Canadian Standards Association
Mississauga, Ontario
To the Part I Committee

Subject No. 3210 Chair: R. Leduc Date: March 31, 2005

Title: Approval of Rod Electrodes, Rule 10-702(3)

Submitted by: A.Z. Tsisserev of The City of Vancouver on October 30, 2004.

Proposal: To amend Rule 10-702(3) as follows:

1) To add new subrule (a) to read:
"(a) be specifically approved for the purpose; and".

2) To renumber present paragraphs **(a)** to **(e)** as ***(b)*** to ***(f).***

3) To amend wording of present paragraph (a) which under proposal (1) will become paragraph (b) to read as follows:
"**Be not less than 15.8 mm in diameter if of iron or steel, or 12.7 mm in diameter if *of stainless steel*, non-ferrous metal or ferrous metal clad with a non-ferrous metal; and".**

Reasons for Request:

CANENA THC 99 is presently harmonizing CSA standard C22.2 No. 41 with relevant U.S. and Mexican documents.
It has been acknowledged by the THC 99 that the NEC [Article 250.52(5)] requires all rod electrodes that are less 16 mm in diameter - to be listed (i.e. approved for the purpose).

It has also been reflected during the meeting that all rod electrodes are certified by the manufacturers.
Thus, addition of new paragraph (a) will assist the installers and regulators in understanding that only rod electrodes certified for the application must be used.

It has also been pointed out during the meeting that stainless steel rods may not necessarily be considered as ferrous metals and that this fact has been recognized by the NEC.

Thus, the amendment to the current paragraph (a) will harmonize the CEC with similar provisions of the NEC.
By the copy of this e-mail to Rene I'm advising Chair of Section 10 S/C of this proposal.
By the copy of this e-mail to Brian I'm advising the CSA member of the THC 99 on my follow up to the discussion during this meeting.

Chair's Comments:
Two observations:

1. The inclusion of Part II requirements in Part I. My understanding is that Part I has a policy to avoid doing this.
2. Clause C12.13 of Appendix C of the CEC deters the use of the term "approved".

That being said, I see where the submitter is inclined to introduce this proposal. Rule 26-702 is full of Part II product requirements. Perhaps the SC has an opportunity here to do some cleaning up in this regard with concurrence from the submitter. Also, when it comes to electrodes, we basically have three kinds:

1. Those that are manufactured to C22.2 No. 41 (e.g., rods, plates, etc.): and
2. Those that are manufactured on site (e.g., copper conductor encased in concrete); and
3. Those that form part of the facility infrastructure (copper water line, well casing…

Perhaps we could also consider other electrode types recognized by IEC and the NEC such as reinforcing steel (IEC) ground ring (NEC), metal building frame (NEC).

I would like to take this opportunity to better organize the 700 series Rules in such a manner that would clean up and clarify the Rules in this series while at the same time addressing the submitter's proposal. In consultation with the submitter, we have prepared a revised proposal for TSC consideration:

(Submitter's and Chair's Revised Proposal)

Grounding Electrodes

10-700 Grounding Electrodes (see Appendix B)

(1) Grounding electrodes shall consist of:

(a) Manufactured grounding electrodes specifically approved for the purpose;

(b) Field-assembled grounding electrodes installed in accordance with this Rule; or

(c) In-situ grounding electrodes forming part of existing infrastructure as defined in this Rule.

Rationale: This subrule introduces the notion that there are basically 3 kinds of grounding electrodes: 1) those that are manufactured in a factory setting in accordance with the applicable national standard [C22.3 No. 41, Grounding and Bonding Equipment] such as rod and plate electrodes; 2) those that can be manufactured on-site using readily available materials such as bare copper conductor directly buried or encased in concrete; and 3) those where a grounding medium is already present in the form of building infrastructure such as water piping systems, well casing, etc.

(2) Manufactured grounding electrodes shall:

(a) In the case of a rod grounding electrode, consist of 2 rod electrodes (except for a chemically charged rod electrode where only one need be installed):

(i) Spaced no less than 3 m apart;

(ii) Bonded together with a grounding conductor sized in accordance with Table 17; and

(iii) Driven to the full length of the rod;

or

(b) In the case of a plate electrode, be:

(i) In direct contact with exterior soil at no less than 600 mm below grade level; or

(ii) Encased within the bottom 50 mm of a concrete foundation footing in direct contact with the earth at not less than 600 mm below finished grade.

Rationale: This Rule is introduced to accommodate current installation requirements for certified manufactured electrodes. For example, the standard does not specify that there must be 2 manufactured rod electrodes spaced 3 m apart to form a proper grounding electrode; this is an installation requirement that must be captured in the Code. Similar installation requirements are captured for plate electrodes. Note that product requirements addressed in the standard are removed from the rules.

(3) A field-assembled grounding electrode shall consist of:

(a) A bare copper conductor not less than 6 m in length, sized in accordance with Table 43 and encased within the bottom 50 mm of a concrete foundation footing in direct contact with the earth at not less than 600 mm below finished grade; or

(b) A bare copper conductor not less than 6 m in length, sized in accordance with Table 43 and directly buried in earth at least 600 mm below finished grade;

Rationale: This rule re-establishes the installation requirements for a bare copper conductor concrete encased electrode. It also introduces the ground ring concept found in the NEC article 250.53(4). This only recognizes existing practices but could serve as the place for introducing new field-assembled ground electrode concepts.

(4) An in-situ grounding electrode shall consist of:

(a) A metal underground water piping system in direct contact with earth for not less than 10 m and located at least 600 mm below grade;

(b) A metal water well casing of not less than 75 mm in diameter extending not less than 15 m below grade level;

(c) The metallic reinforcement of concrete located within the bottom 50 mm of a concrete slab or foundation footing in direct contact with earth at not less than 600 mm below finished grade; or

(d) The continuous metal frame of a building that is effectively grounded to:

(i) A manufactured grounding electrode;

(ii) A field assembled grounding electrode; or

(iii) Another in-situ grounding electrode.

Rationale: This rule recognizes existing practices of using the metal water-piping system or a water-well casing as a suitable ground electrode. It also recognizes the metallic reinforcement of concrete as recognized by the IEC 60364-5-54 clause 542.2.1. And it recognizes the metal frame of a building that is effectively grounded to any of the other electrodes… this to harmonize with the NEC Article 250.52(2).

(5) Where a local condition such as rock or permafrost prevents a rod or a plate grounding electrode from being installed at the required burial depth, a lesser acceptable depth shall be permitted.

Rationale: This Rule is a combined version of existing Rules 10-702(3)(d)(ii) and 10-702(5). However, rather than specifying conditions, it uses the defined term "acceptable". The reason for this is because of the variety of alternatives that might be available to address situations where rock bottom is encountered and the inspection authority should be making the final determination what is acceptable.

Rationale for Rule 10-700: Proposed Rule 10-700 combines existing Rules 10-700 and 10-702 and moves away from the term "artificial" (a term I've never really completely understood) in favour of distinguishing between different types of ground electrodes: manufactured, field assembled, and in-situ. It moves away from specifying product requirements (e.g., size of rods or plates).

10-702 Spacing and interconnection of Grounding Electrodes

(1) Where multiple grounding electrodes exist at a building, including those used for signal circuits, radio, lightning protection, communication, community antenna distribution systems or any other purpose, they shall be:

(a) Separated by at least 2 m from each other;

(b) Bonded together with not less than a No. 6 AWG copper conductor; and

(c) In the case of lightning protection systems, bonded together in accordance with paragraph (b) at or below ground level.

Rationale: This Rule combines Rules 10-700(2), (3) and 10-702(6). However it defaults to the minimum requirement for sizing the conductor bonding the various electrodes, # 6 AWG. Existing Rule 10-700(3) already establishes a minimum #6 as suitable for bonding the separate artificial grounding electrodes. There appears to be no technical rationale for having a different requirement where non-artificial electrodes are involved. All electrodes require the grounding conductor to them be sized in accordance with Rule 10-812… Once that is done the grounding is sufficient. Interconnecting all electrodes together only extends the equipotential plane and #6 is deemed sufficient for this purpose. Paragraph (c) maintains the "at or below ground level" stipulation for interconnecting with a lightning protection system grounding electrode.

Chair's Comment to TSC members: Can we extend the "at or below ground level" requirement to all electrodes or conversely, can we eliminate the "at or below ground level" requirement altogether?

10-704 Railway Track as Electrodes

Rails or other grounded conductors of electric railway circuits shall not be used as a

ground for other than railway lightning arresters and railway equipment, metal conduit, armoured or metal sheathed cable, metal raceway, and the like; and in no case shall such rails or other grounded conductors of railway circuits be used for grounding interior wiring systems other than those supplied from the railway circuit itself.
No Change

~~10-706 Spacing or Bonding Electrical and Lightning Rod Systems (see Appendix G)~~

~~Where practicable, a clearance of at least 2 m shall be provided between lightning rod conductors and electrical conductors and equipment, but where this separation is not possible, the ground electrodes for the two systems shall be connected together, at or below ground level, with a copper conductor of a size not less than that of the grounding conductor for the electrical system and in no case shall the bonding conductor be smaller than No. 6 AWG copper.~~

Rationale: This Rule contradicts existing Rule 10-702(6), which says that a minimum of 2 meters must be maintained between electrodes of different systems… there is no "where practicable". Furthermore the rule also suggests that if more than 2 m is maintained, bonding between electrodes of the different systems is not required; this contradicts the notion of bonding electrodes together as indicated in exiting Rules 10-700(2) & (3) and 10-708. As a result, we now default to proposed Rule 10-702.

~~10-708 Spacing and Bonding of Electrical, Communication, and Community Antenna Distribution System Grounding~~

~~Where separate artificial electrodes are provided as the grounding means for electrical, communication, and community antenna distribution systems, each electrode shall be separated at least 2 m from any other electrode as required by Rule 10-702(6) and these shall be bonded together with a copper conductor not smaller than No. 6 AWG.~~

Rationale: Redundant, covered by proposed Rule 10-702.

10-706 Use of Lightning Rod System Conductors and Grounding Electrodes (see Appendices B and G)

(1) Lightning rod conductors, driven pipes, rods, or other grounding electrodes (excluding metal water-piping systems) used for grounding lightning rod systems, shall not be used for grounding wiring systems or other electrical equipment.

Incorporates only a slight change in wording to clarify the "metal water-piping system" exclusion.

Subcommittee Deliberations (1st Round)
Only 6 SC members responded, 4 of which disagreed with the revised proposal. The main comments in disagreement stated

1. I am concerned that we would require certain types of electrodes to be "specifically approved for the purpose" just because there is a standard for them while also describing many other types of electrodes as acceptable. It would seem illogical that an electrode

would have to be specifically approved if we call it a plate, but not if we call it an in-situ electrode. It would also seem to be illogical that a metal water well casing would be acceptable but a steel piling would not. It is simply not possible to name all possible types of electrode that could be a very effective, yet to leave them out would make many very suitable devices in non-compliance with the code.

2. I think there is too much detail being added to this rule. For instance the detail that the electrode must be in the "bottom" 50 mm of the foundation. What if the foundation is a pile and the electrode is the rebar cage that is contained throughout the pile and not just in the bottom 50 mm. This kind of detail should not be in a code.

3. a) Rule 10-702(c) sounds that lightning protection electrodes have to be bonded to the all the electrodes
   b) There is a need to have grounding conductors buried a certain depth in the ground similar (250mm) or Table 53. The grounding conductor is an important part of the installation and should be protected by location.

4. Concern with extending the ground electrode to the "continuous metal frame of a building" that is effectively bonded to an electrode. There is a danger that it may be interpreted that electrical equipment mounted on the metal frame of the building would not require a bonding conductor.

Chair's Comments (for a 2nd Round)
The disagreeing votes raise some persuasive arguments. Following are the chair's comments to various aspects of the disagreeing comments.

1. I am concerned that we would require certain types of electrodes to be "specifically approved for the purpose"…

   Chair's Comment: *The requirement that electrical equipment be approved is entrenched in the Code through Rule 2-024. However, Rule 10-700 and 10-702, because of the prescriptive product requirements, have traditionally been seen as either exempted from Rule 2-024 or seen as non-electrical equipment.*

   I agree that we should not introduce barriers to what has traditionally been accepted. Perhaps we can use objective wording and re-introduce the term "or other similar devices" to recognize alternatives to "approved" or perhaps an Appendix B note that clarifies "In-Situ" and "Field-assembled" electrodes as being considered non-electrical equipment.

2. Too much detail…

   Chair's Comments: *I agree… the fact that the concrete slab or foundation is in contact with earth at or below 600mm should be enough.*

3. a) Rule 10-702(c) sounds that lightning protection electrodes have to be bonded to the all the electrodes

   Chair's Comment: *This is correct. Existing Rule 10-700(2) & (3) basically require that all electrodes be bonded together. Rule 10-700 is entitled "Grounding Electrodes" which would be all encompassing and include lightning protection electrodes.*

b) There is a need to have grounding conductors buried a certain depth in the ground similar (250mm) or table 53. The grounding conductor is an important part of the installation and should be protected by location.

Chair's Comment: *I agree that it is important to protect grounding conductors from damage. My only observation is that the grounding conductor does not present a shock hazard to persons in the same way that power conductors do. Table 53 is very prescriptive and may not necessarily apply in all situations. Perhaps here too we can use some type of language around "protection by location".*

4. Concern with extending the ground electrode to the "continuous metal frame of a building"…

   Chair's Comment: *attaching a grounding conductor to the metal frame of a structure that is effectively grounded is a well-established practice in many areas of the country… more so in industrial or manufacturing settings. The definition of 'conductor' suggests that a "form of metal installed for the purpose of carrying electric current from piece of electrical equipment to another or ground" could be interpreted to allow electrical metallic equipment mounted directly on the metal frame of a building as being bonded to ground and not requiring the bonding conductor. Although this may be appropriate in certain circumstances, it may not be in others and we should avoid any changes that might lead down the path of permitting something that should have more detailed design analysis.*

To address the concerns expressed, the Chair proposes the following changes:

1. Proposed Rule 10-700(1), (2) & (3) – stays the same

2. Proposed Rule 10-700(4) – Revise to read:

   (4) An in-situ grounding electrode shall for the purposes of Rule 2-024 not be considered "electrical equipment" and shall provide, at 600 mm or more from finished grade, a surface area exposure to earth equivalent to that of a similar manufactured electrode; and

3. Add an Appendix B note as follows:
   It is important that in-situ grounding electrodes provide an equivalent surface area contact with earth as similar manufactured electrodes (see C22.2 No. 41). Consideration should also be given the effects corrosion may have on the in-situ ground electrode impacting durability and life- expectancy.

   For example, an underground metal water piping system located at least 600 mm below finished grade and extending at least 3 m has traditionally been recognized as a suitable grounding electrode. Similarly, the metallic reinforcement of a concrete slab, concrete piling, or concrete foundation and iron pilings in significant contact with earth at 600mm or more below finished grade have also been found to be suitable in-situ electrodes.

4. Proposed Rule 10-700(5) – stays the same

5. Proposed Rule 10-702 – Revise to read:

10-702 Spacing and interconnection of Grounding Electrodes
Where multiple grounding electrodes exist at a building, including those used for signal circuits, radio, lightning protection, communication, community antenna distribution systems or any other purpose, they shall be:

(a) Separated by at least 2 m from each other;

(b) Bonded together with not less than a No. 6 AWG copper conductor protected by location from mechanical injury; and

(c) In the case of lightning protection systems, bonded together in accordance with paragraph (b) at or below ground level.

6. Proposed Rule 10-704 and 10-706 – stays the same

Subcommittee Deliberations (2nd Round)
Only 7 of a possible 13 members responded to Chair's revised proposal. With 4 members agreeing and 3 disagreeing, consensus has yet to be reached. Following is a brief accounting of the comments received:

1. Plate electrodes in concrete… what about corrosion?
2. What is the reason for an increase in length of water piping?
3. Building footings should not be used as an electrode… rebar has never been tested for ability to carry fault currents.
4. Building frame has numerous bolted connections, potentially increasing impedance.
5. In-situ electrodes should be engineered.
6. Chemical rods should not be included. Does Part II cover them?
7. The provision for in-situ electrodes has the potential of being abused.
8. Should not allow water well casings as an electrode.
9. Where the minimum clearance of 2 m between lightning rod conductors and electrical equipment conductors cannot be maintained, where is the provision that the electrodes be connected together.
10. Are we fully harmonized with the NEC?

Chair's Comments (3rd Round)
To address the comments and any minor proposed changes, the Chair will completely lay out the proposal and will included comments (highlighted) addressing the members' latest comments.

1. Replace existing Rules 10-700 and 10-702 with the following proposed Rule 10-700

10-700 Grounding Electrodes (see Appendix B)

(1) Grounding electrodes shall consist of:

(a) Manufactured grounding electrodes ~~specifically approved for the purpose~~; *(Chair's note: Clause C12.13 discourages the use of the term approved. An Appendix B note will be added to elaborate on what we mean by a "manufactured grounding electrode".*

(b) Field-assembled grounding electrodes installed in accordance with this Rule; or

(c) In-situ grounding electrodes forming part of existing infrastructure as defined in this Rule.

(2) Manufactured grounding electrodes shall:

(c) In the case of a rod grounding electrode, consist of 2 rod electrodes (except for a chemically charged rod electrode where only one need be installed): *(Chair's note: In response to the concern with chemically charged electrodes, C22.2 No. 41 Clause 4.8.2.8 has provisions for chemically charged grounding electrodes.)*

(i) Spaced no less than 3 m apart;

(ii) Bonded together with a grounding conductor sized in accordance with Table 17; and

(iii) Driven to the full length of the rod;

or

(d) In the case of a plate electrode, be:

(i) In direct contact with exterior soil at no less than 600 mm below grade level; or

(ii) Encased within the bottom 50 mm of a concrete foundation footing in direct contact with the earth at not less than 600 mm below finished grade. *(Chair's note: Clause 4.8.3 and referenced Clause 4.3.10 of C22.2 No. 41require that plate electrodes be resistant to corrosion.)*

(3) A field-assembled grounding electrode shall consist of:

(a) A bare copper conductor not less than 6 m in length, sized in accordance with Table 43 and encased within the bottom 50 mm of a concrete foundation footing in direct contact with the earth at not less than 600 mm below finished grade; or

(b) A bare copper conductor not less than 6 m in length, sized in accordance with Table 43 and directly buried in earth at least 600 mm below finished grade;

(4) An in-situ grounding electrode shall for the purposes of Rule 2-024 not be considered "electrical equipment" and shall provide, at 600 mm or more below finished grade, a surface area exposure to earth equivalent to that of a similar manufactured electrode; and *(Chair's note: This Subrule on in-situ grounding electrodes no longer references water mains, structural steel, well casings, etc. The Appendix B note does provide some clarification on water main and reinforcement steel electrodes.*
The reason for including this Subrule is to accommodate the existing provision in Rule 10-702(1) "... or other similar devices." This term was never expanded on and proposed Subrule (4) is an attempt to provide the user better direction. By using the phrase "...equivalent to that of a similar manufactured electrode", it is intended that a homemade plate should be equivalent the manufactured plate and that a homemade rod should be similar to a manufactured rod. It also is an attempt to recognize the obvious such as a steel girder or piling. This may put the onus on the user to prove to the inspector that his in-situ electrode is equivalent which may require some engineering, and if he can't do that, the use of field-assembled or manufactured electrodes is always available.
While well casing is not specifically mentioned here or in the Appendix B note, if it can be demonstrated to provide equivalency, it would be deemed acceptable as it always has in the past.)

(5) Where a local condition such as rock or permafrost prevents a rod or a plate grounding electrode from being installed at the required burial depth, a lesser acceptable depth shall be permitted.

2. Replace existing Rules 10-706 and 10-708 with the following proposed Rule 10-702

10-702 Spacing and interconnection of Grounding Electrodes

Where multiple grounding electrodes exist at a building, including those used for signal circuits, radio, lightning protection, communication, community antenna distribution systems or any other purpose, they shall be:

(a) Separated by at least 2 m from each other;

(b) Bonded together with not less than a No. 6 AWG copper conductor protected by location from mechanical injury; and

(c) In the case of lightning protection systems, bonded together in accordance with paragraph (b) at or below ground level.

(Chair's note: The former requirement in Rule 10-706 to require that when a spacing of 2 m could not be maintained between equipment conductors and lightning rod conductors that the rods of the 2 systems was to be bonded together was redundant since there was a requirement that all electrodes be bonded together regardless. This proposed Rule maintains the requirement for bonding together all electrodes at a building.)

3. Existing Rule 10-704 stays the same.

4. Renumber Existing Rule 10-710 to 10-706 and include a slight editorial revision for clarification.

10-706 Use of Lightning Rod System Conductors and Grounding Electrodes (see Appendices B and G)

Lightning rod conductors, driven pipes, rods, or other grounding electrodes (excluding metal water-piping systems) used for grounding lightning rod systems, shall not be used for grounding wiring systems or other electrical equipment.

5. Add Appendix B notes as follows:

10-700(1)(a) *Manufactured grounding electrodes are those manufactured and certified to CSA Standard C22.2 No. 41-Grounding and Bonding Equipment.*

10-700(4) *It is important that in-situ grounding electrodes provide an equivalent surface area contact with earth as similar manufactured electrodes (see C22.2 No. 41). Consideration should also be given the effects corrosion may have on the in-situ ground electrode impacting durability and life- expectancy.*

For example, an underground metal water piping system located at least 600 mm below finished grade and extending at least 3 m has traditionally been recognized as a suitable grounding electrode. Similarly, the metallic reinforcement of a concrete slab, concrete piling, or concrete foundation and iron pilings in significant contact with earth at 600mm or more below finished grade have also been found to be suitable in-situ electrodes.

Subcommittee Deliberations (3rd Round)

7 members responded, all but one agreed with the latest proposal. The member that disagreed requested a slight adjustment to warn against those situations where reinforcement steel may be encapsulated with an insulating material for corrosion protection.

Chair's Comment (final)
To address the one negative, the Chair proposes adding an appendix B note in this regard. In fact, any metallic material being considered for use as an in-situ ground electrode should be examined for its conductivity, especially when encapsulated with a corrosion protection material. The Appendix B note already refers to metal and metallic materials and common sense would dictate that if they were encapsulated with a non-conductive compound, it would not be suitable for consideration as an in-situ ground electrode.

The Chair's declares consensus for the following:

Subcommittee Recommendation
Accept the proposal under "**Chair's Comments (3rd Round)**" with the addition of the following paragraph added to the Appendix B note to 10-700(4):

> *Any metallic material encapsulated with a non-conductive compound to protect it from corrosion would not meet the criteria for use as an in-situ ground electrode.*