14.3.5.2 to 14.3.5.6; or b) the test in Clause 5.7.1 of IEEE 1547.1.
14.3.5.2		The ~~utility-interconnected~~ interactive inverter or PCE shall be connected to a utility source and to the balanced RLC load circuit as described in Figure 9.
14.3.5.3		The ~~utility-interconnected~~ interactive inverter or PCE shall be tested at three ~~output power levels:~~ 25~~–~~33%, 50~~–~~66%, and 100% of its full rated output power. For units capable of supplying power levels higher than their rated output power, an additional test shall be performed at the highest output power possible.
14.3.5.4		The test circuit shall be balanced with the following parameters: a) R shall be adjusted to draw the test load power as defined in Clause 14.3.5.2; b) L shall be adjusted to draw a reactive power equal to ~~2.5 times~~ the real power drawn by R; c) C shall be adjusted so ~~that~~ the reactive power at S is within zero ± 1.0% of the real power drawn by the RLC load; ~~and~~ d) the ~~dc input~~ output power of the unit shall be adjusted so ~~that~~ the real power at S is ~~within~~ zero ± 1.0% of the real power drawn by the RLC load. For an interactive inverter or PCE in which the output power is a function of the input power (for example a maximum power point algorithm on a PV inverter), the output power shall be set by setting the available input power; and e) for PCE adjustable for non-unity power factor operation, balancing of the RLC load shall take into account the reactive power output of the PCE. **Note:** *Details of balancing the RLC load for non-unity power factor situations are given in IEEE 1547.1, Clause 5.7.1.2.*
14.3.5.5		When the test circuit is balanced as described in Clause 14.3.5.3, switch S shall be opened. The ~~utility-interconnected~~ interactive inverter or PCE shall a) cease to deliver power to the test load within 2 s; and b) comply with Clause 14.3.4.3 for restoration of power.
14.3.6	Info	**Loss of control circuit power**
14.3.6.1		There shall be no normal or single fault condition in which the PCE control circuits that implement the utility disconnect functions and islanding protection of Clause 14.2.2 have lost power, while the PCE continues to export power to the utility, when tested in accordance with Clause 14.3.6.2.

Clause	Verdict	Comment
14.3.6.2		With the PCE connected as in Clause 14.3.1, single faults that could disable power to the applicable control circuit(s) are applied, one at a time. For each fault applied, the PCE shall a) ~~The unit shall de~~ cease to energize the grid, and shall remain de-energized until the control circuit power is restored; or ~~regains power when tested as specified in Clause 15.3.6.2.~~ b) continue to operate, provided that utility disconnect functions and islanding protection of Clause 14.2.2 are still functioning properly even with the single fault in place.
14.3.7		**Maximum backfeed current into the PCE input circuit** ~~**Component Faults**~~ ~~During the component fault tests described in Clause 6.6.7.~~ The maximum backfeed current that can flow from the utility into the ~~dc source~~ input circuit as a result of a faulted component in the PCE, or a single fault in the input source or its wiring, shall be measured. ~~The value measured shall not exceed the maximum utility backfeed current marked in Clause 15.4.1.2.~~ Testing shall be conducted under the conditions of Clause 14.3.1, with faults applied in the PCE or in the input source or its wiring. During each fault condition, the RMS value of the backfeed current shall be measured using a 1 min RMS calculation window, starting 10 s after application of the fault, and continuing until the backfeed current drops to zero or stabilizes at a value. The maximum backfeed current shall be considered to be a) zero if the current is zero after the first minute; or b) the maximum 1 min RMS value observed during the test (excluding the first 10 s) if the current is not zero after the first minute. The maximum backfeed current shall not exceed the value marked in accordance with Clause 14.4.1.2.
14.3.8		**Testing of automatic disconnecting means for non-isolated inverters** Verify the normal functioning of the automatic disconnecting means by varying the input voltage below the start-up level and raising it up again or in some other way making the inverter execute the self-test. The inverter shall execute the self-test routine and start operating normally. The single faults shall then be applied to components that form part of the automatic disconnecting means, its control circuits, or its power supply circuits. The input or output electrical parameters shall be set such that an inverter protection function operates for which opening of the automatic disconnecting means is required. For each fault applied, one of the following shall be verified: a) all galvanic isolation devices of the automatic disconnecting means still properly open; or b) the system detects the fault the next time the self-test routine executes, leaves the remaining unfaulted galvanic isolation devices in the open position, does not start operating, and indicates a fault.

Clause	Verdict	Comment
14.3.9	Info	**AC output short circuit current contribution tests**
14.3.9.1		The interactive inverter or PCE shall be connected to a utility source in accordance with Clause 6.1, with a fault switch (short circuiting device) located in accordance with Clause 14.3.9.4. The test setup shall a) measure the fault current contribution from the inverter; b) not include any fault current contribution from the utility source; c) use a fault switch which has a low enough impedance and high enough capacity to withstand the short circuit currents it will be subjected to without significantly affecting the test result; and d) use the largest size conductors in accordance with the installation instructions for the inverter for the connections between the inverter and the shorting device. The conductor length shall be as short as is practical while allowing the fault switch to be outside, but within 1 m of, the enclosure of the inverter or external transformer. The conductor size and length and the fault switch contact resistance shall be recorded in the test report. An example of a possible test setup is given in Figure 13; other test setups may be used. **Note:** *In Figure 13, the interrupting devices shown on the utility side of the fault switch are intended to reduce the fault current through the fault switch to reduce the withstand requirements for that switch. The interrupting devices have no impact on the measured inverter fault current contribution and are optional.*
14.3.9.2		Before the application of the short circuit, the interactive inverter or PCE shall be operating at its maximum rated output power, with the dc input supply at its maximum rated operating voltage.
14.3.9.3		The fault switch used to simulate the fault shall stay closed as long as the inverter delivers current in the fault.
14.3.9.4		The short circuits are to be applied to the inverter ac output from each ungrounded phase to each other ungrounded phase, and all ungrounded phases together. It is not required to apply shorts from phases to neutral (if present). **Note:** *This testing is intended to capture the highest short circuit current contribution levels. It is assumed that tests to ground or tests to a neutral would result in lower peak and RMS fault currents. If this testing is being combined with the ac output short circuit test required by Clause 6.6.1 a), consideration should be given to shorts to ground if they could represent a worst-case test for the purposes of Clause 6.6.1.*

Clause	Verdict	Comment
14.3.9.5		For units with an integrated transformer, the short shall be applied to the grid side of the inverter. For units intended for use with fully specified external low voltage transformers, the short shall be applied on the grid side of the external transformer. For units with partly-specified low voltage transformers, the short shall be applied to the output of the inverter. For any unit with an external transformer having a medium voltage grid connection, the short shall be applied to the inverter (low voltage) side. External transformers shall be specified in accordance with Clause 14.4.2.5.
14.3.9.6		Each short-circuit test in Clause 14.3.9.4 shall be iterated four times so the shorts occurs in different positions of the line cycle. At least one iteration of each test shall be performed within 10 degrees of the peak of the ac voltage sine wave.
14.3.9.7		For each short-circuit test iteration, the following parameters, as defined in Clause 3, shall be measured, calculated, and recorded, and the maximum value of each parameter shall be used for the installation instructions of Clause 14.4.2.4: a) short circuit current — initial: amps (rms) and duration of 16.7 ms or 1 cycle; b) short circuit current — maximum: amps (peak) and duration (ms); and c) short circuit current — breaking: amps (RMS) and duration (ms).
14.3.10		**Current unbalance test** For a multi-phase PCE, during the ratings test of Clause 6.2, the individual phase currents shall be measured and recorded and used to calculate the current unbalance specified in the installation instructions as required by Clause 14.4.2.8. The current unbalance shall be defined as the maximum deviation of line current on any phase, from the average line current of all phases, expressed as a percentage: $\%\ \text{Current unbalance} = \frac{\text{largest line current deviation from the average line current}}{\text{average line current}} \times$ (New)
14.4	Info	**Markings**
14.4.1	Info	**Product markings**
14.4.1.1		The following marking or the equivalent shall appear on the PCE where it will be readily visible after installation: INTERACTIVE INVERTER or INTERACTIVE PCE.
14.4.1.2		The maximum utility backfeed current as determined by the test in Clause 14.3.7 shall be marked on the PCE in the same location as the other required ratings.
14.4.1.2		Where required by Clause 14.2.3, the interactive inverter or PCE shall be marked with the following, or the equivalent: WARNING: MUST BE USED WITH AN EXTERNAL ISOLATION TRANSFORMER.
14.4.2		**Installation, operating, and servicing instructions**
14.4.2.1		The installation instructions shall inform the installer that utility interconnection may require approval from the authority having jurisdiction.

Clause	Verdict	Comment
14.4.2.2		For interactive inverters or PCE with a) field adjustable utility interconnection protection set points, the installation manual shall indicate the presence of such controls, and shall specify the following information, co-located in a single place in the manual: i) the ranges of adjustability for the voltage and frequency trip points; ii) the ranges of adjustability for the time delay(s); iii) the default values for each of the above features, including whether or not the feature is enabled or disabled in the factory default setting; and iv) the range of adjustability and factory default setting for the reconnection delay. The installation and operating manual(s) shall indicate the need to obtain approval from the authority having jurisdiction before making adjustments to these setpoints. b) fixed utility interconnection protection setpoints, the installation manual shall indicate that the setpoints are not adjustable, and shall specify the following information, co-located in a single place in the manual: i) the factory settings for the voltage and frequency trip points; ii) the factory settings for the time delay(s); and iii) the factory setting for the reconnection delay.
14.4.2.3		In accordance with Clause 14.2.1.1, the installation manual shall indicate that the ~~input and~~ ac output circuits are isolated from the enclosure and that ac system grounding, when required by the *Canadian Electrical Code, Part I*, is ~~the responsibility of the installer~~ to be done in the installation.
14.4.2.4		The installation instructions shall contain a table presenting the ac output short-circuit contribution data of the interactive inverter or PCE equal to or greater than that determined by the tests in Clause 14.3.9. This table shall present the following current and time data: a) short circuit current — initial: amps (RMS) and duration of 16.7 ms or 1 cycle; b) short circuit current — maximum: amps (peak) and duration (ms); and c) short circuit current — breaking: amps (RMS) and duration (ms). Where phase-to-ground testing is required by Clause 14.3.9.4, the data provided shall include the phase-phase and phase-G results.
14.4.2.5		For non-isolated interactive inverters or PCE that must be used with an external isolation transformer in accordance with Clause 14.2.3, the installation instructions shall specify the required parameters of the transformer: a) For a fully-specified transformer in accordance with Clause 14.3.9.5, the manufacturer's name and specific model number for the transformer. b) For a partly-specified transformer in accordance with Clause 14.3.9.5, the relevant transformer ratings depending on the type of transformer, including at least the required nominal voltage of the winding to which the inverter connects, and the continuous power rating. **Note:** *For some applications, other parameters such as percent impedance may be relevant.*

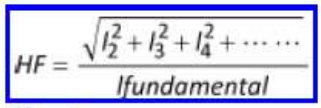
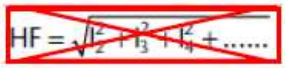
Clause	Verdict	Comment
14.4.2.6		For non-isolated interactive inverters or PCEs that do not provide the fault tolerant automatic disconnecting means of Clause 14.2.3, but must be used with an external isolation transformer, the installation instructions shall specify that there shall be no other equipment connected between the inverter and the inverter-facing winding of that isolation transformer, except a) other inverters meeting the interactive inverter or PCE requirements of this standard; or b) other ac utilization equipment supplied through transformer(s) located between the inverter output circuit and the equipment input.
14.4.2.7		The installation instructions shall specify the action taken by the PCE under abnormal voltage or frequency conditions or in response to a detected unintentional island. Specifically the instructions shall specify whether the PCE opens a disconnecting means, or ceases to deliver power without opening a disconnecting means. **Note:** *The purpose of this information is to allow compliance with* Canadian Electrical Code, Part I*, Rules 84-008 and 84-018 to be addressed at the system level.*
14.4.2.8		For a multi-phase PCE, the installation instructions shall specify the maximum current unbalance measured in the test of Clause 14.3.10.
15		**DC charge controllers**
15.1		**Scope** The requirements of Clause ~~16 supplement and amend the requirements~~ 15 cover PCE or portions of ~~Clauses 2~~ PCE intended to ~~6~~ charge batteries from a variable dc source of energy, such as a PV array or a wind turbine, and that may incorporate load control systems.
15.2		**Construction**
15.2.1		**General**
15.2.1.1		A charge controller shall be rated for operation with grounded batteries, or ungrounded batteries, or both, and shall operate as intended in all systems for which it is rated. The installation manual shall contain the information required in Clause 15.4.2.3. **Note:** *For PV charge controller input circuit grounding, see also Clause 13.2.*
15.2.1.1		A charge controller incorporating controls for the adjustment of the charge algorithm or setpoints shall be provided with the instructions in Clause 15.4.2.5.
15.2.2	Info	**Galvanic isolation**
15.2.2.1	Info	**Isolated charge controllers**
15.2.2.1.1		A charge controller marked in accordance with Clause 15.4.1.2 a) indicating an isolated design shall comply with Clauses 15.2.2.1.2 and 15.2.2.1.3.
15.2.2.1.2		Electrical spacings across the galvanic isolation shall comply with Clause 4.16.
15.2.2.1.3		The dielectric strength of the galvanic isolation shall comply with the applicable tests of Clause 6.5.
15.2.2.2		**Non-isolated charge controllers**

Clause	Verdict	Comment
15.2.2.2.1		A charge controller not complying with Clause 15.3.1 shall be marked in accordance with Clause 15.4.1.2 b) indicating a non-isolated design.
15.2.2.2.2		A non-isolated charge controller, with or without integral ground fault protection, that is rated for connection to an input source exceeding extra low voltage (ELV) shall be provided with markings and installation instructions indicating that battery terminals and connected circuits may be ungrounded and hazardous when a ground fault is present, in accordance with Clauses 15.4.1.3 and 15.4.2.4. The battery warning markings and instructions are not required for a non-isolated charge controller containing integral ground fault protection that includes automatic disconnecting means for all grounded and ungrounded conductors between the non-ELV input circuit and the battery circuit.
15.3	Info	**Tests**
15.3.1	Info	**Test conditions**
15.3.1.1		A charge controller shall be connected in accordance with the installation instructions, and tested using the test configuration shown in Figure 10. For the purpose of these tests, the battery terminals on charge controllers with load control are to be considered and tested as both input and output terminals based upon the respective test.
15.3.1.2		The battery interface terminals shall be connected to a battery bank or a simulated battery load. A simulated battery load shall be as specified in Table 18. The capacitance shall be in parallel with a resistor and a ~~bipolar~~ power supply adjusted to simulate the battery voltage and adjusted to draw a specified operational battery charge current as required by the charge controller design.
15.3.2	Info	**Normal operation**
15.3.2.3		The unit shall be connected to a source that has the same current-voltage characteristics as the source intended to be used with the charge controller. The battery terminals of the unit shall be open circuited, ~~**Exception:** For a charge~~ unless the charge controller ~~that does not~~ is not able to operate with open-circuited battery terminals, in which case the battery terminals of the charge controller shall also be connected to a battery or battery simulator operating at the charge controller rated battery voltage. The load terminals shall be connected to a load adjusted to draw the maximum attainable output current from the charge controller. The voltage shall be measured at the load terminals and at the battery terminals.
15.3.6		**Charge controller miswiring**
15.3.6.1		The unit shall be connected as specified in Clause 15.3.1~~, with no additional overcurrent protection~~. The unit shall not become a shock or fire hazard as a result of the test described in Clause 15.3.6.3.

Clause	Verdict	Comment
15.3.6.3		The unit shall be energized as follows: a) with no source and the polarity of the battery reversed; b) with the polarity of the battery reversed followed ~~by~~ with the connection of the source; c) with the polarity of the battery reversed followed by the connection of the source with reversed polarity; d) with no battery and the polarity of the source reversed; e) with the polarity of the source reversed followed by the connection of the battery; and f) with the polarity of the source reversed followed by the connection of the battery with reversed polarity. ~~**Exception:**~~ In accordance with Clause 15.3.1.2, a unit marked with a connection sequence shall not be required to be tested with sequences that violate the marking.
15.4		**Marking**
15.4.1		**Product marking**
15.4.1.1		A charge controller that requires a specific connection method in accordance with Clause 15.3.1.3 shall be marked with the following wording: ~~CAUTION~~ WARNING: RISK OF FIRE AND SHOCK. CONNECT TERMINALS PRIOR TO THE CONNECTION OF ____ TERMINALS, indicating the battery or source terminals as appropriate.
15.4.1.2		A charge controller shall be marked to identify whether or not galvanic isolation is present between the dc input and the battery circuit, as follows: a) "WARNING: DC INPUT ISOLATED FROM BATTERY CIRCUIT" or equivalent, when the charge controller contains galvanic isolation complying with Clause 15.2.2.1; or b) "WARNING: DC INPUT NOT ISOLATED FROM BATTERY CIRCUIT" or equivalent, when the charge controller does not contain galvanic isolation complying with Clause 15.2.2.1. When the PCE is a charge controller only, with no ports other than the dc input and battery circuit, Items a) and b) may be simplified to "ISOLATED" and "NON-ISOLATED", respectively.
15.4.1.3		When required by Clause 15.2.2.2.2, a charge controller shall be marked with the following wording or equivalent where visible after installation, and an additional label with the same or equivalent wording shall be provided to be applied by the installer on or adjacent to the battery: WARNING: WHEN A GROUND FAULT IS INDICATED, BATTERY TERMINALS AND CONNECTED CIRCUITS MAY BE UNGROUNDED AND HAZARDOUS. **Note:** *See also Clause 13.5.1.4, which might apply even if the above does not apply.*
15.4.1.4		A charge controller shall be marked with the wording "CHARGE CONTROLLER" or equivalent where visible after installation.
15.4.2		**Installation instructions**

Clause	Verdict	Comment
15.4.2.2		The installation instructions for a charge controller with a temperature compensating means shall ~~indicate~~ provide instructions for configuration of the temperature compensation set points (if applicable), and instructions regarding the use and location of the temperature sensing means provided. ~~(a) proper location of the unit with respect to the battery;~~ ~~(b) proper location of the temperature sensor (if applicable); and~~ ~~(c) configuration of temperature compensation set-points (if applicable).~~
15.4.2.3		The installation instructions shall specify the allowed battery grounding configuration(s): ungrounded, or grounded and if so which polarities are required or allowed to be grounded. For a charge controller without galvanic isolation between the input and output, the instructions shall specify the allowed grounding on the input or output such that grounding is only present at one point.
15.4.2.4		Where required by Clause 15.2.2.2.2, the charge controller installation instructions shall comply with the following: a) The instructions shall contain the following or equivalent wording: WARNING: WHEN A GROUND FAULT IS INDICATED, BATTERY TERMINALS AND CONNECTED CIRCUITS MIGHT BE UNGROUNDED AND HAZARDOUS. b) The instructions shall describe the circuit grounding conditions and voltages present on the charge controller output, battery and connected circuits, under both normal and ground fault conditions. c) The instructions shall require battery terminals and other bare live parts of connected circuits to be installed in enclosures or otherwise guarded against inadvertent contact. d) The instructions shall require the installer to apply the additional label of Clause 15.4.1.3 on or adjacent to the battery, in a location where it is visible before removal of guards, opening of a battery enclosure, etc.
15.4.2.5		When required by Clause 15.2.1.2, the installation and operating instructions for a charge controller with controls for the adjustment of the charge algorithm or setpoints shall include a warning statement that adjustment of charging controls should only be done in accordance with the battery manufacturer's recommendations for that specific battery type.
16		**Electric vehicle chargers**
16.1		**Scope**
16.1.1		Clause 16 applies to ~~off-board~~ charging system equipment for recharging the storage batteries in electric vehicles (EV) not already covered by the requirements of CSA C22.2 No. 280. Equipment within the scope of this section is intended for either a) mounting in a location other than the EV; or b) transportation in the EV, but placed outside the EV during operation.
16.1.3		The requirements for devices or systems intended to reduce the risk of electric shock to the user in grounded or isolated circuits for charging electric vehicles are covered in CSA ~~Standard~~ C22.2 No. 281.1 and CSA C22.2 281.2.

Clause	Verdict	Comment
16.2.2		**Supply connections for cord-connected units** The supply cord shall be of a size and rating suitable for ~~wet locations~~ the application, and shall be ~~of~~ type ~~Extra Hard usage~~ G, SEO, SO, STO, SJEO, SJO, SJTO, or W, or a cord that is equally serviceable in accordance with CSA C22.2 No. 49.
16.2.3		**External output connections and wiring**
16.2.3.1		~~The~~ If provided, an output cable ~~and supply conductors~~ shall be of a size and rating suitable for the application and ~~outdoor wet locations~~ shall be of type EV as specified in CSA ~~Standard~~ C22.2 No. 49.
16.2.4		**EV bonding** The output circuit of a unit shall provide a means for bonding the EV during charging~~, unless the charging system is inductively coupled and complies with Clause 16.2.6.~~ ~~**Exception:** This requirement does not apply to an EV that is intended to be inductively coupled to charging system equipment having insulation complying with requirements in Clause 17.2.6.~~
16.2.5		**Output circuit insulation for conductively coupled units**
16.2.5.1		A connector for the output circuit shall have a voltage rating equal to the output rating of the charger and shall comply with the requirements of CAN/CSA Standard-C22.2 No. 282, except that a connector shall a) have a nonstandard pin configuration; b) be polarized; and c) be constructed such that the ~~grounding~~ EV bonding connection is the first to connect and the last to disconnect.
16.2.5.2		Outputs of electric vehicle supply equipment that are provided with a permanently connected output cord and vehicle connector shall include a charging circuit interrupting device/line isolation monitor complying with the requirements of CSA C22.2 No. 281.1 and CSA C22.2 281.2 protecting the corded output. Protection of outputs of electric vehicle supply equipment that are provided via a general use receptacle shall be provided in EV cord sets intended for use with the EVSE.
16.3		**Tests**
16.3.1		**Vibration test**
16.3.1.1		Equipment ~~that may~~ intended to be transported on an EV shall be subjected to a vibration test. After the unit is subjected to the vibration test described in Clause 16.3.1.2, a) the unit shall comply with the requirement in Clause 6.6.11; b) there shall be no loosening of parts; and c) the unit shall operate normally.
16.3.2		**Harmonic distortion test**

Clause	Verdict	Comment
16.3.2.1		A device rated for a harmonic factor (HF) or total harmonic distortion (THD) of the supply current ~~is to~~ shall be tested as described in Clauses 16.3.2.2 and 16.3.2.3. With the device energized at the input voltage and frequency in accordance with Clause 6.1 ~~and 6.2.2~~, HF or THD shall not be more than ~~by~~ 10% higher than the manufacturer's suggested rating made for the device when controlling the intended load.
16.3.2.2		The supply for the test ~~shall~~ is to have a voltage distortion of 0.5% or less. Since the source (supply) voltage will affect the magnitude of the harmonics, for measuring purposes the supply impedance for cord-connected units rated 240 V or less shall be 0.08 Ω or less, and the supply impedance for other units shall be sufficiently low so as not to affect the results of the test.
16.3.2.3		The magnitude of the various harmonics of the supply frequency is to be recorded to the thirty-third (33) harmonic. The harmonic distortion factor is the ratio of the harmonic content to the rms value of the fundamental. The harmonic factor (HF) shall be calculated as follows:  (New)  ~~(Deleted)~~
16.4	Info	**Marking**
16.4.5		The equipment shall be plainly marked, in a permanent manner, in a place where the details will be readily visible after installation, with the following: FOR USE WITH ELECTRIC VEHICLES.
16.4.6		The following caution, or the equivalent, shall be shown at or near the point where the field connections will be made a) "FOR USE WITH COPPER CONDUCTORS ONLY" when intended for connection to copper wire only; b) "FOR USE WITH ALUMINUM CONDUCTORS ONLY" or "FOR USE WITH ALUMINUM OR COPPER-CLAD ALUMINUM CONDUCTORS ONLY" when intended for connection to aluminum wire only; and c) "FOR USE WITH COPPER OR ALUMINUM CONDUCTORS" or "FOR USE WITH COPPER, COPPER-CLAD ALUMINUM, OR ALUMINUM CONDUCTORS" when intended for connection to either copper or aluminum wire.
16.4.7		Devices on or remote from a unit that remains energized during servicing functions shall be marked to indicate that the circuit remains energized while the unit is off.

Clause	Verdict	Comment
16.4.8		If the charging circuit interrupting device includes a manual test device, the unit shall be marked with the following or equivalent: TEST BEFORE EACH USE.
16.4.9		Where applicable, compartments with removable covers shall be marked with the following or equivalent: WARNING: RISK OF ELECTRIC SHOCK. DO NOT REMOVE COVER. NO USER SERVICEABLE PARTS INSIDE.
16.4.10		Capacitors that are accessible during servicing shall be marked with the following or equivalent: WARNING: CAPACITOR CIRCUIT. WAIT 5 MIN AFTER OPENING, THEN SHORT CAPACITORS BEFORE HANDLING.
16.4.11		Cord-connected units provided with provisions for bonding to ground shall be marked with the following or equivalent: WARNING: TO REDUCE THE RISK OF ELECTRIC SHOCK. CONNECT ONLY TO PROPERLY GROUNDED OUTLETS.
16.4.12		Electric vehicle supply equipment shall be marked with the following or equivalent: WARNING: HAVE DEFECTIVE CORDS OR WIRES REPLACED BY QUALIFIED SERVICE PERSONNEL.
16.4.13		Unless suitable for use outdoors, portable units shall be marked with the following or equivalent: WARNING: I NDOOR USE ONLY.
16.4.14		Electric vehicle supply equipment shall be marked with the following or equivalent: WARNING: DO NOT USE THIS EQUIPMENT IF DAMAGED.
16.4.15		Where applicable, electric vehicle supply equipment shall be marked with the following or equivalent: WARNING: DO NOT USE EQUIPMENT WHERE EXPOSED TO FLAMMABLE VAPOURS.
16.4.16		Cord connected units shall be marked with the following or the equivalent: CAUTION: REFER TO MANUFACTURER'S INSTRUCTIONS FOR DETERMINING THE SUITABILITY OF PLUGGING THIS EQUIPMENT INTO GFCI PROTECTED RECEPTACLES.
16.4.17		Cord connected units shall be marked with the following or the equivalent: CAUTION: DO NOT PLUG INTO EXTENSION CORD.
16.5.1		**Important safety instructions** The following information ~~described in Items (a) to (d), as appropriate,~~ shall be provided for a unit under the heading "IMPORTANT SAFETY INSTRUCTIONS". ~~The information contained in Items (c) and (d) may be marked on the unit in lieu of providing it in the instruction manual.~~ SAVE THESE INSTRUCTIONS — This manual contains important instructions for Models (_____) (*blank space is to be filled in with appropriate model numbers*) that should be followed during maintenance of the unit.) **Note:** *If the instructions are exactly the same for all models, specific model numbers*

Clause	Verdict	Comment
		need not be specified. ~~(b) In accordance with Clause 4.5.3, if pressure terminal connectors or the fastening hardware are not provided on the unit as shipped, the instruction manual shall indicate which pressure terminal connector or component terminal assemblies are for use with the unit.~~ ~~(c) With reference to Item (b), the terminal assembly packages and the instruction manual shall include information identifying wire size and the manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product may be identified.~~ ~~(d) If a pressure terminal connector provided in the unit (or in a terminal assembly covered in Clause 4.5.3(e)) for a field installed conductor requires the use of other than an ordinary tool for securing the conductor, identification of the tool and any necessary instructions for using the tool shall be included in the instruction manual.~~
17		**PV modules with integrated power conversion equipment (PVIPCE)**
17.1		**Scope**
17.1.1		Clause 17 applies to photovoltaic modules with dc-ac or dc-dc PCE's that are a) integrated within the PV module encapsulation; b) permanently attached to the PV module backsheet; or c) mounted to the frame of the PV module and are evaluated as a combination.
17.1.2		The evaluation and testing of the PVIPCE shall follow the flowchart in Figure 14. The PV module construction shall comply with the relevant PV module standards of the *Canadian Electrical Code, Part II*. The PCE subassembly shall comply with the construction and testing requirements of this Clause and all other applicable Clauses of this Standard. The combination of PV module and PCE shall comply with the testing requirements of this Clause.
17.2		**Construction**
17.2.1		**General**
17.2.1.1		The physical assembly and/or electrical connection of the PCE to the module may be completed in the factory or in the field. If intended for field assembly, the following requirements shall apply: a) The individual parts shall be evaluated together as an assembly. b) The individual parts shall be identified and marked as an assembly. c) The installation instructions shall include directions on how to assemble and connect the parts and wiring system(s). d) Pluggable connections shall be provided for all field assembled connections. The connections shall i) ensure that the grounding and bonding connections, if required, are made automatically as part of the same pluggable connection containing the supply circuit(s) involved; the ground connection shall be the first to make contact and the last to break contact; ii) maintain the required environmental enclosure type rating of the PCE in accordance with Clause 4.2.7.1;

Clause	Verdict	Comment
		iii) require a tool to separate the connector, if used in a circuit over 30 V; and iv) be rated for the maximum rated conditions of use. e) The mechanical attachment method shall be evaluated for field assembly. f) All required parts and materials to assemble the PVIPCE must be provided and the installation instructions shall contain the information in Clause 17.4.3.1. g) Any required specialized tools must be readily available to the installer and listed in the installation instructions in accordance with Clause 17.4.3.1. h) Mounting secureness and compliance with the required environmental enclosure type rating of the PCE shall not rely on field application of materials such as adhesives or sealing compounds.
17.2.1.2		The wiring and connections between the PV module and the PCE PV input shall be mechanically protected against damage during installation and operation. Mechanical protection shall be considered adequate if a) wiring is internal to the module, an enclosure or raceway; or b) double insulated PV style wiring is used, and the wiring is i) routed and mechanically secured in a manner that minimizes the risk of physical damage to the wiring; and ii) is not causing stress on connections or wiring insulation due to sharp bend radius.
17.2.1.3		All components and materials of the PCE that are relied on for compliance with this Standard shall have a temperature rating not less than the actual temperature the component or material reaches under normal worst case conditions, taking into account the ambient and surface temperatures expected on the part of the PV module to which the PCE is attached, and shall comply with the temperature test of Clause 17.3.9. In no case shall the components and materials in contact with the PV module backsheet be rated less than 90 °C.
17.2.2		**PCE input voltage rating** The PCE input circuit voltage rating shall be not less than the maximum PV module open circuit voltage calculated by adjusting the rated (under standard test conditions) open circuit voltage for the worst case temperature across the full rated temperature range of the PVIPCE, in accordance with the PV module manufacturer's stated temperature coefficient.
17.2.3		**Disconnecting means** A means to disconnect, such as a terminal or connector, shall be provided for each output and input intended to be wired or connected in the field.
17.2.4		**PV ground fault detection/interruption** The ground fault detection/interruption requirements of Clause 13.3.4 do not apply to PVIPCE input circuits complying with Clause 17.2.1.2 a) or if the input connection is constructed in accordance with Clause 17.2.1.2 b) and implements the following additional requirements: a) All conductors shall be tested for deflection in accordance with Clause 17.3.4. b) If connectors are used, they shall be a locking type, require a tool to be opened, and include the requirements of Clause 17.4.3.2 in the installation instructions.
17.2.5		**Backfeed protection**

Clause	Verdict	Comment
17.2.5.1		For a PVIPCE, over-current protection shall be built into the unit for protection against backfeed to the photovoltaic module if the backfeed current rating of the PCE, measured in accordance with Clause 17.3.2.7, exceeds the reverse current rating of the PV module tested in accordance with test MST 26 of CAN/CSA-C22.2 No. 61730-2.
17.2.5.2		The overcurrent protection built into the unit to comply with Clause 17.2.5.1 shall be sized with a current rating smaller than or equal to the maximum over-current protection rating of the PV module as defined in CAN/CSA-C22.2 No. 61730-2.
17.2.6		**Input circuit voltage** The PCE input circuit shall be capable of operating safely at a voltage not less than the maximum PV module open circuit voltage calculated by adjusting the rated (under standard test conditions) open circuit voltage of the module for the worst case temperature across the full rated temperature range of the PVIPCE, in accordance with the PV module manufacturer's stated temperature coefficient.
17.3		**Tests**
17.3.1		**PV module component tests** Photovoltaic modules used with integrated power converters shall be tested or approved in accordance with CAN/CSA-C22.2 No. 61730-2 with the intended PCE enclosures in place but with the PCE active circuit bypassed or removed. Frame mounted PCE enclosures are not required to be in place during the CAN/CSA-C22.2 No. 61730-2 testing unless it impacts the outcome of the test. **Note:** *Provisions may be needed for making connection to the dc output of the PV module for some of the tests of CAN/CSA-C22.2 No. 61730-2.*
17.3.2		**PCE component tests**
17.3.2.1		**General** Unless otherwise stated below, PCE used in PVIPCE shall be tested or approved in accordance with the general Clauses (1 to 6) and application-specific Clauses (10, 13, 14, and 15) of this Standard, as applicable. The PCE shall be integrated with the module, in the intended manner, for any test for which the presence of the module can impact the outcome of the test.
17.3.2.2		**Output rating** The maximum output rating test of Clause 6.2 shall be performed with the PCE powered with a source having the electrical characteristics corresponding to the PVIPCE module operating at the lowest temperature rating with an irradiance of 1200 W/m2.
17.3.2.3		**Dielectric strength test** PCE inputs that are totally enclosed or complying with the requirement of Clause 17.2.1.2 are not required be submitted to Clause 6.5.1 b).
17.3.2.4		**DC input reverse polarity test** The dc input reverse polarity test in Clause 13.4.2 is not required for PVIPCE with no provisions for field connection of the dc input wiring between the PV module and the PCE.

Clause	Verdict	Comment
17.3.2.5		**Charge controller miswiring tests** The charge controller miswiring tests of Clause 15.3.6.3, Items c), d), e), and f) are not required for PVIPCE with no provisions for field connection of the dc input wiring between the PV module and the PCE.
17.3.2.6		**Reverse polarity test** Notwithstanding Clause 15.3.6.3, only those connections that are intended for field wiring shall be tested for reversed polarity and connection sequence.
17.3.2.7		**Maximum backfeed current test** The maximum backfeed current that can flow into the photovoltaic input circuit as a result of a faulted component in the PCE, or a single fault in the field connected wiring, shall be measured. Testing shall be conducted on the PCE under the conditions of Clause 14.3.1, with faults applied in the PCE or on the wiring of the field connected components. During each fault condition, the RMS value of the backfeed current shall be measured using a 1 min RMS calculation window, starting 10 s after application of the fault, and continuing until the backfeed current drops to zero or stabilizes at a value. The maximum backfeed current shall be considered to be a) zero if the current is zero after the first minute; or b) the maximum 1 min RMS value observed during the test (excluding the first 10 s) if the current is not zero after the first minute. During this test the lowest ampacity conductors intended to be used to connect the dc input of the PCE to the module shall be used. In addition to establishing the backfeed current value in accordance with Clause 17.2.5.1, this test shall be performed in accordance with the test duration and pass/fail criteria in Clause 6.6 for an abnormal test.
17.3.3		**Combined PVIPCE — Sequence of tests**
17.3.3.1		The complete assembly of the photovoltaic module and the integrated power converter shall be subjected to the test in Clause 17.3.4, and in sequence to the tests in CAN/CSA-C22.2 No. 61730-2 using Figure 14 of this Standard as a replacement of Figure 1 of CAN/CSA-C22.2 No. 61730-2.
17.3.3.2		For a PVIPCE where the PCE is mounted on the frame of a PV module, without contact with the backsheet, for those specific tests for which the outcome would not be affected by the presence of a PV module, the PCE may be tested without the PV module.
17.3.4		**Conductor deflection test** When pulled or pushed with a force of 2.5 N, none of the cables shall deflect to an extent that allows contact with metal parts or bonding or grounding conductors, including parts of the PVIPCE and parts of the installation such as array racking, a metal roof, etc. when installed in accordance with the provided installation instructions.
17.3.5		**Functional test**

Clause	Verdict	Comment
17.3.5.1		**General** The functional test described in Clauses 17.3.5.2 and 17.3.5.3 applies to complete module and power converter assemblies tested in accordance with Figure 14. This test shall be performed at the beginning of the sequence in Figure 14, and again at the end of the sequence.
17.3.5.2		**Test conditions** The test conditions shall be as follows: a) The unit shall be connected as recommended by the manufacturer. b) The output circuit of the unit shall be connected to the necessary apparatus to measure its output power. c) A load, utility or simulated utility shall be connected to the output of the PCE. d) The unit shall be exposed with a radiant source (natural sunlight or a steady-state solar simulator class B or better in accordance with IEC 60904-9) at an intensity of 500 W/m2 to 1100 W/m2 in the plane of the solar module. e) Mounting arrangement, load, irradiance and cell temperature shall be the same for the initial test as well as for all repeats of the functional test. f) The output power of the unit shall be measured when it has reached its steady-state operation. **Note:** *Cell temperature may be measured on the back sheet in the middle of a single cell around the center of the module. The same cell should be measured for all tests.*
17.3.5.3		**Pass criteria** When first performed, this functional test shall establish a baseline. Subsequent repetitions of the functional test may be acceptable when the unit delivers an output power level within 10% of the initial functional test.
17.3.6		**Simplified functional test for frame mounted PCE**
17.3.6.1		**General** As an alternative to the functional test in Clause 17.3.5, PCE intended to be mounted on a PV module frame, without contact with the backsheet of the PV module, and tested in accordance with Figure 14, may use the simplified functional test in Clauses 17.3.6.2 and 17.3.6.3. This test shall be performed at the beginning of the sequence in Figure 14 and again at the end of the sequence.
17.3.6.2		**Test conditions** The test conditions shall be as follows: a) The unit shall be connected as recommended by the manufacturer. b) The output circuit of the unit shall be connected to the necessary apparatus to measure its output power. c) A load, utility or simulated utility shall be connected to the output of the PCE. d) The PCE shall be operated at an output level of at least 50%. e) Output level, input power settings and PCE temperature shall be the same for the initial test as well as for all repeats of the functional test. f) The output power of the unit shall be measured when it has reached its steady-state operation.

Clause	Verdict	Comment
17.3.6.3		**Pass criteria** When first performed, this functional test shall establish a baseline. Subsequent repetitions of the functional test may be acceptable when the unit delivers an output power level within 10% of the initial functional test.
17.3.7	Info	**Accessibility test**
17.3.7.1	Info	**General**
17.3.7.1.1		The requirements of Clause 17.3.7 supplement and amend the requirements of Clause ~~2 to 6~~ 10.2 of CAN/CSA-C22.2 No. 61730-2.
17.3.7.1.2		The requirements of Clause 17.3.7 apply to the complete assembly of module and PCE.
17.3.7.2		**Test conditions** The probe test procedure described in Clause 10.2.3 of CAN/CSA-C22.2 No. 61730-2 shall be performed for all parts of the combined PVIPCE. In addition, the articulated probe test of Clause 4.2.5 of this Standard shall be applied to all parts of the PCE.
17.3.8	Info	**Hot spot test**
17.3.8.1	Info	**General**
17.3.8.1.1		The requirements of Clause 17.3.8 supplement and amend the requirements of CAN/CSA-C61215 or Clause ~~2 to 6~~ 10.9 of CAN/CSA-IEC 61646.
17.3.8.1.2		The requirements of Clause 17.3.8 apply to all PVIPCE unless it is demonstrated that the PCE is not affecting the temperature of the backsheet by more than 5 °C.
17.3.8.1.3		For a module that has already been tested in accordance with CAN/CSA-C22.2 No. 61730-2 or CAN/CSA-C61215 or CAN/CSA-IEC 61646, only those cells opposite the PCE shall be tested in accordance with Clause 17.3.8.3 of this Standard.
17.3.8.2		**Test conditions** In addition to the requirement of CAN/CSA-C61215 or Clause 10.9 of CAN/CSA-IEC 61646, the following apparatus shall be used: a) A PVIPCE providing separate access to the dc output circuit of the PV module and to the dc input circuit of PCE: i) If ports need to be added, they shall be added in an area of the PVIPCE that will not influence the results of this test. ii) The dc output circuit of the PV module will be used for PV module tests. iii) The dc input of the PCE will be connected to the dc output circuit of the PV module during the hot-spot test of the cell(s) opposite the PCE. b) A load, a utility or a simulated utility shall be connected to the output of the PCE and shall be set to ensure the PVIPCE can deliver its maximum continuous available power. c) Shaded cells for the PVIPCE combination: i) For crystalline silicon, the cell chosen to be shaded shall be a cell which is located fully or partially opposite the PCE. If more than one cell is opposite the PCE, the test shall be repeated for each cell one at a time. ii) For thin-film, the active cell(s) that are directly opposite the PCE with an additional 25 mm margin shall be shaded with an opaque cover. The same area shall

Clause	Verdict	Comment
		be maintained for the entire duration of the test (no adjustment of the shaded area).
17.3.8.3		**Hot spot test sequence** The test of MST 22 as specified in CAN/CSA-C22.2 No. 61730-2 shall be performed with the following modifications: a) The module performance test of CAN/CSA-C22.2 No. 61730-2 shall be performed with the dc output circuit of the PV module disconnected from the dc input of the PCE. b) The hot-spot test on the PV module alone shall be performed with the dc output circuit of the PV module shorted and the PCE non activated. The shading shall be determined in accordance with CAN/CSA-C61215 or Clause 10.9 of CAN/CSA-IEC 61646. c) The hot-spot test on the cell(s) opposite the PCE shall be performed with the dc output circuit of the PV module connected with the dc input of the PCE and the PCE output loaded. The shading shall be applied in accordance with Clause 17.3.8.2 c) of this Standard. d) The dielectric strength verification test shall be performed on the dc output circuit of the PV module when disconnected from the dc input of the PCE. e) The wet leakage verification test shall be performed on the dc output circuit of the PV module when disconnected from the dc input of the PCE f) During the execution of the wet leakage test in accordance with CAN/CSA-C22.2 No. 61730-2 MST 17, the cable entries of the extra ports added for providing access to the dc output circuit of the PV module and to the dc input circuit of the PCE shall be kept dry.
17.3.9	Info	**Temperature test**
17.3.9.1		**General** The temperature tests in Clauses 6.3.1 to 6.3.4 shall be replaced by the following: a) PVIPCE shall be subjected to the temperature test of Clause 17.3.10 using either one of the following test assemblies: The complete assembly as described in Clause 17.3.9.2 that makes use of the complete PVIPCE; or b) The simulated PVIPCE as described in Clause 17.3.9.3 that uses a smaller modified version of the PVIPCE. **Note:** *An example of the test assembly is illustrated in Figure 15.*
17.3.9.2		**Complete PVIPCE test assembly** The test assembly shall consist of a) the actual PV module used for the PVIPCE; b) a PCE mounted to the PV module as follows: i) the input is not wired to the PV module output but provides access for connection to an external source of supply; and ii) the PCE is located and mechanically attached to PV module in the intended production manner; and c) a controllable heat source added to the glass side of the PV module capable of heating either:

Clause	Verdict	Comment
		i) the whole surface that would normally be exposed to the sun; or ii) an area not less than twice the projected area of the PCE onto the surface of the module, located so as to cover the whole projected area of the PCE and extending beyond all sides of the PCE without extending past the boundary of the PVIPCE. **Note:** *An example of heating pad arrangement for different PCE mounting locations is illustrated in Figure 16.*
17.3.9.3		**Simulated PVIPCE test assembly** The simulated PVIPCE test assembly shall consist of the elements in Clause 17.3.9.2, except as follows: a) instead of using the actual PV module used for the PVIPCE, as in Clause 17.3.9.2 a), a smaller size PV module or portion of a module, or simulated PV module may be used. The module or simulated module shall consist of i) a cut out portion of the PV module normally forming part of the PVIPCE; ii) a smaller size PV module using the same laminate; or iii) an equivalent laminate and frame constructed with materials having similar emissivity and thermal conduction as the module forming part of the PVIPCE. If the module, portion of a module, or simulated module used is smaller than the module that is used in the production PVIPCE, the simulated PV fixture shall have an area not less than twice the projected area of the PCE onto the surface of the PVIPCE. b) The PCE shall be located and mechanically attached to the simulated PV fixture in a manner representative of the intended production manner with respect to thermal transfer and emissivity.
17.3.10	Info	**Temperature test procedure**
17.3.10.1		**General** The PVIPCE shall be tested in accordance with the tests in Clauses 17.3.10.2 to 17.3.10.4.
17.3.10.2		**Test conditions** The test conditions shall be as follows: a) The normal operating cell temperature (NOCT) of the PV module forming part of the PVIPCE shall be established in accordance with Clause 10.5 of CAN/CSA-C61215. b) The cell temperature associated with the test ambient temperature shall be calculated as *Tcell* = *Tamb* + 1200/800 (*NOCT* – 20) where *Tamb* is the rated ambient air temperature of the PVIPCE defined in Clause 17.4.3.3 a) or 40° whichever is greater. **Note:** *NOCT is determined at 800 W/m2 at an ambient temperature of 20 °C. The above adjusts this for more realistic worst-case irradiance to ensure maximum temperatures.* c) The unit shall be tested in a temperature controlled chamber. d) The device under test shall not be subjected to air movement in excess of 1 m/s resulting from the test apparatus operation. If tested in an air circulation chamber, the PCE shall be shielded from direct air movement from the chamber fans. e) The power output of the heat source in Item c) shall be adjusted for the

Clause	Verdict	Comment
		temperature of the backsheet to stabilize at the cell temperature –0 °C/+5 °C calculated in Item b). f) The unit shall be connected as recommended by the manufacturer and energized from a power source adjusted to provide the output power available from the intended photovoltaic module at an irradiance of 1200 W/m2 and at the calculated cell temperature, within a tolerance of – 0%/+5%. g) A load, a utility or a simulated utility shall be connected to the output of the PCE and shall be set to ensure the PVIPCE can deliver its maximum continuous available power. h) The chamber temperature shall be regulated to maintain the air temperature behind the module to +/–5 °C in accordance with the manufacturer's specified behind the module air temperature rating of Clause 17.4.3.3 b). The temperature of the air space behind the module shall be measured i) 25 to 35 mm from the perimeter of the PCE measured parallel to the plane of the module; ii) away of heat exhaust from the PCE; and iii) 50 to 60 mm from the backsheet measured perpendicular to the plane of the module. The difference between the maximum rated air temperature and the measured air temperature behind the module shall be subtracted from or added to the measured temperatures used for pass/fail criteria of the PVIPCE. i) If the conditions in Items c) to h) result in less than the PCE maximum output, an additional test shall be performed in order to maximize the power by reducing the ambient temperature as follows: i) The cell temperature that would provide the current voltage characteristics necessary for the PCE to deliver its maximum power shall be established. ii) The associated ambient air temperature shall be calculated using the following equation: *Tamb* = *Tcell* + 1200/800 (*NOCT* – 20) **Note:** *NOCT is determined at 800 W/m2 at an ambient temperature of 20 °C. The above adjusts this for more realistic worst-case irradiance to ensure maximum temperatures.* iii) If the ambient temperature calculated in Item ii) is lower than 25 °C, 25 °C shall be used. iv) The test described in Items b) to h) shall be performed based on the ambient temperature established in Item iii).
17.3.10.3		**Test procedure** The PVIPCE shall be tested in accordance with CAN/CSA-C22.2 No. 61730-2, Clause 10.7.3. The temperature measurement points shall include all applicable points listed in Table 9 of CAN/CSA-C22.2 No. 61730-2 and Tables 9 and 10 of this Standard. **17.3.10.4 Pass/fail criteria** The pass/fail criteria shall be as follows: a) No measured temperatures shall exceed any of the temperature limits of surfaces, materials, or components, as described in Table 9 of CAN/CSA-C22.2 No.

Clause	Verdict	Comment
		61730-2 and Table 9 of this Standard. b) No measured surface temperature shall exceed Table 10 of this Standard unless the instructions contains the warning in Clause 17.4.3.5. c) There shall be no creeping, distortion, sagging, charring or similar damage to any part of the module, as indicated in Clause 10.1 of CAN/CSA-C22.2 No. 61730-2, MST 01.
17.3.11		**Wet leakage current test**
17.3.11.1		**General** Frame mounted PCE may be tested without the PV module.
17.3.11.2		**Test conditions** Pre-conditioning shall be performed in accordance with CAN/CSA-C22.2 No. 61730-2, MST17.
17.3.11.3		**Test procedure** A PVIPCE with non-metallic enclosure PCE shall be tested using the procedure described in CAN/CSA-C22.2 No. 61730-2, MST 17. For a PVIPCE with an enclosure that is wholly or partly metallic, the 500 V insulation resistance test of MST 17 may be replaced with the dielectric withstand test of Clause 6.5 of this Standard. he depth of the solution shall be sufficient to cover all surfaces except junction box entries and PCE entries not designed for immersion.
17.4	Info	**Marking**
17.4.1		**General** Unless otherwise stated in Clause 17.4, PVIPCE shall be marked in accordance with Clause 5 and other applicable Clauses of this Standard.
17.4.2	Info	**Product markings**
17.4.2.1		Notwithstanding Clauses in other sections of this Standard that require markings to be visible after installation, markings on PVIPCE may be applied on the backsheet or frame of the photovoltaic module where visible after integration of the PCE, before mounting the PVIPCE in the final installation.
17.4.2.2		Notwithstanding Clause 13.5.1.2, a PVIPCE without provision for dc input field connections, or with provision for dc input field wiring provisions complying with Clause 17.2.1.1 shall not be required to have the markings in Items a) to d) of Clause 13.5.1.2 for those inputs complying with Clause 17.2.1.1.
17.4.2.3		PVIPCE shall be marked for their minimum and maximum allowable ambient air temperature.
17.4.2.4		A PVIPCE shall be marked with a) or b) as applicable: a) A PVIPCE with sc output shall be marked with the following: AC MODULE. b) All other devices shall be marked with the following, or the equivalent: THIS MODULE CONTAINS INTEGRATED ELECTRONICS.
17.4.2.5		A PVIPCE shall be marked with the wording “REFER TO INSTALLATION INSTRUCTIONS” or the equivalent, or with the ISO 7000-1641 symbol (see Figure 17).

Clause	Verdict	Comment
17.4.2.6		A PVIPCE without provision for dc input field connections, or with provision for dc input field wiring provisions complying with Clause 17.2.1.1 shall not be required to have the markings in Clauses 10.4.3, 13.5.2.4, 14.4.1.2, and 15.4.1.2 for those inputs complying with Clause 17.2.1.1.
17.4.3	Info	**Instruction manuals**
17.4.3.1		For a PVIPCE requiring field mounting or connection, as required by Clause 17.2.1.1 f), the installation instructions shall include directions on how to assemble and connect the parts and wiring system(s), a list of the required parts, materials, and any specialized tools required to perform the field assembly process, and a list of the PV modules which the PCE is intended to be integrated with.
17.4.3.2		A PVIPCE that is not provided with PV ground fault protection, and is provided with connectors for field assembly of the PV input, shall include the following warning in the installation instructions when describing the connection of such inputs: WARNING: PV GROUND FAULT PROTECTION NOT PROVIDED. CONNECT ONLY TO THE INTENDED PV MODULE, USING THE PROVIDED AND UNMODIFIED PARTS, WIRING, AND MATERIALS.
17.4.3.3		The instruction manual shall include a) minimum and maximum ambient air temperature rating; b) temperature rating of the air space behind the module used for the test in Clause 17.3.9; c) mounting height, including minimum distance between the backsheet and any surface behind the module or the PCE; and d) mounting clearances, restrictions against obstructing air circulation, etc. if required to comply with this Standard.
17.4.3.4		For a PVIPCE with dc output, the installation and operating instructions shall specify the intended purpose of the PVIPCE output. **Note:** *The intent is to identify the intended application(s) for the output of the PCE, such as battery charging, connection to a particular type of downstream power converter, etc.*
17.4.3.5		For a PVIPCE which has surfaces that exceed the limits in Table 10 during the temperature test of Clause 17.3.9, the installation and operating manuals shall contain the following or equivalent wording: WARNING: HOT SURFACE(S). A list or illustration specifying which surfaces are referred to shall also be included. The marking of Clause 5.46 is not required. **Note:** *This exception to Clauses 6.3.8 and 5.46 is allowed for PVIPCE because a "HOT SURFACE" warning label cannot be mounted on the front of a PV module for operational reasons and will not be visible after installation it if is located on the back of the PVIPCE.*
18	Info	**Inverters for use in vehicles** **Note:** *These requirements were formerly published as CSA TIL No. I-35.*

Clause	Verdict	Comment
18.1		**Scope** This Clause applies to inverters that receive power from a battery supply in a vehicle other than a recreational vehicle as covered by Clause 8. Inverters covered by this Clause receive their dc input power from a plug connected to a 12 V cigarette lighter socket or 12 V power outlet, or from a hardwired connection to the vehicle battery supply if the inverter is permanently mounted in the vehicle.
18.2	Info	**Construction**
18.2.1		Portable inverters for use in vehicles shall have no openings except for those that comply with Clause 4.2.5.7 d). Inverters intended for permanent installation may have openings other than those that comply with Clause 4.2.5.7 d) if they are not openings in the bottom of the enclosure in accordance with Clauses 4.2.5.5 and 4.2.5.6, and if the orientation for mounting the inverter is shown in the installation manual in accordance with Clause 18.3.1.
18.2.2		Inverters intended for permanent mounting in a vehicle shall be provided with permanent mounting means. Portable inverters intended for use in vehicles may be provided with a permanent mounting means.
18.2.3		The polymeric enclosure of a cigarette lighter connector shall comply with the vertical burning test of CAN/CSA-C22.2 No. 0.17 for a flammability classification of at least V-2, and the corresponding hot-wire ignition (HWI) rating and high-current arc ignition (HAI) rating as shown in Table 21.
18.2.4		The cord of an inverter provided with a cigarette lighter connector shall be not less than 0.9 m when measured from the tip of the connector to the point of entry or attachment to the inverter. The power input cord may be of the two or more parallel conductor type or jacketed cord type. The power input cord shall be No. 18 AWG or larger, and shall be one of the following: a) a cord complying with the requirements of Clause 18.2.5 if the rated input voltage of the inverter is 42.4 V dc or less; or b) a type i) as shown in Table 12 of the *Canadian Electrical Code, Part I*; ii) has a serviceability rating of at least Type SV; and iii) is not listed as “equipment wire”.
18.2.5		For compliance with the requirements of Clause 18.2.4 a), the power input cord of an inverter with a cigarette lighter input having a rated input voltage of 42.4 V dc or less shall have the following minimum insulation thickness: a) 0.8 mm for thermoplastic; b) 1.2 mm (total thickness) for oil-resistant rubber or neoprene; or c) 1.6 mm (total thickness) for rubber or neoprene.
18.2.6		The allowable ampacity of the power input cord of an inverter with a cigarette lighter shall be in accordance with Table 12 of the *Canadian Electrical Code, Part I* or Table 22 of this Standard, whichever is greater.

Clause	Verdict	Comment
18.2.7		A terminal block for the field connection of a dc input cord or input conductors for an inverter intended for use in a vehicle shall be protected in a fire enclosure, unless it is a type that provides protection against short circuiting of the dc supply and short circuiting to the chassis (e.g., projecting strands).
18.2.8		An input overcurrent protective device shall be provided in or adjacent to the cigarette lighter connector. It shall be connected in the positive side of the dc supply circuit and it shall be rated not more than 12 A. The current rating of the overcurrent protective device shall not exceed the ampacity of the interconnecting cord, as specified in Clause 18.2.6, except that if the ampacity value is not equal to a standard overcurrent device rating, the next largest overcurrent device may be used.
18.2.9		An input overcurrent protective device, not located within the cigarette lighter connector, shall be located not more than 125 mm from the point of entry of the cable into the cigarette lighter connector.
18.2.10		The manufacturer may provide instructions to remove the cigarette lighter connector and make the input of the inverter permanently connected in accordance with Clause 18.2.11.
18.2.11		For inverters intended to be permanently installed in a vehicle, the overcurrent protection for the dc input wiring shall be located as closely as practical to the dc supply end of the input wiring and shall be connected in the positive side of the dc supply circuit. The rating of an overcurrent protective device shall not exceed the ampacity of the input conductors in accordance with Clause 18.2.12.
18.2.12		An inverter intended to be used in a vehicle not supplied with a dc input overcurrent protective device, shall be provided with an instruction manual in accordance with Clause 18.3.2 a) stating the type and rating of the overcurrent protective device to be used and instructions to install the device as closely as practical to other dc supply end of the input wiring. An inverter not supplied with dc input wiring shall be provided with an instruction manual stating the size, ratings and type of an overcurrent protective device to be used.
18.2.13		Spacings for an inverter intended for use in a vehicle shall comply with the spacings requirements for “other than a controlled environment” unless a micro environment equivalent to a controlled environment is provided inside the equipment by one of the means as shown in the Note of Clause 4.16.2. The spacings of the dc input circuit and to circuits derived from the dc input circuit, including the ac output circuit, shall comply with the spacings requirements for secondary circuits.
18.2.14		For an inverter intended for use in a vehicle protection shall be provided to prevent a shock hazard as a result of accessible non-current-carrying conductive parts of the inverter or its load from becoming energized in the event of a fault. The protection may be achieved by means of grounding and bonding, insulation, isolation, limitation of leakage current, or a combination of these means, as specified in Clauses 18.2.15 to 18.2.17.

Clause	Verdict	Comment
18.2.15		Accessible non-current-carrying conductive parts of an inverter shall be prevented from becoming live by one of the following means: a) The accessible non-current-carrying conductive part shall be bonded to the dc input negative circuit. b) The accessible non-current-carrying conductive part shall be separated from all live parts by double or reinforced insulation in accordance with CSA C22.2 No. 60950-1, and if an ac output ground is provided, it shall not be connected to the inverter chassis unless the chassis is also bonded to the dc input negative circuit. c) Isolation shall be provided to limit the leakage current available from live parts to the dc negative terminal to 5 mA or less, when measured in accordance with Clause 18.4.6 a).
18.2.16		Accessible non-current-carrying conductive parts of the user-load equipment shall be prevented from becoming energized by one of the following means: a) The inverter shall provide an ac output ground that is bonded to the dc input negative circuit. b) The ac output line and neutral shall be isolated from the dc power input and from accessible non-current-carrying conductive parts of the inverter. The leakage current from the ac output to the dc input and the chassis of the inverter shall not exceed 5 mA when measured in accordance with Clause 18.4.6 a). c) The ac output of the inverter shall be provided with a ground-fault circuit interrupter or other circuit that reduces the output to 30 V rms or 42.4 V peak, or less when the ac output current imbalance exceeding 5 mA is detected. d) The output voltage of the inverter shall be reduced to non-hazardous levels when a fault is applied from any ungrounded output conductor to the ac output ground, as specified in Clause 18.4.6 b). e) The ac output neutral (identified) conductor shall be bonded to the ac output ground and the overcurrent protection specified Clause 4.21 shall be provided and shall function in the event of a ground fault in the user's load equipment.
18.2.17		The neutral (identified) conductor of the ac output circuit of an inverter provided with an ac output ground shall be bonded to the ac output ground, unless one of the following conditions is met: a) Isolation is provided to limit the leakage current from the ac output neutral to the ac output ground and the dc negative, to 5 mA, when subjected to the leakage current test of Clause 18.4.6 a). b) The output is provided with a ground-fault circuit interrupter, or other protective circuit that reduces the output to 30 V rms or 42.4 V peak, or less when the ac output current imbalance exceeding 5 mA is detected. c) The output voltage of the inverter shall be reduced to non-hazardous levels when subjected to the short circuit test of Clause 18.4.6 b).

Clause	Verdict	Comment
18.2.18		An ac output receptacle on an inverter intended for use in a vehicle having the configuration as shown in Diagram 1 of the *Canadian Electrical Code, Part I* shall be of the correct type for the nominal ac output voltage and current ratings of the inverter.
18.2.19		As an alternate to requirements of Clause 18.2.18, the ac output receptacle may be a non-standard configuration if it is polarized or no hazard is introduced by a reversed or incorrect connection.
18.2.20		As an alternative to the ac output receptacle connection described in Clauses 18.2.18 and 18.2.19, the output of an inverter may be provided with means for permanent connection, in accordance with Clause 4.4.1. The inverter shall also have provision for permanent connection of the dc input and for permanent mounting. The neutral (identified) conductor of the ac output circuit shall be bonded to the ac output ground unless the condition in Clause 18.2.17 a) or b) is met.
18.3	Info	**Markings**
18.3.1		An inverter intended for permanent mounting in a vehicle shall be provided with mounting instructions. The instructions shall include details of the intended mounting method and location and as applicable the correct mounting orientation.
18.3.2		An inverter intended for permanent connection shall be provided with wiring instructions and the following requirements: a) the type, location, and connection method for the dc input fuse as applicable; and b) the recommended methods and materials for connection to the vehicle's battery system, including the size, ratings, and type of dc input wiring to be used and the ratings of any other components or materials not provided with the inverter.
18.3.3		Where required by Clause 18.4.2 b) i), an inverter shall be marked with the following: "CAUTION: OUTPUT NON-SINUSOIDAL. REFER TO MANUAL" or equivalent, and the operating instructions shall list those types of equipment for which the inverter waveform is not suitable, and caution the user of the type of damage that can be expected.
18.3.4		For an inverter with an output rating exceeding 100 VA, the instruction for use shall include the following or equally definitive wording. The blanks shall be completed with the appropriate current and voltage ratings based on the adapter input ratings. WARNING: RISK OF FIRE. DO NOT REPLACE ANY VEHICLE FUSE WITH A RATING HIGHER THAN RECOMMENDED BY THE VEHICLE MANUFACTURER. THIS PRODUCT IS RATED TO DRAW AMPERES FROM A V VEHICLE OUTLET. ENSURE THAT THE ELECTRICAL SYSTEM IN YOUR VEHICLE CAN SUPPLY THIS PRODUCT WITHOUT CAUSING THE VEHICLE FUSING TO OPEN. THIS CAN BE DETERMINED BY MAKING SURE THE FUSE IN THE VEHICLE WHICH PROTECTS THE OUTLET IS RATED HIGHER THAN AMPERES. INFORMATION ON THE VEHICLE FUSE RATINGS ARE TYPICALLY FOUND IN THE VEHICLE OPERATOR'S MANUAL. IF A VEHICLE FUSE OPENS REPEATEDLY, DO NOT KEEP ON REPLACING IT. THE CAUSE OF THE OVERLOAD MUST

Clause	Verdict	Comment
		BE FOUND. ON NO ACCOUNT SHOULD FUSES BE PATCHED UP WITH TIN FOIL OR WIRE AS THIS MAY CAUSE SERIOUS DAMAGE ELSEWHERE IN THE ELECTRICAL CIRCUIT OR CAUSE FIRE.
18.4		**Tests**
18.4.1		An inverter intended for use in a vehicle shall be subjected to the applicable tests as specified in Clauses 18.4.2 to 18.4.6.
18.4.2		The following tests shall be performed in addition to the applicable Clauses of 1 to 6: a) abnormal — Rated load blanketing (open bench) — Clause 8.4.6.2; b) harmonic distortion — Clause 10.5.2. An inverter shall comply with the requirements of Clause 10.5.2, except that if it is evaluated to Clause 10.5.2.5 and is not suitable for use with specific types of loads, it may still be considered to comply with the harmonic distortion requirements provided all of the following conditions are met: i) the inverter is marked as in Clause 18.3.3; ii) the instruction manual contains information required by Clause 18.3.3; and iii) the inverter is not provided with a means for permanent connection of the ac output. c) non-metallic enclosure (mold stress relief) test — Clause 10.5.2 of CAN/CSA-C22.2 No. 61010-1 for the enclosure; and d) output voltage variation — Clause 10.2.2.
18.4.3		For an inverter intended for use in a vehicle, during the normal temperature test, the temperature measured on the input conductors shall not exceed 60 °C or the marked temperature of the conductor, whichever is greater.
18.4.4		For an inverter intended for use in a vehicle, during the normal temperature test, the temperatures of the following parts shall not exceed the values specified: a) 90 °C on the contact tip of the cigarette lighter connector; and b) 90 °C on the insulation adjacent to the contact tip of the cigarette lighter connector.
18.4.5		For an inverter intended for use in a vehicle, during the normal temperature test, the surface temperatures shall not exceed the value shown in Table 23.
18.4.6		When required by Clauses 18.2.15, 18.2.16, and/or 18.2.17, an inverter intended for use in a vehicle shall be capable of withstanding the following tests: a) Leakage current: The leakage current meter described in Clause 6.4 shall be connected between the points specified in Clause 18.2.14 and the leakage current shall not exceed 5 mA. Short circuit: In addition to the output short circuit test of Clause 6.6.1 a), the short circuit test shall be conducted between ungrounded output conductors and the ac ground. In addition the ac output voltage shall be reduced to 30 V rms or 42.4 V peak, or less in not more than 2 s after the fault is applied. If the voltage is reduced by means of failure of an electronic component, two additional samples of the inverter shall be subjected to the test to ensure that the failure mechanism provides consistent, repeatable results.

Clause	Verdict	Comment
18.4.7		During the abnormal operation (see Clause 6.6), the specified 3 A ground fuse is connected between the chassis and either the ac ground or dc negative, or left out, depending on the shock-hazard protection scheme used in the inverter, as specified in Clause 18.2.14. The inverter shall be oriented in a position that will most likely cause fire-hazardous components to be located above an opening of the inverter.
19		**PCE for use in marine applications** **Note:** *These requirements are based on the marine supplement in CAN/CSA-C22.2 No. 107.2.*
19.1		**Scope**
19.1.1		Clause 19 applies to PCE intended for installation on boats that are not required to be certified by Transport Canada. Marine PCE are intended for installation in accordance with CSA C22.2 No. 183.1 and/or CSA C22.2 No. 183.2.
19.1.2		These requirements do not cover portable PCE, except those PCE that employ demountable brackets to facilitate removal when not in use.
19.2	Info	**Construction**
19.2.1	Info	**General**
19.2.1.1		A PCE shall employ mounting means such that it will be held securely in position when subjected to vibration, shock, pitching, yawing, and rolling.
19.2.1.2		PCE having a battery charging function shall be provided with an ammeter that displays the output current.
19.2.1.3		With reference to Clause 19.2.1.2, a meter may be located in an area remote from the charger, provided that a) if a meter shunt is used, it shall be located within an enclosure; and b) if the external meter leads are subject to current under normal or single fault conditions exceeding the ampacity of the leads, overcurrent protection shall be provided based on the ampacity of the leads, and located or intended to be installed in all ungrounded conductors at the source end of the leads
19.2.2	Info	**Frame and enclosure**
19.2.2.1		PCE intended to be mounted on a bulkhead or other vertical surface shall be provided with mounting holes of the same nominal size as the threaded portion of the intended mounting screws, plus a minimal allowance for clearance.
19.2.2.2		PCE may have keyhole slots for mounting, as long as they are accompanied by one or more ordinary mounting holes and the PCE is provided with installation instructions in accordance with Clause 19.4.3.
19.2.2.3		The enclosure of PCE intended to be installed in an open cockpit or on a weather deck shall comply with the test and construction requirements for a minimum type 3R enclosure as specified in CSA C22.2 No. 94.2.
19.2.3	Info	**Input and output wiring connections**
19.2.3.1		A cord-connected PCE shall be provided with at least a Type SJT or SJTO cord, or the equivalent.

Clause	Verdict	Comment
19.2.3.2		A PCE employing demountable brackets shall not be intended for permanently connected wiring.
19.2.4		**Ignition protection**
19.2.4.1		PCE intended for installation in an area where ignition protected equipment is required shall be a) subjected to the test specified in Clause 19.5.3.1; and b) marked in accordance with Clause 19.3.2.
19.2.4.2		PCE not complying with all requirements of this Standard for ignition protected equipment shall be marked in accordance with Clause 19.3.3.
19.2.4.3		The areas where ignition protected equipment is required are described in CSA C22.2 No. 183.1.
19.2.5		**Receptacles** An attachment-plug receptacle shall not be employed in PCE intended for use in an area in which ignition protected equipment is required.
19.2.6		**Arcing parts**
19.2.6.1		Except as provided for in Clause 19.2.6.2, a component that can produce an arc, such as a snap switch or a relay, shall not be employed in a PCE intended for use in an area in which ignition protected equipment is required.
19.2.6.2		With reference to Clause 19.2.6.1, a component that complies with the test specified in Clause 19.5.3.2 shall be acceptable.
19.2.7		**Vibration and shock** The PCE shall withstand the vibration test prescribed in Clause 19.5.1 and the shock test prescribed in Clause 19.5.2, unless the PCE is for use only on vessels more than 20 m long and is marked in accordance with Clause 19.3.5.
19.3		**Marking**
19.3.1		A PCE that complies with the requirements of Clause 19 shall be marked the following or equivalent wording: FOR MARINE USE.
19.3.2		PCE complying with all requirements of this Standard for ignition protected equipment shall be marked with the following: IGNITION PROTECTED.
19.3.2		PCE not complying with all requirements of this Standard for ignition protected equipment shall be marked with the following or equivalent wording:
19.3.3		PCE not complying with all requirements of this Standard for ignition protected equipment shall be marked with the following or equivalent wording: WARNING: DO NOT INSTALL IN MACHINERY SPACE IN WHICH IGNITION-PROTECTED EQUIPMENT IS REQUIRED. SEE INSTALLATION INSTRUCTIONS.
19.3.4		PCE not intended for use in an open cockpit or on a weather deck shall be marked with the following or equivalent wording: WARNING: DO NOT EXPOSE TO RAIN OR SPRAY.

Clause	Verdict	Comment
19.3.5		Unless subjected to the vibration and shock tests specified in Clauses 19.5.1 and 19.5.2, a PCE shall be marked with the following or equivalent wording: FOR USE ON VESSELS OVER 20 M LONG.
19.4		**Installation and operating instructions**
19.4.1		Installation and operating instructions shall be provided with each PCE.
19.4.2		Operating instructions shall include a description of the functions of the PCE.
19.4.3		Installation instructions for a PCE having keyhole slots as allowed by Clause 19.2.2.2 shall include a statement that the keyhole slots are only to be used if the ordinary mounting holes provided are also or exclusively used.
19.4.4		Installation instructions for a PCE not complying with all requirements in this Standard for ignition protected equipment shall include instructions not to install the PCE in a space in which ignition protected equipment is required, and shall list the potential sources of ignition, as described in CSA C22.2 No. 183.1.
19.5		**Tests**
19.5.1		**Vibration**
19.5.1.1		A PCE shall withstand the vibration test specified in Table 24 for 12 h, when tested as described in Clauses 19.5.1.2 and 19.5.1.3, without structural damage to the mounting means or the enclosure that might result in a) an increase in the risk of fire, electric shock, or injury to persons; b) a reduction of spacings to a value less than the minimum specified in Clause 4.16; or c) exposure of a live part. The intended operation of the PCE shall not be impaired.
19.5.1.2		The PCE shall be mounted as intended on a rigid test fixture that is secured to the vibration table. The PCE shall be wired so as to permit the device to be monitored in accordance with Clause 19.5.1.4 during the last hour of vibration in each plane and after the complete vibration test.
19.5.1.3		The PCE shall be subjected to a variable frequency test in each of three rectilinear axes (horizontal, lateral, and vertical) for 4 h in each plane (total of 12 h) at the peak-to-peak amplitude specified in Table 24. The vibration frequency shall be automatically cycled at a constant rate from 10 to 60 to 10 Hz every 4 min.
19.5.1.4		To determine whether a PCE operates as intended, the PCE shall be connected to a supply adjusted to rated voltage, and the output shall be connected to normal load.
19.5.2		**Shock**
19.5.2.1		The same sample of the PCE that has been subjected to the vibration test in Clause 19.5.1 shall withstand 5000 impacts of 10 *g* peak with a duration of 20–25 ms (measured at the zero reference line of the half-sine wave shock pulse) without structural damage to the mounting means or the enclosure that might result in a) an increase in the risk of fire, electric shock, or injury to persons; b) a reduction of spacings to a value less than the minimum specified in Clause 4.16; or

<table>
<tr><th>Clause</th><th>Verdict</th><th>Comment</th></tr>
<tr><td></td><td></td><td>c) exposure of a live part.
The intended operation of the PCE shall not be impaired, and the PCE shall comply with the requirements in Clause 19.5.1.4 upon completion of the test.</td></tr>
<tr><td>19.5.2.1</td><td></td><td>The PCE shall be mounted as intended on a rigid test fixture secured to the shock table. The PCE need not be operable during the test.</td></tr>
<tr><td>19.5.3</td><td></td><td>Ignition protection</td></tr>
<tr><td>19.5.3.1</td><td></td><td>PCE rated for installation in areas requiring ignition protected equipment shall be subjected to the spark ignition test for nonincendive circuits specified in CAN/CSA-C22.2 No. 157.</td></tr>
<tr><td>19.5.3.2</td><td></td><td>A component that can produce an arc shall be subjected to the spark ignition test for nonincendive components specified in CAN/CSA-C22.2 No. 157.</td></tr>
<tr><td>Table 5</td><td></td><td>Minimum spacings for <s>Power Supplies</s> PCE for use in other than controlled environments (See Clause 4.16.2<s>(a) and Table 7</s>.)
<table>
<tr><th></th><th colspan="3">Minimum spacing, mm*</th></tr>
<tr><th></th><th colspan="2">Between bare live parts of opposite polarity, between circuits required to be isolated from each other, and between bare live parts and exposed non-current-carrying metal parts other than the enclosure‡</th><th>Between bare live parts and the walls of a metal enclosure, where subject to decrease of spacings due to deflection or impact, and fittings for conduit or armoured cable</th></tr>
<tr><th>Voltage involved, V rms†</th><th>Through air</th><th>Over surface</th><th>Through air and over surface</th></tr>
<tr><td>50 or less</td><td>1.6§</td><td>1.6§</td><td>1.6§</td></tr>
<tr><td>Over 50 to 150</td><td>3.2§</td><td>6.4</td><td>6.4</td></tr>
<tr><td>Over 150 to 300</td><td>6.4</td><td>9.5</td><td>12.7</td></tr>
<tr><td>Over 300 to 600</td><td>9.5</td><td>12.7</td><td>12.7</td></tr>
</table>
(New)
* Spacings are not specified for secondary circuits or battery circuits excluded by Clause 4.16.7.
† Peak or dc voltage is limited to 1.414 times the rms (sinusoidal) voltage for each voltage range. For higher ac, peak, or dc voltages, refer to Clause 4.16.1.1.</td></tr>
<tr><td>Table 6</td><td></td><td>Minimum spacings for PCE for use in controlled environments
(See Clause 4.16.2<s>(b) and Table 8</s>.)
<table>
<tr><th></th><th colspan="3">Minimum spacing, mm*</th></tr>
<tr><th></th><th colspan="2">Between bare live parts of opposite polarity, between circuits required to be isolated from each other, and between bare live parts and exposed non-current-carrying metal parts other than the enclosure‡</th><th>Between bare live parts and the walls of a metal enclosure, where subject to decrease of spacings due to deflection or impact, including fittings for conduit or armoured cable</th></tr>
<tr><th>Voltage involved, V rms†</th><th>Through air</th><th>Over surface</th><th>Through air and over surface</th></tr>
<tr><td>50 or less</td><td>1.2§</td><td>1.2§</td><td>1.6§</td></tr>
<tr><td>Over 50 to 150</td><td>1.6§</td><td>1.6§</td><td>6.4</td></tr>
<tr><td>Over 150 to 300</td><td>2.4§</td><td>2.4§</td><td>12.7</td></tr>
<tr><td>Over 300 to 600</td><td>5.5</td><td>12.7</td><td>12.7</td></tr>
</table>
(New)
* Spacings are not specified for secondary circuits or battery circuits excluded by Clause 4.16.7.
† Peak or dc voltage is limited to 1.414 times the rms (sinusoidal) voltage for each voltage range. For higher ac, peak, or dc voltages, refer to Clause 4.16.1.1.</td></tr>
</table>

<table>
<tr><th>Clause</th><th>Verdict</th><th>Comment</th></tr>
<tr><td></td><td></td><td>‡ For printed wiring boards, see Table 8.
§ The spacing between field-wiring terminals of opposite polarity and between a field-wiring terminal and a grounded non-current-carrying metal part shall be not less than 6.4 mm.</td></tr>
<tr><td>Table 7</td><td></td><td>Conductor spacings on printed wiring boards for use in other than controlled environments
(See Clauses 4.16.3, 4.16.4, 4.16.8, 6.15.1, and Table 5.)
<table>
<tr><th rowspan="3">Volts, ac rms or dc</th><th colspan="3">Spacings, mm</th></tr>
<tr><th colspan="2">Coated*</th><th>Uncoated</th></tr>
<tr><th colspan="2">Transients</th><th></th></tr>
<tr><th>Not limited</th><th>Limited†</th><th></th></tr>
<tr><td>50</td><td>0.18</td><td>0.025</td><td>1.7</td></tr>
<tr><td>100</td><td>0.25</td><td>0.1</td><td>2.0</td></tr>
<tr><td>120</td><td>0.28</td><td>0.15</td><td>2.1</td></tr>
<tr><td>160</td><td>0.32</td><td>0.25</td><td>2.2</td></tr>
<tr><td>200</td><td>0.42</td><td>0.40</td><td>2.8</td></tr>
<tr><td>250</td><td>0.56</td><td>0.56</td><td>3.6</td></tr>
<tr><td>320</td><td>0.75</td><td>0.75</td><td>4.5</td></tr>
<tr><td>400</td><td>1.0</td><td>1.0</td><td>5.6</td></tr>
<tr><td>500</td><td>1.3</td><td>1.3</td><td>7.1</td></tr>
<tr><td>630</td><td>1.8</td><td>1.8</td><td>9.0</td></tr>
<tr><td>800</td><td>2.4</td><td>2.4</td><td>11.0</td></tr>
<tr><td>1000‡</td><td>3.2</td><td>3.2</td><td>14.0</td></tr>
</table>
(New)
* The coating will have passed the tests of Clause 6.15.
† By a component or assembly such as an overvoltage protective device, a transformer with isolated windings, or a damping impedance suitably located. Refer to Clause 4.16.8.
‡ For higher ac, peak, or dc voltages, refer to Clause 4.16.1.1.
Note: This Table was derived from IEC Publication 60664-1.</td></tr>
<tr><td>Table 8</td><td></td><td>Conductor spacings on printed wiring boards for use in controlled environments
(See Clauses 4.16.3, 4.16.4, 4.16.8, and Table 6.15.1.)
<table>
<tr><th rowspan="2">Voltage involved, V rms†</th><th colspan="2">Minimum spacing, mm*</th><th></th></tr>
<tr><th>Between bare live parts of opposite polarity, between circuits required to be isolated from each other, and between bare live parts and exposed non-current-carrying metal parts other than the enclosure‡</th><th></th><th>Between bare live parts and the walls of a metal enclosure, where subject to decrease of spacings due to deflection or impact, including fittings for conduit or armoured cable</th></tr>
<tr><th></th><th>Through air</th><th>Over surface</th><th>Through air and over surface</th></tr>
<tr><td>50 or less</td><td>1.2§</td><td>1.2§</td><td>1.6§</td></tr>
<tr><td>Over 50 to 150</td><td>1.6§</td><td>1.6§</td><td>6.4</td></tr>
<tr><td>Over 150 to 300</td><td>2.4§</td><td>2.4§</td><td>12.7</td></tr>
<tr><td>Over 300 to 600</td><td>5.5</td><td>12.7</td><td>12.7</td></tr>
</table>
(New)
* The coating will have passed the tests of Clause 6.15.
* † By a component or assembly such as an overvoltage protective device, a transformer with isolated windings, or a damping impedance suitably located. Refer to Clause 4.16.8.
‡ For higher ac, peak, or dc voltages, refer to Clause 4.16.1.1.
†The coating will have passed the tests of Clause 6.16.
Note: This Table was derived from IEC Publication 60664-1.</td></tr>
</table>

<table>
<tr><th>Clause</th><th>Verdict</th><th>Comment</th></tr>
<tr><td>Table 10</td><td></td><td><u>Total touch temperature limits for accessible surfaces</u>
<u>(See Clause 6.3.2, 6.3.3, 6.3.4, 6.3.8, 7.3, 8.4.1.6, 17.3.10.3, 17.3.10.4, and 17.4.3.5.)</u>
<table><tr><th rowspan="2">Part</th><th colspan="3">Limit, °C</th></tr><tr><th>Metal</th><th>Glass, porcelain, and other vitreous material*</th><th>Plastic and rubber*</th></tr><tr><td>User operated devices (knobs, handles, switches, displays, etc.) which are continuously held in normal use</td><td>55</td><td>65</td><td>75</td></tr><tr><td>User operated devices (knobs, handles, switches, displays, etc.) which are held for short periods only in normal use</td><td>60</td><td>70</td><td>85</td></tr><tr><td>Enclosure parts accessible to user by casual contact.</td><td>70</td><td>80</td><td>95</td></tr></table><u>(New)</u>
<u>* Non-metallic materials shall not be used above their temperature ratings.</u></td></tr>
<tr><td>Table 14</td><td></td><td><u>Minimum and maximum output voltages for RV converter outputs for dc loads other than battery charging</u>
<table><tr><th>Converter nominal voltage rating, V</th><th>Minimum voltage at rated output current, V</th><th>Maximum voltage at 5% of rated current, V</th></tr><tr><td>12</td><td>10.5</td><td>14.5</td></tr><tr><td>24</td><td>21.0</td><td>29.0</td></tr><tr><td>48</td><td>42.0</td><td>58.0</td></tr></table><u>(New)</u></td></tr>
<tr><td>Table 16</td><td></td><td><u>Grid-interconnected inverter</u> voltage <s>and Frequency Operation</s> <u>disconnect</u> limits
(See Clauses 14.2.2.2, 14.2.2.5, 14.3.4.1, and 14.3.4.2.)
<table><tr><th rowspan="2">Condition</th><th rowspan="2">Utility source voltage (% of nominal output rating)</th><th>Units with fixed setpoints*</th><th>Units with adjustable setpoints*</th></tr><tr><th>Maximum clearing time(s)</th><th>Default clearing time(s)</th></tr><tr><td>A</td><td>V < 50%</td><td>0.16</td><td>0.16</td></tr><tr><td>B</td><td>V < 88%</td><td>2.00</td><td>2.00</td></tr><tr><td>C</td><td>V > 110%</td><td>1.00</td><td>1.00</td></tr><tr><td>D</td><td>V ≥ 120%</td><td>0.16</td><td>0.16</td></tr></table>(New)
<u>* See Clause 14.2.2.2.</u></td></tr>
<tr><td>Table 17</td><td></td><td><u>Grid-interconnected inverter frequency disconnect limits</u>
<u>(See Clauses 14.2.2.2 and 14.3.4.1.)</u>
<table><tr><th rowspan="2">Condition</th><th rowspan="2">Utility source frequency (Hz)</th><th>Units with fixed setpoints*</th><th>Units with adjustable setpoints*</th></tr><tr><th>Maximum clearing time(s)</th><th>Default clearing time(s)</th></tr><tr><td>E</td><td>f > 60.5</td><td>0.16</td><td>0.16</td></tr><tr><td>F</td><td>f < 59.3</td><td>0.16</td><td>not applicable</td></tr><tr><td>G</td><td>f < (59.8–57.0) adjustable</td><td>not applicable</td><td>0.16–300 adjustable</td></tr><tr><td>H</td><td>f < 57.0</td><td>not applicable</td><td>0.16</td></tr></table><u>(New)</u>

<u>Note:</u> <u>*See Clause 14.2.2.2.</u></td></tr>
</table>

<table>
<tr><th>Clause</th><th>Verdict</th><th>Comment</th></tr>
<tr><td>Table 19</td><td></td><td>
<u>PV array to ground insulation resistance (RISO) limits vs. inverter rating</u>
<u>(See Clauses 13.3.4.2.1 and 13.3.4.2.3.)</u>
<table>
<tr><th>Inverter rating (kVA) per Clause 13.3.4</th><th>R_{ISO} limit (kΩ)</th></tr>
<tr><td>≤ 20</td><td>30</td></tr>
<tr><td>> 20 to ≤ 30</td><td>20</td></tr>
<tr><td>> 30 and ≤ 50</td><td>15</td></tr>
<tr><td>> 50 and ≤ 100</td><td>10</td></tr>
<tr><td>> 100 and ≤ 200</td><td>7</td></tr>
<tr><td>> 200 and ≤ 400</td><td>4</td></tr>
<tr><td>> 400 and ≤ 500</td><td>2</td></tr>
<tr><td>≥ 500</td><td>1</td></tr>
</table>
<u>(New)</u>
</td></tr>
<tr><td>Table 20</td><td></td><td>
<u>Table 20 Ground fault current detection settings</u>
<u>(See Clauses 13.3.4.3.2, 13.3.4.3.3, and 13.3.5.5.)</u>
<table>
<tr><th>PCE rating (kVA) per Clause 13.3.4</th><th>Maximum ground fault current detection setting</th></tr>
<tr><td>≤ 25 kVA</td><td>1A</td></tr>
<tr><td>> 25 kVA to ≤ 50 kVA</td><td>2A</td></tr>
<tr><td>> 50 kVA to ≤ 100 kVA</td><td>3A</td></tr>
<tr><td>> 100 kVA to ≤ 250 kVA</td><td>4A</td></tr>
<tr><td>> 250 kVA</td><td>5A</td></tr>
</table>
<u>(New)</u>
</td></tr>
<tr><td>Table 21</td><td></td><td>
<u>Flammability, HWI, and HAI ratings</u>
<u>(See Clause 18.2.3.)</u>
<table>
<tr><th></th><th colspan="3">HWI and HAI ratings</th></tr>
<tr><td>Flammability</td><td>V-0</td><td>V-1</td><td>V-2</td></tr>
<tr><td>HWI (minimum)</td><td>7</td><td>15</td><td>30</td></tr>
<tr><td>HAI (minimum)</td><td>15</td><td>30</td><td>30</td></tr>
</table>
<u>(New)</u>
</td></tr>
</table>

<table>
<tr><th>Clause</th><th>Verdict</th><th>Comment</th></tr>
<tr><td>Table 22</td><td></td><td><u>Conductor size and ampacity</u>
<u>(See Clause 18.2.6.)</u>

<table>
<tr><th rowspan="2">AWG Size</th><th colspan="2">Ampacity</th></tr>
<tr><th>Jacketed or parallel conductor cord shown in Table 12 of the CE Code Part I [see Clause 18.2.4 a)]</th><th>Other [see Clause 18.2.4 b)]</th></tr>
<tr><td>18</td><td>10</td><td>6</td></tr>
<tr><td>16</td><td>13</td><td>8</td></tr>
<tr><td>14</td><td>18</td><td>17</td></tr>
<tr><td>12</td><td>25</td><td>23</td></tr>
<tr><td>10</td><td>30</td><td>28</td></tr>
</table>
<u>(New)</u></td></tr>
<tr><td>Table 23</td><td></td><td><u>Location and maximum temperature of handles</u>
<u>(See Clause 18.4.5.)</u>

<table>
<tr><th rowspan="2">Location</th><th colspan="2">Material</th></tr>
<tr><th>Metal</th><th>Nonmetallic</th></tr>
<tr><td>Handles or knobs that are grasped for lifting, carrying, or holding</td><td>50 °C</td><td>60 °C</td></tr>
<tr><td>Handles or knobs not to be grasped for lifting, carrying or holding and surfaces subject to contact and user maintenance</td><td>60 °C</td><td>85 °C</td></tr>
<tr><td>Surfaces subject to casual contact</td><td>70 °C</td><td>95 °C</td></tr>
</table>
<u>(New)</u></td></tr>
<tr><td>Table 24</td><td></td><td><u>Vibration test requirements</u>
<u>(See Clauses 19.5.1.1 and 19.5.1.3.)</u>

<table>
<tr><th>Location</th><th>Duration</th><th>Peak-to-peak amplitude, mm</th><th>Frequency, Hz</th></tr>
<tr><td>Ignition-protected battery charger</td><td>12 h (4 h each in planes x, y, and z)</td><td>0.51 ± 0.025</td><td>10–60</td></tr>
<tr><td>Battery charger installed above cockpit deck — not ignition-protected</td><td>12 h (4 h each in planes x, y, and z)</td><td>0.38 ± 0.025</td><td>10–60</td></tr>
</table>
<u>(New)</u></td></tr>
</table>

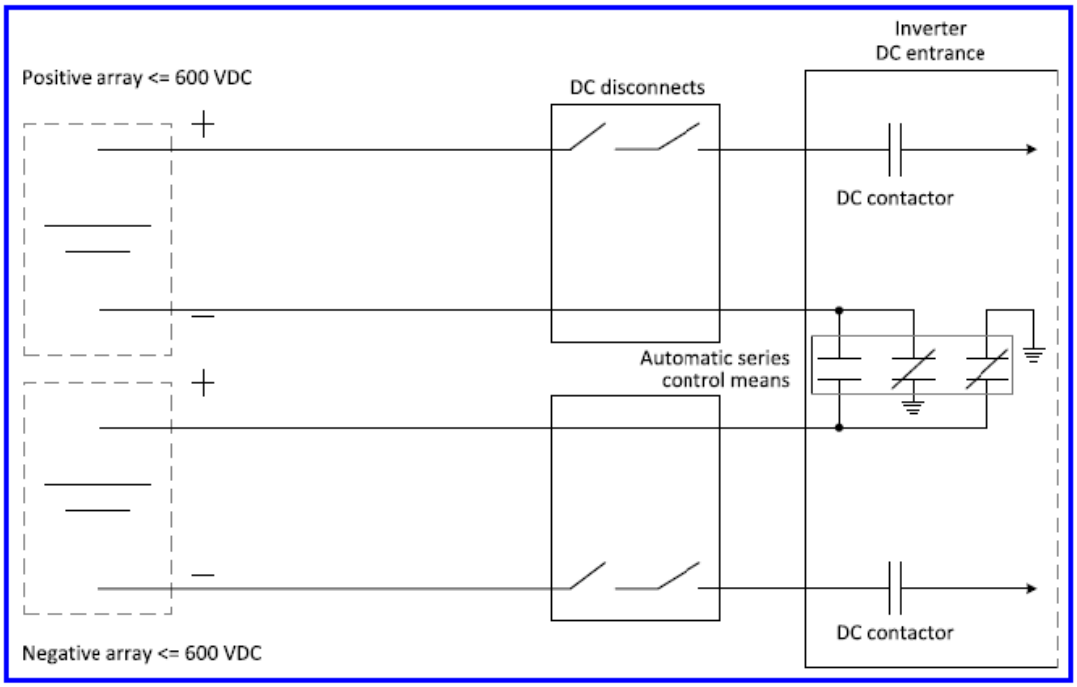
<table>
<tr><th>Clause</th><th>Verdict</th><th>Comment</th></tr>
<tr><td>Table 24</td><td></td><td>
<u>Ground fault current detection/interruption requirements by system type</u>
<u>(See Clause 13.3.4.3.1.)</u>
<table>
<tr><th>PCE isolated? (see Note)</th><th>PV grounding</th><th>Grid grounding</th><th>Current detection/interruption needed?</th></tr>
<tr><td>Yes</td><td>floating</td><td>floating</td><td>no</td></tr>
<tr><td>Yes</td><td>grounded</td><td>floating</td><td>yes</td></tr>
<tr><td>Yes</td><td>high Rg</td><td>floating</td><td>no</td></tr>
<tr><td>Yes</td><td>low Rg</td><td>floating</td><td>yes</td></tr>
<tr><td>Yes</td><td>floating</td><td>grounded</td><td>no</td></tr>
<tr><td>Yes</td><td>grounded</td><td>grounded</td><td>yes</td></tr>
<tr><td>Yes</td><td>high Rg</td><td>grounded</td><td>no</td></tr>
<tr><td>Yes</td><td>low Rg</td><td>grounded</td><td>yes</td></tr>
<tr><td>No</td><td>floating</td><td>floating</td><td>no</td></tr>
<tr><td>No</td><td>grounded</td><td>floating</td><td>yes</td></tr>
<tr><td>No</td><td>high Rg</td><td>floating</td><td>no</td></tr>
<tr><td>No</td><td>low Rg</td><td>floating</td><td>yes</td></tr>
<tr><td>No</td><td>floating</td><td>grounded</td><td>yes</td></tr>
<tr><td>No</td><td>grounded</td><td>grounded</td><td>yes</td></tr>
<tr><td>No</td><td>high Rg</td><td>grounded</td><td>yes</td></tr>
<tr><td>No</td><td>low Rg</td><td>grounded</td><td>yes</td></tr>
</table>
(New)

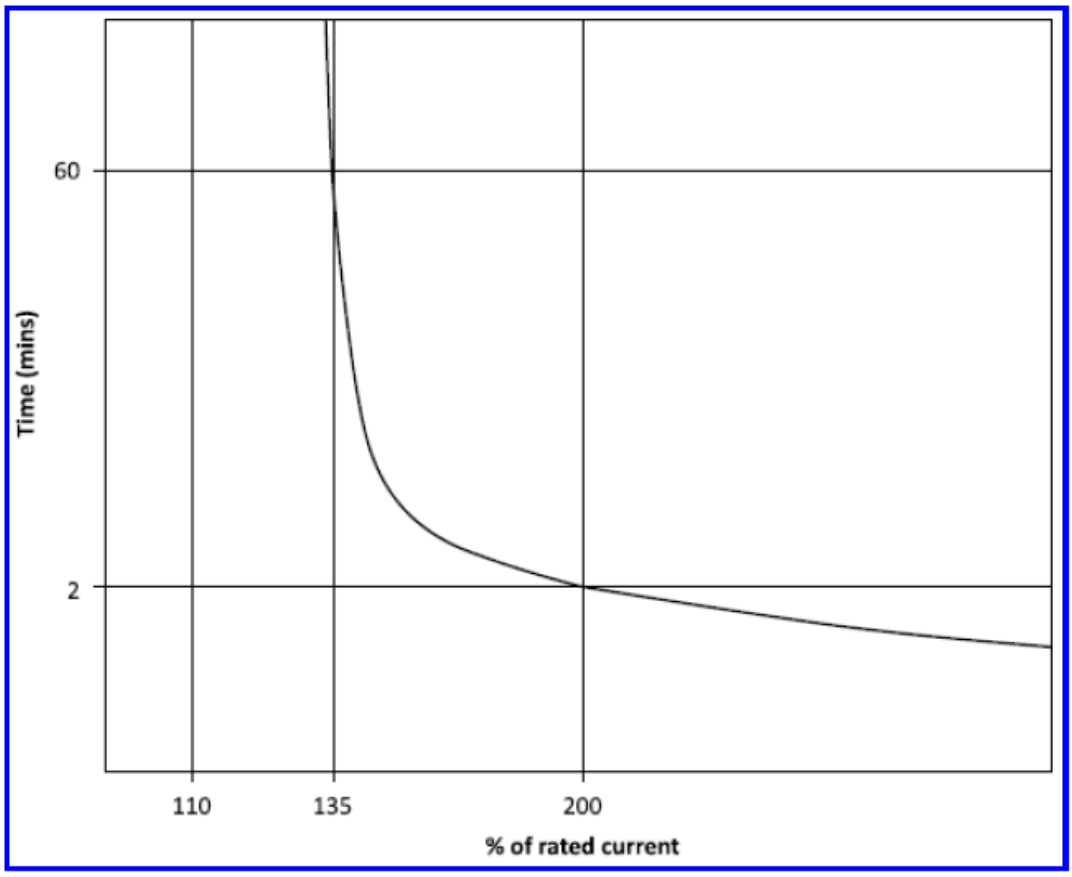
<u>Legend:</u>
<u>RgI = the value of the grounding resistor in a resistively-grounded system. The following limits shall apply for “high Rg” and “low Rg”:</u>

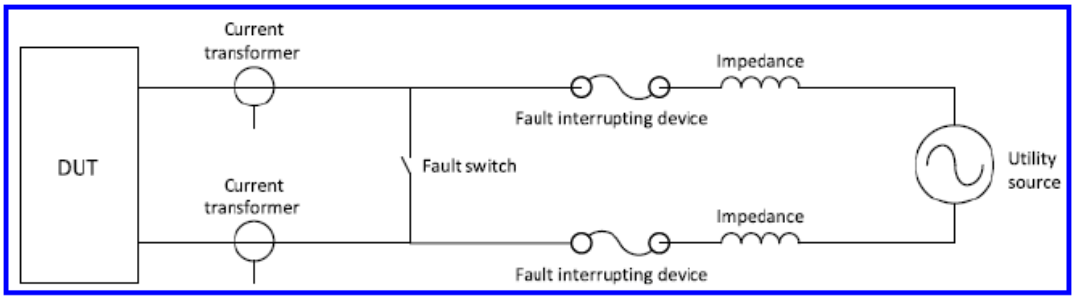
<u>High Rg = a value of ground resistance greater than or equal to the max open circuit array voltage the PCE is rated for, divided by the applicable ground fault current limit in Table 20</u>

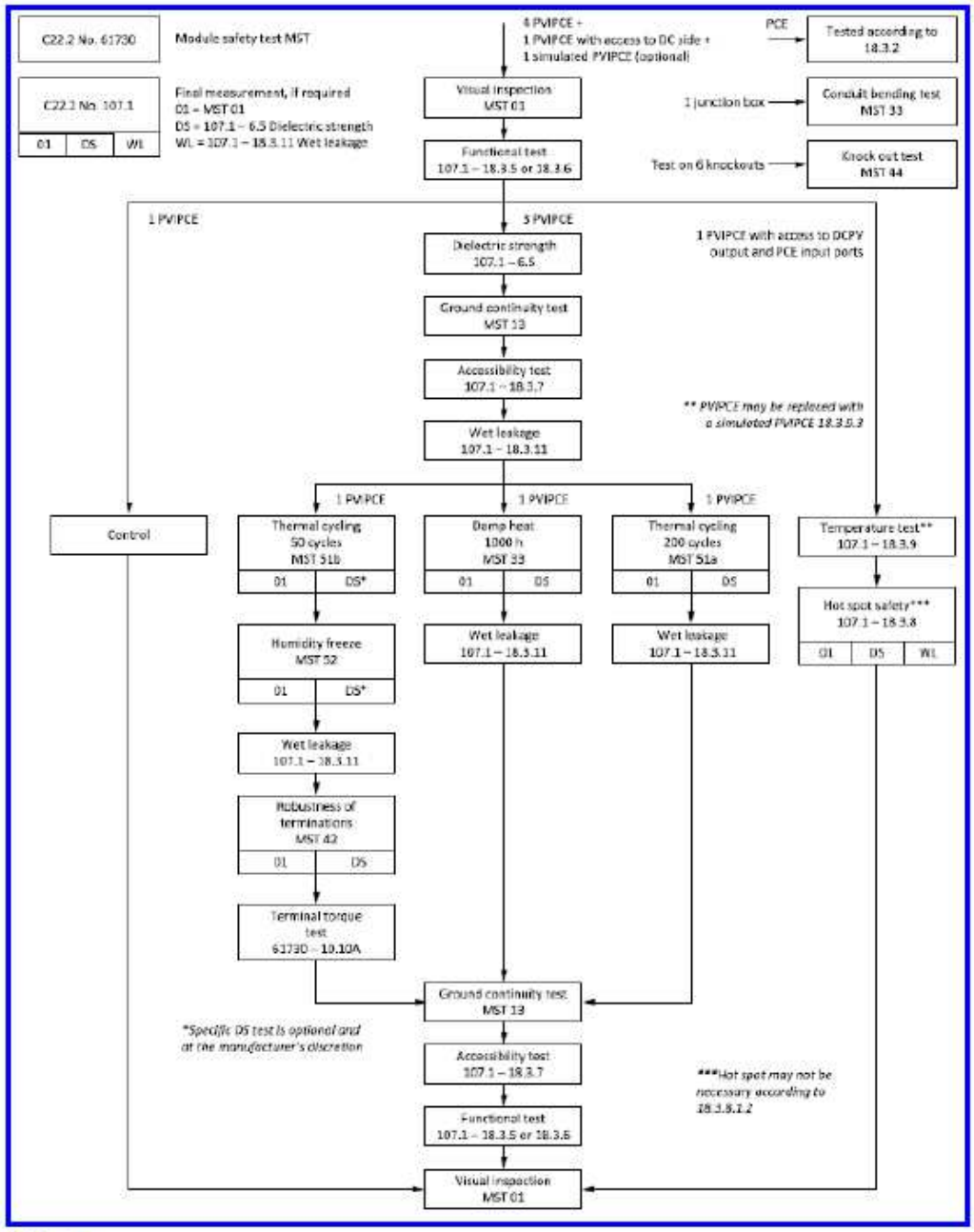
<u>Low Rg = a value of ground resistance less than the max open circuit array voltage the PCE is rated for, divided by the applicable ground fault current limit in Table 20</u>

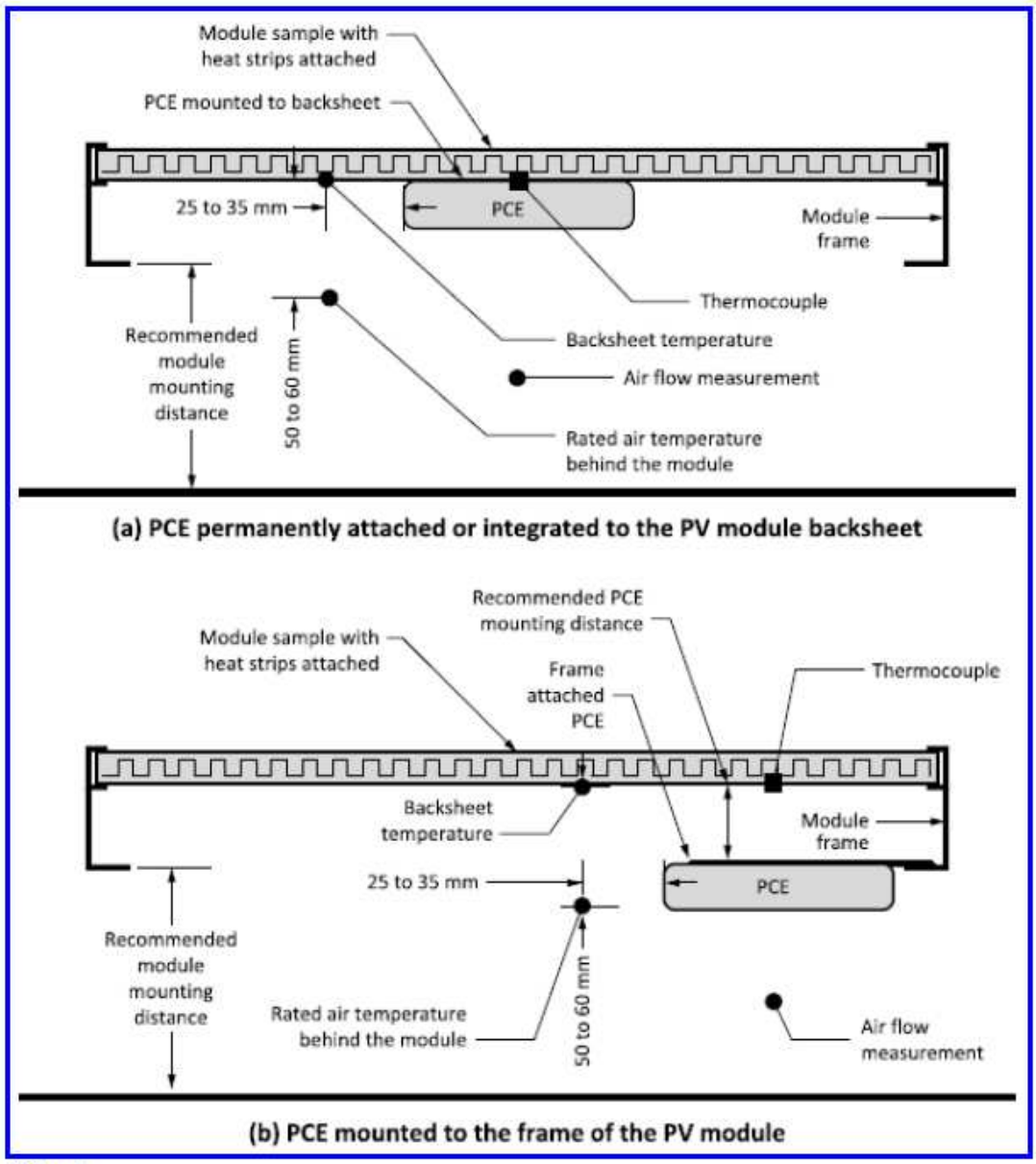
<u>Note: Isolated between the PV input and the ac (grid) output circuit.</u>
</td></tr>
</table>

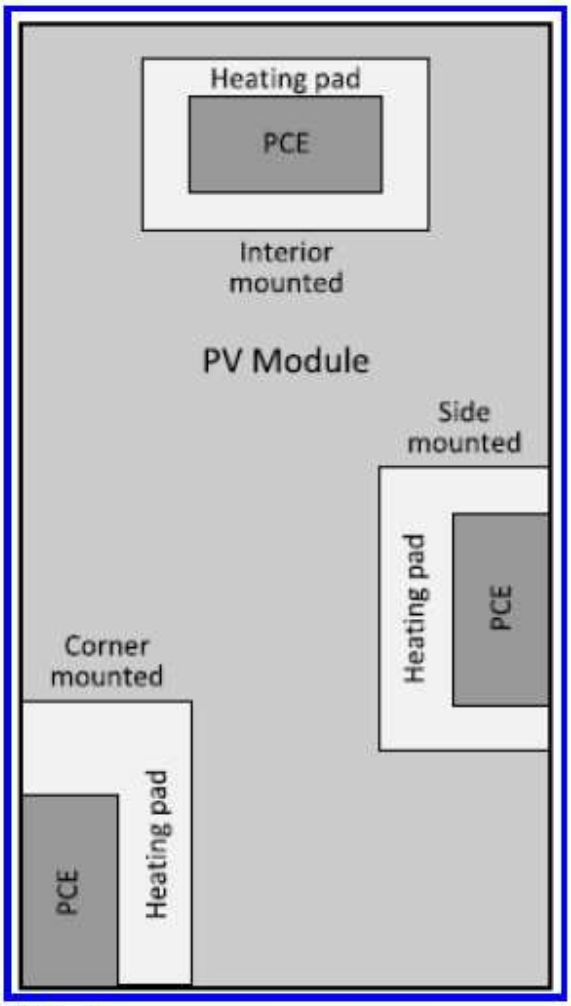
Clause	Verdict	Comment
Figure 11		**Example of automatic series control for non-isolated inverters designed to operate with bipolar system** (See Clause 13.3.1.2.)  (New)

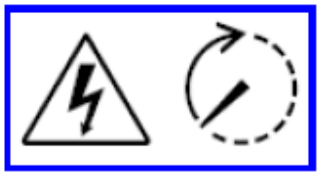
Clause	Verdict	Comment
Figure 12		**Equivalent electronic overcurrent protection current vs. time characteristic** (See Clause 4.19.1.4)  (New)

Clause	Verdict	Comment
Figure 13		**Example test circuit for testing grid-interconnected inverter ac output short circuit contribution** (See Clause 14.3.9.1.)  (New)

Clause	Verdict	Comment
Figure 14		**PV module with integrated power converter equipment test sequence** (See Clauses 17.1.2, 17.3.3.1, 17.3.5.1, and 17.3.6.1.)  (New)

Clause	Verdict	Comment
Figure 15		**Example of temperature test setup** (See Clause 17.3.9.1.)  (New)

Clause	Verdict	Comment
Figure 16		**Example of heating pad arrangement for different PCE mounting locations** (See Clause 17.3.9.2.)  (New)

Clause	Verdict	Comment
Figure 17		**Symbol for referring to instructions** (See Clause 17.4.2.5.)  (New)
Figure 18		**Symbol for discharge time required** (See Clause 5.42.)  (New)
		CUSTOMERS PLEASE NOTE: This Table and column "Verdict" can be used in determining how your current or future production is or will be in compliance with new/revised requirements.