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Industrial Control Panels for North America

Implementing current Canadian standards successfully

White Paper I March 2018

The world of Canadian standards for industrial control panels and machinery has undergone significant further development since 2016. The requirements for panel and machine builders have been refined with the issuance of two new standards: CSA C22.2 No. 286 for control panels (Industrial control panels and assemblies) and CSA C22.2 No. 301 for industrial machinery (Industrial electrical machinery). In this white paper, you will learn about important specifics you must observe when undertaking electrical planning for a control panel in conformance with the new Canadian standards.

A white paper from: Siemens.

Contents

Market access and general conditions

Market access conditions

In Canada, it is not just various laws that must be complied with, but also local regulations and standards. If these standards and laws are not complied with, authorities will not issue an operating permit. Without this permit, the equipment or machinery is not permitted to be connected to the supply circuit or put into operation.

The most important standard in Canada for an electrical installation is the Canadian Electrical Code, or CEC for short. The CEC has the effect of law, and its use is mandatory. It can be seen as the counterpart to the National Electrical Code (NEC) in the United States.

Conformity with national safety standards does not release the manufacturer from product liability, but does document that the manufacturer has complied with its duty of care, which can prove useful to the manufacturer in a possible product liability case.

Important Canadian authorities and organizations

Compliance with laws and codes is inspected by the authorities having jurisdiction in the respective provinces, districts and counties. The Canadian Electrical Code (CEC) calls them generally as **inspection departments**. In Ontario, Canada's most important industrial province, all inspection departments are administered by the **Electrical Safety Authority** (ESA).

On behalf of the inspection departments, so-called **electrical inspectors** approve equipment before their initial connection. According to the CEC definition, an electrical inspector is any person duly appointed by the inspection department for the purpose of enforcing the CEC.

The **Standards Council of Canada** (SCC) certifies accredited testing laboratories – the so-called "accredited certification organizations" in Canada. These accredited certification organizations test products and certify panel builders and even complete control panels. They are always certified only for tests or preliminary approvals according to specific standards. By applying their certification marks to an item of equipment, they declare its conformity with the CEC. For this reason, they are very helpful to electrical inspectors of the inspection departments when deciding whether to authorize the putting into service of equipment. You can find the list of accredited testing laboratories on the SCC homepage (www.scc.ca). There, you will also see the standards for which the respective accredited testing laboratory is permitted to test.

CSA is the **Canadian Standards Association**. Among other things, it publishes various standards – both application standards including the Canadian Electrical Code (CEC) and product testing standards accepted in Canada. For products to be used in Canada, they must be tested according to the specifications of the product testing standards. Testing is done by accredited testing laboratories in Canada, which include CSA itself. CSA also certifies panel builders for the Canadian market.

Approval options

According to the CEC, equipment must be approved by an electrical inspector of the inspection department having jurisdiction, or it can be approved by a specially certified testing laboratory under certain conditions.

Approval by the electrical inspector

A preliminary test for export to Canada is not required by law. Thus, you have the option of exporting the control panel to Canada without a preliminary test. This is the lowest-cost solution but also the most risky one with regard to successful approval, and we only recommend it if you have sufficient experience with the Canadian standards.

If you are not familiar with the standards in Canada and have entered into a contract with the customer that stipulates time conditions for putting equipment into service (e.g. contractual penalties), you can have a customized preliminary test performed by an accredited testing laboratory in your own factory before delivery of your equipment. In case of objections, you can implement the necessary rework relatively easily in your own factory. After a passed preliminary test, the accredited testing laboratory will mark your equipment with a label that indicates to the electrical inspector that the equipment conforms to all applicable Canadian standards. Typically, the electrical inspector will readily approve the equipment.

If large quantities of identical control panels are to be made in series production, it may be beneficial to have a preliminary series test performed by the accredited testing laboratory. Then all structurally identical control panels of the series will be provided with a label. In this case as well, the advantage lies in the faster and more straightforward approval by the electrical inspector. However, a disadvantage is that subsequent changes to the control panel are not possible.

Alternatively, a control panel manufacturer can itself be certified by an accredited testing laboratory. It is then periodically audited by the testing organization. After a certain amount of time, it is able to apply certification marks on its own. This approach also simplifies approval by the electrical inspector.

Special field inspection: Final approval by an accredited certification organizations certified by the SCC

In addition to the final approval by the inspection department, the CEC also provides for approval of equipment by an accredited certification organizations under the following two conditions:

1. The chosen accredited certification organizations is not only a testing laboratory certified by the SCC but is also authorized to approve equipment according to SPE-1000 (Model code for the field evaluation of electrical equipment).
2. These special inspection bodies must be recognized by participating provincial and territorial authorities having jurisdiction (inspection departments)

Before the equipment is exported, it is already designed, tested, inspected and approved at the manufacturer's factory by the special inspection body. After the equipment is marked with a "SPECIAL INSPECTION SERVICE" label and the inspection department receives the inspection report. Once the equipment has been transported and installed at the customer's facility, the final approval by the certified testing laboratory takes place.

Example of an SPE-1000 label

Source: Canadian Electrical Code Handbook 2015

The most important Canadian standards

Canadian application standards on the move

Until recently, the standards to be followed when building industrial control panels and machinery for Canada were straightforward. To successfully pass inspection by the electrical inspector, an industrial control panel had to consist of components approved for the Canadian market and meet the relevant requirements from the Canadian Electrical Code (CEC) and the CSA C22.2 No. 14 (Industrial Control Equipment) standard, which in reality is merely a product testing standard.

In practice, this often led to uncertainty, as there were no statements to be found in the applicable standards regarding the implementation of many control panel and machinery applications. Up to now, control panels were certified only in accordance with C22.2 No.14. This industrial control equipment standard is formulated primarily for switchgear and not for industrial control panels.

The Canadian Standards Association (CSA), remedied this situation with the publication of two new standards:

- February 2015: Publication of CSA C22.2 No. 286-15 Industrial control panels and assemblies (updated in 2017 as CSA C22.2 No 286-17)
- January 2016: Publication of CSA C22.2 – No. 301-16 Industrial electrical machinery

Both standards have been listed in Appendix A of the 2018 CEC since January 2018. They will become mandatory after a transition time (by 2022 for C22.2 No. 301).

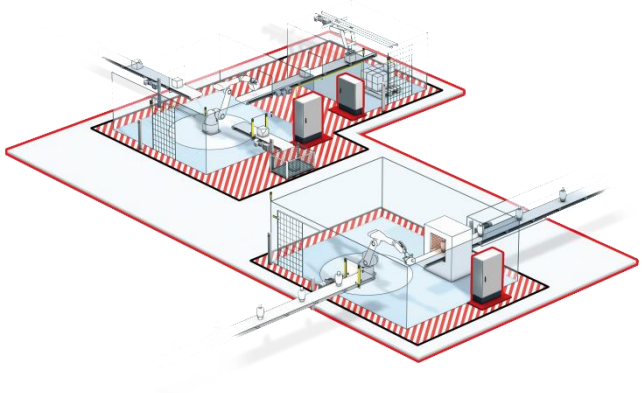
As a result, the following standards in Canada are of vital importance to panel and machine builders:

- CEC (Canadian Electrical Code) for electrical installation on site (required by law)
- CSA C22.2 No. 286 for control panels (Industrial control panels and assemblies)
- CSA C22.2 No. 301 for industrial machinery (Industrial electrical machinery)

Current standards

The following table summarizes the currently applicable versions of the standards (status as of: March 2018)

Standard	Last revised
CEC Part I (CSA C22.1)	2018
CEC Part II (CSA C22.2 No. 0)	2010
CSA C22.2 No. 286	2017
CSA C22.2 No. 301	January 2016



Legend:

- CEC
- CSA C22.2 No. 286
- CSA C22.2 No. 301

CSA C22.2 No. 286

CSA C22.2 No. 286 is defined as an application standard for the design of control panels with a maximum voltage of 1,500 V AC or DC, but is not to be applied to the rest of the equipment. The scope excludes control panels in hazardous locations and is limited to ambient temperatures of 0 °C to 40 °C.

The standard is structured as follows:

INTRODUCTION: Contents, technical and integrated exclusions, preface, etc.

Section 1: SCOPE
Section 2: REFERENCE PUBLICATIONS
Section 3: DEFINITIONS
Section 4: CONSTRUCTION REQUIREMENTS
Section 5: MARKINGS
Section 6: SPECIFIC APPLICATION REQUIREMENTS
Section 7: Testing

Appendix A French translations of cautions, warnings and safety instructions
Appendix B: Examples of wiring space and wire-bending space
Appendix C: Calculating available fault current
Appendix D: Guidelines for the use of supplementary protectors
Appendix E: Production line dielectric strength testing

Section 4, which describes the construction requirements, is particularly important.

CSA C22.2 No. 301

CSA C22.2 No. 301 is the relevant standard in Canada for electronic components of industrial machinery and equipment up to 1,000 V in normal ambient conditions.

The most important subjects addressed by the standard are as follows:

Section 5: Supply circuit, disconnecting means, excepted circuits
Section 6: Personal protection, enclosures, door interlocking
Section 7: Equipment protection, main circuit/control circuit ratings
Section 10/11: Operator interfaces, control equipment
Section 12/13: Conductors and cables/wiring methods
Section 14/15: Motors and associated equipment, mechanical brakes, servo drives and motors, motors in combination with converters
Section 16: Receptacles and lighting
Section 17: Nameplate, marking and warnings

Product testing standards and product selection

These are important primarily for component manufacturers because components must comply with certain product standards, depending on their use purpose, before they may be used in equipment in Canada. However, it is not just the component manufacturer that must ensure that requirements applicable to the components are met. The panel builder must also ensure this through proper selection of components. In the latter case, the use of certified ("listed" or "labeled") devices alone is not enough.

Depending on their use purpose, components that are installed in the control panel must be tested according to product testing standards referenced in the application standards. As a consequence, components are subject to use limitations that must be taken into account.

Components can be explicitly assigned to their use purpose based on their designation, the applicable product testing standard and the class number. You can find this information in the general product approvals for the Canadian market (Certificate of Compliance) that you receive from the manufacturer or in the CSA database for listed products (CSA Group Product Listing, www.csagroup.org).

To deal with the variety of products efficiently, you should know engineering-relevant information about the equipment in addition to the relevant product testing standards. These informations must be requested from the customer.

Certification marks

In principle, the certification marks of all accredited certification organizations are accepted in Canada, including TÜV and UL, for example. Below is an overview of the most common certification marks:

	Products that bear this mark have been tested by CSA and found to meet the requirements of Canadian product testing standards.
	You can find this symbol on a component that has undergone successful testing by CSA according to product testing standards of CSA and additional to the U.S. (UL) product testing standards. Components with this label can be used in Canada and the USA.
	Devices that bear this symbol were successfully tested by UL according to Canadian and U.S. product testing standards and may be used in both countries.
	Products bearing this mark have been tested by CSA in accordance only with U.S. product testing standards. They are therefore not permitted to be used in Canada.

Units, definitions and other specifics

Units

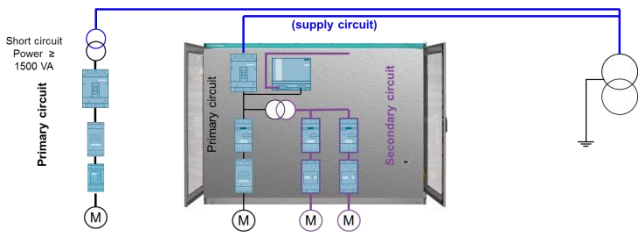
Although Canada officially switched to the metric system many years ago, the CSA standards still use many imperial system units, such as horsepower for motors and AWG/kcmil for wire cross-sections. In other cases, physical units from the metric system, such as temperature in °C, torque in Nm, and length in mm, are used.

Power supply systems

There are a variety of power supply systems in Canada whose designations do not correspond to the usual designations in IEC standards (e.g. TN-S, IT, TT, TN-C systems). You can find an overview of Canadian power supply systems in the CEC, Appendix B, and in C22.2 No. 301, Annex B, Grounding and Bonding. Because knowing the power supply systems is essential for selecting the overcurrent protective devices, you should agree on this with the equipment owner in the run-up to the planning phase. In the Canadian CoC of the protective devices, you can see the voltage for which the protective devices are approved.

Primary and secondary circuits

C22.2 No. 286, Section 3, distinguishes between the primary circuit and the secondary circuit.
A primary circuit is defined as the complete wiring and all the components up to the load that are connected directly to the supply circuit. A secondary circuit is defined as the wiring and components connected to a circuit whose power is isolated from the primary circuit by a transformer or similar device and is limited to a maximum of 1500 VA.



Grounding

The Canadian standards use the terms grounding, bonding and neutral when addressing the power supply system, fault protection wiring and equalizing voltage potential to earth. Detailed procedures, e.g. for dimensioning, design and marking, are described in all three relevant standards:

- CEC, Section 10 Grounding and Bonding
- C22.2 No. 286, Section 4.3
- C22.2 No. 301, Section 8

Important: C22.2 No.286, Section 3 distinguishes between a primary equipment bond and secondary equipment bond.

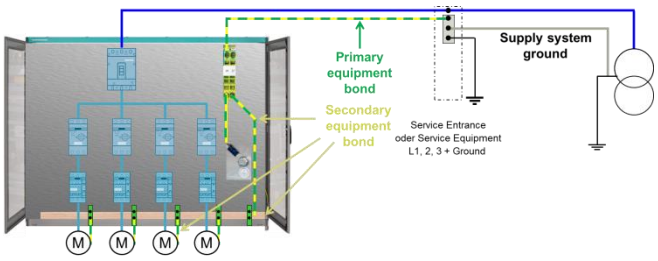
Primary equipment bond

"The bonding means that maintains the non-current-carrying parts of the equipment at the same equipotential the supply system ground." (Definition C22.2 No. 286)

Secondary equipment bond

"All other bonds within the equipment that maintain the non-current-carrying parts of the individual components and devices within the equipment at the same equipotential as the main bond, and is supplied as part of the final assembly." (Definition C22.2 No. 286)

This secondary equipment bond is an integral component of the final assembly of the equipment.



Branches with motor load

According to CSA 22.2 No.14, Table 42, a motor branch is designed in six different standardized ways (Construction Types A to F):

Table 42
Various constructions of combination motor controllers

Component parts *	Construction type					
	A	B	C	D	E ‡	F§
Disconnecting means	Manual discon-nect†	Manual disconnect†	Circuit breaker	Circuit breaker	Self-protected control device	Self-protected control device
Short-circuit protective device	Fuse	Motor short-circuit protector	Inverse-time trip circuit	Instantane-ous-trip circuit		Self-protected control device
Motor controller	Magnetic or solid state	Magnetic or solid state	Magnetic or solid state	Magnetic or solid state		Magnetic or solid state
Overload protection	Overload relay	Overload relay	Overload relay	Overload relay		Self-protected control device

** These are certified components in accordance with the applicable CSA standards.*
† The manual disconnect shall comply with Clause 4.9.12.
‡ The Type E self-protected control device performs the functions of all four component parts.
§ See definition in Clause 4.11.1.10.

The motor branch has to be configured based on the motor values, ideally determined from the load.

Markings

The most important requirements for marking an industrial control panel for Canada can be found in Section 5 of C22.2 No 286.

A specific marking requirement that applies generally in Canada is that all warning signs shall be implemented in both English and French. The French translations of the warning signs can be found in Annex A of C22.2 No. 286.

Example of a required marking of a supply terminal for connection of a grounded wye system in English and French:

5.20	WARNING: FOR CONNECTION TO A SOLIDLY GROUNDED WYE SYSTEM ONLY
	AVERTISSEMENT : DOIT ÊTRE RELIÉ SEULEMENT À UN SYSTÈME BRANCHÉ EN ÉTOILE ET SOLIDEMENT MIS À LA TERRE

Short-circuit current ratings in Canada

General information regarding short-circuit current rating

Section 4.13 of C22.2 No. 286, the application standard for industrial control panels, describes how the short-circuit current rating (SCCR) of a control panel is determined. The important thing here is that the SCCR corresponds to the maximum possible short-circuit current in the supply circuit, which must be specified by the owner of the equipment.

The SCCR is determined in the following 3 steps:

Step 1: Determination using standard SCCR of the relevant components

The standard SCCR of all components in the main circuit must first be determined. The SCCR-relevant components include circuit breakers, contactors, overload relays and solid-state switching devices as well as terminals, busbars, the incoming side of control transformers and frequency converters.

You can find the standard SCCR values for contactors in Table 9 of C22.2 No. 286 and for all other components in Table 10. In general, of all the SCCR-relevant components, the one with the lowest SCCR value determines the overall SCCR value for the industrial control panel. To put it another way: all the SCCR-relevant components must have at least a short-circuit current rating that corresponds to the maximum short-circuit current occurring in the supply circuit.

Step 2: Increase of the SCCR of components through use of tested combinations, so-called high capacity short circuit ratings

If components whose SCCR is less than the available maximum short-circuit current at the point of supply are identified in the power circuit, the most useful approach in practice is to check whether the component involved has been tested by the manufacturer with an upstream protective device for a high capacity short circuit rating.

For many devices such as contactors, soft starters, solid-state contactors and overload relays, these specifications can be found in the "Certificate of Compliance (CoC)". The CoC is prepared by CSA for the manufacturer of the respective component and must be made available to the user by the device manufacturer. You can find the CoCs of Siemens' devices in Siemens Industry Online Support.

Step 3: Reduction of the maximum possible short-circuit by current-limiting devices

In contrast to the specifications of UL 508A in the USA, for example, only transformers are permitted as current-limiting devices in Canada.

The possible approach is described in Annex C.1: There you will find a table from which you can take standard values for the transformers. Alternatively, a calculation method is also specified here.

Further information from Siemens!

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Siemens Industry, Inc.
Digital Factory Control Products
5300 Triangle Parkway NW

Norcross, GA 30092