Canadian Electrical Code, Part I
Full Impact Assessment

Subject 3660
Rule 8-102 — New voltage drop calculations

CONTENTS

1 INTRODUCTION TO THE FULL IMPACT ASSESSMENT

The Full Impact Assessment follows the rationale of the Canadian Electrical Code Ranking Tool (CRT) and provides supporting information to validate the rankings of the CRT. It includes all the questions of the CRT either verbatim or modified. However, the scope of the Full Impact Assessment extends beyond that of the CRT and, therefore, the assessment includes additional questions that may help to substantiate the rankings.

The CRT is referenced throughout the Full Impact Assessment. The questions from the CRT are identified in the Full Impact Assessment by numbers in parentheses. Whenever applicable, chapter titles also include references to the relevant sections of the CRT.

The Full Impact Assessment follows the sequence of the CRT as closely as possible but, to enhance the analytical function of the document, risk-related and benefits-related questions have not been separated in the Full Impact Assessment.

2 PURPOSE OF THE FULL IMPACT ASSESSMENT

The purpose of the Full Impact Assessment is to provide the provinces and territories with an enhanced rationale and detailed assessment of a particular change to the *Canadian Electrical Code, Part I* (*CE Code, Part I*). This assessment is submitted for review to provincial and territorial regulatory authorities to aid with their adoption process for the Code. Jurisdictions may decide to conduct further analyses or to hold additional consultations.

3 BACKGROUND OF THE CHANGE

Section 8 is a general Section of the Code that provides requirements specifying ratings for electrical equipment supplying various types of loads and covering conductor ampacities for consumer's services, feeders, and branch circuits.

The impedance of circuit conductors creates a voltage drop in a circuit. This can result in lower than satisfactory voltage at the load or equipment, unless suitable preventive measures are applied. In general, low voltage decreases the operating efficiency of electrical equipment such as motors, heating systems, electronic equipment, and lighting systems. Establishing criteria for maximum allowable voltage drop in a circuit ensures that the required utilization voltages for the electrical installation are provided to obtain optimum performance from electrical equipment.

Rule 8-102 provides basic parameters to ensure that the utilization voltage for electrical equipment is within required values. Voltage drop, for the designer and installer, is a calculated value based on the impedance of the conductor and the current flowing in the conductor. According to Ohm's Law, if the conductor size remains the same and the current is increased,

or if the current remains the same and the conductor size is reduced, the voltage drop increases. Subrule (1) requires that the voltage drop calculation be based on the calculated demand load on the feeder or branch circuit and sets the maximum percentages allowed in the installation.

4 THE NATURE OF THE CHANGE

4.1 The change

(A) Revise Rule 8-102 as shown below:

8-102 Voltage drop (see ~~Appendix~~Appendices B and D)

~~(1) Voltage drop in an installation shall~~

~~(a) be based upon the calculated demand load of the feeder or branch circuit;~~

~~(b) not exceed 5% from the supply side of the consumer's service (or equivalent) to the point of utilization; and~~

~~(c) not exceed 3% in a feeder or branch circuit.~~

~~(2) For the purposes of Subrule (1), the demand load on a branch circuit shall be the connected load, if known; otherwise it shall be 80% of the rating of the overload or overcurrent devices protecting the branch circuit, whichever is smaller.~~

(1) The voltage drop in an installation shall be based on the connected load of the feeder or branch circuit if known; otherwise it shall be based on 80% of the rating of the overload or overcurrent device protecting the branch circuit or feeder, and not exceed

(a) 3% in a feeder or branch circuit; and

(b) 5% from the supply side of the consumer's service (or equivalent) to the point of utilization.

(2) Notwithstanding Subrule (1), where overcurrent devices are selected in accordance with other Sections of this Code, the voltage drop shall be based on the calculated demand load of the feeder or branch circuit.

(3) Notwithstanding Subrule (1), wiring for general-use branch circuits rated at not more than 120 V or 20 A in dwelling units, with the conductor length measured from the supply side of the consumer's service to the furthest point of utilization in accordance with the values in Table 68, shall be acceptable.

(4) Notwithstanding Subrule (1), at industrial establishments where conditions of maintenance and supervision ensure use by qualified persons, the design shall ensure that the voltage at the point of utilization is within the rating or voltage tolerance of the connected device(s).

(B) Add an Appendix B Note to Rule 8-102(2) as follows:

It is intended by this Subrule that, when overcurrent devices for feeders and branch circuits are selected such that their rating is greater than the ampacity of the load due to

the nature of the equipment they feed (e.g., motors, transformers, and capacitors), the permitted voltage drop should be calculated on the demand load of the feeder or branch circuit and not on the overcurrent device feeding the feeder or branch circuit.

(C) Add an Appendix B Note to Rule 8-102(3) as follows:

Experience indicates that the voltage drop of lighting and general-use branch circuits in dwelling units will meet the requirements of Rule 8-102(1) when the conductor length from the supply side of the consumer's service to the furthest point of utilization is less than or equal to the values in shown in Table 68.

This Rule is not intended to apply to branch circuits for the following:
(a) household appliances (e.g., refrigerators, washing machines, central vacuum systems, and other receptacles as per Rule 26-722);
(b) kitchen receptacles [Rule 26-724(b) and (e)];
(c) electrical heating and cooking appliances (Rule 26-744); and
(d) other specific receptacles installed in dwellings, such as those dedicated for medical devices.

Rule 8-102(1) and Table D3 are applicable to these branch circuits excluded from Rule 8-102(3), based on either the connected load, or one load equal to 80% of the rating on the overcurrent device, connected at the furthest point.

It is intended by this Subrule that when the load on a circuit or feeder is unknown, the load value used in determining the voltage drop calculation should be based on the maximum loading permissible in accordance with Rule 8-104.

Further analysis has shown that these values will not affect the operation of the branch circuit overcurrent protection.

(D) Add the following Table:

Table 68
Maximum conductor length measured from the supply side of the consumer's service to the furthest point of utilization on a circuit using 90 °C rated copper conductors at 30 °C ambient temperature for 120 V single-phase ac circuits (2-wire circuits) when used in dwelling units
(See Rule 8-102.)

Conductor size, AWG	Maximum conductor length, m Overcurrent protection setting/rating	
	15 A	20 A
14	38	—
12	60	50
10	96	78

4.2 How is it different from the status quo?

Currently, Rule 8-102 reads as follows:

8-102 Voltage drop (see Appendix D)
(1) Voltage drop in an installation shall
(a) be based upon the calculated demand load of the feeder or branch circuit;
(b) not exceed 5% from the supply side of the consumer's service (or equivalent) to the point of utilization; and
(c) not exceed 3% in a feeder or branch circuit.
(2) For the purposes of Subrule (1), the demand load on a branch circuit shall be the connected load, if known; otherwise it shall be 80% of the rating of the overload or overcurrent devices protecting the branch circuit, whichever is smaller.

5 PURPOSE/REASON FOR THE CHANGE

5.1 What is the issue that the change is intended to address?

Many electronic devices, such as computers and LEDs, are voltage sensitive. They have a narrow voltage range, outside of which they do not operate. As a result, installers have to be precise in calculating the allowable voltage drop. This can be challenging, and the change is designed to help with the calculations.

At the same time, equipment within certain industrial environments can, with appropriate design and maintenance, operate satisfactorily with a voltage drop greater than the 5% permitted by the current Rule. In such environments, unnecessary installation (cabling) costs have been incurred to limit voltage drop to 5%, in accordance with the Rule.

In addition to the proper operation of voltage-sensitive electrical equipment, the purpose of the voltage drop Rule is to ensure that overcurrent devices operate as fast as possible in the event of a short-circuit. The Rule is also intended to address issues such as emergency lighting (to ensure proper luminance for egress) and electric heating used to keep pipes from freezing.

5.2 How does the change accomplish the desired results?

The new Table 68 is being introduced to make it easier for users to comply with the voltage drop Rule when they are performing voltage drop calculations. The calculations on which the table is based are derived from the length of the cable. In addition, the new Rule also permits greater flexibility in voltage drop calculations for oversized overcurrent devices for feeders and branch circuits feeding larger equipment.

5.3 What are the implications/consequences if action is not taken?

If the status quo persists, Code users will continue to experience difficulties in calculating voltage drop, which may lead to equipment malfunctioning, potential safety issues, and unnecessary installation costs.

6 WHY IS ACTION REQUIRED AT THIS TIME?

While no new technology is involved in the change, the electrical industry has been advocating it on the grounds of enhancing the global competitiveness of Canadian industry. Optimal functioning of voltage-sensitive equipment is another element of the rationale.

This initiative is not driven by a particular deadline.

7 (14) PREVALENCE OF RULE USE IF ACCEPTED

The Rule will be used on a daily basis in all environments addressed by the Code.

8 IMPACT ON KEY STAKEHOLDERS

8.1 (16) Largest type of stakeholder who would benefit

In the short term, electrical engineers/designers and contractors will be the largest groups who will benefit from the change:

- **Engineers/Designers**: This group is interested in providing cost-effective and safe designs and installation requirements to minimize the risk of injury to personnel, damage to facilities, and insurance and legal costs. As such, engineers/designers will need to receive a communication about the change (e.g., a formal letter from the authority having jurisdiction).
- **Electrical contractors**: This group of stakeholders is responsible for the application of the Code. As such, they need to be informed about changes to it to help ensure full compliance with its requirements. The updates can be delivered through formal training or through industry literature, depending on current practices in a particular jurisdiction. It is the responsibility of individual contractors to keep themselves informed about changes to the Code.
- **Installation owners**: In the long term, this group, in particular industrial users such as the oil and gas industry, will likely benefit from the cost savings.

8.2 (24) Largest type of stakeholder who would be negatively affected

No stakeholder group that would be negatively affected has been identified.

8.3 (15) Other stakeholders affected on a frequent basis

The change will affect a broad range of stakeholder groups, as follows:

- **Trainers:** This is a broad group that may include those providing training to other stakeholder groups, such as electrical contractors and installers of equipment as well as repair and maintenance personnel where applicable. Training programs and literature, including electronic content, will need to be updated to include the change.
- **Other standards development organizations (SDOs)**: All references to the provisions of the Code that are being changed will need to be updated in documents published by other SDOs.
- **Provincial/territorial electrical regulatory authorities:** This group of stakeholders is responsible for enforcement of the Code and will, therefore, need to be informed of changes to it.
- **Insurance**: Insurance policies contingent on following the Code will need to be updated.
- **Builders**: This group will need to be informed of the change because the new requirements will have to be implemented in new construction.
- **Inspectors**: This group of stakeholders is accountable for enforcing compliance with the Code and needs, therefore, to stay informed about changes to it. It is the responsibility of a particular province or territory to make the information on Code changes available to electrical inspectors. Depending on the practice in a particular jurisdiction, changes can

be communicated through training (provided by the jurisdiction or a third party) or through jurisdiction-specific or national industry literature.

8.4 Is the proposed change limited to a specific group/geographic area?

The change will have nationwide application.

8.5 What is the affected stakeholders' readiness to act on the change(s)?

Research has not revealed any evidence of the market not being ready to implement this change.

8.6 Recommended stakeholder management strategy

Not applicable.

8.7 Communication and implementation plan

Not applicable.

9 ANALYSIS OF ANTICIPATED ECONOMIC IMPACT

9.1 (20) The jurisdiction or stakeholder's ability to compete, based on incompatibility with other standards

The change should not affect a jurisdiction's competitive position.

9.2 (21) Complexity of implementation (is training required to implement the Rule?)

The change can be included as an update in existing training programs. No specific training is recommended to introduce the change.

9.3 (22) Total costs to implement (for example, cost to install, educate, manufacture, inspect, purchase additional product, and of the increased use of electricity)

The change is expected to reduce implementation costs.

With regard to training, while it is important that the change be communicated to all the relevant stakeholder groups, this can be done in the course of routine training on changes to the Code. No dedicated training is necessary.

10 IMPACT ON BUSINESS: LARGE AND SMALL (IF APPLICABLE)

- **Compliance costs:** No additional costs are expected to result from compliance with the change. In fact, compliance may help to reduce project costs as well as costs for equipment maintenance and replacement**.**
- **Change of investment:** Not applicable.
- **Job creation/job loss:** Not applicable.
- **Labour mobility:** Not applicable.
- **Impact on import/export of goods:** Not applicable.
- **Certification and licensing:** Not applicable.
- **Insurance:** Not applicable.

11 WHAT IS THE PRACTICE/EXPERIENCE IN OTHER JURISDICTIONS?

11.1 Are standards consistent with (or lesser/greater than) other jurisdictions?

Currently, there are no deviations from this requirement of the national Code in provincial electrical codes. Input from other jurisdictions is pending.

11.2 (23) Conflict with other Ministries or Codes

No conflict has been observed.

11.3 Consequences for other Departments/Ministries, e.g., apprentice training

Not applicable.

11.4 Consequences for other Codes from other jurisdictions (US, European standards)

Not applicable.

12 CONSULTATION PROCESS

Representatives from the following groups of stakeholders were involved in the consensus approval of this change as part of CSA Group's standards development process:
Note: *For details about the standards development process as it applies to the* CE Code, Part I*, please refer to Appendix C of the Code.*

- Regulatory authorities from various provincial, territorial, and municipal electrical inspection authorities
- Owners/Operators/Producers from groups with national stature, representing the viewpoints of electrical equipment manufacturers, electrical installation designers and installers, and electrical installation users
- General interest groups with national stature, representing the viewpoints of

  (a) fire chiefs;
  (b) electric utilities;
  (c) committees responsible for related electrical codes and standards;
  (d) fire insurers;
  (e) labour;
  (f) issuers of building codes; and
  (g) educators.

A regulatory/legislative body may want to hold additional consultations with all or some of these groups within its jurisdiction to clarify issues specific to the jurisdiction.

13 PROPOSED EFFECTIVE DATE OF CHANGES

The change will be included in the 2015 edition of the *CE Code, Part I*, to be published in January 2015.

APPENDIX 1 — CODE RANKING TOOL VALUES

Subject #	**3660**
Reason for Change	
Safety consideration (Severity)	3
Safety consideration (Frequency)	8
For clarity	6
Crucial to harmonize	7
Purely administrative	3
Community's desire to change - Environment, Health, Safety	5
Technological change/New Rule	8
Total Score for Reason for Change	40
Extent of Use & Value Add	
Prevalence of rule use if accepted	10
Number of stakeholders affected on frequent basis	10
Largest type of stakeholder who would benefit	10
Benefit to society	10
Total Score for Extent of Use	40
Risk for Changing Rule/Staying Status	
The jurisdiction or stakeholder's ability to compete based on incompatibility with other standards	0
Complexity of implementation	7
Total costs to implement, e.g. cost to install, to educate, to manufacture,or inspect, increased product cost, increased cost of electricity.	1
Conflict with other Ministries or Code	0
Largest type of stakeholder who would be negatively affected	1
Total Score for Risk of Changing Rule/ Staying Status Quo	9
Total	**89**