



Canadian Standards Association
Mississauga, Ontario
To the Part I Committee

Subject No. 3096-26

Chair: R. Leduc

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Title: Selection of Electrical Equipment Ratings, Rules 8-104 and 26-X000

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Proposal:

Delete Rules 8-104(4) to (7) inclusive.

Add the following rules:-

26-X000 Selection of Electrical Equipment Rating

26-X002 Installations Above Ground

(1) The ampacity of the circuit shall be not less than the calculated demand, as obtained by the method specified in Section 8, :-

- (a) when the load is non-continuous, as determined in accordance with Rule 8-104(3), or
- (b) when the load is continuous, as determined in accordance with Rule 8-104(3), and the conductors are connected to equipment that is other than a service box, fusible switch, circuit breaker, or panelboard.

(2) When the load is continuous, as determined in accordance with Rule 8-104(3), and the conductors are connected to a service box, fusible switch, circuit breaker, or panelboard, the ampacity of the circuit shall be not less than the value obtained by multiplying the calculated demand, as determined in accordance with Section 8, by the following factor:-

- (a) when the conductors are selected according to Rule 4-004(1)(a) or (2)(a), for copper or aluminum conductors, respectively,

- 1.17, for equipment which is marked for continuous operation at 100% of the ampere rating of its overcurrent devices, or
- 1.41, for equipment which is marked for continuous operation at 80% of the ampere rating of its overcurrent devices.

- (b) when the conductors are selected according to Rule 4-004(1)(b), or (2)(b) for copper or aluminum conductors, respectively,

- 1.00, for equipment which is marked for continuous operation at 100% of the ampere rating of its overcurrent devices, or
- 1.25, for equipment which is marked for continuous operation at 80% of the ampere rating of its overcurrent devices.

- (3) The electrical equipment ampere rating shall not be less than the value determined by Subrule (1) or (2).
- (4) The conductor size selected shall have an ampacity not less than that determined by Subrule (1) or (2).

26-X004 Underground Installations

- (1) The conductor size shall not be smaller than that determined in accordance with Rule 4-004(1)(d) or (2)(d) for copper or aluminum conductors, respectively, in any case, for an ampere value not less than the calculated demand, as obtained by the method specified in Section 8.
- (2) The conductor size shall not be smaller than that required for the ampere value determined in accordance with:-
 - (a) Rule 26-X002(1), or
 - (b) Rule 26-X002(2)(a).
- (3) The electrical equipment rating shall be not less than the ampere value determined in accordance with:-
 - (a) Rule 26-X002(1) or
 - (b) Rule 26-X002(2)(a).
- (4) Notwithstanding Subrule (3), an equipment ampere rating determined in accordance with Rule 26-X002(2)(b) shall be permitted, provided also that the conductor size is no smaller than that required by Rule 26-X002(2)(b).

Reasons For Request:

- 1) There are currently no applicable rules in Part I for the selection of electrical equipment ratings connected to conductors in underground installations as there are for conductors installed above ground in accordance with Rules 8-104(4) and (5). This oversight needs to be addressed.
- 2) Current rules for the selection of equipment ratings are obscure and open to interpretation, even for installations in air.
- 3) The proposal will add the necessary rules which are missing, and will delete current confusing rules of Section 8, which imply rather than require equipment and cable ratings, and replace them with other rules which are more explicit.

Supporting Information:

The proposal was developed with consultation with Part I members Ted Olechna and Dave Clements, and it arose out of an earlier proposal under Subject 2997, which has been withdrawn.

In order to validate the approach developed here, an Excel spreadsheet was developed which applied the draft proposals and which illustrate in real numbers the concept developed in the proposal. This is to be made available to Part I members, and Section 26 members, for greater comprehension of the proposal. The spreadsheet outlines the application of the current and proposed rules in underground circuits having calculated demands from 200 amps to over 2600 amps in 5% increments. For copper conductors, the spreadsheet develops all the options for conductor sizes and equipment ratings for each selected value of calculated demand, throughout all the underground options provided in Tables D8B-D14B and above ground options of Tables 1 and 3, for 80% and 100% rated equipment. In pursuing this exercise step by step, the basis for the proposed rules become clear.

OUTLINE OF CURRENT REQUIREMENTS

Present rules for cables in air are not particularly clear, but familiarity with accepted practices for their application over time has diminished problems with their application. The rules for equipment

and overcurrent device ratings for continuous loads do not specify derating factors directly, but apply by inference through application of loading factors as derating factors by inverting the p.u loading factor. (The actual rules express the loading factor as a percentage, rather than p.u.) The complexities of rules for conductor ampacities in air are a major part of the complexity of the application of the ampacity rules for underground cables.

The application of the present rules for underground cables create some confusion on account of the following factors:

- 1) Equipment ratings are not addressed for underground ampacities in the present code, and this is a deficiency in the code which needs to be addressed. (See Rules 8-104(4) and (5), which apply only to conductors in air.) This leads to improvised, inconsistent, solutions in the field for derating factors for underground cables, for the purpose of sizing equipment.
- 2) Thermal dissipation in underground circuits is by conduction through the earth, as compared with the convection and radiation mechanisms of conductors in air. Mutual heating leads to widely divergent ampacities for any given conductor, depending on the number of buried conductors, configurations and spacings, and choice of underground raceways. In air, mutual heating is much lower, and so the range of permissible ampacities is much less for any given conductor. For this reason the range of calculated underground ampacities for any given conductor often exceeds its single conductor free air rating, and may also be lower than its wire-in-raceway rating.

FACTORS IN THE DEVELOPMENT OF NEW RULES

- 1) Even when the cables are run underground, the equipment connected to them is always in air.
- 2) Consequently, the choice of uprating factors for equipment and overcurrent devices should match those applicable in air.
- 3) Underground ampacities fall into one of 3 ranges for any given set of conductors:-
 - i) higher than "free air" ratings
 - ii) between "wire-in-raceway" ratings and "free air" ratings
 - iii) lower than "wire-in-raceway" ratings.

Sub-rule 8-104(7) lays down the "free air" rating as an upper limit for the underground ampacity, so i) effectively becomes "i) Equal to free air rating"

- 4) Logically, rules for equipment uprating factors should match those for single conductor free air ratings in range i)
- 5) In addition, rules for equipment uprating factors should **normally** match those for single conductor free air ratings for conductors in range ii).
- 6) In addition, rules for equipment uprating factors should normally match those for wire in-raceway ratings in range iii)
- 7) As an alternative to using the uprating factor outlined in item 5), in range ii) the lower uprating factors associated with wire-in-raceway ratings could be allowed provided that the conductor sizes will never be smaller than those permitted according to wire in conduit ratings. Essentially, this represents a potential trade-off of a larger conductor size for a lower equipment rating.
- 8) Section 26 is considered to be a better location for rules for the correct selection of equipment ratings than Section 8, as it addresses the correct matching of conductor and equipment ratings in the field. This also permits the designation of uprating factors prescriptively, rather than implicitly, which is the present method afforded in Section 8.

In conclusion, the exercise for the development of suitable rules for the choice of equipment ratings, particularly for continuous loads, becomes a choice between the most appropriate rules already in existence for equipment connected to conductors in air. In those cases in which the underground ampacity is higher than the wire-in-raceway ratings, the most appropriate uprating factors applied to the equipment should be those developed for the free air ratings. In those cases in which the underground ampacity is lower than the wire-in-raceway ratings, the most appropriate uprating factors applied to the equipment should be those developed for the wire-in-raceway ratings. In the intermediate zone, in which the underground ampacity of the conductor is higher than the wire-in-raceway rating, but less than the single conductor free air rating, the lower wire-in-raceway uprating factor can only be justified for the equipment when the conductor size is

not less than it would be as if it were sized from the wire-in-raceway rating. To permit a smaller conductor size based on conductor ampacity considerations alone in this zone risks overloading the equipment (although not the conductor.) In such cases, the installer has a choice between a (probably) lower equipment rating tied to a larger conductor size compared to the higher rated equipment tied to a smaller conductor size. In some cases the application of the higher and lower uprating factor to the calculated demand results in the same equipment rating, due to the finite steps in the range of available equipment ratings.

FURTHER EXPLANATION

Proposed Rules 26-X002 replace existing Rules 8-104(4) and (5). The form of the rule changes from implicit to explicit, in determining the progression from the calculated demand to the decision of conductor and equipment ratings.

Proposed Rule 26-X004(1) essentially details that there is no application of derating factors for underground ampacities for continuous loads. That is, non-continuous and continuous loads are treated the same from a conductor ampacity standpoint.

Proposed Rule 26-X004(2) places the upper limit on underground ampacities, that is that they not exceed single conductor free air ampacities of Tables 1 and 3. This rule addresses the case of both continuous loads and non-continuous loads, both of which may limit the underground ampacity. This rule replaces the current 8-104(7). However, it carries superior wording to 8-104(7), in that it is more clearly tied to both continuous and non-continuous loads, and is prescriptive rather than implicit.

Proposed Rule 26-X004(3) has no counterpart in the current rules, and the lack of such a rule is a major motivator for change. It addresses the derating factors necessary for the selection of equipment as if the installation were in air by cross-reference to rules for installations in air. The proposed rule covers non-continuous loads (Rule 26-X002(1)) and continuous loads (Rule 26-X002(2)(a)) as if the installations were in free air, as for the cable. This effectively addresses the equipment uprating factors arising out of the above "FACTORS IN THE DEVELOPMENT OF THE NEW RULES", item 5).

Proposed Rule 26-X004(4) addresses equipment uprating factors arising out of the above "FACTORS IN THE DEVELOPMENT OF THE NEW RULES", items 6) and 7). This is based on the sizing of equipment when the conductor size is determined according to the wire-in-raceway ratings.

The above proposal is the result of several months work intended to address the deficiencies of the present code requirements with respect to the selection of equipment ratings when the conductors in the circuit are installed underground. In particular the lack of appropriate rules to address continuous loads is a significant void at present. Present rules in Section 8 address continuous loads only for installations in air, as in Subrules (4) and (5).

For consistency of interpretation and ease of application, the rules for the selection of conductor and equipment ratings, for continuous and non-continuous loads, for above ground and underground installations, for 80% and 100% rated equipment, have been grouped together. By removing them from Section 8 and reconstituting them in Section 26, the rules are transformed from de-ratings applied, by inference, inversely to the calculated demand into appropriate uprating factors applied prescriptively for each situation. In my view, the required upratings of conductors and equipment have never been totally convincing expressed as demand factors, which is the scope of Section 8.

Although the proposals were developed conceptually at first, their application in the attached spreadsheet illustrates how they would be interpreted, and in doing so they validate the proposal.

This proposal addresses the same goals as an earlier proposal, still before Section 8, under Subject 2997, which can now be withdrawn.

Chair's Comments:

Before we proceed with this subject, I would like to have the Subcommittee's views on the appropriateness of this being a Section 26 subject. I would like to identify how the proposed rules relate to the "Installation of Electrical Equipment".

The title of proposed Rule 26-X000 would suggest that Section 26 may be the proper place for the proposed rules. However, as I read through the Rules, the content deals primarily with circuit loading, calculated demand, conductors...

I am not convinced that these proposed Rules would not be better served in either Section 4 or Section 8. Perhaps the Submitter(s) and the Subcommittee members could comment on this.

Subcommittee Deliberations (1st Round)

Seven (7) Subcommittee members of a possible 13 responded to the question of whether this subject belongs in Section 26. The submitter also responded.

One member and the submitter agreed that the subject should be in Section 26. Some of their rationale includes:

- Section 8 scope is really demand factors rather than rating factors. Section 8 is not the appropriate repository for deratings of equipment. Demand factors are really something quite different than deratings, which is what the subject is really all about.
- There are some grounds for connecting the issue with Section 4. In fact, the proposal contains a number of cross-references for Section 4, but only for conductors. This proposal addresses the issue of deratings of equipment even more than the application of ampacities of conductors. Were the proposal to address only conductors, the case for putting the proposal to the Section 4 Subcommittee would have some validity. There are precedents already in Section 26 for the application of factors to equipment and cable ratings, in order to arrive at the appropriate equipment rating and conductor size. They include Rules 26-210, 26-216, 26-252, 26-254, 26-256, 26-258, 26-266, and 26-756. Some of those rules address the application of factors to ampacities depending on type of equipment and the installation limitations that they impose. The proposed rule amendments can be considered complementary to rules of this type.
- The application of factors for equipment rating and conductor ampacity is dependent upon the selection of the equipment and method of conductor installation. Equipment whose nameplate indicates suitability for 100% of its nameplate rating is sized differently than for equipment not so marked, and may vary according to the choice of cable or conductor installation. It all comes together at the installation, where there needs to be compatibility of conductors, equipment, and overcurrent devices. This appears to be appropriate for Section 26.

The 6 other members disagreeing that the subject should be in Section 26 basically all felt that Section 8 was more appropriate and offered the following comments:

- A lot of work and thought have gone into this and I think we have something that can be utilized for the benefit of the code. My feeling is that the subject should be in section 8. The scope of section 8 includes conductor ampacities and equipment ratings. The proposal is seeking to deal with what has been up to now a cloudy issue with some regulators making a provincial decision on the application of the 8-104 rules to equipment. The proposal certainly makes it clear where equipment stands. However, I

spent about two hours trying to understand what it meant. To my mind, the verbiage needs some simplification.

- The scope of Section 8 states “This section covers ...conductor ampacities and equipment ratings required for consumer’s services, feeders, and branch circuits...”
- If this proposal were integrated with 8-104, it would help and make the whole thing more user friendly. It might be wise to have one set of rules for conductor ratings and another for equipment ratings. This would completely avoid confusion for code users.
- Perhaps other options should be considered in order to find an appropriate home for the intended rules. For instance, Rule 8-104(7) could be expanded and modified so as to deal with all aspects of the proposal. However, the proposed submission (in my view) is not appropriate for Section 26 S/C.

Chair’s Comments (1st round)

There are good arguments on both sides as to where this subject belongs. Another problem is the fact that Section 26 does not have a Scope, which makes it difficult to determine with clarity what type of installation practices it is dealing with. Although this is not germane to the subject, I recommend that Section 26 work on developing a Scope for the Section. Meanwhile, I must agree that the Subcommittee does have consensus that Section 26 is not the appropriate place for the proposed rules as currently presented.

I also sense that because of the complexity of the proposal, Section 8 may be the best repository for most of the proposed requirements but there may be overlap where other Sections (including 26) may be more appropriate to carry some of the rules. Perhaps a task force would be appropriate to look into how these rules need to be organized and submitted.

Subcommittee Recommendation

1. That the proposal be rejected in terms of residing entirely in Section 26.
2. That the Technical Committee on Part I consider striking a task force to explore ways and means of introducing the proposal into the appropriate section(s) the Code.