



IEEE Southern Alberta Section, Industrial Applications and Power & Energy Chapter – Technical Program

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IEEE Southern Alberta Section, Industrial Applications and Power & Energy Chapter – Technical Program

# IEEE SAS, IAS/PES Chapter - 2013 Program

| <u>Topic</u>                                       | <u>Date</u>         | <u>Presenter/Author</u>                                     |
|--|---------------------|---|
| <b><u>Seminars:</u></b>                            |                     |   |
| ▪ Transmission Line Design<br>Calgary              | January 21          | Bill Kennedy, Electric Power Systems,                       |
| ▪ Substation Design                                | March 18            | Jim Bowen, Saudi-Armco, Houston                             |
| ▪ Arc Flash Calculation,<br>Hazards and Mitigation | May 13              | Lanny Floyd, Dupont, Wilmington                             |
| ▪ <b>Grounding &amp; Bonding</b>                   | <b>September 30</b> | <b>Ark Tssisserev, Stantec, Vancouver</b>                   |
| ▪ <b>Power System<br/>Coordination</b>             | <b>November 4</b>   | <b>Peter Sutherland<br/>Rasheek Rifaat, Jacobs, Calgary</b> |

**Next**  
← **Event**

**Course:**

- Power System Stability (4d) Sept. 16-19, 2013 Prabha Kundur, Toronto

**Conferences 2014:**

- IAS ESTMP (3d) **March 3-5, 2014** Hyatt Regency, Calgary
- PES EPEC (3d) **Nov. 12-14, 2014** Westin, Calgary

*Note: Due to rate increase on Catering, new Seminar Rates for remainder of 2013 will be \$24/34 for IEEE/Non-IEEE Member*





IEEE Southern Alberta Section, Industrial Applications and Power & Energy Chapter – Technical Program

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- Chapter is looking for more Committee Members and Volunteers
- Monthly lunch hour Committee meetings at Jacobs Quarry Park office

- **Section**

- Several Chapter Exec and Committee Members have moved to Section Executive
  - Chair - Patrick Wong, Vice Chair - Doug Brooks, Controls Chair - Matt Eskander

# Bonding and Grounding

**What?**

**Why?**

**How?**

Ark Tsisserev, FEC, M.Sc., P.Eng.  
Principal

IEEE, Alberta section, September, 2013

One Team. Infinite Solutions.



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Object of bonding and grounding

Sections 10 and 36 of the CE Code



# Definitions

**Bonding** - a low impedance path obtained by permanently joining all non-current carrying metal parts to ensure electrical continuity and having the capacity to conduct safely any current likely to be imposed on it.

**Bonding conductor** - a conductor that connect the non-current-carrying parts of electrical equipment, raceways, or enclosures to the service equipment or system grounding conductor.

**Ground fault circuit interrupter (GFCI)** – a device whose function is to interrupt, within a predetermined time, the electrical circuit to the load when a current to ground exceeds a predetermined value that is less than that required to operate the overcurrent protective device of a supply circuit.



# Definitions

**Ground fault protection** – a device, other than a ground fault circuit interrupter of the Class A type, whose function is to control or interrupt ground fault current or voltage-to-ground in the circuit or system where it is installed.

**Grounded** – connected effectively with the general mass of the earth through a grounding path of sufficiently low impedance and having an ampacity sufficient at all times, under the most severe conditions liable to arise in practice, to prevent any current in the grounding conductor from causing a harmful voltage to exist.

a) Between the grounding conductors and neighbouring exposed conducting surfaces that are in good contact with the earth or;

b) Between the grounding conductors and neighbouring surfaces of the earth itself.



# Definitions

**Grounding** – a permanent and continuous conductive path to the earth with sufficient ampacity to carry any fault current liable to be imposed on it, and of a sufficiently low impedance to limit the voltage rise above ground and to facilitate the operation of the protective devices in the circuit.

**Grounding conductor** – the conductor used to connect the service equipment or system to the grounding electrode.

**Grounding electrode** – a buried metal water-piping system or metal object or device buried in, or driven into, the ground to which a grounding conductor is electrically and mechanically connected.



# Definitions

**Grounding system** – all conductors, clamps, ground clips, ground plates or pipes, and ground electrodes by means of which the electrical installation is grounded.



# Grounding and Bonding

## 10-000 Scope

- 1) This Section covers the protection of electrical installations by grounding and bonding.
- 2) Insulating, isolating and guarding may be used as means of affording supplemental protection to grounding or, where permitted, in the Code, as a suitable alternative.



# Grounding and Bonding

## 10-002 Object

Grounding and bonding as required by this Code shall be done in such a manner as to serve the following purposes:

- a) To protect life from the danger of electric shock and property from damage by bonding to ground non-current-carrying metal systems;
- b) To limit the voltage on a circuit when it is exposed to higher voltages than that for which it is designed;
- c) In general to limit as circuit voltages-to-ground to 150 V or less on circuits supplying interior wiring systems;
- d) To facilitate the operation of electrical apparatus and systems; and
- e) To limit the voltage on a circuit that might otherwise occur through exposure to lightning.



# System and Circuit Grounding

## 10-100 Circuits

Circuits shall be grounded as necessary in accordance with this Section.

## 10-102 Two-wire direct-current systems

- (1) Two-wire direct-current systems supplying interior wiring and operating at not more than 300 V or not less than 50 V between conductors shall be grounded, unless such systems are used for supplying industrial equipment in limited areas and the circuit is equipped with a ground detector.
- (2) If such a circuit operates at more than 300 V between conductors and a neutral point can be established so that the maximum difference of voltage between the neutral point and any other point on the system does not exceed 300 V, the neutral shall be permitted to be grounded.

## 10-104 Three-wire direct-current system

The neutral conductor of all 3-wire direct-current systems supplying interior wiring shall be grounded.



# System and Circuit Grounding

## **10-106 Alternating-current systems** (see Appendix B)

- (1) Except as otherwise provided for in this Code, alternating-current systems shall be grounded if
  - (a) by so doing, their maximum voltage-to-ground does not exceed 150 V; or
  - (b) the system incorporates a neutral conductor.
- (2) Wiring systems supplied by an ungrounded supply shall be equipped with a suitable ground detection device to indicate the presence of a ground fault.

## **10-108 Electric arc furnace circuits**

Circuits supplying electric arc furnaces shall be permitted to, but need not, be grounded.



# System and Circuit Grounding

## **10-110 Electric crane circuits**

Circuits supplying electric cranes operating over combustible fibres in Class III hazardous locations shall not be grounded.

## **10-112 Isolated circuits**

Special circuits shall be permitted to be supplied from the ungrounded secondaries of transformers having the primary and secondary windings separated by a grounded metal shield if

- (a) installed under the provisions of other Sections of the Code; or
- (b) this is required to recognize a particular accident or fire hazard.



# System and Circuit Grounding

## **10-114 Circuits of less than 50 V**

Circuits of less than 50 V shall be grounded

- (a) where run overhead outside of buildings; or
- (b) where supplied by transformers energized from
  - (i) systems of more than 150 volts-to-ground; or
  - (ii) ungrounded systems, unless the circuits are provided in accordance with Rule 10-112.

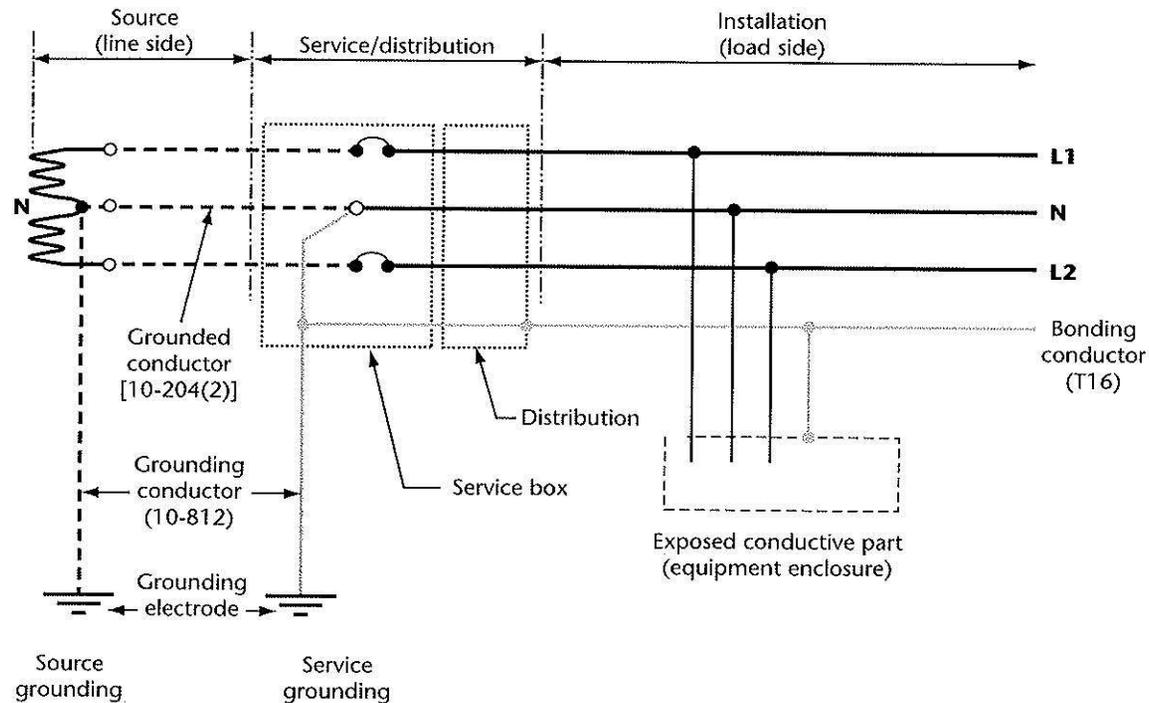


# Single-phase, 3-wire solidly grounded system (midpoint grounded)

## Rules 10-204, 10-812, 10-814

The following types of system grounding are examples of grounded alternating-current systems commonly used in Canada:

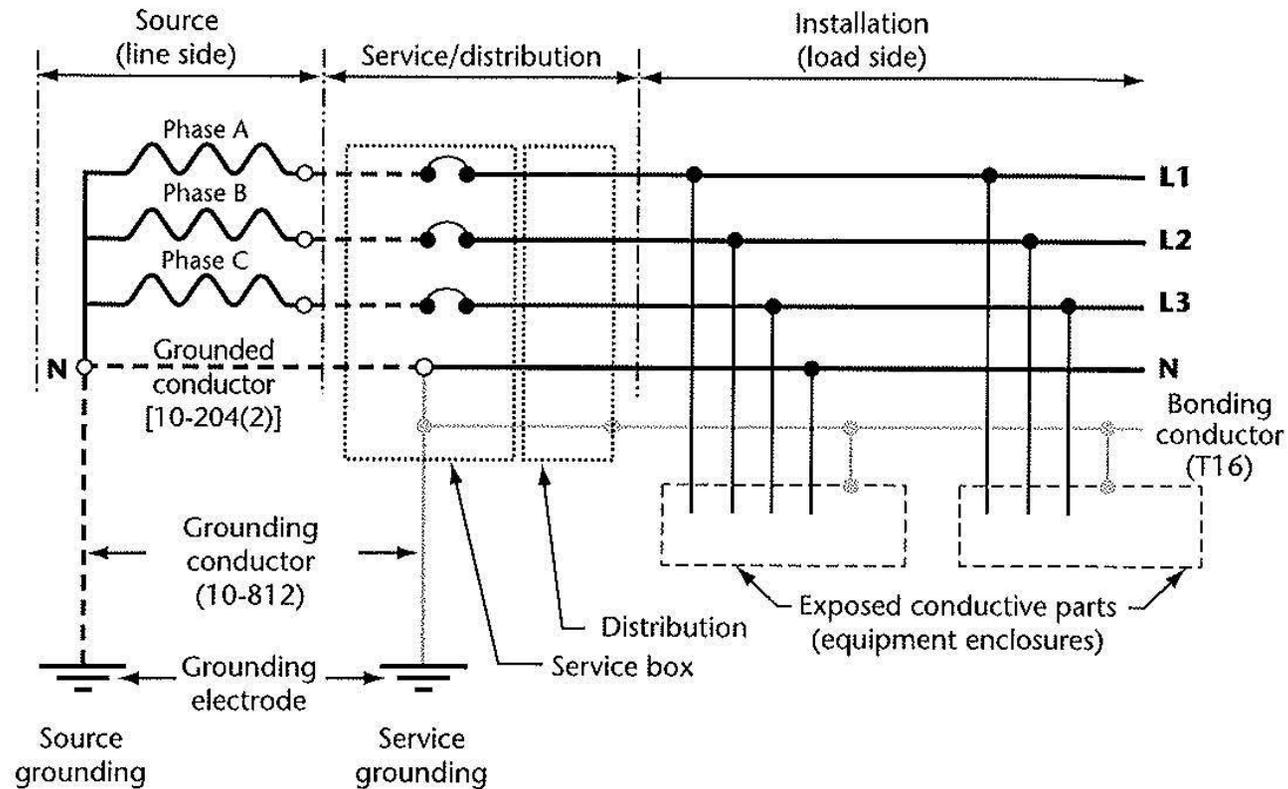
- (a) single-phase, 3-wire solidly grounded systems (see Figure 1);
- (b) three-phase, 4-wire solidly grounded systems (see Figures 2 and 3);
- (c) three-phase, 4-wire impedance grounded system (see Figure 4).



### Notes:

- (1) Neutral and bonding conductor functions are combined in a single conductor (system grounded conductor) on the line side of the service [Rule 10-624(2)].
- (2) Neutral (grounded circuit conductor) and bonding conductor function are separate on the load side of the service [Rule 10-624(1)].

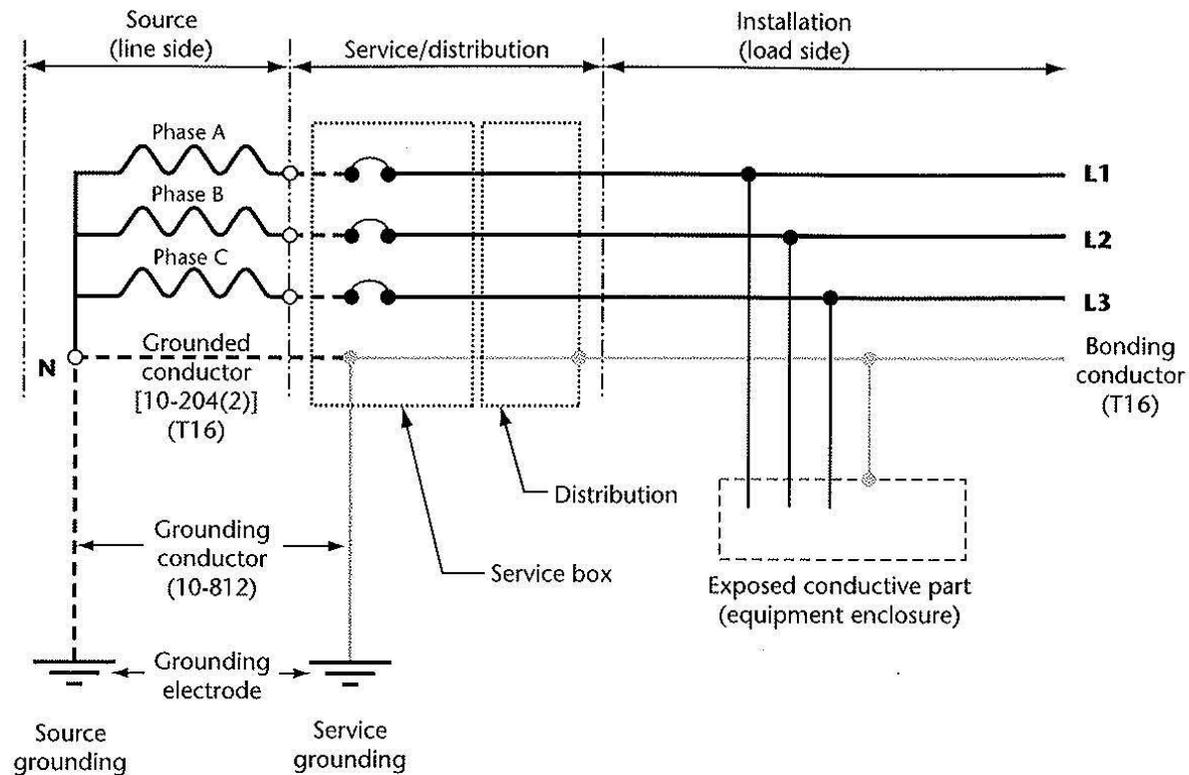
# Three-phase, 4-wire solidly grounded system (midpoint grounded)



## Notes:

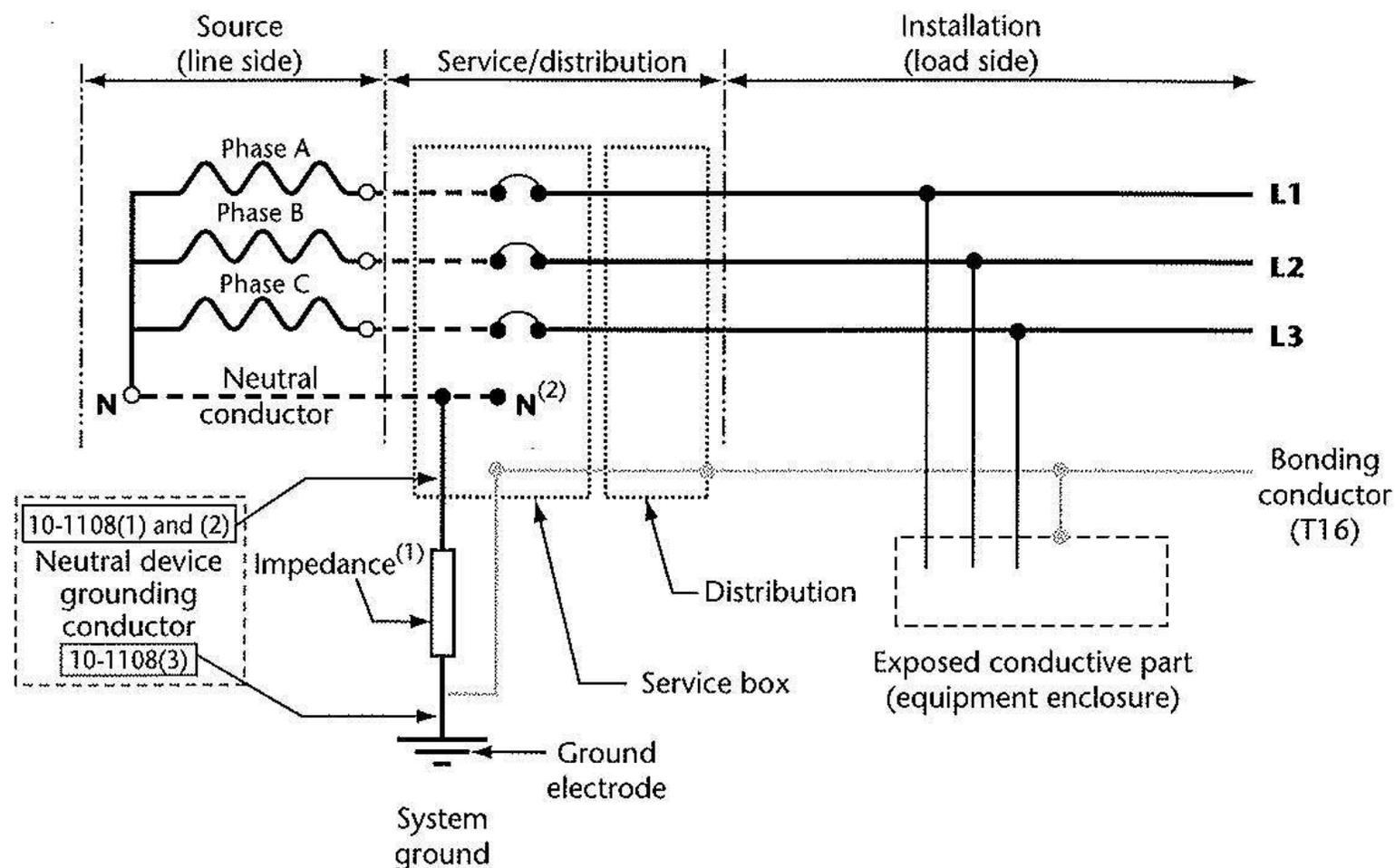
- (1) Neutral and bonding conductor functions are combined in a single conductor (system grounded conductor) on the line side of the service [Rule 10-624(2)].
- (2) Neutral (grounded circuit conductor) and bonding conductor function are separate on the load side of the service [Rule 10-624(1)].

# Three-phase, 4-wire solidly grounded system with no neutral load (3-wire on load side) (midpoint grounded)



**Notes:**

- (1) The grounded conductor on the load side of the service functions as a bonding conductor with no distributed neutral throughout the system.
- (2) The grounded conductor on the line side of the service (system grounded conductor) with no neutral currents is sized as specified for bonding conductors (Table 16).



**Notes:**

- (1) System connected to ground via sufficiently high impedance.
- (2) The neutral may or may not be distributed.
- (3) See Subsection "Installation of neutral grounding devices" (1100 series of Rules) of Section 10.

# Three-phase, 4-wire impedance grounded system (midpoint grounded)

## **Rule 10-204(1)**

The supply side of the disconnecting means is deemed to include all of the interior of the service box.

## **Rule 10-204(2)**

“Grounded conductor” is a commonly used term in the Code that may serve different functions.

On the load side of the service disconnecting means, it serves only as the identified conductor intended to carry the unbalanced load (neutral currents) and can be referred to as the “grounded circuit conductor” [see Rules 10-204(1)(c) and 10-624(1)].

On the supply side of the service disconnecting means, it serves as a neutral conductor only in a single- or multi-phase system requiring a grounded circuit (neutral) conductor (see Rule 10-210). Where the grounded circuit conductor (neutral) is not intended to be used in a wiring system, the grounded conductor serves as a bonding conductor to carry fault currents to source. On the supply side of the service, the grounded conductor is also referred to as the “grounded service conductor” [see Rules 10-624(2)].

For the purposes of Rule 10-204, the term “grounded conductor” refers to the grounded conductor (or “system grounded conductor”) on the supply side of the service that serves as a bonding conductor to carry fault currents and that may also serve as a grounded circuit conductor to carry neutral currents.

Like the bonding conductor, the system grounded conductor’s primary function is to provide a low impedance path capable of withstanding any fault currents that may be imposed on it. In addition, the system grounded

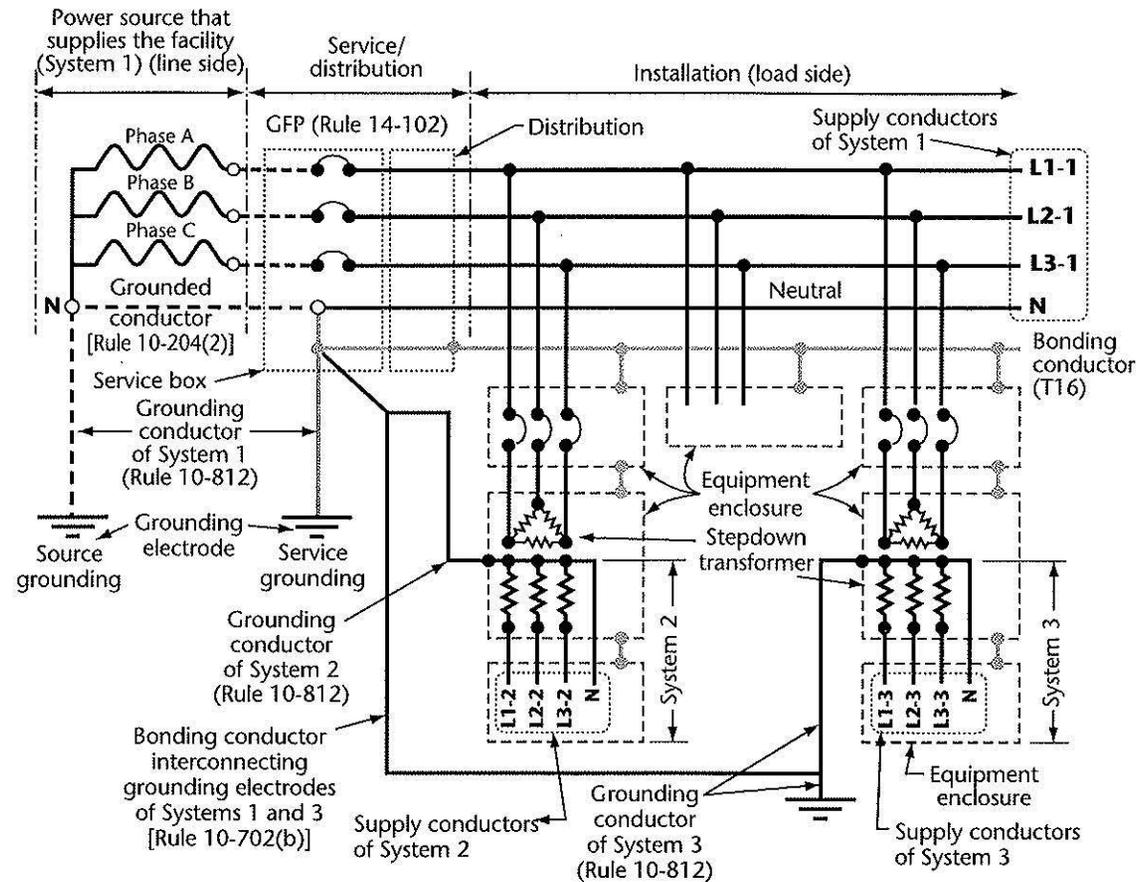


## Rule 10-206

There may be one or more different systems installed at a facility in addition to the system that supplies it (e.g., a generator to supply emergency power, or a transformer to supply a different voltage, to parts of a facility). When these different systems are required to be grounded, each newly established (different) system will be connected to a grounding electrode either at the facility's service, or at a separate grounding electrode. When separate grounding electrodes are installed, they will be interconnected in accordance with Rule 10-702 (see Figure 5).



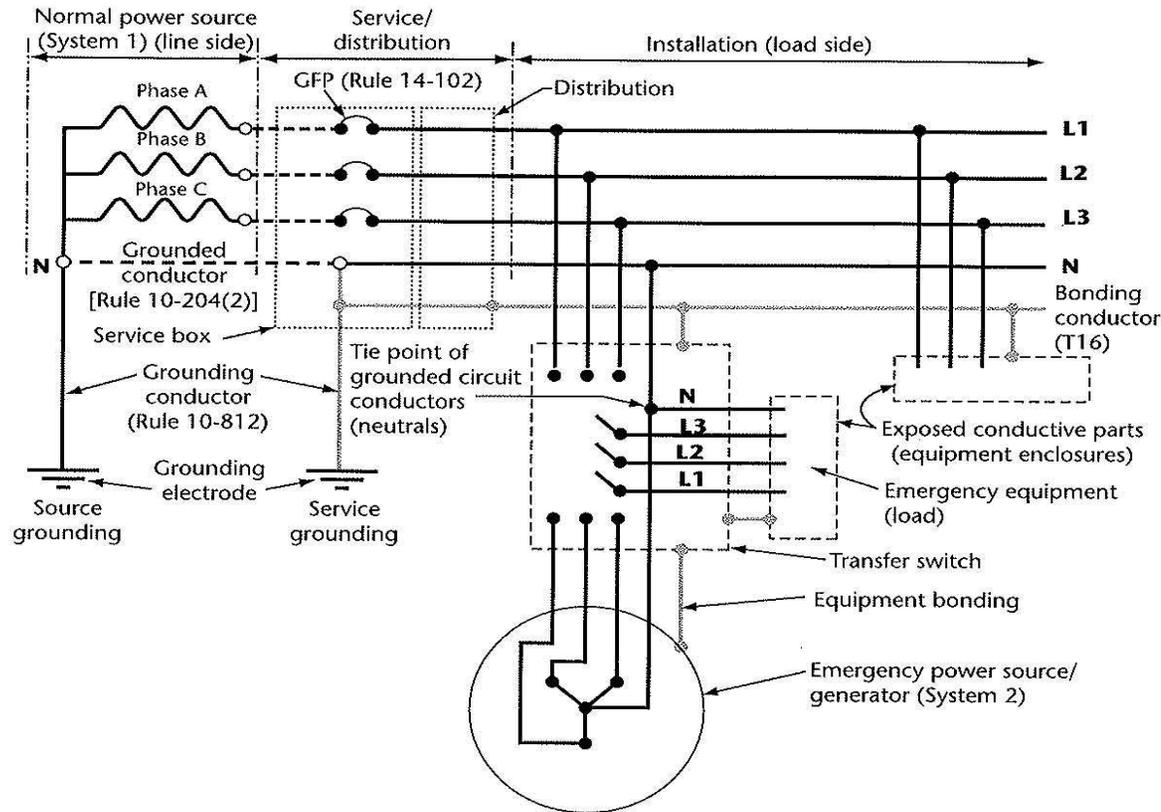
# Different three-phase, 4-wire solidly grounded systems at a facility (midpoint grounded)



**Note:** In addition to the main solidly grounded system that supplies the facility, two different solidly grounded systems are established at the secondary of each stepdown transformer. A neutral of each transformer is bonded to the transformer enclosure (Rule 10-624) and connected to

- (a) the grounding electrode of the system that supplied the facility (Systems 1 and 2) [see Rule 10-206(1)(c)]; or
- (b) a separate grounding electrode established for a different system (System 3). Electrodes of Systems 1 and 3 are interconnected. [See Rules 10-206(3) and 10-702(b).]

When the grounded circuit conductors from two different systems are tied in a transfer switch, a single connection to the grounding electrode is sufficient for both systems. The connection may be made at the transfer switch or at the service equipment (see Figure 6).

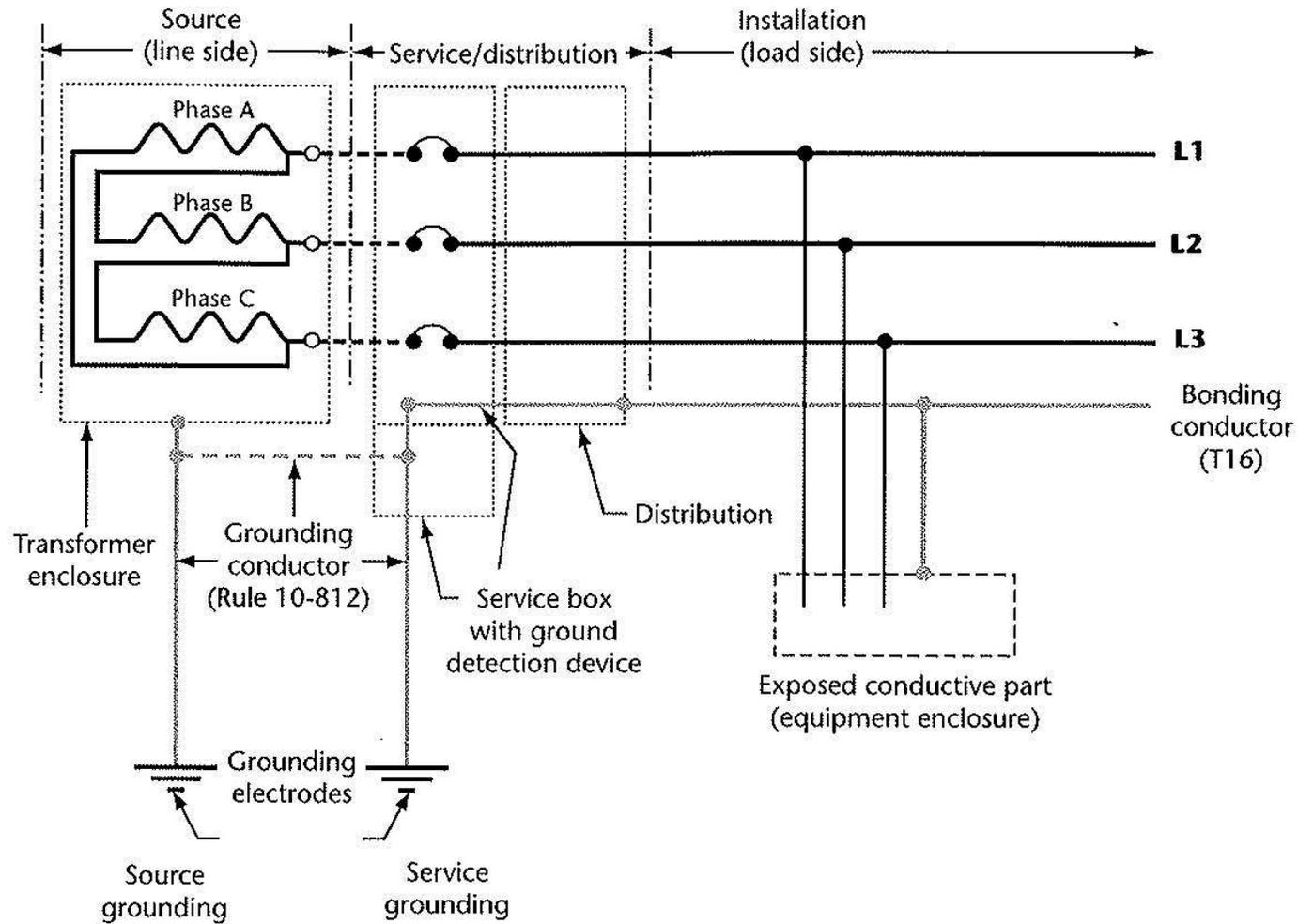


**Note:** The neutral of the emergency generator is not grounded at the generator. The generator neutral is solidly interconnected with the neutral of the supply system in the transfer switch. A single connection to the grounding electrode is made at the service equipment in order to prevent the possibility of a ground fault at the emergency equipment from bypassing the ground-fault-protection sensor at the service equipment.

**Figure 6**  
**Two different three-phase, 4-wire solidly grounded systems (midpoint grounded)**

Code users should be aware that when neutrals from two systems (the system supplying a facility and an emergency generator) are solidly connected in the transfer switch, the neutral should not be grounded at the generator. An additional ground at the generator could prevent a portion of the ground fault current from flowing through the neutral of the on-site generator and bypassing the sensor for the ground fault protection at the service equipment. For additional information, see IEEE 446.

# Three-phase, 3-wire ungrounded (delta) system



**Note:** An ungrounded system is required to have a ground detection device in accordance with Rule 10-106(2).

# Grounding electrodes

## **10-700 Grounding electrodes** (see Appendix B)

- (1) Grounding electrodes shall consist of
  - (a) manufactured grounding electrodes;
  - (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
  - (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) spaced no less than 3 m apart,
    - (i) bonded together with a grounding conductor sized in accordance with Table 17; and
    - (ii) 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.



# Grounding electrodes

- (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) For the purposes of Rule 2-024, an in-situ grounding electrode shall 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.
- (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.



# Grounding electrodes

## **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 Item (b) at or below ground level.

## **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.

## **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.



# Grounding electrodes

## Grounding and bonding conductors

### **10-800 Continuity of grounding and bonding conductors**

No automatic cut-out or switch shall be placed in the grounding or bonding conductor of a wiring system unless the opening of the cut-out or switch disconnects all sources of energy.

### **10-802 Material for system grounding conductors**

The grounding conductor of a wiring system, whether also used for grounding electrical equipment or not, shall be permitted to be insulated or bare and shall be of copper.



# Rules 10-700(1)(a), 10-700(4)

Manufactured grounding electrodes are those manufactured and certified to CSA C22.2 No. 41.

It is important that in-situ grounding electrodes provide an equivalent surface area contact with earth so as do manufactured electrodes (see CSA C22.2 No. 41). Consideration should also be given to the effects that 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 600 mm or more below finished grade have also been found to be suitable in-situ electrodes.



# Rules 10-700(1)(a), 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.



# Grounding and Bonding

## **36-300 Material and minimum size of grounding conductor and ground grid conductor and connections** (see Appendix B)

- (1) Except as provided for in Subrule (2), bare copper conductors shall be used for grounding purposes and shall be not smaller than those specified in Rules 36-302 to 36-310 and Table 51.
- (2) Notwithstanding the requirement of Subrule (1), a galvanized steel, copper-weld, or other conductor shall be permitted for grounding purposes, provided that
  - (a) its current-carrying rating is equal to or greater than that of the copper conductor specified in Rules 36-302 to 36-310;
  - (b) consideration is given to galvanic action if such conductors are buried in the ground or come in contact with dissimilar metals; and
  - (c) the method of bolting or connecting such conductors to each other and to other surfaces is such as to maintain the required current-carrying capacity for the life of the electrode design.



# Grounding and Bonding

## **36-302 Station ground electrode** (see Appendix B)

- (1) Every outdoor station shall be grounded by means of a station ground electrode that shall meet the requirements of Rule 36-304 and shall
  - (a) consist of a minimum of four driven ground rods not less than 3 m long and 19.0 mm in diameter spaced at least the rod length apart and, where practicable, located adjacent to the equipment to be grounded;
  - (b) have the ground rods interconnected by ground grid conductors not less than No. 2/0 AWG bare copper buried to a maximum depth of 600 mm below the rough station grade and a minimum depth of 150 mm below the finished station grade; and
  - (c) have the station ground grid conductors in Item (b) connected to all non-current-carrying metal parts of equipment and structures and shall form a loop around the equipment to be grounded, except that
    - (i) a portion of the loop shall be permitted to be omitted where an obstacle such as a wall prevents a person from standing on the corresponding side or sides of the equipment; and
    - (ii) loops formed by the rebar in a reinforced concrete slab are adequate when the rebar members are interconnected and reliably connected to all other parts of the station ground electrode.



# Grounding and Bonding

- (2) Where a deviation has been allowed in accordance with Rule 2-030, a buried station ground electrode other than that described in Subrule (1) shall be permitted to be used.
- (3) Where it is not practicable to locate the station ground electrode adjacent to the station as described in Subrule (1), the station ground electrode shall be permitted to be remote from the station, and
  - (a) two grounding conductors of a minimum of No. 2/0 AWG copper shall connect the ground electrode to the station equipment in such a way that should one grounding conductor or ground electrode be damaged, no single metal structure or equipment frame may become isolated; and
  - (b) in locations with system short-circuit currents exceeding 30 000 A, the grounding conductor wire size shall be increased and shall be such that it will not suffer thermal damage or be a fire hazard under the severest fault conditions occurring on the system.
- (4) Every indoor station shall be grounded by means of a station ground electrode
  - (a) in accordance with Subrule (1), (2), or (3); or
  - (b) if it is not practicable to ground an indoor station in accordance with Subrule (1), (2), or (3) and the indoor station receives its supply from a main station on the same property, the station equipment shall be connected to the main station ground electrode in accordance with Subrule (3).



# Grounding and Bonding

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  - (a) in accordance with Subrule (1), (2), or (3); or
  - (b) if it is not practicable to ground an indoor station in accordance with Subrule (1), (2), or (3) and the indoor station receives its supply from a main station on the same property, the station equipment shall be connected to the main station ground electrode in accordance with Subrule (3).



# 36-304 Station ground resistance

- (1) The maximum permissible resistance of the station ground electrode shall be determined by the maximum available ground fault current injected into the ground by the station ground electrode or by the maximum fault current in the station, and the ground resistance shall be such that under all soil conditions that exist in practice (e.g., wet, dry, and frozen conditions), the maximum ground fault current conditions shall limit the potential rise of all parts of the station ground grid to 5000 V; whereas in special circumstances where this level cannot be reasonably achieved, a higher voltage up to the maximum insulation level of the communication equipment shall be permitted where a deviation has been allowed in accordance with Rule 2-030.
- (2) In addition to the requirements of Subrule (1), the touch and step voltage at the edge, within, and around the station grounding electrode, including all areas in which metallic structures electrically connected to the station are to be found, shall not exceed the tolerable values specified in Table 52.

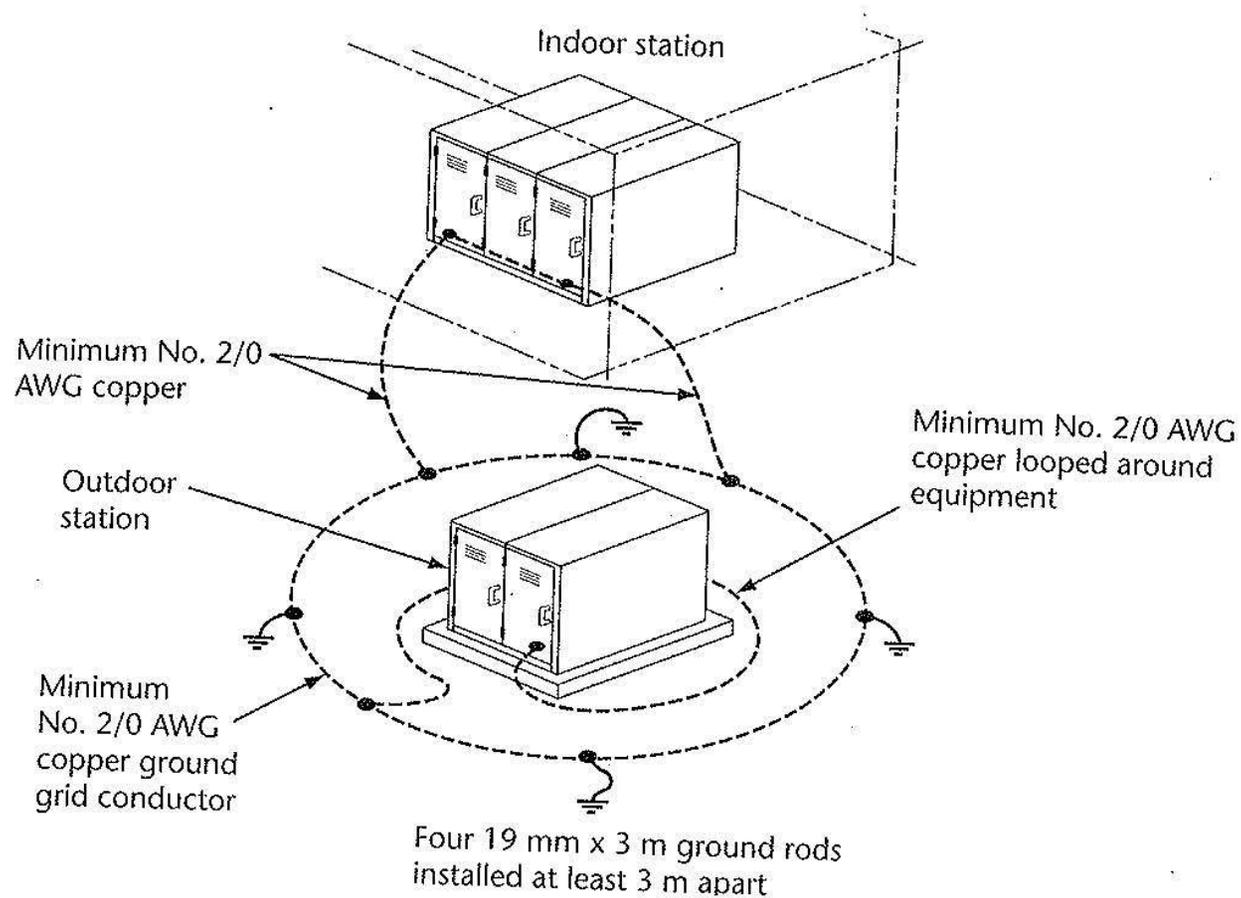


# 36-304 Station ground resistance

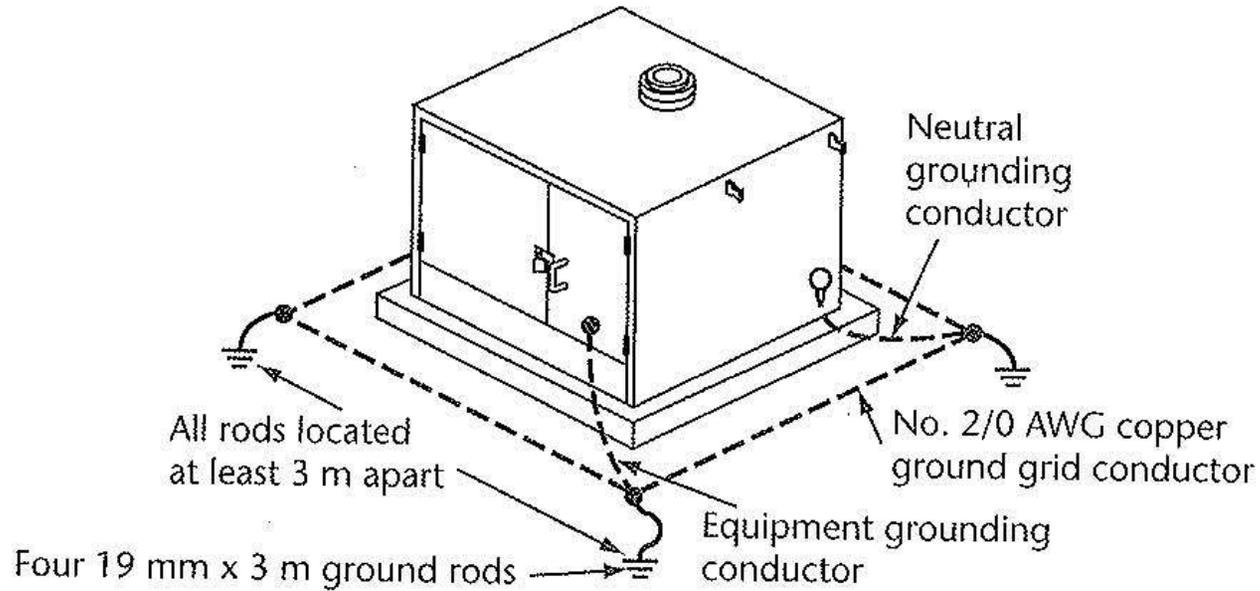
- (3) When a station ground electrode design is selected according to the procedure delineated in Appendix B and when it is proven that the station parameters used in the procedure are valid, this electrode design shall be deemed to meet the requirements of Subrules (1) and (2).
- (4) After completion of construction, the resistance of the station ground electrode at each station shall be measured and changes shall be made if necessary to verify and ensure that the maximum permissible resistance of Subrule (1) is not exceeded.
- (5) Where the safety of persons depends on the integral presence of a ground surface covering layer, such as crushed rock or asphalt, the ground surface covering layer shall exist throughout the station grounding electrode area, including all areas in which metallic structures electrically connected to the station are to be found and shall extend at least 1 m beyond the station grounding electrode area on all sides.



# Grounding inside and outside equipment to remote grounding grid electrode



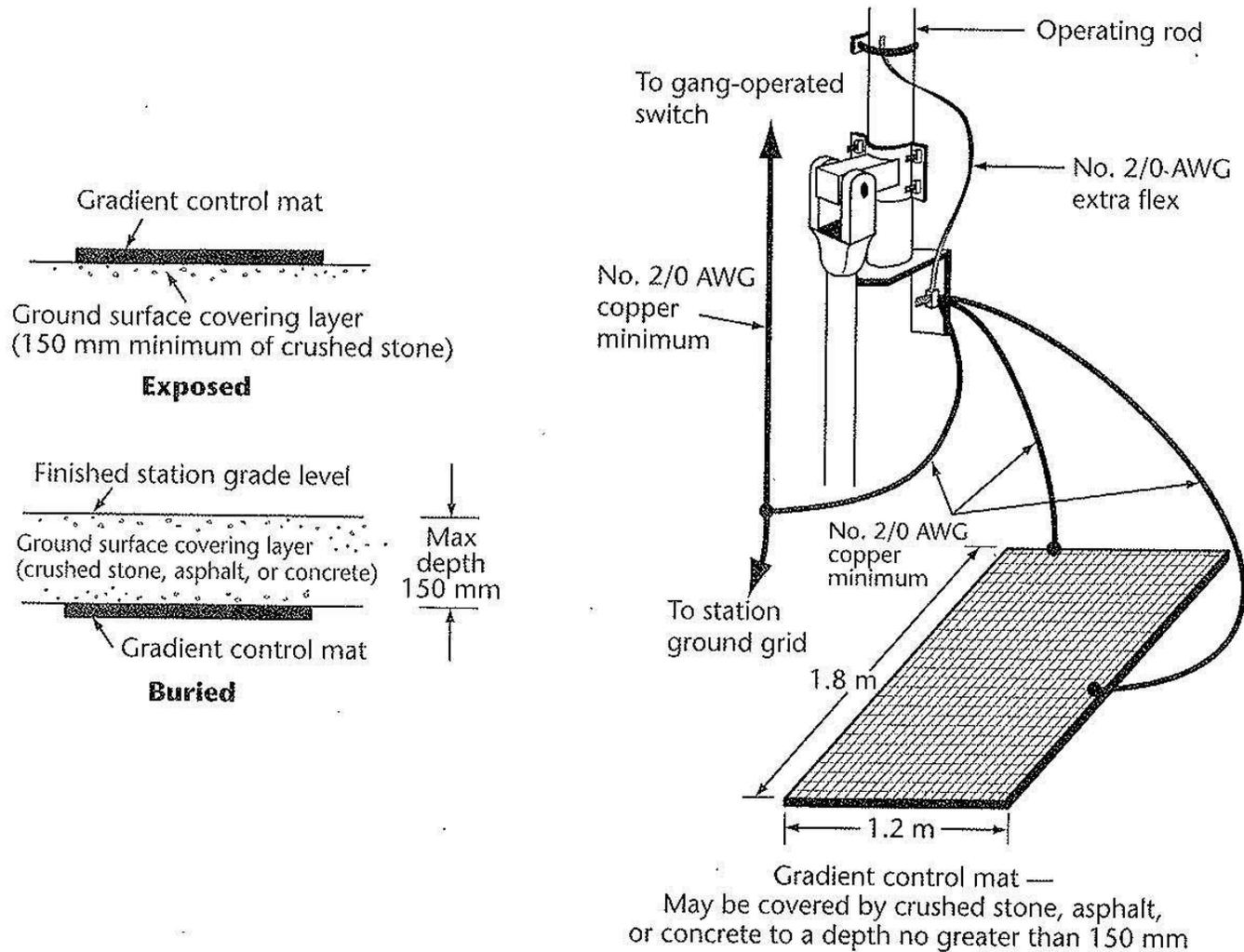
# Grounding of pad-mounted transformer



**Note:** Although the rods may be located adjacent to the equipment, spacing them so that a loop is formed around the equipment satisfies the requirement of Rule 36-302(1)(c) for looping the station ground grid conductors.

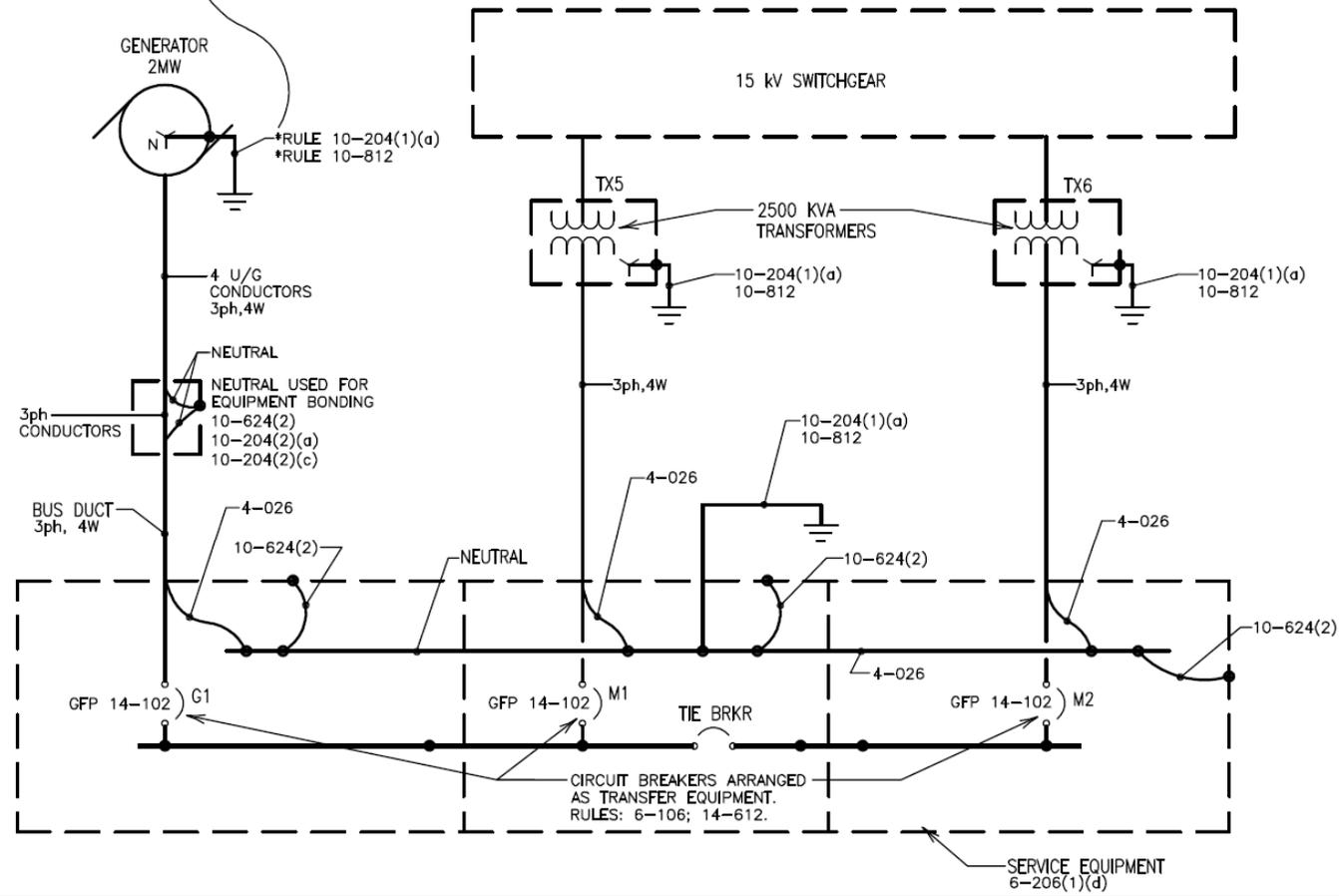


# Grounding of gang-operated switch handle



## EXAMPLE OF SYSTEM GROUNDING AND EQUIPMENT BONDING

\* DENOTES RULES OF THE CEC, PART 1



### Notes:

- (1) 3 pole switching arrangement conforming to Rules 6 – 106 and 14-612 might work with MDGF installed in breakers G1; M1 and M2. Such approach will meet provisions of Rule 14-102 (see diagram 3 in the CEC).
- (2) Grounding electrodes of all three solidly grounded systems (derived by each transformer – TX5; TX6 and by 2 MW generator) could be interconnected at a common tie point at the service equipment. Re: Rule 10-206 (2).
- (3) Grounded service conductor from each such source (G-Generator; TX5; TX6) is allowed to carry unbalanced current (to function as neutral), and to carry fault current (to function as bonding conductor). Re: Rules 10-204 (2) (a) – (c); 10-624 (2).

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**BULLETIN 2005-004-EL**

**Revised May 7, 2008**

Note: this Bulletin repeals Bulletin 2000-029-EL

## **TESTING/COMMISSIONING OF HIGH VOLTAGE STATIONS AND UNIT SUBSTATIONS**

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**Background:**

Rule 36-304(4) of the CEC, Part I mandates that “after completion of construction, the resistance of the station ground electrode at each station shall be measured and changes shall be made if necessary to verify and ensure that the maximum permissible resistance of Subrule (1) is not exceeded”. It is intended by this requirement of the Code that a detailed testing/commissioning of all components comprising a High Voltage Station is undertaken to ascertain acceptable levels of step and touch voltages in conformance with Table 52 and of potential rise not more than 5000 Volt at all parts of the station ground grid under maximum ground fault current conditions.

**Requirements:**

This Bulletin establishes the City of Vancouver testing/commissioning requirements for the purpose of Rule 36-304(4). When an electrical installation includes a High Voltage component, such installation shall not be energized until a testing/commissioning report is provided to the City Electrician by an acceptable independent agency (other than the installing electrical contractor). The commissioning report submitted by the independent agency must indicate that the High Voltage Station or a Unit Substation has been successfully tested in accordance with provisions of Section 36 of the CEC, Part I, and that the installation is ready to be energized.

The testing/commissioning report must include (but not be limited to) the following:

1. Operation of all required interlocks between fuse compartments, load breaking or isolating means;
2. Operation of all isolating and disconnecting means;
3. Insulation resistance of all isolating and disconnecting means;
4. Contact resistance of all insulating and disconnecting means;
5. Protection coordination study;
6. Step and touch voltages calculations and ground resistance test.
7. Visual inspection of all isolating and disconnecting means;
8. Hi-Pot test of all isolating and disconnecting means and the cells for termination of the incoming BC Hydro cables;
9. Visual inspection of transformer(s);
10. Transformer insulation resistance test (Megger test);
11. Transformer “Turn to turn ratio” (TTR) test on all taps;
12. Transformer winding temperature test (test of WTI trip);
13. Visual inspection of all connections to the Station Ground Electrode;
14. Confirmation that all interconnections between pieces of electrical equipment assembled on the site into a “unit substation” are in compliance with the CEC, Part I and with the shop drawings provided by the supplier of the “unit substation”.
15. Confirmation that the tested High Voltage Station or Unit substation is ready to be energized.

(Applicable checklists (attachments 1-3) must be completed and submitted with the commissioning report.)

A.Z. Tsisserev, P. Eng.  
ELECTRICAL SAFETY MANAGAER,  
CHIEF ELECTRICAL INSPECTOR  
AND CITY ELECTRICIAN



ATTACHMENT #1 – to COV Bulletin 2005-004-EL

Note 1: To be completed by the Professional Engineer of the Testing/Commissioning Agency

Note 2: For information requirements of a portable unit substation installation, refer to COV Bulletin 2000-048-EL

CHECKLIST FOR H.V. UNIT SUBSTATIONS

Installation Address: \_\_\_\_\_ Permit Number EL: \_\_\_\_\_

| ITEM No. | DESCRIPTION   | REFERENCES<br>(Applicable CEC Rules, C.O.V. Bulletins, BC Safety Authority Directives) | Conformance to the referenced requirements |    |
|----------|---|--|--|----|
|          |   |  | Yes  | No |
| 1        | (a) H.V. Station Ground Resistance Report<br>(See Attachment 2)   | 36-304   |  |    |
| 2        | H.V. Equipment approval<br>Note: Includes equipment comprising a unit substation  | 2-024;<br>BCSA Information Bulletin<br>No: B-E3 0710193                                |  |    |
| 3        | Clearance and spacing of live parts   | 36-108; 36-110; 36-212;<br>Tables 30, 31, 32, 33, 34, & 35                             |  |    |
| 4        | Operation of H.V. switches  | 36-212; 36-214   |  |    |
| 5        | Interlocks  | 36-208; 36-214   |  |    |
| 6        | Switch, fuse, and breaker ratings   | 36-202; 36-204   |  |    |
| 7        | Transformer overload and overheating protection   | 26-252;  |  |    |
|          | (a) Relay and tripping device settings  |  |  |    |
| 8        | (b) Transformer core temperature device   | As per shop drawings   |  |    |
|          | Installation integrity:   |  |  |    |
|          | (a) Insulation  |  |  |    |
|          | (b) Torqued as per installation spec.'s   |  |  |    |
| 9        | (c) Stand-off supports and bushings   | Shop drawings of unit substation;<br>CE Code, Part I                                   |  |    |
|          | Interconnection between pieces of electrical equipment assembled on site is in conformance with the shop drawings and in accordance with the CE Code Part I |  |  |    |
| 10       | Tested H.V. Station (Unit Substation) is ready to be energized  | Item 15 of:<br>Bulletin 2005-004-EL  |  |    |

Additional Comments: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Testing Agency: \_\_\_\_\_

Name: \_\_\_\_\_ P.Eng

Signature: \_\_\_\_\_

Address: \_\_\_\_\_

Telephone: \_\_\_\_\_ Affix Professional Seal

Facsimile: \_\_\_\_\_

Email: \_\_\_\_\_



**ATTACHMENT #2 – to COV Bulletin 2005-004-EL**

Note 1: To be completed by the Professional Engineer of the testing agency or by the Professional Engineer responsible for the design of the H.V. installation. (P.Eng. of record)

Note 2: For information requirements of a portable unit substation installation, refer to **COV Bulletin 2000-048-EL**

Note 3: Completed report - to be provided as part of Attachment 1 (Item 1)

**GENERAL CHECKLIST FOR H.V. SERVICE**

Installation Address: \_\_\_\_\_ Permit Number EL: \_\_\_\_\_

| <b>HIGH VOLTAGE STATION GROUND RESISTANCE REPORT</b>    |   |  |    |
|---|---|--|----|
| Installation Address: _____                             |   | Permit Number EL _____                               |    |
| Testing Agency: _____                                   |   |  |    |
| Item  | Requirements of Table 52                                  | Conformance with applicable requirements Of Table 52 |    |
|   |   | Yes  | No |
| 1   | Type of Soil (specify): _____                             |  |    |
| 2   | Measured Resistance of the station Ground Electrode _____ |  |    |
| 3   | Calculated Step Voltage at the HV station _____           |  |    |
| 4   | Calculated Touch Voltage at the HV station _____          |  |    |
| Company Name: (if other than the testing agency): _____ |   |  |    |
| Name: _____ P. Eng                                      |   |  |    |
| Signature: _____ Date: _____                            |   |  |    |
| Address: _____  |   |  |    |
| Telephone: _____ Affix Professional Seal                |   |  |    |
| Facsimile: _____  |   |  |    |
| Email: _____  |   |  |    |

ATTACHMENT #3 – to COV Bulletin 2005-004-EL

Note 1: To be completed by the Professional Engineer responsible for the design of the H.V. installation. (P.Eng. of record)

Note 2: For information requirements of a portable unit substation installation, refer to **COV Bulletin 2000-048-EL**.

GENERAL CHECKLIST FOR H.V. SERVICE

Installation Address: \_\_\_\_\_ Permit Number EL: \_\_\_\_\_

| ITEM No. | DESCRIPTION  | REFERENCES<br>(Applicable CEC Rules,<br>C.O.V. Bulletins, BC Safety<br>Authority Directives)                      | Conformance to the referenced requirements |    |     |
|----------|--|---|--|----|-----|
|          |  |   | Yes  | No | N/A |
| 1        | Horizontal clearance of H.V. conductors from adjacent structures; guarding | 36-004; 36-110; Table 33;<br>COV Bulletin 2003-016-EL   |  |    |     |
| 2        | Service raceways, including drainage and pull box facilities               | 2-320; 6-300; 12-942; 36-100;<br>COV Bulletin 2000-028-EL<br>COV Bulletin 2003-002-EL<br>COV Bulletin 2007-003-EL |  |    |     |
| 3        | Working space; entrance to and exit from                                   | 2-308; 2-310; Table 56<br>COV Bulletin 2007-002-EL<br>BCSA Directive No:<br>D-E3 070302 3                         |  |    |     |
| 4        | Space for service and distribution equipment                               | 6-206; 26-352- 36-200<br>COV Bulletin 2000-045-EL<br>BCSA Directive No:<br>D-E3 070302 5                          |  |    |     |
| 5        | Access to nameplates and parts requiring maintenance                       | 2-118   |  |    |     |
| 6        | Presence of other than electrical equipment                                | 2-120;<br>COV Bulletin 2000-045-EL  |  |    |     |
| 7        | (a) Dielectric liquid-filled equipment, indoors                            | 26-012; 26-242; 36-212;   |  |    |     |
|          | (b) Dielectric liquid-filled equipment, outdoors                           | 26-014; 26-242; 36-212;<br>COV Bulletin 2003-016-EL   |  |    |     |
| 8        | Illumination of equipment  | 2-314; 26-356   |  |    |     |
| 9        | Warning notices  | 36-006  |  |    |     |
| 10       | Electrical equipment service room/Vault                                    | 26-012  |  |    |     |
|          | (a) Location   | 36-200;   |  |    |     |
|          | (b) Construction   | VBBL DIV. B<br>3.6.2.1./3.6.2.7   |  |    |     |
|          | (c) Door Swing   | VBBL DIV. B 3.6.2.6.  |  |    |     |
|          | (d) Fire alarm system devices (Smoke detectors if not sprinklered)         | COV Bulletin 2000-045-EL<br>VBBL DIV. B 3.6.2.7. (3)(b)   |  |    |     |
|          | (e) Adjacent Hazardous Areas   | 20-102(5)   |  |    |     |
|          | (f) If sprinklered, adequate protection for electrical equipment           | 26-008; 26-248(5);<br>COV Bulletin 2000-024-EL<br>NFPA 13 5-13.11   |  |    |     |

| ITEM No.  | DESCRIPTION   | REFERENCES<br>(Applicable CEC Rules, C.O.V. Bulletins, BC Safety Authority Directives)         | Conformance to the referenced requirements |    |     |
|---|---|--|--|----|-----|
|   |   |  | Yes  | No | N/A |
| 11  | Ventilation<br>(a) Proof that the system is adequate and suitable for the purpose   | VBBL DIV. B 3.6.2.7(6)2-318; Appendix B;<br>BCSA Directive No:<br>D-E3 070302 3 – P. Eng. Ltr. |  |    |     |
|   | (b) Intake location   | VBBL DIV. B 6.2.3.12   |  |    |     |
| 12  | Grounding and bonding requirements:   | COV Bulletin 2005-004-EL<br>COV Bulletin 2000-047-EL   |  |    |     |
|   | (a) Station ground electrode  | 36-300; 36-302   |  |    |     |
|   | (b) Connections to the station ground electrode   | 36-104(5); 36-308;<br>Appendix B   |  |    |     |
|   | (i) Method of connection (as specified by the design professional)  | 36-300;<br>36-308; Appendix B  |  |    |     |
|   | (ii) Conductor sizes (as specified by the design professional)  | CEC Table 51   |  |    |     |
|   | (c) If a ground bus (pad) for testing purposes is installed:  |  |  |    |     |
|   | (i) Accessibility   | 2-312  |  |    |     |
|   | (ii) Conductors marked for testing purposes   | 36-308(7); 2-100   |  |    |     |
|   | (d) If a gang-operated switch is installed:   |  |  |    |     |
|   | (i) Operating shaft grounded  | 36-310(1)(a) or (b)  |  |    |     |
|   | (ii) 1.2 m X 1.8 m gradient control mat   |  |  |    |     |
|   | (iii) positioned for vertical or horizontal operation   |  |  |    |     |
|   | (iv) connection of the mat by two separate conductors (size and method of connection as specified by the design engineer) |  |  |    |     |
| (e) If a metallic fence is installed:                                     |   |  |  |    |     |
| (i) located minimum 1 m inside perimeter of station ground electrode area |   |  |  |    |     |
| (ii) connections to the fence   |   |  |  |    |     |
| 13  | L.V. breakers and fuses:  | Section 14   |  |    |     |
|   | (a) Size/trip setting   | Accepted Plans and Specifications  |  |    |     |
|   | (b) Interrupting capacity   | 14-012; 14-014;  |  |    |     |
| 14  | Ground Fault protection or indicator  | 14-102;<br>10-106(2)   |  |    |     |
| 15  | L.V. metering sockets   | BCSA Directive No:<br>D-E3 070302 5  |  |    |     |
| 16  | Seismic restraints  | VBBL DIV. B 4.1.8.17   |  |    |     |
| 17  | Other - (Please specify)  |  |  |    |     |

**Additional Comments:** \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**Company Name:** \_\_\_\_\_

**Name:** \_\_\_\_\_ **P.Eng**

**Signature:** \_\_\_\_\_

**Address:** \_\_\_\_\_

**Telephone:** \_\_\_\_\_ **Affix Professional Seal**

**Facsimile:** \_\_\_\_\_

**Email:** \_\_\_\_\_

# Questions?

