ELECTRICAL CODE INTERPRETATION

STANDATA

2018 CANADIAN ELECTRICAL CODE
Section 64 – Renewable energy systems

1. Rules 64-210, 64-216, and 2-200

Purpose:

Industry has requested clarification on solar photovoltaic (PV) dc arc fault protection and how this relates to rodent protection requirements.

Code references:

2-200 General

Electrical equipment shall be installed and guarded so that adequate provision is made for the safety of persons and property and for the protection of the electrical equipment from mechanical or other damage to which it is liable to be exposed.

64-210 Wiring method

5) Where the dc arc-fault protection referred to in Rule 64-216 is not located at the module, photovoltaic source circuit conductors and cables installed on or above a building, and installed in accordance with Subrules 1), 2), and 3) shall be provided with mechanical protection, in the form of an enclosed raceway or other acceptable material to protect against damage from rodents.

64-216 Photovoltaic dc arc-fault circuit protection

1) Photovoltaic systems with dc source circuits or output circuits, or both, and operating at a maximum system voltage of 80 V or greater, shall be protected by
   a) a dc arc-fault circuit interrupter; or
   b) other system equipment approved to provide equivalent protection.

2) The arc-fault protection system required in Subrule 1) shall
   a) detect and interrupt arcing faults resulting from a failure in the intended continuity of a conductor, connection, photovoltaic module, or other system component in the dc photovoltaic source and output circuits;
   b) not have the capability of being automatically restarted;
   c) have annunciation, without an automatic reset, that provides a visual indication that the circuit interrupter has operated; and
   d) disable or disconnect
      i) inverters or charge controllers connected to the faulted circuit when the fault is detected; or
      ii) the photovoltaic dc source circuits or dc output circuits either within the combiner, at the module junction box, or at the module cable connectors.

Unless stated otherwise, all Code references in this STANDATA are to the Canadian Electrical Code, Part I, 2018.

Issue of this STANDATA is authorized by
the Provincial Electrical Administrator

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Discussion:

Solar PV system dc arc-fault protection is designed to detect and mitigate the effects of arcing faults that can pose a risk of fire ignition under certain conditions if the arcing persists. This may be the result of a failure of (or damage to) a conductor, connection, PV module or other system component.

The dc arc-fault protection required under Rule 64-216 provides series arc fault protection. This position is supported by the rule's requirement to detect and interrupt arcing faults resulting from a "failure of the intended continuity of a conductor".

Solar PV inverters sold in Canada are manufactured under a number of standards. Standard CSA C22.2 No. 292 dc arc fault protection for photovoltaic applications has recently been published. Prior to its development, manufacturers followed CSA Technical Information Letter T.I.L. M-07 and the UL1699B standard for photovoltaic dc arc-fault circuit protection. These standards describe testing for both Type 1 series arc-fault protection and Type 2 parallel arc-fault protection.

However, only series faults are required to be detected and protected against by current electrical codes. For this reason, today's Type 1 PV inverters are only certified to detect and interrupt series arc-faults. When the inverter senses a series arc fault within the specified fault value (≥ 300W), the inverter shuts down and stops current flow in the entire circuit feeding into that inverter, effectively quenching the arc. This arc fault protection is provided for the entire run of dc conductors from the inverter to the module, inside the module and the connections between modules. When this occurs, the inverter provides a fault message and must be reset manually. Each string in the PV system feeding that inverter must be inspected for faults as per the manufacturers' installation manual.

A certified dc arc fault protective device can also be embodied in a number of ways such as in a combiner box. Module integrated products are in development stages, but are not yet readily available due to a number of technical challenges.

Interpretation:

Subrule 64-210 5)

This Subrule indicates that where the dc arc-fault protection referred to in Rule 64-216 is not located at the module, PV source circuit conductors and cables installed on or above a building require mechanical protection against damage from rodents. Detection and interruption of arc-faults provided by shutdown of an approved Type 1 inverter (or other certified component) referenced in Rule 64-216 is required to quench a series arc-fault. It will accomplish this throughout all of the PV source circuits and PV output circuits connected to that inverter. Because of this protection provided by the inverter (or other certified component), up to and including at the module, there is no requirement for additional rodent protection **above that which would be normally required by Rule 2-200 to protect equipment and cables from damage from environmental hazards which may be present (such as the presence of rodents and wildlife)**, when such equipment that is compliant with Rule 64-216 is installed.

Rule 2-200

Even when arc-fault protection has been provided under the terms of Rule 64-216, **Rule 2-200 requires that electrical equipment be guarded from mechanical or other damage to which it is liable to be exposed**. For solar PV systems, the owner and designer are responsible to identify the likelihood of damage from any means (including rodents) on the specific site of

installation. Those specific individual site conditions will dictate the requirement for installation of protection.

For example, a solar array installed on a roof of a house surrounded by mature trees would be a strong candidate for rodent protection compared to an installation on the roof of an industrial building of non-combustible construction.

Caution must be exercised in the application of rodent protection in certain conditions. In flat roof ballasted systems, there is a potential risk of increased wind loading. Racking systems have specific wind tunnel testing to generate wind coefficients but may not include additional mesh/fencing that could create wind drag and change the wind behavior and dynamics of the original design. This could potentially void the engineered racking design. There is also a high likelihood that energy production would be reduced and temperatures increased due to restricted air movement under the array during warmer weather.

For projects with professional involvement, this responsibility to identify the risks and the protection system should fall on the designer and should be fully acknowledged by the owner. It is strongly recommended that the installer consult the local Authority Having Jurisdiction well in advance to discuss the need for, and the type(s) of, additional protection required. No matter what type of equipment is installed, the owner should be made aware that regular inspections of the system are essential.

2. Rules 64-218 sub rules 1) through 4)

Purpose:

The purpose is to clarify what systems require photovoltaic rapid shutdown (RSD) as well as the approval requirements for equipment and systems used for this purpose.

Code references:

64-218 Photovoltaic rapid shutdown (see Appendix B)
1) Photovoltaic rapid shutdown shall be provided for a photovoltaic system installed on or in buildings where the photovoltaic source or output circuit insulated conductors or cables installed on or in buildings are more than 1 m from a photovoltaic array.
2) Notwithstanding Subrule 1), photovoltaic rapid shutdown shall not be required for ground-mounted photovoltaic system circuits that enter a building whose sole purpose is to house photovoltaic system equipment.
3) Photovoltaic rapid shutdown shall limit photovoltaic source or output circuits located more than 1 m from the photovoltaic array to not more than 30 V within 30 s of rapid shutdown initiation.
4) A device used to initiate photovoltaic rapid shutdown shall be readily accessible and located
- a) for single dwelling units, at the supply authority meter location;
- b) for other than single dwelling units, at the consumer's service equipment or supply authority meter location, and
  - i) at a permanent access to a building roof where an array(s) is installed; or
  - ii) within sight and within 9 m of the array(s); and
- c) for a stand-alone system, in accordance with Items b) i) and ii).

5) The location of the device used to initiate photovoltaic rapid shutdown shall be shown on the diagram required in Rule 84-030 2).

6) A label indicating that the photovoltaic system is equipped with photovoltaic rapid shutdown shall be installed at the supply authority meter location and at the consumer's service equipment location.

Appendix B

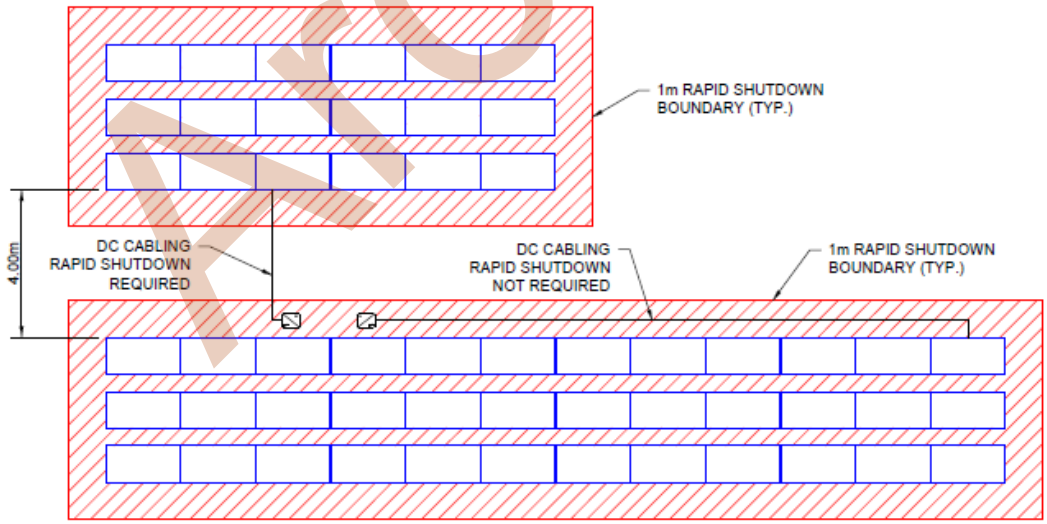
Rule 64-218
The requirements for a photovoltaic rapid shutdown system are given in CSA C22.2 No. 330.

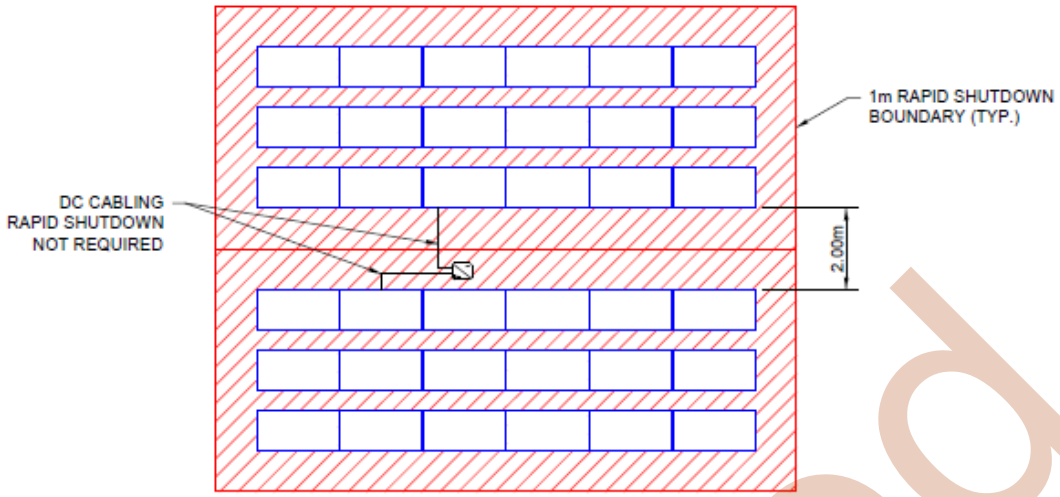
Rule 64-218 3)
The intent of Subrule 3) is to limit photovoltaic source or output circuits to not more than 30 V within 30 s of rapid shutdown initiation, where the voltage and power are measured between any two photovoltaic source or output circuit conductors, and between any photovoltaic source or output circuit conductors and ground.

Discussion:

To further mitigate electrical and fire safety hazards for emergency responders, PV rapid shutdown (RSD) requirements changed in the 2018 Canadian Electrical Code. It is important to consider that RSD rules specifically deal with shutdown for this purpose and other rules of the code deal with disconnecting means and isolation for fire and shock hazards for maintenance and operation. The changes include controlling conductors extending from a PV array to a new specific level (not actually fully shut down), a tighter and more clearly defined boundary for controlled conductors and new location requirements for rapid shutdown initiation devices. There are also newly referenced product standards for the RSD equipment and systems.

Rapid shutdown boundary illustrations:





Interpretations:

Is rapid shutdown function required on every system?

It is important to consider which systems require Rapid Shutdown. Once the controlled conductors extend beyond 1 m from the PV array inside or outside a building, rapid shutdown control of these conductors is required. If a string inverter or micro-inverters are placed inside the boundary, this would result in no controlled conductors leaving the boundary. As such, no rapid shutdown functionality is necessary and none of the initiating devices required by 64-218 (4) would be required. See sub-rule (2) for ground mount systems.

What equipment can be used for Rapid Shutdown?

Devices that act as photovoltaic rapid shutdown systems (PVRSS) or photovoltaic rapid shutdown equipment (PVRSE) must be certified to CSA C22.2 No. 330-17. The scope of the standard specifies requirements for PVRSS and PVRSE (components) intended to be used in ordinary locations in accordance with CE Code, Part I and rated 1500 V or less. This standard is intended to be used in conjunction with the inverter standard CSA C22.2 No. 107.1-16 power conversion equipment.

Off-the-shelf components (such as an ordinary contactor) cannot be used as rapid shutdown equipment. However, initiation devices that would interrupt the inverter ac output circuit such as a certified disconnect switch, circuit breaker or control switch do not specifically need to be certified as RSD equipment. Some existing service equipment may be able to provide dual function.

Can you use rapid shutdown components from different manufacturers to make a system?

Certified rapid shutdown equipment on its own does not guarantee CE Code compliance. If only each piece of equipment is certified, how do you know it works as a system? Each piece of equipment must interact with other pieces of equipment to perform Rapid Shutdown. This includes the inverter, which must also be evaluated for compatibility with the respective equipment or system. The C22.2 No. 330-17 standard indicates the operability of complete rapid shutdown systems built from individual devices covered under the standard has not been determined. These compatibility evaluations are up to the manufacturers and equipment that can be used together must be referenced in the installation manuals for the equipment.

What can be used as a rapid shutdown initiator?

The system needs a switching device which is “manually activated by an operator” to initiate rapid shutdown process.

The RSD initiator must have a visual status indication that the PV conductors are in the controlled state. This could be a status light, a display readout or permanent marking on a switch to identify its current position. The status indicator “shall be located near the actuator to ensure the operator can view the system status in a timely manner” - C22.2 No. 330.

The initiator could be:

- A control switch that is a part of a complete rapid shutdown system
- Service disconnecting means (the main breaker) on a load side connected system
- PV system disconnecting means (the dc switch on the inverter)
- A properly rated switch that plainly indicates whether it is in the “off” or “on” position.
- Depending on system capacity, this could be a small ac disconnect switch up to a large ac disconnect switch with integral shunt trip capability.

The location of the initiation device must meet 64-218 (4).

The initiator cannot be:

- A pull-out type of switch (such as those used for air conditioners)
- The electrical meter (pulling the meter)

3. 64-222 and STANDATA LEG-ECR-2 http://municipalaffairs.gov.ab.ca/documents/330-LEG-ECR-2-rev25.pdf

Purpose:

The purpose of this information is to clarify the approval requirements for Photovoltaic (PV) systems racking and rails.

Code references:

64-222 Photovoltaic module bonding (see Appendix B)
1) Exposed, non-current-carrying metal parts of photovoltaic modules shall be bonded to ground.
2) Module bonding connections shall be as specified in the module installation manual.

3) Notwithstanding Subrule 2), bonding connectors intended for bonding photovoltaic modules and installed in accordance with the manufacturer's instructions shall be permitted to be used.
4) The connections to a photovoltaic module shall be arranged so that removal of a photovoltaic module from a photovoltaic source circuit does not interrupt a bonding conductor to other photovoltaic source equipment.

Appendix B

Rule 64-222
CAN/CSA-C22.2 No. 61730-1 requires all conductive parts of a module that are accessible during normal use to be bonded together and the method of bonding to be detailed in the installation manual. During the approval process, all components, such as bonding clips, brackets, hardware, lugs, etc., used for bonding are tested in accordance with CAN/CSA-C22.2 No. 61730-2.

Discussion:

PV racking products have appeared in Alberta that have no evidence of approval and without manufacturer's installation instructions.

The racking of a modern PV system is part of a bonding grid with the rail or rack itself utilized as a bonding path. Modules are attached with clamps c/w bonding clips that, when bolted down, simultaneously secure the equipment to the rail and electrically bond adjacent modules and the underlying rail. Module level power electronics such as micro-inverters and dc-dc optimizer bonding can also be accomplished utilizing this method. This system eliminates separate bonding conductors connected to each piece of equipment and minimizes running equipment bonding conductors throughout PV arrays. A single bonding conductor is run to the array and would be connected at one or more points of the rack or rail following the manufacturer's installation instructions.

Interpretation:

PV module racking systems are required to be approved. Any one of these approval processes are currently acceptable for PV racking systems:

a. Certified by a Certification Body accredited by the Standards Council of Canada;
b. Special Inspection by an Inspection Body accredited by the Standards Council of Canada under SPE 1000 to test for bonding/grounding with a separate structural engineering evaluation for the structural capabilities of the racking.

An array is an assembly of specific compatible components that have been tested as a system. All the parts of an array such as modules, racks and clamps are listed as "components" intended for use in end-product equipment. When an end-product evaluation is conducted by a Certification Organization, the suitability of these components is determined in that evaluation. Standards UL 2703 for racking, ULC/ORD-C1703 for modules and CSA-C22.2 No. 41 bonding & grounding equipment are all used together to investigate products as a system.

In order for the terms of the equipment approval agreement to be met, the manufacturer must provide installation instructions, and those instructions must be followed. The instructions will address the structural and electrical installation along with information about compatibility of components for use with their racking system.

For example, the installation manual may have a list of specific manufacturer's modules that are compatible with the racking system. You also may be able to use any ULC/ORD-C1703 module as long as they are within specific dimensional tolerances. Only those modules that meet the criteria laid out in the installation manual can be used with that racking system. Bonding must be completed using the methods and devices (such as lay-in lugs and washers) as specified in the manuals.

When applying for a PV system permit, applicants should provide the AHJ with a complete list of all equipment. Installation manuals should be reviewed pre-construction and referenced during the installation to ensure that the system has been installed according to the manufacturer's instructions and all the equipment is compatible.

Ground Mount Systems and Carports

It is common for ground mount system manufacturers to utilize UL 2703 racking equipment and CSA-C22.2 No. 41 bonding & grounding equipment. The structural element requirements would be met with Professional involvement with a site specific stamped structural drawing. Large ground mount systems are custom designed for the site with local consideration for terrain, wind pressures, snow loads as well as racking layout for the most efficient design. For smaller low-risk ground mount systems such as those found on farms, Professional involvement is normally not required for the mounting structure.

This INTERPRETATION is applicable throughout the province of Alberta.