
# CANADIAN ELECTRICAL CODE HANDBOOK

## AN EXPLANATION OF THE RULES OF THE CANADIAN ELECTRICAL CODE, PART I

CSA Group

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| | |
|---|---|
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| **Navigating the 2018 Canadian Electrical Code** | Provides practical guidance on how to navigate and use the Code to easily locate the information you need, when you need it. |
| **Grounding & Bonding 2018 Canadian Electrical Code** | Provides detail on the grounding, bonding and equipotential bonding requirements of Section 10 of the *CE Code, Part I*. |
| **Modularized Customized Canadian Electrical Code** | Offers a flexible training approach where you control the content, timing and cost of your training session. Choose from 47 subject areas from the *CE Code, Part I* and other electrical topics. |
| **Alberta Online Updates – Changes 2018 CE Code** | Provides an overview of the provincial amendments for applying the Code in Alberta. |
| **2018 Online Pre-Master Electrician Course** | Designed to help electricians in preparing for their Master Electrician Examination. |
| **Workplace Electrical Safety based on CSA Z462** | Updated to reflect numerous changes in the 2018 edition of *CSA Z462*, this course can help you and your business become better equipped to deal with electrical hazards. |
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| | |
|---|---|
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## *C22.1HB-18*
## *January 2018*

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# *C22.1HB-18*
# ***CE Code Handbook***

## *An Explanation of the Rules of the*
## Canadian Electrical Code, Part I

CSA Group



- The *Canadian Electrical Code, Part I*, is a voluntary code for adoption and enforcement by regulatory authorities.
- The *Canadian Electrical Code, Part I*, meets the fundamental safety principles of International Standard IEC 60364-1, *Low-voltage electrical installations*.
- Consult with local authorities regarding regulations that adopt and/or amend the Code.

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# Contents



  

# Introduction to the *CE Code Handbook*

This Handbook provides background information on the reasons behind the requirements in the *Canadian Electrical Code, Part I*, and gives an explanation of the Rules in plain, easy-to-understand language. The Handbook is intended to provide a clearer understanding of the safety requirements of the Code.

The content of this Handbook is not meant to form a code of mandatory requirements. The mandatory language ("shall") that is used in the *CE Code, Part I,* has not been used here. Care has been taken to ensure that the intent of the Code Rules is clear to the users of the Handbook. However, users of the Handbook must not under any circumstances rely on it to determine the current requirements of the Code. As always, reference must be made to the Code itself and any local amendments. CSA Group does not assume responsibility for any errors or omissions resulting from the information contained in this Handbook.

The Rules in the *CE Code, Part I*, are divided into two groups. Sections 0 to 16 and 26 are considered general Sections, and the other Sections supplement or amend those general Sections. Therefore a requirement in the supplementary Sections takes precedence over a general requirement. For example:

- Rule 12-1008 requires 3 threads to be engaged when making a threaded connection, whereas Rule 18-102 requires 5 threads to be engaged when making a threaded connection in a Zone 1 area.
- Section 4 permits the use of aluminum conductors, but Rule 32-100 does not allow aluminum conductors to be used in fire alarm systems.

## About the development of the *CE Code Handbook*

The Rationale and Intent for the first edition of this Handbook (1990) were researched and written by technical experts selected for their experience and knowledge of the subject. Their contributions were reviewed by a panel consisting of experienced inspection authorities, manufacturers, and educators responsible for teaching the *CE Code, Part I*. Technical experts developed the figures and schematics for each Section.

In the second edition of the Handbook (1994), changes were made to the Rationale and Intent, based on the deliberations of technical experts, members of the Subcommittees, and members of the Committee on *Canadian Electrical Code, Part I*. In that edition, additional information was provided in some areas under the heading "Field considerations". Field considerations consisted of nonmandatory information to consider in the field, to ensure safe installation.

In the third edition of the Handbook (1998), changes were made to the Rationale and Intent, based on the deliberations of technical experts, members of the Subcommittees, and members of the Committee on *Canadian Electrical Code, Part I*. Supplementary information was added in some areas under the heading "Field considerations".

In the fourth edition of the Handbook (2002), similar changes were made to the Rationale and Intent, based on the deliberations of technical experts, members of the Subcommittees, and members of the Committee on *Canadian Electrical Code, Part I*. Many detailed figures were added; the general Sections were rewritten in a simpler format; and other information was added under the heading "Field considerations".

In the fifth edition of the Handbook (2006), the Rationale, Intent, and Field considerations were consolidated to provide a more user-friendly explanation of the Code Rules. Additional figures were provided, as well as more examples and calculations to help the user put the Code into practice.

In the sixth edition of the Handbook (2009), the content was reviewed to ensure that it was both useful and accessible to the reader. Where the Handbook commentary on a specific Code Rule in previous editions provided little or no information beyond what was given in the Code itself, the Handbook commentary was deleted. Therefore, the sixth edition of the Handbook, unlike its predecessors, did not contain commentary on every Code Rule.

In the seventh edition of the Handbook (2012), significant revisions were made to address the extensive changes introduced in the 2012 edition of the Code. These changes affected most areas of the electrical industry. They included major updates to Section 50 on solar photovoltaic systems; a new Section 64 on renewable energy systems; several new conductor types and wiring methods; changes in ampacity calculations; revised and clarified grounding and bonding requirements; new requirements for receptacles; and new and revised requirements for electric vehicle charging infrastructure, hazardous locations, and electric heating.

In the eighth edition of the Handbook (2015), significant revisions were made to address extensive changes introduced in the 2015 edition of the Code, including the rewriting of Sections 18, 62, and 64. These revisions included changes in the calculation of ampacities, voltage drops, and conduit and tubing capacities; the use of meter bases and arc-fault and ground fault circuit interrupters; the selection of material for grounding conductors; and disconnecting requirements for generators.

In this, the ninth edition of the Handbook (2018), significant revisions have been made to many Sections, as follows:

- Section 0 clarifies the terms "jacketed", "insulated", and "covered", as applied to conductors, by providing a new definition of the term "jacket" and a revision of the definition of the term "conductor" (as a result of the revision, the term "conductor" has been replaced with "insulated conductor" in many Sections of the Code);
- in many Sections, the redundant use of the term "approved" has been eliminated;
- Section 4 now requires that an identified conductor be provided for all devices controlling permanently installed luminaires;
- Section 8 now formally recognizes energy management systems as a method of reducing the load on building services;
- Section 10 has been updated, reorganized, and significantly reduced in length;
- Section 16 now has requirements for power over ethernet (POE) systems;
- Section 26:
  - now mandates the use of tamper-resistant receptacles in additional areas where children might be present;
  - has been reorganized and renumbered (from Rule 26-400 to Rule 26-726) in order to group related concepts together and provide a more logical flow for the requirements;
  - clarifies requirements for dining area and refrigerator circuits; and
  - clarifies requirements for receptacles exempted from arc-fault circuit interrupter protection;
- Section 32:
  - clarifies requirements for arc-fault circuit interrupter protection for bathrooms, washrooms, existing circuits, and circuits supplying carbon monoxide or smoke alarms; and
  - provides updated requirements for the feeders and circuits supplying fire pumps;
- Section 62 now requires ground fault circuit interrupter protection for heating devices and controls in proximity to tubs, sinks, and shower stalls;
- Section 78 provides substantially updated and reorganized requirements for marinas, wharves, and similar facilities; and
- Section 82 has been deleted as it covered a technology that is no longer in use.

**Notes:**

**1)** *Use of the singular does not exclude the plural (and vice versa) when the sense allows.*

**2)** *Although the intended primary application of this Handbook is stated in its Introduction, it is important to note that it remains the responsibility of the users of this Handbook to judge its suitability for their particular purpose.*

3) *All enquiries regarding this Handbook should be addressed to CSA Group, 178 Rexdale Blvd., Toronto, Ontario, Canada M9W 1R3.*

# Excerpt from the Preface to the *CE Code, Part I*

This twenty-fourth edition of the *Canadian Electrical Code, Part I*, was approved by the Committee on the *Canadian Electrical Code, Part I*, and by the Regulatory Authority Committee at their June 2017 meetings in Halifax, Nova Scotia. This twenty-fourth edition supersedes the previous editions, published in 2015, 2012, 2009, 2006, 2002, 1998, 1994, 1990, 1986, 1982, 1978, 1975, 1972, 1969, 1966, 1962, 1958, 1953, 1947, 1939, 1935, 1930, and 1927.

This edition features important revisions to many Sections. Section 26 now mandates the use of tamper-resistant receptacles in additional areas where children may be present. Section 62 now requires ground fault circuit interrupter protection for heating devices and controls in proximity to tubs, sinks, and shower stalls.

Section 10 has been updated, reorganized, and significantly reduced in length. Requirements for power over ethernet systems have been added to Section 16, and requirements for marine wharves and similar facilities have been substantially updated and reorganized in Section 78.

To address the increasing use of electric vehicles, Section 8 now formally recognizes energy management systems as a method of reducing the load on building services. Because lighting control devices associated with energy management or home automation require power to operate, Section 4 now requires that an identified conductor be provided for all devices controlling permanently installed luminaires.

Other revisions in this edition include the following:
- in Section 26, Rules 26-400 to 26-726 have been reorganized and renumbered in order to group related concepts together and provide a more logical flow for the requirements;
- in many Sections, the redundant use of the term "approved" has been eliminated;
- clarification has been provided on arc-fault circuit interrupter protection for bathrooms, washrooms, existing circuits, and circuits supplying carbon monoxide or smoke alarms;
- requirements for dining area and refrigerator circuits have been clarified;
- the terms "jacketed", "insulated", and "covered" as applied to conductors have been clarified through a new definition of the term "jacket" and a revised definition of the term "conductor" in Section 0. As a result, the term "conductor" has been replaced with "insulated conductor" in many Sections of the Code;
- Section 82 has been deleted as it covered a technology that is no longer in use; and
- a new Appendix M containing French translations of markings has been added.

Many of the changes in this edition were developed by cross-functional working groups. Their work is gratefully acknowledged.

## General arrangement

The Code is divided into numbered Sections, each covering some main division of the work. Sections 0 to 16 and 26 are considered general Sections, and the other Sections supplement or amend the general Sections. The Sections are divided into numbered Rules, with captions for easy reference, as follows:

a) **Numbering system** — With the exception of Section 38, even numbers have been used throughout to identify Sections and Rules. Rule numbers consist of the Section number separated by a hyphen from the 3- or 4-digit figure. The intention in general is that odd numbers may be used for new Rules required by interim revisions. Due to the introduction of some new Rules and the deletion of some existing Rules during the revision of each edition, the Rule numbers for any particular requirement are not always the same in successive editions.

  

b) **Subdivision of Rules** — Rules are subdivided in the manner illustrated by Rules 8-204 and 8-206, and the subdivisions are identified as follows:

| | |
|---|---|
| 00-000 | Rule |
| 1) | Subrule |
| a) | Item |
| i) | Item |
| A) | Item |

c) **Reference to other Rules, etc.** — Where reference is made to two or more Rules (e.g., Rules 10-200 to 10-206), the first and last Rules mentioned are included in the reference. Where reference is made to a Subrule or Item in the same Rule, only the Subrule number and/or Item letter and the word “Subrule” or “Item” need be mentioned. If the reference is to another Rule or Section, then the Rule number and the word “Rule” shall be stated (e.g., “Rule 10-206 3)” and not “Subrule 3) of Rule 10-206”).

## The history and operation of the *Canadian Electrical Code, Part I*

The preliminary work in preparing the Canadian Electrical Code began in 1920 when a special committee, appointed by the main Committee of the Canadian Engineering Standards Association, recommended its development. A third meeting of this Committee was held in June 1927 with representatives from Nova Scotia, Québec, Ontario, Manitoba, Saskatchewan, and British Columbia in attendance. At this meeting, the revised draft, which had been discussed at the previous two meetings, was formally approved and it was resolved that it be printed as Part I of the *Canadian Electrical Code*.

The Committee on the *CE Code, Part I*, is composed of 41 members, with representation from inspection authorities, industry, utilities, and allied interests. The main Committee meets once a year and deals with reports that have been submitted by the Section Subcommittees, which work under the jurisdiction of the main Committee. Suggestions for changes to the Code may be made by any member of the Committee or anyone outside the Committee as outlined in Clause C6.

# Metric units

## Symbols and conversion factors for SI units

Recognized symbols for SI units have been used in the *Canadian Electrical Code, Part I*. For the convenience of the user, these symbols and the units they represent have been listed in the following table; the table also gives a multiplying factor that may be used to convert the SI unit to the previously used unit.

| Symbol | SI unit | Multiplying factor for conversion to previously used unit | Previously used unit |
|---|---|---|---|
| A | ampere(s) | 1 | ampere(s) |
| $cm^3$ | cubic centimetre(s) | 0.061 | cubic inch(es) |
| °(s) | degree(s) (angle) | 1 | degree(s) (angle) |
| °C rise | degree(s) Celsius | 1.8 | degree(s) Fahrenheit |
| °C temperature | degree(s) Celsius | 1.8 plus 32 | degree(s) Fahrenheit |
| h | hour(s) | 1 | hour(s) (time) |
| Hz | hertz | 1 | cycles per second |
| J | joule(s) | 0.7376 | foot-pound(s) |
| kg | kilogram(s) | 2.205 | pound(s) |
| kJ | kilojoule(s) | 737.6 | foot-pound(s) |
| km | kilometre | 0.621 | mile(s) |
| kPa | kilopascal(s) | 0.295 | inch(es) of mercury |
| | | 0.334 | feet of water |
| | | 0.145 | pound(s) per square inch (psi) |
| kW | kilowatt | 3415.179 | BTU/h |
| lx | lux | 0.093 | foot-candle(s) |
| L | litre | 0.220 | gallon(s) |
| m | metre(s) | 3.281 | feet |
| $m^2$ | square metre(s) | 10.764 | square feet |
| $m^3$ | cubic metre(s) | 35.315 | cubic feet |
| MHz | megahertz | 1 | megacycles per second |
| min | minute(s) | 1 | minute(s) |
| mL | millilitre(s) | 0.061 | cubic inch(es) |
| mm | millimetre(s) | 0.03937 | inch(es) |
| $mm^2$ | square millimetre(s) | 0.00155 | square inch(es) |
| N•m | newton•metre | 8.85 | pound-force inches |
| Ω | ohm(s) | 1 | ohm(s) |

| Symbol | SI unit | Multiplying factor for conversion to previously used unit | Previously used unit |
|---|---|---|---|
| Pa | pascal(s) | 0.000295 | inch(es) of mercury |
| | | 0.000334 | feet of water |
| | | 0.000145 | pounds per square inch (psi) |
| s | second(s) | 1 | second(s) |
| V | volt(s) | 1 | volt(s) |
| W | watt(s) | 1 | watt(s) |
| µF | microfarad(s) | 1 | microfarad(s) |

## Conduit sizes

Starting in the 2006 edition of the Code, the metric trade designator has been used exclusively to identify conduit size. The following table is provided for convenience only.

### Conduit trade sizes

| Inches | Metric designator |
|---|---|
| 3/8 | 12 |
| 1/2 | 16 |
| 3/4 | 21 |
| 1 | 27 |
| 1-1/4 | 35 |
| 1-1/2 | 41 |
| 2 | 53 |
| 2-1/2 | 63 |
| 3 | 78 |
| 3-1/2 | 91 |
| 4 | 103 |
| 5 | 129 |
| 6 | 155 |
| 8 | 200 |

# Reference publications

The *Canadian Electrical Code, Part I* refers to the following publications, and the year dates shown indicate the latest editions available at the time the Code was approved:

**CSA Group**

6.19-17
*Residential carbon monoxide alarming devices*

ASME A17.1-2013/CSA B44-13
*Safety code for elevators and escalators*

CSA B44.1-14/ASME A17.5-2014
*Elevator and escalator electrical equipment*

B52-13
*Mechanical refrigeration code*

CAN/CSA-B72-M87 (R2013)
*Installation code for lightning protection systems*

B108-14
*Compressed natural gas fuelling stations installation code*

B149.1-15
*Natural gas and propane installation code*

B149.2-15
*Propane storage and handling code*

B355-15
*Lifts for persons with physical disabilities*

CAN/CSA-B613-00 (withdrawn)
*Private residence lifts for persons with physical disabilities*

CAN/CSA-C22.2 No. 0-10 (R2015)
*General requirements — Canadian Electrical Code, Part II*

C22.2 No. 1-04 (withdrawn)
*Audio, video, and similar electronic equipment*

C22.2 No. 3-M1988 (withdrawn)
*Electrical features of fuel-burning equipment*

C22.2 No. 4-16
*Enclosed and dead-front switches*

C22.2 No. 5-16
*Molded-case circuit breakers, molded-case switches, and circuit-breaker enclosures*

  

C22.2 No. 14-13
*Industrial control equipment*

C22.2 No. 18.1-13
*Metallic outlet boxes*

C22.2 No. 18.2-06 (R2016)
*Nonmetallic outlet boxes*

C22.2 No. 18.3-12 (R2017)
*Conduit, tubing, and cable fittings*

C22.2 No. 18.4-15
*Hardware for the support of conduit, tubing, and cable*

C22.2 No. 29-15
*Panelboards and enclosed panelboards*

C22.2 No. 35-09 (R2014)
*Extra-low-voltage control circuit cable, low-energy control cable, and extra-low-voltage control cable*

C22.2 No. 38-14
*Thermoset-insulated wires and cables*

C22.2 No. 41-13
*Grounding and bonding equipment*

C22.2 No. 42-10 (R2015)
*General use receptacles, attachment plugs, and similar wiring devices*

C22.2 No. 42.1-13
*Cover plates for flush-mounted wiring devices*

C22.2 No. 45.1-07 (R2017)
*Electrical rigid metal conduit — Steel*

C22.2 No. 46-13
*Electric air-heaters*

C22.2 No. 48-15
*Nonmetallic sheathed cable*

C22.2 No. 49-14
*Flexible cords and cables*

C22.2 No. 51-14
*Armoured cables*

C22.2 No. 52-15
*Underground secondary and service-entrance cables*

  

C22.2 No. 56-17
*Flexible metal conduit and liquid-tight flexible metal conduit*

C22.2 No. 64-10 (R2014)
*Household cooking and liquid-heating appliances*

C22.2 No. 65-13
*Wire connectors*

C22.2 No. 66.3-06 (R2015)
*Low voltage transformers — Part 3: Class 2 and Class 3 transformers*

C22.2 No. 75-17
*Thermoplastic insulated wires and cables*

C22.2 No. 77-14
*Motors with inherent overheating protection*

C22.2 No. 82-1969 (R2013)
*Tubular support members and associated fittings for domestic and commercial service masts*

C22.2 No. 83-M1985 (R2017)
*Electrical metallic tubing*

C22.2 No. 83.1-07 (R2017)
*Electrical metallic tubing — Steel*

C22.2 No. 85-14
*Rigid PVC boxes and fittings*

C22.2 No. 96-17
*Portable power cables*

C22.2 No. 100-14
*Motors and generators*

C22.2 No. 106-05 (R2014)
*HRC-miscellaneous fuses*

C22.2 No. 107.1-16
*Power conversion equipment*

C22.2 No. 111-10 (R2015)
*General-use snap switches*

C22.2 No. 123-16
*Metal sheathed cables*

C22.2 No. 124-16
*Mineral-insulated cable*

  

C22.2 No. 126.1-17
*Metal cable tray systems*

CAN/CSA-C22.2 No. 126.2-02 (R2017)
*Nonmetallic cable tray systems*

C22.2 No. 127-15
*Equipment and lead wires*

C22.2 No. 129-10 (R2014)
*Neutral-supported cables*

C22.2 No. 130-16
*Requirements for electrical resistance trace heating and heating device sets*

C22.2 No. 131-14
*Type TECK 90 cable*

C22.2 No. 141-15
*Emergency lighting equipment*

CAN/CSA-C22.2 No. 157-92 (R2016)
*Intrinsically safe and nan-incendive equipment for use in hazardous locations*

C22.2 No. 174-M1984 (R2017)
*Cables and cable glands for use in hazardous locations*

C22.2 No. 178.1-14
*Transfer switch equipment*

C22.2 No. 179-09 (R2014)
*Airport series lighting cables*

C22.2 No. 208-14
*Fire alarm and signal cable*

C22.2 No. 211.0-03 (R2013)
*General requirements and methods of testing for nonmetallic conduit*

C22.2 No. 211.1-06 (R2016)
*Rigid types EB1 and DB2/ES2 PVC conduit*

C22.2 No. 211.2-06 (R2016)
*Rigid PVC (unplasticized) conduit*

C22.2 No. 211.3-96 (withdrawn)
*Reinforced thermosetting resin conduit (RTRC) and fittings*

C22.2 No. 213-16
*Non-incendive electrical equipment far use in Class I and II, Division 2 and Class III, Divisions 1 and 2 hazardous (classified) locations*

C22.2 No. 214-17
*Communications cables*

C22.2 No. 218.1-13
*Spas, hot tubs, and associated equipment*

C22.2 No. 223-15
*Power supplies with extra-low-voltage Class 2 outputs*

CAN/CSA-C22.2 No. 227.1-06 (R2016)
*Electrical nonmetallic tubing*

C22.2 No. 227.2.1-14
*Liquid-tight flexible non-metallic conduit*

C22.2 No. 239-17
*Control and instrumentation cables*

C22.2 No. 248 series
*Low-voltage fuses*

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# Section 0 — Object, scope, and definitions

## Object

The object of the Code is to specify requirements for the installation and maintenance of electrical equipment to help ensure electrical safety. Electrical safety is also ensured through compliance with the objective-based fundamental safety principles of IEC 60364-1 and through the implementation of a quality management or equivalent program acceptable to the authorities having jurisdiction over the adoption and enforcement of the Code.

In the preparation of the Code, consideration has been given to the following four major areas:

- the prevention of fire hazards by
  - using overcurrent protection for
    - short-circuits; and
    - excessive current (overload);
  - providing clearances from combustible materials; and
  - preventing ignition of hazardous and combustible materials;
- the prevention of shock hazards by
  - grounding and bonding to
    - establish an equipotential plane so that the possibility of a potential difference between metal parts is minimized;
    - connect to earth the equipotential plane, thereby minimizing any potential difference to earth; and
    - provide a low impedance path for fault current to flow back to the source; or
  - using insulation to separate conducting surfaces. Insulation can consist of a dielectric material or an air space that has high enough resistance to prevent the flow of current and/or the discharge of disruptive voltage spikes (e.g., from lightning or transients) from causing damage to the installation and/or endangering personnel (electric shock);
- the installation and maintenance requirements for electrical equipment to ensure essentially safe installation and operation; and
- the proper operation of electrical installations and electrical equipment by ensuring that they are
  - installed to meet the conditions of use/applications; and
  - certified to
    - a CSA Group Standard
    - other recognized documents, where such CSA Group Standards do not exist or are not applicable; or
    - the requirements of the authority having jurisdiction.

Safe installations may also be achieved by alternatives to the Code provided that such alternatives meet the fundamental safety principles of IEC 60364-1 (see Appendix K).

The Code recommends that, when considering new installations, designers and field personnel make provision for wiring changes that might be required as a result of future load growth. If future growth is not taken into consideration, electrical installations can become overloaded, resulting in hazardous conditions.

## Scope

The Code applies to all electrical installations for buildings, structures, and premises and is intended to apply to all voltages. Although low voltages might not pose a shock hazard, various conditions can lead to physical injury and damage to equipment, even at seemingly harmless voltage levels.

The Scope specifies the subjects that the Code covers. In addition, it lists subjects not covered so that the reader can determine what other requirements apply, as determined by the authority having jurisdiction. For example, the requirements for electrical systems on aircraft and ships are not covered in the Code but are regulated by Transport Canada. If an application is excluded from the Scope of the Code, the authority having jurisdiction should be contacted to determine the requirements that do apply.

## Definitions

The definitions in the Code help to clarify the intent of the requirements and should be consulted regularly. Terms defined in Section 0 apply equally throughout the Code, while terms defined in an individual Section apply only to that Section. Where a defined term is used, the Code definition and not the dictionary definition should be used. For terms not specifically defined in the Code, the conventional (trade) meaning or dictionary definition should be used.

Although not defined within the Code, the following terms are commonly used in the electrical trade and are provided here for information purposes.

**Across-the-line motor controller** — a full voltage motor controller.

**Alu-sheath** — cable that is aluminum-sheathed.

**Antishort** — the insulated bushing required where armoured cable is terminated.

**Appliance** — a portable unit or a group of units assembled to form a complete unit.

**Authority having jurisdiction** — an umbrella term used to describe an organization, office, or individual responsible for approving equipment, materials, an installation, or a procedure.

The phrase "authority having jurisdiction" is used in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the AHJ may be
- a federal, provincial, local, or other regional department;
- an individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labour department, or health department; building official; electrical inspector; or
- others having statutory authority.

For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the AHJ.

In some circumstances, the property owner or his or her designated agent assumes the role of the AHJ; at government installations, the commanding officer or departmental official may be the AHJ.

**Backfeeding** — electric power flowing in the opposite direction from its usual flow. For cost reasons, many of the circuit (overcurrent) protection and power quality control (voltage regulation) devices used by electric utility companies are designed based on the assumption that power always flows in one direction. For additional information, see Rule 84-004 as well as other Rules in Section 84.

**Bonding, protective** — a low impedance path established to carry fault current to facilitate the operation of the protective device(s) of a circuit during a fault event.

**Burndy® connector** — a split-bolt-type connector for splicing conductors.

**Bus duct** (or **busway**) — a prefabricated electrical distribution system consisting of busbars (high current conductors used to make a common connection between several circuits in a system) in a protective enclosure, including straight lengths, fittings, devices, and accessories.

**BX** — a type of armoured cable.

**Cab tire** — flexible cord with a CSA letter designation beginning with the letter "S".
**Note:** *Cab tire is usually hard usage or extra-hard usage.*

**Chico** — a sealing compound used in explosion-proof seals.
**Note:** *See Sections 18 and 20.*

**Code fuse** — a standard certified fuse.

**Condulet®** — an electrical box used to provide access to wires placed within conduit. It differs from a junction box, which is larger, providing space for pulling wires and making splices.

**Coreflex (RA90 and RC90)** — single or multiple copper or aluminum conductors with cross-linked polyethylene insulation (RW90 XLPE) enclosed in a continuously welded and corrugated solid aluminum or copper sheath.

**Corona** — ionization that occurs in an insulating system when the potential gradient exceeds a certain value and that may lead to insulation failure. Visible corona effects may appear as a luminous discharge on the surface of a conductor due to ionization of air.

**Corona effect** — the effect produced when two wires or other conductors having a difference of voltage are placed in close proximity to one another.

**Problems caused by corona discharges** — Coronas can generate audible and radio-frequency noise, particularly near electric power transmission lines. They also represent a power loss, and their action on atmospheric particulates, along with associated ozone and nitrogen oxide (NOx) production, can be disadvantageous to human health where power lines run through built-up areas. Therefore, power transmission equipment is designed to minimize the formation of corona discharge.

Corona discharge is generally undesirable in
- electric power transmission, where it causes
  - power loss;
  - audible noise;
  - electromagnetic interference;
  - purple glow;
  - ozone production; and
  - insulation damage;
- electrical components such as transformers, capacitors, electric motors, and generators. Corona discharge progressively damages the insulation inside these devices, leading to premature equipment failure. An example of this type of damage is ozone cracking of elastomer items such as O-rings; and
- situations where high voltages are in use, but ozone production is to be minimized.

Coronas can be suppressed by corona rings, toroidal devices that serve to spread the electric field over larger areas and decrease the field gradient below the corona threshold.

**Corrosion** — a process in which a solid, most commonly a metal, is changed by a chemical reaction.

**Device box** — a box that holds a device (e.g., a switch, receptacle, or cover) by means of No. 6-32 machine screws. The following are types of device boxes:
- No. 1100 — 3 × 2 × 1-1/2 inch device box

- No. 1102 — 3 × 2 × 2 inch device box
- No. 1104 — 3 × 2 × 2-1/2 inch device box
- No. 1004 — 3 × 2 × 3 inch device box

**Earthing** — being in direct physical contact with the ground or with a device connected to electrical ground.

**Electro-strip®** — a multi-outlet assembly.

**Enclosure** — an enclosed space that provides mechanical, electrical, and/or environmental protection for a control device.

**Equipotential surface/plane** — a surface having all areas/parts at a single potential to ground.

**EYS** — an explosion-proof, Y-shaped sealing fitting used to prevent passage of gases, vapour, or flames from one portion of a conduit system to another.

**Note:** *See Sections 18 and 20.*

**Functionally associated** — the direct relation of the optical fiber cables to the control or signalling of the electrical circuit involved.

**Grounded conductor** — a conductor that is bonded to ground.

**Note:** *A grounded conductor is often confused with a neutral.*

**Harmonics** — integer multiples of the fundamental frequency (50 or 60 Hz) caused by non-linear loads.

**Heater (in a thermal overload device)** — a field-replaceable component of a thermal overload device that provides the heat that is necessary for the thermal overload device to function.

**Hickey** —
- a manual bending device used to bend rigid metal conduit; or
- a coupling used to connect a luminaire to its supporting device.

**Inspection department** — an organization legally authorized to enforce the Code and having jurisdiction over specified territory.

**Inspector** — any person duly appointed by the inspection department for the purpose of enforcing the Code.

**Loomex** — cable that is non-metallic-sheathed.

**Neutral conductor** — the conductor connected to the neutral point of a system and intended to carry current under normal conditions.

**Neutral point** — the common point on a wye-connection in a polyphase system; the midpoint on a single-phase, 3-wire system; the midpoint of a single-phase portion of a 3-phase delta system; or the midpoint of a 3-wire, direct-current system.

**Notes:**

1) *At the neutral point of the system, the vectorial sum of the nominal voltages from all other phases within the system that utilize the neutral, with respect to the neutral point, is zero potential.*
2) *A 3-phase, 4-wire, wye-connected power system used to supply power to nonlinear loads may necessitate that the power system design allow for the possibility of high harmonic currents on the neutral conductor.*

**Neutral supported cable (Type NS)** — an assembly of one, two, or three insulated phase conductors and an optional insulated control/supply conductor factory-cabled around a neutral conductor. The neutral conductor is the supporting member.

**Nipple** — a short section of conduit between fittings, between fittings and enclosures, or between enclosures.

**Nolox®** — a joint compound that is used to prevent oxide film from forming or reforming on the termination or splice of stranded aluminum conductors.

**Open-circuit voltage** — the voltage when no appreciable current is flowing.

**Open wiring** — where single conductors with no protective covering are run exposed (i.e., not concealed) and supported on insulators.

**Outlet box** — a box that uses No. 8-32 machine screws for the attachment of fixtures (e.g., luminaires, ceiling fans, covers, plaster rings, extension rings). The following are types of outlet boxes:
- Pancake — 1/2 inch deep round box
- Octagonal — 4 × 4 × 1-1/2 inch deep
- Square — 4 × 4 × 1-1/2 inch deep
- Square — 4-11/16 × 4-11/16 × 2-1/8 inch deep

**Plugmold®** — a surface raceway system.

**Pot light** — a recessed luminaire.

**Pyrotenax cable®** — a type of mineral-insulated cable.

**Quadruplex** — neutral supported cable that has three insulated conductors and a support conductor.
**Note:** *A quadruplex is also known as a phaseplex.*

**Romex** — cable that is non-metallic-sheathed.

**Rosette** — a device that is used for supporting and connecting the circuit, cord, and sockets of flexible drop cords.

**Running board** — a piece of material at least 19 mm thick that is used to protect conductors or cables from mechanical damage.

**Running thread** — the length of external thread on a rigid conduit that exceeds the maximum length stated in Table 40 of the Code. A characteristic of running threads is that they are not tapered. As the conduit runs through the die, the smallest diameter is met and more threads are added. The loss of taper at one end reduces the wedge that would make the coupling or hub tight to the raceway and loss of bonding and structural integrity can result. In hazardous locations, the flame path required by the threaded connection could be compromised, creating a potential for atmospheric explosion.

**Seal-tight flex** — liquid-tight flexible conduit.

**Shielding** — a grounded conductive medium that prevents undesirable influence of electromagnetic fields, pick-up of signals, induction, stray currents, ac hum, radiation of an electrical signal, etc. Shielding confines the magnetic field of an electric cable to the inside of the cable installation or insulated conductor assembly by surrounding the insulation or assembly with a grounded conductive medium called a shield.

**Standard fuse** — a certified code fuse.

**Strain-relief device** — a device that is designed to prevent tension or twisting forces from being transmitted to conductors and conductor terminations.

**Stud** (with respect to a luminaire) — a conduit that is run between a luminaire and the fixture hickey (coupling) or between the fixture hickey (coupling) and the outlet box supporting the luminaire.

**Tap conductor** — a conductor that has an ampacity rating less than the ampacity of the conductor or busbar that is feeding it.

**Tracking (surface tracking/leakage)** — the formation of a conducting path, usually caused by solid materials (e.g., carbon) or moisture being deposited on the surface of an insulating material between two parts of different polarity. The tracking/creepage distance is the shortest distance measured along the surface of an electrically insulating material between two conductive parts of different polarity. The length of tracking or creepage distance depends on the working voltage between the two conductive parts and the electrical insulating material's resistance to the buildup of foreign conductive materials or moisture.

**Transient voltage** — a momentary abnormally high voltage on a signal or power line.

**Note:** *Transient voltage can produce false signals or triggering impulses and can cause insulation or component breakdowns and failures.*

**Triplex** — neutral supported cable that has two insulated conductors.

**Wiremould®** — a surface raceway.

# Section 2 — General Rules

Section 2 is a general Section of the Code that contains general, all-encompassing technical requirements and certain administrative provisions. These general requirements apply to all Sections, unless amended within a specific Section. The administrative provisions assist regulators in adopting the Code for regulatory purposes.

## Administrative

Rules 2-000 to 2-032 are administrative requirements that may vary from one administrative authority (city, province, or territory) to another. They are guides to help the jurisdictions standardize the administrative requirements related to enforcing the Code.

### Rule 2-024 Use of approved equipment

Rule 2-024 has two requirements: equipment must be "approved" and be "approved for the specific purpose".

"Approved" equipment is:

- electrical equipment that has been certified by a certification organization accredited by the Standards Council of Canada (SCC) to be in accordance with the requirements (that is, having passed the required construction requirements and testing) outlined in:
  - CSA Group Standards;
  - standards that have been developed by an SCC accredited Standards Development Organization; or
  - other recognized documents where CSA Group Standards do not exist or are not applicable, provided that they:
    - are correlated with provisions of the *Canadian Electrical Code, Part I*; and
    - do not create duplication with existing CSA Group Part II Standards listed in Appendix A; or
- equipment that conforms to the requirements of the regulatory authority (see Appendix B).

When equipment has met the requirements of the certification process, CSA Group or another accreditation certification body grants a licence to apply its mark (sometimes called a monogram or logo) to the equipment, indicating that the equipment complies with applicable requirements.

Certification addresses a product's safety and its compliance with applicable written requirements. The certification process is based on:

- written requirements (in applicable Standards); and
- a documented certification program.

A typical certification process proceeds as follows:

- A manufacturer/organization submits a Request for Quotation to CSA Group (which is an SCC accredited certification body).
- CSA Group determines the location for testing after the quotation is accepted and agreed to.
- CSA Group evaluates the equipment according to program criteria.
- CSA Group prepares a summary report.
- If the equipment complies with the Standards, CSA Group issues a Certificate of Compliance.
- The equipment manufacturer is licensed to put the CSA mark on the equipment and is subject to four unannounced factory audits each year.

The certification mark (usually located on the equipment's nameplate) indicates that the equipment is certified. The authority having jurisdiction (AHJ) has the final say on which certification organization approvals it accepts. Although a certification organization is accredited by the SCC, its certification of a particular piece of equipment might or might not be approved by the AHJ. Although certified, equipment cannot be used in the geographic area of that particular AHJ until it satisfies the AHJ's requirements for approval.

Figure 2-1 shows the CSA Group certification marks for equipment certified for Canada only, Canada and the US, and the US only.

**Figure 2-1**
**Certification marks for Canada only, Canada and US, and US only**

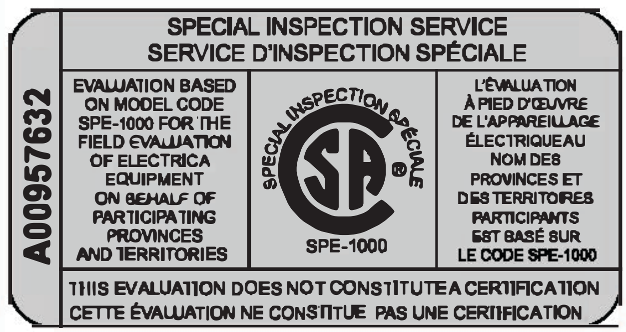
| Canada | Canada and US | US |
| --- | --- | --- |
| SA® | SA® C US | SA® US |

Electrical equipment can be approved by means of field evaluation or special inspection in conformance with CSA SPE-1000. Such field evaluation/special inspection of electrical equipment is to be provided only by the special inspection bodies accredited by the SCC, and only if such bodies are accepted by the participating AHJ. Evidence of approval by a special inspection must be demonstrated by a "Special Inspection" label attached to the equipment (see Figure 2-2).

Field evaluations bridge the gap between uncertified equipment and code-compliant equipment acceptable to the AHJ. Typically, a field evaluation is used for equipment that is specialized or made-to-order with a small annual production.

A field evaluation is:
- not a certification service;
- a product safety service evaluation in accordance with the applicable Standards with site-specific variances accepted by the AHJ; and
- offered as support when approved equipment is required by the AHJ.

**Figure 2-2**
**"Special Inspection" label**




Where field evaluations are done for equipment used in hazardous locations as defined by Section 18, special inspection under CSA SPE-1000 cannot be done. The equipment, however, can still be field evaluated and receive a serialized CSA Group field certification label (see Figure 2-3).

There are three types of field evaluation used globally. They are very similar in concept, though they have different names (according to the certification system in which they are used). The three types are:

- field certification — North America;
- unit verification — IECEx and ATEX; and
- product verification — ATEX.

**Figure 2-3**
**"Field Certification" label**


In addition to being "approved", electrical equipment needs to be "approved for the specific purpose" (that is, suitable for the application). This includes having the appropriate application classifications, ratings, and characteristics. Equipment is approved for a specific purpose for each condition of use.

Although Rule 2-024 is contained in the administrative part of Section 2, this Rule has important technical implications that mandate use of equipment designed, constructed, tested, and approved for installation in accordance with provisions of the Code. The scope of each Part II Standard for electrical products clearly states that the Standard covers the products that are "intended for installation in accordance with the *Canadian Electrical Code (CE Code), Part I*®. These CSA Group Standards are listed in Appendix A of the Code. Sometimes the equipment is approved according to CSA Group engineering Standards that were developed for equipment utilized by power utilities. The scope of the Standards (for example, CSA C227.3) dealing with this equipment does not contain the statement that this equipment is intended to be installed under provisions of the Code, and use of the equipment that has been approved according to these Standards should be discussed with the inspection authorities.

Code users should be aware that when electrical equipment is subjected to field modification by means other than an approved field modification kit, such modifications can void the original approval of the equipment. Thus, one of the intentions of Rule 2-024 is to ensure that – upon completion of any field modification that voids the original approval of the equipment – the equipment is recertified in accordance with provisions of the regulatory authority (in other words, in accordance with CSA SPE-1000 or other programs accepted by the participating AHJ).

Subrule 2) of Rule 2-024 refers the Code user to Item a) of Subrule 1) of Rule 16-222 for determining when electrical equipment is not required to be approved. Item a) of Subrule 1) of Rule 16-222 allows electrical equipment used in Class 2 circuits operating at not more than 42.4 V peak or 30 V rms ac or dc and at energy levels not exceeding 100 V•A to be acceptable for the particular application. Class 2 circuits at such ratings are less likely to cause electric shock or fire hazards. However, Class 2 circuits at these levels generally receive less attention during inspection than higher-power circuits, creating the mistaken impression that they have no potential for danger as they do not require approval. Therefore, Subrule 2) of Rule 16-222 requires that – when connected to Class 2 circuits – all lighting products [including luminaires, signs, rope lights, decorative strings and outfits, illuminated novelty items, and lighting devices that incorporate light-emitting diodes (LEDs)], electromedical equipment, equipment for hazardous locations, and thermostats incorporating heat anticipators be approved, due to the increased risk of fire, shock, or explosion.

### Rule 2-026 Powers of rejection

Although equipment bears evidence of approval (certification mark, special inspection label, or field certification label), the AHJ might reject it if:

- they determine the equipment to be inferior to the sample on which such approval was granted;
- the condition of use associated with the equipment is not suitable (for example, equipment approved for an ordinary location is used in wet location); or
- the terms of agreement between the manufacturer and the certification organization have not been met.

The Code regulators have the right and the responsibility to reject a piece of equipment for installation if the criteria listed in this Rule are not met.

### Rule 2-030 Deviation or postponement

According to the "Object" of the Code, compliance with the requirements of the Code and proper maintenance will ensure an essentially safe installation. The "Object" also allows that safe installations can be achieved by measures that are not specified in the Code, provided that the proponents of such alternatives can demonstrate to the AHJ that the safety objectives of the Code are not compromised by the proposed deviation from the Code's prescriptive requirements.

An understanding of the requirement in Rule 2-030 is important because the Code frequently uses phrases such as "Where a deviation has been allowed in accordance with Rule 2-030…". The AHJ might review requests to grant a deviation from a Code Rule when there are special circumstances that justify the deviation. Such a request could be necessary if the Code does not clearly reflect the specific situation of installation or if the circumstance makes it impracticable to apply the prescriptive Rule. Whatever the reason, the Code requires that "special permission" be obtained before work is commenced. Contact the AHJ to determine the protocol for submitting an application for deviation or postponement. When applying for a deviation or postponement, it is essential to provide adequate evidence that the proposed deviation will not compromise safety. In addition, the intent of this Rule is to allow deviations from the Code installation requirements. Under no condition should a request for deviation be applied to the use of "approved" equipment. Approved equipment must be used in installation without any deviations unless the requirement is waived by specific provisions of the Code.

# Technical

## General

### Rule 2-100 Marking of equipment

Rule 2-100 requires that electrical equipment have markings showing the technical characteristics listed in Subrule 1) to provide information necessary for the installation, servicing, maintenance, testing, repair, replacement, and evaluation of the electrical equipment, and to ensure safe and proper operation of the equipment. These markings ensure that a device has the proper rating for voltage, current, frequency, etc., for the circuit to which it is connected. Item n) of Subrule 1) includes other markings, such as those specified in Section 18 for hazardous locations and markings that relate to specific approval of the equipment for the intended application (e.g., for cables exposed to direct rays of the sun, for tamper-resistant receptacles, etc.).

Electrical equipment can be dangerous and might fail catastrophically if, under fault conditions, the equipment energizes or interrupts a circuit in excess of its short-circuit or withstand rating. Given the critical nature of this information for designers, installers, and inspectors, Item l) of Subrule 1) requires that equipment be marked with the actual short-circuit or withstand rating it has been designed and tested for.

Subrules 2) and 3) require that the maximum rating of the overcurrent device be marked on service and distribution equipment so that conductors and electrical equipment are not exposed to currents and resultant temperatures in excess of their limits. Rule 14-012 requires that electrical equipment required to interrupt fault currents (for example, overcurrent devices) be rated for the fault current that it interrupts. When a specific type or class of overcurrent devices (such as fuses or circuit breakers) is required for the available fault current or for selective overcurrent device coordination (series rated combinations), the type or class of the overcurrent device or short-circuit rating should be added to the label or marking.

Subrule 3) also requires marking that facilitates quick and easy identification of specific control devices in a portion of an installation. This can be vital in an emergency. For example, Rule 32-306 requires a clear identification of the circuit breaker protecting a fire pump feeder, and Rule 32-308 mandates specific labelling of a fire pump transfer switch, etc.

Operations and maintenance personnel working on equipment need to have accurate and current information to locate isolation and disconnection points. The required markings provided on complex distribution systems, such as systems with multiple sources, should be supplemented with additional information such as single-line diagrams, mimic or display panels, drawing packages, etc. This supplementary information should be readily available to personnel who will work on or operate such systems. Also procedures should be in place to ensure the required markings and supplementary information are kept up to date.

In order to avoid damaging heat buildup, the maximum continuous calculated load that is allowed to be connected to a fused switch or circuit breaker is limited by the continuous operating rating marked on the fused switch or circuit breaker. Based on the type of conductor, the installation method, and the continuous operation rating of the fusible switch or circuit breaker, Subrules 5) and 6) of Rule 8-104 limit the continuous calculated load so that it can be from 100% to 70% of the allowable ampacity of the conductors.

Once the fused switch or circuit breaker is put into service, it can be difficult to determine the size of conductors installed to connect the distribution equipment. Subrule 4) requires that a caution label be applied adjacent to the equipment's nameplate to advise the users of the maximum continuous loading permitted on the fused switch or on a circuit breaker, as only under the condition specified in Item a) of Subrule 5) of Rule 8-104 is a circuit breaker or a fused switch allowed to be loaded to 100% of its continuous rating.

This provides important and valuable safety information for owners, installers, and inspectors should an expansion or modification to the electrical system be considered in the future.

**CAUTION:**

**The maximum continuous loading is limited to ____ A**

**ATTENTION :**

**La charge continue maximale est limitée à ____ A**

## Rule 2-102 Warning and caution markings

To avoid safety hazards for the general public and those working on or near electrical equipment, Rule 2-102 requires that any field marking required by the Code be done in the language(s) mandated by the local authorities adopting and enforcing this Code, as shown in the following example:


## Rule 2-104 Electrical equipment ratings

To address a gap between the product Standards and the *Canadian Electrical Code, Part I*, requirements, Subrule 1) of Rule 2-104 requires that where electrical equipment is marked with a short-circuit current rating or withstand rating, it be selected for use with sufficient ratings for the voltage employed and for the fault current that is available at the terminals of the equipment.

Subrule 2) states that electrical equipment with a slash or dual voltage rating, such as 120/240 V or 600 V/347 V, is only to be connected to a circuit that is solidly grounded and where

- the voltage of any conductor to ground does not exceed the lower of the two values of the equipment voltage rating; and
- the voltage between any two conductors does not exceed the higher value of the electrical equipment voltage rating.

### Rule 2-106 Rebuilt equipment

When equipment is rebuilt or rewound, Subrule 3) of Rule 2-106 requires that it meet the requirements of the appropriate *Canadian Electrical Code, Part II,* Standard for new equipment. Note that rebuilt or rewound equipment must be marked with evidence of approval [see Item m) of Subrule 1) of Rule 2-100].

Subrule 4) specifies restrictions for use of rebuilt or refurbished moulded case circuit breakers or moulded case switches.

To prevent shock or fire hazards, moulded case circuit breakers or switches that have been subjected to undesirable conditions (such as smoke, water, environment damage, or fault currents greater than their rating) are considered not approved as required by Rule 2-024 and should be removed from service.

### Rule 2-110 Circuit voltage-to-ground — Dwelling units

The Code restricts the voltage of the electrical system in circuits used in dwelling units to 150 volts-to-ground to limit the exposure from shock and fire hazards.

Exceptions to this requirement are for fixed equipment in dwelling units as follows:

- space heating, provided that wall-mounted thermostats operate at a voltage not exceeding 300 volts-to-ground;
- water heating; and
- air conditioning.

### Rule 2-112 Quality of work

Rule 2-112 clarifies that electrical installations are to be of good quality and that the quality of work is subject to acceptance by the AHJ.

### Rule 2-114 Material for anchoring to masonry and concrete

Rule 2-114 excludes the use of wood or other unsuitable material as an anchor to support electrical equipment in masonry or concrete. Wood used as an anchor in masonry or concrete deteriorates by rotting or drying out and shrinking, ultimately providing no support. To ensure that electrical equipment is well supported and does not become a safety hazard (endangering people, and damaging materials and equipment), plastic or metallic anchors or concrete fasteners installed as per manufacturer's instructions are to be used.

### Rule 2-116 Corrosion protection for materials used in wiring

In many parts of Canada salts or chemicals are used on roads to reduce the danger from surface ice. These salts adhere to vehicles and subsequently drip onto parking areas, pavement, roadbeds, and similar areas, permeating the base material and corroding metals in the floor, pavement, or roadbed. In corrosive environments, chemicals or materials used in these locations can corrode (disintegrate) the metal of raceways, cable sheaths and armour, boxes, fittings, or enclosures, exposing the enclosed conductors or equipment to damage, which can cause an arcing or shock hazard. Subrule 1) of Rule 2-116 requires that the metal be protected against corrosion or be made of corrosion-resistant material suitable for the intended environment.

Dissimilar metals (such as copper and aluminum) when in contact with each other in moist or wet environments can cause galvanic action, which results in one material disintegrating. If this occurs in an electrical connection or in electrical equipment, the connection or equipment can fail, causing arcing and shock or fire hazards. Subrule 2) does not allow the use of dissimilar metals where galvanic action can occur. In certain cases, however, because of the type of equipment available, the infrequent occurrence of the conditions that give rise to galvanic action, the scheduled maintenance, and the type and strength of corrosive material, Subrule 2) allows dissimilar metals to be present in corrosive environments, when coatings or treatments for the prevention of galvanic action are used between the dissimilar metals. However, Code users should be aware that coating and treatments can be compromised over time, thus reducing the integrity of the materials.

### Rule 2-118 Soldering fluxes

Soldering flux is used to help remove oxides from the surface of materials to be joined together by soldering. Flux is a substance that is nearly inert at room temperature but that becomes strongly active at elevated temperatures. Solder attaches very well to copper but poorly to the various oxides of copper that form quickly at soldering temperatures. In the soldering of metals, flux serves three purposes:

- it removes oxidation from the surfaces to be soldered;
- it seals out air thus preventing further oxidation; and
- it improves the wetting characteristics of the liquid solder.

Flux is corrosive, and Rule 2-118 requires that the soldering flux be of the type that does not corrode the materials used in the electrical connection or compromise the integrity of the insulation. Types of flux that can be used for electrical or electronic soldering are made of rosin or are water-soluble. These types of soldering fluxes have been tested to make sure the connection is not compromised at elevated temperatures and humidity. Acid-core flux is not to be used.

### Rule 2-120 AWG sizes of conductors

Conductor material can vary (for example, copper, aluminum, nickel, silver, brass, steel). Reference to the AWG size of conductor in the Code means that the conductive material is copper. In cases where other types of conductive material are used, Rule 2-120 indicates that the Code will identify the specific types.

### Rule 2-122 Installation of electrical equipment

Rule 2-122 requires that nameplates and parts that can require maintenance, servicing, and replacement be accessible after installation to facilitate replacement and servicing, and to allow for identification of the equipment's technical characteristics that are required to be marked in accordance with Rule 2-100.

### Rule 2-124 Installation of other than electrical equipment

When materials not associated with the electrical equipment are placed or stored too close to the electrical equipment, they can pose a fire or shock hazard to people needing access to the equipment. Rule 2-124 prohibits the location of such materials adjacent to electrical equipment.

### Rule 2-126 Use of thermal insulation

Thermal insulation is used to reduce the transfer of heat. Rule 2-126:

- recognizes that proximity of thermal insulation to insulated conductors might increase the ambient temperature above the insulated conductor's insulation temperature rating, causing insulation failure; and
- provides requirements for the use of electrical equipment (particularly insulated conductors and cables) around or in contact with different types of thermal insulation.

This Rule also includes different practices for installing insulated conductors and cables in the proximity of thermal insulation. The objective of Rule 2-126 is to ensure that an electrical installation be made in such a way that the dissipation of heat from electrical equipment is not reduced to the point where excessive temperatures are imposed on electrical insulated conductors, cables, and other equipment, causing fire and shock hazards or equipment failures.

### Rule 2-128 Fire spread

Rule 2-128 requires that, when a fire separation is pierced by a raceway or cable, the effectiveness of the sealing of the opening be acceptable to building code officials. This requirement is aimed at reducing the possibility of fire spread through a building. The Appendix B Note to Rule 2-128 refers to the *National Building Code of Canada* for guidance. Figures 2-4 to 2-8 show some acceptable methods of sealing the opening around cable, conduit, and conductors in cable trays through firestop systems. Installation of firestop systems meeting the fire test requirements referred to in the *National Building Code of Canada* should be performed by qualified installers only.

**Figure 2-4**
**Typical firestop system for cable — Horizontal**

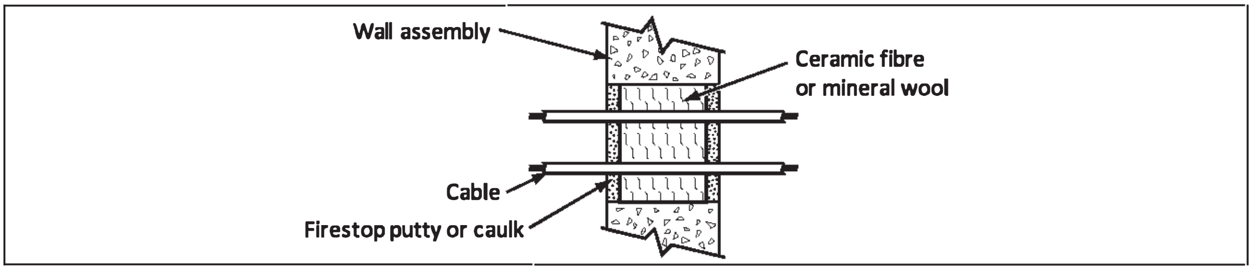



**Figure 2-5**
**Typical firestop system for conduit — Vertical**

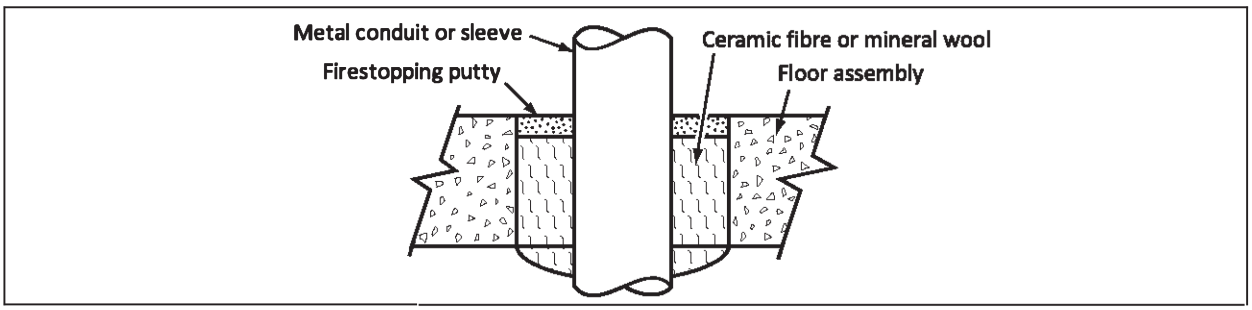
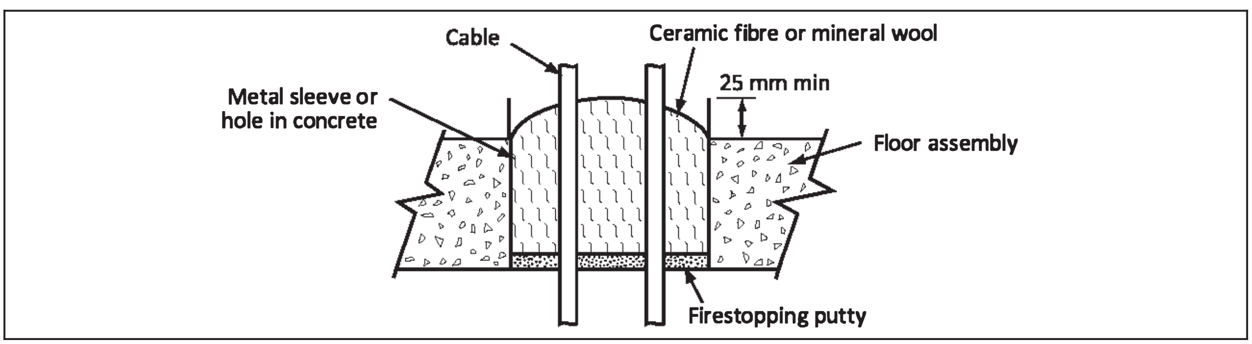
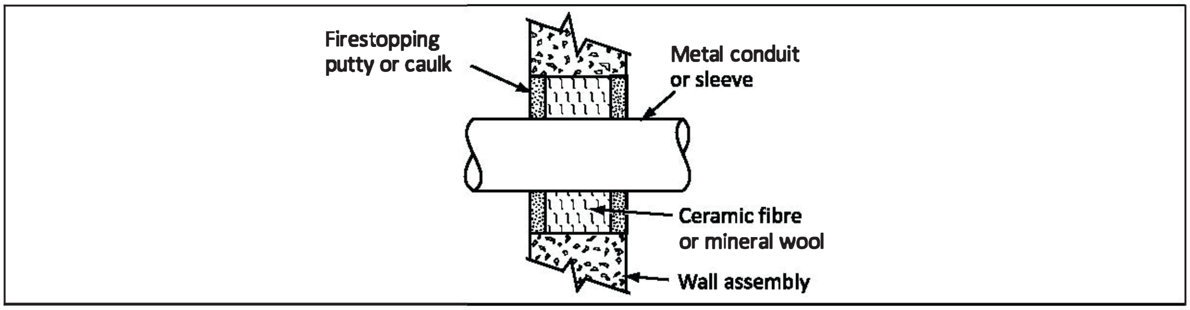


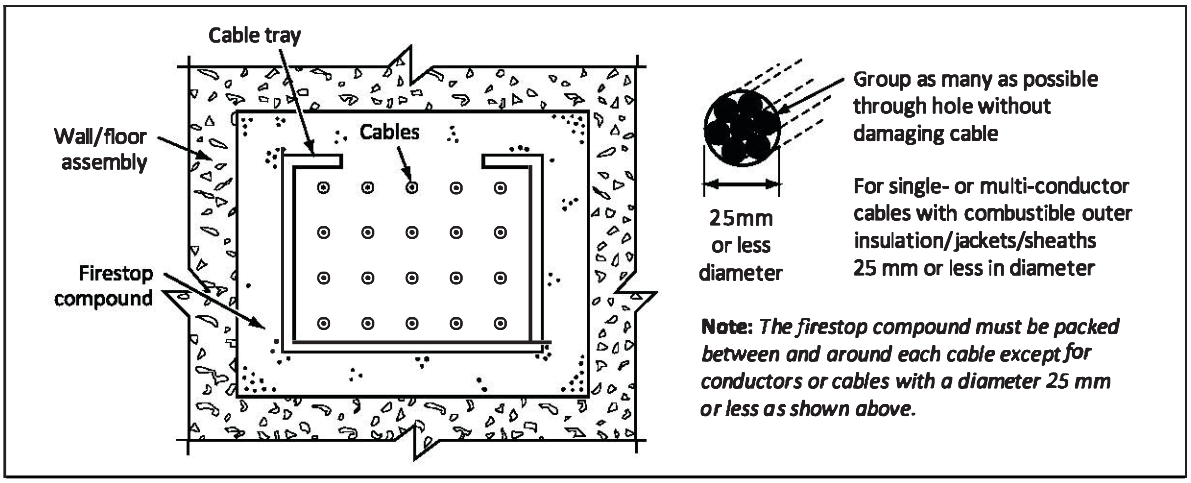

**Figure 2-6**
**Typical firestop system for cable — Vertical**



## Figure 2-7
## Typical firestop system for conduit — Horizontal




## Figure 2-8
## Typical firestop system for cable tray




### Rule 2-130 Flame spread requirements for electrical wiring and cables

Rule 2-130 requires that insulated conductors and cables with combustible jackets that are installed in buildings without being enclosed in a raceway or without being incorporated into the armoured cable meet the flame spread requirements of the *National Building Code of Canada* or local legislation, to minimize the spread of fire in a building. The Appendix B Note to Rule 2-130 provides further information.

In addition, the Appendix B Note to Rule 2-130 points to the Articles in the *National Fire Code of Canada* that deal with the removal of abandoned cables in plenums to keep the acceptable volume for flame spread and smoke development within the acceptable limits as given in the *National Fire Code of Canada*.

**Notes:**

**1)** *The Appendix B Note to Rule 2-130 does not state a* Canadian Electrical Code *requirement; it is just making Code users aware of pertinent Articles in the* National Building Code of Canada *and* National Fire Code of Canada.

**2)** *Insulated conductors and cables with combustible jackets marked FT6 are permitted to be installed in buildings where FT4 and FT1 markings of combustible jackets are required. Insulated conductors and cables with combustible jackets marked FT4 are permitted to be installed in buildings where FT1 markings of combustible jackets are required.*

See Table 2-1.

## Table 2-1
## FT marking of wires and cables

| FT marking | Location |
|---|---|
| FT1 | Wires and cables with combustible insulation or jackets in buildings that are not required by the *National Building Code of Canada* to be of non-combustible construction |
| FT1 | Wires and cables with combustible insulation or jackets within raised computer floors in buildings that are not required by the *National Building Code of Canada* to be of non-combustible construction |
| FT4 | Wires and cables with combustible insulation or jackets meeting the flame spread requirements of the *National Building Code of Canada* for installation in<br>• buildings of non-combustible and combustible construction; and<br>• spaces between a ceiling and floor, or ceiling and roof, that could be used as a plenum in buildings of combustible construction |
| FT6 | Wires and cables that meet the requirements of the *National Building Code of Canada* for installation in<br>• buildings of non-combustible and combustible construction; and<br>• spaces between a ceiling and floor, or ceiling and roof, that could be used as a plenum in buildings of combustible or non-combustible construction |

### Rule 2-132 Flame spread requirements for totally enclosed non-metallic raceways
The *National Building Code of Canada* recognizes the need to use non-metallic raceways in electrical installations to prevent problems that can be associated with metallic raceways, such as corrosion in wet locations. To reduce the fire spread and smoke development from the non-metallic raceways used in electrical installations in buildings required by the *National Building Code of Canada* to be of non-combustible construction, all non-metallic raceways (except those in plenums) are to be marked FT4 when they are installed in all such buildings. When non-metallic raceways are installed in a plenum of a building required to be of non-combustible construction by the *National Building Code of Canada*, such non-metallic raceways are to have the FT6 marking.

**Note:** *The* National Building Code of Canada *allows totally enclosed non-metallic raceways not exceeding 175 mm in outside diameter or equivalent cross-sectional area to be used in non-combustible buildings, provided that the raceway has a flame spread rating of FT4. See the Appendix B Note to Rule 2-132 for more details.*

### Rule 2-134 Sunlight resistance requirements
The insulation on electrical conductors, cables, non-metallic raceways, and enclosures can deteriorate when exposed to the direct rays of the sun, creating a shock and fire hazard. Rule 2-134 requires that all these products when exposed to the direct rays of the sun be marked for such use. The markings are "SR", "Sun Res", "Sunlight Resistant", and "CMX-Outdoor" (for communications cable). The Appendix B Note to Rule 2-134 provides examples of insulated conductors and cables (examples include outdoor flexible cords and equipment wire listed in Table 11 for wet locations, rigid RTRC conduit marked "RTRC Type AG", and totally enclosed non-metallic raceways marked "Outdoor") that meet the standard criteria for sunlight resistance but might not be marked with specific sunlight-resistance markings.

### Rule 2-136 Insulation integrity
Rule 2-136 requires that the electrical system be free from shorts or faults to ground. The Appendix B Note on this Rule states that care should be taken during insulation testing to ensure that voltage-sensitive devices such as certain types of solid state devices and sensors, electronic components, computers, and certain types of protective and control devices are not subjected to voltages that might damage them.

There are two types of tests that can be used to determine the integrity of the insulation on a conductor: a hi-pot test or a megger test. Hi-pot is a term for a class of electrical safety testing instruments used to verify electrical insulation in finished appliances, cables, or other wired assemblies such as printed circuit boards, electric motors, and transformers. A hi-pot test (also called a dielectric-withstand test) verifies that the insulation of a product or component is sufficient to protect the operator from electrical shock. In a typical hi-pot test, high voltage is applied between a product's current-carrying conductors and its metallic chassis. The resulting current that flows through the insulation, known as leakage current, is monitored by the tester. The theory behind the test is that if a deliberate over-application of test voltage does not cause the insulation to break down, the product will be safe to use under normal operating conditions. A standard test voltage is applied (below the established breakdown voltage), and the resulting leakage current is monitored. The leakage current must be below a pre-set limit or else the test result is a fail. This test is non-destructive. Safety agencies require that it is a 100% production line test (for example, performed on all products before leaving the factory and on equipment or cables before placing into service).

A megger test uses an instrument that has a self-contained power source (either a hand crank generator or a push-button-operated battery-driven power source) to determine the conductor's insulation's resistance. A megger test is shorter in duration than a hi-pot test, but the test voltages are fixed (500 V, 1000 V, and 5 kV) and are higher than the hi-pot test voltages.

### Rule 2-138 Use of Class A ground fault circuit interrupters

The use of Class A ground fault circuit interrupters is mandated by specific Rules of the Code. Class A ground fault circuit interrupter protection is intended to provide (supplementary) electric shock protection beyond the insulation or bonding to ground required by the Code. This Rule specifically states that, with the exception of the particular cases described in Subrule 2) of Rule 26-700, a Class A type GFCI should not be used as a substitute for insulation or bonding of electrical equipment to ground.

## Protection of persons and property

### Rule 2-200 General

This Rule requires that adequate provisions be provided for both:

- safeguarding persons and property from any hazards associated with the use of electrical equipment; and
- protecting electrical equipment from potential mechanical damage that might lead to unsafe operation.

The Code does not provide detailed requirements for guarding or protection of people, property, and equipment. For more detailed requirements, the Code user should consult other documents, such as customer's/user's requirements, manufacturer's requirements, Occupational Health and Safety Acts, Standards governing the equipment, the AHJ, and other governmental or regulating legislation.

### Rule 2-202 Guarding of bare live parts

When accidental contact is made with exposed bare live parts of an electrical installation, serious injury can result. The injury can range from a mild electric shock to burns or even death. Take precautions to avoid any accidental contact with live electrical components, conductors, or equipment. Subrule 1) requires that exposed bare live parts be guarded against accidental contact by being installed in suitable enclosures. In certain applications, installing the exposed bare live parts in suitable enclosures might not be practical. Therefore, Subrule 1) also allows them to be located outside of suitable enclosures when permitted by other Rules of Code or in suitable rooms, vaults, or similar enclosed areas with access restricted to qualified persons.

Subrule 3) of Rule 2-202 requires that entrances to guarded locations and rooms having exposed bare live parts be marked with warning signs prohibiting unqualified personnel from entering. See Rule 2-102 and its sample figure for the requirements for typical warning and caution signs used for this purpose.

# Maintenance and operation

## Rule 2-304 Disconnection

Rule 2-304 does not permit electrical work on live (energized) equipment and requires complete disconnection of such equipment when work is being performed. This Code requirement is consistent with the philosophy of work-safe practices mandated by the applicable jurisdictional work-safe regulations. However, this Rule also recognizes the fact that, under certain circumstances, a complete disconnection of electrical equipment might not be feasible. In such cases, work on live (energized) equipment may be performed as long as all necessary precautions – consistent with the nature and extent of the electrical hazards – are taken to ensure that the work can be performed safely. CSA Z462 covers requirements for safe work practices around live (energized) electrical equipment and provides assistance in determining the severity of potential exposure, planning safe work practices, and selecting the appropriate personal protective equipment (PPE) to protect against shock and arc flash hazards.

Subrule 2) of Rule 2-304 requires that a three-way or a four-way switch not be considered a disconnecting means because the:

- design and construction of such switches have no indication of the ON/OFF position; and
- wiring method permits switching from multiple locations.

When work is being done on electrical equipment, Subrule 3) requires that safe work practices be achieved by locking the disconnecting means in the OFF position, posting warning notices, or using other equally effective means to prevent the electrical equipment from being re-energized while work is being performed on the equipment.

CSA Z460 specifies the requirements and performance objectives for procedures, techniques, designs, and methods to protect personnel from injury from the inadvertent release of hazardous energy. Release of hazardous energy can include any motion, energization, start-up, or release of stored energy that – from the perspective of the person(s) at risk – is either unintended or deliberate.

The requirements of CSA Z462 should be followed when the disconnection of electrical equipment is not feasible, but work on the energized equipment is to be performed by qualified persons.

## Rule 2-306 Shock and arc flash protection

Electric shock is associated with the release of energy through the human body caused by contact with or approach to live (energized) electrical conductors or circuit parts. The resulting injuries from the release of energy can range from secondary injuries due to a startled reaction to tissue burns and damage, and even death. An arc flash hazard is a dangerous condition associated with the possible release of energy caused by an electric arc. Injuries that can result from the release of arc flash energy include hearing loss, blindness, lacerations, physical trauma, internal and external burns, and death (usually in cases of extensive and deep external burns).

Although the Code does not mandate the performance of an arc flash study and marking the equipment with the amount of incident energy, Subrule 1) of Rule 2-306 requires that electrical equipment – other than that in dwelling units – that might require examination, adjustment, servicing, or maintenance while live (energized) be marked in the field (see Figure 2-9). The marking:

- warns individuals of the potential arc flash and electric shock hazards; and
- provides awareness to personnel who might work on live (energized) electrical equipment.

Personnel can then:

- determine the potential severity of shock or arc flash exposure;
- plan appropriate safe work practices; and
- select PPE to protect against these hazards.

Subrule 2) requires that the field marking on the equipment be visible to personnel before work is performed on the equipment.

The Appendix B Note to Rule 2-306 lists some reference publications to use in meeting the requirements that address protection against shock and arc flash hazards.

**Figure 2-9**
**Example of warning label**


## Rule 2-308 Working space around electrical equipment

In order to assure work safety around electrical equipment, this Rule mandates a necessary working space of 1 m with secure footing around electrical equipment that:

- contains renewable parts, disconnecting means, or operating means; or
- requires examination, adjustment, operation, or maintenance.

Subrule 2) states that the 1 m working space referred to in Subrule 1) is not required behind equipment where:

- there are no renewable parts such as fuses or switches on the back; and
- all connections are accessible from locations other than the back.

Subrule 3) requires that the 1 m working space referred to in Subrule 1) be in addition to the space required for the operation of draw-out-type electrical equipment in the connected, test, or fully disconnected position and for allowing the enclosure doors and hinged panels to open at least 90°.

Subrule 4) requires that where there are exposed live parts (not inside the enclosure) on electrical equipment such as switchboards, control panels, or motor control centres, there be a working space with secure footing not less than that specified Table 56 using the electrical system's voltage to ground.

Subrule 5) requires that the minimum headroom of working spaces around switchboards or motor control centres where bare live parts are exposed at any time (for example, when the enclosure covers or doors are closed or open for service, testing, and maintenance) be 2.2 m. This should allow individuals working on the equipment to stand erect.

Figures 2-10 and 2-11 provide a summary of the working space requirements of Rule 2-308.

# Figure 2-10
# Working space around electrical equipment

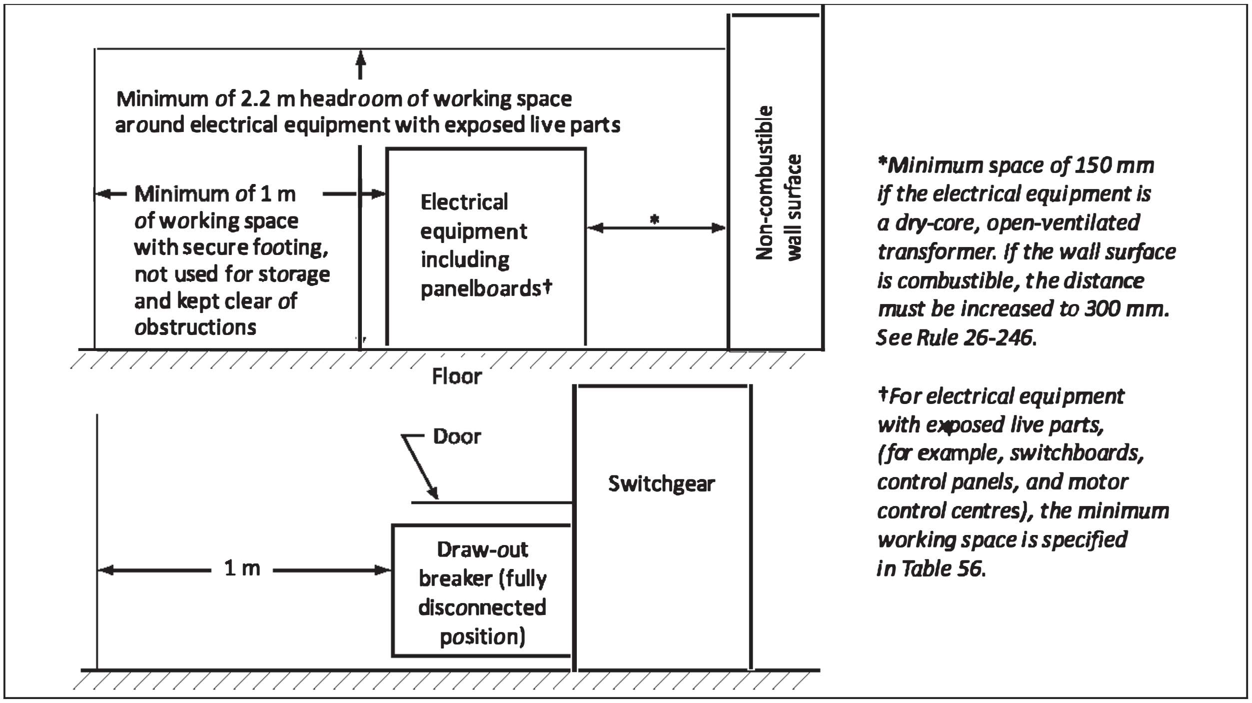
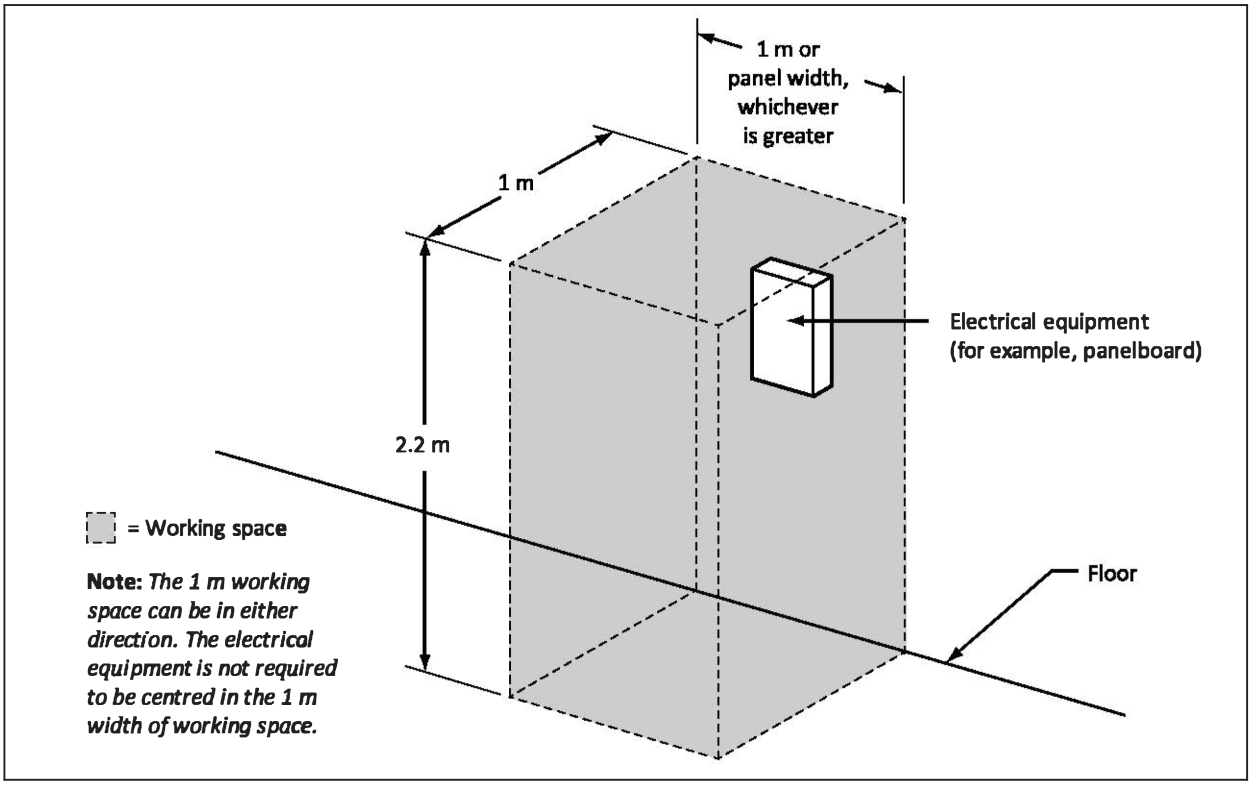


**Figure 2-11**
**Elevation view of working space around electrical equipment**



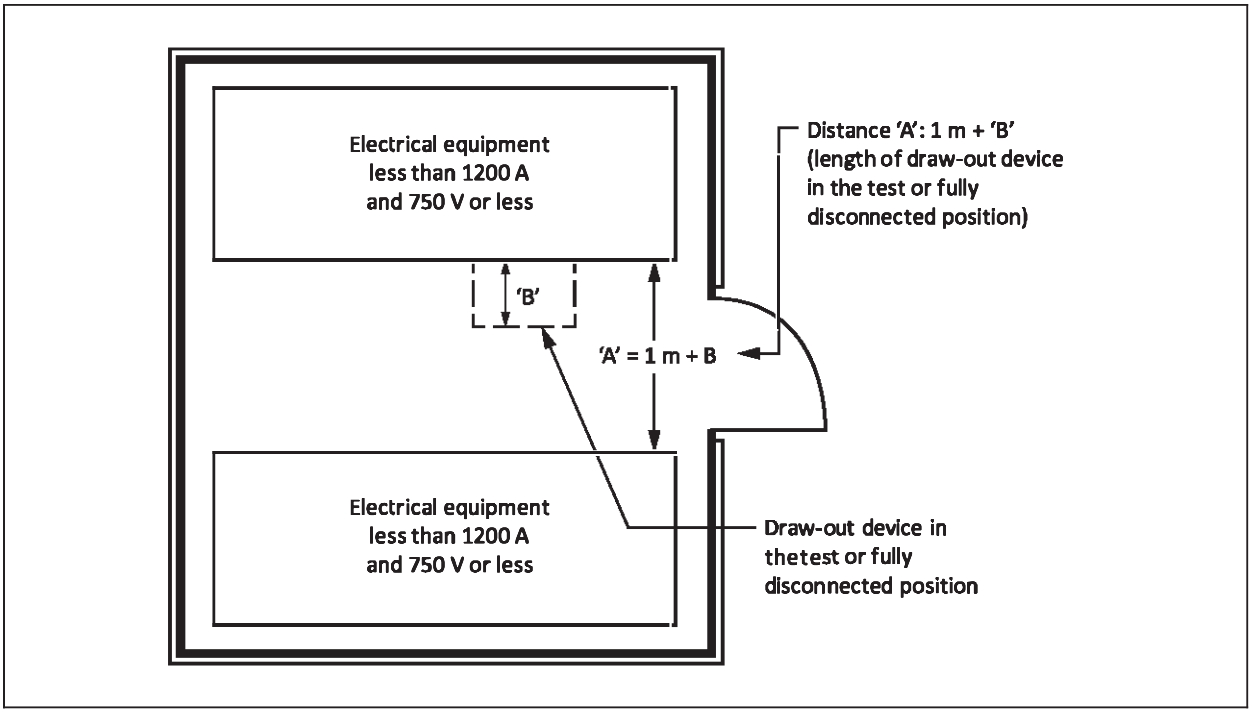

## Rule 2-310 Entrance to, and exit from, working space

Safe and quick entrance to or exit from a room containing electrical equipment or the working space around the equipment is required by Rule 2-310 for those operating and servicing equipment. Also, safe and quick entrance and exit are required in the event of an electrical incident, such as an arc flash or arc blast within the room or area.

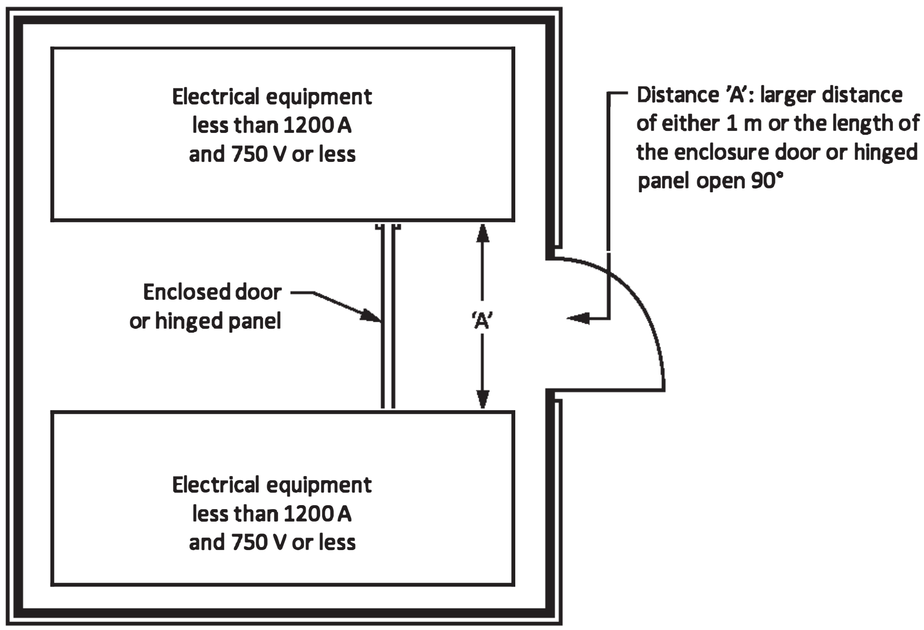
This Rule emphasizes the *National Building Code of Canada* requirements for an unobstructed means of exit from a service room that contains electrical equipment. Specific requirements pertaining to unobstructed means of exit can be found in Articles 3.3.1.23 and 9.9.5.5 of the *National Building Code of Canada*.

This Rule also clarifies that service rooms or working spaces containing equipment that has a nameplate rating of 1200 A or more, or that is rated over 750 V (high voltage), be arranged so that if a fault occurs in the equipment, the exit route from the room or space does not pass by the location of the fault in the electrical equipment. This requirement points to the need to provide two exit doors or paths from the room or space, arranged so that the individual/worker would not have to pass by the fault location when exiting the room or area. When such an exit arrangement (that is, a second exit) is not practicable, the equipment is to have a minimum unobstructed working space of 1.5 m. The Appendix B Note to Rule 2-310 2) recognizes that a second exit might be necessary to provide the required path of travel. See Figures 2-12 to 2-17.

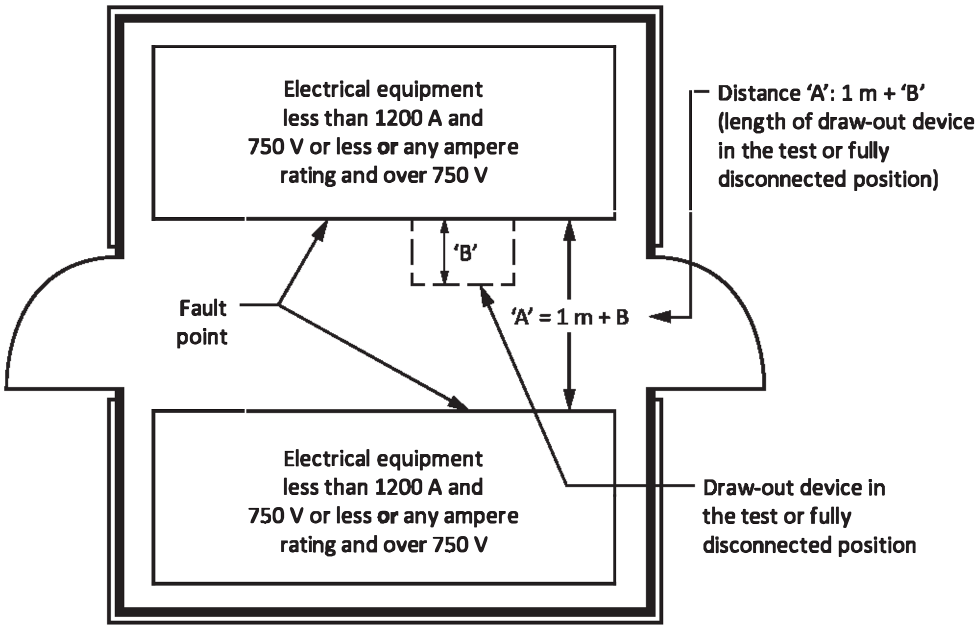
**Figure 2-12**
**Example one — Working space in front of draw-out equipment with one entrance**



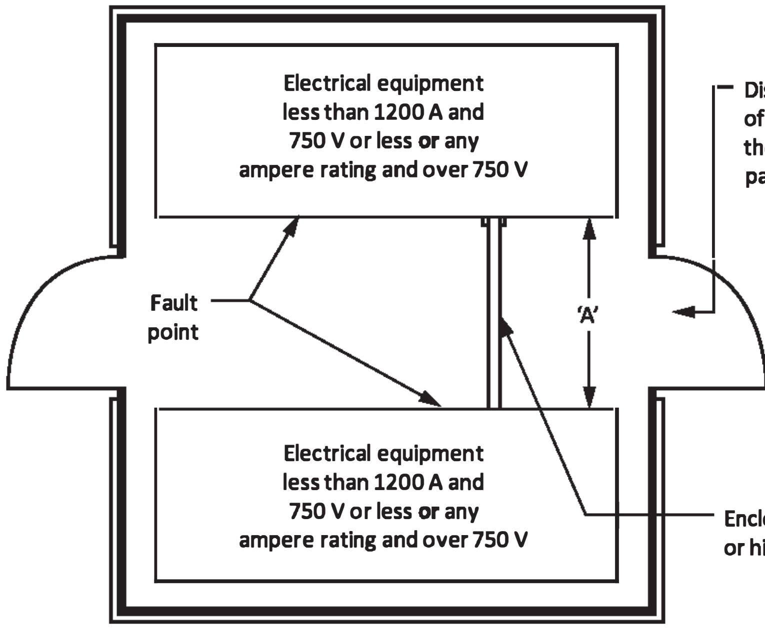
## Figure 2-13
## Example two — Working space in front of equipment with one entrance with a hinged door or cover



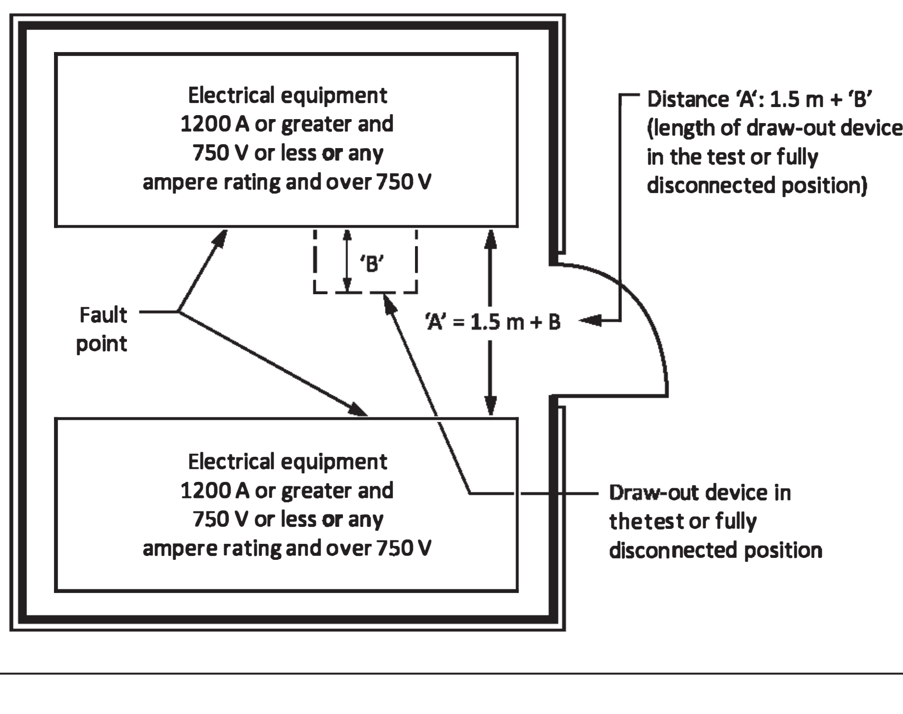
# Figure 2-14
## Example three — Working space in front of draw-out equipment with two entrances



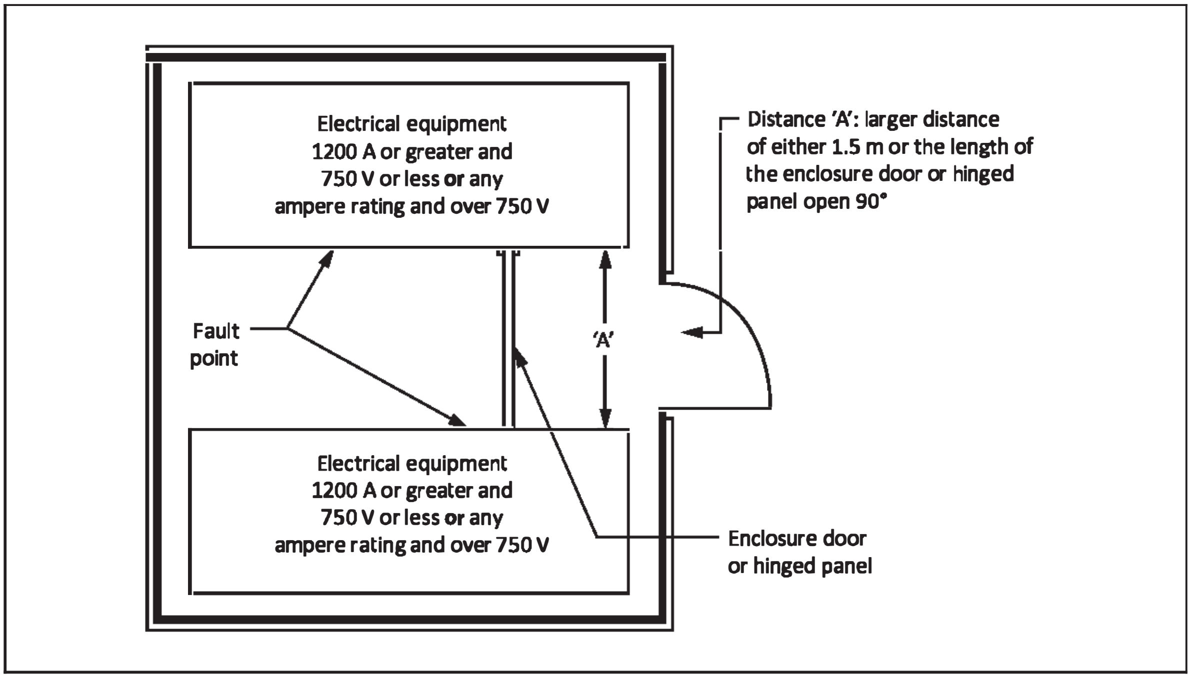
## Figure 2-15
## Example four — Working space in front of equipment with two entrances with a hinged door or cover




## Figure 2-16
## Example five — Working space in front of draw-out equipment with one entrance



## Figure 2-17
## Example six — Working space in front of equipment with one entrance with a hinged door or cover




Subrule 3) explains that the potential fault point for electrical equipment is any point within or on the equipment.

This Rule does not mandate the direction in which exit doors are to open. The Appendix B Note to Rule 2-310 1) advises consulting the *National Building Code of Canada* as to the limitations applying to any door swinging out from an electrical room.

The *National Building Code of Canada* does not mandate the direction that the door swings from an electrical room or a service room unless that room contains a boiler or incinerator. It is intended that doors and gates in the unobstructed means of exit described in this Rule will open in the direction of exit travel. However, where the room is large relative to the required working space, the *National Building Code of Canada* allows doors or gates located more than 7.6 m away from the working space to open in either direction. Consult Articles 3.4.4.4 (7), 3.4.3.3, and 9.9.6.1 of the *National Building Code of Canada* as to the limitations pertaining to any door swinging out from an electrical room.

To protect personnel working on or operating equipment in the event of equipment failure or accident, Subrule 4) requires that gates or doors be easily opened on the equipment side without the use of a tool or key. Door hardware of the push-bar type is considered suitable to meet the intent of this Subrule. Door hardware that is not considered suitable to meet the intent of this Subrule includes a door or gate that:

- requires a key to exit the room;
- is equipped with a door handle and one or more additional devices such as a deadbolt; or
- requires other special devices or specialized knowledge to exit the room.

Consult Article 3.4.6.16 of the *National Building Code of Canada* regarding applicable door-release hardware.

### Rule 2-312 Transformer working space

To provide access to the conductor connections for installation, servicing, testing, and maintenance of transformers with a rating greater than 50 kV•A, Rule 2-312 requires that a minimum working space of 1 m be provided around the sides of a transformer that provides access to the conductor connections. This working space is not in addition to the space required by Rule 26-242.

### Rule 2-314 Accessibility for maintenance

Rule 2-314 requires that passageways and working spaces around electrical equipment:

- not be used for storage;
- be kept clear of any obstruction; and
- be arranged so that all parts requiring attention are readily accessible to authorized personnel.

### Rule 2-316 Receptacles required for maintenance of equipment

This Rule focuses on the safety of maintenance persons who are on rooftops to perform general maintenance and repairs. There are various types of mechanical and electrical equipment on rooftops that require service by either contract service technicians, such as HVAC technicians, or in-house maintenance staff who must periodically do work on rooftops. Maintenance and service workers might require electric power for just a few minutes (for example, to run tools for repairs) or longer (for example, to provide lighting for testing). Power might also be needed for several hours, depending on the work.

In order to improve the safety of such maintenance work, the intention of Rule 2-316 is to prevent use of extension cords in conjunction with such work. The Rule requires that, except in the case of dwelling units, a receptacle be provided for maintenance of rooftop equipment such as heating, ventilation, air conditioning, dust extractors, etc. For the location and requirements of this receptacle, see Rule 26-710.

### Rule 2-318 Illumination of equipment

Rule 2-318 requires that sufficient illumination be provided for those who are required to operate or maintain electrical equipment. Consult Table 9.34.2.7 of the *National Building Code of Canada* for minimum illumination level in Lx for service rooms and other public areas.

### Rule 2-320 Flammable material near electrical equipment

To prevent the ignition of flammable material, Rule 2-320 requires that it not be stored or placed dangerously close to electrical equipment.

"Flammable", as defined by WHMIS, refers to material that will burn or catch on fire easily at normal temperatures (below 37.8 °C), while combustible materials are usually heated before they will ignite at temperatures above normal (between 37.8 °C and 93.3 °C). Flammable and combustible material can be a solid, liquid, or gas. Common examples of flammable materials include gasoline, propane, butane, acetylene, ethanol, acetone, turpentine, toluene, kerosene, Stoddard solvent, spray paints, and varnish.

### Rule 2-322 Ventilation

Air space and circulation around electrical equipment are not to be restricted since ventilation is necessary to keep the temperature of electrical equipment within its design limits. Rule 2-322 requires that sufficient ventilation be provided around electrical equipment to prevent the development of ambient air temperatures in excess of those normally allowed for the equipment.

The Appendix B Note to Rule 2-322 explains that equipment such as generators, motors, and transformers have relatively high losses, and that approximately 3.5 to 4.3 $m^3$ of air per minute for each kilowatt of loss is normally required for ventilating 40 °C rise equipment. A value of 2.8 $m^3$ of air per minute has a temperature rise of approximately 18 °C when absorbing a 1 kW loss. The Appendix B Note also clarifies that the temperature rise of all such equipment is based on a 40 °C ambient temperature.

Such clarification helps in the design of adequate ventilation of an electrical equipment room in order to maintain a room temperature not exceeding 30 °C.

### Rule 2-324 Drainage

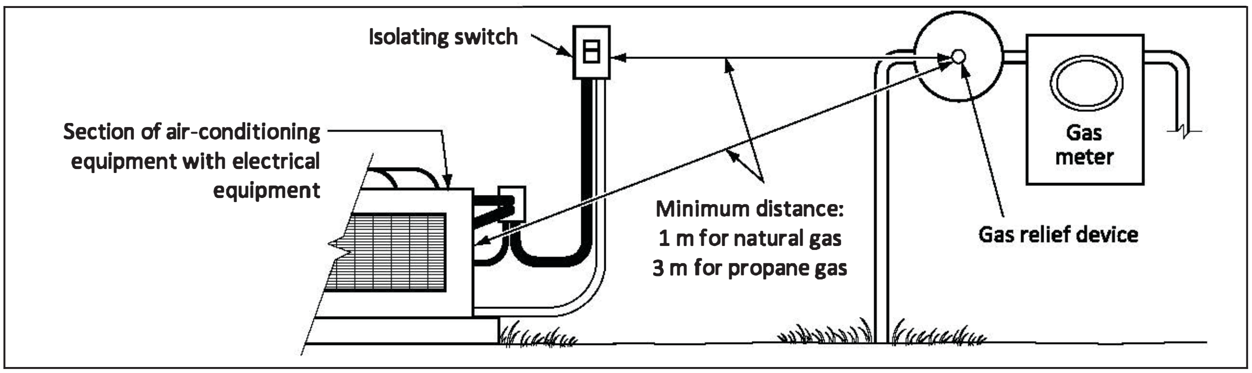
A moisture drainage path in electrical equipment can become blocked, resulting in an accumulation of moisture that can affect the electrical equipment. Rule 2-324 requires that a provision for draining moisture from the electrical equipment be installed so that the drainage path is not obstructed or the flow of moisture impeded.

### Rule 2-326 Electrical equipment near combustible gas equipment

Gases can be released through gas relief devices, resulting in an explosive mixture. Rule 2-326 requires that arc-producing electrical equipment have a clearance distance from a combustible gas relief device or vent that meets the requirements of CSA B149.1. See Figure 2-18.

The Appendix B Note gives the clearance distances between a source of ignition and a combustible gas relief discharge device or vent specified in CSA B149.1 as being 1 m for natural gas and 3 m for propane gas.

**Figure 2-18**
**Electrical equipment near combustible gas meters and other devices**




## Enclosures

### Rule 2-400 Enclosures, type designations, and use

Equipment enclosures vary in construction, purpose, and operating environment. Forms of enclosures are divided into defined categories to allow for ready recognition and proper application. This Rule lists the CSA Types of enclosures intended for particular locations. The Rule also allows use of enclosures of other Types as indicated in Table 65 as a substitute for enclosures indicated in the Rule, provided that these other enclosures:

- offer a degree of protection at least equal to that of the requirement of Subrule 1); and
- are marked as specified in Rule 2-402.

This Rule also states that enclosures intended for equipment for use in hazardous locations must comply with requirements of Rule 18-052.

The Appendix B Note to Rule 2-400 states that conditions such as condensation, icing, corrosion, or contamination that might occur within the enclosure are not covered by these categories. When these conditions are present and could cause premature failure of the enclosure or the components in the enclosure, take these factors into account when choosing an installation method.

When enclosures are tested, check the openings for conduit or cable entry and access covers for adequate sealing. When installing conduit or cable or replacing access covers, take care to use methods that ensure the requirements for the category of the enclosure are not compromised.

## Rule 2-402 Marking of enclosures

To readily distinguish one type of enclosure from another, Subrule 1) of Rule 2-402 requires that the enclosure designations listed in Table 65 [except for Type 1 (general-purpose) enclosures] be marked on the enclosure. An enclosure without a Type or enclosure designation marking is to be treated as a Type 1 (general-purpose) enclosure.

Subrule 2) allows the ingress protection (IP) designation to be used in addition to the markings required by Subrule 1).

The CSA mark for enclosure designations used in Canada is equivalent to the NEMA mark for enclosure designations in the US. Occasionally, electrical designers specify a NEMA Type for an enclosure. Code users should be aware that:

- NEMA Types do not represent "approved" equipment in accordance with the Code;
- enclosures are to be "approved" by being certified to the applicable CSA Group Standard (Part II Standard) for enclosures;
- the IP designation is a mark used outside Canada and the US; and
- while the IP designation might be used in Canada, the enclosure must also bear the certification mark of an accredited certification agency acceptable to the AHJ.

## Rule 2-404 Marking of motors

Motors – which inherently include an electrical enclosure by design and construction – have their own industry terms. Rule 2-404 allows the marking of motors in non-hazardous locations to be different from the enclosure markings required by Rule 2-402. Subrule 1) specifies the particular markings to be used to identify drip-proof, weatherproof, and totally enclosed motors for use in non-hazardous locations. Subrule 2) provides an exception to the marking requirement for special-purpose motors used as a component of specific equipment (for example, the internal ventilation fan for switchgear or a controller).

# Section 4 — Conductors

Section 4 is a general Section of the Code that sets out requirements determining the minimum ampacity rating allowed for insulated conductors and cables used in services, feeders, and branch circuits. Wire and cable, flexible cords, portable power cables, and equipment wire are examples of such categories of conductors and cables. Neutral conductors used in services, feeders, and branch circuits are also covered by Section 4. The requirements of Section 4 apply unless specifically modified or amended in a subsequent Section of the Code.

Wire and cable (see Rules 4-004 to 4-008) consist of conductors or cables:
- where the insulation on the conductor or the sheath on the cable has been designed and tested to withstand the stresses of field installation and conditions of use that it has been certified to;
- where the conductor material is either solid or concentrically stranded; and
- used above ground in free air, in raceways, in multi-conductor cable, and in underground installations.

A flexible cord (see Rules 4-010, 4-012, 12-402, and 12-404) is used when flexibility is required or to minimize vibration transmission. Flexible cord comes in three grades of mechanical serviceability [i.e., "not for hard usage", "for hard usage", and "for extra-hard usage" (see Table 11)], and the conductor material is bunch stranded (i.e., the strands of the wires are twisted together without a predetermined pattern).

Equipment wire (see Rules 4-014 and 12-122) is intended for internal wiring of electrical equipment, for leads of transformers, motors, etc., and for luminous-tube signs and ignition systems. The conductor material of equipment wire is solid or concentrically or bunch stranded, and its insulation is not designed for exposed field installation.

Portable power cable (see Rules 4-034 and 12-406) is flexible cord that is normally used in applications where the cables are subject to frequent flexing and where installation is in accordance with CSA M421 and/or the *Canadian Electrical Code, Part I*.

### Rule 4-000 Scope

Section 4 applies to conductors used for services, feeders, branch circuits, and photovoltaic circuits, with regard to:
- the determination or selection of maximum allowable conductor ampacity;
- the determination of maximum conductor termination temperature;
- the selection of neutral conductors;
- the selection of a conductor type for a specific condition of use; and
- conductor identification.

There are two industry accepted procedures that are used to determine the maximum conductor or cable ampacity or the minimum conductor size: one is based on a calculated load and the other is based on the requirements for a single piece of electrical equipment, such as a motor, capacitor, welder, and transformer. The first method uses the applicable Tables in the *Canadian Electrical Code, Part I,* and the procedure specified in Table 4-1. The second method uses the using the Neher-McGrath methodology, as applied to IEEE 835. The IEEE, electrical consultants, and wire and cable manufacturers are good sources of help on the use of this method.

A conductor covered by Section 4 is a conductor or cable installed for the purpose of conveying electric current from a power supply source to a piece of electrical equipment. The requirements of Section 4 do not apply to conductors used for grounding or bonding.

The allowable ampacities of Tables 1, 2, 3, and 4 are based on temperature alone and do not take voltage drop into consideration (see Table D3).

## Rule 4-002 Size of conductors

For insulated conductors and cables, with the exception of insulated conductors used in flexible cord, as equipment wire, and for control circuits, Rule 4-002 stipulates a minimum size of No. 14 AWG for copper and No. 12 AWG for aluminum. The minimum size requirement ensures that the conductors can handle the electrical stresses of current flow under normal and fault conditions (for example, short-circuit and overload), as well as the physical stresses of installation in raceways, flexing, and terminations.

## Rule 4-004 Ampacity of wires and cables

The ampacity of a conductor is essentially its maximum allowable operating temperature. For example, when a No. 3 AWG copper conductor with 90 °C rated insulation is to be installed in a run of EMT, the 90 °C column of Table 2 assigns a maximum ampacity of 115 A, provided that the ambient temperature surrounding the conduit will not exceed 30 °C. This means that if this conductor continuously carries current of 115 A at 30 °C or less ambient, its insulation temperature will not exceed 90 °C. When an insulated conductor carries current, the temperature of the conductor increases as the conductor's current increases, potentially exceeding the conductor's insulation temperature rating. The temperature will rise even further if heat dissipation is restricted as a result of:

- proximity to other current-carrying conductors;
- the sheath of the cable or the material of the raceway; or
- the ambient temperature exceeding 30 °C in the environment in which the conductor, cable, or raceway is installed.

Heat can cause:

- damage to the conductor's insulation;
- nuisance tripping of temperature-sensitive overcurrent devices (for example, low-melting-point fuses and circuit breakers); and
- breakdown of terminations or equipment.

The conductor's temperature is to be kept at an acceptable level. This can be achieved by:

- reducing the number of heat-producing conductors in a raceway or cable;
- increasing the movement of air around conductors or cable;
- increasing the separation distance between conductors; or
- applying correction factors (derating) to reduce the required current flow that causes the excessive heating.

Rule 4-004 sets out specific requirements related to these methods of controlling or reducing conductor temperature.

Subrules 1) and 2) provide the criteria for selecting or determining the maximum ampacity for copper or aluminum wire and cable-type conductors and cables installed in an area where the ambient temperature does not exceed 30 °C. The criteria are as follows:

- Item a) of Subrules 1) and 2) requires that Table 1 (for copper) and Table 3 (for aluminum) be used for single-conductor and single-conductor metal-sheathed or armoured cables when they are spaced a minimum one cable diameter apart in a free air run and the voltage rating does not exceed 5 kV.

  **Note:** *For spacing less than one cable diameter apart, additional requirements of Rule 4-004 apply.*
- Item b) of Subrules 1) and 2) requires that Table 2 (for copper) and Table 4 (for aluminum) be used for one, two, or three conductors in a run of raceway, or 2- or 3-conductor cable, when the voltage rating does not exceed 5 kV.
- Item c) of Subrules 1) and 2) requires that Table 2 (for copper) and Table 4 (for aluminum) be used for four or more conductors in a raceway or cable, with the correction factors applied as specified in Table 5C for the total number of lighting and power conductors.

- Item d) of Subrules 1) and 2) requires that Tables D8A, D9A, D10A, and D11A (for copper), Tables D8B, D9B, D10B, and D11B (for aluminum), or the IEEE 835 calculation method be used for up to four conductors, installed according to the configurations in Diagrams D8 to D11, in underground runs of direct buried cables or raceways in sizes No. 1/0 AWG and larger.
- Item e) of Subrules 1) and 2) requires that the IEEE 835 calculation method be used for up to four conductors (3 phase, 4 wire) in underground runs of direct buried cables or raceways in sizes No. 1/0 AWG and larger that do not use the installation configurations in Diagrams D8 to D11.
- Item f) of Subrules 1) and 2)requires that Table 2 (for copper), Table 4 (for aluminum), or the IEEE 835 calculation method be used for up to four conductors (3 phase, 4 wire) in underground runs of direct buried cables or raceways in sizes smaller than No. 1/0 AWG, whether or not they use the installation configurations in Diagrams D8 to D11.
- Item g) of Subrules 1) and 2) requires that Tables D17A to D17N or the IEEE 835 calculation method be used for shielded copper or aluminum cables rated 5 kV to 46 kV in sizes No. 2 AWG to 1000 kcmil in the configurations shown in Tables D17A to D17N and in the conditions described in Table D17. The Appendix B Note to Rule 4-004 1) g) and 2) g) explains that ampacities for conductors in the voltage range of 5 kV to 46 kV can vary due to factors such as configuration, construction, orientation, ambient temperature, resistivity of adjacent material, proximity to other cables, and other such criteria. The ampacities listed in Tables D17A to D17N are valid only for the configurations shown and the conditions specified in Table D17. Where conditions or configurations used differ from those shown in the Tables, the cable manufacturer should be consulted for the maximum conductor ampacity values based on the Neher-McGrath method. See Table 4-1.

**Note:** *Using Tables 1 to 4 to calculate the ampacities of direct buried conductors and cables, and conductors run in non-metallic underground raceways, can lead in some cases to the use of undersized conductors, causing conductor overheating and insulation damage. IEEE 835 accounts for load factors, continuous or non-continuous operation, heat dissipation, short-circuit current flow, burial depth, separation distance, type of conductor material, frequency, etc. The Tables in Appendix D of the Code list ampacities determined using the calculation method in IEEE 835 for the cable arrangements shown in Diagrams D8 to D11.*

## Table 4-1
## Ampacity selection chart for wire and cable-type conductors installed in an ambient temperature of not more than 30 °C

| Subrule | Conductors | Condition | Spacing<br>% of cable diameter | Ampacity |
|---|---|---|---|---|
| 4-004 1) and 2) | a) Single | Free air | ≥ 100% | Table 1 or 3 |
| | b) 1 to 3 | Raceway or cable | N/A | Table 2 or 4 |
| | c) 4 or more | Raceway or cable | N/A | Table 2 or 4 × the correction factor from Table 5C |
| | d) Not more than 4 | No. 1/0 AWG and larger underground run — direct buried or in a direct-buried raceway | Installation configurations in Diagrams D8 to D11 | Tables D8A to D11B or as calculated by the IEEE 835 calculation method |

*(Continued)*

## Table 4-1 (Concluded)

| Subrule | Conductors | Condition | Spacing<br>% of cable diameter | Ampacity |
|---|---|---|---|---|
| | e) Not more than 4 | No. 1/0 AWG and larger underground run — direct buried or in a direct-buried raceway | Configuration not described in Diagrams D8 to D11 | Calculated by the IEEE 835 calculation method |
| | f) Not more than 4 | Smaller than No. 1/0 AWG and underground run — direct buried or in a direct-buried raceway | Configuration not described in Diagrams D8 to D11 | Calculated by the IEEE 835 calculation method or as specified in Tables 2 and 4 |
| 4-004 8) | Single | Free air | Spacing between 25% and 100% of the largest cable diameter | Table 1 or 3 × the correction factor from Table 5D |
| 4-004 9) | Not more than 4 single | Free air | Spacing less than 25% of the largest cable diameter | Table 1 or 3 × the correction factor from Table 5B |
| 4-004 11) | 5 or more single | Free air | Spacing less than 25% of the largest cable diameter | Table 2 or 4 × the correction factor from Table 5C |

Although a neutral conductor is a circuit conductor, Subrule 3) excludes the neutral conductor from the determination of conductor ampacities of circuit (current-carrying) conductors using Subrules 1) and 2) since the neutral conductor carries only the unbalanced current from the other conductors in the circuit. Subrule 3) allows a three-phase, 4-wire circuit (120/208 V or 347/600 V) and a single-phase, 3-wire circuit (120/240 V) to be treated as a 3-wire and 2-wire balanced circuit, respectively, for the purposes of computing ampacities and does not require the application of the correction factors from Table SC.

Subrule 4) stipulates that when a circuit derived from a three-phase, 4-wire system consists of one- or two-phase wires and a third common (neutral) conductor, the common neutral conductor is to be taken into account in computing ampacities since it will carry approximately the same current as the phase conductor and so will be a heat-producing conductor. Also, certain types of non-linear (harmonic) loads on three-phase, 4-wire, and single-phase, 3-wire circuits could result in a significant increase of current in the neutral conductor, and this current can cause heating in the neutral conductor. Neutral conductors carrying these types of current are to be included as a power and lighting conductors when determining the correction factor in Table SC since they will carry approximately the same current as the phase conductor and so will also be a heat-producing conductor.

Neutral-supported cable is an assembly of one, two, or three insulated phase conductors and optional insulated control/supply conductors supported by the bare neutral conductor. This cable type is commonly referenced according to the number of insulated conductors around the bare neutral support conductor (duplex-one, triplex-two, or quadruplex-three). Due to the configuration of the cable, Tables 1 to 4 cannot be used to determine ampacities. Subrule 5) specifies that ampacity ratings for neutral supported cable are to be determined using Table 36A for aluminum and Table 36B for copper.

Subrule 6) excludes the bonding conductor from the determination of ampacities and the application of correction factors from Table SC since the bonding conductor is not a circuit conductor and normally carries no current, except under fault conditions.

Subrule 7) emphasizes that the correction factors specified in Rule 4-004 apply only to the number of power and lighting conductors in a cable or raceway. The correction factors Tables specified in this Rule are:

- Table SA, which is used where conductors are installed in an ambient temperature exceeding or anticipated to exceed 30 °C;
- Table SB, which is used where single-conductor cables are installed in free air, where the space between the single conductors or single-conductor cables is less than the largest cable diameter in the group, and where the installation is in accordance with Subrule 9) requirements;
- Table SC, which is used where:
  - single-conductor cables are installed in free air;
  - single conductors are installed in totally enclosed non-ventilated raceways; and
  - multi-conductor cables are installed in ventilated and ladder-type cable trays or in non-ventilated cable trays in accordance with Item c) of Subrule 1) or 2) or with Subrule 11), 12), 13), 23), or 25), as applicable; and
- Table SD, which is used where:
  - single-conductor cables are installed in free air,
  - single-conductor cables or multi-conductor cables are installed in ventilated and ladder-type cable trays in accordance with Subrule 8) or 24), as applicable.

Grounding, bonding, control, balanced neutral (as per Subrule 3), and signal conductors are examples of conductors that are not to be counted in determining the correction factors from Table SC. Subrule 7) also exempts 30 or less conductors installed in an auxiliary gutter from the application of the Table SC correction factors. Auxiliary gutters are considered to be an extension of the electrical equipment wiring space and are limited to 6 m beyond the electrical equipment [see Subrule 2) of Rule 12-1900].

Subrule 8) requires that the application of correction factors from Table SD be applied to the ampacities given in Tables 1 and 3 for single-conductor cables in free air when the spacing is between 25% and 100% of the largest cable diameter in the group. This reduction in the current flow is necessary to reduce the potential for overheating that can result from the air flow around each cable being restricted.

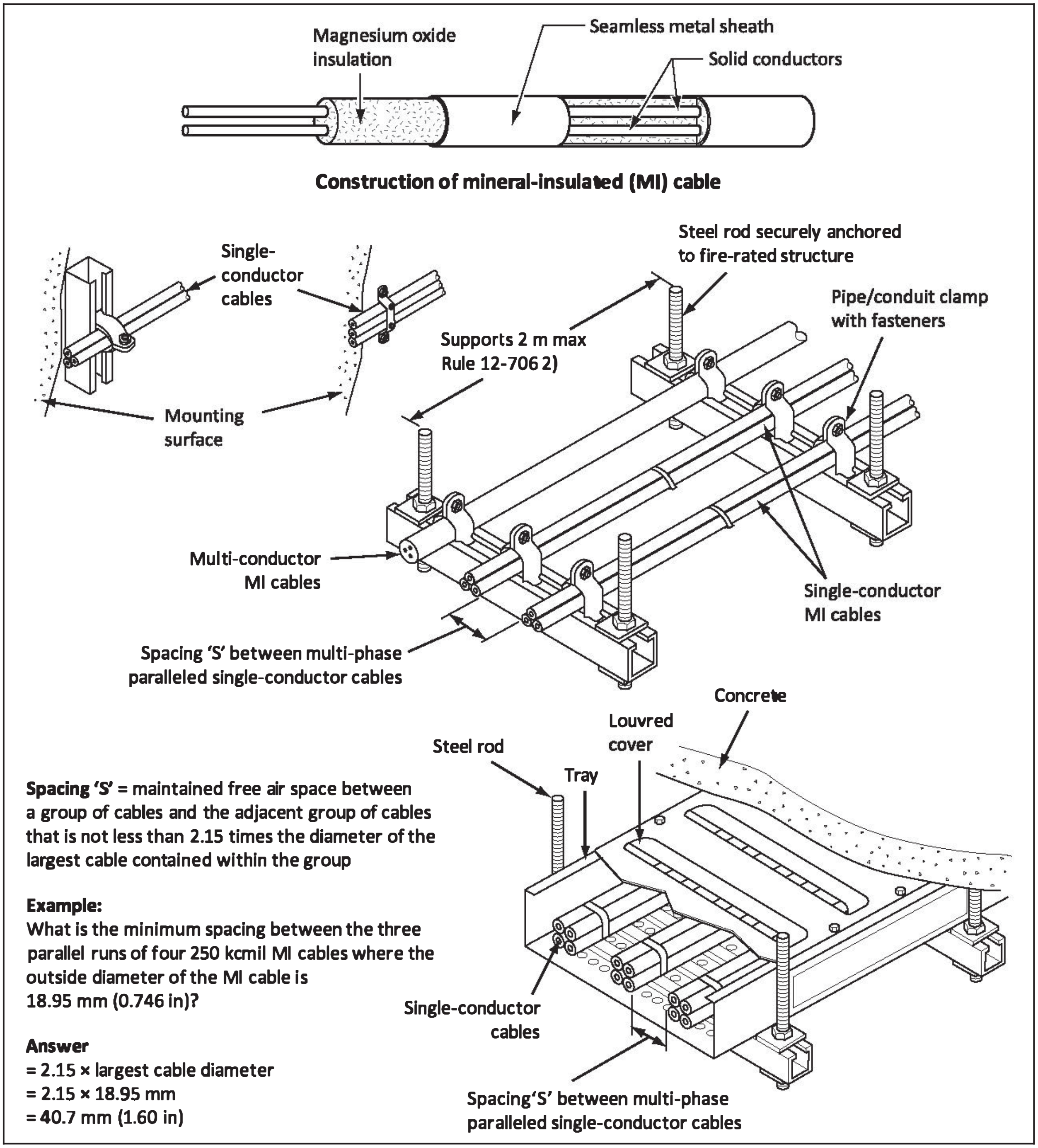
Subrule 9) requires that the application of correction factors from Table SB to the ampacities given in Tables 1 and 3 for up to four single-conductor copper or aluminum cables in free air when the spacing between cables is less than 25% of the largest cable diameter in the group, to reduce the current flow and the potential for overheating that can result from the air flow around each cable being restricted.

Subrule 10) provides an exemption from the correction factors required in Table SB in cases where not more than four non-jacketed single-conductor mineral-insulated (MI) cables are:

- sized using ampacity ratings from Table 1;
- run in contact with each other in accordance with the requirements of Subrules 3) and 7) of Rule 4-008; and
- installed on a messenger or spaced according to Figure 4-1.

**Note:** *The insulation surrounding the conductor of mineral-insulated (MI) cables is, by virtue of its composition/construction, not affected by continuous temperatures up to 250 °C and is therefore not subject to insulation deterioration from heat over time (see Figure 4-1).*

## Figure 4-1
## Support and spacing of mineral-insulated cables




Subrule 11) requires that where there are more than four single-conductor cables in free air, spaced at less than 25% of the diameter of the largest conductor or cable, the ampacity ratings be taken from Tables 2 and 4, with correction factors from Table SC applied based on the total number of conductors.

Subrule 12) states that where the length of a single-conductor cable run spaced at less than 25% of the largest cable diameter is less than 600 mm, the correction factors from Table SC need not be applied to the Table 2 and 4 ampacity ratings.

Subrule 13) states that where multi-conductor cables are run in contact (bundled together) for distances greater than 600 mm, the ampacity of the conductors from Tables 2 and 4 are to be corrected by applying the correction factors in Table SC based on the total number of conductors in the cables. See Table 4-2.

**Table 4-2**
**Correction factor quick reference**

| Rule number | Installation conditions | Ampacity tables to be used | Correction factor table to be used |
|---|---|---|---|
| 4-004 1) c) and 2) c) | Four or more conductors in a run of raceway or cable | Copper — Table 2<br>Aluminum — Table 4 | Table SC |
| 4-004 7) b) i) | Ambient temperature exceeding or anticipated to exceed 30 °C | Copper — Tables 1 and 2<br>Aluminum — Tables 3 and 4 | Table SA |
| 4-004 8) | Free air spacing between adjacent single-conductor cables is maintained at not less than 25% nor more than 100% of the diameter of the largest cable | Copper — Table 1<br>Aluminum — Table 3 | Table SD |
| 4-004 9) | Up to and including four single-conductor cables in free air, spaced at less than 25% of the diameter of the largest conductor or cable | Copper — Table 1<br>Aluminum — Table 3 | Table SB |
| 4-004 10) | Exemption from the Table 5B correction factors when not more than four single-conductor Type MI cables in free air are spaced at not less than 2.1S times the diameter of the largest conductor or cable | Copper — Table 1<br>Aluminum — Table 3 | N/A |
| 4-004 11) | More than four single-conductor cables in free air, spaced at less than 2S% of the diameter of the largest conductor or cable | Copper — Table 2<br>Aluminum — Table 4 | Table SC based on the total number of conductors |

(Continued)

## Table 4-2 (Concluded)

| Rule number | Installation conditions | Ampacity tables to be used | Correction factor table to be used |
|---|---|---|---|
| 4-004 12) | Exemption from the Table 5C correction factors when the length of a single-conductor cable run spaced at less than 25% of the largest cable diameter is less than 600 mm | Copper — Table 2<br>Aluminum — Table 4 | N/A |
| 4-004 13) | Where multi-conductor cables are run in contact for distances greater than 600 mm | Copper — Table 2<br>Aluminum — Table 4 | Table 5C based on the total number of conductors in the cables in contact<br>**Note:** *For distances less than 600 mm, the correction factors in Table 5C do not apply.* |

Subrule 14) requires that, in cases where conductors in a raceway have different temperature ratings, their ampacity be computed on the basis of the conductor having the lowest temperature insulation rating. This prevents damage that could be caused to the lower-rated insulation if the ampacity were based on the conductor with the highest-rated insulation. Insulated conductors that have a 90 °C insulation temperature rating can carry more current and can run hotter than conductors with lower temperature ratings (for example, 60 °C, 75 °C). The heat such conductors generate can cause damage to the insulation of adjacent conductors having lower insulation temperature ratings.

Subrule 15) addresses the addition of conductors into an existing raceway and requires that:

- the ampacity of both the new and the existing conductors be determined in accordance with the applicable Subrules of Rule 4-004 [for example, the insulation temperature ratings determined in accordance with Subrule 14)];
- the number of lighting and power conductors in the raceway or cable be determined in accordance with Subrule 7); and
- the equipment termination temperature rating be determined in accordance with Rule 4-006.

Subrule 16) requires that, when more than one ampacity applies to single-conductor or multi-conductor cables (for example, due to the transition from an underground portion to an aboveground portion), the lower value apply.

Subrule 17), however, makes an exception when there are not more than four conductors (one conductor per phase plus the neutral) in the circuit and the lowest ampacity rating applies for part of the run, but only for a short distance (i.e., a maximum of 3 m or 10% of the circuit length, whichever is less). In such a case, the higher ampacity may be used (see Figure 4-2). This allows the higher ampacity rating to be used for the total circuit length without a termination or transition for the lower ampacity rating.

In power engineering, load factor can be defined as the ratio of average load to maximum load over a period of time. A continuous load is equivalent to a load factor of 1.00. A load factor cannot be applied in direct proportion to the continuous load to arrive at the equivalent ampacity for sizing conductors since the heating effects are proportional not to the current but to the square of the current.

The Neher-McGrath method of calculating conductor ampacity is a long and complex method on which the IEEE 835 ampacities are based.

Subrule 18) allows the use of load factors to increase the ampacity of conductors chosen using the IEEE 835 method for calculating the maximum conductor ampacity ratings allowed in Items d), e), and f) of Subrules 1) and 2) of Rule 4-004.

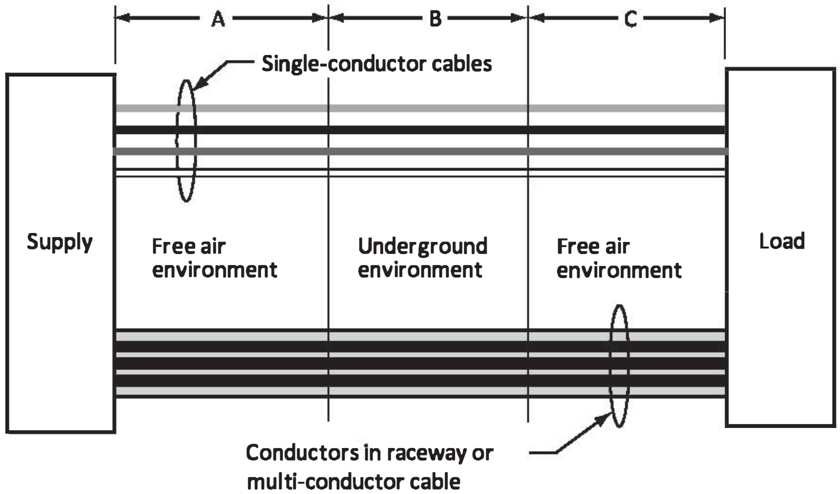
Subrule 19) prohibits any increases of conductor ampacity due to load diversity factors.

The Code ampacity Tables cover only copper and aluminum conductors. To determine the ampacity of nickel or nickel-clad conductors, Subrule 20) requires the use of the IEEE 835 calculation method.

Subrule 21) requires that Table 66 be used to determine the ampacity of bare or covered copper or aluminum conductors in free air for installation in overhead lines. It should be noted that Table 66 indicates higher ampacities for conductors that are covered than for those that are bare. Covered conductors have a larger diameter than the corresponding bare conductor and, as such, the surface area and associated heat transfer are also larger, allowing a higher ampacity.

The calculated loads on service conductors for single dwellings and feeder conductors supplying single dwelling units of row housing, apartments, and similar buildings are to be considered non-continuous loads as stated in Subrule 3) of Rule 8-200 and Subrule 2) of Rule 8-202. Subrule 22) allows the ampacities in Table 39 to be used to size 3-wire 120/240 V and 120/208 V service conductors for single dwellings and feeder conductors supplying single dwelling units of row housing, apartments, and similar buildings when such conductors terminate on equipment having a conductor termination temperature of not less than 75 °C. Table 39 collates the 75 °C ampacity requirements to calculate the minimum conductor size; therefore, no additional factors can be used to reduce the size of conductor as specified in Table 39. Subrule 22) also requires that when Table 39 is used to determine the conductor or cable size, the equipment supplied by these conductors or cables have a permanent, legible caution marking that is field applied adjacent to the fused switch or circuit breaker nameplate to indicate the maximum calculated load from Table 39.

**Figure 4-2**
**Single- and multi-conductor ampacity**




| Determining factors | Method to use |
|---|---|
| Dimension B is greater than 3 m | IEEE 835 |
| Dimension B is greater than 10% of (A+ B + C) | IEEE 835 |
| Dimension B is 3 m or less; Dimension B is less than 10% of (A+ B + C) | Free air, Table 1 or 3 |

When ventilated and ladder-type cable trays are used and when the air space between adjacent conductors, cables, or both is maintained at more than 100% of the diameter of the larger conductor or cable, Subrule 23) requires that Tables 1 and 3 (free air) ampacities be used to determine the ampacity of the conductors or cables. No further correction is required, except for ambient temperature adjustment in compliance with Table SA. However, for each multi-conductor cable containing four or more power and lighting conductors, the correction factors from Table SC are to be applied.

In ventilated and ladder-type trays where the air space between adjacent conductors, cables, or both is maintained at not less than 25% or more than 100% of the diameter of the larger conductor or cable, Subrule 24) requires that the allowable ampacity be determined in accordance with Subrule 23) and multiplied by the correction factors in Table SD for the arrangement and the number of the conductors or cables involved.

When ventilated or ladder-type trays are used and the air space between adjacent conductors, cables, or both is less than 25% of the diameter of the larger conductor or cable, and for any spacing between conductors in a non-ventilated cable tray, Subrule 25) requires that the ampacity be the value specified in Table 2 or 4 multiplied by the correction factor in Table SC for the total number of conductors in the tray.

Subrule 26) requires that where cablebus is installed in a location with an ambient temperature exceeding or anticipated to exceed 30 °C, the ampacity correction factors of Table SA be applied to the cablebus's allowable conductor ampacities marked on the cablebus's nameplate.

### Rule 4-006 Temperature limitations

The maximum ampacity rating of a conductor given in Table 1, 2, 3, or 4 is determined from the maximum allowable operating temperature of the conductor in a 30 °C ambient temperature. This is based on the conductor's insulation temperature rating, calculated using the Neher-McGrath method of calculating conductor ampacity. This means that a conductor with 90 °C insulation will operate at a higher temperature than a conductor with 75 °C or 60 °C insulation when each conductor is carrying its rated current. However, in accordance with CSA Group product standards (CAN/CSA-C22.2 No. 4 for switches, CSA C22.2 No. 14 for industrial control equipment, CSA C22.2 No. 29 for panelboards, etc.), when equipment of 600 V or less is evaluated relative to the appropriate temperature characteristics of the terminations, conductors sized by the 75 °C column of Table 2 or 4 are used. With a maximum allowable temperature termination rating of 75 °C, the excess heat due to the higher ampacity and higher operating temperature of the 90 °C conductor can cause nuisance tripping and can lead to premature temperature-related failures. Therefore, when a conductor with an insulation temperature rating of 90 °C is selected, the assigned ampacity of this conductor is to be based on the maximum value in the 75 °C column of Tables 1 to 4. See the Appendix B Note to Rule 4-006 for additional examples of the effects of the higher operating temperature of 90 °C rated conductors.

**Note:** Canadian Electrical Code, Part II, *Standards for testing products such as breakers or switches specify 75 °C or 60 °C rated conductors for field wiring. Currently, there is no circuit breaker or switch rated up to 600 V or less that is approved for 90 °C conductors and their 90 °C ampacity.*

Rule 4-006 gives the requirements for determining the insulation temperature column in Table 1, 2, 3, or 4 that is to be used to size the conductors terminating on equipment described in Subrules 1), 2) 3), and 4). For the maximum allowable conductor ampacity requirements, see Rule 4-004.

To avoid excess heat due to the higher ampacity and higher operating temperature of the conductors that can be terminated on equipment, Subrule 1) requires that where the equipment is marked with a maximum conductor termination rating, the conductor's ampacity be determined using the smaller value of the conductor's insulation or the equipment termination temperature to determine the appropriate column from Table 1, 2, 3, or 4. See Figure 4-3.

Subrules 2) and 3) give direction on how to determine which temperature column from Table 1, 2, 3, or 4 to use for equipment that is not marked with the termination temperature rating.

Subrule 2) requires that, unless provided for by other Rules of the Code, the maximum conductor termination temperature be considered the following:

- 60 °C for equipment that is
  - rated 100 A or less; or
  - marked for use with conductors sized No. 1 AWG or smaller; and
- 75 °C for equipment that is:
  - rated more than 100 A; or
  - marked for use with conductors sized larger than No. 1 AWG.

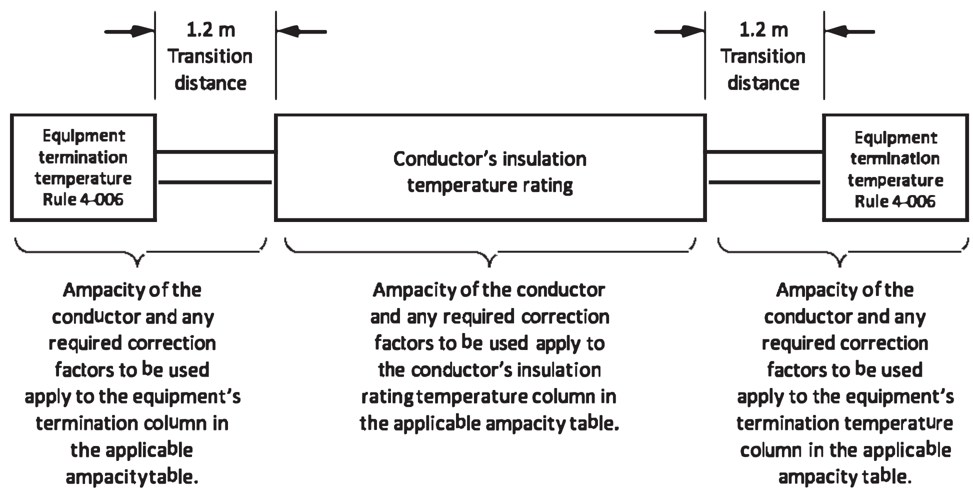
For high-voltage equipment where the conductor termination temperatures are not marked, Subrule 3) allows for consultation with the equipment manufacturer to establish the allowable termination temperature rating.

Subrules 4) and 5) give direction to Code users regarding the minimum length of conductor that can be used for transitions between the equipment's lower termination temperature rating and the higher insulation temperature rating used in the circuit. The minimum length of transition conductor is 1.2 m, measured from the point of termination on the equipment to the connection to the field-installed conductor with the higher insulation temperature rating.

The 1.2 m minimum length of conductor is based on the length of conductor connected to equipment undergoing certification to equipment standards such as CSA Group Standards CAN/CSA-C22.2 No. 4 for switches, C22.2 No. 5 for moulded-case circuit breakers and moulded-case switches, C22.2 No. 29 for panelboards, C22.2 No. 158 for terminal blocks, and C22.2 No. 244 for switchboards.

Subrule 6) requires that when the conductor's ampacity is selected from Tables D8A to D11B (for underground conductors), from Tables D17A to D17N, or from Table 12E (for DLO cables), the equipment termination requirements given in Subrule 1) for marked equipment and in Subrule 2) for unmarked equipment apply. The Appendix B Note to Rule 4-006 explains that the equipment temperature requirements given in Rule 4-006 are to be used to determine the conductor's allowable ampacity when using other Rules in the Code (for underground conductors, flexible cords, portable power cables, DLO cables, conductors with higher temperature ratings, etc.).

## Figure 4-3
## Application of correction factors when determining conductor ampacity




## Table 4-3
## Method to determine the insulation temperature column to use when sizing conductors and cables

| Step | Method |
|---|---|
| 1 | Is the conductor being used terminated within the first 1.2 m of conductor length, measured from the point of termination on the equipment?<br>• If the answer is "yes", go to Step 3.<br>• If the answer is "no", use the conductor's insulation temperature rating to determine the insulation temperature column to use. |
| 2 | Is the equipment high voltage?<br>• If the answer is "yes", consult the manufacturer to establish the equipment's termination temperature rating.<br>• If the answer is "no", use the temperature rating from Step 3. |
| 3 | Determine the equipment's marked termination temperature rating.<br>• If the equipment is not marked with the termination temperature rating, go to Steps 4, 5, and 6.<br>• If the equipment is marked with an equipment termination temperature go to Step 6. |

*(Continued)*

## Table 4-3 (Concluded)

| Step | Method |
|---|---|
| 4 | Determine the maximum ampacity rating of the equipment on which the conductors are being terminated or the conductor size the equipment is marked for use with. |
| 5 | Determine the maximum equipment's termination temperature by using Subrule 2) of Rule 4-006:<br>• 60 °C for equipment when:<br>– rated not more than 100 A; or<br>– marked for use with No. 1 AWG or smaller conductors; and<br>• 75 °C for equipment when:<br>– rated more than 100 A; or<br>– marked for use with conductors larger than No. 1 AWG. |
| 6 | Use either the conductor's insulation temperature rating or the equipment's termination temperature rating, whichever is lower, to determine the temperature column to use. |

## Table 4-4
## Method to determine the minimum conductor size for wire and cable where single conductors are installed in free air

| Step | Method |
|---|---|
| 1 | Determine the:<br>• size of the conductor in AWG or kcmil; or<br>• lowest ampere rating required for the conductor for:<br>– loads calculated using the requirements in Rule 8-104; or<br>– equipment loads (lighting, motors, transformers, capacitors, etc.). See the appropriate Rule in the Code for the type of equipment. |
| 2 | Determine the conductor material. |
| 3 | Determine the ampacity Table to be used. |
| 4 | Determine which insulation temperature column to use from the Table identified in Step 3. See Steps 1–6 in Table 4-3. |
| 5 | Determine the correction factors to be used. |
| 6 | Determine the minimum ampere rating of the conductor using the following formula:<br>Minimum conductor ampere rating = Step 1 / (Step 5 correction factors) |
| 7 | Using the Table identified in Step 3 and the temperature column from Step 4, determine the minimum ampere rating or smallest size of the conductor. |

## Table 4-5
## Method to determine the minimum conductor size for wire and cable for a group of single/individual conductors installed in a raceway, a multi-conductor cable, or a single- or multi-conductor cable installed underground in sizes smaller than No. 1/0 AWG

| Step | Method |
|---|---|
| 1 | Determine the:<br>• size of the conductor in AWG or kcmil; or<br>• lowest ampere rating required for the conductor for:<br>– loads calculated using the requirements in Rule 8-104; or<br>– equipment loads (lighting, motors, transformers, capacitors, etc.). See the appropriate Rule in the Code for the type of equipment. |
| 2 | Determine the conductor material. |
| 3 | Determine the ampacity Table to be used. |
| 4 | Determine which insulation temperature column to use from the Table identified in Step 3. See Steps 1–6 in Table 4-4. |
| 5 | Determine the correction factors to be used. |
| 6 | Determine the minimum ampere rating of the conductor using the following formula:<br>Minimum conductor ampere rating = Step 1 / (Step 5 correction factors) |
| 7 | Using the Table identified in Step 3 and the temperature column from Step 4, determine the minimum ampere rating or smallest size of the conductor. |

## Table 4-6
## Method to determine the minimum conductor size for flexible cord and equipment wire where the circuit voltage rating is 750 V or less

| Step | Method |
|---|---|
| 1 | Determine the:<br>• size of the conductor in AWG or kcmil; or<br>• lowest ampere rating required for the conductor for:<br>– loads calculated using the requirements in Rule 8-104; or<br>– equipment loads (lighting, motors, transformers, capacitors, etc.). See the appropriate Rule in the Code for the type of equipment. |
| 2 | Determine the insulation designation of the flexible cord or equipment wire (for example, TPT, PXT, STP-2, TEW, etc.). See Table 11 for conditions of use. |
| 3 | Determine the number of power and lighting current-carrying conductors to be installed in the raceway or multi-conductor cable. If more than three, apply the appropriate correction factor from Rule 4-012. |
| 4 | Determine the ampacity of the flexible cord or equipment wire from Table 12. |

## Table 4-7
## Method to determine the minimum conductor size for portable power cables that are more than 750 V

| Step | Method |
|---|---|
| 1 | Determine the:<br>• size of the conductor in AWG or kcmil; or<br>• lowest ampere rating required for the conductor for:<br>– loads calculated using the requirements in Rule 8-104; or<br>– equipment loads (lighting, motors, transformers, capacitors, etc.). See appropriate Rule in the Code for the type of equipment. |
| 2 | Determine the number of lighting and power current-carrying conductors in the cable. |
| 3 | Determine whether the conductor is shielded or non-shielded. |
| 4 | Determine the conductor's voltage rating. |
| 5 | Determine the lowest temperature rating from either the conductor's insulation temperature rating or the equipment's termination temperature rating. If it is other than 90 °C, apply the appropriate correction factor from Table 12C. See Steps 1–6 in Table 4-3. |
| 6 | Determine the ambient temperature, and apply the appropriate correction factor from Table 12B. |
| 7 | Where the installation involves more than one layer of flexible cord or equipment wire on a drum, apply the appropriate correction factor from Table 12D. |
| 8 | Calculate the conductor's minimum ampere rating. |
| 9 | Determine the minimum conductor size. |

## Table 4-8
## Method to determine the minimum conductor size using IEEE 835 and Tables D8A to D11B

| Step | Method |
|---|---|
| 1 | Determine the:<br>• size of the conductor in AWG or kcmil; or<br>• lowest ampere rating required for the conductor for:<br>– calculated loads; or<br>– equipment loads (lighting, motors, transformers, capacitors, etc.). See the appropriate Rule in the Code for the type of equipment. |
| 2 | Determine the conductor material. |
| 3 | Determine the ampacity Table to be used from Tables D8A to D11B in Appendix D by using the installation details given in each Table and the conductor's material.<br>For copper, use Tables D8A, D9A, D10A, or D11A.<br>For aluminum, use Tables D8B, D9B, D10B, and D11B. |
| 4 | Determine the conductor's temperature by using the lowest of either the insulation temperature or the equipment's termination temperature. (See Table 4-3.) |

*(Continued)*

## Table 4-8 (Concluded)

| Step | Method |
|---|---|
| 5 | Determine the correction factors to be used.<br>**Note:** *If the conductor's temperature is other than 90 °C, use the derating factor 0.886 on the values in the Tables.* |
| 6 | Determine the minimum ampere rating of the conductor using the following formula:<br>Minimum conductor ampere rating = Step 1 / (Step 5 correction factors) |

### Rule 4-008 Induced voltages and currents in metal armour or sheaths of single-conductor cables

Alternating current flowing in a single-conductor metal-sheathed cable generates an unbalanced electromagnetic field that induces a voltage in the metal sheath. If the metallic sheath is not bonded to ground, the induced voltage in the sheath can become high enough to cause a harmful and even fatal electrical shock if a person who is in contact with earth/ground happens to touch it.

Problems can also arise when the sheath is bonded to ground. If a current path is completed (for example, when the metallic sheath is bonded to ground at both ends or when the cable sheath is allowed to be bonded to ground at points along its length), there is a circulating current flow in the metal sheath. The value of the induced current is directly proportional to the amount of current that the single conductor is carrying and the length of cable. Also, the value of the circulating current is inversely proportional to the thickness of the insulation between the conductor and the sheath. See Figure 4-4.

If sheath currents become too high, they can heat the cable sheath and eventually cause insulation failure on the conductors. Also, sheath currents flow in the direction opposite to the current in the conductor, causing the current-carrying conductor to have greater resistance and increasing the voltage drop over the length of the cable.

To address these concerns, Rule 4-008 imposes limitations to maintain safe levels of sheath currents. Sheath currents on single-conductor metal-sheathed cables carrying current of 200 A and less do not pose any significant hazards.

Subrule 1) requires one of the following:

- a reduction of the cable ampacity to 70% of the ampacity that would otherwise be applied;
- a correction of the cable ampacity in accordance with the manufacturer's recommendation (subject to Rule 2-030); or
- the installation of cables in a manner that prevents the flow of sheath currents that cause a temperature buildup.

**Note:** *When the third alternative is selected, where the intention is to prevent sheath currents from flowing, it is necessary to prevent current flow not only initially but also throughout the life of the electrical installation. All of these alternatives are intended to ensure that the conductor insulation does not overheat and sustain damage.*

The Appendix B Note to Rule 4-008 recommends that all underground single-conductor metallic cable installations either eliminate the flow of sheath currents or correct the cable ampacity, to prevent overheating of the cable. The wider spacing generally employed in underground single-conductor installations can generate larger sheath currents than those in free air installations with smaller spacing. When single-conductor cable is installed with wider spacing, the electromagnetic field cancellation between adjacent conductors of different polarities is reduced, and the total field flux (magnetic line of force) produced by the current-carrying conductor cuts across the metal sheath, producing the maximum amount of circulating sheath current.

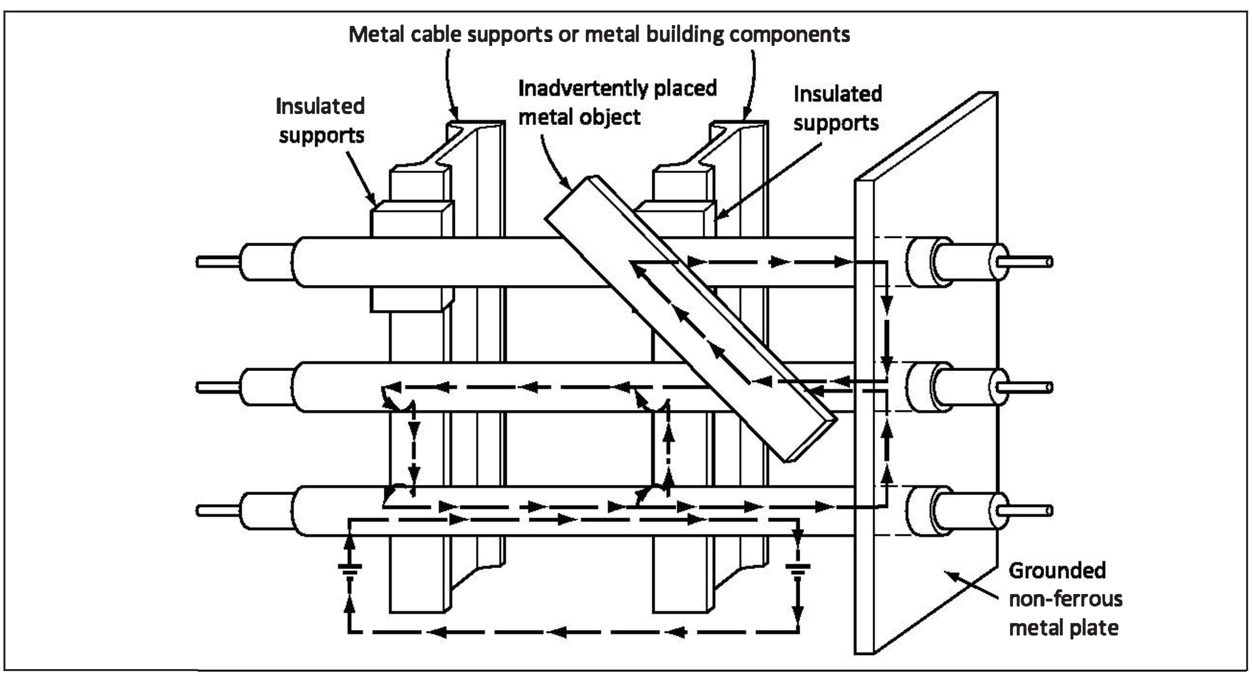
To prevent the flow of sheath currents, all paths (at terminations and supports) in which they might circulate need to be eliminated. The cable sheaths are to be grounded at the supply end termination only and isolated from ground and each other throughout their length and at the load end termination by a plate of insulating material at least 6 mm thick. A run of single-conductor metal-sheathed cables can be isolated by installing the conductors or cables in ducts made of insulating materials, employing conductors or cables with a PVC jacket or other insulating materials, or mounting the conductors or cables on insulated supports. (The Appendix B Note to Rule 4-008 provides more details on methods for preventing the flow of sheath currents.) Since the metallic cable sheaths in this case cannot be used for bonding the electrical equipment, a bonding conductor of the correct size is to be provided.

Subrule 3) does not allow single-conductor cables and single insulated conductors to enter a ferrous enclosure through an individual opening, if the conductor carries more than 200 A. This requirement prevents inductive heating of the magnetic (ferrous) metal.

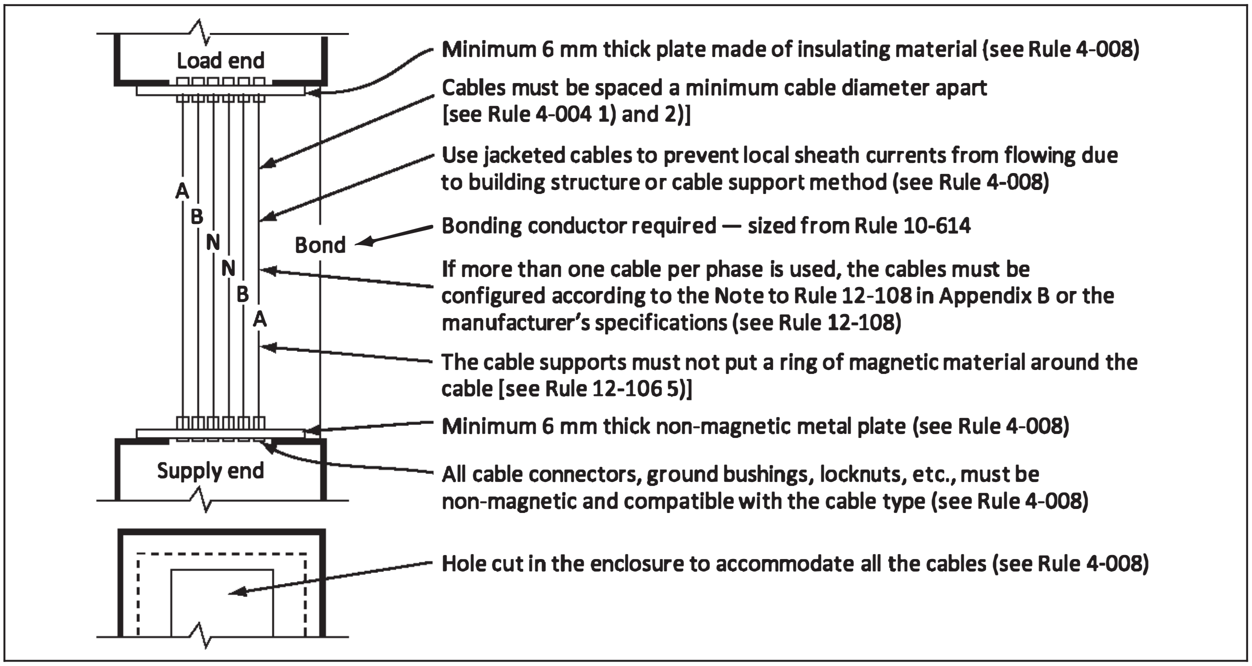
Subrules 4) to 7) and the Appendix B Note to Rule 4-008 list the following measures to prevent overheating of the magnetic (ferrous) metal when single-conductor cables or single insulated conductors enter the enclosure:
- the use of non-magnetic (non-ferrous) or non-metallic box connectors, locknuts, bushings, and ground bushings;
- the use of one non-magnetic (non-ferrous) metal or insulating plate that is at least 6 mm thick to cover the opening in the magnetic (ferrous) material and that is large enough to allow all the conductors of the circuit to pass through, unless a deviation under Rule 2-030 is obtained; and
- where single conductor mineral-insulated cables are used, grouping all current-carrying conductors together where they enter the enclosure.

See Figures 4-5 and 4-6.

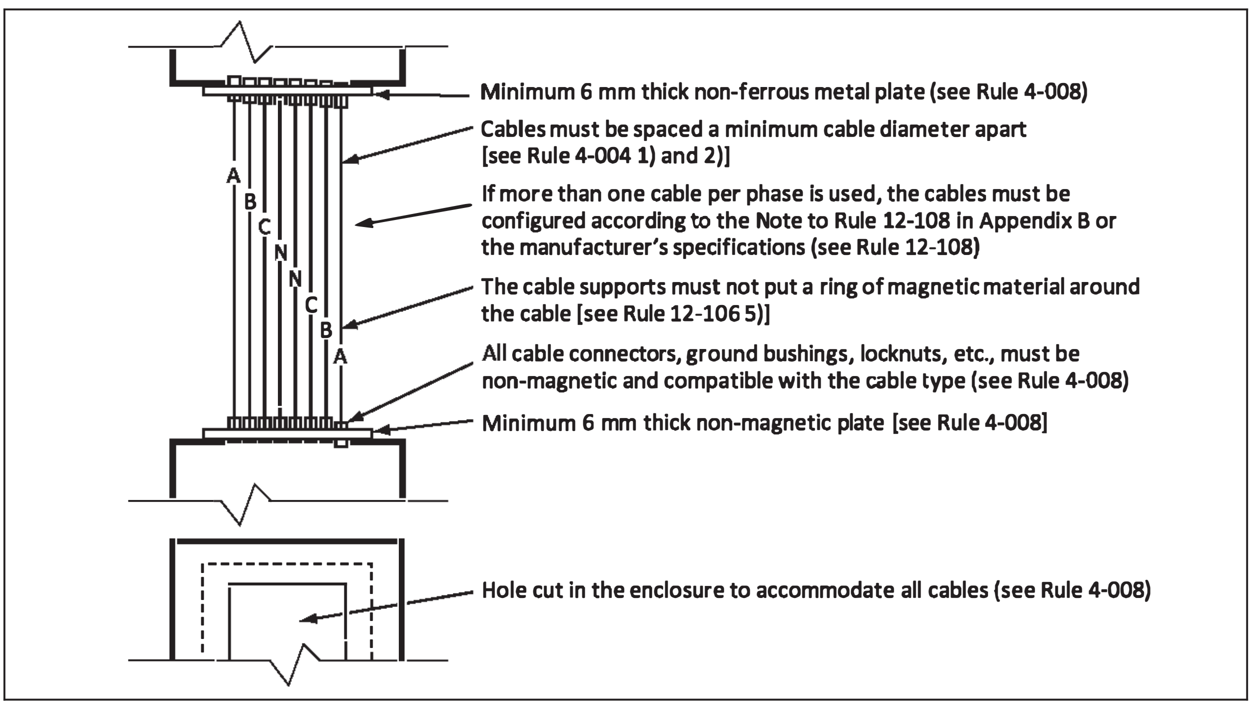
**Figure 4-4**
**Induced sheath current flow**



## Figure 4-5
## Typical installation of single-conductor metal-sheathed cable greater than 425 A




## Figure 4-6
## Typical installation of single-conductor metal-sheathed cable 425 A or less



### Rule 4-010 Sizes of flexible cord

Flexible cords are used to provide flexible connections to items such as electrical equipment and portable electrical equipment, and as extension cords for use with portable handheld equipment. The conductors in the cord must be large enough to carry fault currents in order to prevent a fire hazard and leakage current and consequent shock hazards and mechanical damage to the conductors. Rule 4-010 specifies the minimum sizes for flexible cords. The Code does not recognize flexible cords that use aluminum conductors.

### Rule 4-012 Ampacity of flexible cords

Due to the differences in construction and sizes of flexible cords, the allowable ampacity ratings for different types and applications are given in Table 12. When using Table 12 to determine the ampacity ratings of flexible cords that have a CSA letter designation starting with the letters “N”, “P”, or “S”, it is important to know the number of current-carrying insulated conductors in the cord. Refer to Rule 4-004 for information on current-carrying conductors. Correction factors for the maximum ampacity when there are more than three insulated conductors in a flexible cord are found in Subrule 1).

**Field consideration:** *The Code does not specify ambient temperature correction factors when the ambient temperature is above 30 °C (the base ambient temperature for Table 12). For ambient temperatures above 30 °C, correction factors should be obtained from the flexible cord manufacturer. Alternatively, the correction factors from Table 5A can be used.*

### Rule 4-016 Insulation of neutral conductors

Except for neutral-supported cable, service entrance cable, and conductors used in consumer’s services, Subrule 1) requires that neutral conductors be insulated. Subrule 2) requires that the insulation have a temperature rating not less than that of the insulation on the ungrounded conductors. Rules 4-024 to 4-028 mandate identification of insulation on identified conductors.

### Rule 4-018 Size of neutral conductor

The neutral conductor of a system or of a circuit is a current-carrying conductor, but it carries only the current resulting from an unbalanced load in that system or circuit. Subrule 1) requires that it be sized to carry the unbalanced load current of the system, which is defined in Subrule 2) as the current resulting from connection of the load between any phase conductor and neutral.

Subrule 2) specified the maximum unbalanced load and allows a demand factor of 70% to be applied to an unbalanced load in excess of 200 A, but no reduction is allowed for any portion of the load that consists of electric discharge lighting or other equipment that creates harmonics. Although not specifically mentioned in the Rule, this restriction is due to the fact that harmonic currents can circulate in neutral conductors. It should be noted that certain types of electric discharge lighting loads create high harmonic currents, which can cause heating in the neutral conductor. These high harmonic currents (in excess of 60 Hz), which can also be caused by other types of non-linear loads (for example, personal computers, printers, variable-speed motor drives), should be taken into consideration when sizing a neutral conductor. Installers often use 2-wire rather than 3-wire branch circuits to reduce the overheating problems in the neutral caused by harmonics in branch circuits. Certain types of high harmonic currents in the phase conductors do not cancel each other out in the neutral and cumulatively cause the neutral conductor to overheat.

Subrule 3) requires that a service neutral conductor be no smaller than No. 10 AWG copper or No. 8 AWG aluminum and have an ampacity not less than the ampacity of a grounded conductor in accordance with Rule 10-210 b).

When a bare neutral conductor is run in a raceway with insulated conductors, Subrule 4) requires that the ampacity of the neutral conductor be based on the insulation temperature rating of the adjacent circuit conductors. For example, if the circuit conductors were No. 6 AWG copper Type TW and rated at 60 °C, the ampacity of the neutral, as determined by Column 2 of Table 2, would be 55 A. If the circuit conductors were Type RW90XLPE, the ampacity of the neutral would be 75 A, in accordance with Column 4 of Table 2.

### Rule 4-020 Common neutral conductor

If more than one single-phase, 3-wire feeder, or more than one three-phase, 4-wire feeder, is used, the Code allows one common neutral conductor to be used for two or three sets of 3-wire, single-phase feeders or for two sets of 4-wire, three-phase feeders. Such restriction in use of common neutral conductors for more than one feeder is based on the need to avoid overheating of the neutral conductor and to prevent shock and voltage problems in the neutral conductor.

### Rule 4-022 Installation of identified conductor

Rule 4-022 specifies installation requirements for an identified conductor used in a service, feeder, or branch circuit. Subrule 1) requires that the identified conductor be installed:

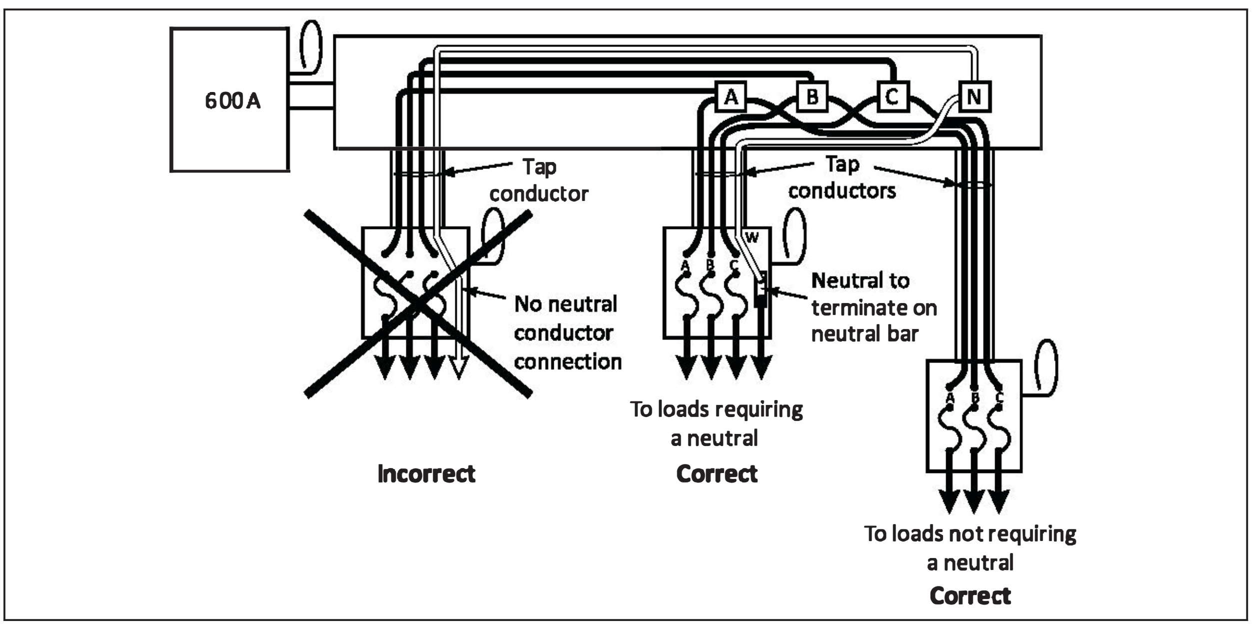
- in all separately enclosed switches and circuit breakers;
- in all centres of distribution associated with the circuit;
- with all connections to the identified conductor being made in the enclosures and centres; and
- in such a manner that any identified conductor can be disconnected without disconnecting any other identified conductor.

See Figure 4-7.

Subrule 2) requires that the identified conductor be installed at each location of a manual or automatic control device (switch) for the control of permanently installed luminaires at a branch circuit outlet.

**Note:** *This Rule is intended to address safety concerns arising from the large-scale introduction into our residential, commercial, and institutional buildings of automatic control devices for permanently installed luminaires, which can be part of an essential energy management or building automation system. Whether or not these automatic control devices combine energy management functions with home automation, aesthetic functionalities, or other functions, they require the identified conductor to be present at the device location. Manufacturers can and do manufacture devices that leak to ground within Code limits in certain cases, but this scheme is a perversion of the bonding philosophy of the Code that neutral return current not flow in the grounding system. Large-scale use of this practice can cause the amount of neutral return current to accumulate beyond the acceptable Code limits.*

**Figure 4-7**
**Installation of neutral conductor**



## Rule 4-024 Identification of insulated neutral conductors up to and including No. 2 AWG copper or aluminum

The neutral conductor, which is normally grounded at the source of a solidly grounded system, is to be identified so that it can be readily distinguished. Also, when neutral conductors of different systems are installed in the same raceway, box, or enclosure, each of the neutral conductors of the different systems is to be easily identified, to avoid overloading and other hazardous conditions caused by connection to the wrong system neutral (for example, connecting the neutral connections from a normal power supply source to the neutral conductor of an emergency power supply system).

Conductors in sizes up to and including No. 2 AWG are readily available with a white or grey continuous colouring or three continuous white stripes along their entire length. These markings are associated, both in field practice and by Code requirements, with neutral (identified) conductors. Conductors larger than No. 2 AWG are not commonly manufactured in a continuous white colour and, therefore, other methods are allowed to be used to identify them when they are used as neutral conductors.

**Note:** *Conductors with a grey or continuous white covering cannot pass the certification test for sunlight resistance, as required by Rule 2-134. When the insulation on a neutral conductor will be exposed to sunlight, conductors with three continuous white stripes along their entire length are to be used.*

To avoid the voltage problems that can occur in single-phase loads where a neutral conductor is used as a current-carrying conductor and the loads are connected to the wrong system neutral, or when neutrals from more than one system are present in an enclosure or raceway, Subrule 2) requires that the neutrals of the systems be easily distinguished from one another. The Code allows the distinction to be a coloured stripe (other than green) run along the white outer covering.

Subrule 4) allows the insulated neutral conductors in multi-conductor cables to be permanently identified by painting or other means where the internal conductors are accessible and visible. Other acceptable means are coloured insulating tape or coloured heat-shrink tubing. In many cases, these means of identification are easier to apply in the field and can be more permanent than painting. Subrule 4) requires that, where such means are used to identify insulated neutral conductors, the manufacturer's numbering of the conductor remain legible.

## Rule 4-026 Identification of insulated neutral conductors larger than No. 2 AWG copper or aluminum

Insulated conductors larger than No. 2 AWG are not always readily available with a continuous white insulation (for example, when the wiring method used for an electrical installation employs single-conductor metal-sheathed cables, or when there is insufficient market demand for specially marked conductors of certain sizes or types). When a marked conductor is not available, other methods are to be used to distinguish the neutral (identified) conductors from other conductors, to avoid incorrect connections and the associated shock and fire hazards.

Rule 4-026 has the same intent as Rule 4-024 but applies to insulated neutral (identified) copper or aluminum conductors larger than No. 2 AWG. These conductors are to be identified by:

- continuous colouring (the same requirement as for neutral conductors No. 2 AWG or smaller);
- suitable labelling at each end so that the conductor is readily identified; or
- clear marking at each end, when the neutral or identified conductor is installed, by readily identifiable means such as white tape, white paint, or white heat-shrink tubing applied to each end of the insulated conductor.

**Note:** *The type of marking for each end of the insulated neutral conductor should be selected taking into account that the marking must distinguish the neutral conductor for the lifetime of the installation. White heat-shrink tubing should be used to identify neutral conductors in environments where white paint could weather or fade, or where white tape could unravel and come off the insulated neutral conductor.*

### Rule 4-028 Identification of Type MI neutral conductors

It is not technically feasible to provide continuous identification of the neutral conductor and other circuit conductors in mineral-insulated cables during manufacture. When terminating multi-conductor mineral-insulated cables, care is to be taken to verify that the bare conductors have the correct identifying insulated sheaths installed at each end of the conductor. Testing should be done after termination to make sure of the correct identification at each end.

### Rule 4-030 Use of identified conductors

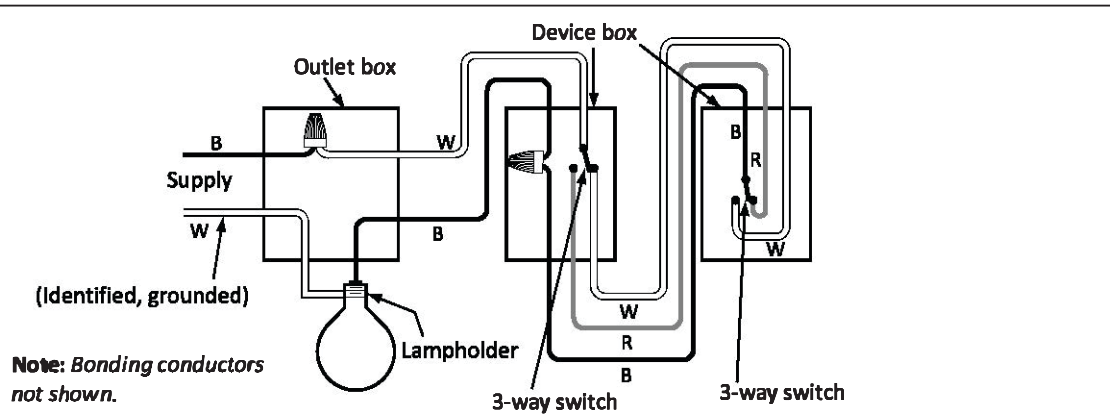
Since identified conductors are marked or otherwise distinguished to indicate that they are grounded conductors and are usually connected to the neutral point (Xo) of the source of the solidly grounded system, special considerations and restrictions apply to their use. Subrule 1) requires that an identified conductor not be used to serve the purpose of an unidentified conductor, except in armoured cable, aluminum-sheathed cable, and non-metallic-sheathed cable work. In such a case, the identified conductor is allowed to be rendered permanently unidentified by painting or other suitable means at every point where the separate insulated conductors are made accessible and visible by the removal of the outer covering of the cable.

When the identified conductor of an armoured cable, aluminum-sheathed cable, or non-metallic-sheathed cable is used as a switch loop, Subrule 2) provides an exception to Subrule 1). The identified conductor need not be rendered unidentified, provided that the connections are made so that an unidentified conductor of the cable is the return from the switch to the outlet. See Figure 4-8.

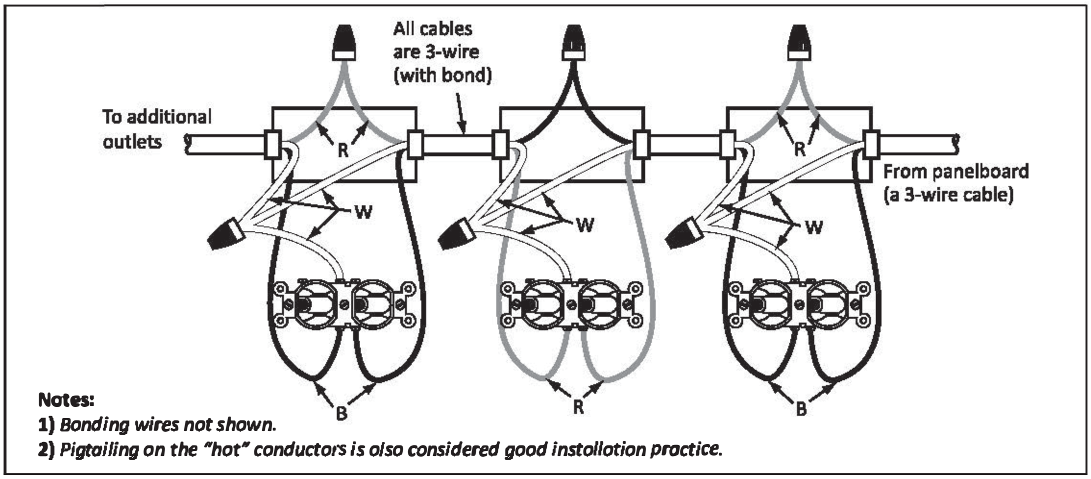
When the identified (white) conductor of an armoured cable, aluminum-sheathed cable, copper-sheathed cable, or non-metallic-sheathed cable is not used in the circuit, Subrule 3) requires that it be obvious that the identified conductor is not part of the circuit. Cutting the conductor off short wherever conductors are accessible or visible is one means of doing so.

Subrule 4) applies to the continuity of the identified grounded conductor in a multi-wire branch circuit (a multi-wire branch circuit consists of two or more ungrounded conductors having a common identified grounded conductor so that the voltage difference between the ungrounded conductors and the identified grounded conductor is equal). The continuity of the identified grounded conductor is to be independent of device connections (for example, lampholders, receptacles, and ballasts) so that devices can be disconnected or removed without interrupting the continuity of the identified grounded conductor required for the other circuit(s). For example, the identified terminals of receptacles or devices are not to be used as feed-through media; instead, a tap-off means to the device terminations is to be used. See Figure 4-9.

**Figure 4-8**
**Use of identified conductor: Three-way switching**



## Figure 4-9
## Use of identified conductor: Multi-wire circuit




### Rule 4-032 Identification of insulated conductors

Colour coding for conductors is consistently adopted nationally and, as much as possible, internationally to avoid confusion and to provide greater electrical safety. Subrules 1) and 2) standardize for Canada the colour coding of the insulation for bonding and grounding conductors, when these conductors are insulated.

Subrule 3) requires that when colour-coded circuits are required, phase A conductors be coloured red, phase B conductors be coloured black, phase C conductors be coloured blue, and neutral conductors be coloured white or grey, or white with a coloured stripe where more than one system is present in the raceway, box, or enclosure.

In some installations, a delta-connection secondary is grounded to supply lighting and similar loads in addition to polyphase motors. As a result, one phase has a higher voltage-to-ground than the other two phases. Subrule 4) requires that this phase be designated as phase A and the conductors be coloured red in accordance with Subrule 3).

When a panelboard is supplied from a 4-wire delta system, in order to reduce the shock hazard and the possible misconnection of equipment supplied by the panelboard, Subrule 5) requires that the panelboard:

- be manufactured with a barriered compartment to accommodate single-phase connections to the grounded conductor; and
- have the phase conductor with the higher voltage-to-ground separated from the barriered compartment.

### Rule 4-034 Ampacity of portable power cable

Subrule 1) refers to Table 12A to determine the ampacity for various sizes of portable power cable.

**Notes:**

1) *Table 12B provides correction factors for ambient temperatures from 10 °C to 50 °C that are applied when determining the ampacity of a portable power cable.*
2) *Table 12C provides correction factors for insulation temperature ratings of 60 °C, 75 °C, and 90 °C.*
3) *Table 12D provides correction factors that are applied when portable power cables are wound on a reel with one or more layers.*

Since Type DLO cable is listed as a portable power cable but is allowed to be used in permanent installations in a cable tray, Subrule 2) requires that Table 12E and Rule 4-004 be used to determine ampacity ratings.

# Section 6 — Services and service equipment

## Scope

### Rule 6-000 Scope

Section 6 is a general Section of the Code that contains requirements for the installation of consumer's services and service equipment. Service equipment is located between the supply authority's distribution equipment and the consumer's distribution equipment. The supply authority's distribution equipment is not subject to the requirements of the Code (see Section 0).

Section 6 sets out requirements for consumer's low-voltage electrical equipment connected to a supply authority's distribution system. These requirements apply to all electrical installations operating at 750 V or less and to the supply authority's indoor and outdoor lines and distribution equipment when these lines and equipment are on private property for the connection of consumer's services and service equipment. Electrical installations in excess of 750 V are considered high-voltage and are to be installed in accordance with the requirements of Section 36.

The Code uses two terms to describe different applications of service entrance equipment: "consumer's service" and "supply service".

The "supply service" conductors belong to the supply authority, and the supply authority is responsible for servicing and maintaining these conductors after their initial installation. While the initial installation can be done by either the supply authority or the customer, the final connections are done by the supply authority.

The "consumer's service" refers to the portion of the electrical installation from the service box or its equivalent up to and including the connection point of the supply authority conductors. The consumer's service, which includes conductors, provisions for metering equipment, and the service disconnect, brings electrical energy into the installation. It can then be distributed through the consumer's distribution equipment to the individual branch circuits to meet the electrical requirements of the consumer.

The connection/demarcation point (the connection between the consumer's service and the supply service) is located:

- where the consumer's service conductors emerge from the service raceway, cable, or mast on overhead low-voltage services;
- in the meter base on underground low-voltage services operating at 300 V or less;
- in the consumer's main disconnecting device on underground low-voltage services operating in excess of 300 V;
- in the transformer on low- or high-voltage services, when the transformer is owned by the supply authority; or
- in the customer's main disconnecting device on high-voltage services, when the transformer is owned by the customer.

# General

## Rule 6-100 Special terminology

A *transformer rated meter mounting device* is a manufactured enclosure, with a socket for connecting the supply authority's meter and with integral current transformers. It might or might not have test switches and is designed to be connected on the supply side of the service box. It is used where:

- the supply voltage to the service does not exceed 300 V between line conductors [see Item b) of Subrule 2) of Rule 6-402];
- the service rating is over 200 A but does not exceed 600 A [see Item c) ii) of Subrule 2) of Rule 6-402 and Subrule 3) of Rule 6-404]; and
- the service is outdoors [see Item c) iii) of Subrule 2) of Rule 6-402].

## Rule 6-102 Number of supply services permitted

When a building has more than one supply service with the same voltage, electrical hazards can arise for:

- personnel servicing and maintaining the building's electrical system; and
- emergency service personnel who are required to disconnect the building's electrical system during emergencies such as floods, fires, explosions, wind damage, or rock or mud slides.

Subrule 1) requires that only one supply service for each particular voltage be provided in a building, with certain exemptions. It allows the use of more than one supply service with the same voltage in a building, provided that the service is used to supply:

- fire pumps as required by Subrule 1) of Rule 32-304;
- industrial establishments; or
- large complex installations such as
  - malls;
  - commercial towers with adjoining parking structures; and
  - buildings with self-contained units that are not located above one another and that have separate entrances with direct access to ground level (i.e., units separated by fire separation in accordance with the requirements of the *National Building Code of Canada*) such as strip malls or row or town housing.

When a building contains more than one supply service with the same voltage, Subrule 2) requires that, where practicable, all the service boxes connected to each consumer's service be grouped in the same location.

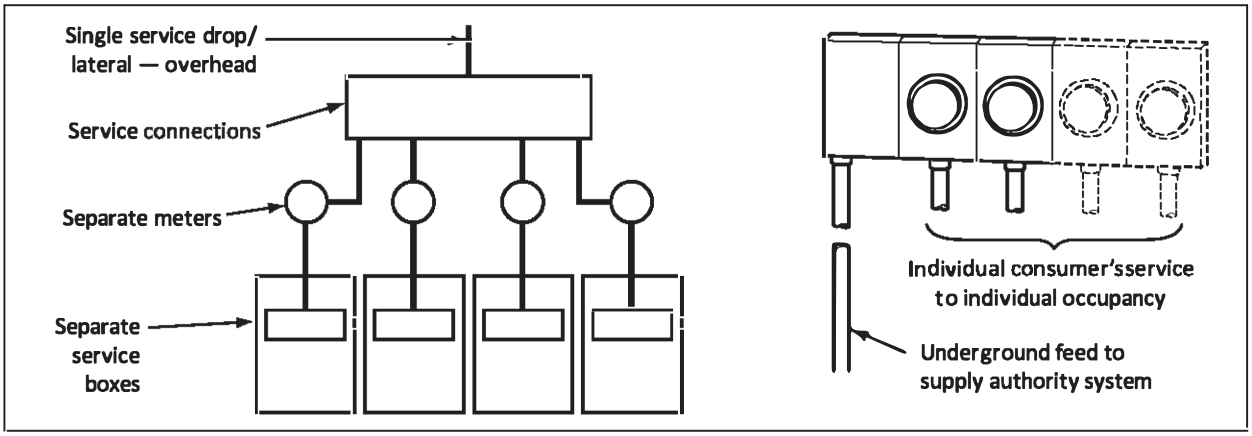
Where the grouping of service boxes in the same location is not practicable, Subrule 3) allows service boxes to be placed elsewhere, provided that a permanent diagram is posted on or near each service box in the building that indicates the location of all other service boxes in the building.

## Rule 6-104 Number of consumer's services permitted in or on a building

Multiple consumer's services connected to one supply authority's service to a building can cause difficulties in emergencies when all service boxes are to be de-energized, creating an electrical hazard for personnel servicing and maintaining the building's electrical system. Rule 6-104 requires that no more than four consumer's services be connected to an individual supply authority's line to a building. See Figure 6-1.

Where the requirements of an installation make it impracticable to conform to the maximum of four consumer's services per supply service, Rule 6-104 allows the number of consumer's services to exceed four if a deviation has been granted under the requirements of Rule 2-030.

## Figure 6-1
## Services from one supply on a building — Overhead and underground




### Rule 6-106 Current supply from more than one system
When an electrical installation or portion of it is supplied by more than one system at the same time, as is the case with a standby generator or an interconnected power production source connected to an electrical installation, there can be:
- damage to electrical equipment; and
- injury to personnel working on the electrical installation.

To prevent both systems from energizing the same electrical installation at the same time, devices such as the following are used:
- a transfer switch;
- a two-position-type switch [double-pole, double-throw (DPDT) or 3-pole, double-throw (3PDT)]; or
- a system of key interlocks.

Rule 6-106 requires that this switching equipment be arranged so that power from one source cannot be switched on unless power from another source has been cut off.

### Rule 6-108 Supply service from an electric railway system
Since electric railway systems use a ground return for their dc systems, and ac systems can incorporate a system ground, problems in an electrical installation can occur when these system grounds are mixed. Electrical equipment and facilities used in the operation of an electric railway and supplied by the same circuits that supply the motive power for the railway (dc ground return system) are built to meet the requirements of electric railways and are usually supplied with 550 V dc.

Rule 6-108 allows an electric railway's power supply system that incorporates a ground return (i.e., uses ground as a conductor) to supply a building electrical system if the building is used in connection with the operation of an electric railway.

### Rule 6-110 Three-wire consumer's services
Where there are only two 120 V branch circuits on a 120 V consumer's service, the imbalance on the supply authority's lines is acceptable from the authority's point of view. If, however, there are more than two 120 V branch circuits used in a building, the branch circuits are to be connected to a 120/240 V multi-wire supply to maintain a balanced current on the supply authority's lines. When the supply for the branch circuits is from a source other than a supply authority's system, such as a portable generator, the requirements for 3-wire branch circuits in Rule 6-110 do not apply.

## Rule 6-112 Support for the attachment of overhead supply or consumer's service conductors or cables

Subrule 1) requires that a means of attachment be provided for the attachment of the overhead supply or consumer's service conductors or cables to the building.

The weight of snow and ice loads and the effects of high winds on the supply authority's or consumer's overhead service conductors can cause:

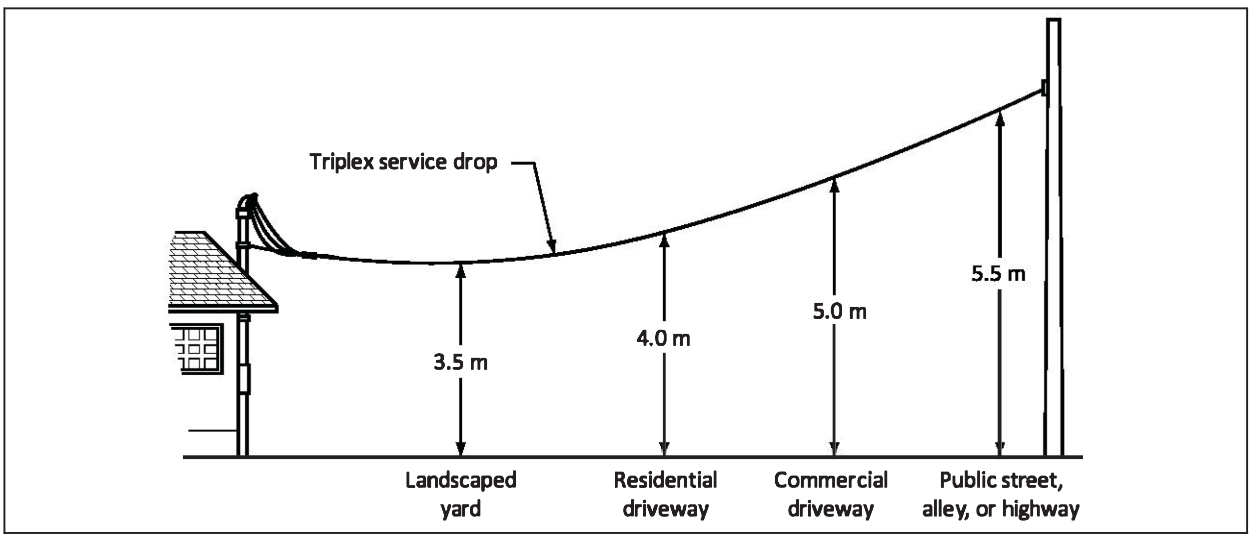
- conductors to sag, reducing the required ground clearance;
- conductors to break;
- the means of attachment (the insulator) to be pulled out of the wall; or
- the service mast to bend.

Subrule 2) requires that the point of attachment be:

- on the same side of the building as the consumer's service head or equivalent;
- solidly anchored to the structure or service mast;
- in a position that allows the overhead service conductors or cables to have an angle away from the structure; and
- in compliance with the requirements of the supply authority

Subrule 3) gives the maximum height above grade for the point of attachment and the minimum heights above grade for the supply conductors running to the point of attachment, based on the area under the conductors (for example, highways, driveways, pedestrian areas, etc.). See Figure 6-2.

**Figure 6-2**
**Minimum clearances**




Subrule 4) sets a minimum clearance for exposed service conductors of 1 m from windows, doors, and porches, unless the conductors are installed above them. See Figures 6-3 and 6-4.

**Figure 6-3**
**Exposed service conductor clearances**

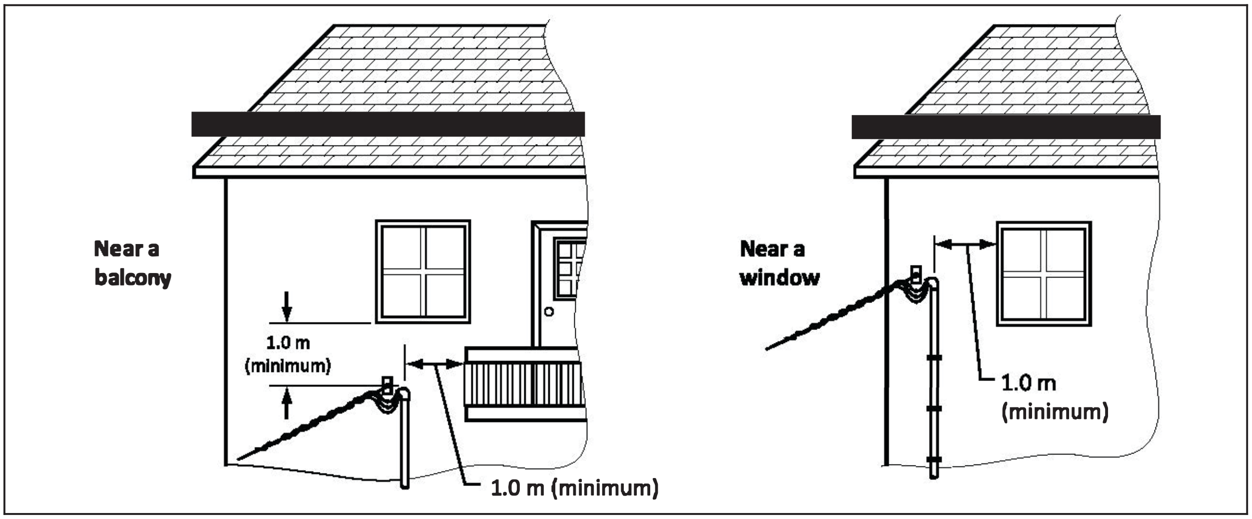
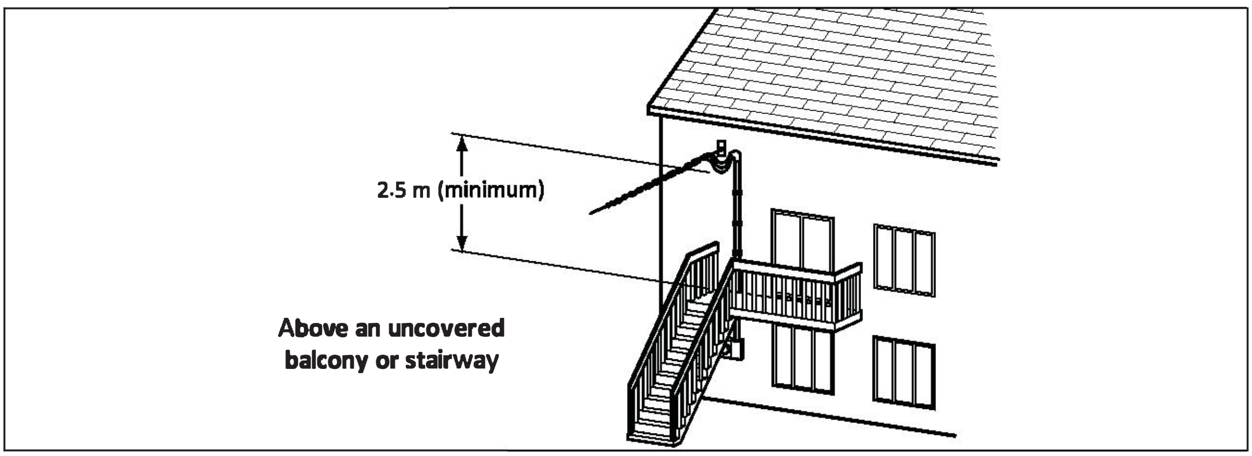



**Figure 6-4**
**Conductor clearances**



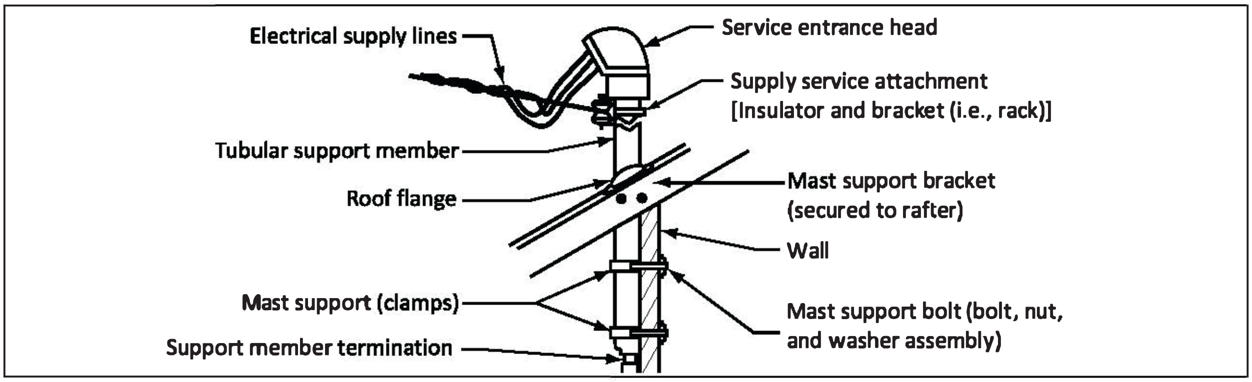

Subrule 5) requires that the service mast be made of metal and suitable components. The Appendix B Note to Rule 6-112 5) identifies the components of a mast that meet the requirements of CSA C22.2 No. 82 as well as the installation requirements of the Code.

Subrule 6) allows rigid steel conduit with a minimum nominal size of 63 to be used as the tubular support member component in a service mast assembly as specified in CSA C22.2 No. 82.

Subrule 7) requires that a 16 mm diameter through-wall bolt be used to secure the means of attachment to its required location. However, if the means of attachment is secured to a wooden structural member, the fastener is allowed to be 38 mm in any dimension.

Subrule 8) does not allow the roof of a structure to be used to secure the point of attachment for the supply or consumer's service conductors. However, Subrule 9) allows a roof rafter, a roof truss, or other structural roof member to be used to secure an eye bolt for a guy wire and the support for the upper portion of a mast. (See Figure 6-5.)

**Figure 6-5**
**Terms associated with a service mast**




**Rule 6-114 Methods of terminating conductors or cables at consumer's service**
Rule 6-114 protects overhead service conductors, cables, raceways, and equipment from water infiltration. If water enters the cables or conduit and then freezes, the cable, raceway, and insulated conductors can be damaged or short-circuited. Water infiltration can also cause the service equipment enclosure and the equipment inside the enclosure to corrode, which can lead to a fire or shock hazard.

Rule 6-114 also prevents the conductors of one polarity from coming in contact with conductors of a different polarity due to damaged or deteriorated insulation. Such contact can cause arcing or short-circuiting. Damaged or deteriorated insulation can result from:
- the environment;
- temperature;
- moisture; and
- sunlight (ultraviolet radiation).

To prevent water from entering the consumer's service, Subrule 1) requires that a service entrance head fitting (for example, an "F" fitting) be suitable for use in a wet location and be installed at the supply end of the service conduit or cable.

The service head at the supply end of a service cable may be omitted when the cable is continuous from the supply authority's service to the consumer's service equipment [see Subrule 2)]. Subrule 3) also allows the service head at the supply end of single- or multi-conductor cables to be omitted when:
- suitable sealing, such as a weatherproof fitting, self-sealing weatherproof thermoplastic tape, or heat-shrinkable tubing, is provided at the cable end;
- the conductors emerging from the seal point downwards to prevent water from running into the insulation and entering the cable; and
- the cables are held securely in place.

To prevent the conductors of one polarity from coming in contact with conductors of a different polarity, which causes arcing or short-circuiting, Subrule 4) requires that conductors of different polarity be brought out of the service head through separate, insulated holes.

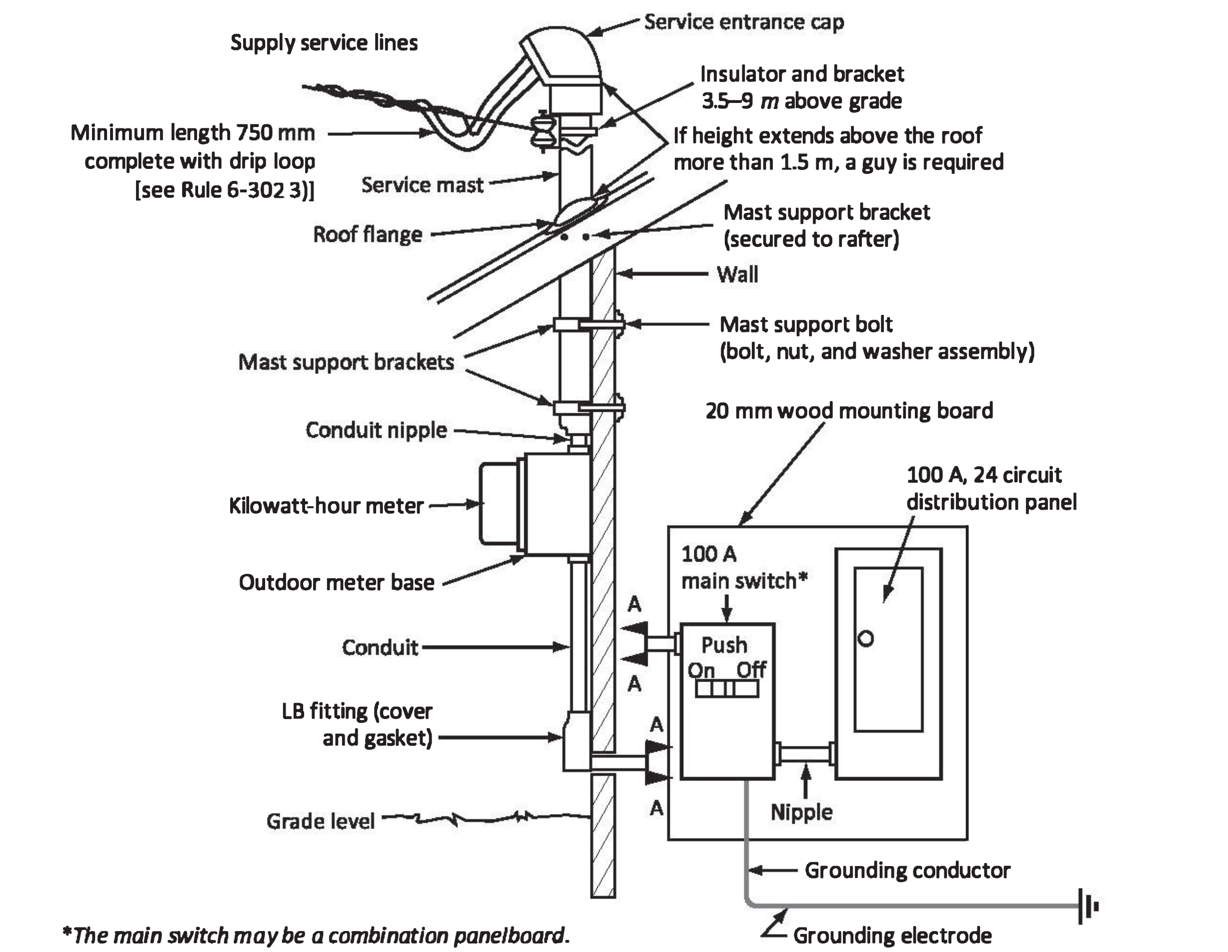
Subrules 5) and 6) require that the service conductors and cables be:
- of sufficient length to form drip loops outside the service head to prevent water from entering the service cable or conduit [Subrule 3) of Rule 6-302 requires a minimum length of 750 mm — see Figure 6-6];
- of sufficient length for proper connection to the supply authority's overhead service conductors; and
- terminated above the point of attachment of the supply authority's overhead service conductors (see Rule 6-116).

**Rule 6-116 Consumer's service head location**

The service head or equivalent is to be in a location that:

- complies with the requirements of the supply authority;
- is a minimum of 150 mm to a maximum of 300 mm above the point of attachment for the overhead supply service conductors or cables; and
- is no more than 600 mm horizontally from the support (means of attachment) for attachment of the overhead supply service conductors to the building.

## Figure 6-6
## Typical termination of service conductors




*The main switch may be a combination panelboard.*

# Control and protective equipment

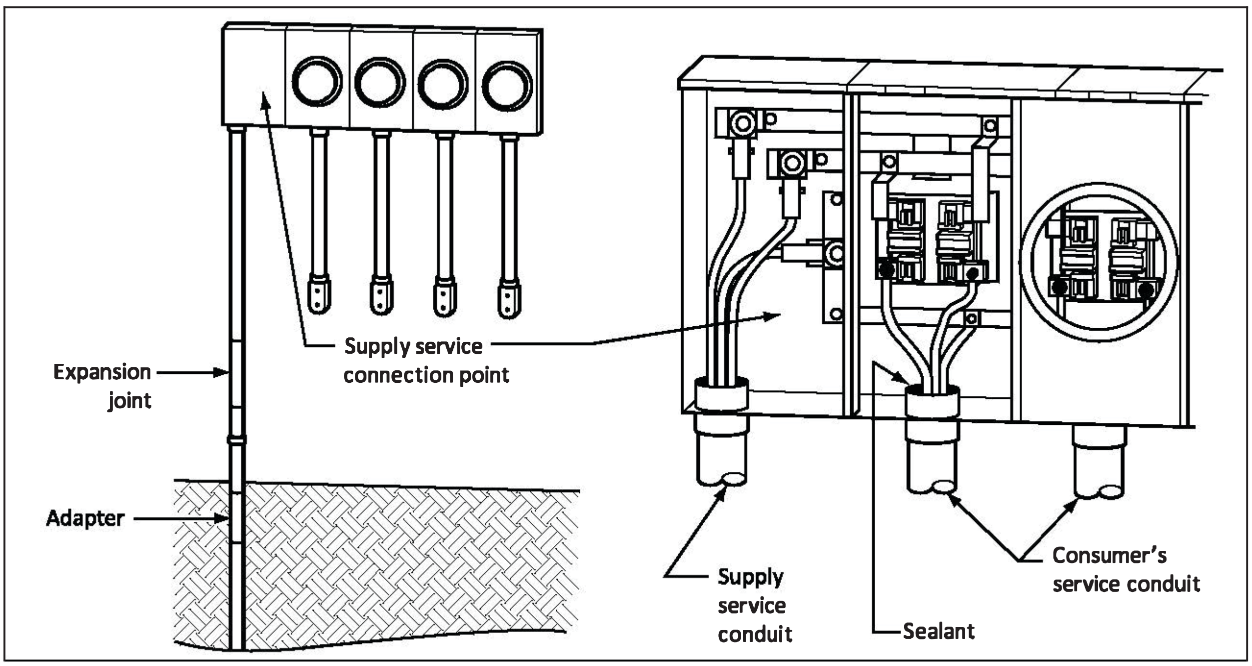
### Rule 6-200 Service equipment
A service box is to be provided to disconnect the distribution equipment in a building from the consumer's service equipment to facilitate the needs of the supply authority and the consumer.

Subrule 2) allows the connection of more than one service box to a single consumer's service when used in such applications as duplex or row housing when the subdivision is made in a multiple or dual lug meter mounting device that:
- does not exceed 600 A;
- does not exceed 150 volts-to-ground; and
- is located outdoors.

Subrule 3) requires that each separate service box count as one consumer's service in the application of Rule 6-104.

### Rule 6-202 Subdivision of main consumer's service
See Figure 6-7 and Rules 6-402 and 26-600.

**Figure 6-7**
**Subdivision of a consumer's service**




### Rule 6-204 Fuse enclosure on service boxes
Rule 6-204 refers to the design and maintenance of service boxes that are no longer in use except in older installations. It specifies design requirements for the doors to these service boxes, which provide protection from electric shock and fuse failure.

### Rule 6-206 Consumer's service equipment location
Personnel should have a safe and adequate working space when they service, operate, and maintain consumer's service equipment. The location is to be clean and environmentally appropriate for the electrical equipment.

The consumer's service conductors are unfused and unprotected until they enter the main service box. Since unprotected conductors can be the cause of a fire or shock hazard, the distance between the outside wall and the service box is to be kept as short as possible.

Subrule 1) requires that the location chosen satisfy the supply authority's requirements and be readily accessible. Undesirable locations [see Item c) of Subrule 1)] include:

- coal bins (coal dust can cause short-circuits in the panel because of tracking and can present a fire/explosion hazard);
- clothes closets (access can be difficult, and the contents of a closet can present a fire hazard);
- bathrooms (moisture can cause shock hazards and deterioration of equipment);
- areas where footing is not level (for example, stairways);
- dangerous or hazardous locations (such locations present a risk of fire or explosion);
- high-temperature areas (heat can cause nuisance tripping of overcurrent devices and deterioration of insulation);
- areas where the ceiling height is less than 2 m (such areas are not easily accessible); and
- any other undesirable location that presents a potential threat to the equipment or to personnel servicing the equipment.

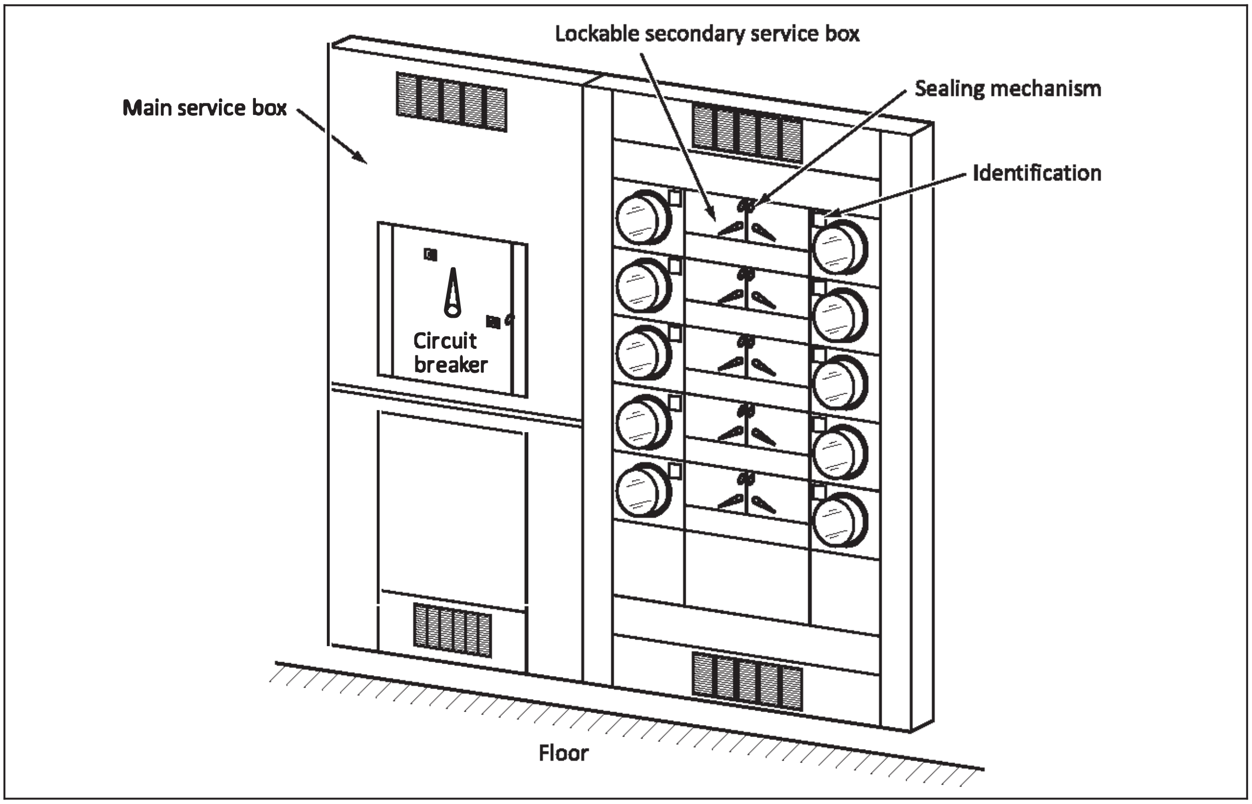
It is the intent of the Code that no unauthorized individual be able to operate service equipment in such cases as multi-occupancy buildings (for example, apartment buildings) in which each occupancy has its own metering equipment and secondary service boxes (see Figure 6-8). To prevent unauthorized operation, Subrule 2) allows the individual service equipment to:

- have an integral locking device;
- have an external lockable cover; or
- be located in a separate building, room, or enclosure.

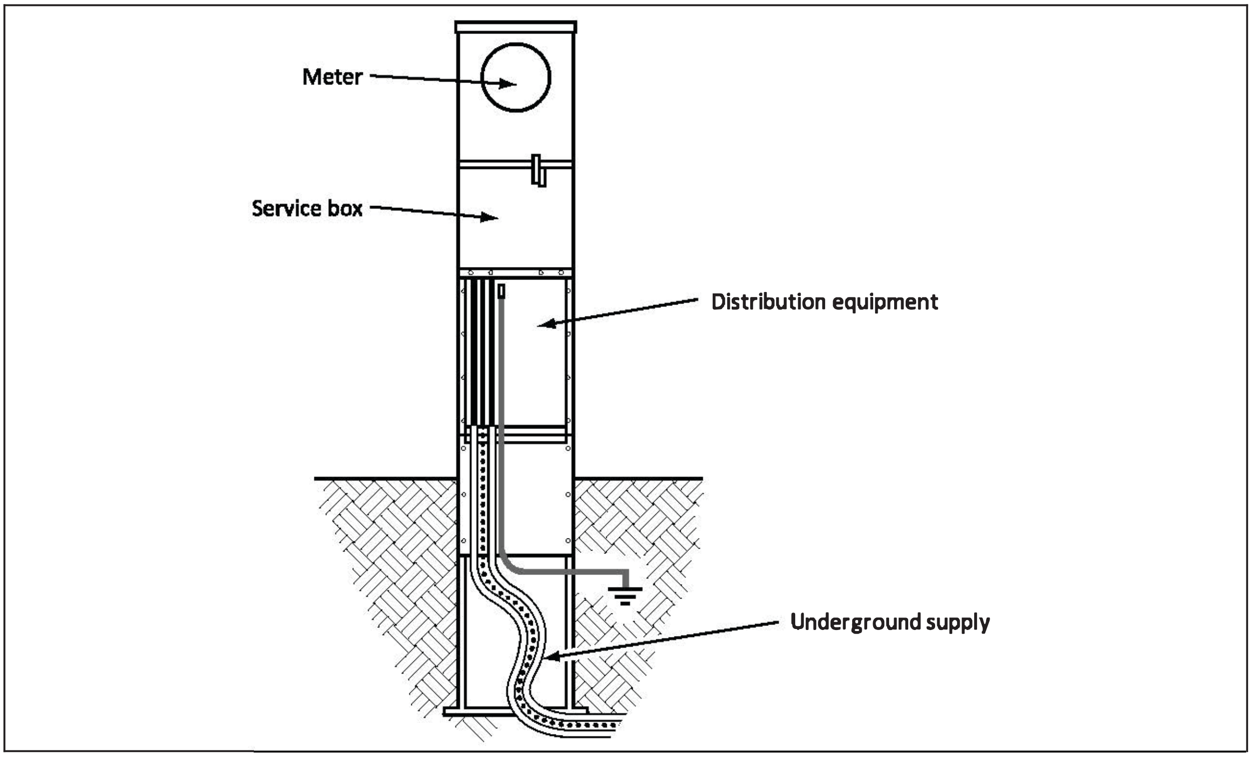
Subrule 3) allows the service disconnecting means to be located on the outside of a building or on a pole provided that it is:

- installed in an enclosure for use in outdoor locations or otherwise protected against the weather; and
- protected against mechanical damage if it is located less than 2 m above ground (see Figure 6-9).

## Figure 6-8
## Service equipment



## Figure 6-9
## Outdoor service




### Rule 6-208 Consumer's service conductors location

Conductors located indoors require a greater degree of overcurrent protection than that provided by supply authorities for conductors located outdoors. The protection on the line side of the supply transformer can supply a number of customers, and it is impractical to size the supply service conductors in accordance with the number of customers. The supply authority bases its protection sizing on estimates of the demand on the conductors. These estimates are based on the different types of occupancies and load operation. The supply authority also takes into consideration the fact that it owns the conductors, so if the conductors become overloaded or damaged, the authority is responsible for replacing them, usually without charging the customer.

Consumer's service conductors are connected to the supply conductors and could, if damaged, be a possible fire hazard. They are to be treated as unprotected. Consumer's service conductors are to be run outside a building to prevent fire hazards to the building or occupants.

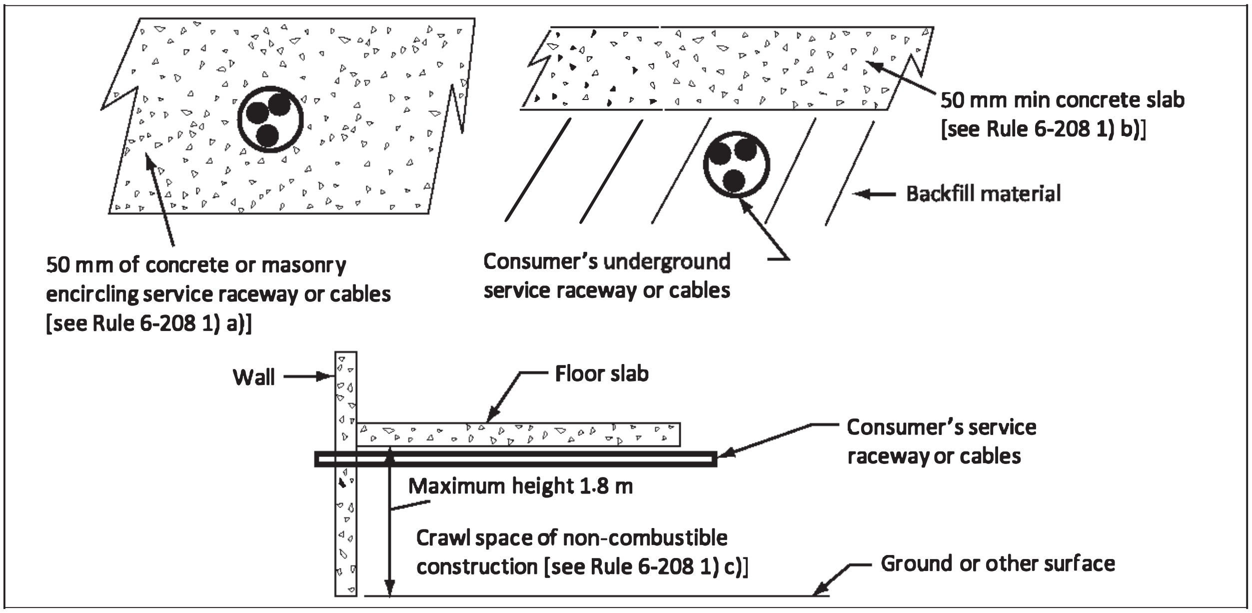
When consumer's service equipment is required to be located inside the building, Item c) of Subule 1) of Rule 6-206 requires that the length of the consumer's or supply service conductors be as short as practicable. In Canada, this distance varies according to the authority having jurisdiction, so the local authority having jurisdiction is to be consulted to determine the maximum allowable distance.

Where it is impractical to locate the service box close to the service conductor entry into a building, Subrule 1) gives the methods for installing service raceways and cables so that unprotected consumer's service conductors can be run inside a building for an unlimited distance before terminating in a service box, without presenting a hazard. The installation methods allowed are as follows (see Figure 6-10):

- encasing the raceway or cables in 50 mm of concrete or masonry where the wiring method is allowed by Section 12;
- directly burying the raceways or cables beneath a concrete slab not less than 50 mm thick; or

- running the raceways or cables in a crawl space, located under the building, that:
  - does not exceed 1.8 m in height;
  - is of non-combustible construction; and
  - is not used for the storage of combustible material.

**Figure 6-10**
**Location of consumer's service conductors**




### Rule 6-210 Oil switches and oil circuit breakers used as consumer's service switches

It is not easy to determine the position of an oil switch, and when the oil is drained, the switch loses its arc-quenching ability and its insulating value. Special provisions are therefore necessary to protect workers from electric shock. Subrule 1) requires that an isolating switch be provided on the supply side and that it be interlocked with the oil circuit breaker when an oil circuit breaker is used as a consumer's service switch. An exemption is allowed when the oil switches or oil circuit breakers are installed in metal-clad equipment. In such cases, the primary isolating device for the equipment is considered to fulfill the isolation requirement. For servicing and checking the oil, it is necessary to isolate the circuit breaker from the source of power by means of the isolating switch. In a three-phase system, one trip coil (similar to a motor starter) is to be installed in each line conductor so that it is possible to detect an overcurrent problem in each phase.

In the case of a four-wire, two-phase ungrounded system in which the transformer's capacity is used to supply an isolated network, such as a tower crane, Subrule 2) allows two trip coils (one trip coil in each phase) to control the oil circuit breaker, provided that a deviation under Rule 2-030 is obtained. The oil in this case is used as an arc suppressant.

### Rule 6-212 Wiring space in enclosures

Heat can affect the proper sensing of the current passing through the overcurrent device. An externally operated fused switch or a circuit breaker enclosure is normally designed for one conductor per phase terminal and is not to be used for conductors feeding through or tapping off to other enclosures/apparatus. Subrule 1) restricts the use of space in a fused switch or circuit breaker enclosure so that only the conductors for that switch or circuit breaker are allowed to enter the enclosure.

Subrule 2) provides an exception that allows current monitoring devices to be installed in service equipment designed for this purpose. Current monitoring devices are installed on service and distribution equipment to monitor the electrical characteristics required by energy management systems.

Subrule 3) requires that where consumer service conductors enter a service box that is not equipped with a barrier between the line and load side (usually both line and load conductors are entering the enclosure on the same wall of the enclosure), these conductors:

- enter the service box as close as possible to the line terminals of the main switch or circuit breaker; and
- not come into contact with or cross conductors connected to the load terminals of the main switch or circuit breaker.

### Rule 6-214 Marking of service boxes

Rule 6-214, which applies to the marking of service boxes/switches, has similar requirements to Subrule 3) of Rule 2-100, which applies to distribution equipment.

## Wiring methods

### Rule 6-300 Installation of underground consumer's service conductors

Subrule 1) gives the requirements for two installation methods for the underground portion of a consumer's service conductor installation (see Figure 6-11).

Provided that underground splice kits are used, Subrule 2) allows splices in the underground portion of the consumer's service conductor installation to repair damage to the existing installation where a pole or service relocation is required, or where conductor transition due to the temperature limitations of Rule 4-006 is required. It is not acceptable, however, to use short pieces of conductor or cable spliced together for a new underground consumer's service installation or to add a new piece of cable to a new installation that was incorrectly measured.

**Note:** *CSA C22.2 No. 198.2 provides requirements for underground cable splice kits, which are allowed under Subrule 5) of Rule 12-112.*

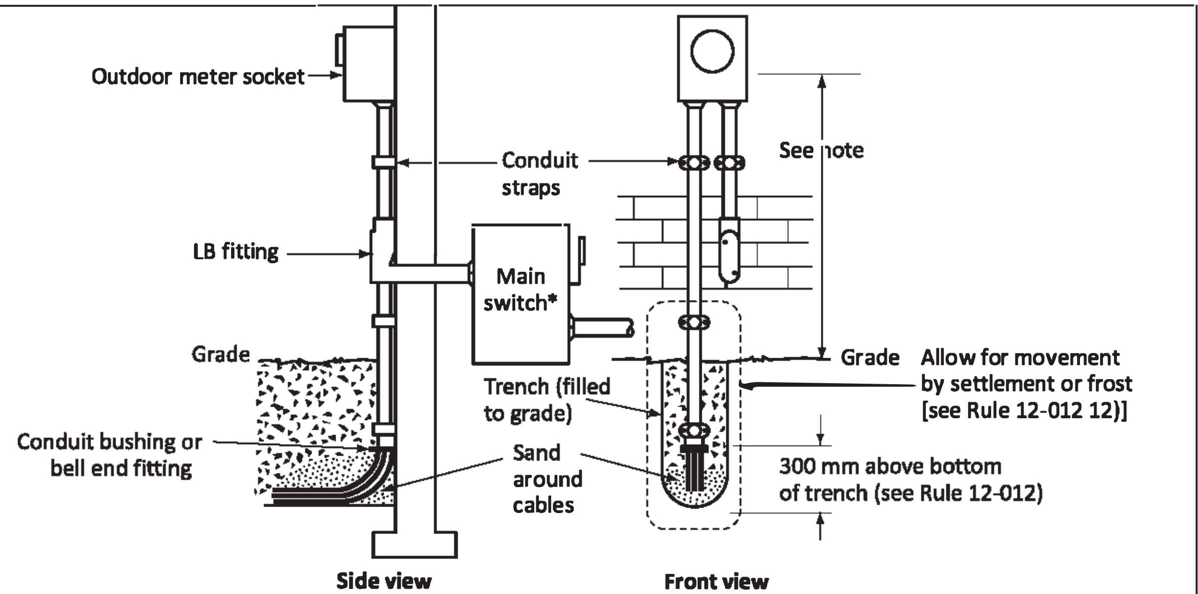
Subrule 3) requires that underground consumer's service raceways entering a building be:

- sealed to prevent moisture and gas from entering the building through the raceway;
- drained before they pierce the building wall to prevent water from entering the service equipment; and
- installed to prevent moisture and gas from entering the building around the outside of the raceway.

Subrule 4) covers the sealing of the consumer's service conduit with a suitable sealing compound to prevent gases or moisture from entering the service equipment and/or the building. The entrance of gas or moisture can be detrimental to the health of the occupants and can also damage the equipment.

**Field consideration:** *When directly buried conductors, cables, or raceways are used for the underground portion of consumer's services, experience has shown that premature failure of the consumer's service conductors can result from earth/soil movement, concrete poured tight on the service raceway, or other settling that causes the pulling of the conduit away from the termination point resulting in stress on the conductors or cable and subsequent shorting. This movement places stress on the conductors at the shifting point. In the selection of the wiring method and the layout of an installation, the potential shifting/movement of the soil and subsequent stress are to be taken into consideration to avoid conductor failure. See Subrule 12) of Rule 12-012.*

## Figure 6-11
## Typical underground residential service




**The main switch may be a combination panelboard.*
**Note:** *The meter mounting height is to be determined by the supply authority and the* National Building Code of Canada.

### Rule 6-302 Installation of overhead consumer's service conductors

Consumer's service conductors depend on the supply authority's protective devices, which are designed to protect the transformer but do not always provide the level of protection for the secondary conductors normally required by the Code. Rule 6-302 therefore provides requirements for the wiring method for the consumer's service conductors located above ground, at any point, on a building or structure.

Subrule 1) requires that consumer's service conductors that are connected to an overhead supply service be installed in a raceway or be part of a cable assembly to:
- provide mechanical protection;
- prevent contact with live parts; and
- limit damage to the structure or building if a fault occurs in the conductors.

The types of raceways and cables allowed to be used are listed in Subrule 1). Exposed cables and raceways are to be protected from mechanical damage up to 2 m above grade.

Subrule 2) gives the requirements for consumer's service conductors that are run exposed on the supply side of the consumer's service head (see Rules 12-302 to 12-318) when the conductors are run between buildings or on the outside walls of buildings, or when they cross over or are installed on the roof of a building.

Subrule 3) requires that a length of conductor be left beyond the service head for connection to the supply authority's conductors.

Subrule 4) requires that consumer's service conductors be no smaller than No. 10 AWG copper or No. 8 AWG aluminum to provide mechanical strength and fault current-carrying capability. [Subrule 3) of Rule 4-018 gives the minimum size requirements for neutral conductors.]

Subrule 5) is intended to ensure that cables and insulated conductors do not crack due to flexing in cold weather conditions and that their insulation does not deteriorate as a result of the ultraviolet rays from sunlight (see Rule 2-134). Subrule 5) also requires that the insulated conductors be of a type and temperature rating suitable for local weather conditions. This can mean a –40 °C rating in some geographical locations.

**Note:** *Low-temperature markings on conductors indicate compliance with a test at the marked temperature at the time of manufacture, but they do not ensure suitability for installation at that temperature. The manufacturer's literature usually provides information on conductors' temperature ranges. See the Appendix B Note to Rule 12-100.*

### Rule 6-304 Use of mineral-insulated and aluminum-sheathed cable

Mineral-insulated, copper-sheathed and aluminum-sheathed cables are easily damaged, and if they are used for consumer's service, this can have serious consequences. Therefore, exposed cables that are run along any surface in lanes and driveways less than 2 m above grade are to be protected by steel guards not less than No. 10 MSG (see Rule 12-934).

When a single-conductor cable is carrying fault currents due to a fault on the electrical system, the flow of fault current or short-circuit current along the cable causes the single-conductor cable to move. The larger the fault current flowing in the single conductor, the more violent the unintentional movement. In order to handle this electrical and physical stress, Subrule 1) requires the use of single-conductor mineral-insulated, copper-sheathed, or aluminum-sheathed cables in sizes not smaller than No. 3.

### Rule 6-306 Consumer's service raceways

To protect the consumer's service conductors installed in raceways from fire and shock, and from damaging other system conductors if the insulation on the conductors fails, Rule 6-306 requires that:

- each service raceway contain the conductors for only one service;
- raceways be protected against mechanical damage (for example, from a scrape by the mirror of a vehicle) by a No. 10 MSG steel guard if the raceway is installed less than 2 m above grade in lanes and driveways (see Rule 12-934); and
- raceways be a minimum 21 trade size to prevent conductor damage during installation and provide a higher degree of mechanical strength during the life of the service.

### Rule 6-308 Use of bare neutral in consumer's service

Rule 6-308 allows bare copper neutral conductors in any consumer's service raceway and bare aluminum neutral conductors to be run above ground in non-metallic or aluminum consumer's service raceways. A bare neutral conductor is allowed to be part of a busway or service entrance cable or part of a neutral supported cable when run as exposed wiring in accordance with Subrule 2) of Rule 6-302 and Rules 12-302 to 12-318.

**Note:** *Bare copper conductors are not to be in contact with an aluminum raceway, especially in damp or wet locations, since their composition and mechanical properties can be chemically affected.*

### Rule 6-310 Use of joints in consumer's service neutral conductors

If the continuity of the neutral or identified conductor is broken (for example, due to an open or high-resistance connection), it can cause fluctuations in the line-to-neutral voltage. This change in the line-to-neutral voltage can damage electrical equipment and create potential shock and fire hazards.
Rule 6-310 prohibits joints and splices in the consumer's service neutral between the point of connection to the supply authority's service conductors and the line terminals in the consumer's service box.

### Rule 6-312 Condensation in consumer's service raceway

Water can cause corrosion, surface tracking, and equipment failure if allowed to enter the consumer's service box. Condensation in cold-weather locations (when the service raceway enters a warm building from the cold outdoors) can also cause corrosion. Rule 6-312 covers requirements for draining consumer's service raceways.

# Metering equipment

### Rule 6-400 Metering equipment

Voltage transformers, current transformers, and any associated measuring devices are considered electrical metering equipment. These include watt-hour meters, demand meters, and any other type of meter used for measuring and recording the quantity of electricity consumed.

### Rule 6-402 Method of installing meter loops

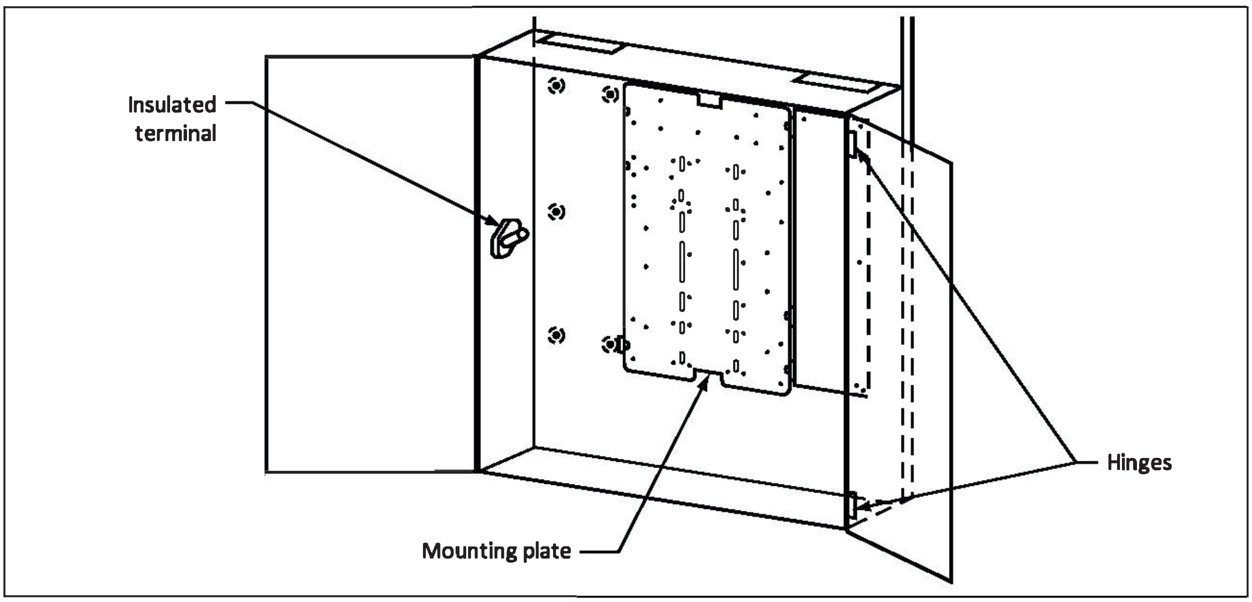
A meter loop is a length of consumer's service conductor that is left in the metering enclosure for the connection to the supply authority's metering equipment. The supply authority is to be consulted for their metering requirements and the length of meter loop that is to be left for their use.

To reduce the possibility of theft of electrical energy, Item a) of Subrule 1) requires that the conductors between the service box and the meter be accessible only to authorized persons.

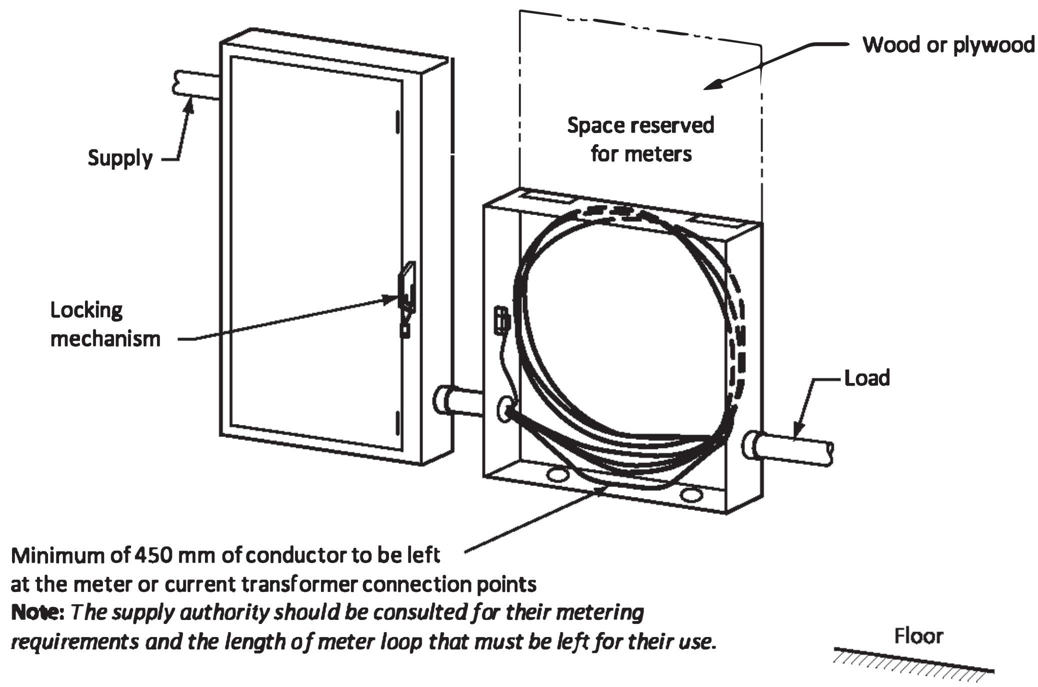
To allow the supply authority to connect its metering equipment to the consumer's service equipment, Items c) and d) of Subrule 1) require that a minimum of 450 mm of conductor be left at the meter or current transformer connection points and a suitable fitting, or a service box with a meter backplate, be provided.

See Figures 6-12 to 6-16.

**Figure 6-12**
**Meter or current transformer enclosure complete with meter backplate**



## Figure 6-13
## Meter or current transformer enclosure showing meter loops




**Note:** *The supply authority should be consulted for their metering requirements and the length of meter loop that must be left for their use.*

Subrule 2) allows an exemption from the requirement to connect the metering equipment on the load side of the service box to the supply side when:

- no live parts or wiring are exposed;
- the supply is ac and the line-to-line voltage does not exceed 300 V; and
- the rating of the consumer's service does not exceed:
  - 200 A for a meter mounting device;
  - 320 A for a meter mounting device equipped with a bypass means; or
  - 600 A for a transformer rated meter mounting device located outdoors.

**Note:** *With the increasing use of electric vehicles and other modern power-consuming equipment, the power demand for many households is increasing. Higher amperage requirements in the future will necessitate upgrades on residential services. In the past the technology has not been available for self-contained metering equipment that could be used on the supply side of a service box between 200 A and 600 A unless a 600 A transformer rated meter mounting outdoors was used. The 320 A meter mounting device does not contain a current transformer; instead, it is equipped with a bypass means. The 320 A meter mounting device allows the meter to be pulled out and reinstalled only when the door is closed and the device is in bypass mode. Also the cover must be in place in order to activate or deactivate the bypass mechanism.*

**Figure 6-14**
**Typical interior enclosure and socket for a self-contained meter, installed ahead of the service box**

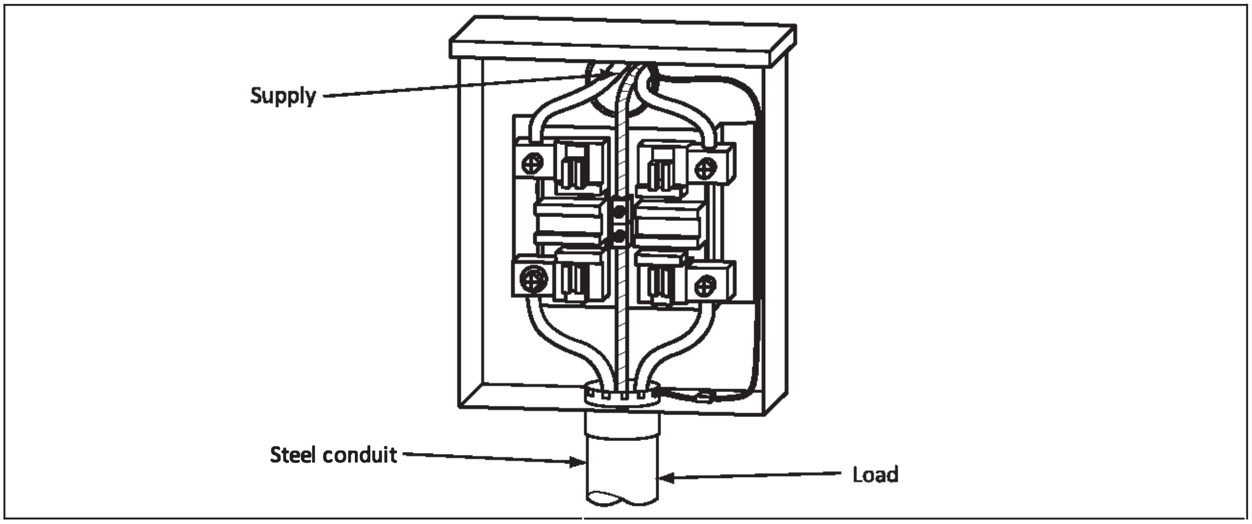



**Figure 6-15**
**Subdivisions where the voltage is over or under 300 V between conductors**

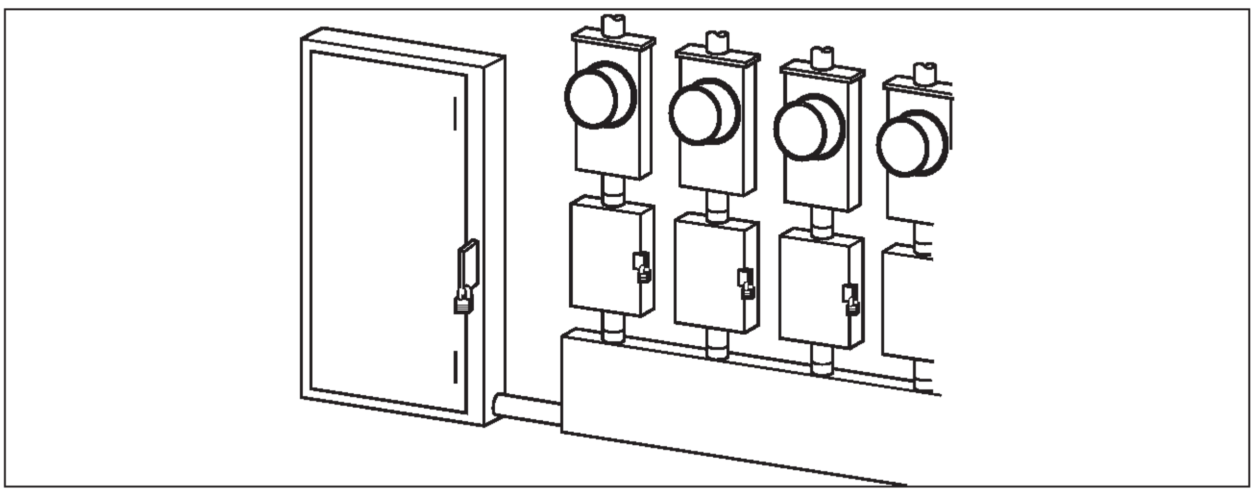
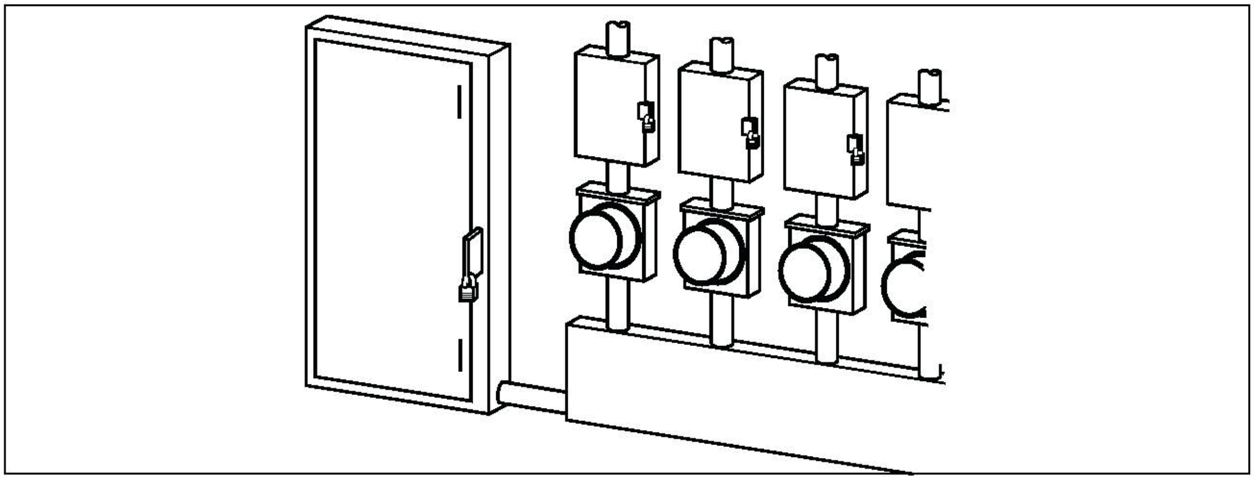


**Figure 6-16**
**Subdivisions where the voltage is 300 V or less between conductors**



### Rule 6-404 Enclosures for instrument transformers

For electrical safety and security, the public is to be protected from contact with instrument transformers. If access to the transformers is not confined to authorized personnel, metal enclosures are to be supplied, complete with provisions such as backing plates for securing the transformers. The type of enclosure is to meet the requirements of the supply authority. See Figure 6-12.

### Rule 6-406 Disconnecting provisions for meters

To ensure that customers are charged only for the electrical energy they use and that the system is safe, Rule 6-406 requires that in multiple occupancy services and in single occupancy multi-rate services with individual metering, the conductors to each meter be provided with a separate service box or service equipment, or a sealable meter fitting. See Figures 6-15 and 6-16.

### Rule 6-408 Location of meters

In addition to the requirements of Rule 6-408 for the location of meters, adequate working space is needed around electrical metering equipment (see Rule 2-308 and Figure 6-8). The location is to be clean and environmentally suitable for the equipment being installed.

### Rule 6-410 Space required for meters

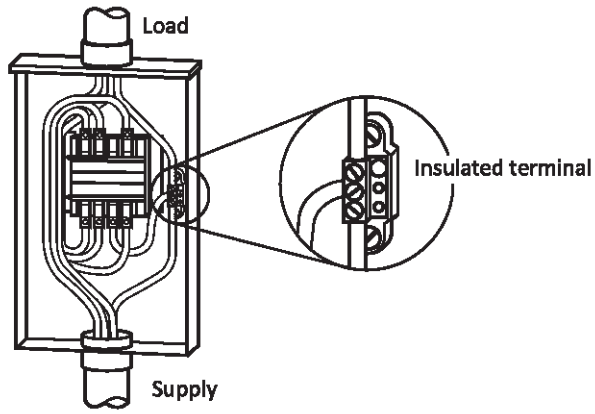
Since the supply authority provides, services, maintains, tests, and reads the meters, Rule 6-410 requires that the space provided for metering equipment comply with the supply authority's requirements. Consult the supply authority and local codes for the actual spacing requirements around metering equipment.

### Rule 6-412 Metering requirements for impedance grounded systems

There are various methods of metering impedance grounded systems available to supply authorities. When the neutral of an impedance grounded system is connected to ground through a neutral grounding device, the neutral grounding device is not to be bypassed by the supply authority's metering. See Rules 10-300 to 10-308 and Figure 6-17.

## Figure 6-17
## Neutral insulated from ground in meter equipment

**Note:** *The neutral must be connected to the insulated terminal, and an insulated neutral conductor must run from jaw seven to the insulated terminal.*



# Section 8 — Circuit loading and demand factors

## Scope

### Rule 8-000 Scope

Section 8 is a general Section of the Code that provides requirements for:
- maximum circuit loading;
- calculated loads for consumer's services, feeders, and branch circuits;
- use of demand factors;
- branch circuit positions required for dwelling units;
- heater receptacles for vehicles powered by flammable or combustible fuels; and
- electric vehicle energy management systems.

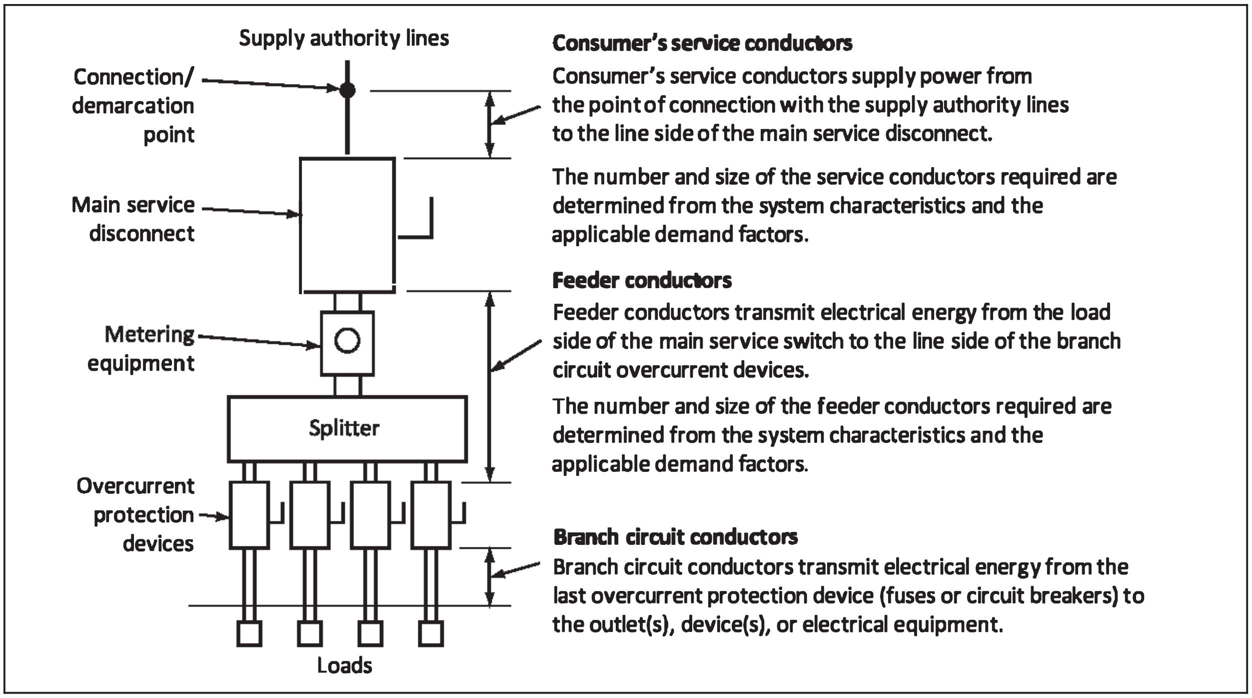
In order to understand the requirements of Section 8 and how these requirements apply to an electrical installation, it is necessary to know the meaning of the terms "branch circuit", "feeder", and "service" (see the Definitions in Section 0). It is also necessary to know:
- the locations of the branch circuits, feeders, and services;
- the loads they supply;
- the electrical characteristics they bring to the load; and
- their function in the electrical system. See Figure 8-1.

When determining the minimum allowable ampere rating of a service, feeder, or branch circuit (for example, when selecting the appropriate ampere rating of a fused switch or circuit breaker and the ampacity of conductors), it is necessary to ensure that the design of the electrical installation:
- meets the mandatory requirements for circuit loading and demand factors from Section 8 and other appropriate Sections of the Code;
- takes into account some provisions for wiring changes that might be required as a result of future load growth; and
- takes into account the customer's budget.

Section 8 deals with a variety of situations and environments, and assigns demand factors to certain loads, recognizing that, in practice, circuits, feeders, and services are not likely to attain maximum loading at the same time, as some loads (for example, electric heating and air conditioning, etc.) do not operate in a building at the same time. Some types of loads are dealt with in other Sections, such as Section 28 for motors, Section 42 for welders, and Section 62 for electric space and surface heating.

Section 8 applies demand factors for sizing conductors and overcurrent protection devices that serve a number of different loads. Since it is highly unlikely that all loads would be connected or would draw maximum current simultaneously, demand factors are used to reduce the total connected load value of the combined downstream equipment.

**Figure 8-1**
**Circuit identification**




In Section 8, a power in watts (and not in volt amperes) is used for calculating loads of branch circuits, feeders, or services. Power factor is not taken into account. Power factor on services and/or feeders is usually measured once the service or feeder has been in use for a given period of time. This allows the required correction for power factor to be determined more accurately, thus ensuring that the installed power factor correction meets the installation's particular requirements. It should be noted that, with a few exceptions, all electrical equipment is rated in watts (W). Only transformers are rated in volt amperes (V•A). Capacitors are rated in volt amperes reactive (VAR), and motors are rated in horsepower (HP).

Section 8 also deals with branch circuit positions for dwelling units. For the purpose of this Rule, the key difference between a single dwelling and a dwelling unit is that every single dwelling (for example, a detached house, unit of row housing, duplex, triplex, or quadruplex) is to be provided with a service box; however, a dwelling unit in an apartment building must be provided with a panelboard only (see Rule 26-600), and the service box for the apartment building must be installed in conformance with Rule 6-206. It should be also noted that a single dwelling is a dwelling unit, but not every dwelling unit (for example, a suite in an apartment building) is a single dwelling. Both, however, are residential occupancies (see Rules 26-652 and 26-654).

## Rule 8-002 Special terminology

The following definitions clarify the requirements in Section 8.

*Basic load* refers to the typical load of lighting and receptacle circuits within an area bound by the outside dimensions of a specific area of the building occupancy and is given in W/m². The value of the basic load for each particular building occupancy is different and is dependent on type of occupancy (see Table 14) and on load calculation requirements. See the Note in Appendix B for additional information.

*Calculated load* refers to the load calculated in accordance with the applicable requirements of Section 8.

*Demonstrated load* refers to historical maximum demand watt information recorded over a period of at least 24 months (based on the type of facility, its geographic location, and climatic conditions). Demonstrated loads are given in $W/m^2$.

*Control of electric vehicle supply equipment loads* refers to the process of connecting, disconnecting, increasing, or reducing electric power to electric vehicle supply equipment loads.

*Electric vehicle energy management system* refers to a means of controlling electric vehicle supply equipment loads comprised of any of the following: monitor(s), communications equipment, controller(s), timer(s), and other applicable device(s).

## General

### Rule 8-100 Current calculations

Rule 8-100 requires that, in load calculations, only the standard voltages listed in this Rule and provided by the power supply sources be applied.

**Example for Rule 8-100 — How different applied voltages can change the ampere draw of the equipment**

A 20 kW, 240 V, single-phase heating load has a nameplate rating of 83 A. If the supply voltage to the 20 kW furnace is reduced to 220 V, what is the current draw?

Because the load is a resistive load, the resistance of the heater must be calculated, since it will not change in response to the drop in voltage.

$E$ = system voltage

$W$ = wattage of furnace heating element or load

$R$ = resistance of furnace heating element

Resistance of the furnace: $E^2 / W$ = (240 V × 240 V) / 20 000 W = 2.88 Ω

Current draw at 220 V: $E / R$ = 220 V / 2.88 Ω= 76.4 A

Current draw at 240 V: $E / R$ = 240 V / 2.88 Ω= 83.3 A

In the Example for Rule 8-100 above, if the designer used the lower value of current for the branch circuit and feeder calculations, the conductors could be undersized and, therefore, overloaded if the rated voltage listed in this Rule were applied to the feeders or branch circuits.

Rule 8-100 establishes a standard voltage base for current calculations from loads in watts (W) or volt amperes (V•A). This enables all Code users to make calculations and arrive at the same current value for sizing conductors and overcurrent devices, and selecting equipment such as transformers and capacitors. Standard voltages are also used to test electrical equipment complying with CSA Group Standards to determine the nameplate ratings.

Application voltages differ in many areas of the country and differ through the life of the electrical installation. Increasing or decreasing loads to the power supply source could affect the system voltage. By using standard voltages regardless of the actual voltage supplied, the Code establishes a standard base to ensure a safe installation within the allowable voltage ranges.

### Rule 8-102 Voltage drop

The impedance of the circuit insulated conductors creates a voltage drop in a circuit. This can result in lower than satisfactory voltage at the distribution or utilization equipment, unless suitable preventive measures are applied. In general, a significant voltage drop decreases the operating efficiency of electrical equipment such as motors, heating systems, electronic equipment, and lighting systems. Establishing criteria for the maximum allowable voltage drop in a feeder or branch circuit ensures that the required utilization voltages for the electrical installation will be provided, which contributes to the safety of the electrical installation and the optimum performance of the 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 insulated conductor and the current flowing in the insulated conductor. According to Ohm's Law, if the conductor size remains the same and the current is increased, the voltage drop increases, and 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 connected load on the feeder or branch circuit, or, if that load is unknown, on 80% of the rating of the overload or overcurrent device protecting the branch circuit or feeder. Subrule 1) also sets the maximum allowed percentage values of the voltage drop in specific portions of the electrical installation.

In a typical installation, with a consumer's service, a feeder, and a branch circuit [as shown in a), b), and c) in Figure 8-2], a 5% voltage drop is allowed between the point of connection of the consumer's service to the supply authority's supply or source of supply and the load terminals of the utilization equipment. Therefore, for a 240 V supply, the total voltage drop allowed is 12 V (i.e., 240 V × 0.05). Item b) of Subrule 1) sets out the parameters for the distribution of the total allowed voltage drop. Item a) of Subrule 1) specifies that the maximum for any feeder or branch circuit is 3%, so for a 240 V supply, it would be 240 V × 0.03 = 7.2 V. Insulated conductor sizing is then determined by the particular requirements of the installation. If at least 2 V are required in the service conductors, then 10 V (12 – 2) are left for the feeder and branch circuit. If the feeder is sized such that the voltage drop in it is 3 V, the remaining 7 V (10 – 3) can be used in the branch circuit.

Subrule 2) requires that in cases where overcurrent devices are selected in accordance with other Sections of the Code (not Section 8), the voltage drop calculation be based on the calculated demand load of the feeder or branch circuit.

Subrule 3) allows the lengths specified in Table 68 to be used for general use branch circuits rated at not more than 120 V or 20 A in dwelling units [instead of basing the lengths on the calculations for voltage drop in Subrule 1)] when using 90 °C rated copper conductors at 30 °C ambient temperature for 120 V single phase ac circuits. The conductor lengths specified in Table 68 are measured from the supply side of the consumer's service to the furthest point of utilization.

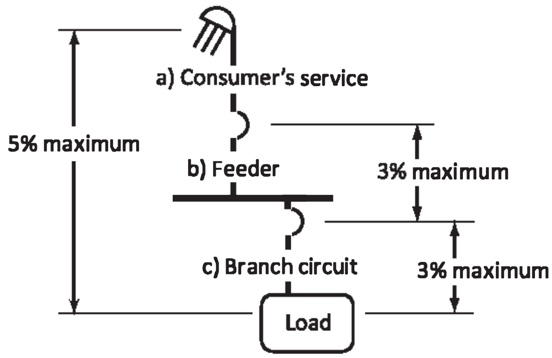
Subrule 4) allows an exemption to the voltage drop requirements in Subrule 1) [i.e., 3% in a feeder or branch circuit and 5% from the supply side of the consumer's service (or equivalent) to the point of utilization] at industrial establishments where conditions of maintenance and supervision ensure use by qualified personnel. However, if the exemption is used, then Subrule 4) requires that the voltage drop calculation ensure that the voltage at the point of utilization is within the rating or voltage tolerance of the connected device or devices.

Table D3 in Appendix D provides the method for calculating voltage drop in low-voltage circuits, based on a non-inductive load of a circuit (for example, a pure dc resistance circuit) and on a conductor temperature of 60 °C. This temperature might seem extreme for oversized or lightly loaded conductors but is adequate for conductors loaded at their rating. Table D3 and the accompanying examples illustrate the method of calculation. See Table 8-1.

Table D4 in Appendix D is used for voltage drop calculations in extra-low-voltage circuits. See Table 8-2.

Wire and cable manufacturers publish information recognizing the variety of wiring methods and the varying effects of magnetic fields on circuits. Manufacturers' handbooks can be referenced for this information.

## Figure 8-2
## Maximum allowable voltage drop in a circuit




## Table 8-1
## Method to determine the maximum insulated conductor length using Table D3 for low-voltage circuits, taking into account voltage drop

Formula

$L = L_t \times P \times DCF \times (V / 120)$

where

$L$ = the distance to the centre of distribution in metres given in Table D3 for 1% voltage drop at 120 V

$L_t$ = the maximum distance to the centre of distribution in metres

$P$ = the voltage drop percent required in the circuit

$DCF$ = the distance correction factor given in Note 3) to Table D3

$V$ = the voltage required by the load

| Step | Method |
|---|---|
| 1 | Determine the calculated load in amperes that the circuit conductor is intended to carry. |
| 2 | Determine the ampacity Table to be used. See Subrules 1), 2), 9), 10), 11), 12), and 13) of Rule 4-004. |
| 3 | Determine the insulation temperature column to use in the Table. See Method in Rule 4-006. |
| 4 | Using the appropriate Rules of the Code, determine the insulated conductor size and ampacity without taking voltage drop into consideration. |
| 5 | Using Table D3, determine the distance ($L_t$) at 1% and 120 V by using the calculated load amperes (Step 1) and the conductor size (Step 2). |
| 6 | Determine the voltage drop percent ($P$) on the circuit. |
| 7 | Determine the distance correction factor ($DCF$):<br>• calculate the % of allowable ampacity according to the following formula:<br>[load amperes (value from Step 1) /conductor amperes (value from Step 2)] × 100%; and<br>• using the conductor's insulation temperature rating and the % allowable ampacity, determine the distance correction factor from Note 3) in Table D3. |

*(Continued)*

## Table 8-1 (Concluded)

| Step | Method |
|---|---|
| 8 | Determine the voltage required by the load (*V*). |
| 9 | Calculate the maximum distance to the centre of distribution in metres by substituting the values from Steps 3 to 6 in the formula above and completing the calculations. |

## Table 8-2
## Method to determine the maximum insulated conductor length using Table D4 for extra-low-voltage circuits, taking into account voltage drop

Formula

$L = (V / 6) \times (P / 5) \times (I_t / I) \times L_t$

where

$L$ = the maximum distance to the centre of distribution in metres

$V$ = the voltage required by the load

$P$ = the voltage drop percent required in the circuit

$I_t$ = the amperes closest to calculated load amperes in Table D4 for a 5% voltage drop at 6 V

$I$ = the calculated load in amperes

$L_t$ = the distance to the centre of distribution in metres given in Table D4 for 5% voltage drop at 6 V

| Step | Method |
|---|---|
| 1 | Determine the calculated load in amperes ($I$) that the circuit conductor is intended to carry. |
| 2 | Using the appropriate Rules of the Code, determine the insulated conductor size without taking voltage drop into consideration. |
| 3 | Determine from Table D4 the amperes ($I_t$) closest to the calculated load amperes. |
| 4 | Using Table D4, determine the distance ($L_t$) at 5% and 6 V by using the conductor size (Step 2) and the amperes determined in Step 3. |
| 5 | Determine the voltage drop percent ($P$) on the circuit. |
| 6 | Determine the circuit voltage ($V$). |
| 7 | Calculate the maximum distance to the centre of distribution in metres by substituting the values from Steps 1, 3, 4, 5, and 6 in the formula above and completing the calculations. |

### Rule 8-104 Maximum circuit loading

A common method is necessary to determine the ampere rating of a consumer's services, feeders, and branch circuit. Some circuits have a conductor with an ampacity rating in excess of the overcurrent device rating or setting (according to the voltage drop requirements), and other circuits have an overcurrent device setting in excess of the conductor ampacity rating (for example, to prevent starting surges in motor circuits or in capacitor circuits from tripping the overcurrent device).

Subrule 1) defines the ampere rating of the circuit (branch circuit, feeder, or consumer's service) and requires that the value of the circuit conductor ampacity or of the ampere rating of overcurrent device protecting the circuit, whichever is smaller, be used to determine the minimum ampere rating of the consumer's service, feeder, or branch circuit. The ampere rating of the consumer's service, feeder, or branch circuit is the smallest rating in amperes allowed for the circuit conductor, the circuit overcurrent device, or the circuit equipment.

Subrule 2) establishes this fundamental relationship between a calculated load and ampere rating of the circuit, and mandates that the minimum ampacity of the conductor or the rating of the overcurrent device be not less than the calculated load. Once the calculated load is determined, the minimum ampacity of the conductor, or the maximum ampere rating of the overcurrent device, can be established, subject to the requirements of Subrules 3) to 6).

This fundamental relationship is based on the fact that when fusible switches and circuit breakers are exposed to loads at 80% or more of their ampere rating for long periods of time, a significant buildup of heat can occur inside their enclosure. This heat buildup is caused by:

- the lack of ventilation in the enclosure;
- the current-carrying components in the enclosure;
- the terminations;
- the connections to the overcurrent devices (fuse clips); and
- the thermal current-sensing elements (providing protection against excessive current) of the overcurrent devices.

This heat buildup can:

- reduce the life expectancy of the electrical equipment by causing insulation breakdown;
- cause nuisance tripping in the case of heat-sensitive overcurrent devices;
- cause component and termination failure; and
- lead to arcing or create a fire hazard.

Subrule 3) provides parameters for determining under what conditions the calculated load connected to equipment containing overcurrent devices can cause a damaging heat buildup. Subrule 3) uses the terms "continuous loads" (loads that can cause damaging heat buildup in the enclosure) and "non-continuous loads" (loads that are not likely to cause damaging heat buildup in the enclosure due to the nature of the non-continuous loads' connection to the equipment). Subrule 3) requires that all calculated loads be considered continuous, unless they can be proven otherwise by the designer or installer. It is the designer's or installer's responsibility to demonstrate to the AHJ that the load classification could be considered non-continuous in accordance with Subrule 3). See Table 8-3. It is interesting to note that loads of a single dwelling or a dwelling unit in an apartment building are automatically considered by the Code to be non-continuous [see Subrule 3) of Rule 8-200 and Subrule 2) of Rule 8-202]. Specific Rules of the Code state that, regardless of conditions listed in Subrule 3), some loads are required to be continuous [for example, data processing loads according to Subrule 2) of Rule 8-302 and electric vehicle supply equipment loads according to Rule 86-302].

**Table 8-3**
**Method to determine if a calculated load is continuous or non-continuous**

| Size of load, A | Total time period | Total time ON | Continuous load | Non-continuous load |
|---|---|---|---|---|
| 225 A or less | 2 h | Over 1 h | Yes | — |
| 225 A or less | 2 h | 1 h or less | — | Yes |
| Over 225 A | 6 h | Over 3 h | Yes | — |
| Over 225 A | 6 h | 3 h or less | — | Yes |

**Note:** *Subrule 3) of Rule 8-200 and Subrule 2) of Rule 8-202 advise that the type of electrical installations used in dwelling units is not considered continuous for the application of Rule 8-104, regardless of the size.*

A load that remains on for a long time and is then switched off is to be regarded as a continuous load. Subrule 4) requires that a load that is thermostatically controlled or frequently goes through cycles also be considered a continuous load. However, Subrule 4) clarifies that a load of a cyclic or intermittent nature is allowed to be classified as non-continuous when it can be proven so by the designer or installer.

A lighting system in a department store or office falls under the continuous designation, as does a commercial water heater, since during normal use it is on for more than 50% of the time. In calculating a service or feeder, it might be necessary to separate the continuous loads from the non-continuous loads to avoid unnecessary oversizing of electrical equipment. Subrule 2) of Rule 8-202 helps Code users to clarify that the load of a dwelling unit in an apartment building is considered a non-continuous load; however, the house load (i.e., equipment located outside the dwelling units) is considered a continuous load, and it is to be calculated with the applicable demand factors.

When an overcurrent device is located in an assembly such as a fused switch or a panelboard, the assembly is required to be marked for continuous operation of its overcurrent devices in accordance with the requirements of CAN/CSA-C22.2 No. 4 or CSA C22.2 No. 29. Certification tests are used to determine the amount of heat buildup in an enclosure. Depending on the temperature inside the enclosure at the end of the test, the assembly is then marked for continuous operation at either 80% or 100% of its overcurrent devices.

The Appendix B Note to Rule 8-104 advises that fusible switches and circuit breakers not marked as suitable for continuous operation at either 80% or 100% of the rating of their overcurrent devices are to be considered suitable for continuous operation at 80% of the rating of their overcurrent devices.

Subrule 5) requires that the maximum continuous calculated load (as determined from the calculated load) supplied by the circuits connected to fusible switches or circuit breakers when marked for continuous operation at 100% not exceed:

- the continuous operation marking on the fused switch or circuit breaker;
- 100% of the allowable ampacities of conductors selected in accordance with Section 4; and
- 85% ofthe allowable single conductor ampacities selected in accordance with Section 4.

### Examples for Subrule 5) of Rule 8-104 — Continuous loads on 100% continuous rated fusible switches

1) A 1000 A fusible switch is marked for continuous operation at 100% of the rating of its overcurrent devices. What size of continuous load can this switch supply if the conductors are intended to be run in a raceway?

**Answer:**

This fusible switch can supply a 1000 A continuous load if:
- the conductors have an insulation temperature rating of 60 °C, 75 °C, or 90 °C; and
- the ampere rating of the conductors is 1000 A as determined from Table 2 or 4 (raceways).

2) A 1000 A fusible switch is marked for continuous operation at 100% of the rating of its overcurrent devices. What size of continuous load can this switch supply if the conductors are intended to be run in free air?

**Answer:**

This fusible switch can supply a (1000 × 85%) = 850 A continuous load if:
- the conductors have an insulation temperature rating 60 °C, 75 °C, or 90 °C; and
- the ampere rating ofthe conductors is 1000 A as determined from Table 1 or 3 (free air).

**Note:** *The derating in Item b) of Subrule 5) of Rule 8-104 applies to the complete circuit. This means that the conductors supplying this 850 A continuous load should be rated at 1000 A in accordance with Table 1 or 3.*

Subrule 6) requires that the maximum continuous calculated load (as determined from the calculated load) supplied by the circuits connected to fusible switches or circuit breakers when marked for continuous operation at 80% or unmarked not exceed:

- the continuous operation marking on the fused switch or circuit breaker;
- 80% of the allowable ampacities of conductors selected in accordance with Section 4; and
- 70% of the allowable single conductor ampacities selected in accordance with Section 4.

Subrules 5) and 6) do not apply if the calculated load is not considered to be continuous and is allowed to be loaded to its rating, regardless of the wiring method used.

When a fusible switch or circuit breaker is intended to supply both continuous and non-continuous calculated loads, the total calculated load to be placed on the overcurrent devices is determined by adding together the continuous calculated loads with the demand factors from Subrules 5) or 6) and the non-continuous calculated loads.

**Examples for Subrule 6) of Rule 8-104 — Continuous loads and non-continuous loads on 80% continuous rated fusible switches**

1) A 1000 A fusible switch is marked for continuous operation at 80% of the rating of its overcurrent devices. What size of continuous load can this switch supply if the conductors are intended to be run in a raceway?

**Answer:**

This fusible switch can supply a 1000 A × 80% = 800 A continuous load if:
- the conductors have an insulation temperature rating of 60 °C, 75 °C, or 90 °C; and
- the ampere rating of the conductors is 1000 A as determined from Table 2 or 4 (raceways).

2) A 1000 A fusible switch is marked for continuous operation at 80% of the rating of its overcurrent devices. What size of continuous load can this switch supply if the conductors are intended to be run in free air?

**Answer:**

This fusible switch can supply a 1000 A × 70% = 700 A continuous load if:
- the conductors have an insulation temperature rating of 60 °C, 75 °C, or 90 °C; and
- the ampere rating of the conductors is 1000 A as determined from Table 1 or 3 (free air).

3) A 1000 A fusible switch is marked for continuous operation at 80% of the rating of its overcurrent devices. What size of non-continuous load can this switch supply?

**Answer:**

This fusible switch can supply a 1000 A non-continuous load.

4) A 1200 A fusible switch is rated for continuous operation at 80% of the rating of its overcurrent devices. The wiring method will be conductors in free air and the conductors will have a 75 °C insulation temperature rating. Will the fusible switch be able to supply a 500 A continuous load and a 480 A non-continuous load?

**Answer:**

| | | |
|---|---|---|
| Calculated continuous load | = 500 / 70% | = 714.3 A |
| Non-continuous load | | = 480 A |
| Combined total load | | = 1194.3 A |

A 1200 A fusible switch can supply the 1194 A combined load if the conductors have a 75 °C insulation temperature rating and an ampere rating of 1200 A as determined from Table 1 or 3.

When cablebus is connected to a fusible switch or circuit breaker supplying continuous calculated loads, Subrule 7) requires that the continuous calculated load requirements of Subrule 5) and 6) be applied.

### Rule 8-106 Use of demand factors

The Code is based on minimum requirements and is not intended to limit design. Services and feeders are to be adequately sized for the actual loads they carry and for the anticipated additional loads. Subrule 1) recognizes this fact for services other than those for single dwellings (as specified in

Rule 8-200) and apartment and similar buildings (as specified in Rule 8-202). Subrule 1) states that when the design of electrical installation is based on requirements in excess of those given in Section 8, the ampere rating of service and feeder is to meet the requirements of the actual load and additional designed load, regardless of Section 8 requirements.

This Rule also allows the use of a demand load less than 100% for all the connected loads when
- loads are controlled to prevent the total load from operating at one time;
- environmental systems such as electric space heating and air conditioning are installed; or
- the loads operate at the same time but are cyclic and do not create a demand equal to the total connected load [see Subrules 3) and 4) of Rule 8-400, Subrule 3) of Rule 28-108, Rule 42-006, Rule 42-014, and Subrule 2) of Rule 72-102].

Subrule 2) requires that when multiple loads are connected so that only one can be used at a time (for example, by the use of controls that interlock the loads), the load providing the greatest demand be used to determine the calculated load. When electric space-heating and air-conditioning loads are installed, interlocks are not required, as buildings are not usually heated and cooled at the same time. In accordance with Subrule 3), when it is known that the heating and air-conditioning loads will not be used at the same time, the larger of the electric space-heating or air-conditioning load is used after any demand factors allowed by other Sections of the Code have been applied.

Subrule 4) is complex since it pertains to loads that are cyclic. Although these loads are physically connected so that it is possible to operate them at the same time, the operational characteristics of the system are such that this is not likely to happen in normal circumstances. In this situation, the ampacity of the feeder conductors is allowed to be based on the maximum load that might be connected at any one time (in recognition of what is called "the operational diversity of the system"). For example, in a custom machine shop or fabricating plant, many machines are connected, but usually only a few operate at one time. Since operation of the machines at the same time depends on the business cycle, any lessening of the load requirements requires careful discussion between the parties involved. In such cases, it is better to calculate loads based on the more stringent load requirements; otherwise, if the installed electrical infrastructure (switches and conductors) are too small for the load, an expensive change might be required.

Subrule 5) allows demonstrated loads (see definition in Rule 8-002), as determined by a qualified person, to be used to reduce the demand factors associated with process equipment and air-conditioning loads provided that a deviation has been allowed in accordance with the requirements in Rule 2-030.

Subrule 6) requires that when the Rules in the individual Sections supplement or amend those in the general Sections, they take precedence over those in the general Sections of the Code. For example, although Subrule 6) of Rule 8-104 requires that the continuous calculated load not exceed 80% of the rating of the overcurrent devices, other Sections might allow higher values (for example, Section 42 on welders or Section 62 on fixed resistance heating loads).

The application of demand factors to some loads can result in the conductors of a branch circuit being larger than the feeder conductors, or the conductors of a feeder being larger than the service conductors. Subrule 7) recognizes this fact (for example, in cases where the feeder supplies motor loads as well as other types of loads or where Table 14 is applied with other loads) and states that in such cases the ampacity of feeder conductors need not exceed that of the service conductors' ampacity, and the ampacity of the branch circuit conductors need not exceed the ampacity of the feeder conductors supplying such branch circuit.

When adding loads to an existing service or feeder, these additional loads are to be calculated in accordance with the requirements of Section 8. However, where it is impracticable to calculate the existing loads, accurate information on the existing (already installed) loads taken over the most recent

12-month period can be used to verify that the ampere rating of the existing feeder or service will be sufficient to accommodate newly added loads. For the purpose of calculating the new calculated load (existing plus additional), Subrule 8) requires the use of:

- the maximum demands of existing loads, measured over the most recent 12-month period; and
- any additional loads, calculated:
  - in accordance with this Section;
  - with demand factors allowed by other Sections of the Code.

The existing load figures are often available from the utility, or if the proposed addition is in the long-term planning stage, customers can install their own measuring equipment. The total new calculated load placed on the existing service or feeder is subject to the requirements of Subrules 5) and 6) of Rule 8-104.

Subrule 9) allows the use of demonstrated loads using historical maximum demand watt information to determine the minimum feeder and service load calculations, except for loads calculated using Rules 8-200 (single dwellings) and 8-202 (apartments and similar buildings), when these calculations are performed by a qualified person, as determined by the AHJ.

Battery technology has advanced dramatically with a 50% increase in energy density in the past 2 years and another 50% expected in 2018. This will create a tipping point in the adoption of electric vehicles that now are boasting ranges that compete directly with gas vehicles.

Municipalities, provinces, and territories are now drafting legislation to require electric vehicle infrastructures in new residential and some commercial construction that will survive for 50 to 100 years. Other countries have announced that they will start to ban gasoline vehicles as early as 2025. London taxis are all converting to electric. Without providing for the new load management technologies specific to electric vehicles, the impact on the grid at the building level would be overwhelming as it is possible to more than double peak loads from electric vehicle charging.

Electric vehicle energy management systems (EVEMS) do more than shed loads by switching. They use a specific protocol defined by SAE J1772 to vary the maximum load allowed to each electric vehicle supply equipment (EVSE). The load is determined by other EVSE charging, and other building loads and feeders that are monitored, including CTs or external communication from a utility at the building supply entrance.

Therefore, Subrule 10) requires that when electric vehicle supply equipment loads are controlled by an EVEMS, the demand load for the electric vehicle supply equipment be equal to the maximum load allowed by the EVEMS.

For the purposes of Item a) vi) of Subule 1) of Rules 8-200, Item d) of Subrule 3) of Rule 8-202, Item d) of Subrule 1) of Rule 8-204, Item d) of Subrule 1) of Rule 8-206, Item d) of Subrule 1) of Rule 8-208, and Item c) of Rule 8-210, where an EVEMS as described in Subrule 10) monitors the consumer's service and feeders, and controls the electric vehicle supply equipment loads in accordance with Rule 8-500, Subrule 11) allows that the demand load for the electric vehicle supply equipment not be considered in determining the calculated load.

### Rule 8-108 Number of branch circuit positions

Insufficient branch circuits can result in overloading of circuits, which might cause nuisance tripping, overheating, and subsequent failure of electrical equipment. The Code presents a minimum standard and where additional equipment is installed, adequate provision is to be made to supply it. Subrule 1) gives the requirements pertaining to the minimum number of spaces to accommodate 120 V branch circuit overcurrent devices in a panelboard installed in a single dwelling. Half of these spaces are to be able to be connected to double-pole overcurrent protection devices. The total number of spaces in the panelboard is based on the ampacity of the service or feeder conductors.

Table 8-4 outlines the minimum branch circuit overcurrent device spaces in a panelboard for common ampacities of single dwelling service or feeder sizes. Different requirements pertain if a central electric furnace is used.

**Table 8-4**
**Minimum number of branch circuit positions in a panelboard for a single dwelling**

| Ampacity of service or feeder | Provisions made for central furnace | Spaces for 120 V branch circuit overcurrent devices |
|---|---|---|
| 0–60 | No | 16 |
| 60–100 | No | 24 |
| 100–125 | Yes | 24 |
| 100–125 | No | 30 |
| 125–200 | Yes | 30 |
| 125–200 | No | 40 |

Subrule 2) requires that, regardless of branch circuit requirements in a single dwelling, the spaces for two 35 A double-pole overcurrent devices (for example, for an electric range and electric clothes dryer) be provided. Subrule 2) also requires space for all other overcurrent devices that are necessary and at least two additional spaces for future use. The Code makes no distinction between a house with a finished basement and one without. If the basement is finished, more branch circuit positions should be used. For example, in the case of a standard non-electrically heated single-storey house with a 24-circuit, 100 A combination service panelboard, where more than 22 circuits are required (leaving fewer than two spare spaces), the panelboard is to be replaced with a 30-circuit panelboard.

Subrule 3) recognizes the limited electrical equipment in apartments and similar residential buildings, and the reduced need for 120 V and 35 A double-pole overcurrent devices. No spare spaces are required since additions are not expected. The words “at least” in Subrule 3) are more significant than in Subrule 2), which presents all the options for a single dwelling. In a suite with an electric baseboard heater and individual washer, dryer, and water heating, the number of branch circuits required might exceed 12.

## Rule 8-110 Determination of areas

A consistent method is required for calculating the living area for single dwellings as required by Rule 8-200 and dwelling units in apartment and similar residential buildings as required by Rule 8-202. The living areas in single dwellings and dwelling units in apartment buildings are calculated as the total of the following areas:

- the area of the ground floor, based on the inside dimensions;
- any living areas above the ground floor, based on the inside dimensions; and
- if the building has an area below the ground, 75% of the this area, based on the inside dimensions.

See the Example for Rule 8-110.

### Example for Rule 8-110 — Determining living area in a single dwelling

A two-storey single dwelling having 200 mm thick walls is 10 m × 12 m and has a basement. To determine the total living area of the single dwelling:

**Step 1**

Area of the ground floor [10 – (2 × 0.200)] × [12 – (2 × 0.200)] = 111.36 m²

**Step 2**

Area above the ground floor [10 – (2 × 0.200)] × [12 – (2 × 0.200)] = 111.36 m²

**Step 3**

Area below the ground floor [10 – (2 × 0.200)] × [12 – (2 × 0.200)] × 75% = 83.52 m²

Total 306.24 m²

## Calculated load for services and feeders

### Rule 8-200 Single dwellings

Subrule 1) gives the requirements for determining the calculated load for the service or feeder for a single dwelling. The calculated load in watts for the service or feeder is determined by using the load calculated in Item a) of Subrule 1) or the load given for the living area in m² of the single dwelling not including the basement area, whichever is the greater of the two. See Method in Table 8-5.

**Note:** *When converting the calculated load to a minimum insulated conductor or cable size, see the additional information in Rule 4-004 on the use of Table 3.*

Item a) of Subrule 1) determines the calculated load in watts by using the Method outlined in Table 8-5.

**Table 8-5**
**Method to determine the calculated load for a single dwelling unit**

| Step | Rule number | Method |
|---|---|---|
| 1 | 8-110 | Calculate total living area of the single dwelling in m². |
| 2 | 8-200 1) a) i)<br>8-200 1) a) ii) | Calculate the total load of the living area as the sum of the following values:<br>• 5000 W for the first 90 m² or less of living area; and<br>• 1000 W for each 90 m² or portion thereof of the remaining living area. |
| 3 | 8-200 1) a) iii)<br>62-118 | Calculate the electric space-heating load using the demand factors from Rule 62-118, as follows:<br>• For other than electric thermal storage heating systems, duct heaters, or electric furnaces, the demand factors are 100% for the first 10 kW, plus 75% for any amount over 10 kW.<br>• For electric thermal storage heating systems, duct heaters, or electric furnaces, the demand factor is 100% of the load. |
| 4 | 8-200 1) a) iii) | Calculate the air-conditioning load at a 100% demand factor. |
| 5 | 8-200 1) a) iii)<br>8-106 3) | Determine the larger of the electric space-heating load from Step 3 or the air-conditioning load from Step 4. |

*(Continued)*

## Table 8-5 (Concluded)

| Step | Rule number | Method |
|---|---|---|
| 6 | 8-200 1) a) iv) | Calculate the load required for an electric range (stove) by using 6000 W for ranges up to 12 kW, plus 40% of any amount over 12 kW.<br>**Note:** *Where an additional electric range (stove) is provided after the initial one, the calculated load for each additional electric range is to be determined using the requirements in Step 9 (see Appendix B Note to Rule 8-200).* |
| 7 | 8-200 1) a) v) | Calculate the load required for any electric tankless water heaters, water heaters for steamers, swimming pools, spas, or hot tubs at 100%. |
| 8 | 8-200 1) a) vi) | Calculate the total load for any electric vehicle supply equipment at a 100% demand factor, unless the EVSE is supplied from an electric vehicle energy management system [see Subrule 11) of Rule 8-106]. |
| 9 | 8-200 1) a) vii) | Calculate the total other additional loads in excess of 1500 W, as follows:<br>• where an electric range has been provided for in Step 6, use a demand factor of 25% of the total rating for the remaining additional loads in excess of 1500 W; or<br>• where an electric range has not been provided for in Step 6, determine the additional load to be added in Step 9 by adding together the total load in watts of all the remaining loads in excess of 1500 W and apply the following demand factors:<br>– 100% for the first 6000 W of the total additional combined loads in excess of 1500 W; and<br>– 25% for the additional combined loads in excess of 6000 W. |
| 10 | | Calculate the total calculated single dwelling load in watts by adding together the loads from Steps 2, 5, 6, 7, 8, and 9.<br>**Note:** *Subrule 3) of Rule 8-200 states that this load is non-continuous for the purpose of applying the requirements of Subrules 5) and 6) of Rule 8-104.* |
| 11 | | Determine the calculated load in watts for single dwelling's service or feeder by the following:<br>• if the maximum living area is less than 80 $m^2$ (see Step 1) and the calculated load from Step 10 is less the 14 400 W, the calculated load for the service or feeder is 14 400 W, but if the calculated load in watts in Step 10 is above 14 400 W, that higher load is to be used; or<br>• if the maximum living area is 80 $m^2$ or more (see Step 1) and the calculated load from Step 10 is less the 24 000 W, the calculated load for the service or feeder is 24 000 W, but if the calculated load in watts in Step 10 is above 24 000 W, that higher load is to be used. |

When two or more dwelling units of row housing are supplied from the single main service or feeder, demand factors are allowed to be applied to that main service or feeder in recognition of the operational diversity of the dwelling units of the row housing. Subrule 2) applies the same principles to the calculation of the calculated load of the service or feeder conductors supplying two or more dwelling units of row housing as Subrule 3) of Rule 8-202 does to the calculation of that supplying dwelling units in an apartment or similar building. See Method in Table 8-6.

**Note:** *When converting the calculated load to a minimum insulated conductor or cable size, see the additional information in Rule 4-004 on the use of Table 3.*

## Table 8-6
## Method to determine the calculated load for a service or feeder supply two or more dwelling units

| Step | Rule number | Method |
|---|---|---|
| 1 | 8-200 2) | Calculate minimum calculated load using the method in Table 8-5 for each different dwelling unit. |
| 2 | 8-200 2) | Subtract any electric space-heating and any air-conditioning loads from the calculated load for each of the dwelling units in Step 1. |
| 3 | 8-202 3) a) | Calculate the total calculated load of all the dwelling units (row houses) using the following demand factors:<br>• 100% of the largest dwelling unit load;<br>• 65% of the next two largest dwelling unit loads;<br>• 40% of the next two largest dwelling unit loads;<br>• 25% of the next 15 largest dwelling unit loads; and<br>• 10% of the remaining dwelling unit loads. |
| 4 | 8-202 3) b) | Calculate the total electric space-heating load from all the dwelling units using the demand factors from Rule 62-118. |
| 5 | 8-202 3) c) | Calculate the total air-conditioning load from all the dwelling units using a demand factor of 100%. |
| 6 | 8-200 1) a) iii)<br>8-106 3) | Determine the larger of the electric space-heating load from Step 3 or the air-conditioning load from Step 4. |
| 7 | 8-200 1) a) vi)<br>8-202 3) d) | Calculate the total load for any electric vehicle supply equipment not located in the dwelling units at a 100% demand factor, unless the EVSE is supplied from an electric vehicle energy management system [see Subrule 11) of Rule 8-106]. |
| 8 | 8-202 3) e) | Calculate any additional lighting loads (security walkway or parking lot), heating loads (in common areas), and power loads not located in the dwelling units using a demand factor of 75%. |
| 9 | | Calculate the total calculated load for the service or feeder by adding together the values from Steps 3, 6, 7, and 8. |

### Rule 8-202 Apartment and similar buildings

To obtain the calculated load for the service or feeder suppling loads in dwelling units from the main service, Subrule 1) requires that it be determined by using the greater of Item a) or b):

- the load determined using the demand factors and loads in Subrules 1) a) i) to 1 a) vii) B); or
- 60 A, when the calculated load determined in Item a) is less than 60 A.

**Note:** *The calculated load for a dwelling unit in an apartment or similar building is 60 A.*

See Method in Table 8-7.

## Table 8-7
## Method to determine the calculated load for service or feeder conductor supplying dwelling units in an apartment or similar building

| Step | Rule number | Method |
|---|---|---|
| 1 | 8-110 | Calculate total living area of the single dwelling in m² |
| 2 | 8-202 1) a) i), ii), and iii) | Calculate the total basic load of the living area as the sum of the following values:<br>• 3500 W for the first 45 m² or less of living area;<br>• 1500 W for next 45 m² or portion thereof of the remaining living area; and<br>• 1000 W for each additional 90 m² or portion after the first 90 m² above has been used |
| 3 | 8-202 1) a) iv)<br>62-118 | Calculate the electric space-heating load using the demand factors from Rule 62-118, as follows:<br>• for other than electric thermal storage heating systems, duct heaters, or electric furnaces, the demand factors are 100% for the first 10 kW, plus 75% for any amount over 10 kW; or<br>• for electric thermal storage heating systems, duct heaters, or electric furnaces, the demand factor is 100% of the load. |
| 4 | 8-202 1) a) iv) | Calculate the air-conditioning load at a 100% demand factor. |
| 5 | 8-202 1) a) iv)<br>8-106 3) | Determine the larger of the electric space-heating load from Step 3 or the air-conditioning load from Step 4. |
| 6 | 8-202 1) a) v) | Calculate the load required for an electric range (stove) by using 6000 W for ranges up to 12 kW, plus 40% of any amount over 12 kW.<br>**Note:** *Where an additional electric range (stove) is provided after the initial one, the calculated load for each additional electric range is to be determined using the requirements in Step 9 (see Appendix B Note to Rule 8-200).* |
| 7 | 8-202 1) a) vi) | Calculate the load required for any electric tankless water heaters, or water heaters for steamers, swimming pools, spas, or hot tubs at 100% demand factor. |
| 8 | 8-202 1) a) vii) | Calculate the total other additional loads in excess of 1500 W, as follows:<br>• where an electric range has been provided for in Step 6, use a demand factor of 25% of the total rating for the remaining additional loads in excess of 1500 W; or<br>• where an electric range has not been provided for in Step 6, determine the additional load to be added in Step 9 by adding together the total load in watts of all the remaining loads in excess of 1500 W and apply the following demand factors:<br>– 25% of the total rating for the remaining additional loads in excess of 1500 W plus 6000 W. |

*(Continued)*

## Table 8-7 (Concluded)

| Step | Rule number | Method |
|---|---|---|
| 9 | | Calculate the total calculated single dwelling load in watts by adding together the loads from Steps 2, 5, 6, 7, and 8.<br>**Note:** *Subrule 3) of Rule 8-200 states that this load is non-continuous for the purpose of applying the requirements of Subrules 5) and 6) of Rule 8-104.* |
| 10 | | Determine the calculated load in watts for service or feeder conductors supplying two or more dwelling units in an apartment or similar building as follows:<br>• not less than the calculated load from Step 10; or<br>• 60 A if the calculated load from Step 10 is less than 60 A. |

For the purposes of Rule 8-104, Subrule 2) allows the loads in the dwelling units calculated in accordance with Subrule 1) not to be considered continuous; consequently, the requirements of Subrules 5) or 6) of Rule 8-104 are not applicable.

Subrule 3) specifies the demand factors for calculating the calculated load for service or feeder conductors from the main service in an apartment building or similar residential buildings when there is a minimum of two dwelling unit loads connected on the conductors. Subrule 3) uses loads inside as well as loads outside the dwelling when supplied by the service or feeder conductors to calculate the calculated load. Subrule 2) requires that the total loads outside the dwelling units (for example, house loads) be considered as continuous loads for the purpose of Subrules 5) and 6) of Rule 8-104. Item d) of Subrule 3) of Rule 8-202 outlines the required demand factors that are to be applied to loads outside the dwelling units.

Subrule 4) is used when the service or feeder conductors feed only loads located outside the dwelling units (for example, hallway and outside lighting loads, laundry room loads, mechanical room loads, elevator loads). Subrule 4) requires that, after any demand factors allowed by the Code are applied, feeders supplying these loads outside dwelling units (or house loads) not be less than the rating of the equipment installed.

**Note:** *These loads outside the dwelling units are always considered to be continuous, unless it can be shown through their off/on times that they are non-continuous.*

See the Method in Table 8-8.

## Table 8-8
## Method to determine the calculated load for a service or feeder supplying two or more dwelling units in an apartment or similar building

| Step | Rule number | Method |
|---|---|---|
| 1 | 8-202 1) | Calculate load using the method in Table 8-7 for each different dwelling unit. |
| 2 | 8-202 1) | Subtract any electric space heating and any air-conditioning loads from the calculated load for each of the dwelling units in Step 1. |
| 3 | 8-202 3) a) | Calculate the total calculated load of all the dwelling units (row houses) using the following demand factors:<br>• 100% of the largest dwelling unit load; |

*(Continued)*

### Table 8-8 (Concluded)

| Step | Rule number | Method |
| --- | --- | --- |
| | | • 65% of the next two largest dwelling unit loads;<br>• 40% of the next two largest dwelling unit loads;<br>• 25% of the next 15 largest dwelling unit loads; and<br>• 10% of the remaining dwelling unit loads. |
| 4 | 8-202 3) b) | Calculate the total electric space-heating load from all the dwelling units using the demand factors from Rule 62-118. |
| 5 | 8-202 3) c) | Calculate the total air-conditioning load from all the dwelling units using a demand factor of 100%. |
| 6 | 8-202 3) c)<br>8-106 3) | Determine the larger of the electric space-heating load from Step 3 or the air-conditioning load from Step 4. |
| 7 | 8-202 3) d)<br>8-106 11) | Calculate the total load for any electric vehicle supply equipment not located in the dwelling units at a 100% demand factor, unless the EVSE is supplied by an electric vehicle energy management system [see Subrule 11) of Rule 8-106]. |
| 8 | 8-202 3) e) | Calculate any additional lighting loads (security walkway or parking lot), heating loads (in common areas), and power loads not located in the dwelling units using a demand factor of 75%. |
| 9 | | Calculate the total calculated load for the service or feeder by adding together the values from Steps 3, 6, 7, and 8. |

**Rule 8-204 Schools**
Subrule 1) describes the method to determine the calculated load for a service or feeder for a school, while Subrule 2) lists the allowable demand factors to be applied to the loads calculated in Subrule 1). See Method in Table 8-9.

### Table 8-9
### Method to determine the calculated load for a service or feeder supplying a school

| Step | Rule number | Method |
| --- | --- | --- |
| 1 | 8-204 1) | Determine the total area of the school in $m^2$. |
| 2 | 8-204 1) | Determine the total classroom area in the school in $m^2$. |
| 3 | 8-204 1) a) | Calculate the basic load in watts for the classroom area by multiplying the total classroom area in $m^2$ by 50 $W/m^2$. |
| 4 | 8-204 1) b) | Calculate the load of the remaining area of the school by multiplying the remaining area in $m^2$ by 10 $W/m^2$. |
| 5 | 8-204 1) c) | Calculate the total load in watts by adding the electric space-heating, air-conditioning, and total loads of other permanently connected equipment based on the rating of the equipment installed.<br>**Note:** *EVSE loads use demand factors from Table 38 unless not required to be included as given in Subrule 11) of Rule 8-106.* |

*(Continued)*

## Table 8-9 (Concluded)

| Step | Rule number | Method |
|---|---|---|
| 6 | 8-204 1) e) | Calculate the total load in watts for cord-connected equipment intended for connection to receptacles rated more than 125 V or 20 A based on:<br>• 80% of the rating of the receptacle; or<br>• the rating of the equipment intended for connection to the receptacle. |
| 7 | | Calculate the total building load by adding Steps 3, 4, 5 and 6. |
| 8 | | Subtract any electric space-heating loads from the total building load calculated in Step 7. |
| 9 | 8-204 2) a) | Determine the total calculated load for a school with an area up to and including 900 m² based on the outside dimensions by adding:<br>• the electric space-heating loads, using the demand factors from Section 62; and<br>• the remaining loads using a 75% (0.75) demand factor. |
| 10 | 8-204 2) b) | Determine the total calculated load for a school with an area over 900 m² based on the outside dimensions by adding:<br>• the electric space-heating loads, using the demand factors from Section 62; and<br>• after calculating the load per square metre rating by dividing the balance of the total building load less the electric space-heating loads (see Step 7) by the total area of the school (see Step 1):<br>– 75% of the load per square metre multiplied by 900 for the first 900 m² of total school area; and<br>– 50% of the load per square metre multiplied by the total area of the school in excess of 900 m². |
| 11 | 8-104 3) | Determine which loads are continuous and which loads are non-continuous. |
| 12 | 8-104 5) or 6) | Determine the correction factor from Subrule 5) or 6) for the continuous load from Step 11, depending on the rating of the equipment used and the Tables used to determine the ampacity of the conductors, and add this value to the total non-continuous load. |
| 13 | | Calculate the total calculated load for the service or feeder by using the value from Step 12. |

### Rule 8-206 Hospitals

Subrule 1) specifies the method of calculating the calculated load for a service or feeder conductors for a hospital, while Subrule 2) lists the demand factors that should be applied to the loads calculated in Subrule 1). See Method in Table 8-10.

## Table 8-10
## Method to determine the calculated load for the service or feeders supplying a hospital

| Step | Rule number | Method |
|---|---|---|
| 1 | 8-206 1) | Determine the total area of the hospital in m² based on the outside dimensions. |
| 2 | 8-206 1) | Determine the total area of the hospital in m² for high-intensity areas such as operating rooms. |
| 3 | 8-206 1) a) | Calculate the basic load of the hospital in watts by multiplying the total hospital area in m² by 20 W/m². |
| 4 | 8-206 1) b) | Calculate the load of the high-intensity areas in the hospital by multiplying the total high-intensity areas in m² by 100 W/m². |
| 5 | 8-206 1) c) | Calculate the total load in watts by adding the electric space-heating, air-conditioning, and total loads of other permanently connected equipment based on the rating of the electrical equipment installed.<br>When calculating the load for motors being placed on a feeder, follow Subrule 1) of Rule 28-110.<br>**Note:** *EVSE loads use demand factors from Table 38 unless not required to be included as given in Subrule 11) of Rule 8-106.* |
| 6 | 8-206 1) e) | Calculate the total load in watts for cord-connected equipment intended for connection to receptacles rated more than 125 V or 20 A based on:<br>• 80% of the rating of the receptacle; or<br>• the rating of the equipment intended for connection to the receptacle. |
| 7 | | Calculate the total building load by adding Steps 3, 4, 5 and 6. |
| 8 | | Subtract any electric space-heating loads from the total building load calculated in Step 6. |
| 9 | 8-206 2) a) | To determine the total calculated load for a hospital with an area up to and including 900 m² based on the outside dimensions, calculate:<br>• the electric space-heating loads using the demand factors from Section 62; and<br>• the remaining loads using a 80% (0.80) demand factor. |
| 10 | 8-206 2) b) | To determine the total calculated load for a hospital with an area over 900 m² based on the outside dimensions, calculate:<br>• the electric space-heating loads using the demand factors from Section 62; and<br>• after calculating the load per square metre rating by dividing the balance of the total building load less the electric space-heating loads (see Step 8) by the total area of the hospital (see Step 1):<br>– the load for the first 900 m² of total hospital area in watts by taking 80% of the load per square metre multiplied by 900; and<br>– 65% of the load per square metre multiplied by the total area of the hospital in excess of 900 m². |
| 11 | | Calculate the calculated load from the loads in either Step 9 or 10. |
| 12 | 8-104 3) | Determine which loads are continuous and which loads are non-continuous. |

*(Continued)*

## Table 8-10 (Concluded)

| Step | Rule number | Method |
|---|---|---|
| 13 | 8-104 5) or 6) | Determine the total calculated load on the service/feeder equipment by applying the requirements from Subrule 5) or 6) of Rule 8-104 to the continuous load from Step 11 (depending on the rating of the equipment used and the Tables used to determine the rating of the service), and add this value to the total non-continuous load. |
| 14 | | Calculate the total calculated load for the service or feeder by using the value from Step 13. |

**Rule 8-208 Hotels, motels, dormitories, and buildings of similar occupancy**
Subrule 1) specifies the method to determine the calculated load for service or feeder conductors for hotels, motels, dormitories, or buildings of similar occupancy. See Method in Table 8-11.

## Table 8-11
## Method to determine the calculated load for a service or feeder supplying a hotel or a building of similar occupancy

| Step | Rule number | Method |
|---|---|---|
| 1 | 8-208 1) | Determine the total area of the hotel, motel, dormitory, or similar occupancy in m² based on the outside dimensions. |
| 2 | 8-208 1) a) | Calculate the basic load in watts of the building by multiplying the total building area in m² by 20 W/m². |
| 3 | 8-208 1) b) | Calculate the total lighting load in watts for special areas such as ballrooms, based on the rating of the electrical equipment installed. |
| 4 | 8-208 1) c) | Calculate the total load in watts by adding the electric space-heating, air-conditioning, total loads of other permanently connected equipment based on the rating of the electrical equipment installed.<br>When calculating the load for motors being placed on a feeder, follow Subrule 1) of Rule 28-110.<br>**Note:** *EVSE loads use demand factors from Table 38 unless not required to be included as given in Subrule 11) of Rule 8-106.* |
| 5 | 8-208 1) e) | Calculate the total load in watts for cord-connected equipment intended for connection to receptacles rated more than 125 V or 20 A based on:<br>• 80% of the rating of the receptacle; or<br>• the rating of the equipment intended for connection to the receptacle. |
| 6 | | Calculate the total building load by adding Steps 2, 3, 4 and 5. |
| 7 | | Subtract any electric space-heating loads from the total building load calculated in Step 5. |
| 8 | 8-208 2) a) | To determine the total calculated load for a hotel with an area up to and including 900 m² based on the outside dimensions, calculate:<br>• the electric space-heating loads using the demand factors from Section 62; and<br>• the remaining loads using a 80% (0.80) demand factor. |

*(Continued)*

## Table 8-11 (Concluded)

| Step | Rule number | Method |
|---|---|---|
| 9 | 8-208 2) b) | To determine the total calculated load for a hotel with an area over 900 m² based on the outside dimensions, calculate:<br>• the electric space-heating loads using the demand factors from Section 62; and<br>• after dividing the balance of the total building load less the electric space-heating loads (see Step 7) by the total area (see Step 1) to determine the load per square metre:<br>– 80% of the load per square metre multiplied by 900 for the first 900 m²; and<br>– 65% of the load per square metre multiplied by the total area in excess of 900 m². |
| 10 | | Calculate the calculated load from the loads in either Step 8 or 9. |
| 11 | 8-104 3) | Determine which loads are continuous and which loads are non-continuous. |
| 12 | 8-104 5) or 6) | Determine the total load on the service/feeder equipment, by applying the correction factors from Subrule 5) or 6) of Rule 8-104 to the continuous load from Step 10 (depending on the rating of the equipment used and the Tables used to determine the ampacity of the conductors) and add this value to the total non-continuous load. |
| 13 | | Calculate the total calculated load for the service or feeder by using the value from Step 12. |

### Rule 8-210 Other types of occupancy

Rule 8-210 provides the basic requirements for determining the calculated load for service or feeder conductors supplying building occupancies other than those covered in Rules 8-200 to 8-208. To establish basic loads, Code users are to refer to Table 14, which extends the concept of watts per square metre and the application of various percentage demand factors in calculating loads for services and feeders in various types of building occupancies.

Loads such as electric space heating, air conditioning, power, and special lighting are handled separately as special loads, using their rated loads and applicable demand factors that are allowed by other Sections of the Code [for example, those for electric space heating (Section 62) and those for motor loads (Section 28)].

See Method in Table 8-12.

## Table 8-12
## Method to determine the minimum calculating load for a service or feeder supplying building occupancies other than those covered in Rules 8-200 to 8-208

| Step | Rule number | Method |
|---|---|---|
| 1 | 8-210 | Determine the total area in m² for each occupancy based on the outside dimensions. |
| 2 | 8-210 a) | Calculate the basic load in watts for the type of occupancy using the watts per square metre from Table 14 for the particular type of occupancy, multiplied by the area of the occupancy from Step 1. |

*(Continued)*

## Table 8-12 (Concluded)

| Step | Rule number | Method |
|---|---|---|
| 3 | 8-210 a) | Apply the demand factor from Table 14 to the basic load calculated in Step 2 for the service or feeder conductors. |
| 4 | 8-210 b) | Calculate the total special loads in watts, such as electric space heating, air-conditioning, motor loads, show window lighting, and stage lighting, based on the rating of the equipment installed, using any demand factors that are allowed by the Code.<br>**Note:** *EVSE loads use demand factors from Table 38 unless not required to be included as given in Subrule 11) of Rule 8-106.* |
| 5 | 8-210 a) and b) | Calculate the calculated load by adding together the loads in Steps 3 and 4. |
| 6 | 8-104 3) | Determine which loads are continuous and which loads are non-continuous. |
| 7 | 8-104 5) or 6) | Determine the total load on the service/feeder equipment by applying the correction factors from Subrule 5) or 6) of Rule 8-104 to the continuous load from Step 6 (depending on the rating of the equipment used and the Tables used to determine the ampacity of the conductors) and add this value to the total non-continuous load. |
| 8 | | Calculate the total calculated load for the service or feeder by using the value from Step 7. |

### Rule 8-212 Exit sign, emergency lighting, and show window loads

The method of calculating the load for feeders according to area is not always practical when the panel supplies specific types of lighting, such as lighting for exit signs, exit luminaires, or emergency lighting, that are not confined to one location within a building. Subrule 1) establishes an alternative method, using the connected load of the circuits instead of watts per square metre for calculating the loads that are supplied.

Subrule 2) sets out requirements for calculating the demands for show window lighting installations. The length of the window is measured along the base, and a value of 650 W/m is applied to establish a demand. Subrule 2) also allows lower demand to be used where special permission has been given in accordance with Rule 2-030.

## Branch circuits

### Rule 8-300 Branch circuits supplying electric ranges

Cooking loads vary in different establishments, and different criteria are required to establish adequate ampacity in branch circuits supplying electrical cooking equipment. Subrule 1) establishes principles for calculating the branch circuit ampacities for ranges in dwelling units that are similar to those previously encountered in Rules 8-200 and 8-202 for service and feeder demands. In Subrule 1), the demand applies only to the branch circuit conductors for a single range. Therefore the demand factors used differ from the demand factors used for feeders, as there are other loads connected to the feeder not just a single range. In Rule 8-200, the demand for a 12 kW range is 6 kW, as this demand is used in the calculation of ampacity of the service conductors for a dwelling. In Subrule 1), it is 8 kW, as this demand is intended to apply to the calculation of ampacity of branch circuit conductors for a single range. The calculation for ratings exceeding 12 kW is the same: 40% of the amount of the rating above 12 kW.

Subrule 2) allows two or more separate built-in cooking units to be considered as one range for determining the minimum ampacity of the branch circuit that supplies the separate units (for example, a countertop range and an oven). Branch circuit requirements for the individual units are covered in

Rule 26-742. For example, the minimum branch circuit conductor ampacity for a 6 kW cooktop and a 5 kW oven connected together on the same branch circuit is: 5 + 6 = 11 kW. The branch circuit ampacity is based on 8 kW [Subrule 1) of Rule 8-300] or 8000 / 240 = 33.3 A, when the voltage rating of both units is 240 V.

Subrule 3) specifies the requirements for electrical cooking equipment in other than residential occupancies to reflect the operational characteristics of this equipment. The demand for calculating the branch circuit ampacities in these occupancies is to be no less than the equipment's rating due to the likelihood that all equipment will be running at the same time.

Subrule 4) recognizes that cord-connected hot plates, rangettes, or other appliances should not exceed 1500 W and might be operated from a standard kitchen counter receptacle.

### Rule 8-302 Branch circuits supplying data processing equipment

To ensure the performance and reliability required for data processing equipment, Rule 8-302 requires that the total connected load of a branch circuit supplying one or more units of data processing equipment be considered a continuous calculated load for the application of Rule 8-104.

### Rule 8-304 Maximum number of outlets per circuit

In designing the electrical layout for any electrical installation, there is to be a limit on the number of outlets on a 2-wire branch circuit. Since the designer of the layout might not know the rating of loads connected to some outlets, an approximate rating for each outlet is needed to calculate the load on the 2-wire branch circuit, in order to avoid nuisance tripping of the branch circuit overcurrent device or unnecessary oversizing of the branch circuit conductors or cables.

An outlet is any point in an electrical wiring installation where current is taken to supply electrical utilization equipment such as luminaires, appliances, or other current-consuming electrical equipment. For the purposes of Rule 8-304, a receptacle as defined in Section 0 is considered one outlet.

When the load at each outlet cannot be determined during the design of a 2-wire branch circuit, Subrule 1) requires that the circuit contain no more than 12 outlets, except as allowed by other Rules [for example, Subrule 3)].

When the load cannot be determined during the design of the wiring layout, Subrule 2) allows an outlet to be rated at a minimum of 1 A. An exception to this rating is given in Subrule 3).

When the connected load at the outlet is known and is fixed due to the character of the outlet or intended use, Subrule 3) allows the number of outlets to exceed 12, provided that the total load does not exceed 80% of the overcurrent device's rating.

For fixed multi-outlet assemblies, Subrule 4) requires that each length of 1.5 m, or fraction of 1.5 m, be counted as one outlet in a branch circuit. When electrical appliances that are likely to be used simultaneously are connected to the assembly, Subrule 4) requires that each length of 300 mm, or fraction of 300 mm, be considered one outlet.

### Example 1

Determine the maximum number of 4 m multi-outlet assemblies installed on a 120 V, 15 A branch circuit:

1) Determine the number of outlets per multi-outlet assembly:
   Length of assembly / 1.5 m = 4 m / 1.5 m = 2.7 or 3 outlets
2) Calculate the number of assemblies per branch circuit:
   Maximum outlets per circuit / outlets per assembly = 12 / 3 = 4 assemblies per branch circuit

### Example 2

Determine the maximum number of 2 m multi-outlet assemblies used to supply electrical appliances on a 120 V, 15 A branch circuit:

1) Determine the number of outlets per multi-outlet assembly:
   Length of assembly / 300 mm = 2000 mm / 300 mm = 6.7 or 7 outlets
2) Calculate the number of assemblies per branch circuit:
   Maximum outlets per circuit / outlets per assembly = 12 / 7 = 1.7 or 1 assembly per branch circuit

## Heater receptacles for vehicles powered by flammable or combustible fuels

### Rule 8-400 Branch circuits and feeders supplying heater receptacles for vehicles powered by flammable or combustible fuels

In the colder areas of the country, outdoor parking lots are generally equipped with receptacles at each parking stall. These receptacles supply car engine block heaters, battery warmers, and sometimes in-car heaters (to keep the windows clear of frost and make the interior of the car more comfortable until the engine warms up). The demand set by such receptacles varies according to use.

Some receptacles are controlled by an automatic system that responds to the temperature and cycles the power to the receptacles. Another type of system, called controlled loading, supplies receptacles for 30 min every hour, provided that the temperature is below a pre-set value. If the temperature rises, no power goes to the receptacle. Some premises post notices prohibiting the use of in-car heaters since a restricted loading system is in effect. In this system, one 2-wire circuit supplies both halves of a duplex receptacle, so that use of an in-car heater can trip the overcurrent devices when another vehicle is sharing the receptacle.

Rule 8-400 gives the requirements for branch circuits and feeders supplying automobile heater receptacles in parking lots. Rule 8-400 does not apply, however, to one or two outdoor or garage receptacles associated with a single dwelling because they are covered by the basic demand for the single dwelling.

Subrule 2) requires a minimum of one 20 A branch circuit for each duplex receptacle used as automobile heater receptacle. This circuit can supply a single duplex receptacle or two single receptacles. This allows one duplex receptacle to be set in the middle of the two stalls.

Subrule 3) gives the loading requirements for each parking space or stall where the vehicle heating load is not restricted or controlled. Subrule 3) also requires that a separate branch circuit be provided for each parking space or stall and that the feeder or service conductors have their calculated load determined as shown in Table 8-13.

**Table 8-13**

| Number of vehicle spaces or stalls | Demand load per space or stall (W) — 15 A circuit | Demand load per space or stall (W) — 20 A circuit |
|---|---|---|
| First 30 | 1200 | 1800 |
| Next 30 | 1000 | 1500 |
| All over 60 | 800 | 1200 |

Subrule 4) gives the loading requirements for parking spaces or stalls in which the loading is restricted or controlled. The feeder or service conductors are to have their calculated load determined from Table 8-14.

**Table 8-14**

| Number of vehicle spaces or stalls | Demand load per space or stall (W) — 15 A circuit | Demand load per space or stall (W) — 20 A circuit |
|---|---|---|
| First 30 | 650 | 975 |
| Next 30 | 550 | 825 |
| All over 60 | 450 | 675 |

Subrule 5) covers parking lots such as those provided for employees, in trucking terminals, or in areas of cold climates that have a high occupancy and therefore require a higher demand load to be applied.

## Electric vehicle energy management systems

### Rule 8-500 Electric vehicle energy management systems

Electric vehicle energy management systems are important due to the increasing requirements for an EVSE infrastructure in local building codes and bylaws and in local zoning bylaws. These requirements have placed significant increases on the electrical distribution systems, such as increases in:

- construction cost;
- distribution size; and
- logistical operational concerns of the industry.

To devise a practical means of reducing calculated loads in services and feeders, Rule 8-500 allows an electric vehicle energy management system to monitor the consumer's service and/or feeders, and control the electric vehicle supply equipment loads [see Subrule 1) of Rule 8-500].

All of the Rules in the 8-200 series now contain two options for demand factors when calculating the calculated load for EVSE equipment:

- basing demand factors on the new Table 38; or
- disregarding the EVSE load when the electric vehicle energy management system controls the electric vehicle supply equipment loads.

The requirements of Rule 8-500 are now directly associated with EV-dedicated demand factors in Subrules 10) and 11) of Rule 8-106.

To meet the industry objectives and requirements of reducing the calculated loads on services and feeders with EVSE loads, Subrule 1) allows electric vehicle energy management systems to monitor electrical loads and to control electrical power going to the electric vehicle supply equipment loads.

Subrule 2) requires that the electric vehicle energy management system not cause the load of a branch circuit, feeder, or service to exceed requirements of Subrule 5) or 6) of Rule 8-104.

Subrule 3) allows the electric vehicle energy management system to control electrical power through the use of a remote means such as a cellular or wireless gateway.

# Section 10 — Grounding and bonding

## Scope, object, and special terminology

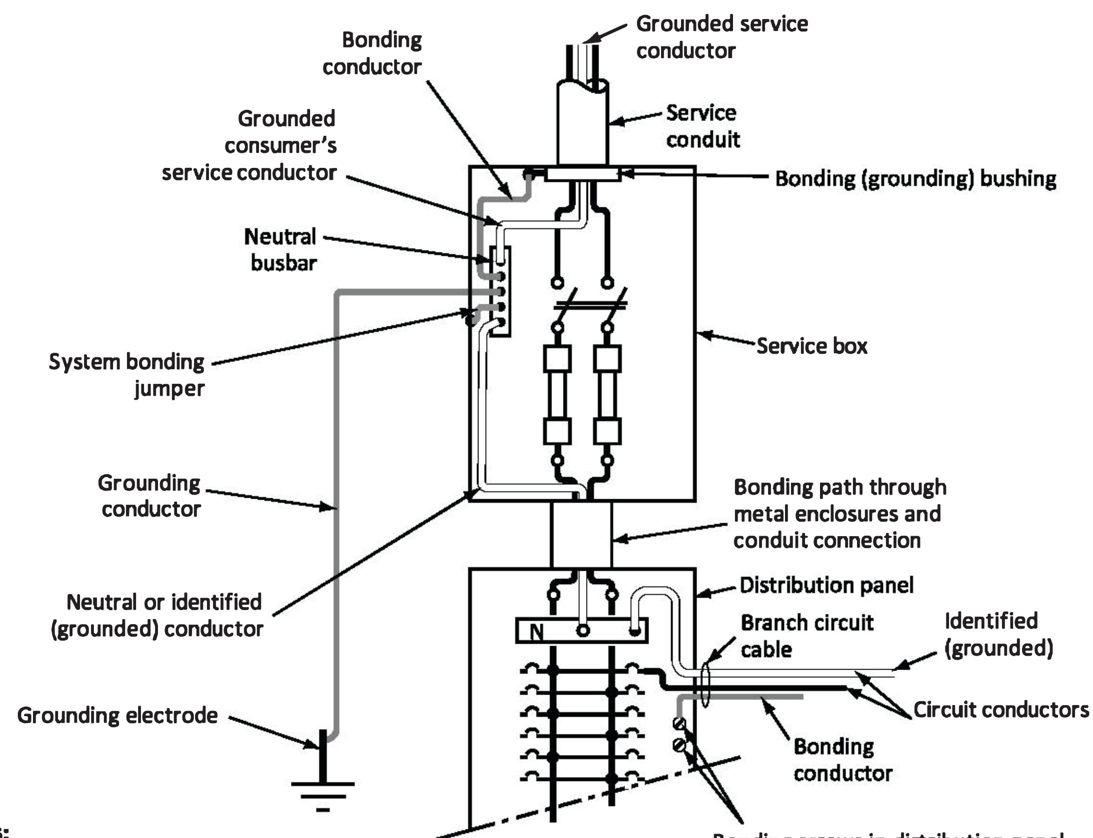
### Rule 10-000 Scope

Section 10 is a general Section of the Code that sets out requirements for grounding and bonding. These requirements apply to all installations, unless amended within a specific Section of the Code.

In Section 10 and throughout the Code, the terms "grounding" and "bonding" have distinct meanings (see Section 0, Definitions). Grounding refers to the provision of a metallic conducting path (grounding conductor) from the source (a solidly grounded or impedance grounded electrical system) or from the non-current-carrying metal enclosures (in the case of an ungrounded system) to a grounding electrode.

Bonding refers to the provision of a low-impedance metallic conductive path/connection between metallic non-current-carrying parts, with the intention that they all be maintained at the same potential to ground and to each other (equipotentiality). A bonding system is usually connected to a grounding conductor, in which case the system is said to be bonded to ground, and the potential difference of all bonded metal parts to earth is minimized (see Figure 10-1). Electrical systems can be solidly grounded, impedance grounded, or ungrounded (isolated). For isolated circuits and isolated systems in patient care areas, see Rules 24-200 to 24-208.

**Figure 10-1**
**Bonding and grounding conductors**




**Notes:**
1) *Metering equipment not shown.*
2) *See requirements in Section 10.*

## Rule 10-002 Object

The object of providing grounding of electrical systems and the bonding to ground of electrical equipment for an electrical installation is to protect people, equipment, and buildings by

- bonding metallic non-current-carrying parts of electrical equipment (and of non-electrical equipment, where warranted) together and to the grounded electrical system conductor to
  - provide a low-impedance path back to the source for fault currents, which ensures the operation of protective devices in the event of a fault or circuit failure and prevents potential arcing or overheating (and resultant property damage) caused by the fault current seeking a random path to source; and
  - establish an equipotential plane so that the possibility of voltage difference between metal parts (and resultant shock hazard) is minimized;
- grounding the solidly grounded electrical source/system (for dc systems, see Rules 10-200 to 10-204 and for ac systems, see Rules 10-206 to 10-210), which connects the electrical source/system to the earth to provide stable voltages under unbalanced load conditions by providing a reference to ground for the electrical source/system, thus safeguarding against undue voltage stress on the conductors' insulation;
- connecting bonded non-current-carrying metal parts of electrical equipment to the earth by the grounding conductor, which reduces the voltage potential between exposed metallic parts of electrical equipment and the earth under fault conditions; and
- using an ungrounded system (see Rules 10-400 and Rules 10-402) or using an impedance grounded system incorporating a neutral grounding device (see Rules 10-300 to 10-308) to provide an alternative to a solidly grounded system to limit the magnitude of fault current and the damage resulting from a single ground fault.

This can be accomplished by:

- solidly grounding an electrical system and bonding its associated equipment to establish a low-impedance connection between the grounded conductor and the non-current-carrying conductive parts of the system to stabilize system voltage;
- grounding an electrical system through an impedance to
  - limit the magnitude of ground fault currents;
  - minimize the damage to equipment resulting from a single ground fault; and
  - stabilize system voltage;
- an ungrounded system to
  - limit the magnitude of ground fault currents resulting from a single ground fault; and
  - minimize the damage to equipment on the occurrence of a single ground fault;
- bonding to interconnect the non-current-carrying conductive parts of electrical equipment and the system to a grounded point, where one exists, with sufficiently low impedance to
  - facilitate the operation of protective devices; and
  - establish equipotentiality.

**Note:** *The objective of equipotential bonding is to establish equipotentiality*

## Rule 10-004 Special terminology

Rule 10-004 gives definitions of specific terms used in Section 10. These terms should be reviewed prior to using this Section to fully understand the requirements and applications.

# Grounding

## Grounding — General

### Rule 10-100 Current over grounding conductors

A grounding system is to be designed and constructed so that it is permanent and continuous and:

- has a rating that can carry any current likely to be imposed on it;
- limits the voltage rise above ground (the ground potential rise) on exposed metal carrying fault current; and
- allows overcurrent devices to operate within their designed time to clear a fault of negligible impedance (short-circuit or ground fault) before damage to equipment or shock and fire hazards occur.

Any current caused by the failure of a system component or a breakdown in the insulation between an ungrounded conductor and ground should flow for only a very brief period, to minimize:

- shock and fire hazards;
- equipment damage;
- electrical disturbances; and
- the propagation of faults.

Rule 10-100 requires that there be no objectionable current flows through the grounding conductors during the normal operation of the electrical system. If current were to flow in the grounding system during normal operation, voltage differences between points in the system (ground loops) might occur, resulting in shock hazards, electrical disturbances, and even overheating of the grounding conductors.

Through the use of multiple grounds on a system (for example, grounding at the transformer and again in the service equipment), a situation might arise where an unbalanced neutral return current flows in the grounding conductor. Any neutral current on the grounding conductor is considered objectionable. Another situation that might cause an objectionable current flow in the grounding conductor is when an accidental loosening or disconnection of the neutral conductor occurs at a grounded main service on the line side of the system grounding connection.

Neutral currents flowing in grounding conductors are considered objectionable currents, and corrective action to stop the flow of neutral return current is required. Corrective actions include:

- abandoning one or more of the grounds on the neutral conductor;
- changing the location of the grounding connections;
- interrupting the continuity of the grounding conductor between the grounding connections; or
- other effective action taken to limit the current.

Currents in the grounding conductor that are not considered objectionable are those that can occur under normal operation, such as the temporary current resulting from a ground fault or the induced current from adjacent single conductors. See Figures 10-4 and 10-5.

### Rule 10-102 Grounding electrodes

All parts of the grounding and bonding system can be controlled by careful design and material selection, except for the system's actual connection to the earth. The quality and reliability of this connection depends on variable factors such as:

- the resistance of the earth on which the building stands;
- the moisture content of that earth; and
- the grounding electrode or electrodes that are placed in the earth.

For this reason installers are to determine the best possible electrode system that is consistent with the requirements of a given electrical installation.

A high-voltage system can deliver considerable current through the ground path and, in so doing, raise the voltage of the earth to a level dangerous to people standing on the ground in the vicinity of the fault. For such systems, a much more complicated grounding electrode system is required in order to limit the ground potential rise (see Rules 36-300 to 36-312).

A grounding electrode is a buried metal water piping system or a metal object or device buried in, or driven into, the ground that makes intimate contact with the earth; a grounding conductor is then electrically and mechanically connected to it.

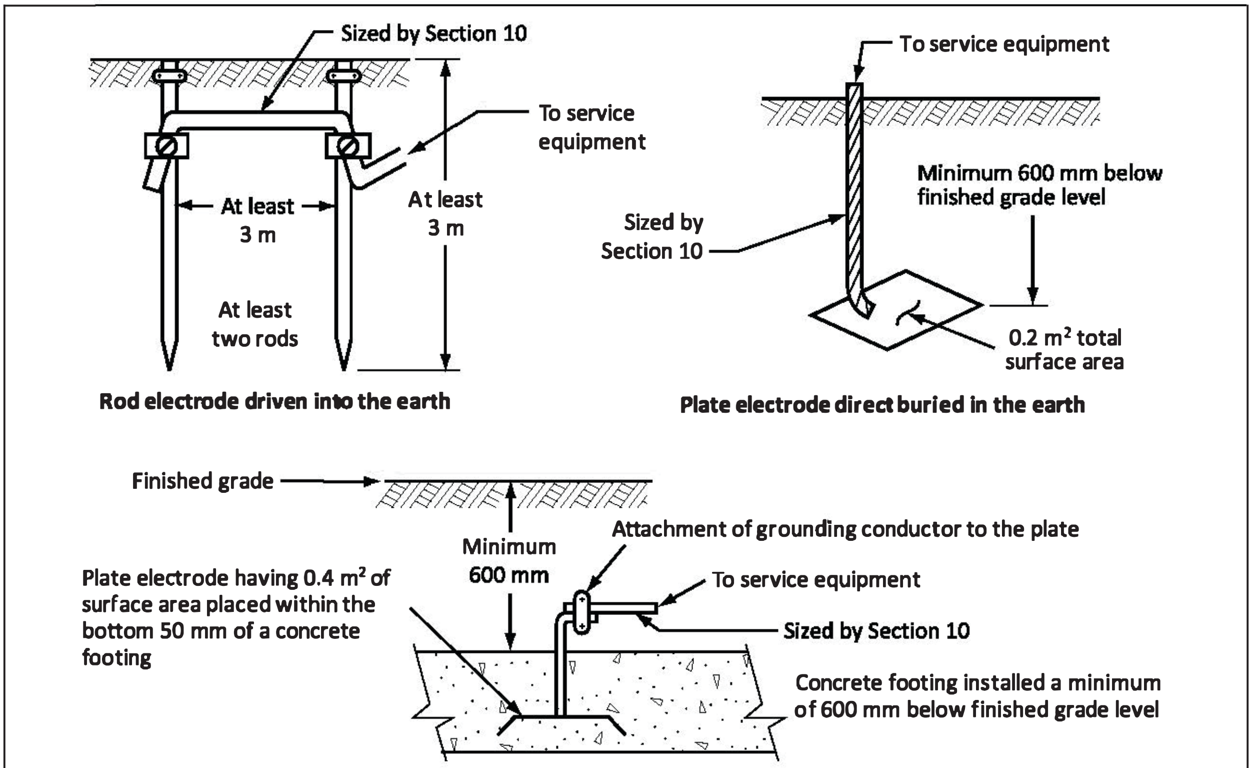
Subrule 1) recognizes three kinds of grounding electrodes:
- manufactured grounding electrodes — types of electrodes that are manufactured in a factory setting and approved in accordance with CSA C22.2 No. 41, such as rod and plate electrodes;
- field-assembled grounding electrodes — electrodes manufactured on site using readily available materials, such as bare copper conductors directly buried or encased in concrete foundation footings; and
- in-situ grounding electrodes — parts of the building's infrastructure that are in contact with the earth, such as a water piping system, metallic reinforcement of a concrete slab, concrete piling, concrete foundation, or iron piling, etc., that have the same surface area in contact with the earth at 600 mm below finished grade as a manufactured grounding electrode.

Item a) of Subrule 2) sets out the requirements for the installation of rod type manufactured grounding electrodes (see Figure 10-2). Rod electrodes are to consist of at least two manufactured rod electrodes. Rods are to be:
- at least 3 m long (as required by CSA C22.2 No. 41);
- driven into the earth to their full length and spaced no less than 3 m apart; and
- bonded together by a grounding conductor sized in accordance with Rule 10-114.

Item b) of Subrule 2) sets out the requirements for a chemically charged rod electrode type of manufactured grounding electrode, which is to be installed to the full length of the rod.

Item c) of Subrule 2) sets out requirements for the installation of plate-type manufactured grounding electrodes (see Figure 10-2). Plate electrodes are to:
- have an exterior surface area of at least 0.2 $m^2$ (as required by CSA C22.2 No. 41) in contact with the soil and be buried at a depth not less than 600 mm below finished grade level; or
- be encased within the bottom 50 mm of a concrete foundation footing that is in direct contact with the earth, with the concrete having an exterior surface area of at least 0.4 $m^2$ (as required by CSA C22.2 No. 41) and buried at a depth not less than 600 mm below finished grade.

## Figure 10-2
## Manufactured grounding electrodes



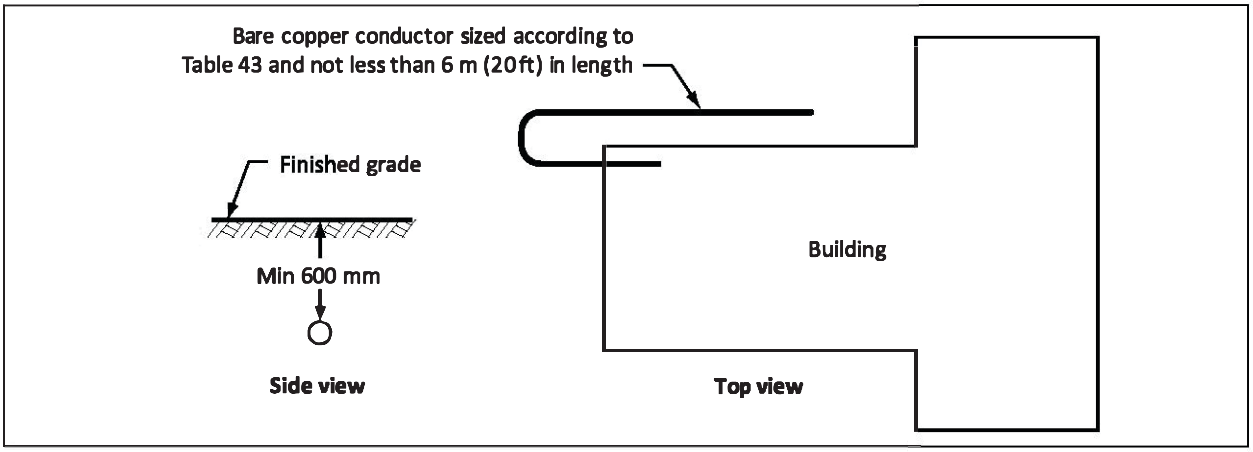

Subrule 3) provides requirements for the installation of field-assembled grounding electrodes. Where a bare copper conductor is encased in concrete footing in direct contact with the earth:

- the bare copper conductor is to be sized in accordance with Table 43;
- the length of conductor is to be no less than 6 m; and
- the conductor is to be encased within the bottom 50 mm of a concrete foundation footing, with the footing in direct contact with the earth, at not less than 600 mm below finished grade.

Where bare copper conductor is directly buried in the earth (see Figure 10-3):

- the bare copper conductor is to be sized in accordance with Table 43;
- the length of conductor is to be no less than 6 m; and
- the conductor is to be in direct contact with the earth and buried at a depth of not less than 600 mm below finished grade.

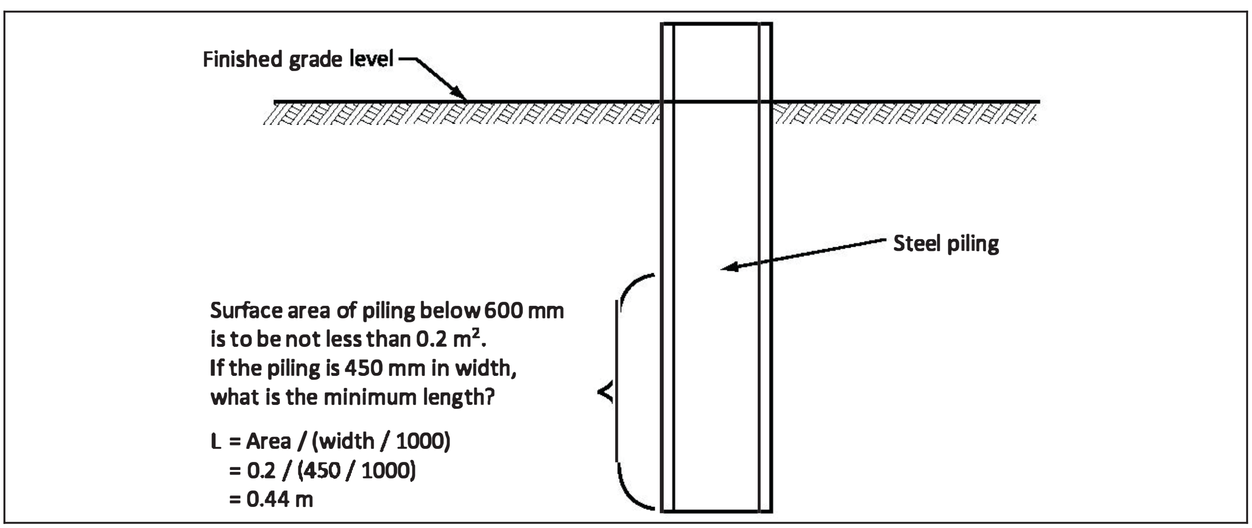
## Figure 10-3
## Field-assembled grounding electrode direct buried in the earth



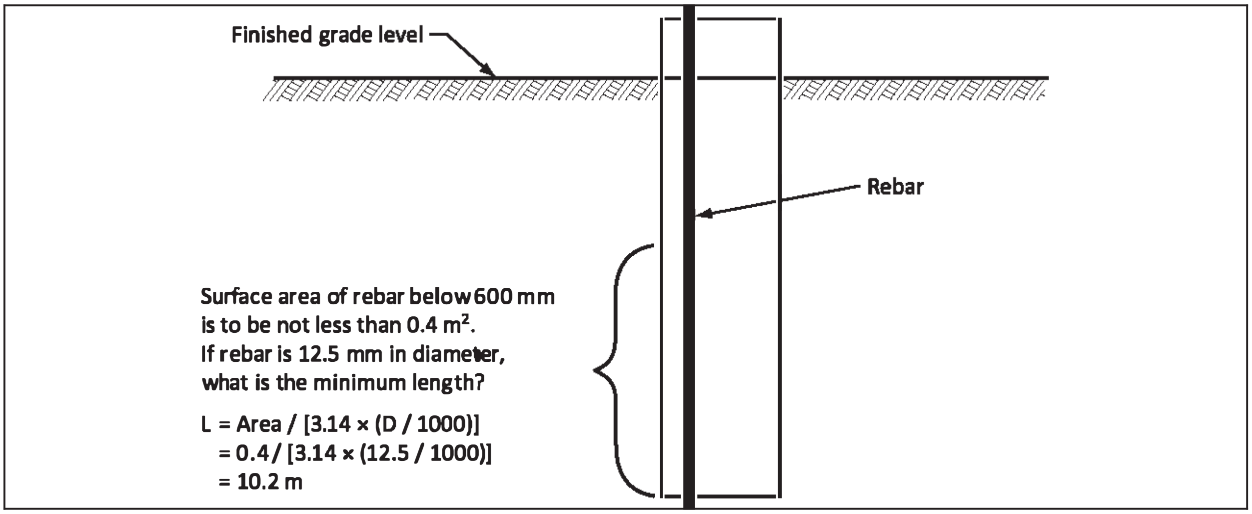

Subrule 4) addresses in-situ grounding electrodes provided by a building's infrastructure, such as a water piping system, iron piling, or metallic reinforcement of a concrete slab, concrete piling, or concrete foundation. Such electrodes are to be 600 mm or more below finished grade and have a minimum surface area of metal equal to that of a manufactured grounding electrode [0.2 $m^2$ when the metal is in direct contact with the earth (see Figure 10-4) and 0.4 $m^2$ when buried in concrete (see Figure 10-5)].

For example, an underground metal water piping system located at least 600 mm below finished grade and extending at least 3 m (see Figure 10-6) has traditionally been recognized as a suitable grounding electrode. Iron pilings and the metal reinforcement of concrete slabs, pilings, and foundations, when they are in significant contact with earth 600 mm or more below finished grade, have also been found to be suitable in-situ grounding electrodes. Any metallic material protected from corrosion by a non-conductive compound, however, is not acceptable for use as an in-situ grounding electrode. The Appendix B Note to Rule 10-102 advises that the potential effects of corrosion on the durability and life expectancy of an in-situ grounding electrode should be considered.

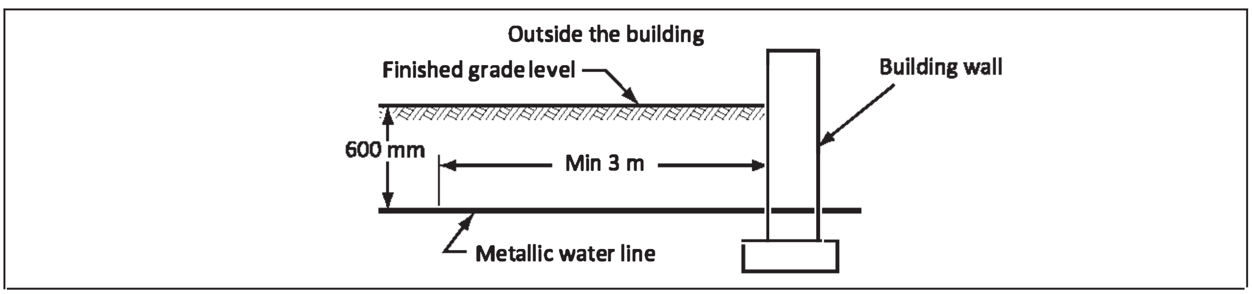
## Figure 10-4
## In-situ grounding electrode — Steel piling



## Figure 10-5
## In-situ grounding electrode




## Figure 10-6
## In-situ grounding electrode — Water piping




Subrule 5) takes into account local conditions (for example, rock or permafrost) that might prevent the installation of a rod or a plate grounding electrode to its required depth. In such cases, the electrode may be buried at a lesser acceptable depth. The defined term "acceptable" is used instead of specifying an alternative depth, since a variety of means are available to address the situation, and the local inspection authority will make the final determination as to the most appropriate one.

### Rule 10-104 Spacing and interconnection of grounding electrodes

Where there are multiple grounding electrodes at a building, they are to be:

- separated by at least 2 m from each other;
- interconnected with a conductor
  - made of material prescribed for grounding conductors;
  - sized as prescribed for grounding conductors; and
  - protected from mechanical damage as required for grounding conductors; and
- in the case of lightning protection systems, interconnected in accordance with Item b) at or below ground level.

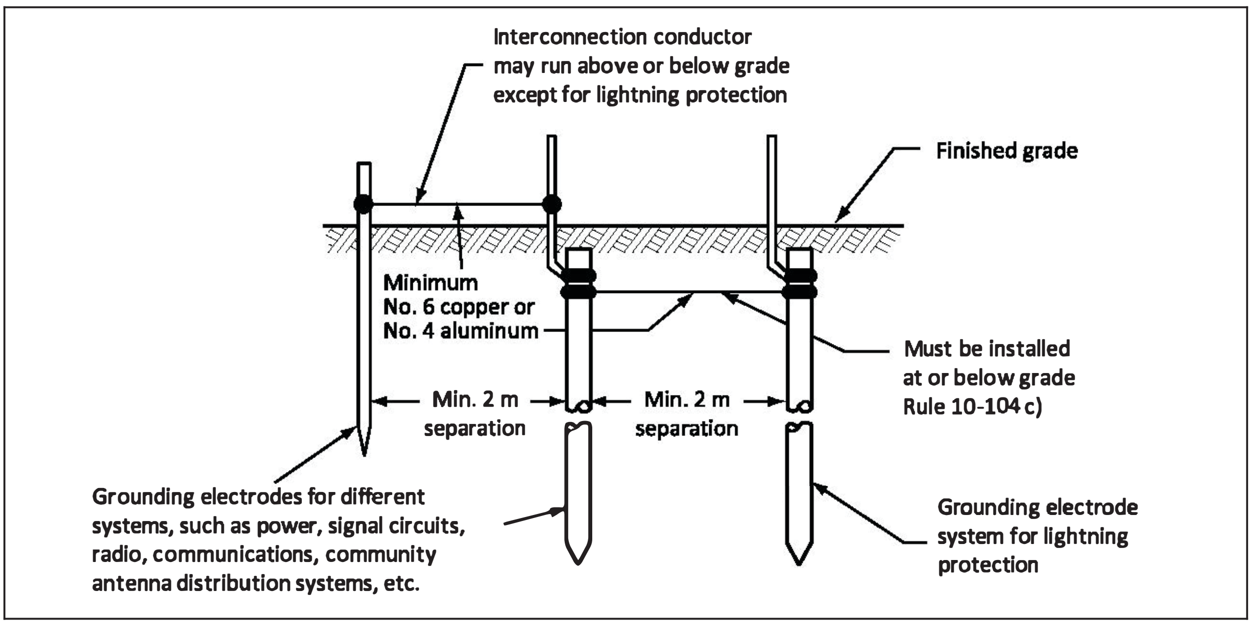
Item a) in Rule 10-104 requires that a separation of at least 2 m be maintained between the grounding electrodes of building electrical wiring systems and the grounding electrodes of other wiring systems, such as lightning rod, communication, and community antenna distribution systems, so that the area of influence of one electrode does not intrude upon that of another. The advantage of having more than one electrode is fully realized only when they are spaced at least 2 m apart. A grounding electrode requires a minimum of 1 m radial space around it for dissipation of any electrical potential into the earth. If the electrodes are closer than 2 m, there is not enough earth between the electrodes to provide a low-resistance connection to earth for each rod and the electrical potential would not be fully discharged into the earth.

Since a fault can occur between one of these grounding systems and the building electrical wiring systems, the grounding electrodes of the two systems must be interconnected to prevent ground loops and circulating currents from occurring between these different grounding and bonding systems. This interconnection offers a low-impedance path for any fault current and enables the quick operation of the overcurrent protection.

Item b) gives the requirements for interconnecting the grounding electrodes to extend the equipotentiality. Item b) requires that a conductor used to interconnect the electrodes be:
- made of material permitted by Rule 10-112 for grounding conductors; and
- sized not smaller than No. 6 AWG if of copper or No. 4 AWG if of aluminum.

The interconnecting conductor is to be protected by location from mechanical damage. When a connection is made between lightning protection system grounding electrodes and other electrical system grounding electrodes, the conductor used for the interconnection is to be run between the electrodes at or below grade, in accordance with Item c) (see Figure 10-7).

**Figure 10-7**
**Bonding requirements for multiple grounding electrode systems**




## Rule 10-106 Railway track as grounding electrodes

The principal intent of Rule 10-106 is to ensure that the railway grounding system and the railway rails are isolated from any system of wiring for buildings or premises that are not part of the railway system.

Rule 10-106 prohibits the use of railway tracks as grounding electrodes. Railway tracks are usually made continuously conductive and extend as conductors over great distances. An electrical fault or a lightning strike to the rails can be transferred over considerable distances, creating:
- problems for, or harm to, any electrical system or any individual contacting the rails; and

- interference with the railway signalling system, since the rails are used to carry signals for the control of the trains, and ground fault current on the rails can interfere with the railway signalling system.

### Rule 10-108 Lightning protection system down conductors and grounding electrodes

Lightning strikes are unpredictable and involve massive amounts of electrical energy. Lightning results from the buildup of an electrical charge on a cloud. When this charge has built to a sufficient level, a lightning strike to earth can occur. This strike is essentially an electric spark and acts as a conductor for the electric charge stored in the cloud. Consequently, throughout the duration of the strike, an electric current flows between the cloud and earth, and this current can reach many thousands of amperes. The damage caused by lightning is mainly due to the very high current flowing in the lightning strike and the magnetic field set up around the lightning strike. Lightning strikes can give rise to harmful potential differences in and on a building. The major concern in the protection of a building is the occurrence of potential differences between the conductors of the lightning protection system and other grounded metal bodies and conductors belonging to the building electrical systems. These potential differences are caused by resistive and inductive effects and can be of such a magnitude that dangerous sparking can occur. In order to reduce the possibility of sparking, it is necessary to equalize potentials by bonding grounded metal bodies to the lightning protection system.

Subrule 1) requires that the down conductors of a lightning protection system not be used for grounding electrical systems or electrical equipment.

Subrule 2) requires that the grounding electrode for a lightning rod system be a separate grounding electrode that is not used as the grounding electrode for any other system.

**Note:** *Rule 10-104 specifies that all grounding electrodes used for the different systems, such as power, signal circuits, radio, lightning protection, communication, and community antenna distribution systems, or for any other purpose are to be interconnected (bonded) together.*

Specifically designed systems are required to protect installations from direct and indirect lightning strikes. Recommended installation practices for lightning protection systems are found in CAN/CSA-B72 and internationally recognized industry standards.

### Rule 10-110 Continuity of grounding conductors

To protect the intent of grounding and electrical systems, Rule 10-110 requires that no automatic cut-out or switch be installed in the grounding conductor unless the opening of the cut-out or switch disconnects all sources of energy. This is similar to the requirement in Rule 14-016 for the continuity of identified conductors.

### Rule 10-112 Material for grounding conductors

The material for the grounding conductor that runs from the grounding connections for systems and circuits (see Rules 10-200 to 10-212 and 10-402) to the grounding electrode is to be copper, aluminum, or other acceptable material. The material to be used for grounding conductors is required to be resistant to, or adequately protected against, any corrosive condition existing at the installation to ensure that under all conditions and after years of service the conductor and its connections continue to provide a low-impedance path to the grounding electrode.

It is recognized that copper and aluminum are the most common materials used for grounding conductors. There might be occasion for other materials to be used such as copper-clad steel, steel-clad copper, or steel-clad aluminum. Where these alternate materials are considered, application should be made to the local inspection department (AHJ) to ensure they are acceptable. Supporting information for the suitability of the material and proper sizing might be required.

Subrule 2), like Rules 2-116 and 10-504, requires that consideration be given for materials subject to corrosive environments. For example, copper conductors in contact with aluminum are subject to galvanic action, and aluminum conductors in contact with masonry or earth are subject to corrosion. Precautions are to be taken to minimize the deterioration from corrosion of the intended material to be used.

The grounding conductor is allowed to be insulated or bare. Since it is connected to the grounding electrode, it is always at ground potential, so there is no need to insulate it to prevent shock hazards.

### Rule 10-114 Grounding conductor size

In selecting the grounding conductor for ac systems, it is assumed a fault will be cleared in a relatively short time (anything from a fraction of a cycle to several cycles or even a number of seconds), depending on the magnitude of the fault current and the characteristics of protective devices on the circuit.

The grounding conductor for an ac service is to be large enough to:
- provide a lower impedance path to the grounding electrode that will provide an alternate path in addition to a grounded/neutral service conductor for fault current to flow back to the source;
- connect the electrical source/system to the earth to provide stable voltages under unbalanced load conditions, which safeguards the electrical installation from undue voltage stress; and
- reduce the voltage potential between exposed metallic parts of electrical equipment and the earth under fault conditions.

Since the resistance of the grounding electrode and the earth/ground limits the amount of current that a grounding conductor can carry, particularly on low-voltage services, Subrule 1) does not require a grounding conductor size larger than No. 6 AWG if of copper or No. 4 AWG if of aluminum.

Subrule 2) allows an exemption from the minimum size required in Subrule 1) as long as the grounding conductor is not sized smaller than the current-carrying conductors (ungrounded conductors) of the system being grounded.

Section 36 modifies the requirements of Rule 10-114 for high-voltage electrical installations, where the grounding conductor selection is based on the calculated maximum available fault current. This can necessitate a much larger conductor than the one called for by Rule 10-114.

### Rule 10-116 Installation of grounding conductors

Subrule 1) requires that the grounding conductor be electrically continuous throughout its entire length. Therefore, splices in the grounding conductor should only be made where they are absolutely necessary.

Subrule 2) allows the use of a device, connected in series with the grounding conductor, to control the effects of stray earth current or tingle voltages.

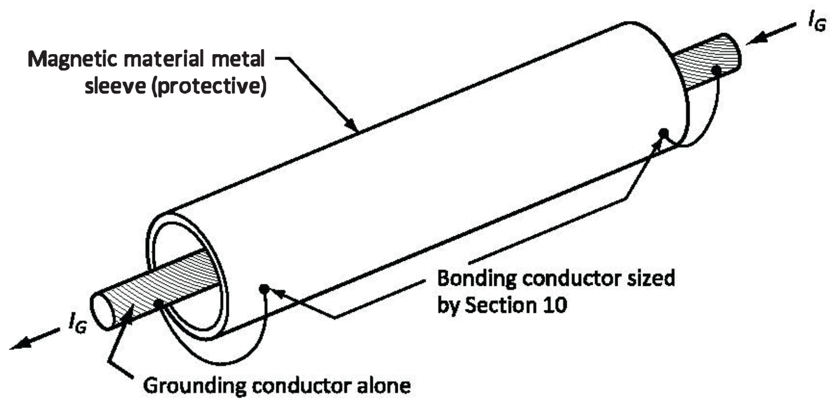
Some of the common causes of stray earth current or tingle voltages are as follows:
- insulation failure in electrical equipment;
- electric fence equipment;
- voltage drop in the secondary neutral system;
- primary and secondary neutral current flowing to earth;
- imbalance on a secondary three-phase system;
- coupled electric/magnetic fields;
- defective grounding systems;
- direct current from sources on and off the property ; and
- an electrical system on a neighbouring property sharing a common primary neutral.

Stray voltage can be steady state or transient and often has more than one source, making it difficult to determine the cause. Before considering the installation of a device in the grounding conductor to eliminate stray earth currents, the grounding and bonding system at the building should be thoroughly checked for compliance with the current Code requirements.

Subrule 3) requires that the grounding conductor be protected from damage
- mechanically; or
- by location.

When, in order to provide protection from damage, grounding conductors are placed in a raceway or in flexible armour using magnetic (ferrous) materials that completely surround the conductor, the magnetic (ferrous) materials can act as a choke. This causes the resistance to increase in the grounding conductor when the grounding conductor is carrying current. To eliminate this resistance, Subrule 4) requires that the magnetic (ferrous) material be bonded to the grounding conductor at both ends [see Figure 10-8 and the Appendix B Note to Rule 10-116 4)].

**Figure 10-8**
**Bonding of magnetic (ferrous) material enclosure**




Although insulating the grounding conductor is not generally required, where it is run in the same raceway as other conductors that are insulated, Subrule 5) requires that it be insulated if it might cause damage to the insulation of the other conductors while being drawn into the raceway. This does not apply when the raceway is short and straight, but when the conduit or raceway is longer than 15 m, or when there are more than two quarter bends between pull points, the grounding conductor is to be insulated.

### Rule 10-118 Grounding conductor connection to grounding electrodes

The integrity of the grounding connection to the grounding electrode is to be preserved under all conditions. Subrule 1) requires that the grounding conductor be connected to the grounding electrode at a point that will assure a permanent connection by using:
- a bolted clamp;
- copper welding by a fusion welding process;
- brazing;
- silver soldering; or
- other equally substantial means.

Subrule 2) requires that the connection to the grounding electrode be, where practicable, at an accessible location that allows for:
- inspection;
- servicing;
- testing; and
- a permanent connection to ground.

## Solidly grounded systems

### Rule 10-200 DC systems required to be solidly grounded

Rule 10-200 requires that dc systems be solidly grounded for voltage stability unless they meet the requirements for:

- ungrounded systems; or
- impedance grounded systems.

### Rule 10-202 Conductor of a dc system to be grounded

Rule 10-202 requires that the following conductors of a dc system be grounded:

- one conductor of a 2-wire dc system; or
- the common conductor of a 3-wire dc system.

### Rule 10-204 Grounding connections for dc systems

Direct current flowing through the earth tends to seek out a metal underground system (for example, a municipal water system), which could suffer severe electrolytic corrosion when dc systems are grounded. To reduce the flow of dc current through the earth from a grounded dc system, Rule 10-204 requires that dc systems that are to be grounded in accordance with Rule 10-200 be grounded at a single point as close as practicable to the dc supply location only and not at individual services or at any point in the interior electrical system. This ensures that the connections to ground do not result in the earth becoming a return path for electrical current.

### Rule 10-206 AC systems required to be solidly grounded

Since many of the components of ac systems are suitable only for voltages up to 150 V, voltage levels on such systems are not to exceed this limit. Subrule 1) states that whenever the voltage on an ac circuit is to be limited to not more than 150 volts-to-ground or wherever a neutral exists (such as in single-phase, 3-wire, and three-phase, 4-wire systems), the system's neutral conductor is to be connected to ground. This requirement limits the voltage level on the circuit and protects the insulation and devices associated with the circuit.

The solidly grounded system also facilitates a low-impedance fault current path through the grounded service conductor that enables the overcurrent devices to operate quickly enough to prevent damage to the conductors and equipment, and prevent potential fire hazards.

If there is no neutral conductor in the system, grounding of the system is not required. Any associated equipment enclosures, however, are still required to be bonded to ground, in accordance with the requirements of Rules 10-400 and 10-402.

Subrule 2) allows ac systems exceeding the 150 V to ground maximum in Item a) of Subrule 1) to be ungrounded or impedance grounded provided that they meet the Code requirements for these systems.

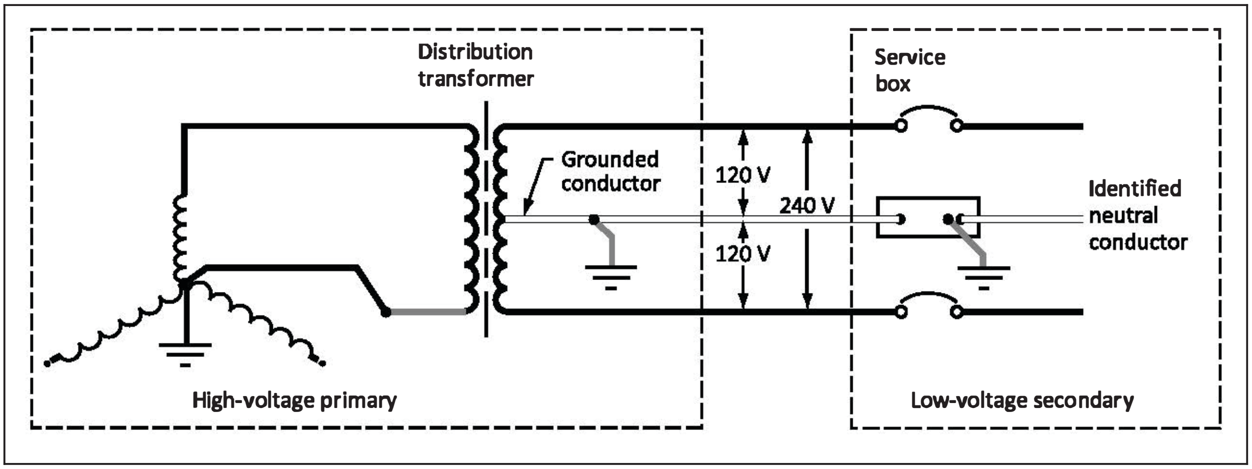
Grounding is not typically required for circuits operating at less than 50 V, unless there is a possibility that a higher voltage might accidentally be imposed on the conductors. Subrule 3) allows a circuit operating at voltages less than 50 V to be ungrounded, unless the circuit is:

- run outdoors (because conductors could be exposed to possible contact with conductors of a higher voltage or a lightning strike);
- supplied by a transformer with a primary voltage of more than 150 volts-to-ground (upon failure of the transformer, a higher voltage could be imposed on the secondary circuit); or
- supplied by a transformer that is connected to an ungrounded system.

### Rule 10-208 Conductor of an ac system to be grounded

To ensure uniform practice in all electrical installations, Rule 10-208 lists the common electrical systems (see Figure 10-9) and specifies whether the identified conductor or the identified neutral conductor is to be grounded. The term "neutral" is used in its strict sense, referring to one of the three conductors in a 3-wire circuit that is bonded to ground and intended to carry the unbalanced load.

**Figure 10-9**
**Grounded conductor for single-phase, 3-wire system (for example, household)**




### Rule 10-210 Grounding connections for solidly grounded ac systems supplied by the supply authority

Item a) of Rule 10-210 requires that the connection of the grounded conductor of an ac system supplied by the supply authority be made at only one point at the consumer's service, usually in the main consumer's service box. See Figure 10-10.

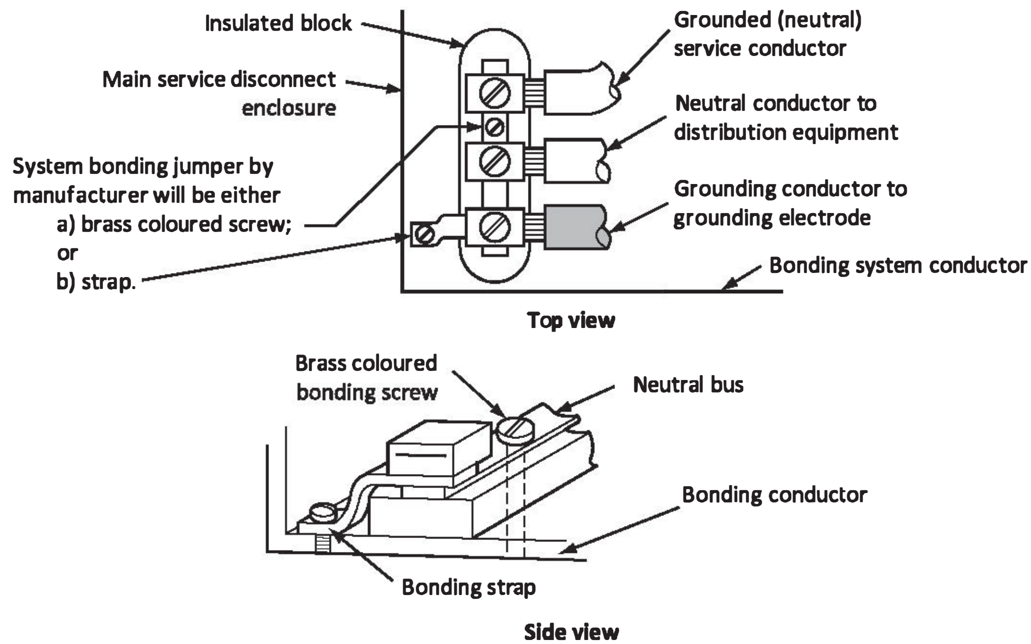
Item b) requires that the minimum size of the grounded conductor be not less than:
- the bonding conductor size that is to be run with the consumer's service conductors; and
- the neutral conductor when the grounded conductor serves as a neutral conductor (see Rule 4-018).

Since the grounded conductor is to terminate and be connected in the main consumer's service, Item c) requires that the grounded conductor be connected to the equipment's bonding terminal by a system bonding jumper. See Figure 10-10.

Item d) requires that the grounded conductor have no other connections, either on the line side or the load side of the consumer's service, to the non-current-carrying conductive parts of electrical equipment once it has been connected to the grounding conductor at the consumer's service. See Figures B10-4 and B10-5 in the Appendix B Note to Rule 10-210.

This means that the grounded conductor on the supply side of the consumer's service box is not to be:
- used to bond to ground items on the supply side of the consumer's service such as the meter base or metal masts [see Item a) of Rule 10-210]; and
- a bare conductor unless it is isolated from contact with any non-current-carrying conductive parts of electrical equipment or metallic raceways [see Item d) of Rule 10-210].

## Figure 10-10
## Common grounding conductor and grounding electrode




### Rule 10-212 Grounding connections for solidly grounded separately derived ac systems

In addition to the supply authority system that supplies electrical power to a facility, one or more separate systems could be installed at a facility (for example, a generator to supply emergency power or a transformer to supply a different voltage to parts of a facility). These separate systems are defined in Rule 10-002 as separately derived systems.

When separately derived systems are required to be solidly grounded, the circuit insulated conductors (the grounded conductor and the ungrounded conductors) of each newly established system will have no direct electrical connection to circuit insulated conductors of the supply authority system other than those established by grounding and bonding connections. The grounded conductor of a solidly grounded separately derived system is grounded at only one point, with no connection between the grounded conductor and the non-current-carrying conductive parts of electrical equipment on the supply side or on the load side of the grounding connection.

Figures B10-7 to B10-10 in the Appendix B Note to Rule 10-212 illustrate the required grounding connections for a solidly grounded separately derived system, as follows:

- at the source of a separately derived system (see Figure B10-7);
- at the first switch controlling the system (see Figure B10-8);
- at each source of two separately derived systems supplying a transfer switch (see Figure B10-9); and
- at the tie point of two separately derived systems supplying a transfer switch (see Figure B10-10).

An exception to Subrule 1) is allowed in Subrule 2): a separately derived ac system operating at 750 V or less is allowed to be grounded by being connected by the system bonding jumper (see definition in Rule 10-002) that is connected to the bonding conductor in the primary supply (the consumer's service).

### Rule 10-214 Grounding connections for portable generator assemblies and vehicle-mounted or mobile generators

"Portable generator assembly" refers to a prime mover, a generator, overcurrent devices, and output receptacles that are assembled and connected together on a common machine frame or mounted on a vehicle and that are capable of being carried or moved about by personnel. The generator is intended to be used as an isolated system for the supply of cord-connected electrical equipment.

A mobile or vehicle-mounted ac generator assembly system is not required to be grounded by a connection to a grounding electrode under the following conditions:
- the generator does not exceed a low-voltage rated output;
- the generator has the neutral bonded to the frame;
- the conductive frame of the generator is connected to the conductive frame of the vehicle by an equipotential bonding conductor;
- the generator supplies only:
  - electrical equipment installed on the vehicle;
  - electrical equipment that is cord-and-plug connected through receptacles mounted on the vehicle or on the generator; or
  - any combination of the equipment specified above; and
- the non-current-carrying conductive parts of the electrical equipment are supplied by a wiring method employing a bonding conductor where they are:
  - installed on the vehicle;
  - cord-and-plug connected to receptacles connected on the vehicle; and
  - any combination of the above.

**Notes:**

1) *A portable or vehicle mounted ac generator assembled ac system that is connected to the fixed wiring of premises is to be grounded by a connection to the premises grounding electrode as required by Rules 10-206 and 10-212.*
2) *As a condition of approval of certain types of electrical equipment, such as portable generators, the manufacturer supplies instructions pertaining to their installation and operation. It is of the utmost importance that the end users closely follow installation and operating instructions supplied by the manufacturer to fulfill the terms of the approval agreement.*

## Impedance grounded systems

### Rule 10-300 Qualified persons

Impedance grounded systems rely on technology to operate safely and reliably. Special training is required to maintain these systems, and when they are installed, it is important that they be kept up to date. Therefore, Rule 10-300 requires that where the electrical system is connected to an impedance grounding device, the impedance grounded system be maintained by a qualified person. A qualified person is defined in Section 0 as an individual who is familiar with the construction and operation of the apparatus and the hazards involved.

### Rule 10-302 Use

Many building systems and industrial processes require the advantages of both the ungrounded delta and the solidly grounded wye systems. These advantages are:
- continuity of service (no tripping of an overcurrent device) when a fault to ground occurs between one phase (line, ungrounded) conductor and ground;
- no damaging arcing or high fault currents flowing between the shorted phase and ground that could injure individuals working on the energized equipment when the fault occurs; and
- constant line-to-line voltage levels when single-phase loads are connected to the three-phase system and not balanced (equal load on each phase).

The most common type of low-voltage system that can provide these advantages is called the "impedance grounded system". Such systems are also referred to as high-impedance (resistance) grounded systems due to the addition of a neutral grounding device (usually a resistor) in the grounding conductor of the transformer. The impedance grounded system has the following advantages:

- the first fault to ground [between one phase (line, ungrounded) conductor and ground] will allow a maximum of 10 A of fault current to flow that is not likely to cause the overcurrent device to trip (open);
- there will be no damaging arcing or high fault currents flowing between the shorted phase and ground that could injure individuals working on the energized equipment when the fault occurs, because only an additional 10 A of fault current will flow; and
- the system's grounding enables the line-to-line voltage levels to remain constant when single-phase loads are connected to the three-phase system and not balanced (i.e., there is not an equal load on each phase).

The following conditions are to be met for impedance grounded systems:

- The ungrounded conductors of an impedance grounded system are to be insulated to the nominal line-to-line voltage of the system [see Subrule 1)].
- The integrity of an impedance grounded system is to be monitored [see Subrule 2)].
- The system is to have an audible or visual alarm that corresponds to the occurrence of
  - a ground fault on current-carrying conductors, including the neutral conductor where line-to-neutral loads are served;
  - a ground fault on the conductor connecting the impedance grounding device to the source; and
  - a loss of continuity of the impedance grounding circuit from the system source through the impedance grounding device to the grounded non-current-carrying conductive parts of the electrical system [see Subrule 2)].
- The alarm required by Subrule 2) and any extra (i.e., redundant) alarms, if installed, are to
  - be clearly labelled as to their purpose;
  - clearly annunciate the status of the system to persons monitoring it; and
  - continue signalling until the fault condition causing the alarm has been corrected [see Subrule 3)].
- On the occurrence of any of the conditions described in Subrule 2), an impedance grounded system is to be automatically and immediately de-energized except as allowed by Subrule 5) [see Subrule 4)].
- On detection of a ground fault on the ungrounded conductors, an impedance grounded system is allowed to remain energized if
  - the system is operating at 5 kV or less;
  - the system serves no neutral loads;
  - the ground fault current is controlled at 10 A or less; and
  - the impedance grounding device is rated for continuous use [see Subrule 5)].

### Rule 10-304 Impedance grounding devices

Impedance grounding devices [sometimes called neutral grounding resistors (NGRs)] include grounding resistors, grounding transformers, ground-fault neutralizers, reactors, capacitors, or a combination of these components. Since ground faults can continue for various lengths of time until corrective measures are taken, these devices have to carry the ground fault current continuously.

Subrule 1) allows impedance grounding devices not having a continuous rating to be used where:

- provision is made to automatically de-energize the system without intentional delay on the detection of a ground fault; and
- the time rating of the device is coordinated with the time-current rating of the protective devices of the system.

To prevent shock hazards, Subrule 2) requires that impedance grounding devices have an insulation voltage rating at least equal to the line-to-neutral voltage of the system.

### Rule 10-306 Location of impedance grounding devices and warning signs

Impedance grounding devices require periodic inspection, testing, and maintenance. When the impedance grounding device is in a ground fault condition, it can present a shock hazard and, depending on its type, become hotter than the ambient temperature of its location. At the initial installation and throughout the life of the installation, therefore, people working on the system (for example, maintenance personnel or supply authority personnel) must be aware of the fact that an impedance grounding device has been installed and must also know the neutral-to-ground voltage of the system, so that they can avoid any actions that are potentially hazardous or that compromise the protective features on the system.

Rule 10-306 requires that impedance grounding systems have warning signs located at the:

- supply source;
- consumer's service box or equivalent; and
- supply authority's metering equipment.

### Rule 10-308 Conductors used with impedance grounding devices

The conductor running between the impedance grounding device and the neutral point of the transformer, generator, or grounding transformer is not a neutral conductor, as strictly defined, although many of the installation requirements are the same.

To ensure the proper operation of the system, Subrule 1) requires that the conductor running between the impedance grounding device and the neutral point of the power supply:

- be insulated for the nominal system voltage;
- be identified white or grey;
- be routed as directly as practicable;
- not be grounded;
- be sized to conduct the rated current of the impedance grounding device, and in no case less than:
  - No. 12 AWG if of copper; or
  - No. 10 AWG if of aluminum; and
- be protected from damage
  - mechanically; or
  - by location.

Subrule 2) requires that the grounded side of the impedance grounding device be connected to the non-current-carrying parts of the electrical equipment by an impedance system bonding jumper sized to conduct the rated current of the impedance grounding device, and in no case less than:

- No. 12 AWG if of copper; or
- No. 10 AWG if of aluminum.

## Ungrounded systems

### Rule 10-400 Ungrounded systems

The three-phase ungrounded delta system has the following advantages:

- there is continuity of service (no tripping of an overcurrent device) when a fault to ground occurs between one phase (line, ungrounded) conductor and ground (see Figure 10-11); and
- no damaging arcing or high fault currents flowing between the shorted phase and ground occur that could injure individuals working on the energized equipment when the fault occurs.

It does, however, have one disadvantage. The line-to-line voltage levels fluctuate when single-phase loads are connected to the three-phase system and not balanced (i.e., there is not an equal load on each phase).

If another/different phase in another part of the ungrounded delta system shorts to ground, a line-to-line voltage fault occurs between the two shorted conductors through the bonding/grounding system.

This will usually cause a higher fault current to flow back to the source via the shorted phase conductors, which will open the overcurrent device(s) (see Figure 10-12).

With ungrounded systems, ground detectors are required (see Rule 10-400) to alert the supervisory personnel of the ground fault condition.

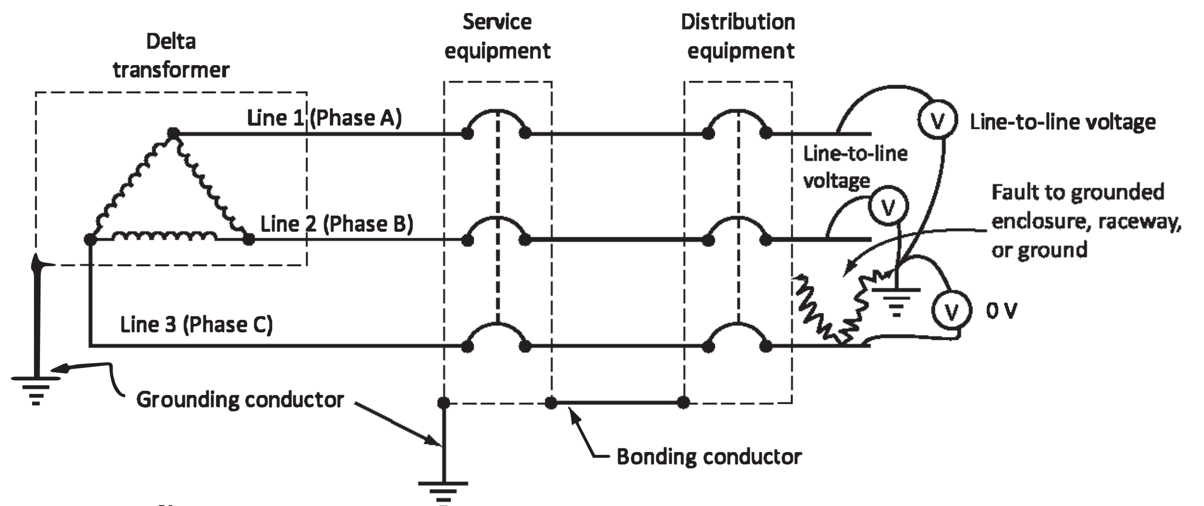
Some industries use ungrounded dc or ac systems, allowing the plant or the system to continue operating without a shutdown even when there is a ground fault on one phase or line. While a single fault on an ungrounded system does not create excessive current flowing to ground that can cause arcing, a second fault can lead to arcing and a potential hazard since the voltage-to-ground increases to the line-to-line value. Therefore, Rule 10-400 requires that ungrounded systems:

- be equipped with a ground fault detection device [see Subrule 1)];
- be maintained by a qualified person [see Subrule 1)];
- provide notification of the fault to the individuals responsible for the system by activating an audible or visual signal indicating that a ground fault has occurred so that timely repairs can be made [see Subrule 2)];
- ensure that the alarms and, if installed, any extra (i.e., redundant) alarms:
  - be clearly labelled with their purpose;
  - clearly indicate the system condition to persons monitoring it; and
  - continue signalling until the condition has been corrected [see Subrule 3)].

Normally, such a fault is repaired during a scheduled maintenance shutdown. However, if the fault is not found and corrected before a second ground fault occurs on another phase, a line-to-line fault will have been established that will cause the overcurrent devices to trip and the plant or system will experience an unscheduled shutdown. Since the fault is a line-to-line fault, the resulting damage can be considerably more extensive than it would be in a grounded system. (See Figure 10-12.)

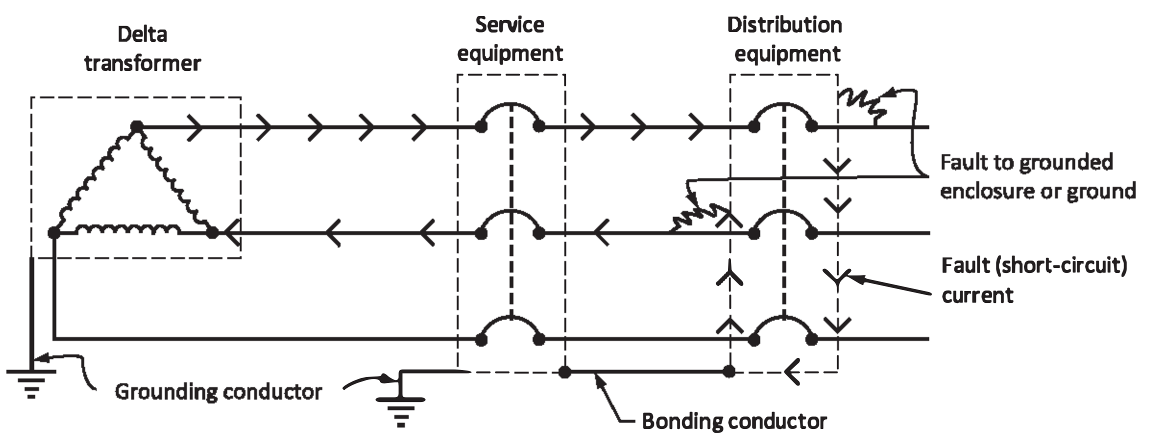
When a ground fault detection device is installed, it should be identified and visible to those who are supposed to know what its purpose is and what to do in the event of a fault. Frequently, although these devices are installed, no one recognizes there is a fault and no one knows what to do in the case of an indication of a fault. Subrule 3) requires that the ground fault detection device required by Subrule 2) be clearly labelled as to its purpose and placed in a location that is visible to persons monitoring the status of the system.

## Figure 10-11
## One ground fault on three-phase ungrounded delta system




**Notes:**
**1)** *There is no complete path for fault current to flow, only a small capacitive charging.*
**2)** *Overcurrent device in fault line does not trip.*
**3)** *Circuit remains operational.*

## Figure 10-12
## Two ground faults on different lines of a three-phase ungrounded delta system




**Notes:**
**1)** *A line-to-line fault current will flow.*
**2)** *One and possibly two overcurrent devices will trip.*

### Rule 10-402 Grounding connections for equipment in an ungrounded system

Subrule 1) requires that when a system neutral conductor is present in the ungrounded power supply system (the source), it not be connected to a grounding conductor, so there is no solid connection between a system neutral and the grounding electrode.

However, Subrule 2) requires that the grounding conductor connect the grounding electrode to the non-current-carrying conductive (metal) enclosure of:

- the supply source equipment of separately derived systems; or
- the service box.

In both cases, the grounding conductor is to be connected to the grounding terminal at the service box or at an equivalent termination in cases where no service box is installed.

# Bonding

## Bonding — General

### Rule 10-500 Current over bonding conductors

Under normal operation, there should be no objectionable current flow in a bonding conductor.

In situations such as a ground fault event, the bonding conductor is designed to carry the available fault current for the time required to mitigate the fault. The equipotential bonding conductor might also carry a portion of the fault current as a parallel fault current path.

See Rule 10-100, as it applies to objectionable current flow in the bonding conductors as well.

### Rule 10-502 Clean surfaces

Care is to be taken to eliminate anything that might restrict the flow of fault current and to ensure that the resistance of the bonding path is as low as possible. Since most paints and many other protective coatings can restrict or impede the flow of current, Rule 10-502 requires that such materials be removed from any surface that forms part of the bonding path.

### Rule 10-504 Dissimilar metals

In certain environments, the connection of dissimilar metals can cause galvanic action. On a bonding connection, galvanic action can cause a bonding connection to deteriorate, compromising the integrity of the bonding path and creating a hazard. To minimize the corrosive effect of galvanic action, Rule 10-504 requires that appropriate materials and methods be used when dissimilar metals are utilized at bonding connections. This can be accomplished by coating the exposed materials with a coating or compound [see Subrule 2) of Rule 2-116].

For example, dissimilar metals (for example, aluminum and steel), when in contact with each other in moist or wet environments (for example, around a swimming pool), can cause galvanic action to occur, resulting in one material disintegrating. If this occurs in an electrical connection or electrical equipment, the connection or equipment can fail, causing arcing and shock or fire hazards.

### Rule 10-506 Continuity of bonding conductors

The integrity of the bonding system used to bond electrical equipment to ground is intended to ensure that the system will function under all normal circumstances and any electrical fault condition. Rule 10-506 requires that no automatic cut-out or switch be installed in the bonding conductor of a wiring system unless the opening of the cut-out or switch disconnects all sources of energy.

## Equipment bonding

### Rule 10-600 Bonding for fixed electrical equipment

A bonding conductor is intended to provide a low impedance path for fault current and facilitate the operation of overcurrent protective devices, in addition to serving as an equipotential bonding connection. To prevent shock and arcing hazards, Subrule 1) requires that non-current-carrying conductive (metal) parts of electrical equipment be connected to a bonding conductor.

Subrule 2) allows an exemption from connecting non-current-carrying conductive (metal) parts of electrical equipment to a bonding conductor when the non-current-carrying conductive parts are on extra-low-voltage electrical equipment.

### Rule 10-602 Conductors in parallel runs

Bonding conductors are to be installed in such a way so that no additional impedance will be encountered when the bonding conductor is carrying ground fault current. To accomplish this, Rule 10-602 requires that when circuit conductors are installed in parallel in separate cables, raceways, or bus, a bonding conductor be installed with each group of parallel conductors.

### Rule 10-604 Bonding continuity for service equipment

Short-circuit/overcurrent protection of a circuit is to be installed at the point where the circuit receives its supply. In the case of consumer service conductors, there usually is no short-circuit/overcurrent protection between the connection to the supply service conductors and the line side ofthe consumer's service overcurrent devices. The bonding requirements for service equipment are more restrictive than the bonding requirements for downstream installations, as the continuity of bonding between the grounded/neutral service conductor (which carries the fault current back to the source) and the downstream bonding system is crucial. Therefore, Rule 10-604 does not consider the use of standard metal bushings a sufficiently dependable method for the bonding of service electrical equipment.

To prevent fire or shock hazards, Items a) to c) of Subrule 1) of Rule 10-604 list methods of making a bonding connection to ensure a secure and continuous bonding path. These methods include the use of:

- threaded couplings or bosses on metal enclosures and rigid metal conduit connections;
- threadless couplings, such as the set-screw or compression type, when electrical metallic tubing (EMT) is used; and
- grounding bushings equipped with bonding jumpers.

Subrule 2), however, allows box connectors with standard locknuts to be used to bond the metal armour or sheath of cables such as AC90 and TECK90, which have an internal bonding conductor. In this case, the metal armour or sheath of the cable is not being relied upon to bond the equipment at each end of the cable.

### Rule 10-606 Bonding continuity at other than service equipment

In the case of installations downstream from the service equipment, Subrule 1) allows less restrictive bonding methods than those for service equipment given in Rule 10-604. These alternative bonding methods are:

- threadless fittings (box connectors) for metal-sheathed or armoured cable;
- double locknuts that make good electrical contact with the enclosure, with one inside and one outside the enclosure; or
- one locknut and metal bushing, provided that the bushing can be installed so that it is mechanically secure and makes positive contact with the inside surface of the box or cabinet.

Since reducing washers have not been tested and certified to maintain the bonding continuity of the system, Subrule 2) prohibits their use in the bonding system to provide continuity of the bonding path.

### Rule 10-608 Loosely jointed metal raceways

Metal raceway systems that do not have reliable connections between sections, such as those in which expansion joints, telescoping sections, or split couplings are used, require the use of a bonding conductor to prevent one or more of the sections from becoming electrically isolated from ground.

### Rule 10-610 Bonding means — Fixed equipment

Rule 10-610 lists the specific conditions in which non-current-carrying metal parts of fixed electrical equipment are to be bonded to ground. If it is possible that someone might touch the metal parts of the equipment and at the same time be in contact with a grounded surface or the ground itself, it is necessary to prevent a shock or arcing hazard by bonding the equipment to ground.

Rule 10-610 requires that any exposed non-current-carrying metallic part of fixed equipment be bonded to ground by the use of:

- a metallic interconnection between fixed equipment consisting of a metal raceway, metal sheath, or cable armour except for
  - armoured cables that do not contain a bonding conductor [see Subrule 2)];
  - armour of flexible metal conduit or liquid-tight flexible conduit [see Subrule 3)];
  - the sheath of mineral-insulated cable when not of copper or aluminum [see Subrule 4)]; or
  - where the raceway or cables are:
    - run underground;
    - run in locations coming within the scope of Section 22; or
    - otherwise subject to corrosion;
- a bonding conductor that is run with circuit conductors as a part of a cable; or
- a bonding conductor that is run with circuit conductors installed in raceways.

When single-conductor cables are used for the supply to fixed equipment, and the metal armour or sheath of the cable has been isolated from the equipment at one end in accordance with Rule 4-008, Subrule 5) requires that a separate bonding conductor be installed between the fixed equipment.

### Rule 10-612 Bonding conductor connection to electrical equipment

Rule 10-612 sets out requirements for the installation of bonding conductors to ensure that they will not be accidentally or inadvertently disconnected, thus minimizing the possibility of damage, shock, or fire.

The connection of the bonding conductors and jumpers to circuits, conduits, cabinets, equipment, etc., is to be secure. Subrules 1) to 6) provide requirements for the bonding connections. These requirements are as follows:

- The bonding conductor to conduits, cabinets, equipment, and similar applications is to be attached by means of lugs, pressure connectors, clamps, or other equally substantial means [see Subrule 1)].
- Due to the unreliability of connections under fault conditions that depend on solder, Subrule 2) requires that they not be used.
- A bonding connection is to be provided at every non-metallic outlet box to provide a means for any fitting or device that requires connection to a bonding conductor [see Subrule 3)].
- To ensure a continuous bonding path between the access cover and the outlet box where the connections between the branch circuit and the internal conductors of fixed equipment pass through an access cover, the bonding conductor is to be connected to the cover and the outlet box [see Subrule 4)].
- Where bonding is provided by the metal enclosure, and a device attached to the enclosure has a bonding terminal, to ensure a continuous and reliable bonding path between the enclosure and the device, a bonding conductor is to be installed to bond the device to the enclosure [see Subrule 5)].
- Where a bonding conductor connection to the bonding terminal of a device is to be installed, the connection is to be made so it allows the disconnection or removal of the device and will not interfere with, or interrupt, the continuity of the bonding conductor [see Subrule 6)].

### Rule 10-614 Size of system bonding jumper or bonding conductor

The grounding conductor is mainly intended to connect the grounded/neutral service conductor and the bonding conductor terminated at the service equipment to ground. Rule 10-614 requires that the bonding conductor be large enough and have impedance low enough to:

- carry the available ground fault current until it is cleared by the overcurrent device within that device's specific time limits, without becoming hot enough to damage:
  - the bonding conductor's own insulation;
  - the insulation of the conductors that the bonding conductor might be in contact with; or

  - any combustible material the conductors might be in contact with (for example, metal raceways and metal enclosures); and
- serve as an equipotential bonding connection.

The size of a field-installed system bonding jumper (the connection between the system grounded point and the non-current-carrying conductive parts of an electrical system, used to establish a solidly grounded system) is required by Subrule 1) to be not less than that determined in accordance with Table 16, Column 1, based on the ampere rating or setting of the overcurrent device protecting the ungrounded conductors.

See the Appendix B Note to Rule 10-614 1) and 3) a) when the system or circuit conductors on the secondary side of a transformer are protected only by the overcurrent devices on the primary side: the Note states that the voltage ratio of the transformer is applied to the primary overcurrent device rating to determine the rating of the overcurrent device to be used in applying Column 1 of Table 16.

Subrule 2) requires that the size of a bonding conductor installed to ensure bonding continuity for service equipment (see the requirements in Rule 10-604) not be less than that determined in Column 2 of Table 16 based on the allowable ampacity of the largest ungrounded conductor.

Subrule 3) requires that the size of a field-installed bonding conductor installed at other than service equipment (see the requirements in Rule 10-606) not be less than that determined in accordance with Table 16 based on:
- the overcurrent device protecting the ungrounded conductors; or
- the allowable ampacity of the largest ungrounded conductor for installations where the size of the circuit conductors is increased to compensate for voltage drop.

See the Appendix B Note to Rule 10-614 3) b), which states that when the size of a circuit conductor is increased to compensate for voltage drop due to circuit length, the ampacity of that conductor will exceed that required for the connected load and the rating of the overcurrent protective device. Therefore, the bonding conductor needs to be increased proportionately to minimize the impedance of the bonding path and facilitate the operation of the overcurrent device. Column 2 of Table 16 bases the size requirement of the bonding conductor on circuit conductor allowable ampacity to compensate for conductor length.

Subrule 4) requires that when a field-installed bonding conductor is installed with each group of parallel conductors run in separate raceways or cables, it be sized in accordance with Subrule 3). To obtain the value to be used in Table 16, Subrule 4) requires that the maximum overcurrent device for the circuit, or the total circuit's ampacity where the size of the circuit conductors is increased to compensate for voltage drop, be divided by the number of groups of parallel conductors.

Subrule 5) allows the bonding conductor size to be not larger than the current-carrying conductors.

Subrule 6) allows that, where a metal raceway is to be used as a bonding conductor, the metal raceway be considered to meet the minimum size of the bonding conductor.

Subrule 7) allows that the bonding means that is integral to a cable assembly be considered to meet the requirements for sizing the bonding conductor as the bonding means meets the requirements of the applicable product Standard.

# Equipotential bonding

## Rule 10-700 Equipotential bonding of non-electrical equipment

"Equipotentiality" refers to the state in which conductive parts are at a substantially equal electric potential. Rule 10-700 applies to equipotential bonding of the conductive surfaces of non-electrical equipment, devices, and structures where the control of voltage rise is required or desired.

Equipotential bonding of these conductive pipes and systems is provided to prevent these systems from carrying a voltage different from the electrical system, so as to control potential differences that might cause unwanted circulating currents, galvanic corrosion, or tingle voltages. Continuous water and waste water systems can, under certain circumstances, carry impressed currents from lightning strike or faults in neighbouring buildings where conductive piping might interconnect the electrical systems of other structures that share the same water supply.

Waste water systems constructed of cast iron and rubber couplings are not considered to be continuous. Metallic waste water systems that used solder joints would be considered continuous. The installer should verify that the system is metallic and continuous.

It should be noted that exterior gas piping systems might be required to be isolated from interior gas piping to prevent the introduction of current and to preserve any cathodic protection of the gas piping system. In general, this is accomplished using dielectric fittings at the demarcation between the interior and exterior gas piping system. Any conditions limiting the equipotential bonding of the exterior gas system should be verified with the local gas inspection authority.

It should also be noted that the requirement to provide equipotential bonding to the metal gas piping system in Item c) of Subrule 1) of Rule 10-700 is not intended to apply to metal gas tubing. Attempts to bond metal gas tubing with conventional bonding means can create a hazardous situation where the tubing can be punctured by installation of the bonding means or by arcing between improperly secured bonding means during fault events or lightning strikes.

Livestock are particularly sensitive to the effects of step and touch voltages. For this reason, equipotential bonding is prescribed for all conductive metal parts accessible by livestock within a building housing livestock. These parts include metal water pipes, stanchions, water bowls or troughs, vacuum lines, and other metals that could become energized.

Methods to establish equipotentiality in buildings housing livestock are described in the American Society of Agricultural and Biological Engineers (ASABE) Standard EP473.2-2001, *Equipotential Planes in Animal Containment Areas.*

Low grounding electrode system resistances can reduce potential differences in livestock facilities.

Conductive materials used for equipotential bonding are not required to be wires and can take the form of structural steel, bus, metallic framing and support structures, conductive static mats, or the support structure of a computer room floor. Each of these materials, when adequately interconnected, form the effective equipotential plane.

The user should be aware of the effects of galvanic corrosion where dissimilar metals are joined together and ensure the materials used are compatible or appropriately protected from corrosion at joints and connections.

Wherever metal parts of non-electrical equipment are installed in buildings, it is possible for electrical wiring to fault to the metal of this equipment, resulting in arcing, electrical shock, or fire. Rule 10-700 lists specific metal parts of non-electrical equipment that are to be bonded to ground to minimize these risks. In practice, this safeguard extends more widely to ensure all large metal components in industrial buildings, including tanks, machinery, and the structural steel itself, are bonded together and tied to ground.

The following parts of non-electrical equipment are to be made equipotential with the non-current-carrying conductive parts of electrical equipment:

- the continuous metal water piping system of a building supplied with electric power;
- the continuous metal waste water piping system of a building supplied with electric power;
- the continuous metal gas piping system of a building supplied with electric power;
- raised floors of conductive material with electrical wiring under the raised floor;
- the conductive metal parts of structures that livestock access; and
- metal tower and station structures of passenger ropeways, passenger conveyors, or material ropeways.

### Rule 10-702 Installation

Subrule 1) allows conductors for equipotential bonding to be installed as open wiring as covered in Section 12, provided that they are adequately secured.

Subrule 2) requires that where equipotential bonding conductors are installed in structural members, these conductors be installed in the same manner as non-metallic sheathed cable, except that they do not require bushed holes where run through metal studs.

### Rule 10-704 Material for equipotential bonding conductors

Equipotential bonding conductors are to be of materials allowed for grounding conductors or for bonding means.

### Rule 10-706 Equipotential bonding connections to non-electrical equipment

Equipotential bonding connections to non-electrical materials are to be made mechanically secure and are to be suitable for the condition(s) to which they are subjected.

### Rule 10-708 Equipotential bonding conductor size

To ensure a continuous, reliable, low impedance equipotential bonding conductor, Subrule 1) requires that these conductors not be smaller than

- No. 6 AWG if of copper; or
- No. 4 AWG if of aluminum.

Subrule 2) allows an exemption from the minimum sizes in Subrule 1): the equipotential bonding conductor is allowed to be a minimum No. 10 AWG copper or a No. 8 AWG aluminum where it is installed:

- as concealed wiring; and
- with mechanical protection.

# Section 12 — Wiring methods

## Scope

### Rule 12-000 Scope

Section 12 is a general Section of the Code that sets out requirements for wiring methods that apply to all Sections unless amended in a subsequent Section of the Code. In planning or installing an electrical installation, the most important Rules in the Code relate to where and under what conditions particular wiring methods are allowed be used. Three general conditions determine the type of wiring method to use:

- conditions of building construction;
- conditions of location; and
- conditions of use.

The *National Building Code of Canada* or the local building authority is to be consulted regarding the electrical installation and use of non-metallic electrical equipment (e.g., raceways, boxes, and conductors) due to the possibility of fire hazard, flame spread, and smoke development.

Subrule 1) states that Section 12 covers all types of wiring methods required for electrical installations operating at a voltage level of 750 V or less, with the exception of:

- Class 2 circuits unless otherwise specified in Rules 12-2300 to 12-2320 and Section 16;
- community antenna distribution and radio and television circuits unless otherwise specified in Section 54;
- optical fiber cables unless otherwise specified in Section 56;
- communication circuit conductors unless otherwise specified in Section 60; and
- conductors that form an integral part of factory-built equipment field evaluated under CSA SPE-1000.

Subrule 2) requires that installations operating at more than 750 V fulfill the Section 12 requirements, except where Section 36 amends them.

## General requirements

### Rule 12-010 Wiring in ducts and plenum chambers

"Plenum", as used in Rule 12-010, refers to an enclosure that has been constructed to transport air as an element of a ventilation or air-conditioning system. The space above a suspended ceiling, when used to transport air, is classified as a plenum.

Subrule 1) requires that electrical installations in ducts or plenums used to transport dust, loose stock, or flammable vapours or substances be marked for the purpose and comply with the applicable requirements, such as Section 18 for hazardous locations.

Subrule 2) requires that only electrical equipment marked for the purpose be installed in a duct or plenum.

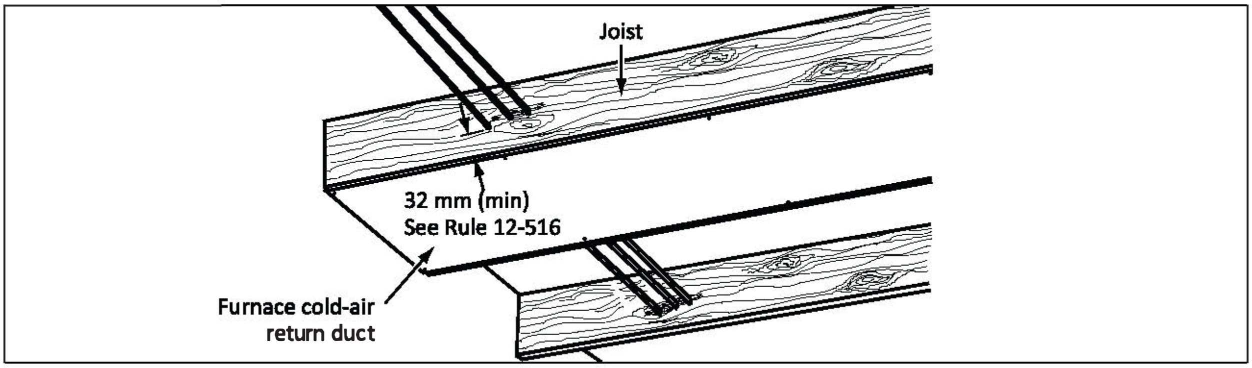
It is essential to prevent the products of combustion from circulating throughout a ventilating or air-conditioning system. Subrule 3) requires that the electrical installation of cables in a duct or plenum comply with Rule 12-100 and meet the flame spread requirements of Rule 2-130.

Since flexibility is needed to relocate pole-type assemblies, Subrule 4) allows the use of flexible cords when a plenum or hollow space is created by a suspended lay-in tile ceiling, provided:

- the cord does not exceed 3 m in length;
- the cord is terminated in an attachment plug;
- the cord is rated for hard usage; and
- the circuit voltage does not exceed 300 V.

Subrule 5) allows cold-air return ducts such as those installed between joists or studs of a building to be used as long as the wiring method meets the requirements of Section 12 for use in the duct (see Figure 12-1). For example, a Type NMD90 non-metallic-sheathed cable is allowed to be installed in a cold-air return duct in a single dwelling when the duct is formed by boxing in between wooden joists.

**Figure 12-1**
**Wiring through cold-air return duct**




## Rule 12-012 Underground installations

Rule 12-012 provides requirements for the installation and protection of cables and raceways in underground locations to provide for the safety of people and the continuing operation of the system.

In Section 12, "direct burial" refers to conductors or cables that are directly buried underground (i.e., the outer surface of the cable is in direct contact with the earth). "Cover", as used in Rule 12-012, refers to the minimum distance between the top surface of the cable or raceway and the finished grade.

Subrule 1) requires that the minimum cover for direct burial cables or raceways be in accordance with the requirements of Table 53 to provide sufficient isolation for the protection of people and electrical equipment.

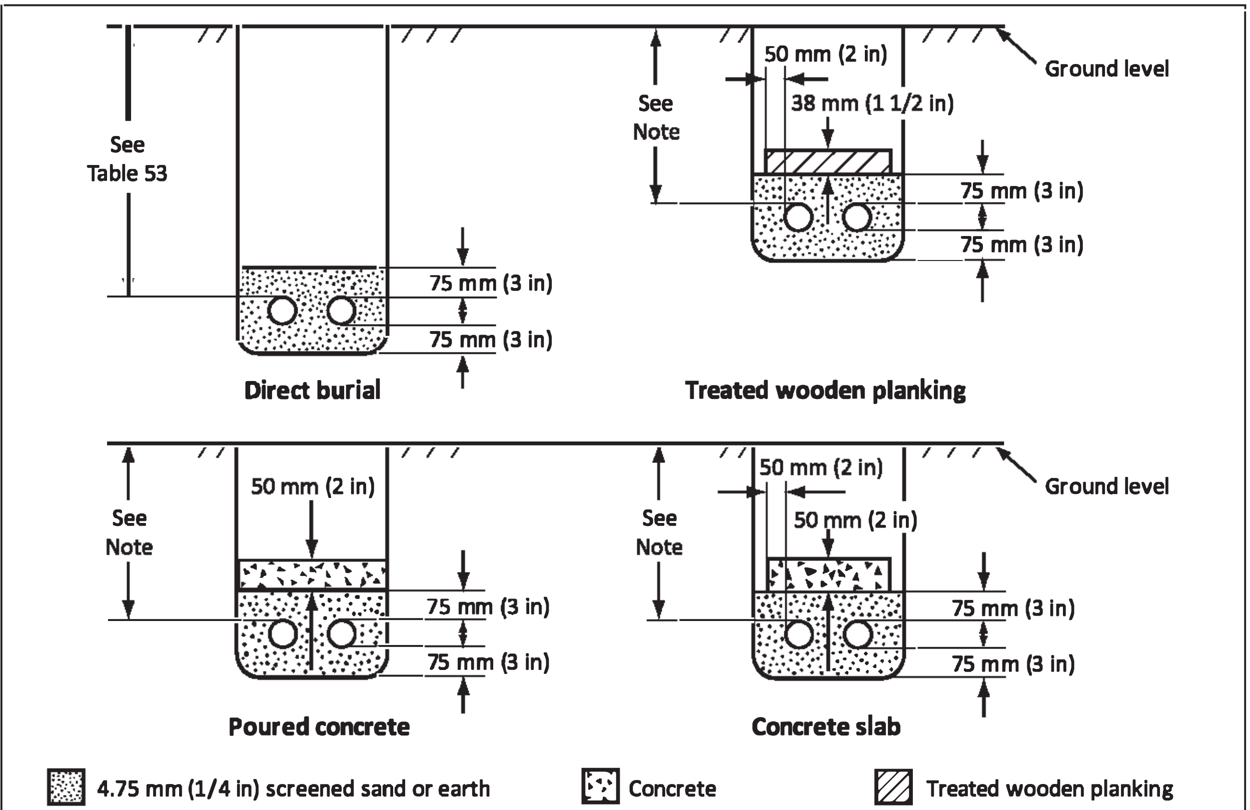
Subrule 2) allows the minimum depth of burial/cover given in Table 53 to be reduced by 150 mm when one of the types of mechanical protection outlined in Subrule 3) is used.

The rationale is that when the mechanical protection allowed by Subrule 3) is provided, it is considered a safeguard that allows a reduction in the burial/cover depth. The protection method must not damage the cables, raceways, or the insulation on conductors in the cable or raceway. When designing or installing underground raceways, the requirements of Rule 12-936 are to be met. Subrule 3) specifies a number of materials that are allowed to be used in providing mechanical protection. These materials are:

- treated planking at least 38 mm thick with a type of treatment that does not damage the insulation on the conductors;
- 50 mm of poured concrete above the cables or raceway;
- 50 mm thick concrete slabs placed above the cables or raceways;
- 50 mm of concrete that encases or surrounds the cables or raceway; or
- other suitable material. It is advisable to check with the authority having jurisdiction (AHJ) to determine the suitability of the material.

**Note:** *The mechanical protection is to extend a minimum of 50 mm beyond the cables or raceways on each side. See Figure 12-2.*

## Figure 12-2
## Underground installation methods




**Note:** *Table 53 requirements may be reduced by* 150 mm *(6 in) where mechanical protection is placed over the installation as per Rule 12-012 2).*

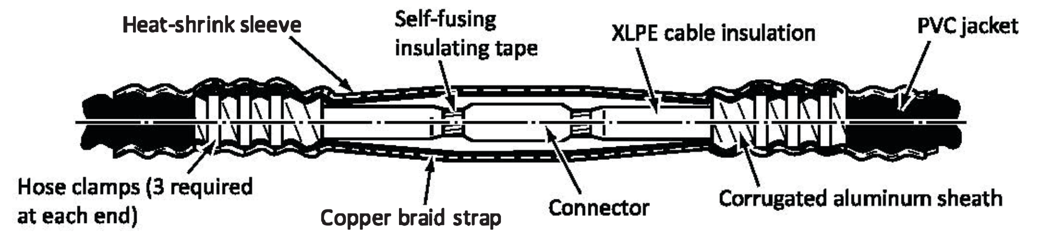
For physical protection of the cables, Subrule 4) requires that the direct buried cables:
- be run parallel or adjacent to each other;
- not cross over each other (pressure from hard objects or the weight of the cover above the cables can result in a weakening of the insulation on the conductor and subsequent failure); and
- be encased by screened sand or earth, with a maximum particle size of 4.75 mm, that is a minimum of 75 mm above and below the cables.

**Note:** *The Appendix B Note to Rule 12-012 4) refers the 4.75 mm particle size to the standard sieve sizes detailed in ASTM D2487.*

When cables leave the ground for termination or access above grade level, Subrule 5) requires that they be protected from mechanical damage. Protection is to be:
- in the form of location (i.e., the location where the cables enter or exit the ground does not leave them open to damage from mechanical or other equipment, contact by people, etc.). For example, the inside corner of a building or similar location where accidental damage is unlikely can be judged to be protection by location;
- in the form of rigid conduit installed from 300 mm above the bottom of the trench to at least 2 m above finished grade. The intention is that slack be provided for the cables entering the vertical conduit to ensure that backfill settling or movement caused by frost does not cause abrasion or physical strain to the cables from the rigid conduit; or
- in the form of another acceptable means of protection.

Subrule 6) requires that a deviation under Rule 2-030 be obtained before a splice or tap located in the trench for underground electrical installations is considered (see Figure 12-3). Splice kits for direct burial are readily available for most cable types.

**Figure 12-3**
**Typical direct burial splice**




When rock is encountered at a depth less than the required depth of coverage, Subrule 7) allows a lesser depth to be used provided that the raceways or cables are:

- installed in a trench in the rock that is not less than 150 mm deep; and
- secured in the trench by concrete grout extending to the surface of the rock.

Subrule 8) allows raceways and armoured or metal-sheathed cables suitable for direct burial to be installed directly beneath a concrete slab at grade level, provided that the

- concrete slab is not less than a nominal 100 mm in thickness;
- location and depth of the underground installation is marked in a conspicuous, legible, and permanent manner; and
- raceway or cable is not subject to damage during or after installation.

When metal raceways or cables are installed in an underground location, they are exposed to moisture and corrosive influences and are considered to be in a wet location. Subrule 9) prohibits the use of dissimilar metals in such a situation to prevent any galvanic action. For example, when concrete with reinforcing steel is used as mechanical protection, the aluminum conduit, the aluminum sheaths, or the armour of cables without PVC jackets are adversely affected and need to be protected with a protective coating [see Rule 2-116, Subrule 3) of Rule 12-602, and Rule 12-936].

Subrule 10) requires that consideration be given to the physical protection of the underground cables or raceways. Backfill containing large rocks can affect backfill settlement, and the additional weight can contribute to sharp objects penetrating the sand or earth cover and damaging the cable insulation. Paving materials containing creosote or gasoline can damage some cable jackets and conductor insulations. Cinders, which are a product of burning bituminous coal containing sulphur, can produce sulphuric acid in a moist location; this causes corrosion that attacks steel cable assemblies and metal conduit.

The location of an underground system is important, not only for the physical protection of the electrical installation but also for people involved with future alterations. Permitted methods of marking include:

- printed signs;
- markers in the concrete;
- plastic tape markers; or
- a drawing indicating the location and depth of the system.

When marking tape is used, it is to be buried halfway between the installation and the finished grade level so that excavators can see the tape before reaching the depth of the buried cable or raceway. Subrule 11) identifies the halfway level of the trench as the location of the marking tape.

Inspectors are seeing the results of installations installed without adequate attention to movement from ground settlement or frost. The damage includes raceways being pulled apart, cables or raceways pulling out of terminations, and damage to meter bases and panels. To avoid damage to the electrical installation due to movement of the building, raceway, or cable, Subrule 12) requires that where underground raceways or cables are subject to movement by settlement or frost, provisions be made to prevent damage to the conductors, the conductor's insulation, or the electrical equipment. Figures 12-4 and 12-5 illustrate some installation methods that take ground movement into account.

**Figure 12-4**
**Use of an expansion joint to accommodate ground movement**

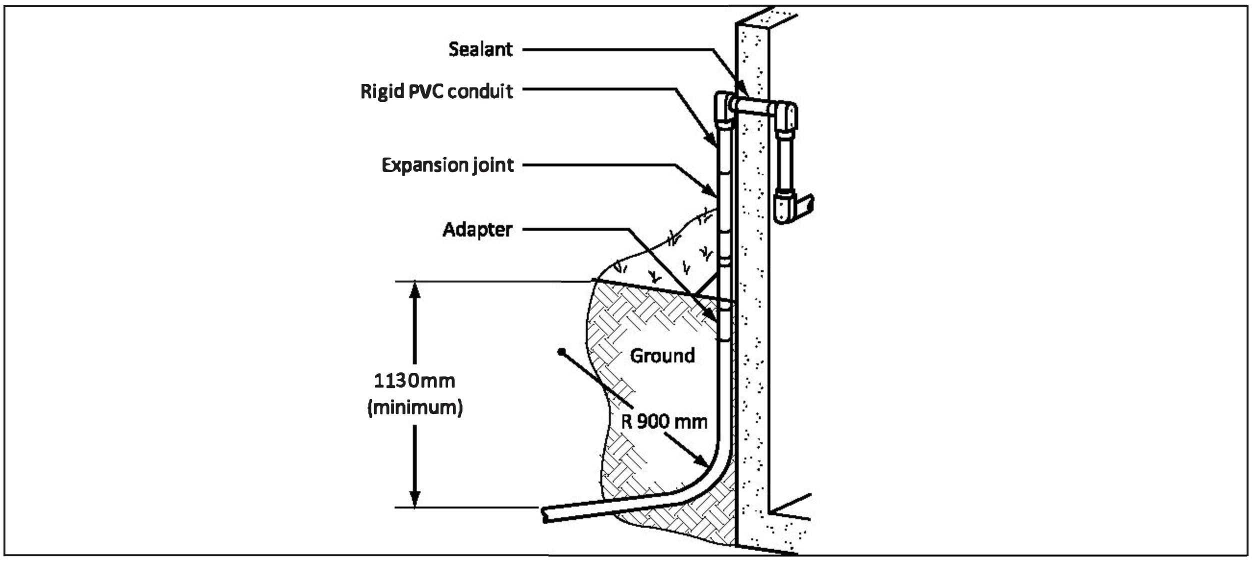
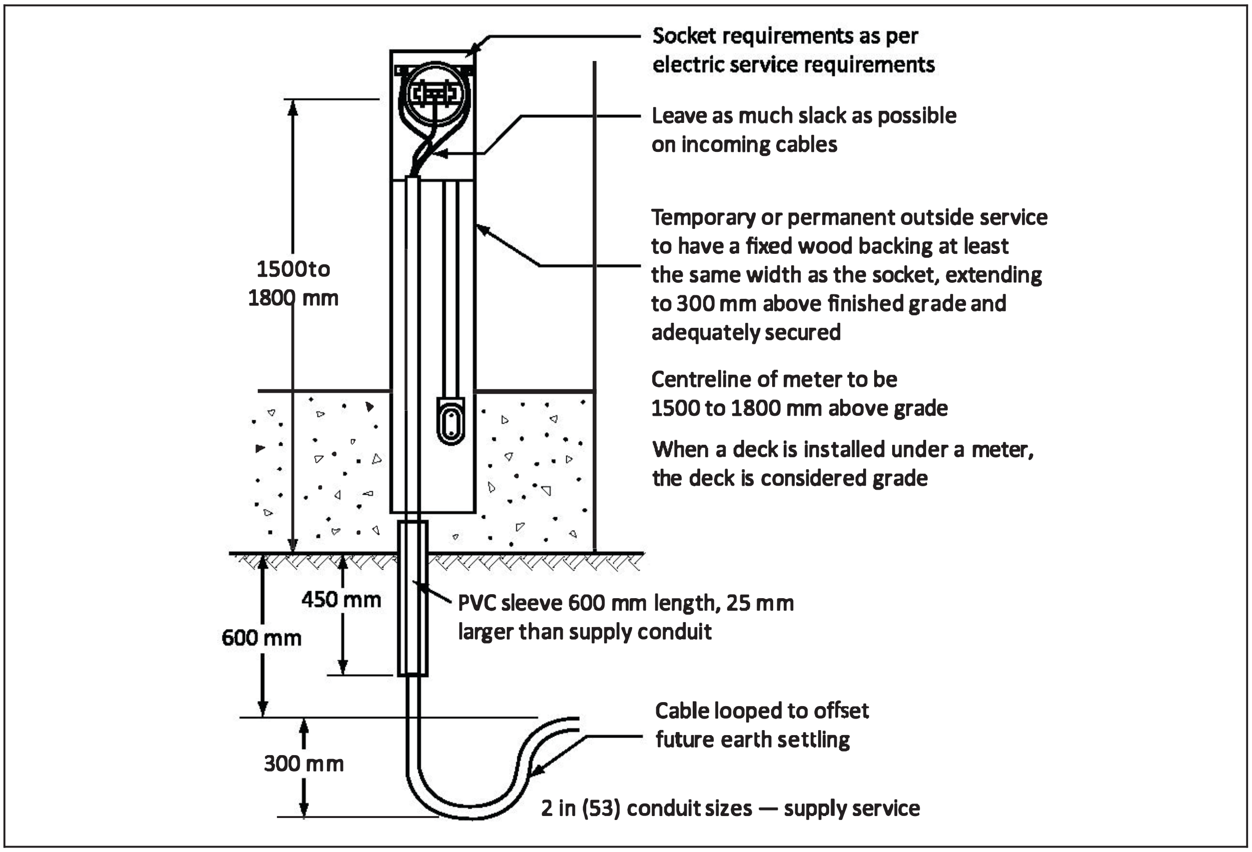


**Figure 12-5**
**Use of PVC sleeving to accommodate ground movement**




Since these requirements do not cover all underground electrical applications, Subrule 13) references CSA C22.3 No. 7 or the applicable standard, whichever is more stringent, to establish equivalent safety objectives. For example, CSA C22.3 No. 7 covers the depth and vertical and horizontal separations for gas, water pipe, and railway crossings.

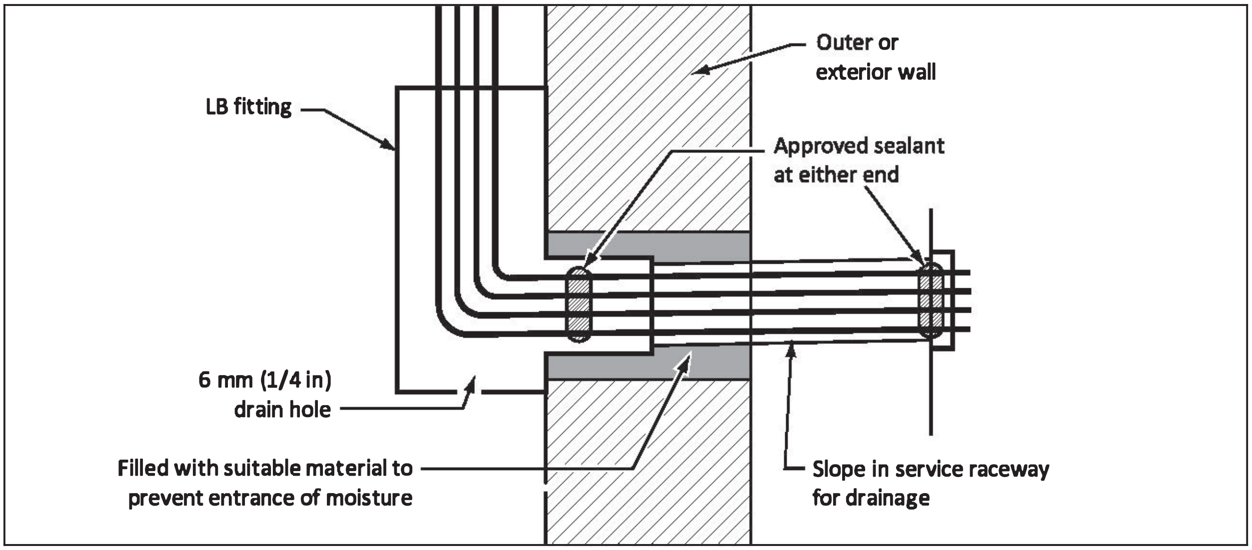
### Rule 12-016 Lightning down conductors

When electrical wiring (for example, electrical equipment, enclosures, conduit, or cables) are installed near lightning down conductors, damage can occur from arcing and surges produced from lightning. Rule 12-016 requires that all electrical wiring be kept at least 2 m away from a lightning down conductor. An exception to this separation is allowed when the lightning system grounding electrode is bonded to the other installation system grounding electrodes in accordance with Rule 10-104.

### Rule 12-018 Entry of raceways and cables into buildings

When holes have been opened in a building structure for the entry of raceways or cables, Rule 12-018 requires that they be sealed (for example, by the use of gaskets, grouting with concrete, or other suitable material) to prevent moisture from entering the building between the outer surface of the raceway or cable and the inner surface of the hole. See Figure 12-6.

**Figure 12-6**
**Example of entry of cable/raceway into a building**




### Rule 12-020 Wiring under raised floors for data processing and similar systems

As wiring installed under a raised floor for data processing and similar systems is not subject to the same mechanical damage as that normally experienced by regular building wiring, the general wiring requirements of Section 12 may be relaxed.

Subrule 1) allows flexible cords or cables, appliance wiring materials with a jacket or covering, and liquid-tight flexible conduit to be installed under a raised floor to connect to or interconnect data processing or similar equipment. The requirements of Rule 12-020 relate to the:

- bonding of conductive floors; and
- use of locking-type plugs complying with Diagram 2 or industrial special-use-type attachment plugs, connectors, and receptacles.

To provide a safe installation by preventing shock, arc, fire hazards, or damage to the wiring method used, Subrule 2) requires that a metallic wiring method be used to install the branch circuits supplying the receptacles under the raised floor.

## Conductors

## General

### Rule 12-100 Types of insulated conductors and cables

Insulated conductors and cables used for electrical installations are to be suitable for the location (for example, dry, damp, wet, or hazardous locations) and suitable for the conditions of use (for example, direct earth burial, exposed or concealed wiring methods, in raceways, and for service entrance use).

Rule 12-100 requires that insulated conductors or cables with the insulation designation listed in Table 19 for the particular location and condition of use be installed with consideration to the following:

- moisture — any moisture present can collect on the surface of the insulated conductors or outer sheath of cables and, given the presence of any contaminants in the moisture, eventually break down the insulation or sheath material. During the manufacture of some insulated conductors and cables, materials are added to the insulation to exclude moisture and contaminants. Table 19 includes a list of designations of insulated conductors or cables having insulation suitable for use in damp or wet locations.

- corrosive action — in electrical installations, corrosion commonly takes the form of a chemical attack from oils, greases, gasoline, and acids; a galvanic attack between dissimilar metals (for example, copper and aluminum); or an electrolytic attack (for example, from moisture entering a break in the insulation of an underground conductor). Table 19 includes a list of designations of insulated conductors or cables that are suitable for use where corrosive conditions are encountered.
- temperature — the heating of conductors or cables installed in a high-temperature environment can cause the insulation to deteriorate and can increase the resistance of the current-carrying conductors, resulting in an increase in the voltage drop. When insulated conductors and cables are used in high-temperature environments, the installer is to make sure that the temperature of the conductor's or cable's insulation will not be exceeded during the lifetime of the installation. Table 19 lists this maximum allowable temperature rating of the insulation. Table 5A lists ampacity correction factors for ambient temperatures greater than 30 °C. Where the surface temperature of, and/or the ambient temperature surrounding, the insulation of conductors, cables, or raceway systems exceeds 90 °C, such assemblies are a potential fire hazard if installed adjacent to combustible material. In such cases, the assemblies are to be relocated or supported to prevent this potential hazard. Low temperatures cause many types of insulation to become brittle and crack when subjected to impact or flexing. For information on low-temperature markings, see the Appendix B Note to Rule 12-100.
- degree of enclosure — heat generated from adjacent conductors installed in a raceway raises the ambient temperature and affects heat dissipation and insulated conductor or cable ampacity. Subrules 1) and 2) of Rule 4-004 and Table 5C outline correction factors based on the number of power and lighting conductors in a raceway or cable [see Subrule 7) of Rule 4-004].
- mechanical protection — retention of the electrical characteristics of the cable's or conductor's insulation depends on the protection from mechanical abuse. Sharp bending can eventually cause cracking of the insulation, lack of support at terminations can cause combined tension and compression stresses, or driving a nail or screw into a wall can result in penetration of the insulation.

## Rule 12-102 Insulated conductors

Insulated conductors and jacketed cables can be handled and installed at temperatures as low as –10 °C without damage due to the temperature. Once a conductor is installed in a fixed position, it can operate safely at much lower ambient temperatures. Where the temperature is below –10 °C, the insulation and jacket can become brittle and can crack or shatter when flexed, bent, or handled during or after installation.

Where insulated conductors and/or jackets are marked –25 °C or –40 °C, they can be handled and installed at temperatures lower than –10 °C. These markings are based on laboratory tests under controlled conditions and are provided as guidance from the manufacturer. However, when installing or designing installations intended to operate continuously at a lower ambient temperature, consideration is to be given to installing an insulated conductor suitable for handling at that temperature and care is to be exercised to minimize the flexing of the insulated conductor. When flexing is required, bend the insulated conductor slowly and increase the minimum bending radius of the insulated conductor. For information on low-temperature markings, see the Appendix B Note to Rule 12-102.

Subrule 3) sets out fundamental safety criteria for the selection of insulated conductors based on exposure to moisture, corrosive actions, temperature, degree of enclosure, and mechanical damage. This Subrule requires that Table 19 be applied in conjunction with specific conditions of use for the various types of certified insulated conductors. However, Subrule 3) recognizes that Table 19 is not applicable in cases where Rules such as 12-400, 12-122, and 12-404, as well as Rules in other Sections of the Code, specify different insulated conductor types for specific applications.

Subrule 4) addresses the harmful effects various chemicals can have on a conductor's insulation. In some cases, insulation can be softened, and in others, it can lose its plastomers and become brittle. In either case, the degradation of the insulation can result in a fire or shock hazard. If a conductor's insulation is not resistant to a chemical to which it might be exposed in a given installation, means are to be provided to prevent contact with the chemical. The means may be a sheath of neoprene or some other material resistant to corrosive elements.

### Rule 12-104 Flame-tested coverings

To prevent creepage of current over the flame-tested covering on the insulation of a conductor (tracking) at terminations and splices, Rule 12-104 requires that the insulation be removed for a short distance back from the termination or splice.

### Rule 12-106 Multi- and single-conductor cables

When an alternating current flows in a single-conductor metal-sheathed cable, a current is induced in the metal sheath proportional to the frequency and amount of current flowing in the conductor (this is caused when the lines of force change direction as a result of the ac current and cut across the metal sheath of the cable). When the sheath contains all the conductors of the circuit, the polarities of the magnetic fields around the conductors cancel each other, due to the phase relationship (180° for single-phase systems and 120° for three-phase systems). As a result of this cancellation, no lines of force cut across the metal sheath and current is therefore not induced in the sheath. Since the metal sheath is not sized to be a current-carrying conductor, as the flow of current in the sheath increases, it causes the material of the metal sheath to heat up.

When multi-conductor cables are used, Subrule 1) requires that:

- all the conductors of the circuit (equal number from each phase and the neutral) be contained in the same cable sheath to prevent the flow of sheath currents that can cause heating of the sheath and reduce the life expectancy of the insulation on the conductor; and
- when single-conductor cables are run in parallel, they comply with Rule 12-108.

When conductors in a multi-conductor cable are supplied from different electrical systems with different voltages or characteristics, potential hazards exist for maintenance personnel, the electrical equipment, and the electrical system. The intent of Subrule 2) is to avoid a hazardous condition by preventing the possibility of conductors in a multi-conductor cable becoming crossed with circuits of a different power, different transformers, or other different sources of voltage. To prevent this hazard, Subrule 2) requires that, when conductors in a multi-conductor cable are supplied from different power, different transformers, or other different sources of voltage, the conductors:

- be used for the supply and/or control of remote devices;
- be insulated for the voltage of the circuit having the highest voltage; and
- not be the conductors of the circuits of a lower voltage that is directly connected to a lighting branch circuit.

Subrule 3) requires that, when single-conductor cables are used as the circuit conductors, they all be of the same type and have the same temperature rating. "Type" refers to CSA conductor type designation/ conditions of use and "temperature" to the maximum allowable conductor insulation temperature, as listed in Table 19. If these single-conductor cables are to be run in parallel, the installation is to conform to the requirements in Rule 12-108.

In magnetic (ferrous) materials, the atoms of the iron, nickel, and cobalt have magnetic properties (a north and a south pole). When placed near a magnet, these atoms line up with their north poles lining up with the south pole of the magnet. If the polarity of the magnet were to be changed, these atoms would change direction 180° so that their south poles would line up with the magnet's north pole. When an ac conductor operates at a frequency of 60 Hz, the polarity of the magnetic lines of force around the conductor changes at a rate of 60 times per second. This causes the atoms of iron, nickel, and cobalt in the magnetic (ferrous) material to change direction the same number of times. The movement of these atoms causes the magnetic (ferrous) material to heat up. This type of heating is called induction heating and accounts for a portion of the heat generated in the iron core of transformers, ballasts, and motor poles.

The intent of Subrule 4) is to reduce the induction heating effect by the use of non-magnetic (non-ferrous) armour, such as aluminum [see also Subrule 7) of Rule 12-3022].

To prevent induction heating in the building components and the supports for single-conductor cable, Subrule 5) requires that each single-conductor cable carrying more than 200 A be installed and supported so that it is completely encircled by only non-magnetic (non-ferrous) materials.

### Rule 12-108 Conductors in parallel

When conductors are chosen to be installed in parallel, the load current is to be evenly divided between all the conductors involved to avoid overheating of the conductors. Copper or aluminum conductors sized No. 1/0 AWG and larger are allowed to be installed in parallel by conductively connecting both ends to form a single conductor, provided that they comply with the requirements listed in Subrule 1). The purpose of these requirements is to make sure that each conductor of each parallel phase, polarity, or grounded circuit conductor has the same impedance to share the load equally. The requirements for single conductors in parallel are:

- to be not less than a No. 1/0 AWG and larger to prevent overheating;
- to be free from splices between termination points, to prevent overheating and increased resistance at the splice [an exception in Subrule 2) allows one splice to be permitted to meet the requirements of Rule 4-006];
- to be the same size, to keep the conductor material resistance the same;
- to be the same type of insulation, to prevent damage to insulation on one conductor due to lower temperature rating or different conditions of use;
- to be terminated in the same manner at the busbars of the supply and load end equipment, to ensure equal sharing of current without heating of the termination;
- to be the same conductor material, to prevent damage (mechanical or environmental) to one material type; and
- to be the same length, to keep all conductors' resistance the same to ensure equal sharing of current.

Subrule 2) allows a single splice in each conductor of each parallel phase, polarity, or grounded conductor where a transition in conductor size is required to accommodate the equipment's termination temperature rating required by Rule 4-006, and provided that each splice is done in the same manner.

Subrule 3) requires that all the parallel insulated conductors in the same phase, polarity, or the grounded circuit have the same characteristics [Subrules 1) and 2)], but the conductors of a different phase, polarity, or grounded circuit conductors are allowed to be different (see Tables 12-1 and 12-2).

**Table 12-1**
**Example of conductors in parallel having the all the same characteristics**

| | Phase A/Line 1 | Phase B/Line 2 | Phase C/Line 3 | Grounded/ Neutral |
|---|---|---|---|---|
| **Splices** | One in each conductor | One in each conductor | One in each conductor | One in each conductor |
| **Size** | 500 kcmil | 500 kcmil | 500 kcmil | 500 kcmil |
| **Insulation type** | RW90XLPE | RW90XLPE | RW90XLPE | RW90XLPE |
| **Termination type** | Mechanical | Mechanical | Mechanical | Mechanical |
| **Conductor material** | Copper | Copper | Copper | Copper |
| **Conductor length** | 15 m | 15 m | 15 m | 15 m |

**Table 12-2**
**Example of conductors in parallel having different phase/polarity/line or grounded circuit conductors characteristics**

| | Phase A/Line 1 | Phase B/Line 2 | Phase C/Line 3 | Grounded/ Neutral |
|---|---|---|---|---|
| **Splices** | One in each conductor | None | One in each conductor | None |
| **Size** | 500 kcmil | 600 kcmil | 750 kcmil | 500 kcmil |
| **Insulation type** | RW90XLPE | T90 NYLON | T90 NYLON | RW90XLPE |
| **Termination type** | Mechanical | Compression | Compression | Mechanical |
| **Conductor material** | Copper | Copper | Aluminum | Copper |
| **Conductor length** | 15 m | 15.3 m | 15.6 m | 17 m |

When single-conductor cables are chosen for parallel installation, it is important that the individual single conductors of each phase, polarity, and grounded conductor be configured such that each conductor has the same inductive reactance. This means that the influence of the magnetic fields from other phase single conductors is eliminated because all of the single conductors in each phase and the neutral have the same polarity and strength of the magnetic fields influencing the single conductors of each phase, polarity, and grounded conductor. Subrule 4) requires that all single conductors be installed in a configuration that ensures that all single conductors of each phase and the neutral have similar values of inductive reactance. Compliance with Subrule 4) can be achieved by using one of the configurations illustrated in the Appendix B Note to Rule 12-108 or by using a configuration recommended by the cable manufacturer. Additional conductors in parallel are allowed to be arranged in repetitive configurations (see Figure 12-7). These configurations are not to result in unequal division of current in each of the conductors used in each phase, polarity, and grounded conductor.

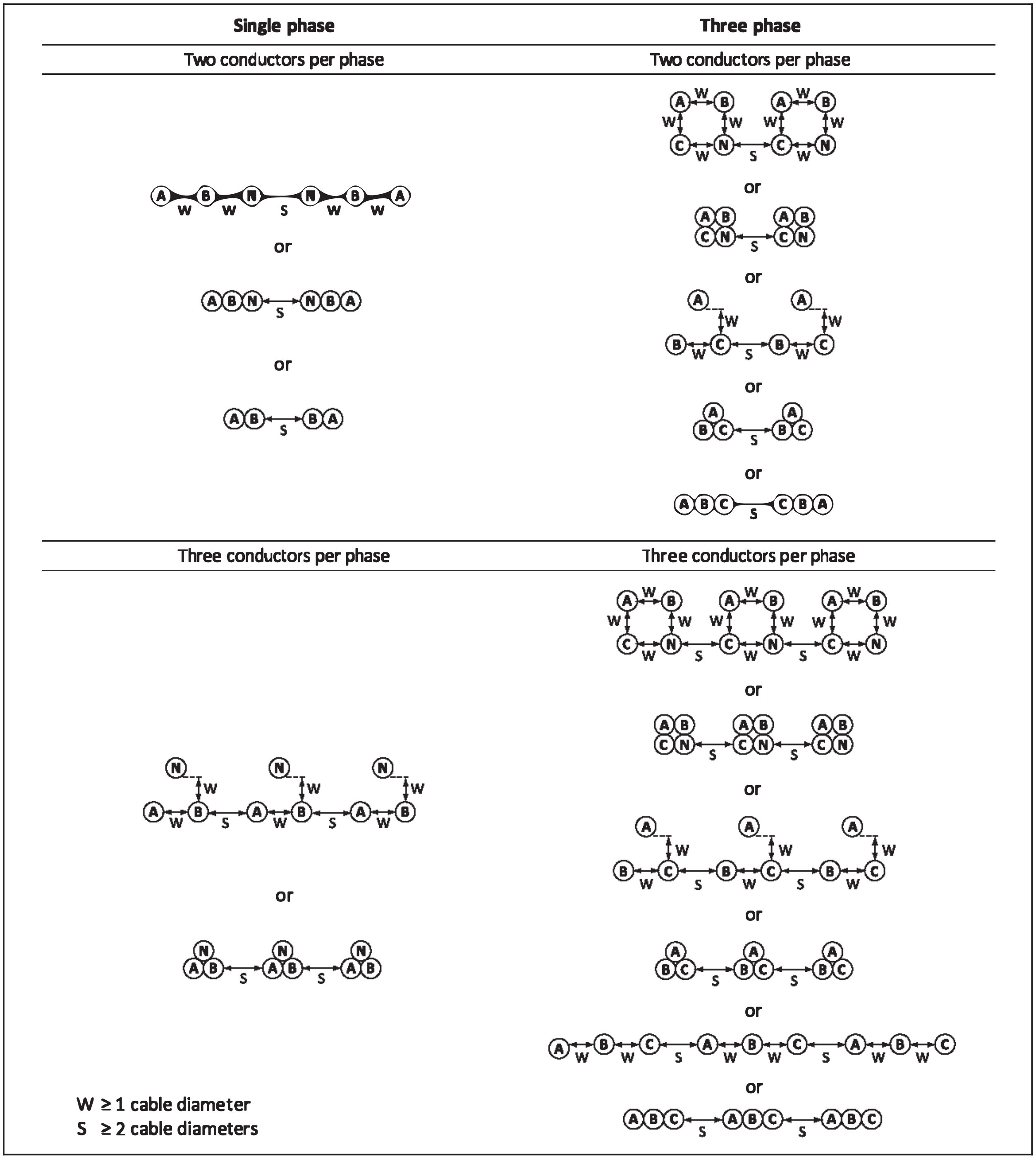
Conductors in sizes smaller than No. 1/0 AWG do not have the same factor of safety built into their ampacity ratings, nor can they handle the same installation stresses as conductors No. 1/0 AWG and larger. Subrule 5) allows conductors to be run in parallel (to reduce their resistance and avoid voltage-drop problems) in sizes smaller than No. 1/0 AWG if:

- the conductors supply control power to specific devices;
- all the conductors are run in one cable;
- each conductor run in parallel can carry the total load; and
- the overcurrent device is equal to or less than the ampacity of each conductor.

To prevent overheating of single-conductor grounded/neutral conductors when run in parallel due to unequal sharing of the grounded/neutral current caused by inductive reactance, Subrule 6) requires that the grounded/neutral conductor be run with each parallel set/group (see Figure 12-7).

Rule 4-018 allows the neutral conductor to be smaller than the ungrounded/phase/line conductors. This could result in a neutral conductor smaller than No. 1/0 AWG being used with phase or polarity conductors No. 1/0 AWG or larger. Therefore, Subrule 7) allows the neutral conductor, when run in parallel with phase or polarity conductors No. 1/0 AWG and larger, to be smaller than No. 1/0 AWG provided these conductors meet all the installation requirements of Subrule 1) other than minimum conductor size.

# Figure 12-7
# Configurations for the installation of parallel single-conductor cables



### Rule 12-110 Radii of bends in insulated conductors and cables

Damage to conductor insulations and cable sheaths can result from excessive bending, strains, or stresses. Rule 12-110 requires that the radii of bends be sized to avoid damage to the conductors and cables, and their insulation or covering. For the actual bending radii of cables, refer to other Rules in the Code (for example, Rules 12-712 and 36-102).

### Rule 12-112 Conductor joints and splices

Conductor joints and splices are to be made to ensure high conductivity (low resistance) and are to be mechanically secure so that the splice or joint does not become loose with normal stresses (movement, vibration, etc.). Subrule 1) requires that joints or splices be made using splicing devices or by brazing, welding, or soldering with a fusible metal or alloy.

Subrule 2) requires that soldered joints and splices be mechanically and electrically secure before soldering as the soldering is not to be relied on for the mechanical strength and conductivity of the joint or splice.

Subrule 3) requires that the insulation applied to the connection be equal to the conductor's insulation voltage rating. Insulating tape with the equivalent insulation rating is suitable for joints and splices with conductors having a voltage rating up to 1000 V. The tape is intended to be applied in layers, each layer being half-lapped.

Subrule 4) requires that all joints and splices be accessible for inspection and maintenance purposes to ensure that the joint or splice does not deteriorate over time. Thermographic imaging is one test method used for testing the reliability of a joint or splice.

Subrule 5) allows underground cables to be spliced [see Subrule 6) of Rule 12-012] if the original electrical installation has been changed due to pole or service relocation or has been damaged. If the splice is located below grade, it is to be made by means suitable for direct buried connections. If splices are located above ground, Subrule 5) requires that, for accessibility, they be in a junction box located 1 m above finished grade and secured to buildings or stub poles.

### Rule 12-114 Ends of insulated conductors

To prevent accidental contact or arcing, the unused ends of insulated conductors are to be insulated (for example, by the use of wire connectors or by the use of insulating tape). See Rule 12-112.

### Rule 12-116 Termination of conductors

Conductor connections at terminations are to be made using materials and methods that ensure that the conductivity is retained. Subrule 1) requires that conductors be terminated by the use of pressure connectors, solder lugs, or splices to flexible leads.

Proper termination of the conductors is important if stranded conductors are used; conductors that are held on by only a few strands can "burn off" or overheat, causing arcing or a fire hazard. Strands not properly confined at their termination point can also come in contact with other conductors or termination points, causing arcing, shorts, or grounds. Subrule 2) requires that stranded conductors be held by wire-binding terminals or solderless wire connectors that confine the strands to prevent arcs, shorts, or grounds.

Subrule 3) allows stranded and solid conductors No. 10 AWG and smaller to be connected by means of wire-binding screws or studs and nuts that have upturned lugs or equivalent.

Subrule 4) requires that stranded and solid conductors larger than No. 10 AWG be terminated in solderless conductor connectors, or they are allowed to be soldered into conductor connectors suitable for the purpose, except where prohibited by Section 10.

## Rule 12-118 Termination and splicing of aluminum conductors

To provide sound performance and service, consideration is to be given to the termination and splicing design for aluminum conductors. Aluminum conductors have been used for overhead transmission lines for nearly 100 years and, due to their lightness, economy, and performance record, are now used in underground distribution and building electrical installations. The basic concerns when connecting aluminum conductors are:

- expansion and contraction;
- conductivity;
- oxide coatings;
- creepage or cold flow; and
- corrosion.

The insulation on the conductors is to be removed carefully because aluminum is less ductile than copper and more easily damaged.

There is usually no problem with a connection when the connector body and the conductor are aluminum due to the compatibility of the metal. When the current flows in the connection, both components expand at the same rate and there is no imbalance when the metals expand. When the connector body is copper and the conductor is aluminum, however, problems arise since the dissimilar metals have different coefficients of thermal expansion. When current flows, the copper expands less than the aluminum, causing a pressure buildup in the connection. To relieve this pressure, the aluminum is forced out, generating a cold flow. The subsequent heating and cooling cycles cause the connection to deteriorate, resulting in a high-resistance termination or splice.

When the bare aluminum is exposed to the air, a non-conductive oxide film is formed on the aluminum conductor. To remove this film and any stray bits of insulation or separation material, Subrule 1) requires that bare aluminum be cleaned using a wire brush.

To prevent the oxide film from re-forming in stranded conductors after cleaning, Subrule 2) requires that, immediately after cleaning, an application of a jointing compound be placed over the bare aluminum before terminating in the connector. The joint compound prevents the air from contacting the bare aluminum and prevents the oxide from re-forming.

Subrule 3) requires that all electrical equipment used with aluminum conductors bear a compatibility mark for the direction of installers and inspectors. Electrical equipment or connectors are to be marked for connecting aluminum conductors. Receptacles suitable for direct connection to aluminum wiring will carry the CU-AL or CO/ALR mark. Connection is made to a screw terminal, either by looping the wire under the screw head or under a screw terminal clamp. Termination of an aluminum wire into a push-in wedge-type terminal is not considered suitable. Where receptacles have push-in wedge-type terminals, the aluminum wire is allowed to be replaced by a copper wire pigtail using a suitable wire connector. Receptacles intended for use with copper or aluminum conductors are marked as shown in Figure 12-8.

## Figure 12-8
## Receptacle markings

**CO/ALR or AL-CU** AND

REPLACE ONLY WITH CO/ALR DEVICE
or REPLACE ONLY WITH AL-CU DEVICE.
NE REMPLACERQUE PAR UN DISPOSITIF
CO/ALR ou NE REMPLACER QUE PAR UN
DISPOSITIF CU-AL.

Marking on receptacles rated 20 A or less
intended for use with copper or aluminum conductors

**AL-CU or CU-AL**

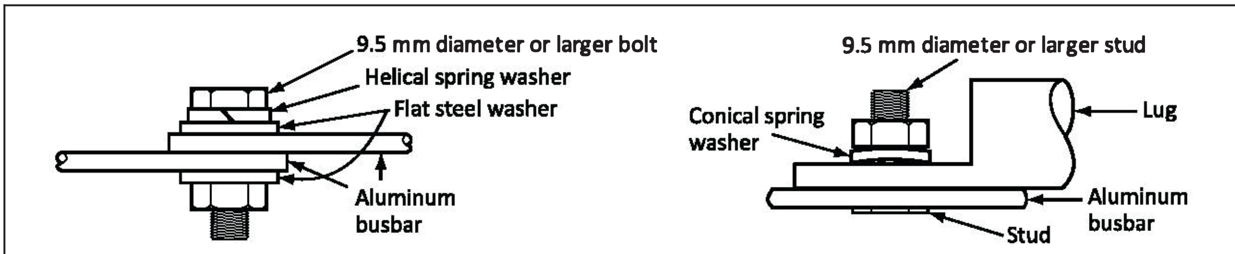
Marking on receptacles rated more than 20 A
intended for use with copper or aluminum conductors

Electrical equipment with only pigtails for the connection is allowed to be connected by the use of wire connectors that are suitable for use with aluminum. Outlet boxes are exempt from receptacle markings since they do not have current-carrying terminal connections. The wire binding screw for terminating bonding conductors is classed as non-current-carrying and experience has shown that the binding screws are reliable.

Corrosion is usually negligible in a dry location. In wet locations, however, it is possible to have some galvanic action; when different metals are used, such connections are to be avoided. If connections are made, the requirement of Subrule 4) calls for connectors to be coated or tinned with an intermediate metal between aluminum and copper in the electrochemical series. In dry locations, a sudden temperature change can cause condensation. A corrosion-inhibiting jointing compound can resolve these galvanic conditions.

Subrule 5) requires that all components of a connection be of the same material to avoid problems with thermal expansion. Since this is not always possible in certain conditions, different methods are allowed to counter the problem of expansion of dissimilar metals (see Figure 12-9).

## Figure 12-9
## Field-assembled connections

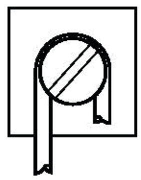



Subrule 6) requires that wiring devices having binding-screw terminals (e.g., receptacles, switches, and lampholders) be connected by looping the aluminum conductor under the screw head for three-quarters of a complete loop (270° clockwise). Aluminum is less ductile than copper and breaks more

readily due to nicking or bending; consequently, care is to be exercised when removing the insulation and when forming the conductor around the terminal screw. See Figure 12-10.

**Note:** *Although not required by the Code, the 270° loop under the screw head, as prescribed for aluminum, also improves the integrity of the connection when terminating copper conductors under the screw head.*

**Figure 12-10**
**Aluminum conductor terminal connection**



### Rule 12-120 Supporting of conductors

To prevent damaging stresses or strains on the termination points, Subrule 1) requires that conductors be supported independently of the electrical equipment termination connections, splices, or joints.

Subrule 2) requires that the weight of conductors installed in vertical raceways not be supported by electrical equipment terminations. When the weight is considerable, the top support alone is not reliable, and intermediate supports are also to be used. Conductors installed in vertical raceways are to be supported in accordance with the distances listed in Table 21.

To prevent damage to the insulation from the weight of the conductor, Subrule 3) requires that the conductors not hang from edges of bushings or from bends supporting the weight of the conductor.

The design and construction of cable types such as TECK90, RA90, RC90, AC90, and ACWU90 do not provide internal support between the sheath or armour and the internal cable assembly. To reduce the strain on conductor terminations, Subrule 4) requires that the internal conductor assembly be supported:

- as specified in Table 21;
- by a minimum bend or bends that total not less than 90° at distances not exceeding those specified in Table 21;
- by a horizontal length run of the cable equal to or greater than the vertical length distance; or
- by a cable designed with vertical supports for the internal cable assembly.

### Rule 12-122 Equipment wire

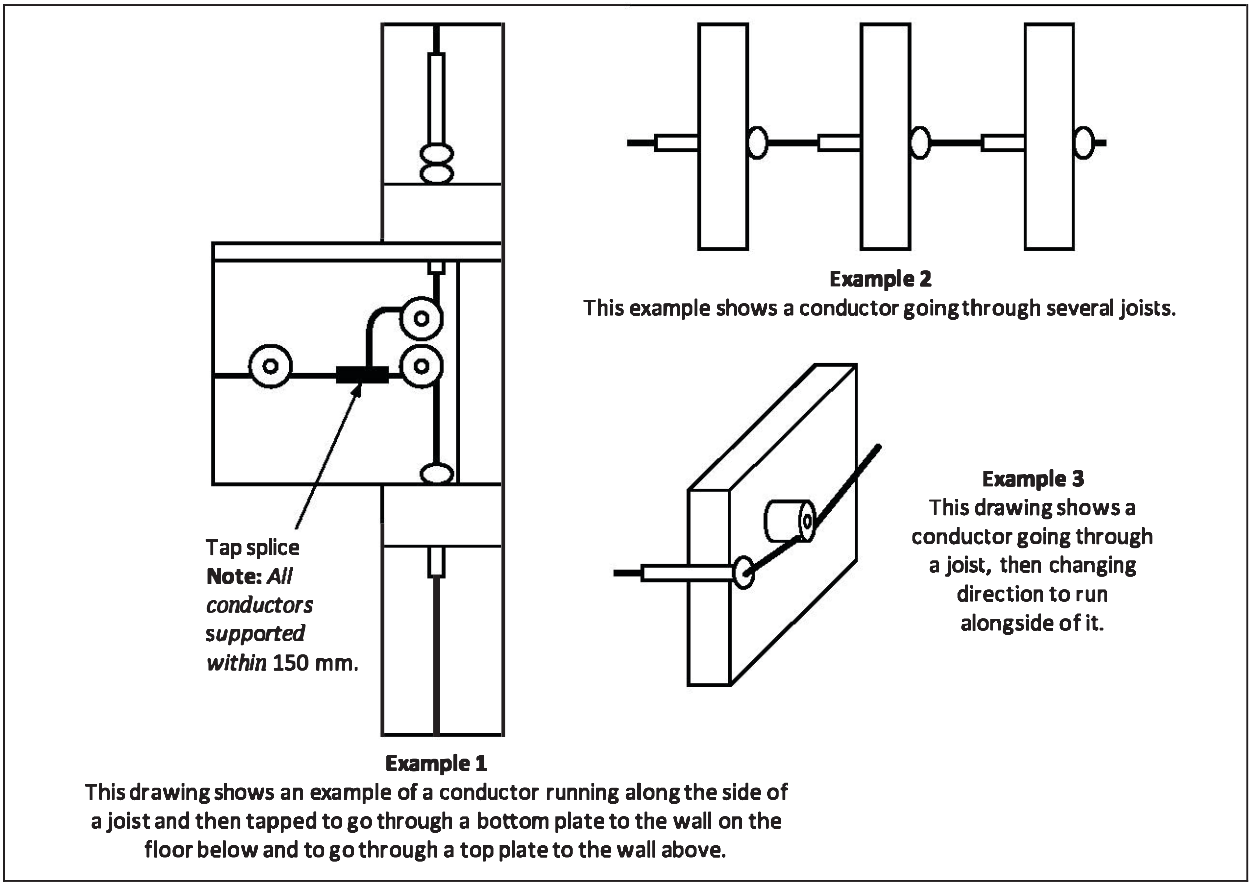
Equipment wire is designed to be used for wiring electrical equipment (for example, luminaires, motor starters, copiers, computers) and is intended to be installed at the time of the manufacture of the equipment. Equipment wire is not designed or tested to meet the stresses associated with being field installed in raceways, enclosures, and equipment, and is not to be used in such applications. Subrule 1) requires that equipment wire be selected in accordance with Table 11 as suitable for the location and specific conditions of use. Subrules 2) and 3) specify the minimum size of equipment wire to be used in various applications.

## Open wiring

### Rule 12-200 Open wiring Rules

Open wiring is a wiring method consisting of single insulated conductors separately supported on insulators. Rules 12-202 to 12-224 give the requirements for open wiring using single insulated conductors mounted in insulators. This Subsection gives many of the requirements for the old knob-and-tube wire systems that are no longer specifically addressed in the Code and can be helpful in finding the requirements for this older system. See Figure 12-11.

## Figure 12-11
## Knob-and-tube wiring installed in framing




### Rule 12-204 Spacing of insulated conductors

Open wiring insulated conductors are to be installed in a manner that provides adequate separation between adjacent conductors and surfaces to prevent shorting between conductors and adjacent surfaces. For the minimum spacing distance see Subrule 1) and Table 12-3.

## Table 12-3
## Open wiring insulated conductor spacings

| **Dry locations – Items a) and b) of Subrule 1) of Rule 12-204** | | |
|---|---|---|
| | **Minimum distance, mm** | |
| **Voltage of circuit** | **Between conductors** | **From adjacent surfaces** |
| 0 to 300 V | 65 | 13 |
| 301 to 750 V | 100 | 25 |
| **Damp locations – Items b) and c) of Subrule 1) of Rule 12-204** | | |
| | **Minimum distance, mm** | |
| **Voltage of circuit** | **Between conductors** | **From adjacent surfaces** |
| 0 to 300 V | 65 | 25 |
| 301 to 750 V | 100 | 25 |
| **All locations – Subrule 2) of Rule 12-204** | | |
| **Minimum distance, mm, between conductors and adjacent metal piping or conducting materials*** | | |
| | 25 | |
| **All locations – Subrule 3) of Rule 12-204** | | |
| **Minimum distance, mm, between conductors when run across open faces of joists, wall-studs, or other timber not exposed to mechanical damage** | | |
| | 150 | |

* *Where practicable, the intention is that conductors be placed over and not under water pipes, to prevent moisture or condensation from dripping onto the conductors.*

When open wiring insulated conductors connect to devices at enclosures or panelboards, or in some other cases, the spacing given in Table 20 cannot be maintained, so Subrule 4) requires that insulated conductors be enclosed in a raceway or insulated tubing to prevent short-circuits.

### Rule 12-206 Insulated conductor supports

Open wiring insulated conductors are to be supported on insulators in a manner that provides continuity of the open wiring system without damage to the conductors or their coverings/insulation. Subrule 1) requires that insulators employed for the support of open insulated conductors be of non-combustible and absorption-resisting material, such as porcelain or glass.

Common types of insulated conductor supports are porcelain knobs (either split or solid) and porcelain cleats. For insulated conductors larger than No. 8 AWG, Subrule 2) prohibits the use of split knobs.

Subrule 3) requires that insulators of the solid type, with tie-wires, be used for conductor sizes larger than No. 8 AWG. Also, the conductors used as tie-wires are to have the same type of insulation as the conductors they secure.

When thermoplastic-type insulation is supported by split knobs or cleats, it can be damaged by the pinching of the split knob or cleat when installed. Thermoplastic insulation when crimped too tightly does not compress effectively and can split. If the holding screw of the split knob or cleat becomes grounded from contact with the metal surface, it can cause a short-circuit. Subrule 4) requires that split knobs or cleats not be used to support thermoplastic-insulated conductors when they are installed on metal surfaces.

### Rule 12-208 Insulated conductors on flat surfaces

Rule 12-208 requires that insulated conductors be rigidly supported to prevent sag between insulators and to maintain the desired spacing from adjacent surfaces. The support intervals between insulators is not to exceed 1.5 m.

### Rule 12-210 Material for attachment of insulated conductor supports

To obtain a rigid method of support, Rule 12-210 requires that knobs and cleats be attached and secured with screws. Incorrect mounting of the supports (for example, with nails) damages the porcelain or glass. In addition, some nails do not hold on certain woods, and if the insulated conductor is not installed correctly, it slackens off at the supports.

### Rule 12-212 Protection from mechanical damage

Insulated conductors are susceptible to damage when they are supported on or run across walls or the open faces of joists, wall-studs, or other timber. In these situations, Subrule 1) requires methods of protection to be:

- running-boards;
- guard-strips;
- wooden boxing; or
- sleeves of iron pipe.

Subrule 2) allows the insulated conductors to be run directly from timber to timber when they are:

- not exposed to mechanical damage;
- not less than No. 8 AWG copper or aluminum;
- separate from each other by a distance not less than 150 mm; and
- supported at each timber.

To prevent mechanical damage to conductors, Subrule 3) requires that open wiring not be run across the tops of ceiling joists in unfinished attics or similar places because these spaces are often used for storage, access, insulation installation, etc.

### Rule 12-214 Material for running-boards, guard-strips, and boxing

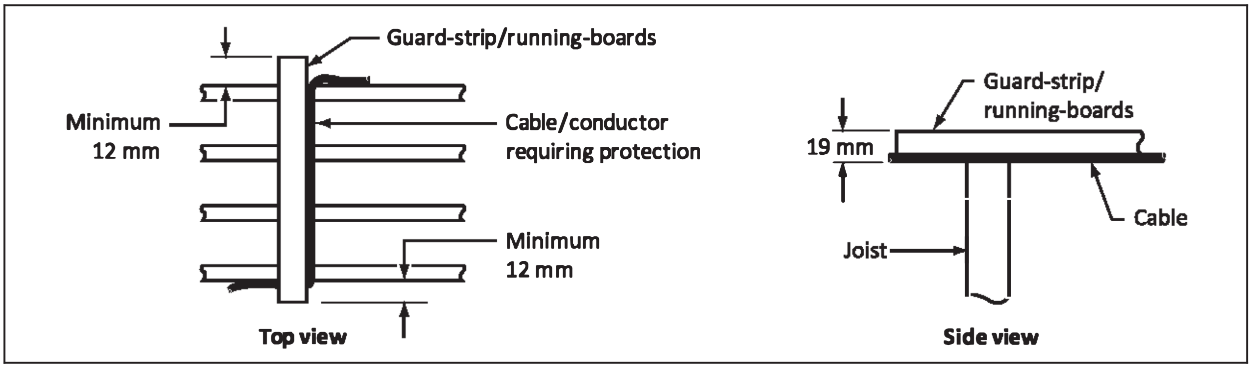
The choice of protection is governed by the conditions and locations in which the insulated conductors are exposed to mechanical damage.

Subrule 1) requires that the material used for mechanical protection be at least 19 mm thick and, when used as running boards, extend at least 12 mm beyond the sides of the supporting insulators. See Figure 12-12.

Subrule 2) requires that guard strips and side protection strips of running boards be at least equal to the height of the support insulators and as close to the insulated conductors as allowed in Table 20.

When wooden boxing is used, Subrule 3) requires that there be a clear space within the box of at least 25 mm between insulated conductors and adjacent surfaces of the box. Also, when the ends of the box are not against the building structure, they are to be closed.

## Figure 12-12
## Material for running-boards, guard-strips, and boxing




### Rule 12-216 Ends of insulated conductors

Dead-ends of insulated conductors are to be rigidly supported to prevent any slackening between supports. When insulated conductors are to be dead-ended at fittings (for example, lampholders or receptacles), Subrule 1) requires that the insulator supports be within 300 mm of the fitting.

When insulated conductors No. 8 AWG and larger are dead-ended, they put extra stress on the dead-end supports. Subrule 2) requires that they be dead-ended by the use of solid knobs or strain insulators.

### Rule 12-218 Insulated conductors passing through walls or floors

To prevent mechanical damage to the insulated conductors when they pass through walls, floors, timbers, or partitions, Rule 12-218 requires that they be installed in raceways or insulating tubing.

### Rule 12-220 Maintaining clearances

Rule 12-220 requires that conductors not be in contact with any surface or object except their supporting insulator. When clearances cannot be maintained at the surface-mounted devices, sub-bases are to be installed.

## Exposed wiring on exteriors of buildings and between buildings on the same premises

### Rule 12-300 Exterior exposed wiring Rules

The exterior exposed wiring method is similar to the open wiring method, except that the wiring is run outside on the exterior surfaces of buildings or between buildings on the same premises. Rules 12-302 to 12-318 apply only to exposed wiring.

### Rule 12-302 Types of insulated conductors and cables

Insulation on the conductors and cables used on the exterior of buildings is to be as listed in Table 19 as suitable for exposure to weather.

### Rule 12-304 Location of insulated conductors and cables

Subject to the provisions of Rule 6-112, where insulated conductors and cables are supported on or in close proximity to the exterior surfaces of buildings, they are:

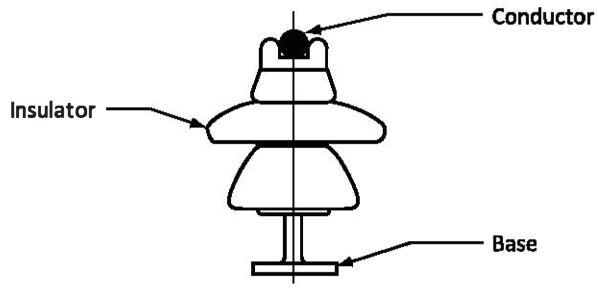
- to be installed and protected so that they are not a hazard to persons or exposed to mechanical damage; and
- not to be less than 4.5 m from the ground unless a deviation has been allowed in accordance with Rule 2-030.

Where the insulated conductors and cables are exposed to mechanical damage from awnings, swinging signs, shutters, or other movable objects, Subrule 2) requires that they be run in rigid conduit that is to be made watertight.

### Rule 12-306 Insulated conductor and cable supports

Petticoat insulators (see Figure 12-13) are designed to handle greater conductor sizes, weights, and stresses. When petticoat insulators are used, Subrule 2) permits the support intervals to be increased to not more than 4.5 m and requires that they be kept 300 mm from adjacent insulated conductors and at least 50 mm from adjacent surfaces.

**Figure 12-13**
**Typical petticoat insulator**




When insulated conductors and cables are not exposed to the weather (for example, under overhangs), Subrule 3) allows the insulated conductors and cables to be supported on glass or porcelain knobs at intervals of not more than 1.5 m and with at least 25 mm separation from adjacent surfaces.

### Rule 12-314 Conductors on trestles

When a deviation under Rule 2-030 has been granted allowing conductors to pass over a building, the conductors must be provided with their own means of support, independent of the building, to avoid third-party involvement. Where a means of self-support is not obtainable, the conductors may be mounted on trestles, provided that the clearances of Rule 12-310 are maintained. The trestles are to be designed to bear the mechanical forces likely to be exerted on them by the conductors in the particular installation. To determine these forces, consideration must be given to potential ice and wind loading, as well as the conductor weight.

### Rule 12-316 Power supply insulated conductors and cables

Rule 12-316 is intended to prevent higher power voltages from being impressed on the communication circuits.

### Rule 12-318 Use of neutral supported cables

The intent of Rule 12-318 is to allow neutral supported cable to be used for:

- single-phase, 3-wire, or three-phase, 4-wire, circuits, in which the supporting wire acts as a neutral conductor; and
- single-phase, 2-wire, or three-phase, 3-wire, circuits, in which the supporting wire is not used as a circuit conductor.

## Flexible cables

### Rule 12-400 Flexible cord Rules

Rules 12-402 to 12-406 apply only to the installation of flexible cord.

### Rule 12-402 Uses of flexible cord

A flexible cord is a cable with multiple conductors used for functions requiring flexibility. Flexible cords can be employed for a range of power applications, such as operating motors in small and large tools and equipment, power extensions, home appliances, and machinery.

Flexible cords are allowed to be used in commercial, industrial, and residential applications. They work well on job sites where resistance to oil, chemicals, and abrasion is a requirement and also perform well in extreme environments, both in the heat and the cold, and either outside or inside. Additionally, some flexible cords can be water-resistant or water-submersible. Due to their characteristics, flexible cords are commonly used in a range of facilities, such as construction sites, mills, mines, sports complexes, or even marinas.

Although the construction of a flexible cord varies depending on the type, a standard flexible cord has at least two bunch stranded insulated copper conductors. The copper stranding, insulation, and jacket directly influence the physical properties of the cord. Flexible cord usually comes with a non-metallic outer sheath. It is used in electrical installations for single- or three-phase systems with voltage ratings of 750 V or less, most commonly when an application requires a flexible connection or when it is important to avoid transmitting vibration (for example, connecting portable equipment or vibrating motors; running pendant cords to cranes and movable cutting heads). Flexible cord satisfies these requirements through its construction: it uses bunch stranding consisting of numerous fine strands of wire, in no particular pattern, with an insulating covering that allows flexing. Flexible cord comes in three types (see Table 11):

- not for hard usage — a cord intended for use with light equipment, classified as the lowest grade in mechanical serviceability;
- for hard usage — a cord intended for use with moderately heavy equipment and for handheld appliances and tools, classified as the medium grade in mechanical serviceability; and
- for extra-hard usage — a cord intended for use with heavy equipment and for handheld appliances and tools, classified as the highest grade in mechanical serviceability.

See Table 12-4 for characteristics of the three types of flexible cords.

**Table 12-4**
**Characteristics of flexible cords**

| Characteristics | Types of flexible cords | | |
|---|---|---|---|
| | **Not for hard usage** | **For hard usage** | **For extra-hard usage** |
| Voltage rating | 300 V | 300 V | 600 V |
| Insulation temperature rating | 60, 75, or 90 °C | 60, 75, 90, or 105 °C | 60, 75, 90, or 105 °C |
| Number of conductors | 2 or 3 | 2 to 6 | 2 or more |
| Weather resistance tested | No | Yes | Yes |

Table 12-5 lists the colours used on insulated conductors found on flexible cords having up to four wires, as well as the applications corresponding to the colour codes.

## Table 12-5
## Flexible cord applications and conductor colour coding

| Conductor combination | Number of insulated conductors | Application |
|---|---|---|
| Black, white | 2 | For use where grounding is not required on a 2-wire circuit having an identified neutral conductor |
| Green, black, white | 3 | For use where grounding is required on a 2-wire circuit having an identified neutral conductor |
| Green, black, red | 3 | For use where grounding is required on a 2-wire circuit having no identified neutral conductor |
| Brown, light blue, green/yellow | 3 | For use when international colour coding is required |
| Green, black, red, white | 4 | For use where grounding is required on a 3-wire circuit having an identified neutral conductor |
| Green, black, red, blue | 4 | For use where grounding is required on a 3-wire (three-phase) circuit having no identified neutral conductor |

Since flexible cord is an easily misused product, Subrule 1) requires that Table 11 be used to determine the types of cord that are allowed to be used under specific conditions with respect to exposure to:
- moisture;
- corrosive action;
- temperature;
- degree of enclosure; and
- exposure to mechanical damage.

Subrule 2) lists in more detail the applications in which flexible cord is allowed to be used as a wiring method. In general, such applications involve:
- electrical equipment intended to be moved from one place to another (for example, appliances, cranes, passenger ropeways and conveyors, machinery that accommodates different processes);
- electrical equipment that requires a flexible connection (for example, pendants for controls, sump pumps, pool pumps); and
- the prevention of excessive noise or vibration associated with some equipment (for example, motors, compressors, industrial equipment).

Subrule 3) prohibits flexible cord from being:
- used as a substitute for the fixed wiring of an installation, which becomes fixed wiring when it is:
  - permanently supported to any structural member of a building;
  - run through walls, ceilings, or floors; or
  - run through doorways, windows, or comparable openings;
- installed in ambient temperatures above or below the cord's temperature rating; and
- used to suspend a device weighing more than 2.3 kg unless the assembly is marked for supporting a weight up to 11 kg.

Subrule 4) requires that flexible cord be protected from damage by an insulated bushing or other means of protection when the cord enters or passes through enclosure walls or device partitions or enters a lampholder.

When flexible cord is used as an extension cord, Subrule 5) requires that there not be any exposed live parts on the fittings used at either end of the extension cord when one end is connected to a source of supply and the other end is free.

### Rule 12-404 Flexible cord used in show windows or show cases

Flexible cord used in show windows or show cases can be used for various different tasks that require it to have a medium grade of mechanical serviceability; therefore Subrule 1) requires that, except for chain-type luminaires, flexible cords be of the hard-usage type.

Subrule 2) allows the use of flexible cord to supply current to portable lamps and other devices for exhibition purposes.

### Rule 12-406 Uses of portable power cable

The uses of portable power cable are similar to the uses of flexible cords covered in Rule 12-402 (see the explanation provided for Rule 12-402 in this Handbook). In general, as required by Subrule 1), Table 11 is to be used to determine the type of portable power cable suitable for the location and condition of use.

Subrule 2) lists in more detail the applications in which portable power cables are allowed to be used as a wiring method. In general, such applications involve electrical equipment:

- intended to be moved from one place to another (for example, appliances, cranes, passenger ropeways and passenger conveyors, machinery that accommodates different processes);
- that requires a flexible connection (for example, pendants for controls, sump pumps, pool pumps); and
- requiring the prevention of excessive noise or vibration associated with some equipment (for example, motors, compressors, industrial equipment).

Subrule 3) prohibits portable power cable from being:

- used as a substitute for the fixed wiring of an installation, which is considered fixed wiring when it is:
  - permanently supported to any structural member of a building;
  - run through walls, ceilings, or floors; or
  - run through doorways, windows, or comparable openings; or
- installed in ambient temperatures above or below the cable's temperature rating.

Subrule 4) provides an exemption from the requirements of Subrule 3) to allow Type DLO cable in sizes 1/0 or larger to be used in permanent installations in cable tray provided that the cable:

- is marked as Type TC cable;
- conforms with conditions of use for Type TC cable in accordance with Rule 12-2202 and as listed in Table 19;
- terminates in connectors marked for use with fine-strand cables; and
- has an ampacity rating as described in Table 12E and Rule 4-004.

Where portable power cable enters or passes through the wall of an enclosure or fitting, Subrule 5) requires that it be protected in accordance with Rule 12-3022.

Subrule 6) requires that where a single-conductor Type DLO cable is installed in accordance with Subrule 4), the installation comply with Subrules 3) to 6) of Rule 4-008.

## Non-metallic-sheathed cable

**Rule 12-500 Non-metallic-sheathed cable Rules**
Non-metallic-sheathed cable (NMSC) is a cable with an assembly of two, three, or four insulated conductors contained in a non-metallic sheath. It is a wiring method where the cable can be fastened directly to the surface in either exposed or concealed locations. Its advantage over the open wiring method is that the sheath gives abrasion protection over the entire length of the conductor.
Rules 12-502 to 12-526 list the requirements for non-metallic-sheathed cable installation.

**Rule 12-502 Maximum voltage**
Non-metallic-sheathed cable has a continuous outer sheath made of thermoplastic material that does not give the insulated conductors much mechanical protection. To limit the potential for shock, Rule 12-502 limits the voltage between conductors to 300 V.

**Rule 12-504 Use of non-metallic-sheathed cable**
Non-metallic-sheathed cable can be used in buildings of combustible construction provided that it has the flame spread rating required by Rule 2-130 (i.e., FT1). Also, non-metallic-sheathed cable is allowed to be used in other types of construction such as non-combustible buildings where allowed by the authority having jurisdiction (AHJ).

**Rule 12-506 Method of installation**
The temperature ratings of non-metallic-sheathed cable vary from 60 to 90 °C. This cable is required to be installed in locations with an ambient temperature not exceeding 30 °C. When the cable is installed adjacent to heat sources (for example, near heating pipes or ducts, masonry or concrete chimneys, and chimney and flue cleanouts), the clearances provided from the different heating sources depending on the intensity of the heat source are to be as given in Subrule 4) (see Figures 12-14 and 12-15).

**Figure 12-14**
**Typical installation of non-metallic-sheathed cable close to hot air heating duct**

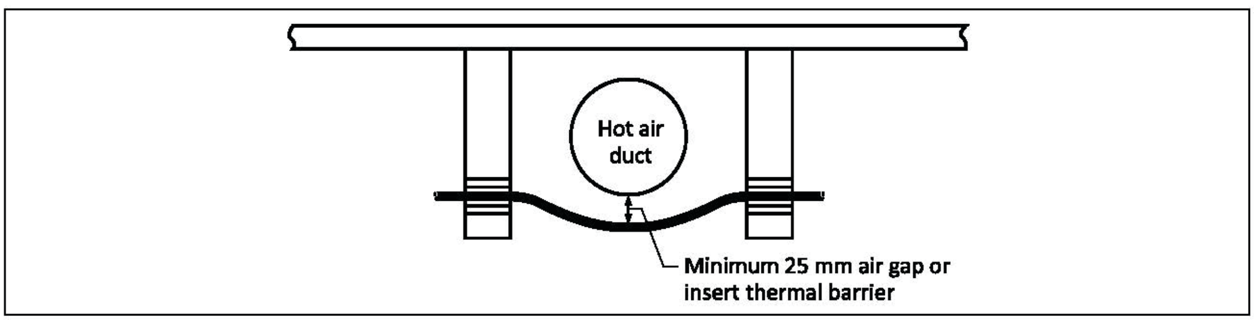
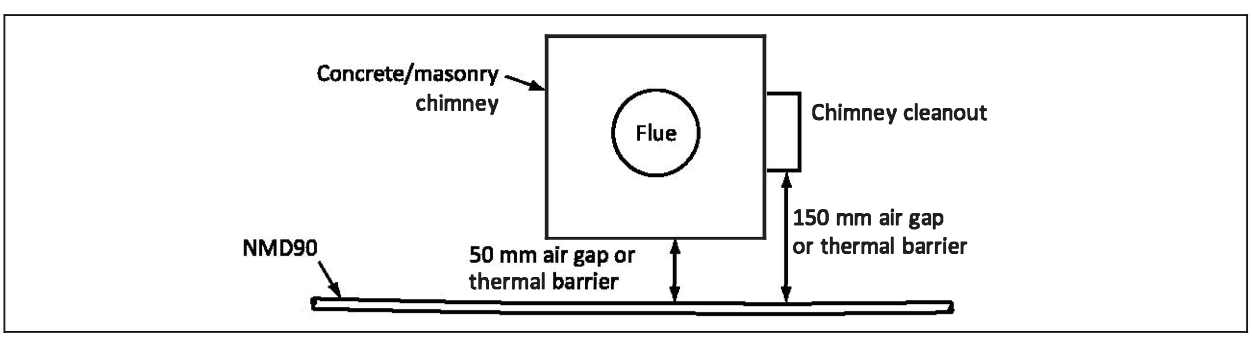



**Figure 12-15**
**Typical installation of non-metallic-sheathed cable close to chimneys and cleanouts**



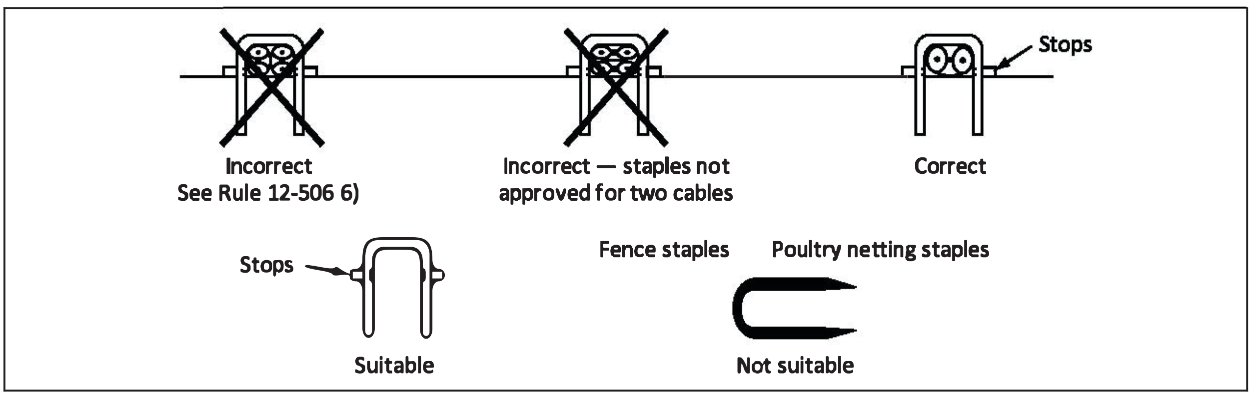
Subrule 5) allows an exemption from the clearances given in Subrule 4) when a thermal barrier conforming to the requirements of the *National Building Code of Canada* or local building legislation is installed between the cable and heating sources to maintain ambient temperature at the cable at not more than 30 °C.

Subrule 6) requires that two-conductor non-metallic-sheathed cables not be stapled on edge. Stapling on edge can damage the cable by driving the insulation of the current-carrying conductors into the bare bonding conductor, creating an arc or fire hazard. See Figure 12-16.

### Rule 12-508 Bending and stapling of cable

Staples with stops are required to be used to limit the depth of penetration so that the insulated conductor or the outer cable sheath is not damaged (see Figure 12-16). Staples are tested using a single non-metallic sheathed cable so unless the staples are so marked they are only to be used with one cable. Unapproved staples such as fence or poultry netting staples are not allowed.

**Figure 12-16**
**Typical staple for armoured cable, flexible metal conduit, and non-metallic-sheathed cable**




### Rule 12-510 Running of cable between boxes and fittings

Non-metallic-sheathed cables are to be supported in a manner that does not damage them. Subrule 1) requires that the cable be supported by straps, Type 2S or Type 21S cable ties, or other devices. The supports are to be located:

- at intervals of not less than 1.5 m throughout the run to prevent the cable from sagging; and
- within 300 mm of a box or fitting to support and prevent the cable from being pulled away from the box or connector.

**Note:** *See Table 12-6.*

Subrule 2) considers NMSC run through holes in joists or studs to be supported.

When it is impractical to support the NMSC such as when it is fished in hollow spaces of walls and ceilings or other non-accessible locations, Subrule 3) allows the cables to be installed without means of support except where metal sheeting or cladding, metal joists, metal top or bottom plates, or metal studs are used (see Rule 12-520).

Subrule 4) allows the use of self-contained devices in lieu of a device box. Self-contained devices are wiring devices with an integral enclosure that have brackets that securely fasten the device to walls or ceilings of conventional frame construction, for use with non-metallic-sheathed cable. Self-contained devices are used in dry locations and are primarily used in mobile homes, recreational vehicles, manufactured buildings, and on-site frame construction.

**Note:** *CAN/CSA-C22.2 No. 62275 recognizes six types of cable ties: Types 1, 11, 2, 21, 2S, and 21S. See Table 12-6 for types for support of non-metallic sheathed cables (Rule 12-510); mineral-insulated cable, aluminum-sheathed cable, and copper-sheathed cable (Rule 12-706); flexible metal conduit (Rule 12-1010); liquid-tight flexible conduit (Rule 12-1308); and electrical non-metallic tubing (Rule 12-1504).*

## Table 12–6
## Cable ties — Types and uses

| | |
|---|---|
| Type 1 and Type 11* | Approved type of cable tie but not specifically approved to provide primary support for a flexible conduit, flexible tubing, or cable in accordance with the Code.<br>**Examples of uses:** In approved equipment, used to bundle wires for circuit identification or to maintain critical spacings in cabinets; or to otherwise provide supplemental means for routing wires, flexible conduits, flexible tubing, or cables. |
| Type 2 and Type 21* | Approved type of cable tie but not specifically approved to provide primary support for a flexible conduit, flexible tubing, or cable in accordance with the Code.<br>**Examples of uses:** In approved equipment, used to bundle wires for circuit identification or to maintain critical spacings in cabinets; or to otherwise provide supplemental means for routing wires, flexible conduits, flexible tubing, or cables. |
| Type 2 also identified with AH-2 | Approved type of cable tie but not specifically approved to provide primary support for a flexible conduit, flexible tubing, or cable in accordance with the Code.<br>**Examples of uses:** In approved equipment, used to bundle wires for circuit identification or to maintain critical spacings in cabinets; or to otherwise provide supplemental means for routing wires, flexible conduits, flexible tubing, or cables; and suitable for use in air-handling spaces (plenums) in accordance with Subrules 3), 4), and 5) of Rule 12-010 and Rule 12-020. |
| Type 2S and Type 21S* | Specifically approved to provide primary support for flexible conduit, flexible tubing, or cable in accordance with the Code. |
| Type 2S and Type 21S* also identified with AH-2 | Specifically approved to provide primary support for a flexible conduit, flexible tubing, or cable in accordance with the Code, and suitable for use in air-handling spaces (plenums) in accordance with Subrules 3), 4), and 5) of Rule 12-010 and Rule 12-020. |

** For the purposes of the Code, Type 1 is identical to Type 11, Type 2 is identical to Type 21, and Type 2S is identical to Type 21S.*

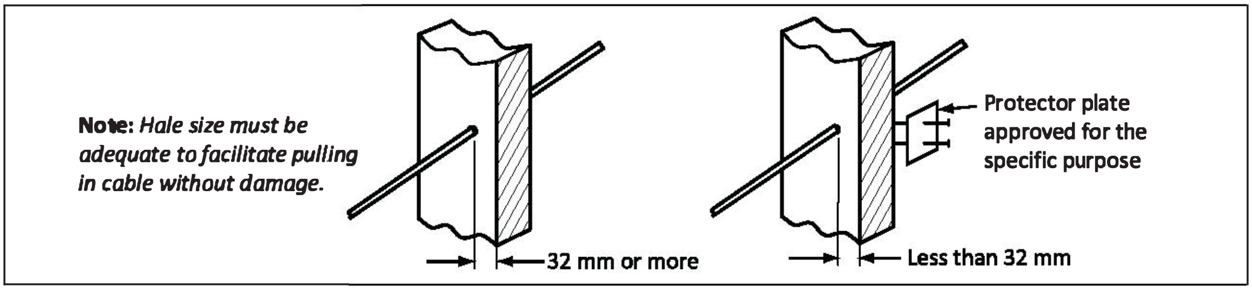
### Rule 12-512 Not to be embedded

Rule 12-512 requires that NMSC not be embedded in plaster, cement, or similar finishes since these materials are wet when installed and can react with and damage the outer covering and the insulated conductors of the cable. Also, if the cable is punctured with a metal object (for example, a nail or picture hanger), it can energize the exposed metal object, creating a shock hazard, since the metal object can puncture the energized insulated conductor without coming in contact with a grounded conductor, bonding conductor, or grounded surface.

## Rule 12-516 Protection for cable in concealed installations

Rule 12-516 requires that the NMSC be protected from damage by either location or mechanical means (see Figure 12-17). Subrule 1) requires that when cables pass through studs, joists, or similar members, protection be provided where the outer surface of the cable is less than 32 mm from the nearest edge of a member. Protection is to be in the form of a protection plate that covers the width of the member, or a cylindrical bushing that allows the cable to pass through and is sized for the hole through the member, extending a minimum of 13 mm beyond both sides of the member. This protection is intended to safeguard the cable from damage from such causes as penetration by nails or drywall screws.

**Figure 12-17**
**Cable protection**




## Rule 12-518 Protection for cable in exposed installations

The outer jacket of non-metallic sheathed cables is not designed to adequately protect the inner insulated conductors from mechanical damage. Rule 12-518 requires that NMSC be protected from mechanical damage when the exposed cables:

- pass through floors;
- are located less than 1.5 m above the floor; or
- are exposed to potential damage.

This can be accomplished by such means as providing metal conduit or guard strips or by installing the cables in a location where there is no potential hazard.

## Rule 12-520 Fished cable installation

This Rule covers the requirements for situations where, due to conditions of building construction, the NMSC is installed in enclosed walls and ceiling spaces in existing buildings (in new buildings, NMSC can be installed prior to walls and ceilings being closed in by drywall or by other wall or ceiling finishing materials). One of the methods of installing electrical wiring in these locations is called fishing, which is pulling electrical cable through or down walls and across ceilings of an existing construction using a pulling wire or fish that has been inserted or fished through the ceiling and walls. This method allows the cable installation to be done with minimal damage to the wall or ceiling finish. When cables are fished in an installation, it is not feasible to provide the supports required by Rule 12-510. Rule 12-520 allows such cables to be installed without the required supports.

With the wider use of metal components in construction, the fishing of non-metallic cables could potentially damage the outer non-metallic-sheathed cable covering and/or insulation on the conductors in the cable. If this occurs, there is a chance of energizing the metal components of the wall or ceiling construction creating a potential electric shock hazard. Rule 12-520 also requires that where metal sheeting or cladding, metal joists, metal top or bottom plates, or metal studs are used, non-metallic-sheathed cables not be fished.

## Rule 12-522 Where outlet boxes are not required

When non-metallic-sheathed cable is installed in exposed locations, switches, outlets, and tap devices of insulated material (for example, a combination device made up of an integral box and device) are allowed to be used instead of boxes.

Subrule 2) requires that the openings in insulated devices form a close fit around the outer covering of the NMSC when the cable enters the devices to prevent the entrance of dirt or moisture that could cause an arc or shorting hazard.

### Rule 12-524 Types of boxes and fittings

The intent of Subrule 1) is to ensure that boxes and fittings used with NMSC be of a type that is suitable for use with this type of cable.

Subrule 2) allows non-metallic outlet and device boxes and covers to be used, provided that they have a fire-resisting composition.

### Rule 12-526 Provision for bonding

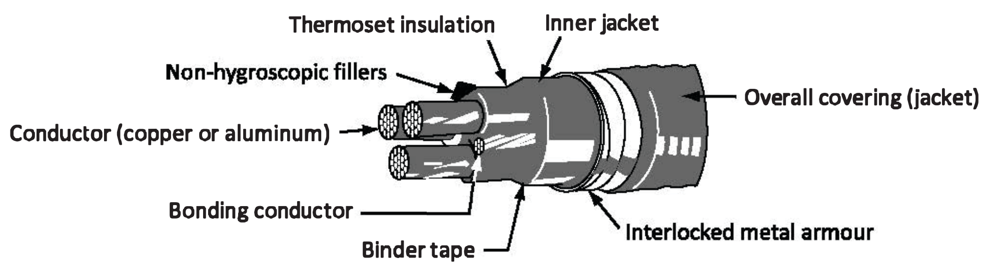
Rule 12-526 requires that all electrical equipment connected by non-metallic-sheathed wiring methods be bonded to ground in accordance with the requirements of Section 10. A bare bonding conductor is incorporated in the cable assembly for bonding purposes.

## Armoured cable

### Rule 12-600 Armoured cable Rules

Armoured cable is a suitable wiring method for concealed work, due to its flexibility, and for exposed work where appearance is not a concern. The metal armour sheath, made of either steel or aluminum strip, provides mechanical protection for the insulated conductors (see Figure 12-18). The cable armour (or the cables incorporating an internal copper or aluminum strip that is in contact with the armour) does not constitute a bonding conductor. Cables with aluminum armour have the letters "AL" indented or embossed in the armour.

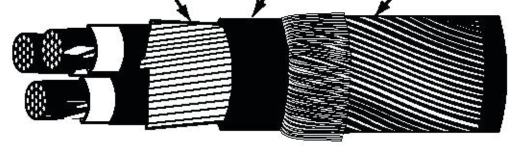
**Figure 12-18**
**Armoured cable TECK90**




### Rule 12-602 Use

Subrule 1) allows armoured cables to be used in buildings of either combustible or non-combustible construction due to the protection provided for the insulated conductors by the metal-armoured sheath. The construction of steel wire armour (SWA) cables (see Figure 12-19) provides high tensile strength, but where subject to mechanical damage, such as puncture, it might provide less protection than that of interlocking armour cables. The Appendix B Note to Rule 12-602 advises users to consider the particular application before using SWA cables.

## Figure 12-19
## Steel wire armour (SWA) cable




Subrule 2) allows armoured cables to be used under the conditions of use indicated in Table 19 (see Figure 12-20). If the cable is suitable for use for direct earth burial, it is also allowed to be used for:

- underground services (see Rule 6-300);
- underground runs;
- circuits in masonry or concrete, provided that the cable is encased or embedded in at least 50 mm of the masonry or concrete; or
- locations in which it is exposed to weather, continuous moisture, excessive humidity, oil, or other substances having a deteriorating effect on the insulation.

Subrule 3) requires that armoured cable with aluminum armour that is suitable for direct burial not be embedded in steel-reinforced concrete (see Figure 12-20), unless the:

- concrete does not contain chloride additives; or
- armour has been treated using bituminous paint, has a PVC outer jacket, or other means to prevent any galvanic action.

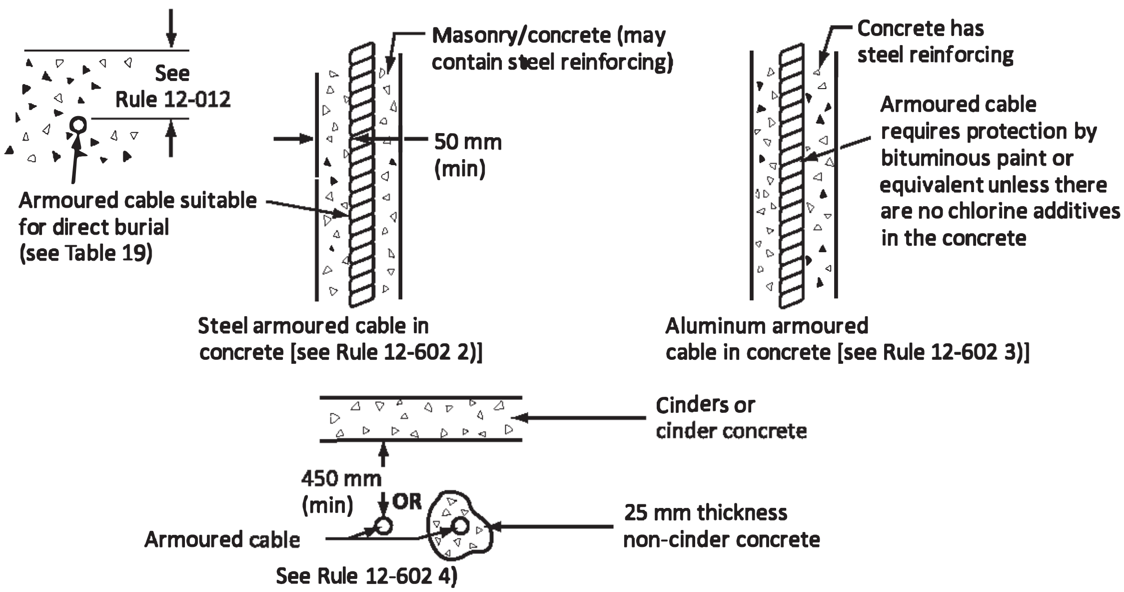
Subrule 4) requires that extra protection be provided when armoured cables are installed in areas containing cinders or cinder concrete. Cinders are a product of burning bituminous coal containing sulphur. With moisture, a galvanic action is established that attacks the armour. The extra protection is allowed to take the form of embedding the cable in at least 25 mm of non-cinder concrete. However, no extra protection is required if the cables are located more than 450 mm beneath the cinders or cinder concrete since it is believed that the corrosive materials will have been diluted by that depth.

In buildings of non-combustible construction, Subrule 5) allows armoured cable not having conductors larger than No. 10 AWG to be run exposed on the face of masonry or other construction materials, or to be buried in plaster provided that the cable is for extensions from existing outlets only.

Subrule 6) allows the installation of jacketed armoured cables in raceways where the following requirements are met:

- the requirements in Subrule 3) of Rule 12-614 for the minimum bending radii of the conduit or tubing; and
- the requirements in Subrule 2) of Rule 12-902 for the conduit fill, the pulling tension, and the length of cable allowed.

## Figure 12-20
## Use of armoured cable suitable for direct burial




**Note:** *Some jacketed-armoured cable can be used instead of paint where the jacket is resistant to the chlorine additives in the concrete. The manufacturer of the cable should be consulted.*

### Rule 12-604 Protection for armoured cables in lanes
When armoured cable is installed in locations subject to mechanical damage (for example, on poles or on the face of buildings adjacent to vehicular traffic) and less than 2 m above grade, Rule 12-604 requires that it have mechanical protection in the form of a No. 10 MSG steel guard.

### Rule 12-606 Use of thermoplastic-covered armoured cable
Rule 12-606 requires that armoured cables provided with a thermoplastic outer covering and suitable for direct earth burial be used only in locations where the covering is not subject to damage. Such locations might include those described in Subrule 4) of Rule 12-012, where the cables are embedded in sand or screened earth.

### Rule 12-608 Continuity of armoured cable
Armoured cables consist of single strips of interlocking steel or aluminum and provide good mechanical strength and flexibility. For mechanical and electrical continuity, Rule 12-608 requires that the armoured cable be handled with care so as not to open the armour convolutions and be securely fastened to electrical equipment. Electrical continuity is important for bonding of the armour to ground. Mechanical continuity is obtained when the cable is securely supported on runs between and to equipment, in accordance with Rule 12-510. For a good mechanical and electrical connection, the armour of the cable is to be gripped securely by the box connector or cable clamp.

### Rule 12-610 Terminating armoured cable
To prevent abrasion or cutting by the sharp edges of armour, Subrule 1) requires that the conductor's insulation be protected by the use of insulated bushings (sometimes called anti-short bushings), inserts, or equivalent devices inserted between the insulated conductors and the inside of the armour at the point where the:

- armour has been cut and removed; or
- inner jacket of an armoured cable, when provided, does not extend a minimum of 5 mm beyond the armour.

Subrule 2) requires that insulated conductors No. 8 AWG or larger be provided with protection in the form of:

- insulated bushings or hubs with a smooth, rounded throat; or
- insulated material that is securely inserted to separate the armour and conductor's insulation.

Subrule 3) requires that the connectors or clamps be designed to allow visual inspection after installation of the protective insulated devices.

Subrule 4) requires that when conductors come out of the end of an armoured cable to connect to open wiring, to protect the conductors from contacting the armour, a fitting be used on the end of the cable with a separately bushed hole for each conductor.

### Rule 12-612 Proximity to knob-and-tube and non-metallic-sheathed cable systems

Armoured cable is not to be fished in locations where concealed knob-and-tube wiring or non-metallic-sheathed cables have been installed. The armoured cables could damage the insulation on the conductors or cables, causing arcing or shorting and creating a potential fire hazard or loss of power to circuits or equipment.

### Rule 12-614 Radii of bends in armoured cables

The intent of Rule 12-614 is to restrict the radii of bending to prevent the opening of the interlocking armour and exposure of the conductor assembly. Subrules 1) and 2) require that, during installation, the radius of a bend be at least 6 times the external diameter of the cable and be made without undue distortion to the armour sheath or damage to the insulation on the conductors inside the armour sheath.

To prevent damage to the armour sheath and inner insulated conductors due to the increased pulling tension required when pulling in armoured cable into a raceway system as allowed in Subrule 6) of Rule 12-602, Subrule 3) requires that the bending radius of the raceway bends be increased to a minimum of:

- 10.5 times the diameter of the cable for low-voltage armoured cable;
- 18 times the diameter of the cable for high-voltage armoured cable; or
- the diameter specified by the cable manufacturer.

**Note:** *When pulling armoured cable into a run of conduit or tubing, Subrule 2) of Rule 12-902 requires that the calculated maximum pulling tension or the calculated maximum sidewall bearing pressure not be exceeded and the radius of the bends in the conduit or tubing be increased to not less than 0.944 m for cable rated 1000 V or less and 1.524 m for cable rated in excess of 1000 V. It also requires that the length of armoured cable being pulled not be greater than*

- *for copper conductor armoured cable:*
  - *15 m for a three-conductor cable; or*
  - *45 m for a single-conductor cable; and*
- *for aluminum armoured cable:*
  - *35 m for a three-conductor cable; or*
  - *100 m for a single-conductor cable.*

### Rule 12-616 Concealed armoured cable installation

Subrule 1) requires that the armoured cables be protected from damage by either location or mechanical means. When cables pass through studs, joists, or similar members, protection is required where the outer surface of the cable is less than 32 mm from the nearest edge of a member. Permitted forms of protection include steel plates or metal sleeves to protect the cable from damage such as penetration of nails or drywall screws.

# Mineral-insulated cable, aluminum-sheathed cable, and copper-sheathed cable

## Rule 12-700 Mineral-insulated cable, aluminum-sheathed cable, and copper-sheathed cable Rules

Mineral-insulated (MI) or lightweight mineral-insulated (LWMI) cable, aluminum-sheathed cable, and copper-sheathed cable are single- and multi-conductor metal-sheathed wiring systems. In mineral-insulated cable, the conductors are spaced and insulated by densely compressed magnesium oxide encased in a copper, aluminum, or stainless steel sheath. A cable with a stainless steel sheath (SSMI) is to be bonded to ground. In aluminum-sheathed and copper-sheathed cables, the conductors are spaced and enclosed in a closely fitting, seamless sheath of smooth or corrugated aluminum or copper. The thickness of the copper sheath on Type MI or LWMI cables, aluminum sheath on aluminum-sheathed cables, and the copper sheath on copper-sheathed cables required by the cable certification standards ensures that the bonding to ground requirements of Section 10 are met.

## Rule 12-704 Use when embedded

Extensions under plaster are a practical means of avoiding an excessive amount of channeling or drilling of walls and floors. Subrule 1) allows mineral-insulated cables, aluminum-sheathed cables, and copper-sheathed cables to be installed under plaster as extensions from existing outlets or when encased or embedded in at least 50 mm of masonry or poured concrete.

Depending on the location, flat two-conductor aluminum-sheathed cable is susceptible to mechanical and electrical damage when embedded under plaster or in masonry or concrete. Subrule 2) requires a deviation under Rule 2-030 to allow its use when embedded in masonry or concrete.

Due to the possible galvanic corrosion, Subrule 3) requires that aluminum-sheathed cables be restricted from use in concrete containing reinforced steel with chloride additives. If the sheath is treated with a bituminous paint or materials suitable to prevent corrosion, the cable is allowed to be embedded in reinforced concrete. Jacketed sheath cable is considered acceptable provided that it is suitable for the application.

## Rule 12-706 Method of supporting

Subrule 1) requires that mineral-insulated cable, aluminum-sheathed cable, and copper-sheathed cable be supported securely by staples, straps, hangers, Type 2S or Type 21S cable ties, or similar fittings in a manner that prevents damage to the cable and avoids subjecting the terminations to undue stress or strain.

Mineral-insulated cable, aluminum-sheathed cable, and copper-sheathed cable have a solid liquid- and gas-tight outer sheath and are not as flexible as non-metallic-sheathed and armoured cables. Subrule 2) requires that they be supported at intervals not exceeding 2 m. When the cable is fished, added support might be needed at the terminations to prevent undue strain on the termination fitting.

Subrule 3) requires that cables be installed in a manner that prevents any stresses or strains from being imposed on the cable or the sheath terminal fittings. When settlement of a structure could injure the cable or fittings, extra physical support or mechanical protection is required.

Subrule 4) allows the cables to be installed in exposed locations, provided that mechanical protection is supplied in accordance with Rule 12-710.

## Rule 12-708 Direct earth burial

When mineral-insulated cable having an aluminum sheath and aluminum-sheathed cable are directly buried in earth, Rule 12-708 requires that they be provided with a jacket or other corrosion-resistant covering in order to prevent corrosion of the outer sheath.

## Rule 12-710 Mechanical protection

When mineral-insulated cables, aluminum-sheathed cables, and copper-sheathed cables are installed in locations exposed to damage, Subrule 1) requires that they be provided with suitable mechanical protection such as rigid metal conduit or running boards.

Subrule 2) requires that when these cables are installed on the surface of a wall, partition, ceiling, or structural member within 1.5 m of the floor and subject to mechanical damage from things such as vehicles, equipment, stockpiling, or excessive vibration, suitable guarding against such damage be provided.

Subrule 3) requires that mineral-insulated cable, aluminum-sheathed cable, and copper-sheathed cable be protected from being pierced by a 2-1/2 inch common nail when the cables are:

- run through bored or notched holes or grooves in wooden structural members;
- secured directly to the underside of wooden flooring; or
- located behind baseboards or casings.

Subrule 4) allows the potential damage to the cable in a hole or groove to be reduced or prevented by oversizing the hole, groove, or supporting strap in locations outlined in Subrule 3). The oversizing is to allow movement of at least half the diameter of the cable to prevent the nail from penetrating the cable.

When cables emerge from or enter the earth for direct burial, Subrule 5) requires that mechanical protection for the cable be provided for a distance of at least 300 mm above grade. Protection may be in the form of a suitable pipe stub-up (rigid conduit) that encases the cable or a metal guard. In locations subject to frost heaving, the encasement is to fit loosely around the cables to prevent possible damage to the cable.

## Rule 12-712 Radii of bends

During installation, Subrule 1) requires that all bends made to mineral-insulated cable not damage the outer sheath. The radius of the bend is not to be less than 6 times the external diameter of the sheath (see Table 12-7).

Aluminum is less ductile than most metals; as a result, it breaks more readily on bending. Subrule 2) requires that bends made on smooth aluminum-sheathed cable be limited to a radius not less than the external cable diameter times the multiplier (as specified in Table 12-7).

Due to their corrugation, corrugated aluminum-sheathed and copper-sheathed cables can have a reduced bending radius from smooth aluminum-sheathed cables. Therefore, Subrule 3) requires that the minimum bending radius for the corrugated cables be not less than 9 times the external diameter of the sheath.

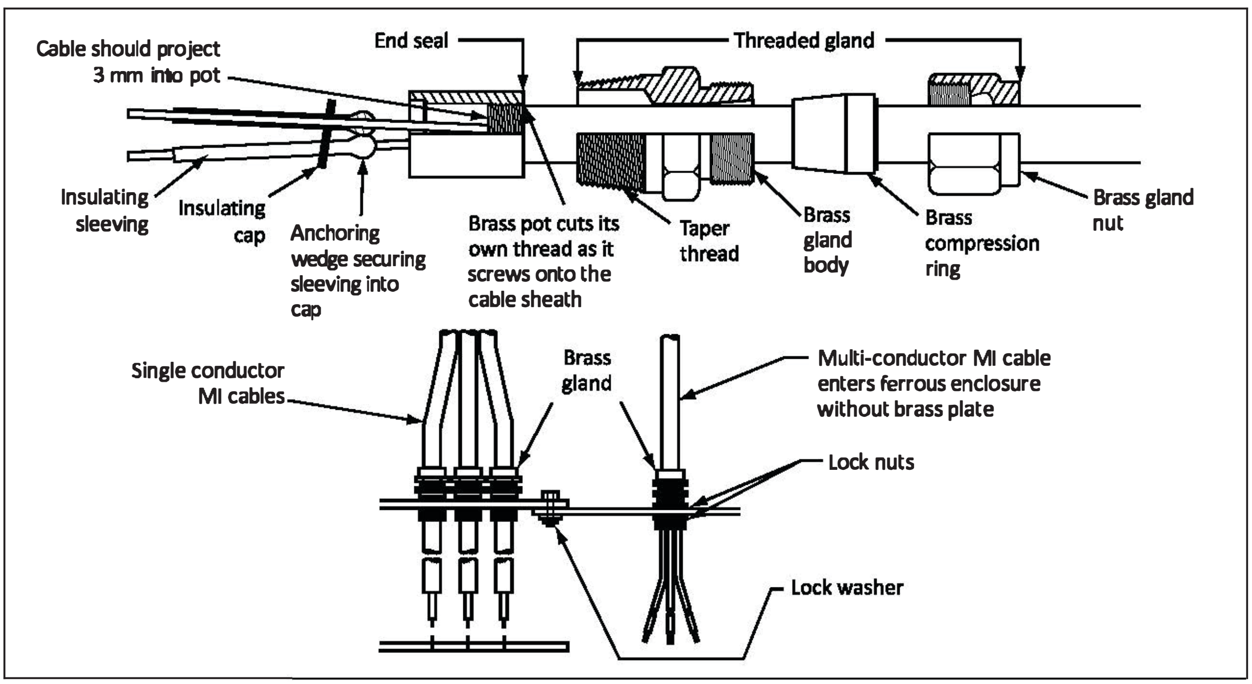
## Table 12-7
## Mineral-insulated, aluminum-sheathed, and copper-sheathed cable bending radius multiplier

| Mineral-insulated cable — Subrule 1) | External diameter multiplier |
|---|---|
| Any external diameter | 6 |
| **Smooth aluminum-sheathed cable — Subrule 2)** | **External diameter multiplier** |
| Not greater than 19 mm in external diameter | 10 |
| More than 19 mm but not greater than 38 mm in external diameter | 12 |
| More than 38 mm in external diameter | 15 |
| **Corrugated copper-sheathed and aluminum-sheathed cable — Subrule 3)** | **External diameter multiplier** |
| Any external diameter | 9 |

### Rule 12-714 Termination of mineral-insulated cable

Rule 12-714 requires that in all terminations of MI cables, the cable ends be sealed as soon as the outer sheath has been removed to prevent the entrance of moisture into the cable that might compromise the densely compressed magnesium oxide insulation. Termination kits supplied by the manufacturer of the cable are to be used for terminations (see Figure 12-21).

## Figure 12-21
## Mineral-insulated cable box connector

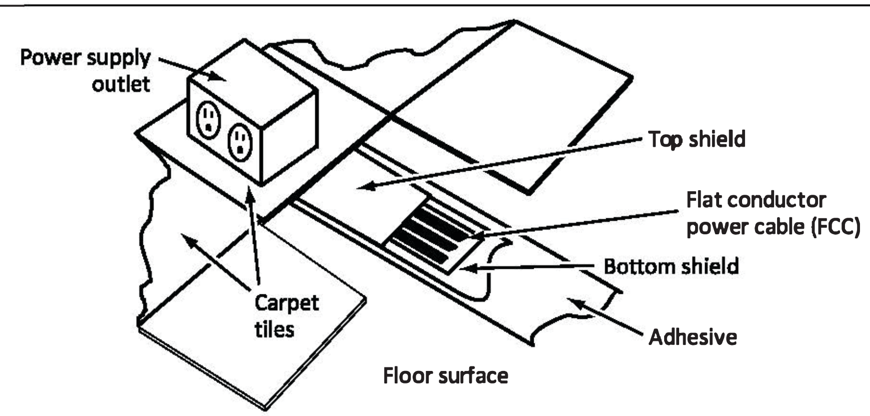


# Flat conductor cable Type FCC

### Rule 12-800 Type FCC under-carpet wiring system Rules

Type flat conductor cable (FCC) is a wiring method intended for concealed electrical installations under removable carpet squares. The system uses a cable consisting of three or more flat conductors, paralleled in the same plane and enclosed within an insulating assembly. Protection from physical damage is provided by the use of top and bottom shields (see Figure 12-22). Accessories include boxes, fittings, insulating ends, devices, steel tape, and transition assemblies.

**Figure 12-22**
**Flat conductor cable installation**




### Rule 12-808 Floor covering

Rule 12-808 requires that the FCC system be covered with removable carpet squares, the sides of which are not larger than 750 mm, to allow easy access for repairs, servicing, and adding or replacing carpet squares.

### Rule 12-814 Enclosure and shield continuity

Metal shields, tapes, boxes, receptacle housings, and self-contained devices have a conductive surface. To prevent a shock hazard or arcing, these components are to be electrically continuous and bonded to ground.

### Rule 12-818 Anchoring

Type FCC cable is to be secured to the floor using an adhesive. Double-edged adhesive tape is also allowed in most cases as it makes it easier to remove the cable from the floor surface. Using mechanical fasteners to secure the FCC cable creates bumps under the carpet that can present a safety hazard.

# Raceways

## General

### Rule 12-900 Raceway Rules

Raceways are channels designed for enclosing and loosely holding insulated and bare conductors, cables, or busbars. They may be metal or non-metallic. Conductors or cables can be pulled in or laid in, depending on the type of raceway.

### Rule 12-902 Types of insulated conductors and cables

Subrule 1) requires that insulated conductors and cables be of types suitable for the conditions of use in the chosen raceway wiring method. Table 19 indicates the conditions of use and the locations suitable for the different types of insulated conductors and cables for installation in a raceway.

Subrule 2) requires that when armoured cable is to be installed in a conduit or tubing run, the following requirements be met:

- The conduit and tubing fill listed in Table 8 is not to be exceeded.
- The installation conforms to either of the following requirements:
  - the calculated maximum pulling tension or the calculated maximum sidewall bearing pressure required to pull in the armoured cable does not exceed the manufacturer's specification for the armoured cable; or
  - there is not more than the equivalent of two 90° bends in the run with a minimum bending radius of 0.944 m (944 mm) for cables rated 1000 V or less or 1.524 m for cables rated over 1000 V, and the maximum length of armoured cable does not exceed:
    - for copper armoured cable:
      - ◆ 15 m for three-conductor cable; or
      - ◆ 45 m for single-conductor cable; and
    - for aluminum armoured cable:
      - ◆ 35 m for three-conductor cable; or
      - ◆ 100 m for single-conductor cable.

**Note:** *When determining the minimum bending radius for the conduit and tubing from Item b) ii) of Subrule 2) of Rule 12-902, note that the Rule is using the voltage rating of the cable (1000 V or less, or over 1000 V) instead of low-voltage and high-voltage used in Subrule 3) of Rule 12-614. The intent of using 1000 V instead of low-voltage in Item b) ii) of Subrule 2) of Rule 12-902 is to allow 1000 V rated armoured cable typically used in a low-voltage system (750 V or less) to use the smaller bending radius.*

### Rule 12-904 Conductors in raceways

To prevent inductive heating of the metal raceway, Subrule 1) requires that all insulated conductors of the same circuit be contained in the same metal raceway or channel. Due to the required ac load on the circuit it might be necessary to run the insulated conductors in parallel (more than one insulated conductor per phase, or grounded) to carry the load. Subrule 1) allows the parallel conductors to be run in additional enclosures provided that:

- the insulated conductors meet the requirements of Subrule 1) of Rule 12-108;
- each enclosure includes an equal number from each phase and the neutral; and
- each enclosure or cable sheath is of the same material and has the same physical characteristics.

The intent of Subrule 2) is to prevent conductors connected to different power or distribution transformers, or other different sources of voltage from becoming crossed and impressing another voltage on a circuit. This is accomplished by prohibiting these different voltage source conductors from being installed in the same raceway or compartment channel of a multiple-channel raceway. Rule 12-904 exempts conductors run in cable tray provided they meet the requirements of Rule 12-2202.

Subrule 2) also allows the conductors of each voltage source to be in the same raceway (except cable tray) when they are:

- separated by the metal armour or metal sheath of cables listed in Table 19, as the bonded to ground of the metal armour or sheath prevents the voltage from crossing between conductors;
- separated by a barrier of sheet steel not less than 1.34 mm (No. 16 MSG) thick or a flame-retardant non-metallic insulating material not less than 1.5 mm in thickness; or
- used for the supply and/or control of remote devices, are insulated for at least the same voltage as that of the circuit having the highest voltage, and none of the conductors of the circuits of lower voltages is directly connected to a lighting branch circuit.

**Note:** *Lower voltage conductors are not to be directly connected to lighting branch circuits of higher voltages as problems with performance, safety, and the life expectancy of the lower voltage lighting systems could arise if voltage were to cross between conductors rated to different voltages [see also Subrule 4) of Rule 46-108]. Therefore, the conductors of a 115 V control circuit are allowed to be installed in the same conduit as conductors* *supplying a 440 V, three-phase motor, provided that the insulation of all the conductors is rated 600 V. However, the conductors for 24 V extra-low-voltage lighting circuits cannot be installed in the same run of electrical metallic tubing as conductors for 120 V lighting circuits, even though the insulation voltage rating on all conductors is 600 V.*

### Rule 12-908 Inserting insulated conductors in raceways

When selecting a lubricant to help insert insulated conductors in a raceway, Subrule 1) requires that care be exercised to avoid types that are electrically conductive since they could increase the capacitive leakage, resulting in potential interference on instruments (for example, in patient care areas). Subrule 2) requires that lubricants be wire-pulling compound, talc, or soapstone. Lubricants (such as oils or greases) or cleaning agents containing minerals of a conductive nature are not to be used.

### Rule 12-910 Conductors and cables in conduit and tubing

Determining the size and number of conductors and cables allowed in conduit and tubing requires a detailed study of the circuit components, design layout, and material and installation costs of both conduit or tubing and conductors.

Subrule 1) requires that conduit and tubing be large enough to allow conductors to be inserted (pulled in) and withdrawn (removed) without the pulling stress damaging the conductors or the insulation on the conductors.

Subrule 2) states that the limit on the number of conductors required by Subrules 3), 4), and 5) applies only to complete systems and not to short sections of conduit and tubing used for the protection of portions of open wiring that would otherwise be exposed to mechanical damage.

Subrule 3) limits the maximum number of conductors allowed in conduit and tubing to 200.

Subrule 4) requires that the number of insulated conductors or multi-conductor cables in a single conduit or tubing meet the requirements for maximum conduit and tubing percentage fill given in Table 8. For other types of raceways, obtain the maximum percentage fill from the appropriate Rule in Section 12. These percentages are based on:

- a reasonable limit on lengths of pull;
- number of bends [not be greater than the equivalent of four 90° bends (360°)];
- ease of insertion and withdrawal (pulling tension); and
- heat dissipation, so as to limit damage to the conductor's insulation.

**Note:** *Grounding and bonding conductors, insulated or bare, are to be included when computing conduit and tubing fill and not included when computing ampacities as provided in Subrule 6) of Rule 4-004.*

The interior cross-sectional area for the types of conduit and tubing are given in Tables 9A to 9P. When the raceway is not conduit or tubing (for example, surface raceways, wireways, auxiliary gutters) or not listed in Tables 9A to 9P, Item 4) b) allows the cross-sectional area to be determined from the manufacturer's specifications or calculated based on the internal dimensions of the raceway (see Table 12-8).

To obtain the diameters and cross-sectional areas of single-conductor bare and insulated wires and multiple-conductor cables, Item 4) c) allows field measurements and calculations to be used.

Item 4) d) gives an exemption from field measurement of the single conductors to determine their diameter or cross-sectional area by allowing these dimensions to be obtained from Table 10A for the types of conductors identified in the Table; Table 10B can be used for the dimensions of photovoltaic cables, Table 10C for the dimensions of solid conductors, and Table 10D for the dimensions of DLO cable.

Tables 10A and 10B give dimensions for Class B or Class C conventional concentric stranded conductors, based on the stranding classes currently being supplied; the applicable Standards are listed in the Appendix B Note to Rule 12-910.

**Note:** *Dimensions of bore bonding or grounding conductors, such as bonding conductors that ore required for some raceway installations under applicable Code Rules, can be obtained from Table D5 in Appendix D. They should be verified by measurement before installation.*

Subrule 5) states that when conductors of the same size and the same insulation designation are installed in a single conduit or tubing, the maximum number of conductors is allowed to be determined by using the number given in Tables 6A to 6K (see Table 12-9). The calculated values for conductor dimensions used in Tables 6A to 6K are based on the dimensions for conventional concentric stranded conductors as listed in Tables 10A and 10B. Also the calculated values for conduit and tubing dimensions used in Tables 6A to 6K are based on the smallest conduit and tubing dimensions from Tables 9A to 9P, not the actual dimensions for each specific type of conduit and tubing given in Tables 9A to 9P.

As a result, the maximum number of conductors allowed by the Code in a conduit or tubing will vary depending on which calculation method is used — Subrule 4) using Tables 8, 9A to 9P, and 10A to 10D or Tables 6A to 6K. The Code deems both methods correct for determining the maximum number of conductors in a conduit or tubing. See Example below.

## Example

Determine the minimum size of EMT for four No. 6 T90 NYLON to be used for a 347/600 V, three-phase, 4-wire feeder in a commercial office building:

| Method | Using Subrule 4) of Rule 12-910 | Using Subrule 5) of Rule 12-910 |
|---|---|---|
| Cross-sectional area for 3/0 RW90XLPE | 32.71 mm² – Table 10A | N/A |
| Total cross-sectional area of conductors | 32.71 × 4 = 130.8 mm² | N/A |
| % tubing fill | 40% – Table 8 | N/A |
| Minimum size of EMT | 21 trade size – Table 9I | 27 trade size – Table 6K |

Both answers are acceptable under Rule 12-910.

**Note:** *When determining the size of conduit or tubing for on installation, the size determined according to Rule 12-910 is the minimum size allowed by the Code. The conduit or tubing size might need to be increased due to any of the following conditions:*

- *length of run;*
- *number of bends;*
- *required pulling tension;*
- *location (for example, concealed, encased, underground, or exposed);*
- *environment (for example, dry or wet, high or low temperature, Category 1 or 2, or a hazardous location);*
- *purpose of the conduit run (for example, feeder, branch circuit, control, signal, or data);*
- *type of insulation on conductor;*
- *type of conductor or cable; or*
- *allowance for future expansion (i.e., to make room for cables to be added in the future).*

## Table 12-8
## Method to determine the minimum size of conduit or tubing containing conductors and of various sizes and types when Tables 6A to 6K cannot be used

| Step | Method |
|---|---|
| 1 | Using field measurements, determine the cross-sectional area of each single bare and insulated conductor and multi-conductor cable to be installed in the conduit or tubing.<br>**Note:** *Tables 10A to 10D can be used to determine the cross-sectional area for the types of single insulated conductors listed in the Table using the conductor's size, its structure (i.e., stranded or solid), and insulation designation* |
| 2 | Calculate the total area in $mm^2$ required by the number and size of each of the conductors or cables that are to be installed in the conduit, tubing, or raceway. |
| 3 | Calculate the total area in $mm^2$ required by all the conductors or cables that are to be installed in the conduit, tubing, or raceway. |
| 4 | Determine from Table 8 the maximum percentage conduit or tubing fill. For other types of raceways, obtain the maximum percentage fill from the appropriate Rule in Section 12. |
| 5 | Determine from Tables 9A to 9P the minimum size of conduit or tubing by using:<br>• the type of conduit or tubing;<br>• the maximum percentage conduit fill obtained from Table 8 (see Step 4); and<br>• the maximum area in $mm^2$ of all the conductors or cables (see Step 3).<br>When using a raceway with other than a circular cross-sectional area, determine the maximum area of the raceway that can be filled with conductors or cables by multiplying the total cross-sectional area of the raceway by the percentage fill obtained from Step 4. The area of the conductors or cables in $mm^2$ (see Step 3) is not to exceed the required conduit/raceway fill in $mm^2$. |

## Table 12-9
## Method to determine the minimum size of conduit containing conductors of the same size (other than lead-sheathed conductors) using Tables 6A to 6K

| Step | Method |
|---|---|
| 1 | Find the conductor's voltage rating, insulation designation, and its status as jacketed or not jacketed in the left-hand column of Tables 6A to 6K. If the conductor's insulation designation is not listed in this column, use the method given in Table 12-8 and Subrule 4) of Rule 12-910. |
| 2 | In the next column of the appropriate Table from Tables 6A to 6K, opposite the conductor's insulation designation, locate the conductor's size in AWG or kcmil. |
| 3 | In the row opposite the conductor's size, select the first column that has the number of installed conductors (or where the exact number of conductors is not listed, choose the column having the next highest number of conductors). The minimum conduit size is the number listed at the top of the selected column. |

**Note:** *In order to use this method:*

- *the conductors are to be the same size (AWG or kcmil);*
- *the CSA insulation letter designation is to be listed in Tables 6A to 6K; and*
- *the conductors are to be installed in a raceway type that allows the use of Tables 6A to 6K to determine conductor fill in accordance with Subrule 5) of Rule 12-910.*

*The maximum permitted number of insulated conductors of the same size in one HDPE conduit is not to be determined from Tables 6A to 6K in accordance with Subrule 6) of Rule 12-910.*

### Rule 12-914 Stranding of conductors

Rule 12-914 requires that conductors sized No. 8 AWG or larger and installed in a raceway be stranded. Stranded construction affords greater flexibility and prevents damage to the insulation when the conductors are installed in long raceway runs or when they contain bends that the conductors or cables must be pulled around.

### Rule 12-916 Electrical continuity of raceways

Rule 12-916 requires that metal raceways be securely connected together and to electrical equipment in order to form a continuous electrical conductive path. A securely attached metal raceway system forms a continuous low-impedance path to ground that is intended to carry the amount of fault current required to trip the overcurrent protective device on the occurrence of a fault to ground on the system.

When the raceway system is constructed of non-metallic materials or the metal raceway system cannot be relied on to provide a continuous low-impedance path to carry the fault current for the lifetime of the raceway system installation, a bonding conductor is to be installed according to the requirements set out in Section 10.

### Rule 12-918 Mechanical continuity of raceways

For the purposes of Rule 12-918, "mechanically secured" refers to the fastening of components of the raceway system to each other, to electrical equipment, and to the building structure so that they do not slacken or come apart when subjected to normal conditions of use, including vibration. Rule 12-918 requires that the raceways be mechanically secured together and to electrical equipment (for example, by the use of couplings, locknuts, or threaded connections) to provide mechanical continuity of the system. Fittings and supports are to be of materials that when in contact will not allow galvanic corrosion to occur between dissimilar metals.

### Rule 12-922 Removal of fins and burrs of raceways

To prevent damage to the conductor's insulation, Rule 12-922 requires that all rough or knifelike edges be removed from the ends of raceways.

### Rule 12-928 Entry of underground conduits into buildings

Moisture and gas in the equipment can cause corrosion and surface tracking, resulting in failure of the equipment as well as health concerns. To prevent moisture and gas from an underground distribution system from entering the building through a conduit, Rule 12-928 requires that the conduit be sealed with an appropriate compound.

### Rule 12-934 Protection for raceways

When raceways are installed in locations that are less than 2 m above grade and subject to mechanical damage, Rule 12-934 requires that they be protected. Protection is to be provided:

- by using raceways of the rigid steel type;
- in the form of steel guards of not less than No. 10 MSG, adequately secured to the face of buildings;
- by the use of poles or posts; or
- by positioning raceways in a location where they are not subject to hazards

### Rule 12-936 Raceways installed in concrete, cinder concrete, and cinder fill

Concrete can be considered a wet or damp location. In the presence of steel reinforcing and chloride additives, a galvanic action takes place, resulting in corrosion of the aluminum. Refer to Subrule 3) of Rule 12-602 for requirements for aluminum-armoured cable.

Subrule 2) requires that extra protection be provided for metal raceways installed in areas containing cinder or cinder concrete. Cinders, when produced by burning bituminous coal, contain sulphur, and if moisture is present, sulphuric acid forms and attacks the metal raceway. Protection is to be obtained by:

- encasing the raceway in at least 25 mm of non-cinder concrete; or
- installing the raceway more than 450 mm beneath the cinders or cinder concrete as it is believed that the corrosive materials will have been diluted by that depth.

Refer to Subrule 4) of Rule 12-602 regarding metal-armoured cables.

### Rule 12-938 Raceway completely installed before insulated conductors or cables are installed

Rule 12-938 requires that, except for HDPE conductors-in-conduit, raceways be installed as a complete system before any insulated conductors or cables are inserted or laid in. This procedure prevents damage to the insulated conductors and cables before and after the installation of the raceway. In buildings under construction, however, insulated conductors and cables are allowed to be installed in areas where construction operations will not damage the raceway, cables, or insulated conductors and where they are physically protected from the weather.

### Rule 12-940 Capping of unused raceways

Rule 12-940 requires that unused raceways terminating in an enclosure be capped to prevent a "fish tape" from being inserted into a raceway and emerging into an enclosure where it could possibly contact live parts.

### Rule 12-942 Maximum number of bends in raceways

Raceway runs are to be constructed so that the insulated conductors can be easily installed or withdrawn without undue damage to their insulation. To help accomplish this requirement, Rule 12-942 requires that the maximum number of bends in a raceway between draw-in points or between outlets be the equivalent of four 90° bends. This also means that the maximum bend is to be no greater than 90°.

### Rule 12-944 Metal raceways

In many parts of Canada, salts or chemicals are used on the roads to reduce the danger from ice. These salts adhere to vehicles and subsequently drip onto the floor of parking areas, pavement, road beds, and similar areas, permeating the base material and corroding metals in the floor, pavement, or road bed. For that reason, the protection of any raceway system embedded in these areas from corrosion damage is an important consideration during the initial installation. This protection is to be attained through the choice of wiring method or the provision of a protective screen or coating around or over the wiring method. For metal boxes, see Subrule 4) of Rule 12-3000.

The Appendix B Note to Rule 12-944 advises that CSA S413 restricts the use of metal raceways and boxes embedded in concrete slabs in parkades and similar structures where they are subject to corrosion.

## Rigid and flexible metal conduit

### Rule 12-1000 Rigid and flexible metal conduit Rules

Rigid and flexible metal conduits are raceways of circular cross-section metal into which conductors are installed and from which conductors are withdrawn. Used extensively for general work, rigid metal conduit is constructed to the same dimensions as standard pipe and is suitable for threading with standard tapered pipe threads. Flexible metal conduit is frequently used for short runs (for example, motor connections) and is easy to install since it is flexible and can be bent without the use of tools.

### Rule 12-1002 Use

When rigid metal conduit is used in a damp or wet location, Subrule 2) requires that the threads at joints or fittings be made secure to prevent any water from entering the conduit. Roofs are considered to be a wet or damp location, as are areas where the walls are frequently washed. In these conditions, conduit and fittings are to be made:

- water-tight to prevent corrosion; and
- of the same material to prevent the contact of dissimilar metals (galvanic action).

Under some conditions, Section 10 requires that a separate bonding conductor be placed in rigid metal conduit.

### Rule 12-1006 Conduit threads

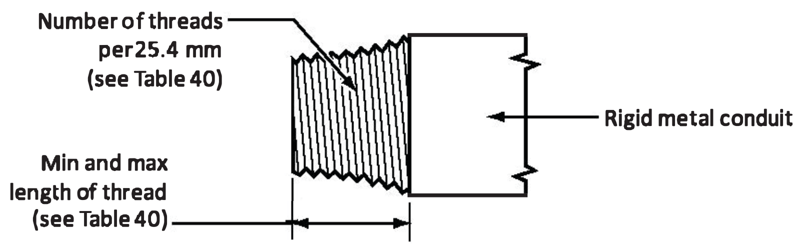
To provide a strong mechanical and effective electrical connection, Subrule 1) requires that all rigid conduit threads be tapered (see Figure 12-23). Straight tapped couplings are allowed to be used with tapered threads on the rigid metal conduit without compromising the strength of the joint, its ability as a ground fault return path, and its performance in hazardous locations.

Subrule 2) requires that external threads cut in the field for rigid metal conduit comply with Table 40 for minimum and maximum length of thread and number of threads per 25.4 mm (1 in), and are to be tapered using a standard chaser with a taper of 1 to 16.

Running threads are field-cut tapered threads cut longer than the maximum dimension given in Table 40. When running threads are used to join lengths of rigid conduit together, the connection is considerably weakened and the impedance of the ground fault return path increases. Subrule 3) requires that running threads not be allowed except in special situations, as outlined in Subrule 4).

When the conduit thread protrudes through an enclosure wall, and there is not sufficient thread length to apply a conduit bushing, Subrule 4) allows additional thread length cut on the conduit as a continuation of the tapered thread dimensions given in Table 40 to accommodate the conduit bushing required by Rule 12-906. This does not weaken the connection at the enclosure because the enclosure does not use the rigid conduit as support.

**Figure 12-23**
**Tapered threads**




### Rule 12-1010 Maximum spacing of conduit supports

To support the weight of the conduit and to prevent any strain or stress at the terminations, all rigid metal conduit is to be firmly fastened in place to a solid surface by conduit straps or by hangers. Subrule 1) requires that the maximum support spacing be as shown in Table 12-10.

When mixed sizes of rigid conduit are being supported by a common rack (conduit gallery), Subrule 2) requires that the support spacing be arranged so that the maximum support spacing is for the smallest conduit. For example, the support spacing for a 63 trade size conduit and a 16 trade size conduit mounted on the same hanger is 1.5 m.

When flexible metal conduit is used, Subrule 3) requires that it be supported straps, Type 25 or Type 21S cable ties, or other devices at intervals not exceeding 1.5 m and within 300 mm of each side of a box or fitting. An exception for supports is allowed when flexible metal conduit is fished or its length does not exceed 900 mm and is required to be flexible.

## Table 12-10
## Maximum support spacing — Rigid metal conduit

| Trade size | Rigid metal conduit maximum support spacing, m |
|---|---|
| 16 | 1.5 |
| 21 | 1.5 |
| 27 | 2 |
| 35 | 2 |
| 41 | 3 |
| 53 | 3 |
| 63 | 3 |
| 78 | 3 |
| 91 | 3 |
| 103 | 3 |
| 116 | 3 |
| 129 | 3 |
| 155 | 3 |

### Rule 12-1012 Expansion and contraction of conduits

Rigid metal conduit lengths vary due to expansion and contraction of the metal caused by temperature changes. Subrule 1) requires that provision be made for the expansion and contraction of long runs of rigid conduit by the use of expansion joints. In the case of surface-mounted rigid metal conduit, the installation of two 90° bends in a run is acceptable. The Appendix B Note to Rule 12-1012 shows the method of calculating the expansion in a run of rigid metal conduit.

### Examples

To determine the change in length of a 60 m run of 78 trade size aluminum conduit in a temperature range of –43 °C to 34 °C:

Length change (mm) = length of run (m) × temperature change (°C) × coefficient of expansion*
= 60 × (43 + 34) × 0.022 = 60 × 77 × 0.022 = 101.64 mm

To determine the change in length of a 50 m run of 53 trade size rigid steel conduit in a temperature range of –35 °C to 31 °C:

Length change (mm) = length of run (m) × temperature change (°C) × coefficient of expansion*
= 50 × (35 + 31) × 0.0114 = 50 × 66 × 0.0114 = 37.62 mm

** See the Appendix B Note to Rule 12-1012 for coefficients of expansion for various materials.*

### Rule 12-1014 Insulated conductors and cables in conduit

See the requirements in Rule 12-910 to determine the maximum number of insulated conductors and cables allowed in rigid and metal flexible conduits.

# Rigid PVC conduit

**Rule 12-1100 Use**
Rigid PVC conduit is a non-metallic, circular cross-section raceway that conductors are pulled into or withdrawn from. Rigid PVC conduit is manufactured from unplasticized polyvinyl chloride and is intended for use at a maximum working temperature of 75 °C. Each length of conduit, elbow, or bend is marked "Rigid PVC Conduit 75 °C". Rigid PVC conduit does not convey flame, as it is inherently flame-retardant; however, it will melt in a sustained fire, which can allow the fire and smoke to travel along the length of the rigid PVC conduit run to other parts of the building.

Rigid PVC conduit is allowed to be used for exposed or concealed work above or below ground, according to the Rules for rigid metal conduit. When installed in buildings, rigid PVC conduit is to conform to the flame spread requirements (FT rating) of the *National Building Code of Canada* (see Rule 2-132). The Appendix B Note to Rule 2-132 states that in buildings of non-combustible construction, the *National Building Code of Canada* assigns rigid PVC conduit a flame spread and smoke development rating of FT4.

**Rule 12-1102 Restrictions on use**
Rigid PVC conduit is not to be used in locations where it will be enclosed in thermal insulation. Temperatures in such areas, due to internal conductor heating, could exceed those for which the rigid PVC conduit is approved (see Rule 12-1104).

**Rule 12-1104 Temperature limitations**
Since rigid PVC conduit material has a maximum working temperature of 75 °C, the location of use and the type of insulated conductor is to be carefully examined. Tests have shown that 90 °C insulated conductors, continuously loaded, under conditions of 50% fill and 30 °C ambient, do not reach a temperature greater than 75 °C.

Insulated conductors with temperature ratings in excess of 75 °C are allowed to be used in rigid PVC conduit, provided that the ampacities are corrected to those of 90 °C insulated conductors. For example, insulated conductors with the insulation temperature ratings shown in Table 2, Column 5 (110 °C) are allowed to be used, provided that the ampacities shown in Column 4 (90 °C) are not exceeded.

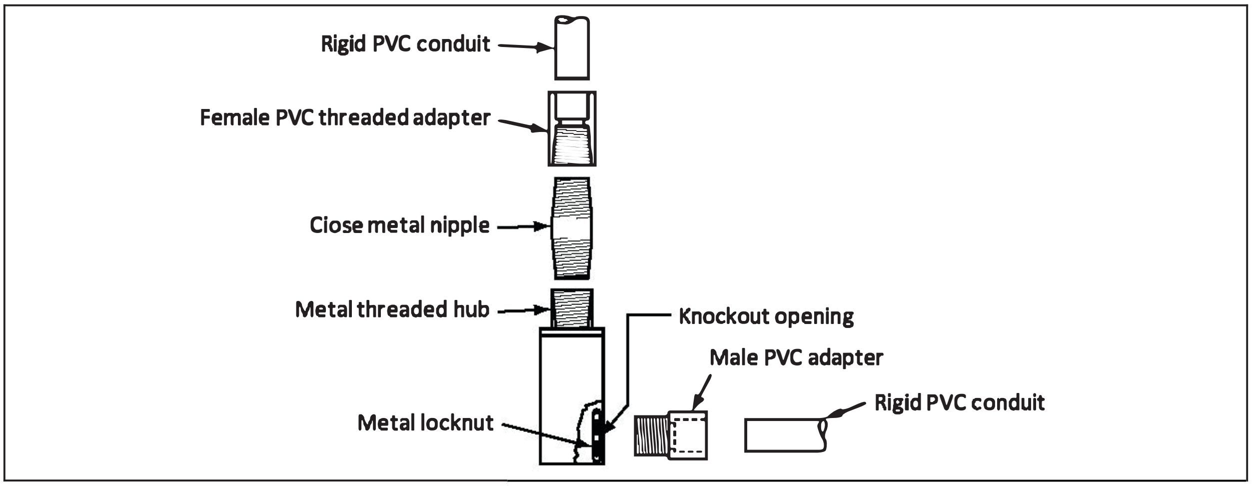
**Rule 12-1106 Mechanical protection**
The mechanical protection referred to in Rule 12-1106 can be provided through the use of rigid metal pipe or a metal shield, or by relocating the conduit.

**Rule 12-1108 Field bends**
Field bending of rigid PVC conduit is allowed permitted provided that the bending equipment is specifically intended for the purpose. Flame-producing devices used as a heat applicator are not acceptable. Excessive heat could damage the conduit when improperly applied. Thermostatically controlled heat guns for trade sizes up to 53 uniformly apply heat without damaging the conduit. For trade sizes 27 to 53, springs or equivalent devices are to be used in conjunction with the heat gun to prevent reduction of the internal diameter. For trade sizes larger than 53, special jigs, moulds, springs, and heating arrangements are required.

**Rule 12-1112 Fittings**
Since rigid PVC conduit elbows, fittings, and bends are not threaded, Subrule 1) requires that they be joined together by adapters and couplings using a solvent cement. Each container of solvent cement for use with rigid PVC conduit is to be marked "FOR USE WITH RIGID PVC CONDUIT". Using the incorrect type of solvent or contact cement (for example, ABS solvent cement) can prevent the conduit connections from joining properly, resulting in connections that might come apart.

Since PVC conduit and rigid metal conduit have different coefficients of expansion, Subrule 2) requires that female PVC adapters be used with metal conduit nipples for terminations in threaded metal hubs or bosses (see Figure 12-24). PVC material has only 0.4% of the thermal conductivity of steel; as a result, when using a metal female hub or boss with a PVC nipple, the higher expansion of the PVC inside the metal hub can damage the PVC nipple or crack or bend the metal hub.

**Figure 12-24**
**Fittings for rigid PVC conduit**




### Rule 12-1114 Maximum spacing of conduit supports

Subrule 1) requires that rigid PVC conduit be supported as indicated in Table 12-11. The required support intervals for rigid PVC conduit are less than those specified for rigid metal conduit since the PVC conduit has lower tensile strength and is prone to buckling or bowing at increased ambient temperatures.

**Table 12-11**
**Maximum support spacing — Rigid PVC conduit**

| Trade size | Rigid PVC conduit maximum support spacing |
|---|---|
| 16 | 750 mm |
| 21 | 750 mm |
| 27 | 750 mm |
| 35 | 1.2 m |
| 41 | 1.2 m |
| 53 | 1.5 m |
| 63 | 1.8 m |
| 78 | 1.8 m |
| 91 | 2.1 m |
| 103 | 2.1 m |
| 116 | 2.1 m |
| 129 | 2.1 m |
| 155 | 2.5 m |

### Rule 12-1116 Support of equipment

Rule 12-1116 requires that rigid PVC conduit not be used as a support for electrical equipment (for example, boxes, fittings, and luminaires). The conduit is not capable of withstanding a continuous load and can sag from temperature changes.

### Rule 12-1118 Expansion joints

Rule 12-1118 requires that expansion joints be installed in a conduit that is run in locations where the maximum temperature changes can cause an expansion of over 45 mm. If the conduit is enclosed in concrete, expansion and contraction do not need to be considered.

The Appendix B Note to Rule 12-1118 refers to the method of calculating the expansion in a run of rigid PVC conduit.

#### Example 1

To determine the amount of expansion of a 30 m run of rigid PVC conduit, when the maximum expected temperature is 35 °C and the minimum expected temperature is -40 °C:

**Step 1**

Calculate the temperature change in °C: 35 + 40 = 75

**Step 2**

Determine the coefficient of linear expansion from Appendix B: 0.0520

**Step 3**

Note the length of run in m: 30

**Step 4**

Calculate the amount of expansion in mm:
length of run in m × temperature change in °C × coefficient of expansion
= 30 × 75 × 0.0520 = 117 mm

#### Example 2

To determine the maximum length of run of rigid PVC conduit before an expansion joint is required when the minimum expected temperature is -45 °C and the maximum expected temperature is 25 °C:

**Step 1**

Calculate the temperature change in °C: 45 + 25 = 70

**Step 2**

Determine the coefficient of linear expansion from Appendix B: 0.0520

**Step 3**

Determine the maximum amount of expansion before an expansion joint is required (Rule 12-1118): 45 mm

**Step 4**

Calculate the maximum length of run before an expansion joint is required:

$$\frac{\text{maximum amount of expansion}}{\text{temperature change} \times \text{coefficient of expansion}} = 45 / (70 \times 0.0520) = 12.36 \text{ m}$$

### Rule 12-1120 Maximum number of conductors

See the requirements in Rule 12-910 to determine the maximum number of insulated conductors and bare conductors allowed in rigid PVC conduits.

### Rule 12-1122 Provision for bonding continuity

Since rigid PVC conduit is made from non-metallic materials that do not provide a bonding path, Subrule 1) requires that separate bonding be provided by installing a bonding conductor at each outlet. A bonding conductor is also to be installed to ground metal boxes that are used with PVC conduit (see Rule 10-612).

Subrule 2) allows an exemption for a separate bonding conductor when rigid PVC conduit is used as the consumer's service raceway between the wet location service head and the meter base or service box.

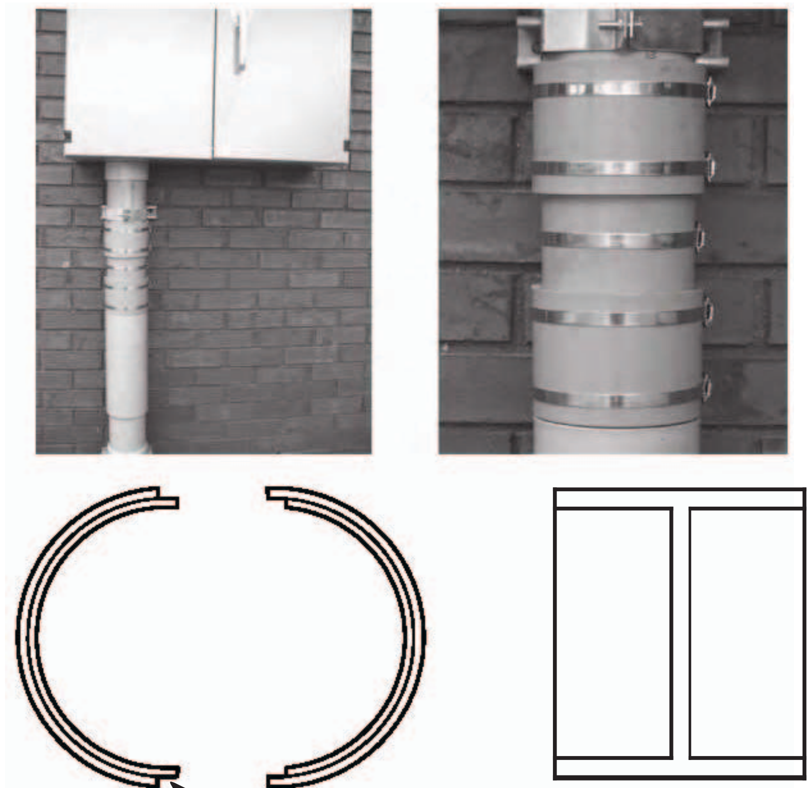
### Rule 12-1124 Split straight conduit

The current method of dealing with damaged rigid PVC conduit requires the removal of all the existing cabling and conductors and then the replacement of the broken section of conduit using couplers and conduit. To allow repairs of above-ground damaged conduit without removing existing wiring located inside the conduit, Rule 12-1124 allows the use of split straight conduit to repair a damaged portion of conduit in an existing installation (see Figure 12-25).

Rule 12-1124 sets out the following requirements for making the repair to an existing installation using split straight conduit:

- both halves of each split conduit length are to be made with notches or grooves to ensure the integrity of the conduit and are to be properly matched together to form a close-fitting joint using PVC solvent cement;
- when one end of the assembly is not equipped with an integral bell adapter, it is to be fixed with split couplings, which are to be applied with PVC solvent cement;
- each length of split straight conduit and each split coupling is to be tightly clamped at both ends, with additional clamps spaced not more than 500 mm apart;
- non-removable band clamps made of stainless steel are to be used; and
- the insulation of conductors in the conduit is not to be damaged.

**Figure 12-25**
**Repair to an existing installation using split straight conduit**




## Rigid Types EB1 and DB2/ES2 PVC conduit

### Rule 12-1150 Use permitted

This Subsection applies to the following types of rigid PVC conduit and associated fittings:

- Type EB1 for encasement in concrete or masonry; and
- Type DB2/ES2 for direct burial or encasement in concrete or masonry.

The conduits and associated fittings covered by this Subsection are intended for a maximum continuous operating temperature of 75 °C.

The accessories covered by this Subsection include the following:

- straight couplings;
- 5° angle couplings;
- caps;
- plugs;
- bell end terminators;
- bends; and
- adapters.

### Rule 12-1152 Restrictions on use

Since Type EB1 and Type DB2/ES2 conduit have thin walls subject to cracking, they are prohibited from use above ground level, except when they are installed in walls, floors, or ceilings and are encased or embedded in 50 mm of poured concrete or masonry.

### Rule 12-1158 Fittings

Subrule 1) requires that Type EB1 and Type DB2/ES2 conduit and associated fittings not be threaded. However, when connecting Type EB1 and Type DB2/ES2 conduit to conduit made of materials other than PVC through the use of a taper-threaded connection, the female threaded adapter should be made from the same PVC material as the PVC conduit. The male threaded adapter is to be made from materials other than PVC materials [see Subrule 2) of Rule 12-1112].

Subrule 2) allows threaded adapters to be used, provided that they can be properly attached to the conduit. The solvent cement used is to have the marking of the manufacturer's name, the product designation PVC, and instructions in English and French on efficient use and handling. Conduit and fittings are to be marked with the manufacturer's name or trademark; PVC; the diameter, size, or angle; and the designation CSA C22.2 No. 211.1.

### Rule 12-1160 Maximum number of conductors

See the requirements in Rule 12-910 to determine the maximum number of insulated conductors and bare conductors allowed in rigid Types EB1 and DB2/ES2 PVC conduits.

### Rule 12-1162 Metbod of installation

To prevent disturbance during pouring operations, the conduit is to be mechanically secured in position in accordance with Subrule 3).

### Rule 12-1164 Split straight conduit

To allow for repairs, alterations, and extensions to existing underground or concrete embedded installations, Rule 12-1164 allows raceways to be repaired using split straight conduit, provided that

- both halves of each conduit length are properly matched and clamped together to form a concrete-tight joint;
- each length is tightly clamped at each end, with additional clamps spaced along the length no greater than 900 mm apart; and
- clamps when not encased in concrete are made of stainless steel or other corrosion-resistant material.

### Rule 12-1166 Provision for bonding continuity

Since Type EB1 and Type DB2/ES2 conduit are made of non-metallic materials and do not afford a bonding path, separate bonding is to be provided by installing a bonding conductor at each outlet. The bonding conductor is to be installed to ground metal boxes that are used with these conduits (see Rule 10-612).

## Rigid RTRC conduit

### Rule 12-1200 Scope

This Subsection specifies the requirements for halogen-free reinforced thermosetting resin conduit (RTRC) and associated fittings for installation and use in hazardous locations, in accordance with the Rules of the Code. The material used in the construction of rigid RTRC conduit can be chosen from various types of reinforced thermoset material, such as epoxy resin and fibreglass. Type AG is for use above ground and/or below ground, Type BG is for use below ground only, and Type XW is for use in specified hazardous locations. The rigid RTRC conduit is intended for use at a continuous operating temperature ranging from –40 °C to 110 °C.

Rigid RTRC conduit gives the user two methods of joining the conduit and fittings: an adhesive joint or a proprietary urethane gasket. Rigid RTRC conduit is shipped from the factory with the joining materials for the method specified by the customer.

### Rule 12-1206 Mechanical protection
Where rigid RTRC conduit is exposed to physical damage, either during or after installation, mechanical protection such as rigid metal pipe, a metal shield, or other suitable material is to be provided.

### Rule 12-1214 Expansion joints
Since rigid RTRC conduit can be made of various types of reinforced thermoset material, such as epoxy resin and fibreglass, the amount of expansion differs. Rule 12-1214 requires that expansion joints be installed in a conduit run where the maximum temperature change can cause an expansion over 45 mm. The Appendix B Note to Rule 12-1214 gives the range of coefficient of linear expansion factors, and the manufacturer should be consulted to obtain the correct coefficient for the type of rigid RTRC conduit being used.

#### Example
To determine whether a 50 m run of rigid RTRC conduit requires an expansion joint when the maximum expected temperature is 30 °C and the minimum expected temperature is –42 °C:

#### Step 1
Calculate the temperature change in °C: 30 + 42 = 72

#### Step 2
Determine the coefficient of linear expansion from the manufacturer: 0.0120

#### Step 3
Note the length of run in m: 50

#### Step 4
Calculate the amount of expansion in mm:
length of run in m × temperature change in °C × coefficient of expansion
= 50 × 72 × 0.0120 = 43.2 mm

This run of rigid RTRC conduit does not require an expansion joint.

### Rule 12-1216 Conduit supports
In areas subject to temperature changes, Rule 12-1216 requires that allowance be made for the expansion and contraction of rigid RTRC conduit. To allow for linear movement, Rule 12-1216 requires that supports not be clamped tightly around the conduit. If the rigid RTRC conduit is encased or embedded in at least 50 mm of masonry or poured concrete (see Rule 12-1214), expansion and contraction do not need to be considered.

Rule 12-1216 also requires that exposed runs of rigid RTRC conduit be supported at distances no greater than those allowed for rigid metal conduit. These support distances are as follows:
- 1.5 m for trade sizes 16 and 21;
- 2 m for trade sizes 27 and 35; and
- 3 m for trade sizes 41 and larger.

### Rule 12-1218 Maximum number of conductors
See the requirements in Rule 12-910 to determine the maximum number of insulated or bare conductors allowed in rigid RTRC conduits.

### Rule 12-1220 Provision for bonding
Since Type EB1 and Type DB2/ES2 conduits are non-metallic materials and do not afford a bonding path, separate bonding is to be provided by installing a bonding conductor at each outlet. The bonding conductor is to be installed to ground metal boxes that are used with these conduits (see Rule 10-612).

## High-density polyethylene (HDPE) conduit and HDPE conductors-in-conduit

### Rule 12-1250 Use permitted

CSA C22.2 No. 327 covers the specifications for high-density polyethylene (HDPE) conduit and conductors-in-conduit, and fittings. This type of conduit offers:

- corrosion and chemical resistance;
- flexibility;
- durability;
- long reel lengths, which reduce joints and installation time. In this respect, HDPE conduits are like fiber optical cables, which are used in underground installations as these cables are typically made and installed in very long lengths [up to 9145 m (30 000 feet)], with the goal of using as few splices as possible to minimize signal attenuation or decibel (dB) losses in a complete system; and
- variety of sizes, colours, dimensions, and lengths.

HDPE conduit is non-metallic, coilable, smooth-walled conduit for direct burial or encasement in concrete or masonry.

HDPE conductors-in-conduit are a factory assembly of conductors or cables inside a continuous length of HDPE conduit. This is a smooth-walled, coilable, high-density polyethylene (HDPE) conduit (duct) that contains preassembled conductors and cables. The outside diameter of the conduit is controlled and the wire or cable encased within may be comprised of single or multiple configurations consisting of electrical/power wires or cables, fiber optic, traditional copper communication, coaxial cable, or any combination thereof. The conductor configurations are preassembled into the conduit during the extrusion process and in industry-specific designs for use in commercial, industrial, transportation, government, and utility applications.

HDPE conduit, HDPE conductors-in-conduit, and fittings are allowed to be used:

- for installation underground in accordance with Rule 12-930; or
- where encased or embedded in at least 50 mm of masonry or poured concrete.

### Rule 12-1252 Restrictions on use

Since HDPE conduit, conductors-in-conduit, and fittings can be easily damaged when installed above grade, Rule 12-1252 does not allow them to be used above ground unless they are encased or enclosed by 50 mm of masonry or poured concrete for mechanical protection.

### Rule 12-1254 Method of installation

Rule 12-1254 gives the installation requirements for HDPE conduit, conductors-in-conduit, and fittings.

One of the installation methods for installing HDPE conduit and conductors-in-conduit is by horizontal directional drilling and plow-trenching. Subrule 5) gives the following requirements for this type of installation method:

- a breakaway device is to be installed set to the maximum pulling tension of the conduit;
- dimension Ratio 11 or thicker conduit walls are required unless thinner conduit walls are allowed by assessment;
- installations are to be performed on continuous runs without the use of couplings or joints; and
- pipe elongation is to be compensated for before cutting the conduit.

### Rule 12-1256 Temperature limitations

HDPE conduit and conductors-in-conduit are to be marked with the maximum continuous ambient temperature and therefore are not allowed to be used where normal conditions are such that any part of the conduit is subjected to a temperature in excess of its marked continuous operating temperature.

### Rule 12-1258 Field bends

To prevent damage to the conductors inside of HDPE conductors-in-conduit and distortions in the field bends of HPDE conduit, Rule 12-1258 requires that the radius of the curve not be less than that specified by the HDPE conduit manufacturers or, if not specified, at least 12 times the external diameter.

### Rule 12-1262 Expansion joints
Since HDPE conduit and conductors-in-conduit can be made of various types of high-density polyethylene, the amount of expansion differs. Rule 12-1262 requires that expansion joints be installed in a conduit run where the maximum temperature change can cause an expansion over 45 mm.

### Rule 12-1264 Maximum number of conductors
See the requirements in Rule 12-910 to determine the maximum number of conductors allowed in HDPE conduits.

### Rule 12-1266 Split straight conduit
To allow for repairs, alterations, and extensions to existing underground or concrete embedded installations, Rule 12-1266 allows raceways to be repaired using split straight conduit, provided that:
- the insulated conductors are not damaged;
- both halves of each conduit length are properly matched and clamped together to form a concrete-tight joint;
- each length is tightly clamped at each end, with additional clamps spaced along the length no greater than 900 mm apart; and
- clamps when not encased in concrete are made of stainless steel or other corrosion-resistant material.

### Rule 12-1268 Provision for bonding continuity
Since HDPE conduit and conductors-in-conduit are made of non-metallic materials and do not afford a bonding path, separate bonding is to be provided by installing a bonding conductor at each outlet. The bonding conductor is to be installed to ground metal boxes that are used with these conduits (see Rule 10-612).

## Liquid-tight flexible conduit

### Rule 12-1300 Scope
Rules 12-1302 to 12-1308 list the requirements for the installation of both metallic and non-metallic liquid-tight flexible conduit.

Liquid-tight flexible metal conduit and liquid-tight flexible non-metallic conduit, in trade sizes 12 to 103 and excluding 14, are intended for use as flexible conduit for the installation or withdrawal of conductors where installed in accordance with the requirements of the Code. Liquid-tight flexible metal conduit is provided with an overall thermoplastic liquid-tight jacket specified for use at a maximum working temperature of either 60 °C or 75 °C, depending on the grade of the thermoplastic covering. The flexible metal conduit is fabricated from zinc-coated steel strip or from strips cut from zinc-coated sheet steel. Liquid-tight flexible non-metallic conduit is fabricated from thermoplastic; it can easily be bent by hand and is intended to flex throughout its life.

### Rule 12-1302 Use of liquid-tight flexible metal and non-metallic conduit
Subrule 1) allows liquid-tight flexible metal and non-metallic conduit to be used for flexible connections in dry, damp, or wet locations or in other locations as allowed by other Rules of the Code.

Subrule 2) permits runs of not more than 1.5 m of 12 trade size liquid-tight flexible conduit for the connection of equipment.

Subrule 3) specifies where liquid-tight flexible conduit is not to be used, as follows:
- where subject to mechanical damage;
- in locations that might damage the jacket (for example, near gasoline, petroleum solvents, corrosive liquids, or vapours);
- under conditions where the ambient temperature exceeds 60 °C, unless the conduit is marked for higher ambient temperatures ; or

  **Note:** *Liquid-tight flexible conduit with a thermoplastic covering suitable for 75 °C ambient temperatures has the temperature rating "75 °C" marked on the surface of the outer covering.*

- under conditions when flexing at low temperatures might damage the jacket or conduit. The conduit is not intended to be handled or installed in low temperatures unless marked for a lower temperature.

Subrule 4) allows liquid-tight flexible conduit to be direct buried as per Rule 12-012 where the conduit is marked for direct burial.

Since liquid-tight flexible conduit has an overall thermoplastic liquid-tight jacket, Subrule 5) requires that it meet the flame spread requirements for totally enclosed non-metallic raceways in Rule 2-132.

### Rule 12-1304 Maximum number of conductors

Subrule 1) requires that the maximum number of insulated or bare conductors allowed in a conduit be determined in the same manner as that described in Rule 12-910 for conduit and tubing. A bonding conductor is also to be included in computing the conduit or tubing fill. For the purposes of determining the maximum number of insulated or bare conductors allowed in No. 12 trade size liquid-tight flexible conduit, Subrule 2) defines the cross-sectional area as 118 $mm^2$.

### Rule 12-1306 Provisions for bonding

Rule 12-1306 requires that a separate bonding conductor be installed in liquid-tight flexible metallic or non-metallic conduit in accordance with Section 10.

### Rule 12-1308 Supports

Liquid-tight flexible conduit is to be supported by straps, Type 2S and Type 21S cable ties, or other devices, except that, where it is impracticable to provide such supports, the liquid-tight flexible conduit is allowed to be fished.

## Electrical metallic tubing

### Rule 12-1400 Electrical metallic tubing Rules

Electrical metallic tubing (EMT) is a metallic raceway and, like rigid conduit, has a circular cross-section that conductors are intended to be drawn into or withdrawn from. However, EMT is not a conduit; it is a tubing with a thinner wall than that of rigid metal conduit. Therefore, it cannot be threaded by standard pipe threads. The tubing is fabricated from mild steel, aluminum alloy, or copper alloy. Tubing of steel can be of the seamed, welded, or seamless type, while tubing of aluminum alloy or copper alloy is of the seamless type. The intention is that both the inside and outside surfaces of steel EMT is to be coated for protection against corrosion. Coatings are generally zinc on the outside surface and zinc or enamel on the inside surface. Since EMT has a circular cross-section like rigid conduit, it is subject to similar Rules for conductor fill, bending radius, support requirements, etc. Special requirements for bonding can be found in Item c) of Rule 10-610.

### Rule 12-1402 Use

Subrule 1) allows electrical metallic tubing to be used in the following applications:

- for exposed work;
- for concealed work;
- in wet locations;
- in outdoor locations; and
- in or on buildings or portions of buildings of either combustible or non-combustible construction.

Due to the extra strength and better corrosion resistance of steel-type electrical metallic tubing, Subrule 2) allows it to be used in concrete or masonry slabs in contact with the earth, in addition to the applications in Subrule 1). Item c) of Rule 10-610 requires that when EMT is used in a concrete or masonry slab in contact with the earth, a separate bonding conductor be installed inside the tubing.

### Rule 12-1404 Restrictions on use

Electrical metallic tubing is a tubing with a much thinner exterior wall than rigid metal conduit and is therefore more prone to mechanical damage and deterioration of its external wall from corrosion or the elements when direct buried in the earth. Rule 12-1404 therefore does not allow the use of electrical metallic tubing:

- where it will be exposed to mechanical damage either during or after installation;
- where it will be exposed to corrosive vapour unless protective measures allowed by Rule 2-116 are taken; or
- for direct earth burial.

### Rule 12-1406 Supports

Electrical metallic tubing is tubing, not conduit, so stress at termination points (for example, boxes, cabinets, and fittings) can cause the EMT to come apart. To reduce the stress at terminations, Rule 12-1406 requires that supports be installed within 1 m of termination points and that the spacing between supports be the same as for rigid metal conduit (see Rule 12-1010). Rule 12-1406 also requires that EMT be installed as a complete system before the conductors are installed (see Rule 12-938).

### Rule 12-1410 Maximum number of conductors

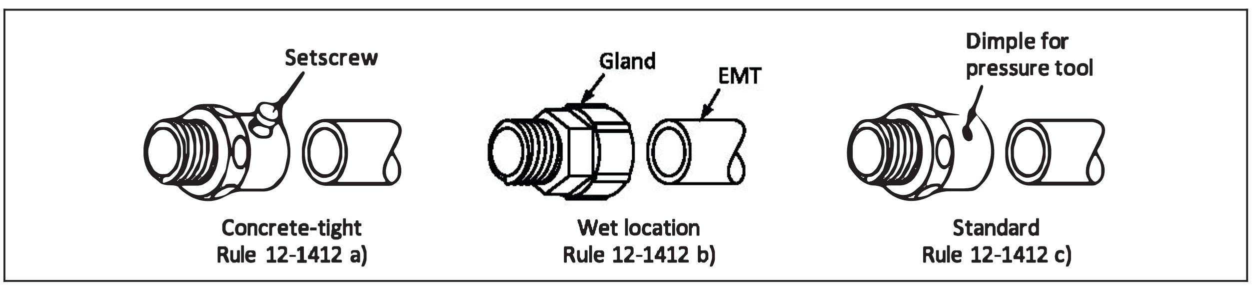
The internal dimensions of EMT are similar to those for rigid conduit of corresponding sizes. The same requirements are to be applied when determining the size of tubing and the number of conductors using Rule 12-910.

### Rule 12-1412 Connections and couplings

Where lengths of electrical metallic tubing are coupled together or connected to boxes, fittings, or cabinets, couplings and connectors are to be electrically and mechanically secured to the tubing and prevent the entrance of foreign material into the tubing. Rule 12-1412 requires that the following types of couplings and connectors be used in the following locations:

- concrete-tight type for installations in poured concrete or in masonry block walls in which cores are filled with concrete or grout;
- wet location type for installations exposed to the weather in a wet location or outdoor locations; or
- standard, concrete-tight, or wet location type for installations in ordinary locations or buried in plaster or masonry block walls. See Figure 12-26.

**Figure 12-26**
**Connectors for electrical metallic tubing**




### Rule 12-1414 Provision for bonding continuity

Due to the deterioration of its external wall from corrosion when electrical metallic tubing is installed in concrete or masonry slabs in contact with the earth, in a wet location, or outdoors, Subrule 1) requires that a separate insulated bonding conductor be installed in the tubing.

Subrule 2) allows an exemption from the requirement for a separate bonding conductor when EMT is used as the consumer's service raceway between the wet location service head and the meter base or service box.

## Electrical non-metallic tubing

### Rule 12-1500 Use

Electrical non-metallic tubing (ENT) is a pliable non-metallic corrugated raceway of circular cross-sectional shape. As ENT is a pliable raceway, it can easily be bent by hand with reasonable force and easily damaged by mechanical forces during installation or during the life of the installation. ENT is not threaded and is intended to be joined by the use of suitable solvent cement or by mechanical couplings. ENT, being fabricated from a thermoplastic compound, is classified by the *National Building Code of Canada* as a raceway and is subject to the same restrictions as other combustible wiring methods when installed in a non-combustible construction (see Rule 2-132).

Rule 12-1500 allows ENT to be used as an electrical raceway in masonry walls, in concrete slabs, or in concealed or exposed locations. When ENT is installed in an exposed location in a non-combustible building, compliance with the requirements of the *National Building Code of Canada* is necessary (see Rule 2-132).

### Rule 12-1504 Supports

Electrical non-metallic tubing is quite flexible and is to be fastened securely in place by supports within 1 m of each outlet box, junction box, cabinet, coupling, or fitting by straps, Type 2S or Type 21S cable ties, or other devices. The maximum distance allowed between supports is 1 m.

### Rule 12-1506 Maximum number of conductors

Rule 12-1506 states that the maximum number of insulated or bare conductors allowed is not to exceed the number specified in Rule 12-910. The internal dimensions of ENT are given in Table 9J.

### Rule 12-1508 Temperature limitations

Since ENT material has a maximum working temperature of 75 °C, the location of use and the type of insulated conductor are to be carefully examined. Tests have shown that 90 °C insulated conductors, continuously loaded, under conditions of 50% fill and 30 °C ambient, do not reach a temperature greater than 75 °C.

Insulated conductors with temperature ratings in excess of 75 °C are allowed to be used in rigid PVC conduit, provided that the ampacities are corrected to those of 90 °C insulated conductors. For example, insulated conductors with the insulation temperature ratings shown in Table 2, Column 5 (110 °C) are allowed to be used, provided that the ampacities shown in Column 4 (90 °C) are not exceeded.

### Rule 12-1512 Support of equipment

Due to its ductility, ENT is prohibited from being used to support electrical equipment.

### Rule 12-1514 Provision for bonding continuity

Since electrical non-metallic tubing is made from non-metallic materials and does not afford a bonding path, separate bonding is to be provided by installing a bonding conductor at each outlet. The bonding conductor is to be installed to ground metal boxes that are used with these conduits (see Rule 10-612).

## Surface raceways

### Rule 12-1600 Scope

Rules 12-1602 to 12-1614 list the requirements for the installation of surface raceway systems. A surface raceway is a raceway in the form of a metallic or non-metallic channel, consisting of a backing and a capping for holding the conductors. The two parts are constructed so that they are firmly fastened together to form an enclosed raceway. Surface raceways are intended to be run exposed on the surface of walls, floors, or ceilings. They can be used to extend a wiring system (for example, an external raceway on a wall from a switch to a receptacle) and can be installed as a complete system.

### Rule 12-1606 Conductors in surface raceways

Insulated conductors in surface raceways are subjected to the same stresses as insulated conductors in circular cross-sectional raceways during installation or withdrawal from the raceway. The cross-sectional areas of surface raceways can be obtained from the manufacturer.

Subrule 2) requires that the cross-sectional areas of surface raceways that can be filled with insulated or bare conductors not exceed 40% of the minimum available area. The cross-sectional area of surface raceways can be obtained from the manufacturer.

Subrule 3) states that the maximum number of insulated or bare conductors allowed is not to exceed the number specified in Rule 12-910.

### Rule 12-1610 Joints and splices

Rule 12-1610 allows joints or splices to be made when surface raceways have covers that can be removed after installation and when the conductor fill does not exceed 75% of the cross-sectional area at the point where the splices or joints are made.

### Rule 12-1612 Provisions for bonding

Since non-metallic surface raceways are made from non-conducting materials and do not afford a bonding path, separate bonding must be provided by installing a bonding conductor at each outlet. Metal surface raceways do not require a mandatory bonding conductor, although installing a bonding conductor can help to prevent electrical disturbance due to a loose raceway connection.

### Rule 12-1614 Flat cable systems

Flat cable systems employ specially constructed cable that, together with specific types of fittings, can be used with metal surface raceways. The cable is an assembly of parallel conductors and side wings, formed with an integral insulating material and designed specifically for use in metal surface raceways. Also, the cable is marked with its ampacity, voltage, and temperature ratings.

Subrule 1) allows flat cable to be field-installed in metal surface raceways, with tap fittings and end cap devices suitable for use with the raceway. Flat cables are to be used only in horizontal runs, with the flat cable in the uppermost section of the raceway.

Subrule 2) does not require covers on the underside to protect the flat cable from mechanical damage or accidental contact if the raceway is installed in a location where it is isolated or out of reach.

## Underfloor raceways

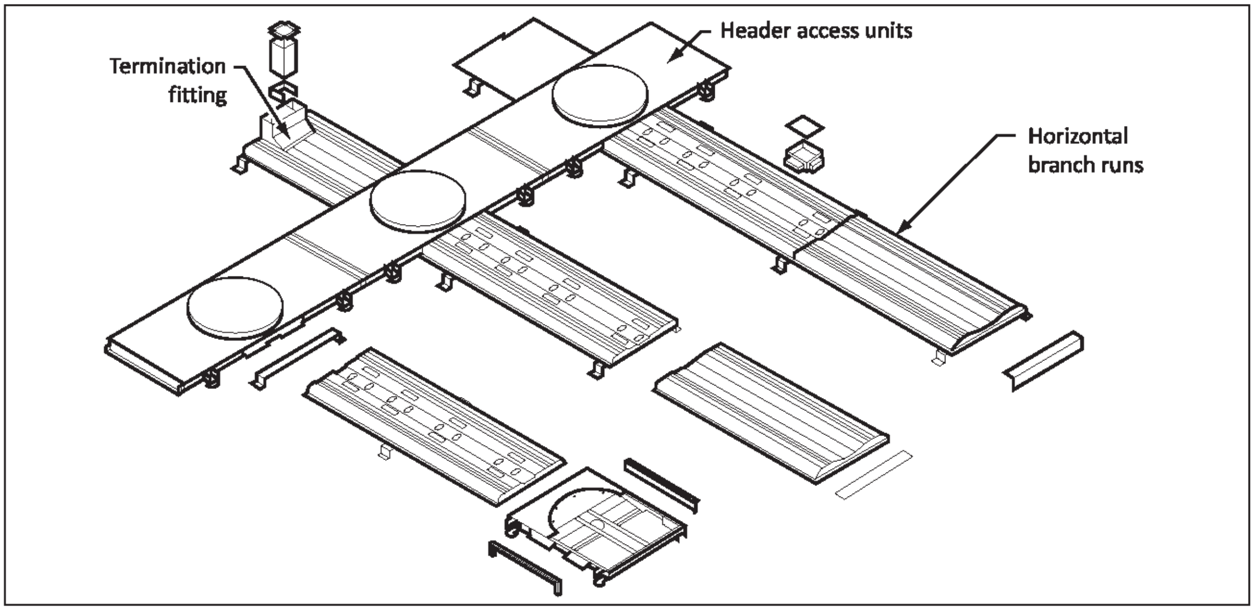
### Rule 12-1700 Where underfloor raceways are permitted

Underfloor raceway systems are used in office buildings for the installation of the wiring for telephone and signal systems and for convenience outlets for electrically operated office machinery. They provide a flexible system through which the location of outlets can be changed easily to accommodate the rearrangement of furniture and partitions.

The underfloor raceway wiring method is a means of providing power and communication systems to large offices and retail and commercial areas. The raceway is intended to be installed within the concrete slab or other flooring material. Underfloor raceways are an arrangement of distribution and header raceways, couplings, junction boxes, and header access units used to install or remove the conductors. These requirements of Rule 12-1700 do not apply to cellular metal or cellular concrete floor raceways.

Subrule 1) allows underfloor raceways to be installed beneath or flush with a concrete floor surface or other flooring material. In other words, the raceway is intended to be encased in or to be inside the floor material (concrete) either at the surface or directly below it. The raceway may be covered with floor covering material. The raceway is not intended to be installed below or on the underside of the floor structure. See Figure 12-27.

**Figure 12-27**
**Typical underfloor raceway system**




### Rule 12-1702 Method of installing underfloor raceways

In addition to requiring compliance with this Rule, Subrule 1) requires that underfloor raceways be installed in accordance with the manufacturer's instructions. Note that minimum concrete cover thickness is marked by the manufacturer on each length of raceway and fitting.

Subrule 2) requires that the raceway be laid in a straight line between junction boxes, so that the raceway can be easily located.

Subrule 5) requires that the system be installed so that there are no low points in a run or crossing. The low points can form traps for water.

### Rule 12-1706 Taps and splices in underfloor raceways

Taps and splices are to be accessible when the installation is completed. Rule 12-1706 allows taps and splices to be made only in header access units or junction boxes since these components are to be accessible after the installation is complete.

### Rule 12-1708 Inserts and junction boxes for underfloor raceways

Inserts and outlets in underfloor raceways are to be:

- electrically secure, usually by means of a bonding conductor, since the connection between the raceway and insert cannot always be secure; and
- mechanically secure by being attached to the raceway and grouted in place. Exceptions to this requirement are allowed when:
  - using the pre-set type; or
  - installing the inserts after the finished floor is laid so that the inserts and outlets can be properly secured by mechanical fasteners.

### Rule 12-1710 Setting of inserts

When inserts are installed by cutting through the walls of the raceway, either during or after the laying of the floor, Rule 12-1710 requires that they be installed in a manner that prevents chips and dirt from falling into the raceway. The intention is to ensure that specific tools designed for use in cutting the raceway wall are used and that care is taken not to damage any of the insulated conductors in the raceway.

### Rule 12-1712 Discontinued outlets in underfloor raceways

Where an outlet is abandoned or removed from the system, Rule 12-1712 requires that the circuit's insulated conductors be removed to prevent a buildup of unused insulated conductors that could obstruct the installed insulated conductors or obstruct the insulated conductors that are added at a later date.

### Rule 12-1714 Area of conductors in underfloor raceways

Subrule 1) requires that the underfloor raceways be of sufficient size to allow the insulated or bare conductors to be easily installed or removed and that the conductor fill not exceed 40% of the cross-sectional area of the raceway.

Subrule 2) states that the 40% conductor fill requirement of Subrule 1) does not apply when only mineral-insulated cable, aluminum-sheathed cable, copper-sheathed cable, armoured cable, or non-metallic-sheathed cable is used, due to the characteristics of the cable and their installation methods.

Subrule 3) states that the maximum number of insulated or bare conductors allowed is not to exceed the number specified in Rule 12-910.

### Rule 12-1718 Inserts in post- and pre-stressed concrete floors

Pre-set inserts are factory installed in the raceway. After-set inserts are field installed.

The methods of installation for after-set inserts and access units are not detailed in the *National Building Code of Canada*, other than by reference to CSA A23.3, which describes the design of such structures. It is good practice to consult with the structural engineer prior to placing such units since the installation might interfere with the structural reinforcing of the concrete flooring.

## Cellular floors

### Rule 12-1800 Installation

Cellular floor raceways are a type of underfloor raceway in which the hollow spaces (cells) in the floor construction are made suitable for use as a raceway for electrical conductors to be installed in or withdrawn from. Cellular floor raceways differ from an underfloor raceway in that they form part of the structural aspect of the flooring system. The floor consists of rolled sheet steel that is shaped to form cells. The cells are various sizes and designs, depending on the required structural strength of the floor. Header ducts extend across the cells to provide access to those cells being used for electrical circuit conductors. Complete instructions, furnished by the manufacturer, facilitate proper installation of the floor system; these include illustrations of all essential features, the relationship between all components, and the type, size, and use of special tools.

Since cellular floors are part of the building structure, Rule 12-1800 requires that they be installed in accordance with the manufacturer's instructions (drawings and specifications).

### Rule 12-1802 Conductors in cellular floors

Insulated or bare conductors are not allowed to be installed in a cellular floor in:

- areas exposed to corrosive vapours, as covered in Section 22;
- commercial garages where gas seepage can create a hazardous condition;
- storage-battery rooms, due to the possible spillage of corrosive liquids; and
- cells or headers that contain pipes for steam, water, gas, or other non-electrical services to prevent damage to the electrical systems from these services.

### Rule 12-1804 Maximum conductor size in cellular floors

Cellular floors limit the size of insulated or bare conductors that are allowed to be installed to a maximum size of No. 0 AWG copper or aluminum, unless a deviation has been allowed in accordance with Rule 2-030.

### Rule 12-1806 Cross-sectional area of cellular floors
Subrule 1) states that the cross-sectional areas of cellular floors that are filled with insulated or bare conductors or cables are not to exceed 40% of the header's cross-sectional area. The cross-sectional area of headers feeding the individual cells can be obtained from the manufacturer. The 40% conductor fill requirement does not apply when only mineral-insulated cable, aluminum-sheathed cable, copper-sheathed cable, armoured cable, or non-metallic-sheathed cable is used, due to the characteristics of the cable and the methods used to install it.

Subrule 2) states that the maximum number of insulated or bare conductors or cables allowed is not to exceed the number specified in Rule 12-910.

### Rule 12-1812 Cellular floor junction boxes
If spot welding is used for electrical continuity, Subrule 4) requires that the welding be done in the open spaces between the cells and not to the cell walls to avoid creating rough edges in the cells that might damage the conductors or the insulation on the conductors.

### Rule 12-1814 Provision for bonding
To establish an electrically conductive path, equipotential plane, and fault current path (see Rule 10-002) between non-current-carrying metal parts of the different components of a cellular floor wiring method, Subrule 1) requires that a separate bonding conductor, sized in accordance with Table 16, be installed with the circuit conductors in the cells and headers.

Subrule 2) requires that metal components of a cellular floor wiring method be bonded to ground in compliance with the requirements in Section 10.

### Rule 12-1816 Cellular floor inserts
When installing metal inserts, Subrule 3) requires that care be taken to prevent chips of metal or dirt from falling into the cell. The intention is to ensure that specific tools designed for use in cutting the cellular flooring wall are used and that care is taken not to damage any of the insulated conductors in the flooring.

## Auxiliary gutters

### Rule 12-1900 Where auxiliary gutters are used to supplement wiring spaces
Auxiliary gutters are metal enclosures used to enclose insulated or bare conductors or cables at meter centres, distribution centres, switchboards, or control centres. An auxiliary gutter is a wireway fabricated from sheet metal, limited in length, and intended to enclose only insulated or bare conductors or cables.

Subrule 1) requires that auxiliary gutters be used, as part of a complete assembly of electrical equipment at distribution centres, to supplement wiring space by enclosing insulated or bare conductors and cables that are used as feeders or branch circuit conductors. The gutter is not to be used to enclose busbars, switches, overcurrent devices, or other equipment since it is not designed or certified for this purpose.

Subrule 2) requires that gutters not extend more than 6 m beyond the electrical equipment they supplement. If a gutter is extended beyond 6 m, the enclosure is to comply with the provisions for wireways under Rule 12-2100 or for busways under Rule 12-2000.

### Rule 12-1904 Auxiliary gutter cross-sectional area
Subrule 1) states that the cross-sectional area of auxiliary gutters to be filled with insulated conductors is not to exceed 20% of the gutter's cross-sectional area.

Subrule 2) states that a single compartment of an auxiliary gutter is to contain no more than the maximum number of insulated or bare conductors as allowed in Rule 12-910.

# Busways and splitters

## Rule 12-2000 Use

A busway is an assembly of copper or aluminum conductors or rigid busbars that are enclosed in a metal trough and intended for use as feeders or subfeeders. Busways provide a power distribution system that allows flexibility in changing electrical equipment. Enclosures can be ventilated with openings or totally enclosed (non-ventilated). Splitters are similar to busways, except that they contain busbars or terminal blocks provided with main and branch connections for carrying power in or out of the splitter. A splitter enclosure exceeding 4900 mm in length is considered a busway.

Subrule 2) requires that busways suitable for use in other than dry locations be marked for their intended location (for example, CSA Enclosures 2, 3, 4, and 5) (see Rule 2-400). Busways provided with drain holes are marked "Install with drain holes down."

Subrule 3) requires that busways or splitters not be installed:
- where subject to mechanical damage. To prevent damage, the electrical equipment may be protected by elevation, covers, or guards;
- where subject to corrosive vapours, as described in Section 22;
- in hoistways, due to the restricted space, access, and hazards involved when servicing equipment (see Rule 38-021); or
- in storage-battery rooms, in accordance with Rule 26-500.

Subrule 4) allows busways to be installed as risers in buildings of non-combustible construction, provided that fire stops are installed at each location where a fire separation has been pierced.

If a deviation under Rule 2-030 is obtained, Subrule 5) allows busways to be installed in false ceiling spaces, provided that the following conditions are met:
- the working space between the busway and any other services or structural parts is adequate for servicing, maintenance, and installation;
- the ventilation is adequate to prevent the ambient temperature from exceeding 30 °C. If the temperature exceeds 30 °C, the busway is to be derated by 82%, 71%, and 58% for temperatures of 40 °C, 45 °C, and 50 °C, respectively. Busways are not to be installed in ceiling spaces where the ambient temperature is higher than 50 °C;
- the take-off devices do not contain arcing or heat sources (for example, switches or circuit breakers). Overcurrent protection may be installed outside the ceiling space; and
- the busway is of the totally enclosed type, except that the ventilated type is allowed to be used provided that:
  - the busbars are insulated for their full length, including joints between sections;
  - the false ceiling is non-combustible; and
  - there is no combustible material within 150 mm of the busway.

Where two or more conductors are to be connected to a conductor larger than No. 6 AWG copper or No. 4 AWG aluminum, Subrule 6) requires that a splitter with a separate screw or stud be installed in an accessible location for each connection. Only one conductor is to be installed in a connection, unless it is marked for multiple connections.

**Note:** *Sometimes factory-assembled equipment appears in the field with more than one conductor connected in a terminal that would not normally be accepted for dual conductors in a field assembly. Factory-assembled equipment is subject to a variety of tests, and the integrity of such connections is part of the test procedure. Such testing is not practical in the field.*

Subrule 7) allows splitters to be installed so that they are flush with the wall covering provided that they are accessible through removable covers.

### Rule 12-2004 AC circuits in busways and splitters

To prevent overheating of the metal enclosure by induction, Rule 12-2004 requires that all ac insulated conductors of a circuit be placed in the same busway, splitter enclosure, or section, when the splitter is made of magnetic material.

### Rule 12-2006 Busway and splitter supports

Subrule 1) requires that, due to their weight, busways be supported at least every 1.5 m unless the busways are marked to allow greater spacing between horizontal supports.

Vertically mounted busways are designed to prevent any vertical movement of the busbars within the enclosure; therefore Subrule 2) requires that each length of busway intended for vertical mounting be marked to indicate its suitability for such use.

For busways that are mounted in the vertical position, Subrule 3) requires that they be supported at each floor level and at distances not greater than 1.5 m unless the busways are marked as allowing greater spacing between supports.

To allow for servicing and maintenance of busways, Subrule 4) requires that the supports and joints be accessible after installation.

Subrule 5) requires that splitters be supported in a way similar to busway support, at distances not greater than 1.5 m unless marked as being suitable for support at greater distances.

### Rule 12-2008 Method of installation of busways

In order for busways to be serviced and repaired after installation, Subrule 1) requires that busways where they are to pass through dry walls or partitions be in unbroken lengths, with no splices or joints inside the wall or partition. To prevent a fire or smoke hazard if damage occurs to the busway when the walls or partitions are of combustible construction or of masonry construction containing voids, Subrule 1) also requires that a totally enclosed type of busway be used.

Subrule 2) allows busways to extend vertically through a floor, provided that they are:

- in a dry location;
- in a location accessible only to qualified personnel;
- totally enclosed for the first 300 mm above where they pass through the floor; and
- provided with fire stops in accordance with Rule 2-128.

To prevent damage from daily building operations in areas accessible to other than qualified personnel, Subrule 3) requires that protection be provided against:

- mechanical damage; and
- contact with live parts.

Protection is considered adequate if the horizontally or vertically mounted busway is covered for at least 2 m above the floor.

Subrule 4) requires that dead-ends of busways be enclosed with a closure fitting to prevent access to current-carrying parts and the entrance of dust or other foreign materials.

Subrule 5) requires that busways installed in outdoor areas, parking areas, or areas accessible to other than authorized personnel be of the totally enclosed type, preventing the public from contacting the internal components.

### Rule 12-2014 Length of busways used as branch circuits

Busways have multiple tap points along their length for the insertion of bus plugs where branch circuits can be tapped off. Since the design of a busway allows for many bus plugs to be inserted into the length, Subrule 1) requires that the length of busways used to connect to branch circuits be limited so that in normal use the circuits are not overloaded by the later addition of bus plugs.

Subrule 2) gives the designer a method to limit the length of a busway to prevent the overload of the busway by the addition of branch circuits. The method is to limit the length of busway in metres to the ampacity of the overcurrent protection for the branch circuit.

### Rule 12-2016 Manufacturer's identification on busways and splitters

Rule 12-2016 requires that each section of a busway or splitter be permanently marked in such a way that the marking is visible after installation. Marking is to consist of the manufacturer's name or trademark, ratings in volts and amperes, and support spacing for either vertical or horizontal mounting.

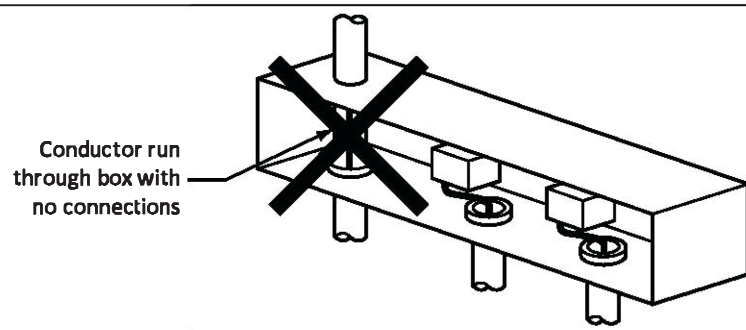
### Rule 12-2018 Taps in splitters

Rule 12-2018 requires taps made from busbars or terminal blocks in splitters to issue from the enclosure on the side nearest to the terminal connection. To prevent a short from occurring in the splitter, insulated conductors are not to contact or touch the uninsulated current-carrying parts (busbars) of opposite polarity.

### Rule 12-2020 Circuit restrictions in splitters

Rule 12-2020 requires that splitters be used only for connecting insulated conductors to busbars or terminal blocks. Splitters are not intended for use as a raceway for circuit or feeder insulated conductors not connected to the busbars. See Figure 12-28.

**Figure 12-28**
**Circuit restrictions in splitters**

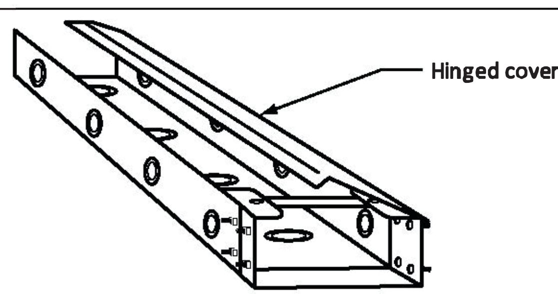



## Wireways

### Rule 12-2100 Where wireways may be used

Wireways are a wiring method consisting of a metal trough with a removable cover (see Figure 12-29 and Table 12-12). They are formed so that insulated conductors can be drawn or laid in, and removed after the system has been installed, without damage to the insulated conductors or their covering.

**Figure 12-29**
**Lay-in wireway**



### Rule 12-2102 Method of installation of wireways

When installing wireways, Rule 12-2102 requires that the wireways be:

- in unbroken lengths where they cross dry walls or partitions [Subrule 1)];
- supported at intervals of not more than 1.5 mm [Subrule 2)];

  **Note:** *The wireways may be supported at greater intervals, provided that they are marked to indicate the maximum support spacing.*
- provided with suitable end fittings to prevent the entrance of dust and foreign materials [Subrule 3)]; and
- protected against mechanical damage for a distance of 2 m above a floor when installed in areas that are accessible to other than qualified personnel [Subrule 4)].

### Rule 12-2104 Conductors in wireways

Rule 12-2104 requires that insulated conductors in wireways be:

- insulated and of the types listed in Table 19 as being suitable for use in raceways [Subrule 1)]; and
- not larger than 500 kcmil copper or 750 kcmil aluminum, to prevent damage to smaller conductors as conductors are usually laid into wireways and often added or removed through the lifetime of the installation [Subrule 3)].

Table 12-12 below shows the requirements of Subrules 2) and 4) for determining the maximum number of insulated or bare conductors allowed in a single compartment of a wireway.

**Table 12-12**
**Number of conductors and percentage conductor fill for wireways**

| Conductor application | Maximum number of conductors per wireway or in each compartment of a divided wireway | Maximum cross-sectional area fill, % |
|---|---|---|
| Control and signal | 200 | 20 |
| Other than control or signal | 200 | 40 |

Subrule 5) states that the cross-sectional area of insulated or bare conductors allowed is to be as specified in Rule 12-910.

### Rule 12-2106 Taps and splices in wireways

Rule 12-2106 requires that splices and taps to conductors made in wireways conform to the requirements of Rule 12-112 to prevent potential shock hazard and shorts. To allow inspection for maintenance or fault finding, the connection must be accessible when the wireway cover is in the open position.

### Rule 12-2108 Extensions from wireways

Examples of acceptable wiring methods for use in extensions are rigid conduit or flexible metal conduits, surface raceways, cable trays, EMT, armoured cables, and metal-sheathed cables. Type SJ, SJO, or SJT (see Table 11) are examples of hard-usage cords that may be used.

### Rule 12-2110 AC circuits in wireways

When the wireway is made of ferrous/magnetic material and ac is used, Rule 12-2110 requires that all insulated conductors of an ac circuit be placed in the same wireway. If a barrier made of ferrous material is installed, all insulated conductors of an ac circuit are to be contained in the same barriered section to prevent overheating of the ferrous/magnetic material (see also Rule 12-904).

# Cable trays

## Rule 12-2200 Method of installation

Subrule 1) requires that cable trays be installed as a complete system before any insulated conductors or cables are installed. To avoid exceeding the allowable bending radii, as specified in Rules 12-110, 12-614, 12-712, and 36-102, the cable tray system is to be designed and installed to prevent damage to insulated conductors or cables. Insulated conductors and cables are to be supported in place by mechanical means in the tray.

CSA Group Standards require that the marking on the cable tray include the load/span rating of the cable tray. Subrule 2) requires that the cable trays be designed and installed so that the maximum design load and associated design support spacing (as marked on the cable tray) are not exceeded.

Subrule 3) allows cable trays to pass through a wall, provided that the wall is constructed of non-combustible materials. When allowed by the authority having jurisdiction (AHJ), trays passing through a wall constructed with combustible material are to be totally enclosed to prevent possible ignition of the combustible material.

Subrule 4) allows cable trays to pass in the vertical position through a floor of combustible or non-combustible construction, provided that:

- the floor is in a dry location;
- the tray has been provided with fire stops installed at each location where a fire separation has been pierced; and
- the tray is totally enclosed when passing through the floor, and extends a minimum distance of 2 m above the floor for protection against mechanical damage.

Subrule 5) requires that cable trays be supported by non-combustible supports of adequate strength and rigidity to withstand the maximum design load, as discussed in Subrule 2).

**Note:** *When designing and installing supports for cable trays, it is important to take into account that people commonly walk or crawl along cable trays and that extra conductors are added to the trays throughout the lifetime of the installation.*

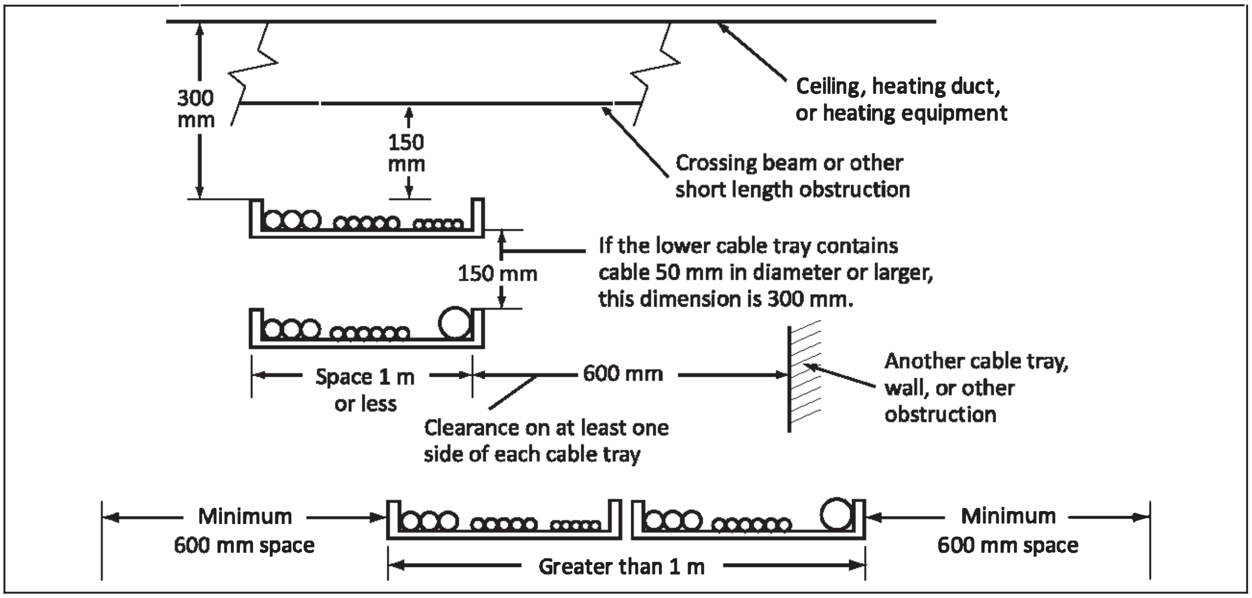
Subrule 6) requires that adequate working space be provided to provide access to the cable trays, to facilitate the installation and removal of the insulated conductors or cables, and to maintain the system (see Figure 12-30).

**Note:** *For the purposes of Rule 12-2200, "short length obstructions" are obstructions that do not completely cover the cable tray installations, such as a ceiling that restricts the access to the tray needed to install or remove conductors, or a heating duct and heating equipment that, by increasing the ambient temperature at the tray, can damage the conductor's insulation.*

Modular assemblies such as natural gas compressor stations and gas plants can be required to have the electrical installation installed using a cable and cable tray as the wiring method. Due to the constraints of space in these units as well as in other installations, it is often difficult, if not impossible, to maintain the clearances as outlined in Item b) of Subrule 6) of 12-2200. Although the requirement to install and withdraw cable without damaging the cable is important, Subrule 7) will allow reduced clearances in installations where the cable tray passes through chases, under grating, under process pipes, and other such obstructions.

Expansion and contraction of the cable tray can damage the cable tray, building components, and the insulated conductors or cable inside the tray. Subrule 8) requires that at least one expansion joint be installed in any cable tray run where temperature changes can damage the tray.

## Figure 12-30
## Clearances for cable tray




### Rule 12-2202 Insulated conductors and cables in cable trays

Subrule 1) requires that insulated conductors and cables used in cable trays be as listed in Table 19 and have a continuous metal sheath or interlocking armour. An exception to the continuous metal sheath or interlocking armour is allowed for the type of cables listed in Subrule 2).

Type TC tray cable has a non-metallic sheath and is suitable for use in cable trays in areas in industrial establishments that are inaccessible to the public. The cable is marked "TC" and the mark "FT4" is added to indicate flame spread and smoke development ratings.

Type TC tray cable can be installed in areas of industrial establishments that are inaccessible to the public provided that the conditions set out on Subrule 2) are satisfied. The protection specified in Subrule 2) includes:

- mechanical protection:
  - by being installed in conduit or other suitable raceway or direct buried when not in the cable tray; and
  - by guarding from possible damage from falling or movable objects;
- ensuring that it is installed only where qualified personnel service the installation; and
- a size limitation of No. 1/0 AWG for single insulated conductors or single-conductor cable.

Subrule 3) allows an exemption from Items a) and b) of Subrule 2) when Type TC-ER tray cable is used to extend the cable between cable trays and between the cable tray and utilization equipment or devices provided that the distance does not exceed:

- 1.5 m without continuous support; and
- 7.5 m where continuous supported.

Subrule 4) allows conductors having moisture-resistant insulation and flame-tested non-metal coverings or sheaths that are listed in Table 19 to be used in ventilated or non-ventilated cable trays when they are not exposed to damage during or after installation and the tray is used in:

- electrical equipment vaults and service rooms; and
- other locations, where a deviation under Rule 2-030 has been allowed, that are inaccessible to the public.

Subrule 5) requires that conductors and cables be secured by straps, cable ties, or other devices at distances not exceeding 1.5 m where:

- excessive movement could be caused due to fault current magnetic forces; and
- the minimum spacing requirements between insulated conductors and cables are required to maintain consistent ampacity values for their designed application.

To prevent heating of the supports due to induction from insulated single conductors and single conductor cables used on ac circuits, Subrule 6) requires that supports not encircle them with ferrous/magnetic materials.

### Rule 12-2208 Provisions for bonding

To provide a fault current path and create an equipotential plane between non-current-carrying metal parts of the cable tray system, and to minimize any potential difference to earth, Subrule 1) requires that metal cable trays be bonded to ground and bonded together at intervals not to exceed 15 m and that the minimum size of bonding conductors be based on the ampacity of the largest ungrounded conductor in the circuits carried by the cable tray as specified in Rule 10-614.

Subrule 2) allows an exemption from the use of a bonding conductor to bond the cable tray to ground when the metal supports for the metal cable tray are bolted to the tray and are in good electrical contact with the grounded structural metal frame of a building.

The cable sheaths having an interlocking metal armour (such as for AC90 or TECK90 cables) or having a continuous metal sheath that is to be used as a bonding method/conductor (such as for RA90, RC90, and certain types of MI cables) do not require their supporting metal structure, such as threaded rod and angle iron or unistrut, to be bonded to ground. Since these cables do not require the supporting structure to be bonded to ground due to their construction, certification, and the Code requirements of the cable, Subrule 3) exempts the metal cable tray from being bonded to ground where all of the cables contained within the tray:

- have an interlocking metal armour; or
- have a continuous metal sheath that is allowed to be used as a bonding method/conductor.

Shock hazards and other problems can occur when cables that do not have interlocking metal armour or a continuous metal sheath that is to be used as a bonding method/conductor installed in the cable tray that was not bonded to ground. To avoid this situation, Subrule 4) requires that the unbonded metal cable tray containing these types of metallic cables have a permanent, legible warning notice with the wording "INTERLOCKING METAL ARMOUR CABLES OR CONTINUOUS METAL SHEATH CABLES ONLY" or equivalent, placed in a conspicuous position with the maximum spacing of warning notices not to exceed 10 m.

## Cablebus

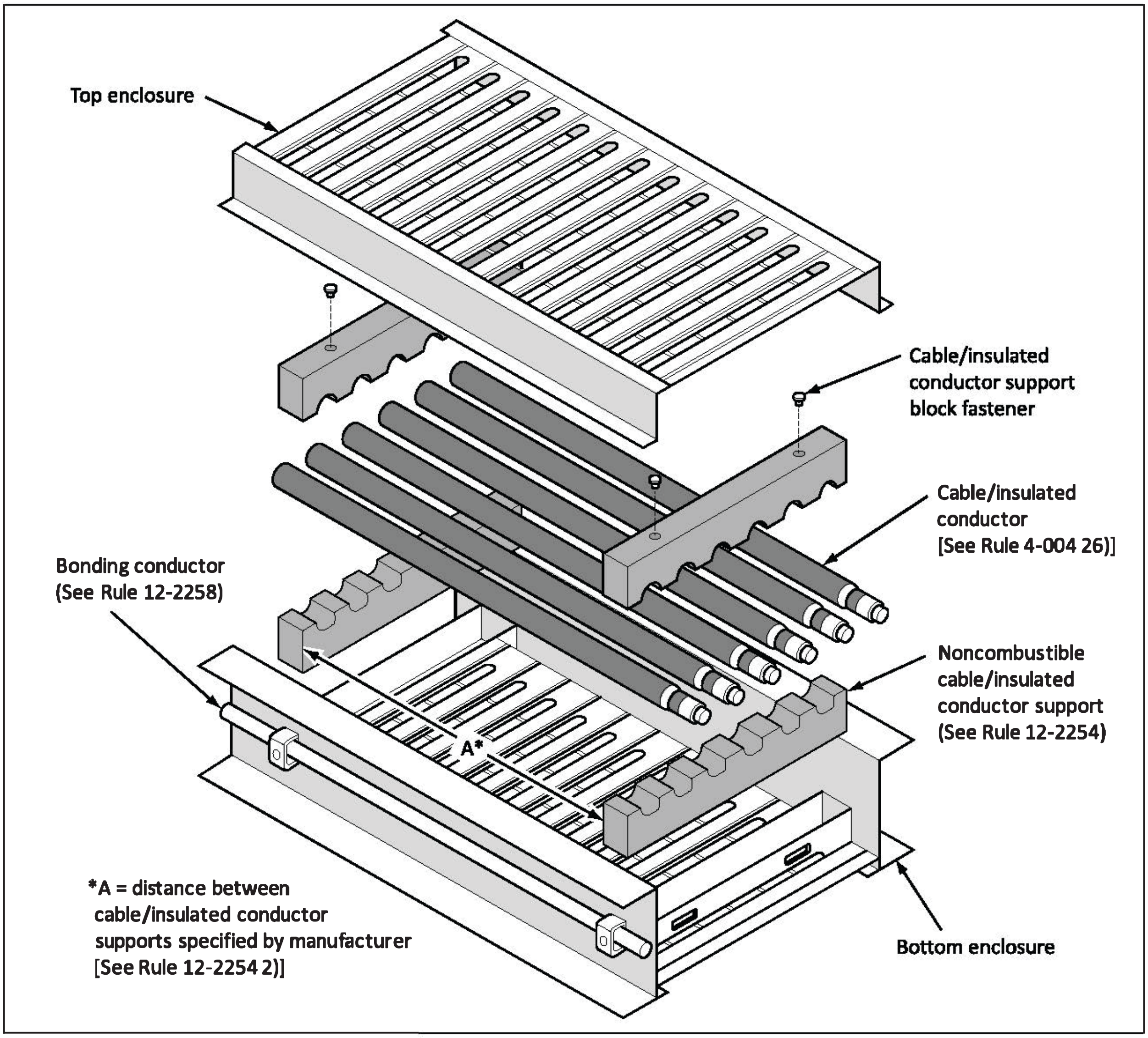
### Rule 12-2250 Scope

Cablebus is a system for distributing power from one electrical apparatus to another using insulated power cables, in lieu of bus bars, inside of a protective metal housing that is similar to a cable tray. Cablebus is designed to carry large amounts of electrical power for use within facilities such as power-generation and industrial plants for service entrances, main feeders, distribution applications, and retrofits for existing power systems. Typical applications include connections between transformers and switchgear, and tie connections between two or more pieces of switchgear, between motor control centres and large motors, and between generators and other power production sources (Sections 64 and 84) and distribution equipment such as breakers, switchgear, or transformers.

Each system is custom designed and manufactured to meet specific project/installation requirements. Cables are held securely using support blocks that are held in place in the metal housing. See Figure 12-31.

Rules 12-2252 to 12-2258 give the requirements for a cablebus installation. Since cablebus installation combines the installation of busways and a cable tray, see Table 12-13 for installation requirement comparisons.

**Figure 12-31**
**Section of typical cablebus**



## Table 12-13
## Comparison between installation requirements of busways, cable tray, and cablebus

| Item | Busways | Cable tray | Cablebus |
|---|---|---|---|
| Use | Rule 12-2000 | Consult the Rules for the specific type of installation | Rule 12-2252 |
| Extension from busways | Rule 12-2002 | Rule 12-2206 | Rule 12-2256 |
| AC circuits in busways | Rule 12-2004 | Rule 12-904 | NA |
| Busway supports | Rule 12-2006 | Rule 12-2200 2) | Rule 12-2254 6) and 7) |
| Methods of installation | Rule 12-2008 | Rule 12-2200 | Rule 12-2254 |
| Extending through walls | Rule 12-2008 1) | Rule 12-2200 3) | Rule 12-2254 8) and 9) |
| Extending through floors | Rule 12-2008 2) | Rule 12-2200 4) | Rule 12-2254 10), 11), and 12) |
| Clearances | Rule 12-2000 | Rule 12-2200 6) | Rule 12-2254 4) |
| Expansion joints | NA | Rule 12-2200 8) | Rule 12-2254 5) |
| Mechanical protection | Rule 12-2008 2) and 3) | Rule 12-2200 4) | Rule 12-2254 10) and 11) |
| Plug-in devices for busways | Rule 12-2010 | NA | NA |
| Reduction in size of busway | Rule 12-2012 | NA | NA |
| Length of busways used as branch circuits | Rule 12-2014 | NA | NA |
| Manufacturer's identification | Rule 12-2016 | NA | Rule 12-2254 1) |
| Conductors in cable trays | NA | Rule 12-2202 | NA |
| Joints and splices within cable trays | NA | Rule 12-2204 | NA |
| Connection to other wiring methods in cable trays/cablebus | NA | Rule 12-2206 | Rule 12-2256 |

*(Continued)*

## Table 12-13 (Concluded)

| Item | Busways | Cable tray | Cablebus |
|---|---|---|---|
| **Provisions for bonding of cable trays/cablebus** | NA | Rule 12-2208 | Rule 12-2258 |
| **Ampacities of conductors in cable trays/cablebus** | NA | Rule 12-2210 | Rule 4-004 26) |

### Rule 12-2252 Use of cablebus

CSA C22.2 No. 273 includes definitions and separate requirements for Class A type and Class B type cablebus. Class A type cablebus has separate requirements and testing because it is used in installations in public areas such as schools, commercial office buildings, and malls. The Class A type cablebus provides protection from contact with conductors by design and construction of the enclosure; therefore, Subrule 1) allows Class A type cablebus to be used in installations where the cablebus is:
- accessible to the public; or
- installed in areas where a Class B type cablebus is allowed.

Class B type cablebus does not provide protection from contact with conductors by design and construction of the enclosure; therefore, Subrule 2) allows Class B type cablebus only for installations where it is:
- accessible only to authorized persons;
- isolated by elevation or by barriers; and
- serviced only by qualified electrical maintenance personnel.

The Appendix B Note to Rule 12-2252 states that cablebus not marked as Class A is considered to be Class B type cablebus.

## Extra-low-voltage suspended ceiling power distribution systems

### Rule 12-2300 Scope

Rules 12-2302 to 12-2320 apply only to the installation of extra-low-voltage suspended ceiling power distribution systems.

These Rules provide the specific requirements for the safe installation of extra-low-voltage suspended ceiling power distribution system loads. These extra-low-voltage systems are intended to be installed as a suspended ceiling grid that provides mechanical support for the ceiling tiles and provides electrical connections between the extra-low-voltage power supply and the extra-low-voltage equipment. The suspended ceiling grid extra-low-voltage system is intended to be permanently connected, to be used in indoor dry locations, and to be installed in accordance with the requirements found in Rules 12-2302 to 12-2320.

An extra-low-voltage system consists of the following components:
- an isolating-type extra-low-voltage power supply with output(s) operating at 30 V (42.4 V peak) or less and not exceeding Class 2 power limits;
- a grid rail power distribution system to provide power from the Class 2 power supply to one or more pieces of Class 2 powered equipment; and
- Class 2 powered equipment that is electrically connected to the suspended ceiling grid extra-low-voltage system.

### Rule 12-2302 Special terminology

This Rule gives the special terminology that is used with extra-low-voltage suspended ceiling power distribution systems. These definitions should be reviewed prior to designing and installing these systems.

### Rule 12-2304 General

Subrule 1) requires that extra-low-voltage suspended ceiling distribution systems be installed as a complete system with the utilization equipment, Class 2 power supply, and fittings.

Extra-low-voltage suspended ceiling power distribution systems are designed as a complete system [see Subrule 1)]. However, Subrule 2) allows the system to supply extra-low-voltage utilization equipment not identified as part of the system.

### Rule 12-2306 Use permitted
Extra-low-voltage suspended ceiling power distribution systems are to be permanently connected for use:
- in extra-low-voltage Class 2 circuits where the energy to the circuit is limited by Rule 16-200;
- in dry locations;
- in residential, commercial, and industrial applications; and
- in other spaces used for environmental air where a duct, plenum, or hollow space is created by the suspended ceiling having lay-in panels or tiles, provided:
  - the electrical equipment has enclosures that are suitable for use within an air handling space; and
  - it is in accordance with the requirements of Rules 2-130 and 12-100.

### Rule 12-2308 Use prohibited
Suspended ceiling power distribution systems are not to be installed:
- in damp or wet locations;
- where subject to corrosive fumes or vapors, such as storage battery rooms;
- where subject to physical damage;
- in concealed locations;
- in patient care areas as defined in Section 24;
- in hazardous locations; or
- as part of a fire-rated assembly, unless designed for use as part of the assembly.

### Rule 12-2310 Class 2 circuit conductors
Since the extra-low-voltage suspended ceiling power distribution system is to be supplied from a Class 2 power supply (see Rule 12-2304), the insulated circuit conductors and cables are to meet the requirements of Rule 16-210 and are to be installed in compliance with the Rules of Section 16.

### Rule 12-2312 Disconnecting means
To ensure the safety of those working on the Class 2 power supply, Subrule 1) requires that a disconnecting means be located so that it is accessible and within sight of the power supply.

The Class 2 power supply is allowed to be connected to a multi-wire branch circuit; in this case, Subrule 2) requires that the disconnecting means simultaneously disconnect all ungrounded conductors from the power supply.

### Rule 12-2316 Connectors
For renovations, testing, troubleshooting, and repairs, Subrule 1) requires that connections to the busbar, cables, and conductors be accessible after installation.

Subrule 2) lists the types of connectors that may be used as connection or interconnection devices, as follows:
- load connectors;
- pendant connectors;
- power feed connectors; and
- rail-to-rail connectors.

### Rule 12-2318 Output connections and reverse polarity protection (back-feed protection)
Subrule 1) requires that a Class 2 power supply not be connected either in series or in parallel with another Class 2 power supply, since in order to limit the voltage, current, and power exposure, the power level in a Class 2 circuit is not to exceed that available from a single Class 2 power supply.

Where a suspended ceiling extra-low-voltage power distribution system with Class 2 dc circuits is to be used, Subrule 2) requires that it be:
- installed as a complete system, including the power supply; or
- provided with reverse polarity (back-feed) protection as part of the grid rail busbar or as a part of the power feed connector if the Class 2 power supply is not provided as part of a complete system.

### Rule 12-2320 System grounding
Class 2 load side circuits for suspended ceiling extra-low-voltage power grid distribution systems are not to be grounded.

## Manufactured wiring systems

### Rule 12-2500 Uses permitted
A manufactured wiring system is a modular wiring system used to supply lighting, power poles, and outlets in full-height partitions. It consists of interface components that quick-connect the system to the item being energized (for example, it provides power drops to convenience outlets and quick connection to service poles). The component parts are assembled by a manufacturer and cannot be inspected at the installation site without damage or destruction to the system.

Cable sets carry power from the distribution junction unit to other components of the manufactured wiring system and between components of the system. They can have a plug on both ends coded according to the manufacturer's instructions to maintain the correct polarity of the connected parts and the proper interconnection of the parts. The sets have metal-clad-type cable and are available in both standard and non-standard lengths depending on the application. Cable sets with pigtail leads on one end only are available for connection to some types of electrical equipment. Field wiring leads are colour-coded in accordance with the Rules of the Code.

### Rule 12-2502 Installation
The installation requirements for manufactured wiring systems are the same as those for armoured cable installations (see Rules 12-602 to 12-618).

## Installations of boxes, cabinets, outlets, and terminal fittings

### Rule 12-3000 Outlet boxes
Subrule 1) requires that a box or equivalent device be installed at each outlet, switch, receptacle, or junction point to enclose the conductors for all electrical wiring installations, except for those employing open wiring methods. Boxes of various designs and sizes are available for use, depending on the wiring method and the number of conductors involved. Boxes can be made of either metal or non-metallic material. Boxes provide means of mounting for switches, receptacles, and luminaires, and an enclosure for conductor connections. A cabinet, junction, or pull box is to be considered an equivalent device (see Rule 12-3036 for acceptable sizes of pull boxes). The Appendix B Note to Rule 12-3000 advises that the *National Building Code of Canada* requires sealing around outlet boxes, wires, and cables to provide an air barrier.

Where the provision for connection is integral to the equipment, Subrule 7) allows an exception to the requirements for the use of a box in Subrule 1). Boxes are allowed to be omitted when conductors are connected in a raceway under the provisions of Rule 12-912 [for example, in the case of surface raceways (Rule 12-1610), busways (Rule 12-2018), wireways (Rule 12-2106), and cable trays (Rule 12-2204)].

Subrule 8) allows the use of self-contained devices in lieu of a device box for the switch and receptacles. Self-contained devices are wiring devices with an integral enclosure having brackets that securely fasten the device to walls or ceilings of conventional frame construction, for use with non-metallic-sheathed cable. Self-contained devices are used in dry locations and are primarily used in mobile homes, recreational vehicles, manufactured buildings, and on-site frame construction.

CSA C22.2 No. 18.1, CSA C22.2 No. 18.2, and Subrule 9) require that when a pendant ceiling fan and all possible accessories is intended to be supported by an outlet box, it weigh less than 16 kg and the outlet box be permanently marked as "Acceptable for Fan Support".

**Note:** *Subrule 9) of Rule 12-3010 gives the requirements for pendant ceiling fans that weigh more than 16 kg.*

CSA C22.2 No. 18.1, CSA C22.2 No. 18.2, and Subrule 10) require that all floor boxes be provided with installation instructions indicating the type of floor structure for which they are intended to be installed. These Standards allow the associated marking to be placed either on the device or on the device packaging. Subrule 10) requires that floor boxes be installed in accordance with the manufacturer's installation instructions for the type of floor.

### Rule 12-3002 Outlet box covers

Subrule 1) requires that cover plates installed on flush-mounted boxes and surface-mounted outlet boxes be of the type designed for the type of box.

Subrule 2) requires that flush-mounted floor box covers be suitable for the type of floor.

### Rule 12-3004 Terminal fittings

When insulated conductors and bare conductors extend from the ends of conduit, armoured or non-metallic-sheathed cables, or surface raceways to connect to open wiring or to supply appliances, Subrule 1) allows an outlet fitting or a terminal to be used instead of the box.

### Rule 12-3006 Terminal fittings behind switchboards

Where insulated conductors issue from a conduit, as at the back of a switchboard, or where more than eight insulated conductors issue from a conduit, such as at a control panel or a similar piece of electrical equipment, Rule 12-3006 allows an insulated bushing to be used to protect the conductors from abrasion, instead of a box.

### Rule 12-3008 Boxes in concrete construction

Where boxes are used at ceiling outlets in concrete slab construction, Subrule 1) requires that the knockouts be spaced above the free or lower edge of the box at a distance of at least twice the diameter of the steel reinforcing bars to prevent offsetting the conduit and interference between the knockout and the horizontal reinforcing bars.

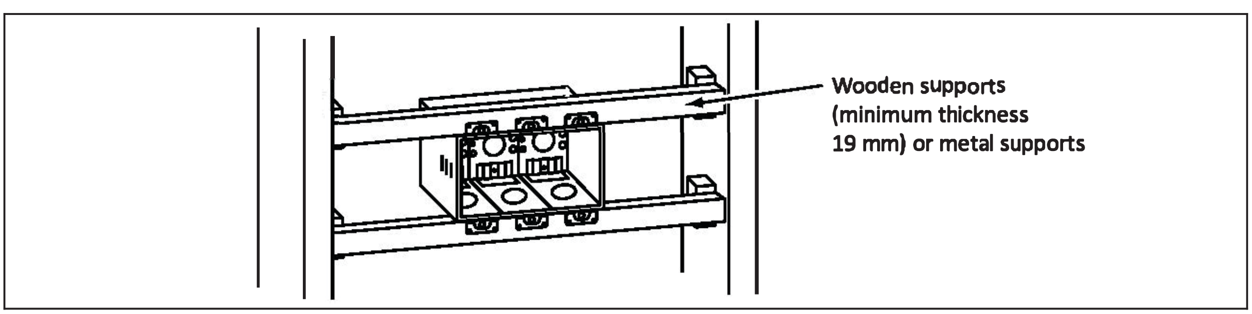
Subrule 2) requires that sectional boxes not be embedded in concrete or masonry construction. Sectional boxes have removable side plates and are not designed for enclosure in concrete.

### Rule 12-3010 Outlet box supports

Boxes and fittings are to be firmly secured to studs, joists, or similar fixed structural units. Boxes are allowed to be secured by the use of mounting brackets or wooden headers, or be securely held in concrete or masonry. Wooden, metal, or composition lath is not considered a fixed structural unit.

"Gang" refers to the number of standard-type wiring devices that a box can accommodate. For example, a 3-gang box can accommodate three standard-type wiring devices. When ganged sectional boxes are used, Subrule 2) requires that they be rigidly secured to metal supports or to wooden boards at least 19 mm thick (see Figure 12-32).

**Figure 12-32**
**Ganged outlet box support**



Subrule 3) requires that boxes having any dimension greater than 100 mm be secured on at least two sides or be supported as outlined in Subrule 2) by the use of metal supports or wooden boards at least 19 mm thick. The 4-11/16 in × 4-11/16 in × 2-1/8 in square box used as a device box for the flush-mounted 14-50R range receptacle in a dwelling unit is an example of a box requiring support on at least two sides.

Subrule 4) requires that additional support be provided for boxes mounted on metal studs to prevent any movement either during or after the drywall installation.

Subrule 6) states that the requirements of Rule 12-3010 need not apply when the outlet boxes are installed (for example, fished in) after the structural units (studs, joists, etc.) are concealed (in this case, Rule 12-3018 applies).

Wiring devices (switches and receptacles) with an integral enclosure having brackets that securely fasten the enclosure to walls or ceilings of conventional frame construction are allowed by Subrule 7) to be exempt from the requirements of Subrules 1) to 6) of Rule 12-3010.

Where the ceiling outlet box required by Subrule 8) of Rule 12-3000 and marked for ceiling pendant fan support is installed, Subrule 8) requires that the box be:
- secured directly to the building structure; or
- attached by a bar hanger that is secured directly to the building structure.

Where a pendant ceiling fan and all possible accessories weighs 16 kg or more, Subrule 9) requires that it be supported independently of the outlet box.

### Rule 12-3012 Boxes, cabinets, and fitting supports

Subrule 1) requires that boxes, cabinets, or fittings be securely fastened in place, that is, held in place by embedding in concrete or masonry or rigidly secured to other structural members (for example, studs or joists) (see Rule 12-3010).

Subrule 2) requires that boxes and fittings having a volume less than 1640 mL be considered securely fastened in place when threaded to an exposed raceway or connected by other equally substantial means (that is, a connection that firmly supports the box or fitting). Locknut and bushing connections are considered unsuitable for this purpose.

### Rule 12-3014 Accessibility of junction boxes

Subrule 1) requires that all boxes, cabinets, and auxiliary gutters be installed so that connections to the enclosed insulated conductors and cables are accessible without the need to remove parts of the building structure.

Subrule 2) requires a vertical space of at least 900 mm to provide ready access.

### Rule 12-3016 Outlet boxes, cabinets, and fittings

Subrule 1) requires that the front edges of boxes, cabinets, and fittings installed in non-combustible construction be positioned not more than 6 mm back from the finished surface of the wall. When installed in combustible construction, the front edges are to be positioned flush with, or project beyond, the finished wall surface.

To prevent foreign materials from getting into the flush-mounted boxes, cabinets, and fittings in plaster surfaces of walls or ceilings, Subrule 2) requires that any gaps or open spaces in the wall material surfaces around the front edges of boxes, cabinets, or fittings be filled in so that the box, cabinet, or fitting is completely enclosed.

To protect installations of flush-mounted boxes, cabinets, and fittings against the ingress of the elements in wet locations, Subrule 3) requires that the wet location cover plates be installed in such a manner that the intended seal between the outlet box and the cover prevents the elements from entering the enclosure and causing corrosion.

To further prevent the elements from entering a flush-mounted enclosure and causing corrosion in a wet location, Subrule 4) requires that flush boxes, cabinets, and fittings be of a type suitable for the intended location.

### Rule 12-3018 Outlet boxes attached to existing plaster work

When boxes are installed as additions to existing electrical installations and cannot be secured as required by Rule 12-3010, Rule 12-3018 allows them to be mounted directly on the existing plaster surface, provided that they are securely fastened in place. Specially designed boxes and fasteners have been developed to help secure the outlets in this situation.

### Rule 12-3020 Outlet boxes, etc., in damp places

Damp locations include interior or exterior locations in which condensation can occur. Damp locations also include partially protected areas, such as under canopies, marquees, or roofed open porches.

### Rule 12-3022 Entrance of cables into boxes, cabinets, and fittings

Subrule 1) requires that when cables pass through the walls of boxes, cabinets, or fittings, provision be made to:

- protect the insulation on the conductors from abrasion from the enclosure walls;
- protect the terminal connections from external stress or strain placed on the conductors (weight, vibration);
- provide electrical continuity between the metal box, cabinet, or fitting and the conduit, armour, or metal sheathing of cables so as not to interrupt the fault current path if a breakdown occurs in the conductor insulation;
- prevent damage to a non-metallic sheath covering metal sheathing or armour for protection against corrosion or moisture; and
- prevent foreign material larger than 6.75 mm from entering the enclosure, which could cause faults to occur inside the enclosure.

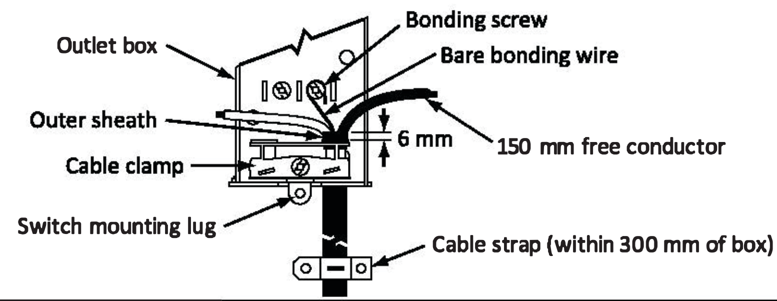
Where insulated conductors installed by the open wiring method enter a box, cabinet, or fitting, Subrule 2) requires that they be protected from damage by the use of insulated bushings or tubing, or raceways.

When non-metallic-sheathed cable or tray cable enters a box, cabinet, or fitting, Subrule 3) requires that a box connector designed for use with the cable or a clamp designed as an integral part of the box, cabinet, or fitting be used to secure the cable in position and to prevent damage to the cable jacket and the conductor insulation. See Figure 12-33.

Subrule 4) requires that when rigid or flexible metal conduit, electrical metallic tubing, or armoured cables enter boxes, cabinets, or fittings, the means of securing the wiring methods also meet the requirements of Section 10 for maintaining the bonding requirements.

Subrule 5) requires that when metal-sheathed cables enter boxes, cabinets, or fittings, the means of securing meet the requirements for the particular type of metal-sheathed cable used and also meet the bonding requirements of Section 10.

**Figure 12-33**
**Method for connecting cable to outlet box**



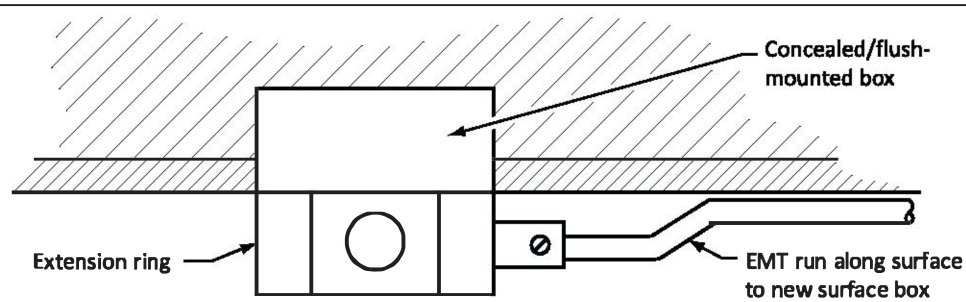

When wiring methods such as liquid-tight flexible metal or flexible conduit, armoured cable, or metal-sheathed cable having a non-metallic sheath covering over the armour or metal sheath enters a box, cabinet, or fitting, Subrule 6) requires that the box connector ensure that electrical continuity to the armour or metal sheath be maintained without damage to the non-metallic sheath covering. In locations exposed to the weather, weatherproof connectors or connectors for use in wet locations are designed to fulfill this requirement. If the point of connection is in a dry location and not exposed to a corrosive atmosphere, the non-metallic sheath covering is allowed to be stripped back to provide continuity with the box connector in lieu of using weatherproof or wet location box connectors.

Subrule 7) requires that, when single-conductor cables or single insulated conductors enter metal boxes through separate openings, the requirements in Rule 4-008 be followed.

### Rule 12-3026 Extensions from existing outlets

In making a surface extension from an existing flush-mounted box, a suitable extension ring that is electrically and mechanically secured to the existing box is to be used. See Figure 12-34.

**Figure 12-34**
**Extension from existing outlet**

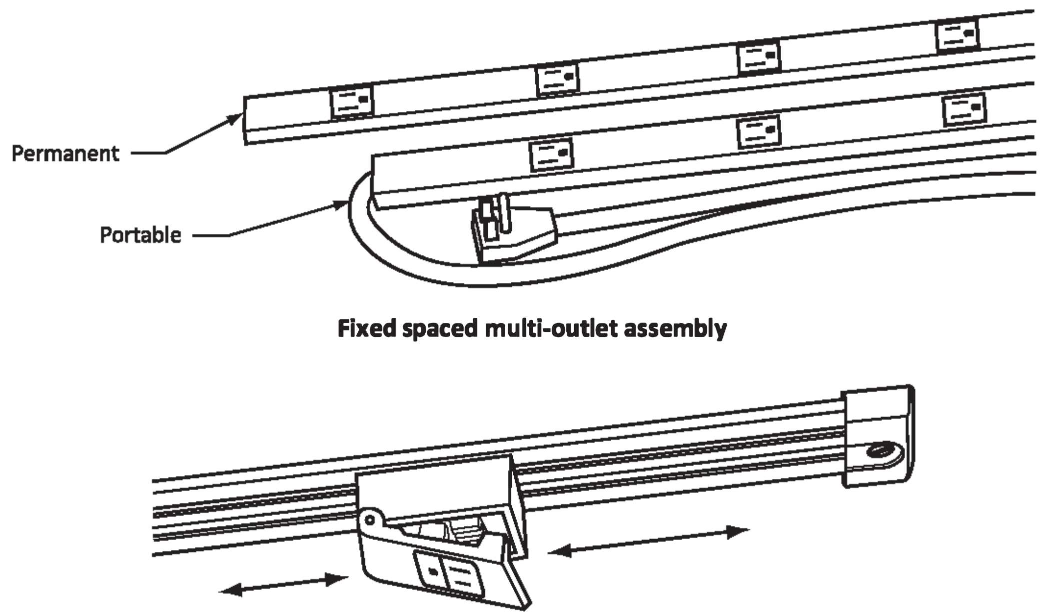



### Rule 12-3028 Multi-outlet assemblies

A multi-outlet assembly is a surface- or flush-mounted, metal or non-metallic raceway designed to contain conductors and receptacles. There are two types of assemblies: in one, the receptacles are built in at fixed intervals along the raceway, and in the other, the receptacles are relocated or spaced as desired along the raceway. Load calculations for multi-outlet assemblies are in accordance with Subrule 4) of Rule 8-304. See Figure 12-35.

Subrule 1) requires that multi-outlet assemblies be installed only in dry locations and be used only as extensions to wiring systems.

## Figure 12-35
## Multi-outlet assembly




### Rule 12-3032 Wiring space in enclosures

Subrule 1) requires that enclosures for overcurrent devices, controllers, or externally operated switches not be used as junction boxes, wiring troughs, or raceways for insulated conductors feeding through to other apparatus. Wiring space within these devices is usually only large enough to contain the supply and load insulated conductors. Situations that can necessitate a feed-through to other apparatus can usually be avoided by the use of wireways or auxiliary gutters.

When an enclosure is supplied with terminal connections that provide individual clamping means for each insulated conductor, Item a) i) of Subrule 2) allows a single feeder to supply another enclosure. For maintenance and inspection purposes, each clamping means is to be accessible.

Item a) ii) of Subrule 2) requires that adequate space be provided in the enclosure to route the insulated or bare conductors when conductors are required to be added to an existing installation. The existing enclosures are allowed to be used as junction boxes or as raceways, provided that the space required for the insulated or bare conductors, splices, and taps does not fill the cross-sectional area of the space to more than 75%.

When the insulated or bare conductors run through the enclosure, Item b) of Subrule 2) does not allow the conductor fill in the wiring space at any cross-section to be more than 40% of the cross-sectional area of the space. This requirement recognizes the need for the installation of energy management systems and other similar upgrades that tap into the existing wiring system for monitoring purposes, etc.

**Note:** *Apart from the single feeder tap in Item a) i) of Subrule 2, the allowances in Items a) ii) and b) in Subrule 2) apply to existing installations only and are not an acceptable practice for new installations in which the design can be incorporated into the required enclosures for the wiring systems.*

To prevent undue bending or strain on the terminations and contact with uninsulated live parts of a different phase or polarity, or grounded parts, Subrule 3) requires that insulated conductors enter the enclosures at a point that is as close as possible to the terminal fittings.

Subrule 4) allows for the installation of and connection to energy usage metering devices in the enclosures for overcurrent devices, controllers, and externally operated switches.

Energy usage metering devices require the installation of a monitoring device (usually a CT coil) around the circuit conductor, usually placed at the overcurrent device protecting the circuit or at the termination of the circuit conductors in controllers and externally operated switches. Monitoring conductors are then run between the monitoring device and the monitoring equipment, which is located either as an integral part of the enclosure or in a separate enclosure.

When these monitoring devices are installed in the enclosure, the enclosure is to be designed for the installation of these devices so that there is sufficient space for the devices without:
- causing damage to the other circuit insulated conductors in the enclosure; or
- creating a condition such as high temperature in the enclosure that could damage the insulation or affect the operating performance of other circuit conductors or components in the enclosure.

When monitoring conductors are added to the wiring space in the enclosure, they are not to increase the cross-sectional area of conductor fill to more than 75%.

### Rule 12-3034 Maximum number of insulated conductors in a box

Subrule 1) requires that a box be of sufficient size to provide usable space for all insulated conductors contained in the box. The box size is determined by the number and size of the insulated conductors to be enclosed. See Figure 12-36. The maximum number of insulated conductors that are to be counted in determining the minimum volume/usable space required in the box is based on the following:
- all insulated conductors entering or leaving the box are to be counted;
- when an insulated conductor runs through the box with no connections, it is considered only one conductor;
- when no part of the insulated conductor leaves the box (that is, when jumpers are used to make connections in the box), the insulated conductor is not to be counted; and
- the No. 18 and No. 16 AWG fixture-wire connections to the luminaire that is attached to the box are not to be counted.

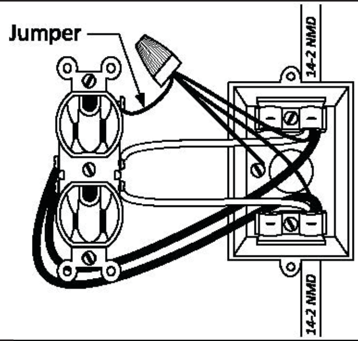
Subrule 2) allows boxes with the dimensions shown in Table 23 to contain no more insulated copper or aluminum conductors of sizes No. 14 AWG to No. 6 AWG than the number specified in the Table subject to the conditions in Items a) to c) of Subrule 2) and Subrules 3) and 4). The number of conductors of the same size as specified in Table 23 is to be reduced by:
- one insulated conductor if the box contains one or more fixture studs or hickeys;
- one insulated conductor for every pair of insulated conductor connectors (see Figure 12-37); and

  **Note:** *There is no reduction for one conductor connector, but the number of conductors is reduced by one for two or three conductor connectors, and by two for four or five conductor connectors.*
- two insulated conductors if the box contains one or more flush devices mounted on a single strap having a depth not greater than 2.54 cm.

Subrule 3) requires that the usable space in a box for insulated conductors for flush-mounted devices having a depth greater than 2.54 cm be reduced by the amount calculated using the following calculation: 32 $cm^3$ × the depth of the device in cm.

## Figure 12-36
## Typical box conductor fill



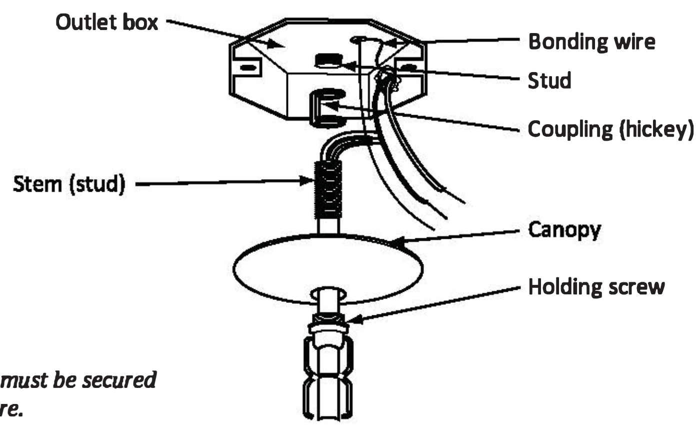

**Note:** *No deduction for*
*a) bare bonding conductor;*
*b) bond jumper;*
*c) one wire connector; or*
*d) built-in clamps.*

Number of conductors to size box
4 — No. 14 entering box
2 — U-ground duplex receptacle

Total 6 conductors (sized No. 14)

Box size from Table 23,
device box at least 3 in × 2 in × 2 in

## Figure 12-37
## Conductors in boxes with fixture studs or hickeys




**Note:** *The box or stud must be secured to the building structure.*

Where boxes have dimensions not given in Table 23, such as sectional boxes ganged together, and where plaster rings, extension rings, or raised covers are used, Subrule 4) requires that the usable space in the box be calculated by adding the total box volume, or ganged volume, to the volume of the rings and covers. Rings and covers are marked with the allowable volumes. Table 22 gives the volume/usable space required for individual insulated copper and aluminum conductors in sizes No. 14 AWG to No. 6 AWG to be used to calculate the minimum usable space required for that size of insulated conductor. See Table 12-14.

## Table 12-14
## Method to obtain the minimum usable space required in the box with different insulated conductor sizes

| Step | Method |
|---|---|
| 1 | Determine the usable space for the insulated conductors by multiplying the number of each size × the volume/usable size in Table 22 for that size. |
| 2 | Reduce the usable space in Step 1 by multiplying the number of insulated conductors for each size by the reductions that are applicable from Subrule 2) × the volume/usable space from Table 22.<br>**Note:** *To determine the volume/usable space required for conductor connectors in Item b) of Subrule 2) when the conductor connector is used with two different conductor sizes, Subrule 4) requires that the volume/usable space from Table 22 be determined by using the larger conductor size.* |
| 3 | Determine the total minimum volume/usable space for all the insulated conductor sizes by adding together the minimum volume/usable space from Step 2. |

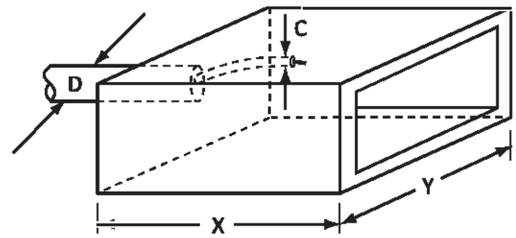
### Rule 12-3036 Pull box or junction box sizes

When calculating the size of the box for pull or junction purposes, the diameter of the cable is considered equivalent to the trade size of raceway that would be required to contain the same size and number of conductors in the cable. For example, a No. 4 AWG RW90 3-conductor cable is equivalent to a 27 trade size conduit (see Tables 6A to 6K). See Figure 12-38.

# Figure 12-38
# Pull box and junction box sizes

1. **Depth of box** — from cover to opposite wall
   where
   C is the diameter of the largest conductor
   D is the trade size of the largest raceway or cable
   Formula: X = D + (6 × C) [See Rule 12-3036 2) a)]

   **Example**
   What is the depth of the box when 2-53 trade size conduits enter the box on the wall opposite the cover and both conduits contain 4-3/0 RW90XLPE conductors?

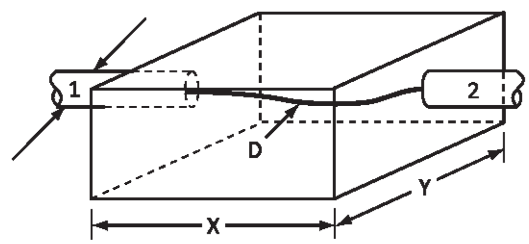



   Trade size of conduit (D) = 53 C = 14.74 mm (See Table 10A)

   Depth of box = D + (6 × C) = 53 + (6 × 14.74) = 53 + 88.44 = 141.44 mm

2. **Straight pulls** — the raceway or cable enters the box on one wall and exits the box on the opposite wall
   where
   D is the largest trade size raceway or cable being used as a straight pull
   Formula: X = 8 × D [See Rule 12-3036 2)]

   **Example**
   What is the minimum length of the box (distance between opposite walls) where 2-78 runs of EMT enter a pull box and exit the box from the opposite wall (straight pull) and each contains 4-500 kcmil T90 conductors?

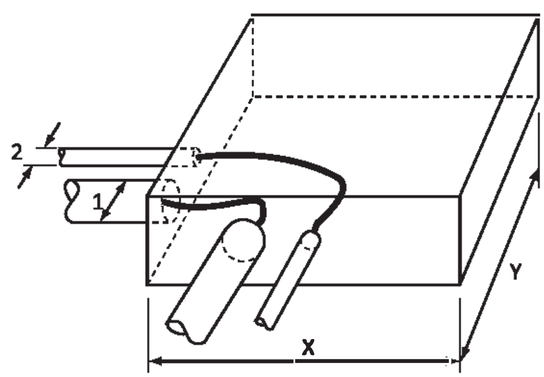



   Trade size of conduit (D) = 78

   Length of box= 8 × D = 8 × 78 = 624 mm

3. **Angle pulls** — the raceway or cable enters the box on one wall and exits the box on an adjacent wall
   where
   D is the largest trade size raceway or cable being terminated on the wall
   U is the total trade size of all other raceways or cables terminating on the wall
   Formula:
   X = (D × 6) + U [See Rule 12-3036 2) c) i)]
   Y = (D × 6) + U

   **Example**
   What is the minimum length and width of a pull box being used for two runs of 63 and 41 PVC conduit to allow for a 90° change in direction?




   Trade size of conduit (D) = 63

   Length of box= (D × 6) + other raceway or cable trade sizes = (63 × 6) + 41 = (378) + 41 = 419 mm

   Width of box = (D × 6) + other raceway or cable trade sizes = (63 × 6) + 41 = (378) + 41 = 419 mm

*(Continued)*

# Figure 12-38 (Concluded)

4. **Layout of angle pulls** — Z is the straight line distance between the nearest edge of each raceway or cable of the same run terminating on adjacent walls

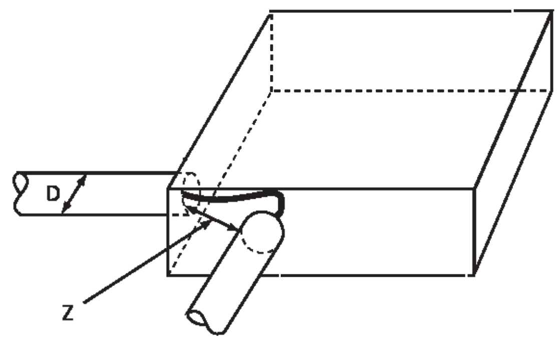
   where
   D is the largest trade size of the raceway or cable being used in the run

   Formula: Z = 6 × D [See Rule 12-3036 2) c) ii) A)]

   **Example**
   What is the minimum distance between two 78 trade size conduits of the same run and terminating on adjacent walls of the box?

   Trade size of conduit (D) = 78

   Length between conduits = 6 × D = 6 × 78 = 468 mm




5. **Layout of U-pulls** — V is the straight line distance between two raceways or cables that terminate on the same wall of the box and are part of a U-pull

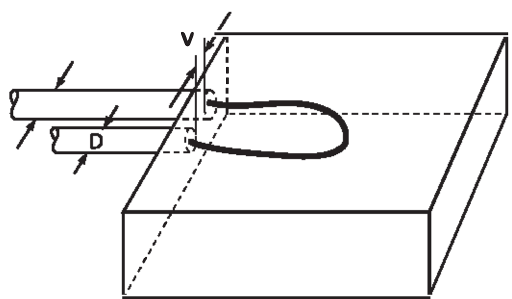
   where
   D is the largest trade size of the raceway or cable being used in the run

   Formula: V = 6 × D [See Rule 12-3036 2) c) ii) B)]

   **Example**
   What is the minimum distance between 2-53 trade size conduits that enter a pull box, terminate on the same wall, and are part of a U-pull?

   Trade size of conduit (D) = 53

   Length between conduits = 6 × D = 6 × 53 = 318 mm



# Section 14 — Protection and control

## Scope

### Rule 14-000 Scope

Section 14 is a general Section of the Code that sets out requirements for the protection of electrical circuits and apparatus from the hazards of overloads, overcurrents, and fault currents. It also provides Rules for the safe and proper control of electrical circuits and apparatus. The Rules of this Section apply to electrical installations, including circuits and apparatus installed in accordance with the requirements of other Sections, except where those Sections provide specific amendments to the general Rules.

## General requirements

### Rule 14-010 Protective and control devices required

All electrical circuits and apparatus are subject to temporary accidental overloads, short-circuits, and ground faults. Overloaded circuits can cause overheating, and if the overload persists, they can reach temperatures that will damage insulation or circuit components, or cause a fire. Short-circuits and ground faults result from the deterioration of insulation, failure of equipment due to environmental conditions, mechanical damage, abuse, human error, or the failure of a device to safely open or close the circuit. Any of these faults can result in arcing and the risk of fire or extensive damage to electrical equipment. Manual switching equipment is required at various points in a system to achieve proper control and/or isolation, but the manual switching equipment is also vulnerable to damage caused by overloads and faults.

Item a) requires that all electrical apparatus and ungrounded conductors be provided with devices (usually fuses or circuit breakers) that de-energize the circuit if an overload or short-circuit occurs. Certain circuits are to be provided with electrical equipment that senses the presence of a ground fault and causes the faulted circuit to be de-energized (see Rule 14-102).

Item b) further requires that all circuits and apparatus be provided with manually operable control devices or disconnects that can disconnect all ungrounded/energized conductors simultaneously at their point of supply. Fuses are protective devices and are to be used in a fusible switch to comply with this requirement, while circuit breakers are both protective devices and disconnecting means.

**Note:** *Circuit breakers can be used as manually operable control devices supplying fluorescent luminaires when labelled with the marking "SWD" as per Rule 30-710.*

To prevent a shock hazard to individuals using or servicing a device supplied by more than one energized line or phase conductor connected to it, all energized lines or phase conductors are to be able to be disconnected simultaneously at their point of supply. The exception stated in Item b) allows a multi-wire branch circuit that supplies only fixed lighting loads or non-split receptacles to be controlled by separate single-pole disconnects in each of the ungrounded/energized conductors of the circuit. In this case, the loads are to be connected only to the neutral and one ungrounded/energized conductor (see Figure 14-1).

**Note:** *The basic intent of Rule 14-010 is to safely disconnect all ungrounded conductors simultaneously to prevent a shock hazard to individuals required to work on them.*

Where electrical equipment or processes can be damaged or cause injury or fires through voltage failure or a reduction in voltage below a safe operational value in all or parts of the equipment or process, Item c) requires the inclusion of a device that will open the circuit when the voltage fails or drops below a safe operating value (for example, see Rule 28-400).

### Rule 14-012 Ratings of protective and control equipment

Electrical equipment (e.g., a circuit breaker or an enclosed fused switch) in circuits of 750 V or less can be dangerous and might fail catastrophically if, under fault conditions, the protective and/or control equipment energizes or interrupts a circuit in excess of its rating.

The value of the current that must be prevented from flowing in the circuit when a fault occurs is to be below the line illustrated in Figure 14-2 to avoid damage. The maximum current that an overcurrent device allows to flow when a fault occurs is called the "let-through current".

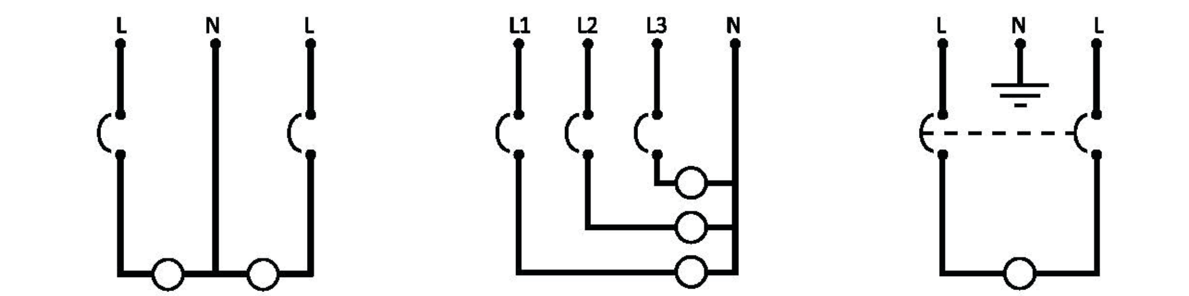
Item a) requires that all electrical equipment intended to clear (open) fault currents (to prevent damage to the equipment and circuits) have an interrupting rating (at the rated system voltage) not less than the maximum available fault (short-circuit, let-through) current rating where it is connected (application point) in the electrical circuit. The equipment is to be able to open (interrupt) under both full-load and fault conditions.

Switches marked "isolating switch" (see definition in Section 0 and installation requirements in Rule 26-100) are intended to be operated only under no-load conditions (i.e., no flow of load current in the circuit), and they do not have a fault current interrupting rating.

Item b) requires that electrical equipment for interrupting current at other than fault levels (e.g., circuit breakers and fused switches, pushbuttons used in motor control circuits) be rated for the circuit voltage and the maximum current that the equipment can safely interrupt.

To apply these requirements, installers need to know the available fault current at the point of application (connection) in the circuit. Local utilities usually provide information on the fault current levels at the supply service, but at other downstream points in the system these levels are to be calculated. Methods for calculating or estimating fault currents can be obtained from available literature, such as CSA C22.2 No. 5, *Molded-case circuit breakers, molded-case switches, and circuit breaker enclosures*, or from fuse, circuit breaker, or electrical equipment manufacturers.

**Figure 14-1**
**Manually operable control devices**

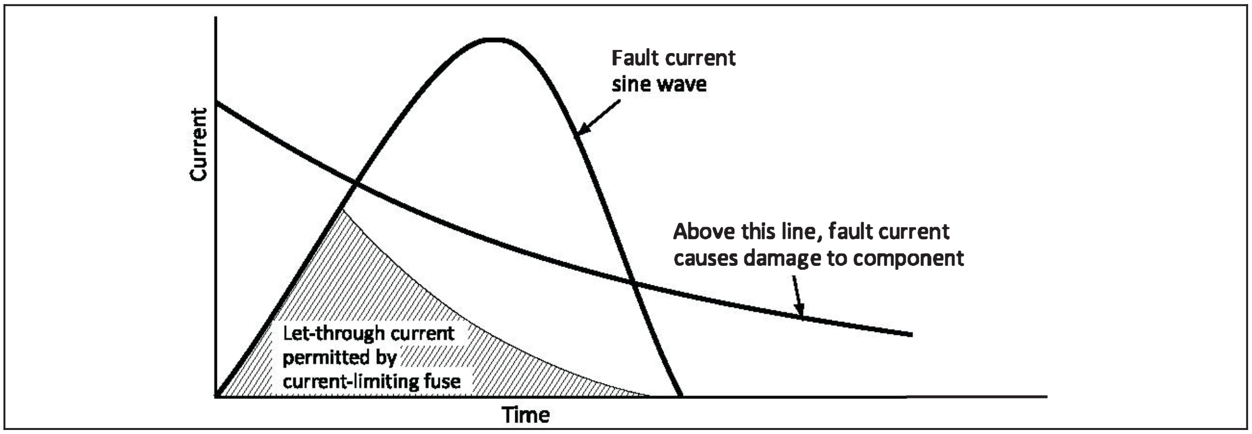



a) Two single-pole circuit breakers permitted where loads are fed only from the neutral and one ungrounded conductor.

b) Three single-pole circuit breakers permitted where loads are fed only from the neutral and one ungrounded conductor.

c) Two single-pole circuit breakers with handle ties permitted in a 3-wire grounded system.

## Figure 14-2
## Typical damage curve



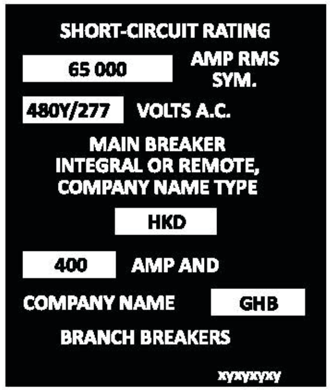

All electrical equipment intended to clear fault currents is to be marked with a voltage rating, a continuous current rating, and an interrupting/short-circuit current rating (see Figure 14-3; see also the Appendix B Note to Rule 14-012). Current ratings are distinguished as follows:

- continuous current rating (rated current) — the marked constant current rating and the maximum rms current that a circuit breaker or an enclosed switch (fused or unfused) can carry continuously at its rated primary voltage and frequency without tripping or adverse effects to its operating characteristics.
- interrupting current rating (fault current rating) — the highest current at rated voltage that a device is intended to interrupt at the instant of contact separation. The interrupting current rating can be given as one of the following values:
  - symmetrical interrupting current — the rms value of the ac component of the short-circuit current that the breaker or switch is capable of interrupting; or
  - asymmetrical interrupting current — the rms value of the total short-circuit current that the breaker or switch is capable of interrupting. This includes the dc and ac components.
- short-circuit current rating — the maximum symmetrical fault current at nominal voltage to which a device can be subjected without sustaining damage that exceeds its accepted criteria when it is connected to a fault of negligible impedance (short-circuit).

**Note:** *Interrupting rating is a fixed rating marked on equipment that has been designed and tested to meet this rating.*

The short-circuit (fault) current rating is the amount of current that is flowing in the circuit under a fault condition of negligible impedance; this value can change over the lifetime of any installation as a result of factors such as poor maintenance on circuit breakers, incorrect fuse replacement, changes in transformer impedances, changes to utility fault current values, etc. Equipment can be marked with either the interrupting rating or short-circuit rating. For example, CSA C22.2 No. 5 covering circuit breakers requires that the marking be the interrupting rating and CSA C22.2 No. 4 covering enclosed switches (fused or unfused) requires that the marking be the short-circuit current.

## Figure 14-3
## Typical label for electrical equipment intended to clear fault currents




The majority of faults are faults to ground rather than line-to-line faults. It is usually difficult for fault current to obtain a good direct ground, so the actual fault current is unlikely to exceed the interrupting/short-circuit rating. In the event of a heavy fault trip-out, caution is to be exercised before any attempt to reset the circuit breaker. While faults usually clear themselves, sometimes they can cause components to fuse together. This keeps the circuit in a fault condition until repairs are made and can present a shock or arcing hazard if an attempt is made to reset the breaker beforehand.

The available fault current is determined on the basis of the transformer size (kV•A). Impedance and voltage are used to determine the maximum current that the transformer can pass to its load terminals if the transformer output terminals are short-circuited. The per cent impedance of a 60 Hz transformer, for example, is approximately 4 to 7% for an average-size power or distribution transformer. The actual fault current, however, is also determined by other fault current contributors such as the impedance of the cable or wire, the impedance of the connections in the installed electrical system, and the motor contribution.

For a three-phase transformer, the available fault current on the load terminals of the transformer can be calculated from the following formula:

Available fault current for a three-phase transformer's V•A rating / [rated secondary voltage × 1.73 × transformer's impedance (expressed as a decimal fraction)]

**Note:** *The industry standard multiplier for the square root of three is 1.73.*

For example, the available fault current at the secondary terminals of a 225 kV•A, 600 to 120/208 V, three-phase, dry-type transformer with 5% impedance and unlimited fault current on the primary can be calculated as follows:

Available fault current = transformer's V•A rating / (rated secondary voltage × 1.73 × transformer's impedance)

= (225 × 1000) / (208 × 1.73 × 0.05)

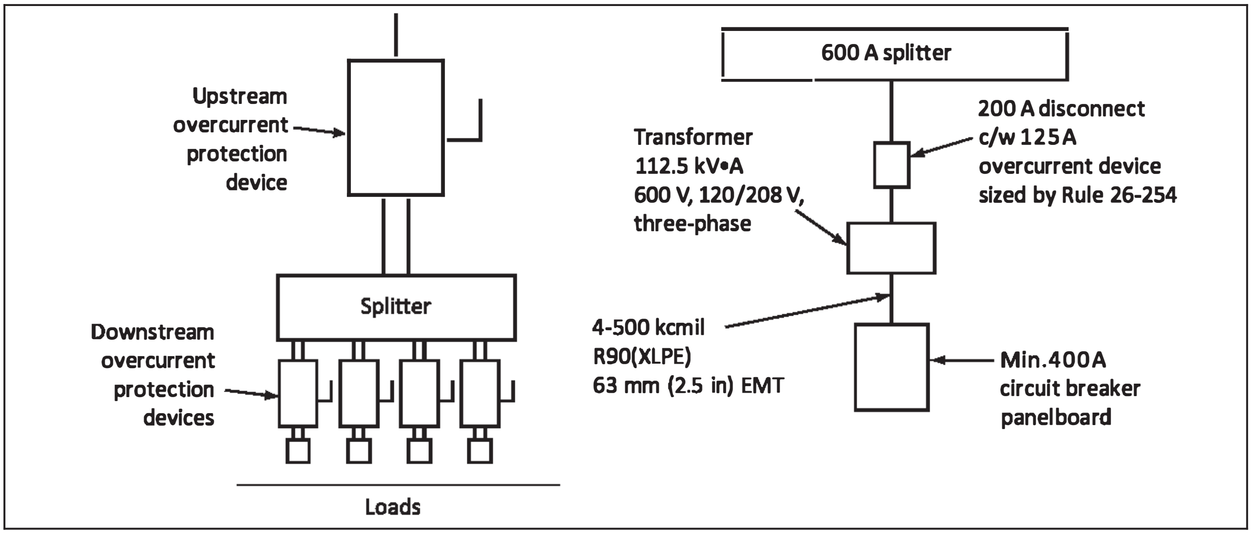
= 12 506 A

Although a transformer can limit fault current, the size of the conductor, the load on the conductor, the length of the conductor, the number of conductors per phase, the number of phases, and the type of raceway material can also reduce the fault current.

### Rule 14-014 Series rated combinations

The Appendix B Note to Rule 14-014 uses the terms *downstream* and *upstream devices* (see Figure 14-4). *Downstream devices* are located on the load side (towards the load) of the device or point in the circuit under discussion. *Upstream devices* are located on the line side (towards the source of supply) of the device or point in the circuit under discussion.

**Figure 14-4**
**Downstream and upstream devices**




Rule 14-012 requires that switches and overcurrent devices be able to interrupt the available fault current at their terminals, which can make distribution centres (e.g., panelboards) costly, depending on the available fault current of the system. For more flexibility in designing installations, Rule 14-014 allows the use of a downstream circuit breaker with a lower interrupting rating than the available system fault level in combination with a fully rated upstream overcurrent device, provided that the upstream breaker opens before the downstream breaker when this level of fault current is detected in order to protect the downstream breaker from blowing up. Item e) further requires that the overcurrent devices be marked for replacement with components only of the same type and rating. Such an installation is called a series rated combination.

In a major fault, both upstream and downstream devices open simultaneously if they are properly coordinated. The let-through current is limited to a value that can be safely cleared by the simultaneous opening of both overcurrent devices. The upstream overcurrent device protects the lower-rated downstream circuit breaker. The upstream device can be either a circuit breaker or a fuse.

The upstream overcurrent device might be protecting many different loads (e.g., feeders or panelboards). When it trips simultaneously with the downstream circuit breaker, portions of a building can be left without power. Each circuit breaker that is intended to be used as a recognized component of a series rated combination is to be marked accordingly.

### Rule 14-016 Connection of devices

In a grounded system, the grounded system conductor (or neutral) is used to connect the electrical system to ground (see Rule 10-206) and to control the voltage-to-ground of the ungrounded conductors. The grounded circuit conductor (or neutral) serves as the common return circuit conductor for multi-wire circuits and is not to be inadvertently disconnected while the rest of the circuit conductors remain live.

Rule 14-016 prohibits overcurrent or control devices from being installed in the grounded conductor, except under the following circumstances:

- where the device simultaneously or previously disconnects all ungrounded conductors in the circuit;

- in a 2-wire grounded circuit in which it is diffiicult to obtain a reliable ground connection, and the grounded conductor might be at a voltage-to-ground that can cause a hazard; or
- in a cord-connected device, using a 2-pole polarized or unpolarized attachment plug rated at 15 A, 125 V or less, where a supplementary overcurrent device is placed in one of the circuits to protect the electrical equipment.

## Protective devices

## General

### Rule 14-100 Overcurrent protection of conductors

Rule 14-100 requires that all ungrounded conductors of a feeder or circuit be protected by overcurrent devices at the point where the conductor receives its electrical energy or where its ampacity rating is reduced. The Appendix B Note to Rule 14-100 clarifies that the Rule applies only to conductors and cables interconnecting electrical equipment; it does not apply to overcurrent protection of electrical equipment as required by other Rules of the Code.

Rule 14-100 also provides specific exceptions to the general requirement, since in some installation cases it is possible to adequately protect a smaller conductor by an overcurrent device installed in an upstream feeder or circuit consisting of larger conductors without compromising the safety of the installation.

The conductors in any electrical distribution system are normally reduced in size and ampacity as they get farther downstream from the power source. They are always to be large enough to carry safely the current required by the load that they supply (see Rule 8-104). Reductions of the size of conductors in distribution systems usually occur in switchboards, at control devices, or at splitters, where the upstream overcurrent device is too large to protect the smaller conductor from overload or short-circuit. The simplest solution is to provide a suitably sized fuse or circuit breaker in the enclosure (e.g., a panelboard) ahead of the smaller conductor, as required by Rule 14-100, but this is sometimes inconvenient or expensive. Within specific limitations, the smaller conductor (tap conductor) can perform safely when the rating of the upstream overcurrent device is higher than the ampacity of the tap conductor, even without the provision of an overcurrent device in the enclosure at the point where the tap conductor size is reduced. A tap conductor has an ampacity rating less than the ampacity of the conductor or busbar feeding it (e.g., a conductor run from a 600 A splitter to feed a 30 A disconnect switch) and does not have its own overcurrent protection at the point of supply in the splitter.

The tap conductor is protected by an upstream overcurrent device rated higher than the conductor's ampacity, so care is to be taken to prevent any fire hazards created by an overload or short-circuit on the tap conductor. Damage due to overload is unlikely if the tap conductor is sized to handle the load initially, and no load is connected between the point of supply and the load side of the downstream overcurrent device that senses excessive load. In some installations, a tap conductor can supply a set of overcurrent devices having the same rating as the conductor and be completely protected against an overload. The main concern in these installations is short-circuits, which are most often caused by physical damage to, or degradation of, the insulation of the tap conductor or the electrical equipment that it supplies.

Short-circuit currents resulting from phase-to-phase or phase-to-ground faults are usually high enough to be sensed and cleared by an upstream overcurrent device, even if its rating is considerably higher than that of the tap conductor; however, it takes slightly longer for the overcurrent device to react. An overcurrent device sized for as much as 300% of the ampacity of the tap conductor or equipment it protects will supply short-circuit protection [see Subrule 2) of Rule 28-110, Rule 30-412, and Subrule 4) of Rule 62-114]. At any rating higher than 300%, the circuit is no longer considered to have short-circuit protection (e.g., a 600 A overcurrent device protecting a 200 A rated conductor or piece of equipment is expected to trip before the 200 A conductor or equipment is damaged by a short-circuit current).

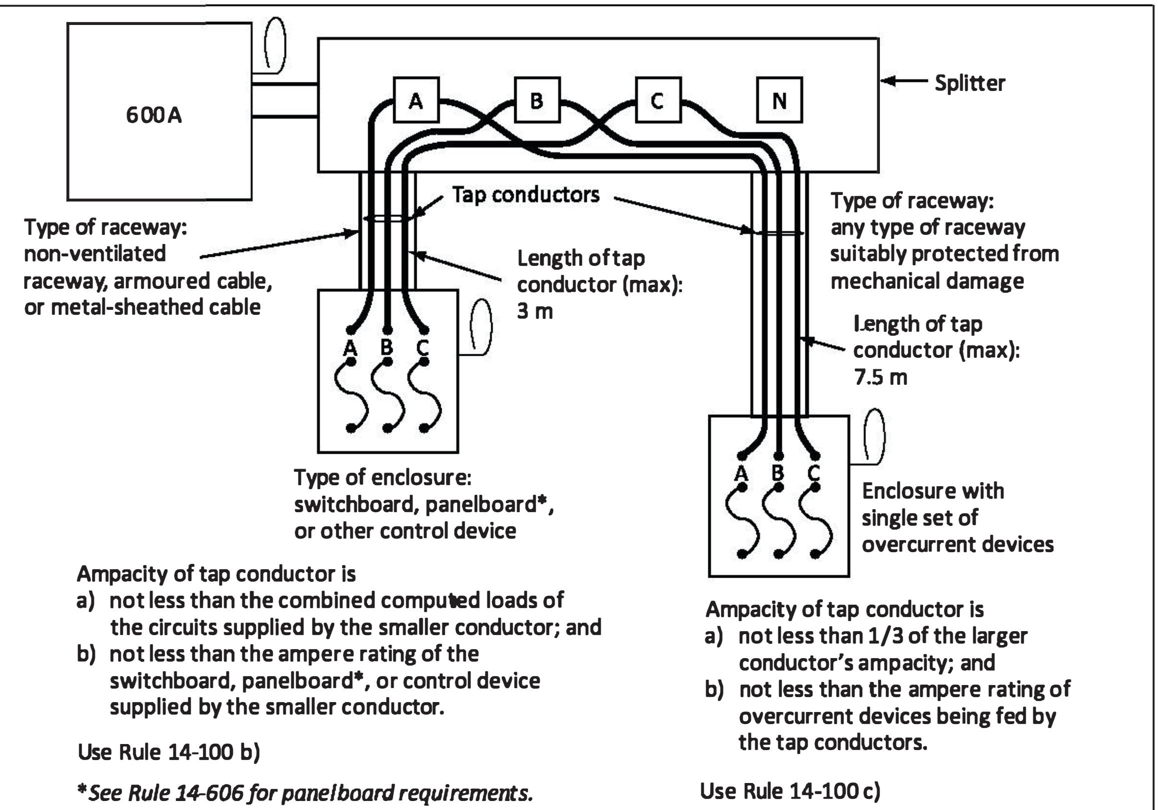
Despite this general limitation, tap conductors still pose some risks. Rule 14-100 restricts the use of reduced ampacity taps from feeders by setting requirements for tap conductor size, length, mechanical protection, and types of load supplied. A tap conductor is allowed to be used where the tap conductor is properly protected from overloads and short-circuits by the overcurrent device in the feeder (larger) conductor. Item b) allows the conductor size to be reduced, without the provision of an overcurrent device, when the tap conductor feeds a switchboard, panelboard, or control device, and when the tap conductor:

- supplies only one device, for example, a switchboard, panelboard, or control device (switch);
- is not longer than 3 m between feeder and tap conductor terminations;
- has an ampacity not less than the ampere rating of the device it supplies and not less than the total computed load of the circuits it supplies; and
- is run in a non-ventilated raceway, armoured cable, or metal-sheathed cable.

Item c) allows a reduced ampacity tap conductor to be used when the tap conductor feeds a set of overcurrent devices, provided that the tap conductor:

- is not longer than 7.5 m between feeder (larger) and tap conductor terminations;
- terminates in a single overcurrent device that has an ampacity no greater than that of the tap conductor;
- has an ampacity at least one-third of the ampacity of the feeder (larger) conductor; and
- is protected from mechanical damage by suitable means (see Figure 14-5).

**Figure 14-5**
**Typical taps off a splitter**

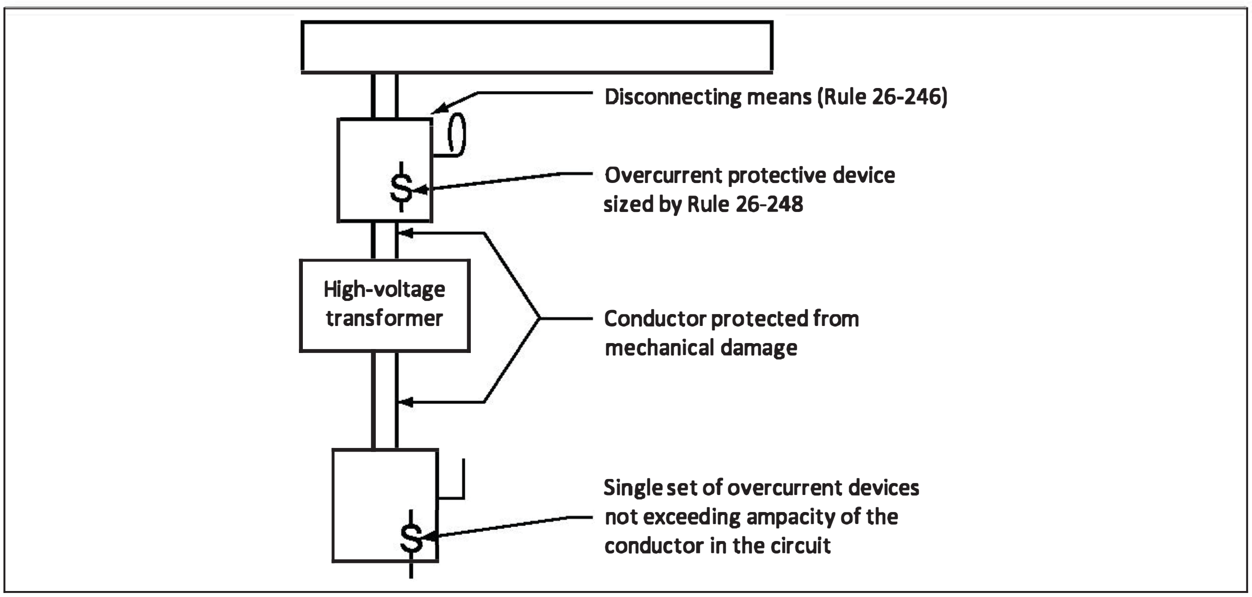


Item d) allows tap conductors to be used, as the primary and secondary conductors, when they feed a high-voltage transformer rated over 750 V with primary protection complying with Rule 26-250, and with a set of secondary overcurrent devices. The tap conductor is to:

- supply only one circuit;
- be part of the secondary circuit of the transformer;
- terminate in a single set of secondary overcurrent devices having an ampacity rating not greater than the ampacity of the tap conductor (see Figure 14-6); and
- be protected from mechanical damage by suitable means.

In this case, Rule 14-100 requires an overcurrent device at the secondary of the transformer. Item d) allows the overcurrent device and switch to be located at the switchboard rather than at the transformer. The primary fusing of the transformer provides short-circuit protection, and the secondary fusing provides overload protection.

**Figure 14-6**
**Tap conductor ampacity for high-voltage transformer**




According to Item e), a tap conductor is considered adequately protected when it is used as a control circuit conductor, provided that:

- it is No. 14 AWG or larger;
- it is run externally from the control equipment enclosure;
- it is connected on the load side of a set of branch circuit overcurrent devices; and
- the rating of the branch circuit overcurrent device is not more than three times the ampacity of the control circuit conductors (see Figure 14-7).

Item e) does not require overcurrent protection where the control circuit performs a critical function and the opening of the control circuit would cause a hazard (for example, fire pump control).

Item f) allows the use of a tap conductor when the tap feeds a transformer installation (see Figure 14-8) in which:

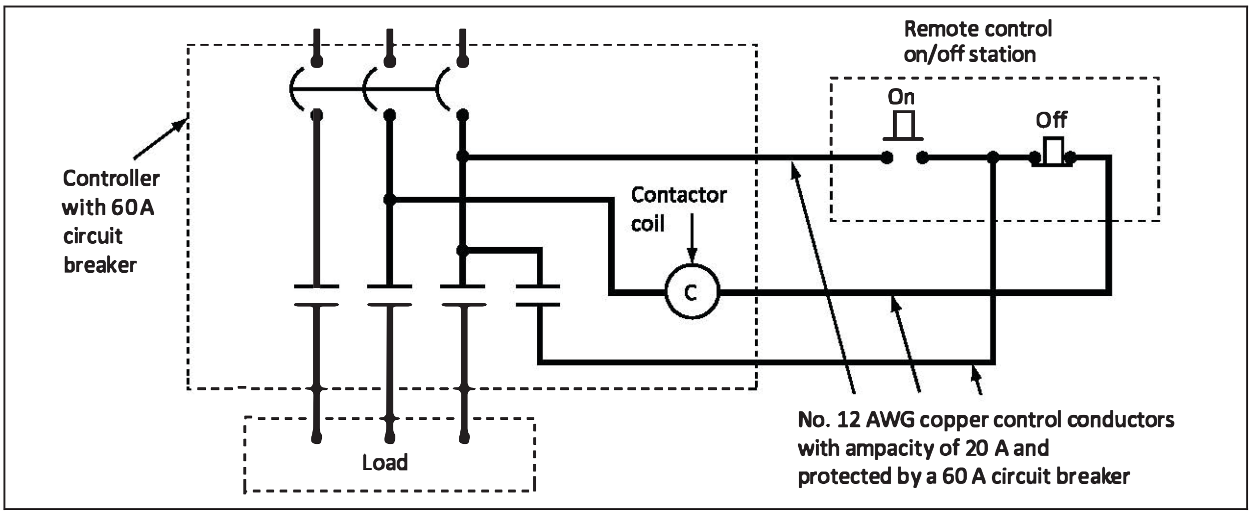
- the minimum primary conductor's ampacity is at least one-third of the ampacity of the feeder (larger) conductor it is being fed from or the demand load [see Subrule 3) of Rule 26-256], whichever is greater;

- the minimum secondary conductor's ampacity is calculated by multiplying the primary conductor's ampacity by the ratio of the primary to secondary voltage;
- the combined length of the primary and secondary conductors is not more than 7.5 m;

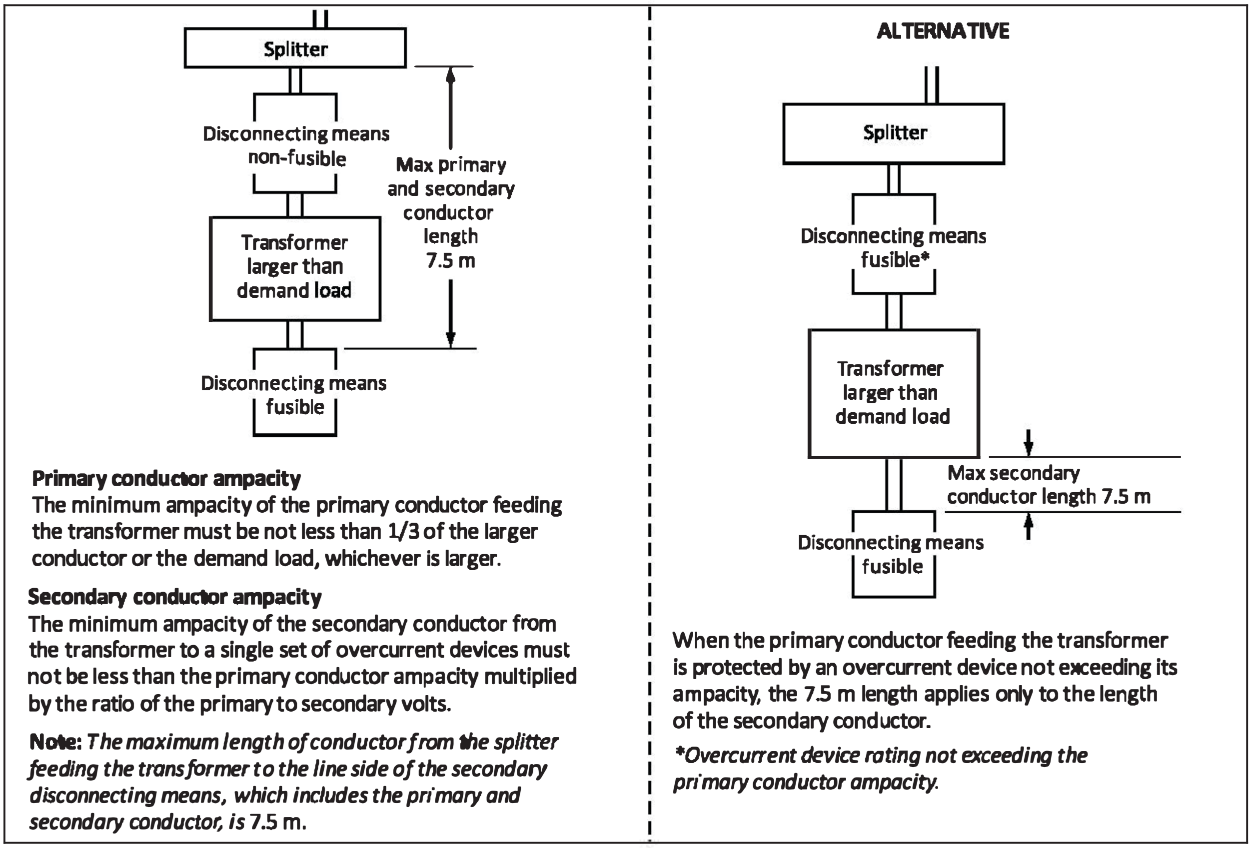
  **Note:** *When the primary conductor is protected at its ampacity rating, the maximum length of the secondary conductor is 7.5 m (see the alternative in Figure 14-8).*
- the primary and secondary conductors are protected from mechanical damage; and
- the secondary conductor terminates in a single set of overcurrent devices having a rating not greater than the secondary conductor's ampacity.

Item g) permits the use of a tap conductor when it feeds an installation and is supplied from an overhead or underground circuit. Item g) requires that:
- the voltage rating of the overhead or underground circuit be 750 V or less;
- the tap conductor be run overhead or underground, except where it enters a building;
- the tap conductor be installed according to the requirements of Section 6; and
- the tap conductor terminate in electrical service equipment in compliance with Section 6.

**Figure 14-7**
**Control circuit conductors tapped from a larger branch circuit**



## Figure 14-8
## Transformer tapped from a feeder



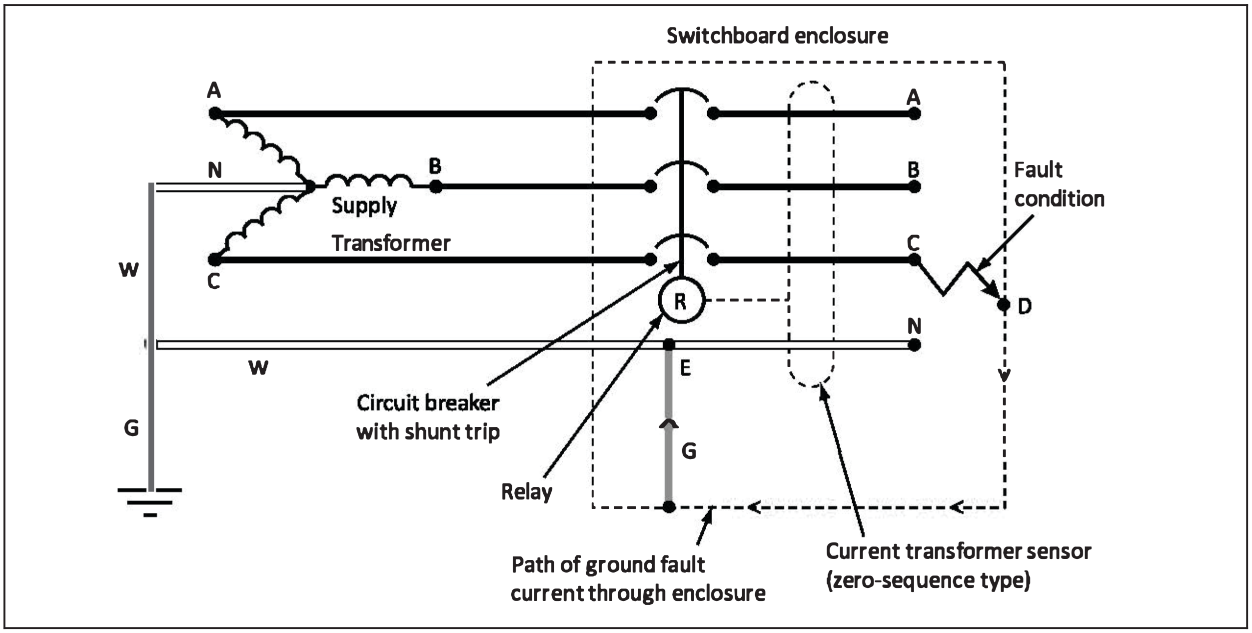

### Rule 14-102 Ground fault protection

The requirements for ground fault protection are intended to minimize and, as far as possible, eliminate equipment damage and fire hazards related to arcing ground faults.

Arcing ground faults in solidly grounded electrical systems or components can cause severe damage to electrical equipment and the surrounding area. Due to the resistance of the arc, the fault current will not necessarily be large enough for the regular overcurrent device to sense its existence and trip, so the arcing can persist for a long time. This can occur in systems operating at more than 150 volts-to-ground and rated at more than 1000 A, where there is adequate voltage and power to sustain the arc. Ungrounded systems are not as prone to extensive damage as solidly grounded systems since a fault on one phase does not result in arcing and destruction of electrical equipment. If this phase remains grounded and another phase faults to ground, a phase-to-phase fault results. This type of fault usually generates short-circuit currents high enough to cause the overcurrent devices to open quickly, thereby limiting damage.

In a solidly grounded system, any ground fault current is returned to the system through a path other than the neutral. The usual ground return path is through conduit and metal enclosures or along bonding system conductors. Electrical equipment can be used to sense the flow of current in a ground return path and signal an overcurrent device to operate. Two common methods are used to sense the current. The first uses a zero-sequence-type current transformer sensor that surrounds all phase and neutral conductors. Under normal circumstances, the vector sum of all currents flowing through the sensor is zero. When a ground fault occurs, the fault current bypasses the sensor. The net current flow through the sensor is no longer zero, and the sensor sends a tripping signal to the overcurrent device (see Figure 14-9).

## Figure 14-9
## Zero-sequence type ground fault protection system



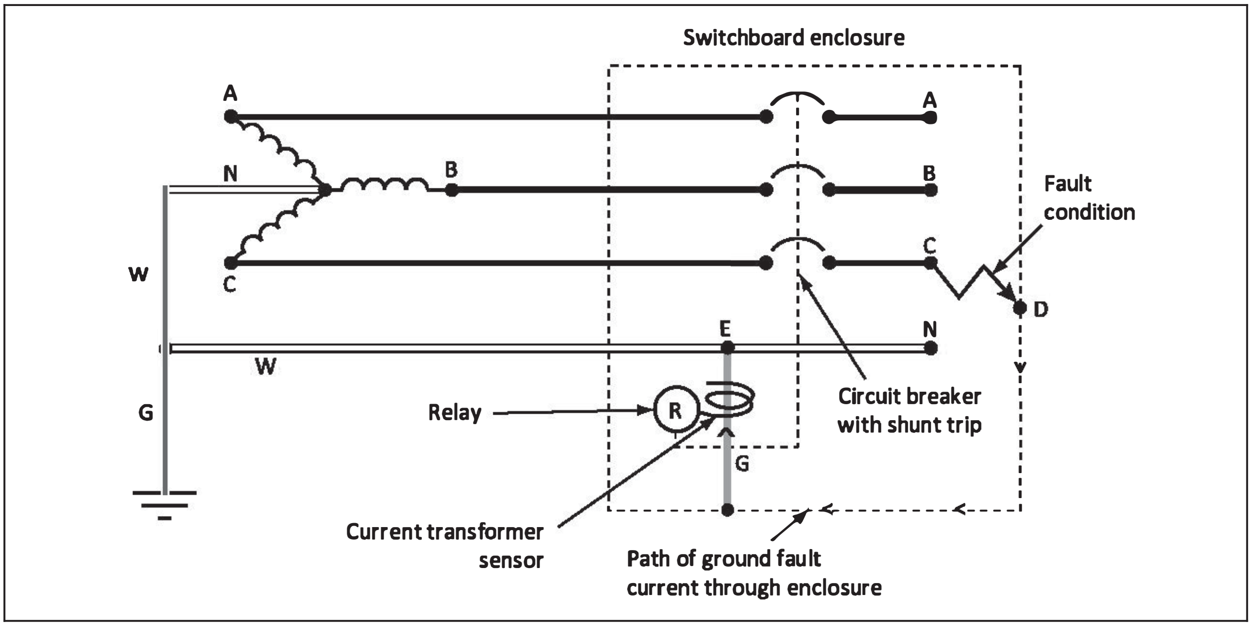

A ground fault in the switchboard on phase C at point D (see Figure 14-9) causes the fault current to return to the neutral through the switchboard enclosure to point E, bypassing the sensor and generating a signal to operate the relay and the shunt trip of the circuit breaker. The neutral is not to be grounded at any point downstream from the sensor; if it is, the fault current can pass through the sensor, and there will be no protection from faults occurring downstream from the sensor.

The second method, called ground-strap sensing, uses a current transformer installed between the neutral and its ground connection in the switchboard. This transformer senses any current returning to the neutral through the switchboard enclosure (see Figure 14-10). Again, a ground fault at point D causes fault current to flow to the neutral at point E through the sensor, operating the relay and causing the circuit breaker to trip.

In the arrangement shown in Figure 14-10, a small portion of the fault current might bypass the sensor and return to the system neutral at the transformer; this possibility is to be considered during design of the electrical installation.

Ground fault relays have adjustable pickup points and time delays, and some are built into circuit breakers. The two methods described above are intended to react to any fault in the system downstream if it is large enough, and this can cause frequent shutdowns of the whole system if ground fault protection is provided only on the mains. To avoid this, the feeders are also allowed to be equipped with ground fault protection with pickup points and time delays set to coordinate with the main overcurrent device, so that, within the specified time, only the affected feeder would be shut down.

**Figure 14-10**
**Ground-strap-type ground fault protection system**




Subrule 1) requires that circuits of solidly grounded electrical systems of 750 V or less be provided with ground fault protection if they are rated 1000 A or more and 150 volts-to-ground, or 2000 A or more and less than 150 volts-to-ground. Subrule 2) requires that the ground fault relay pickup point be 1200 A or less [an exception is specified in Subrule 8)] and operate within 1 s for fault currents of 3000 A or more. When determining the rating of the system, it is assumed that a switch will be supplied with the largest fuse acceptable and that a circuit breaker will be set at its maximum setting. If there is no main disconnect, the circuit rating is to be considered equal to the ampacity of the conductors.

Diagram 3 of the Code shows the location in the circuit where sensors and their disconnecting means are installed for various system arrangements. The protection can be provided by any reliable means. When sensors are used, Subrule 5) requires them to be zero-sequence types, ground-strap types, or a combination of the two. Zero-sequence sensors can be installed ahead of the disconnects they control, but if located downstream, they are to be as close as practicable to the load terminals of the disconnect. If ground-strap sensing is used, there is to be a sensor at each point where the neutral is grounded, except at the supply transformer. If the neutral is grounded at the transformer and the sensor is elsewhere, Subrule 7) requires that the maximum pickup setting of the relay be reduced from 1200 A to 1000 A. If the system has two or more protectors in series, Subrule 8) allows the upstream devices to be set higher than 1200 A and have more than a 1 s time delay for fault currents of 3000 A or more, provided that the final downstream device in each protected circuit does not exceed these values and the higher settings are required to achieve coordination.

### Rule 14-104 Rating of overcurrent devices

Since it is impracticable to provide overcurrent devices rated at the exact ampacity of every size of conductor under all conditions, Rule 14-104 sets out requirements for matching conductor ampacity to the available standard-rated overcurrent devices. It requires that all ungrounded conductors be protected by overcurrent devices rated or set at a value not greater than the conductor ampacity. However, where fuses or circuit breakers having the precise rating required are not available, the use of the next higher standard rating, as specified in Table 13, is allowed, provided that the conductor ampacity does not exceed 800 A and the maximum calculated or known load is in accordance with the Rules of Section 8. When conductors are selected based on a calculated load or a known load, Table 13 is useful in selecting the appropriate rating of overcurrent device based on the installed ampacity of the conductor for the installation. Code users are reminded that the circuit loading requirements of Rule 8-104 apply. It is intended that the ampacities given in the "Ampacity of conductor" column in Table 13 can be made up of single or multiple conductors. Table 13 is also useful in determining standard overcurrent ratings in certain cases [for example, as described in Item b) of Rule 14-212 or Subrule 3) of Rule 26-254].

Rule 14-104 also allows equipment wire, flexible cord in Nos. 16, 18, and 20 AWG copper, and tinsel cord to be protected by a 15 A overcurrent device, regardless of the conductors' precise ampacity. This Rule also recognizes that other Rules in the Code allow overcurrent device ratings to exceed conductor ampacity, as in the case of capacitors, motors, welders, and electric heating. Such Rules supersede the requirements of Rule 14-104.

To limit current when conductors are installed in raceways and cable sheaths, Subrule 2) imposes a limit on the overcurrent protection for conductors as follows: 15 A for No. 14 AWG copper conductors; 20 A for No. 12 AWG copper conductors; 30 A for No. 10 AWG copper conductors; 15 A for No. 12 AWG aluminum conductors; and 25 A for No. 10 AWG aluminum conductors. The *National Electrical Code* (*NEC*) specifies the same limitation.

These requirements are to be applied when the conductor size is dependent on the overcurrent device size, (for example, for the receptacles specified in Rule 14-600 and for the lighting circuits specified in Section 30). The exception in Subrule 2) allows the use of the ampacity ratings in Tables 1, 2, 3, and 4 when the conductor size and the overcurrent protection are determined from different Rules in the Code, (for example, for equipment such as motors, capacitors, welders, and transformers).

### Rule 14-106 Location and grouping

Over time, overcurrent devices need maintenance, replacement, or resetting, so they are not to be located where access is difficult. If they are not grouped together, it might be difficult to locate them when maintenance or replacement is required. Rule 14-106 requires that overcurrent devices be readily accessible and grouped, where possible, or be located as required by other Rules of the Code [for example, Subrule 3) of Rule 6-102].

**Note:** *"Readily accessible" is a defined term, and it is not to be confused with the term "accessible" when it applies to electrical equipment.*

### Rule 14-108 Enclosure of overcurrent devices

Overcurrent devices having exposed live parts are to be contained in enclosures to protect them from airborne contaminants, such as dust or lint, and to guard them against accidental contact. Subrule 1) requires that all overcurrent devices be contained in a suitable enclosure, unless they are located in clean, dry rooms accessible only to authorized personnel. Such rooms are normally locked and identified as containing electrical equipment. Since it is necessary to have access to circuit breaker handles in order to operate or reset them, Subrule 2) requires that the handles be accessible without the need to open a door or cover and thus expose live parts.

### Rule 14-110 Grouping of protective devices at distribution centre

Rule 14-106 requires that overcurrent devices be grouped together. In the case of lighting branch circuits, which are usually switched by unauthorized or untrained people, a special grouping is necessary. In the typical installation, a panelboard is used to enclose the overcurrent devices and to provide users with a directory showing the load that each overcurrent device supplies, an indication of whether the circuit is on or off, and instructions on how to reset the circuit breaker.

Subrule 2) requires that, where a panelboard is not required and a fusible switch is used, all overcurrent devices in the fusible switch have the same rating; this ensures that an oversized fuse is not installed, which would create a potential fire hazard. On a multi-wire branch circuit that shares a common neutral, each ungrounded conductor is to be counted as a separate circuit as required by Subrule 3).

### Rule 14-112 Overcurrent devices in parallel

Under very specific conditions it is permissible to connect overcurrent devices in parallel in order to protect, for example, a 1200 A circuit with two 600 A fuses or circuit breakers. However, such an installation requires special care and installation techniques to ensure that the current is shared equally between the two devices, thereby preventing nuisance tripping, while at the same time ensuring that the interrupting rating of either overcurrent device is not exceeded when it operates under fault conditions. Therefore, such installation approaches are to be strictly controlled to ensure that parallel overcurrent protective devices are factory assembled in parallel as a single operating unit.

### Rule 14-114 Application of supplementary protectors

A supplementary protector is a device designed to open a circuit automatically at a predetermined current value. Supplementary protectors are typically used as components in appliances or other electrical equipment for which branch circuit overcurrent protection is already provided in accordance with the Code. Certified to CSA C22.2 No. 235, supplementary protectors differ primarily from circuit breakers (which are certified to CSA C22.2 No. 5) in that circuit breakers and fuses are required to interrupt fault currents, but supplementary protectors are not. When supplementary protectors are used, the following are to be considered:

- fuses or circuit breakers are required ahead of them in the circuit for overcurrent (short-circuit) protection; and
- resetting them in a circuit containing a fault can subject them to conditions for which they were not designed or certified.

The Appendix B Note to Rule 14-114 emphasizes that the supplementary protectors used in some appliances or equipment are not suitable for the protection of branch circuit conductors.

When supplementary protectors are incorporated in appliances and equipment:

- all such equipment is to have warning signs indicating that the equipment's main disconnect is to be opened before any devices within are reset; and
- personnel likely to be working on such equipment are to be advised of this risk and are to ensure that the proper procedures for resetting these devices are followed.

## Fuses

A fuse is an overcurrent protective device designed and constructed to automatically open an electric circuit under predetermined overload or short-circuit conditions. It contains a metal element that is directly heated by the current passing through it. This metal element is destroyed (melts) when it opens the circuit under overload or short-circuit conditions and is therefore non-reusable.

### Rule 14-200 Time-delay and low-melting-point fuses

In low-melting-point fuses, marked P or D, the fusing element melts at a low temperature. These fuses are designed to eliminate any possible hazard resulting from overheating due to loose connections at the fuseholder and deterioration of the fusing element. Time-delay fuses, marked D, incorporate a low-melting-point element and are also designed to provide a time delay sufficient to handle surges (for example, the starting inrush current of a motor). Both types of fuse are physically interchangeable, so marking is required to help prevent the installation of the wrong kind of fuse.

### Rule 14-202 Use of plug fuses

Plug fuses are round fuses that screw into a base in the fuseholder, thereby completing the circuit. They are to be used only where the voltage between conductors is 125 V or less or in grounded systems where the voltage-to-ground of any conductor does not exceed 150 V. A plug fuse contains a strip of soft wire or metal that is designed to carry a given amount of electric current, such as 15 A. If anything happens to cause more current to flow in the circuit than the circuit and the fuse are designed to carry, the metal strip melts or burns out, opening the circuit, stopping the flow of current, and protecting the wiring.

All plug fuses are rated at 125 V with 10 000 A of interrupting capacity and are suitable for use on 120/240 V grounded neutral systems.

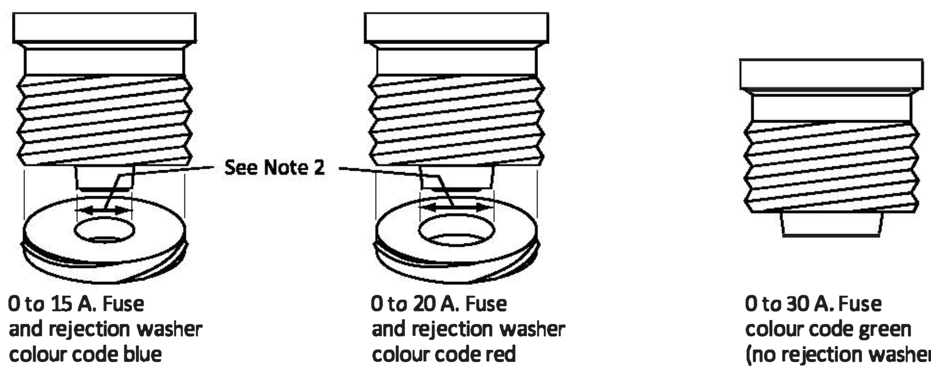
### Rule 14-204 Non-interchangeable fuses

The threads on the base of the common plug or screw-type fuse are the same as those found on light bulbs. This base and thread size is commonly referred to as an Edison base. The Code generally discourages the use of Edison-base fuses because plug fuses of different sizes (ampacity ratings) can easily be interchanged: they can all be placed in the Edison base, without the use of tools. This makes it easy for untrained people to replace a fuse in a circuit or electrical appliance with one having a higher rating (over-fusing), either in error or in a deliberate attempt to prevent an overloaded circuit from repeatedly blowing the fuse.

To prevent over-fusing, Subrule 1) requires that plug fuses be of the non-interchangeable type, so that they cannot be replaced by fuses with higher ratings. Two designs of non-interchangeable fuses have been developed: Type C and Type S. The Type C fuse is most commonly used in Canada. The design features a rejection washer that is placed into the fuseholder; any attempt to insert a fuse with the incorrect rating is defeated by the washer (see Figure 14-11).

Since many fused panelboards were installed before non-interchangeable-type fuses were available, Subrule 1) requires that when alterations or additions are made to existing panelboards, all the fuseholders have the appropriate rejection washers installed.

**Figure 14-11**
**Type C fuse (non-interchangeable)**




**Notes:**
1) *Type C fuses are designed to help prevent loss of protection from over-fusing. They can be used to upgrade a system now using ordinary fuses in standard-base fuseholders. A special rejection washer is inserted into the base fuseholder so that the circuit cannot be over-fused.*
2) *Type C fuses have various sized cylindrical extensions holding the bottom contact. The extensions vary in diameter according to the ampere of the fuse and fit only the appropriate size hole in the rejection washer (which varies in size to match the bottom extension of the fuse). Three ampere ranges of protection are available. Fuses and rejection washers are colour-coded for easy identification.*

### Rule 14-206 Fuseholders for plug fuses

Plug fuses can be changed by people not qualified to service electrical installations. To protect users who are unaware of electrical hazards or unfamiliar with the operation of the electrical equipment and to allow them to change fuses without shock or fire hazards, Rule 14-206 requires that only covered-type fuseholders (in which no live parts are exposed while the fuse is in the holder) be used where the fuses are readily accessible to unauthorized personnel. Fused electrical equipment is designed to meet this protection requirement.

### Rule 14-208 Rating of fuses

Fuses are used with fuseholders in a variety of circuits and vary in voltage, current, and interrupting ratings. Fuseholders are to have adequate clearances and current-carrying capability for the circuit involved. To prevent misapplication and to allow standardized designs of fuseholders, switches, and panelboards, some classes of fuses are limited in ampere rating. Standard or code fuses (Class H fuses), covered by CSA C22.2 No. 248.1, have interrupting ratings of 10 000 A. Subrule 1) limits plug fuses to 30 A and less at 125 V and less. Subrule 2) limits standard cartridge fuses to 600 A and less at 600 V and less. The fuse types listed in Rule 14-212 with interrupting ratings in excess of 10 000 A have ratings up to 750 V and are not limited in ampere rating by the Code. Fuses rated above 750 V are specialized and are not limited in either voltage or current rating.

### Rule 14-210 Fuses and fuseholders

It is essential that the ampere and voltage ratings of fuses are low enough to interrupt an overloaded circuit before it reaches a dangerous temperature and that their interrupting ratings are sufficient to safely interrupt the available fault current or short-circuit current. The fuseholder is to be properly matched to the fuse with which it is used, so that a proper connection is made. Any attempt to bypass a fuse or bridge the fuseholder can result in a loss of protection. Rule 14-210 requires that fuses and fuseholders match each other and that their ratings be properly selected for the circuit in which they are used. It prohibits bridging or short-circuiting of either component.

### Rule 14-212 Use of fuses

Rule 14-212 sets out requirements for the use of fuses, allowable exchanges, and alternatives. Fuses have an inverse-time characteristic, that is, the more the current exceeds the fuse's rating, the faster the fuse blows. This characteristic allows moderate overloads (such as a motor's starting inrush current) to persist for a short time but causes the fuse to blow nearly instantaneously in the case of a short-circuit.

All certified fuses are designed to carry their full rated current indefinitely in open air and to blow with a certain amount of time delay when overloaded. Sample fuses are tested at a particular value of overload, and they are expected to blow within a predetermined maximum time that has been selected to prevent serious overheating of the conductor they protect.

All standard fuses known as Class H fuses (also called code fuses) and all Class CA, CB, CC, G, J, K, L, R, T, and HRCI-MISC fuses are designed and tested to blow within their set time limit when carrying 135% of their current rating. The overload for Class C and HRCII-MISC fuses is 160% of their current rating. As these overload values (referred to as fusing factors) indicate, Class C and HRCII-MISC fuses can provide the same overload protection as Class H, CA, CB, CC, G, J, K, L, R, T, and HRCI-MISC fuses if the former are applied with ratings equal to 85% of the ratings of the latter.

## Circuit breakers

A circuit breaker is an automatic electromechanical device, rated in amperes, voltage, and horsepower, that opens under excessive current and short-circuit current in the circuit conductor. It is not damaged on interrupting the current and is typically reset by hand to restore the supply of power to the circuit.

An instantaneous-trip circuit breaker is a circuit breaker that is designed to trip only under short-circuit conditions. It does not provide protection against excessive currents (overload currents) since it does not have an overload feature (for example, a thermal trip unit). The instantaneous tripping current required to trip the breaker is usually thirteen times the current rating of the circuit breaker. Instantaneous-trip circuit breakers are not designed to allow any time delay in tripping, and they are sensitive to current inrushes, vibration, and shock. Consequently, they are to be used with some discretion where these factors are known to exist.

### Rule 14-300 Circuit breakers, general

Circuit breakers are designed both to open and close a circuit manually and to provide overcurrent protection to the overloaded circuit. When a circuit breaker trips due to overcurrent, it can be reset by means of its handle or other operating means. Rule 14-300 requires that a circuit breaker have markings associated with the handle or other operating means to show whether it is open or closed. As well, the circuit breaker is to be trip-free, that is, it cannot be held closed during a fault. The tripping mechanism is to be such that the circuit breaker trips as a result of overload or overcurrent even when the handle is held in the ON position.

In a fully trip-free design, the main contacts remain open after a fault when the handle is held in the ON position. Some devices, known as cycling trip-free circuit breakers, cannot be forcibly held in the ON position during a fault, but they cycle on and off if the handle is held in the ON position.

### Rule 14-302 Construction of circuit breakers

Circuit breakers are available in single-, double-, or 3-pole construction. Except as noted in Item b) (see below), the construction of double- and 3-pole circuit breakers controlled by a single handle is to be such that all poles operate simultaneously, both by manual operation and automatically by an overcurrent in any pole. This is called common trip operation. Some double-pole circuit breakers, however, are arranged for separate trip operation, such that only the pole that experiences an overload will trip. These breakers are rated at no more than 150 volts-to-ground.

Rule 14-302 requires that a circuit breaker used to protect a circuit be capable of opening all ungrounded conductors simultaneously, either manually or automatically, as a result of overcurrent. This usually requires the use of a common trip circuit breaker.

However, Item b) allows two single-pole breakers to be used as a double-pole separate trip device if their handles are connected by a handle-tie device, provided by the manufacturer, ensuring that manual or automatic operation of either handle will operate both breakers.

Another exception allows the use of two or three single-pole circuit breakers to control a multi-wire branch circuit that feeds only loads connected to the neutral and one ungrounded conductor, as permitted by Item b) of Rule 14-010. A multi-wire branch circuit can also be protected by two single-pole circuit breakers, provided that each breaker has a voltage rating not less than that of the system and that the circuit breakers are equipped with a handle tie that allows all the ungrounded conductors to be opened at the same time (see Figure 14-1).

### Rule 14-304 Non-tamperable circuit breakers

Most circuit breakers are constructed with a fixed calibration setting that is factory-sealed. Some of the larger and more complicated breakers, however, have adjustable tripping and delay settings.
Rule 14-304 requires that all circuit breakers accessible to unauthorized persons be designed so that field alteration of the tripping current setting or time-delay setting is diffiicult (for example, the adjustment requires the use of a tool or the removal of a seal). The adjustments required and the restriction on the range of adjustments depend on the application/equipment that the adjustable breaker is protecting.

### Rule 14-308 Battery control power for circuit breakers

Some large circuit breakers have tripping coils operated by battery power through the contacts of a relay that responds to overcurrent. If the battery charge is too low to operate the tripping coil, the breaker might not respond to an overload or fault condition, creating a potential hazard. Therefore, Subrule 2) requires that when the battery voltage drops below a value required to operate the breaker, it:

- automatically trip the breaker; or
- cause an alarm to sound continuously until the battery voltage is restored.

# Control devices

## General

### Rule 14-400 Rating of control devices

Rule 14-400 requires that all control devices, except isolating switches, have ratings sufficient to allow safe control of the loads that they supply (see Rule 14-012). They are to be rated in amperes, volts, and horsepower. Horsepower ratings are usually required if the device controls a motor branch circuit (see Rule 28-500).

Isolating switches are to be used only to isolate a circuit and are not to be operated under load.

### Rule 14-402 Disconnecting means required for fused circuits

To replace blown fuses safely, it is usually necessary to de-energize the circuit supplying them.
Rule 14-402 requires that disconnecting means be placed close to fuses, so that the power supply to the fuses can be interrupted easily, unless the fuses are:

- located in a switchboard and are used to protect instruments or control circuits at 250 V or less (for example, a fixed stage switchboard — see Section 44);
- on the primary circuits of voltage transformers rated 750 V or less on switchboards; or
- plug fuses where the circuit has only one ungrounded conductor.

Switchboards can contain fuses protecting instruments, control circuits, or voltage transformers. Since these fuses are enclosed within the switchboard and accessible only to authorized personnel, disconnecting means ahead of the fuses are frequently omitted. Plug fuses and their fuseholders are designed so that the fuse can be safely replaced while the circuit is live.

### Rule 14-404 Control devices ahead of overcurrent devices

This Rule requires that control devices used in combination with overcurrent devices or overload devices (for example, contactors, magnetic motor starters, combination motor starters, and fusible disconnect switches) have the overcurrent or overload devices de-energized when the control is in the open position. This prevents any shock hazard to people servicing, replacing, or maintaining the overcurrent or overload devices. An exception is allowed when it is impractical, such as when overcurrent protection is not provided [in accordance with Item e) ii) of Rule 14-100].

### Rule 14-406 Location of control devices

Rule 14-406 requires that all control devices, except isolating switches, be readily accessible. To control electrical circuits and devices properly and safely, operators and service and maintenance personnel are to be able to reach them quickly, without having to climb over or remove obstacles, or use portable ladders, chairs, etc.

Some electrical equipment (for example, motors operating fans on a roof or motors built into a machine) is diffiicult to access and is allowed to be controlled from another location, but this location is to be readily accessible. Isolating switches are exempt from the requirement for accessibility because they are used only for isolating purposes and do not control the circuit.

### Rule 14-408 Indication of control device positions

Rule 14-408 requires that all manually operable control devices be marked to indicate the ON and OFF positions of the operating handle, unless such an indication is unnecessary (for example, in the case of momentary contact switches or push buttons, such as foot switches or limit switches). Control devices such as switches and circuit breakers are to be marked to indicate whether they are open or closed. Contactors and relays, however, usually need not be marked since they are not relied upon for circuit isolation.

### Rule 14-410 Enclosure of control devices

Control devices contain live parts that could arc while making or breaking a circuit. To prevent accidental contact with live parts and to contain any arcs, Rule 14-410 requires that all control devices be contained in an enclosure of metal or other fire-resisting material to prevent a fire or shock hazard, unless they are located or guarded (for example, in an electrical room) so that they are accessible to authorized personnel only.

### Rule 14-412 Grouping of control devices

Rule 14-412 requires that control devices be grouped where practicable. Electrical equipment used to group control devices includes switchboards, panelboards, motor control centres, and enclosed switches (fused or unfused) grouped around a splitter box.

The switches that control a distribution system are to be grouped. Grouping provides a means to control the whole system from one location, allowing personnel to quickly and conveniently de-energize all or part of the system. In some situations this is not practical since some disconnecting means are located close to the electrical equipment that they control for reasons of safety or convenience.

### Rule 14-414 Connection to different circuits

When electrical equipment is supplied from more than one source of voltage (for example, a 208 V, three-phase motor being protected by a 24 V thermistor installed in the motor windings), special hazards might arise if the equipment cannot be completely de-energized by opening a single disconnecting means. This situation occurs most frequently in equipment where control circuits originating elsewhere enter the equipment to perform a necessary interlocking function. When this occurs, anyone servicing the equipment might accidentally contact live parts, unless all supply sources to the equipment are disconnected.

### Rule 14-416 Control devices used only for switching

A control device that has an OFF position marked on it and that does not disconnect all ungrounded conductors to the electrical equipment that it controls can present a shock hazard to personnel maintaining or servicing the equipment (for example, a single-pole switch controlling a 240 V luminaire). Control devices that function only as a switch and have a marked OFF position are to disconnect all ungrounded conductors to the load they control, except where allowed by other Rules in the Code (for example, a single-pole motor starter controlling a 240 V motor [see Subrule 2) of Rule 28-500].

## Switches

A switch is a device for making, breaking, or changing connections in a circuit. Examples include indicating switches, three-way switches, four-way switches, general-use switches, isolating switches, and motor-circuit switches.

### Rule 14-500 Operation of switches

Knife switches are uncommon in modern electrical systems but are still encountered occasionally. They have hinged blades that rotate about the hinge point into a jaw, closing the switch. They are mounted on an insulating plate, are typically operated by means of an insulated handle mounted on the blade, and usually are provided with enclosures. Knife switches are only capable of interrupting their rated current at their rated voltage.

### Rule 14-502 Mounting of knife switches

Subrules 1) and 2) require that single-throw knife switches be mounted with their bases in a vertical plane, so that gravity does not close them. Double-throw knife switches, which have two closed positions and one open position, are allowed to be mounted for either a vertical or horizontal throw. If vertical, however, Subrule 3) requires that a locking device be provided to ensure that the blades stay in the open position when the switch has been opened. This locking device is allowed to be omitted if the switch is not intended to remain open.

### Rule 14-504 Maximum rating of switches

Arcing can occur under load and damage the knife switch, unless the switch has been designed for this purpose. Therefore, this Rule does not allow knife switches rated at more than 600 A at 750 V or less to be used under load conditions.

### Rule 14-506 Connection of switches

Enclosed switches (fused or unfused) intended to be operated manually are connected to the supply by terminals located at one end of the switch. These line terminals and the switch jaws to which they are attached are often shrouded to provide arc control and to prevent inadvertent contact with live parts. Switch blades, fuse clips (if any), and load terminals are to be dead when the switch is open so that fuses can be replaced safely. Moulded case circuit breakers are constructed in such a way that, except for the line and load terminals, all live parts are contained within the moulded case. When the breaker is in the open position, the only exposed live parts are the line terminals. The larger frame circuit breakers and magnetic switches or contactors often have exposed live parts downstream from the actual point of disconnect, and when this is the case, the devices are to be designed so that all live parts are inaccessible, and the blades and moving contacts and all other downstream live parts are dead when the devices are in the open position. All of these constructions are intended to minimize the chances of accidentally contacting live parts when servicing electrical equipment.

In one common power distribution scheme, switches or circuit breakers are backfed under certain circumstances, and their blades are energized even when the devices are open. This occurs in switchgear, for example, which can be fed from either of two supply sources, to provide continuity of service where one source fails. Item e) exempts magnetic switches from the requirement, provided that they are fed from a circuit breaker or manual switch located in the same enclosure (for example, a combination motor starter). The circuit breaker or manual switch is allowed to be mounted in another enclosure located immediately adjacent to the magnetic switch if it has a marking clearly indicating that it controls the magnetic switch.

### Rule 14-508 Rating of general-use ac/dc switches

General-use ac/dc switches have different ratings and are tested with dc. They are to be designed to switch non-inductive loads up to their rating, and some inductive loads if they are derated. An ac/dc switch can also have a T-rating, which indicates that it has had extra tests and is qualified to switch tungsten-filament lamp loads, either ac or dc, up to its voltage and ampere rating. If intended for use with electric discharge lighting, an ac/dc switch is to have additional testing to qualify it for switching these inductive loads.

### Rule 14-510 Use and rating of manually operated general-use ac switches

Manually operated general-use ac switches are designed and tested to be installed in flush-device and surface-type boxes or to have complete self-enclosures in accordance with Subrule 7 of Rule 12-3010). When installed in branch circuits, these switches are to have a current rating of 15 A when in combination with a voltage rating of 120 or 277 V and not less than the current rating of:

- tungsten-filament lamp loads operating at 120 V;
- non-inductive loads; and
- inductive loads at not less than 75% lagging power factor.

### Rule 14-512 Manually operated general-use 347 V ac switches

These switches are to be installed in special device boxes (usually with an HV suffix). A 347 V switch does not fit into a standard 120 V or 277 V device box; this prevents switches with lower voltage ratings from being interchanged with 347 V switches.

## Protection and control of miscellaneous apparatus

### Rule 14-600 Protection of receptacles

Receptacle configurations are standardized according to voltage and ampere ratings as shown in Diagrams 1 and 2. The configurations for locking and non-locking types are arranged to prevent the connection of a load greater than the rating of the receptacle. Rule 14-600 requires that branch circuit overcurrent protective devices supplying receptacles be rated not larger than the rating of the receptacles, except in specific circumstances allowed in other Sections of the Code (for example, Rule 42-004 for welders).

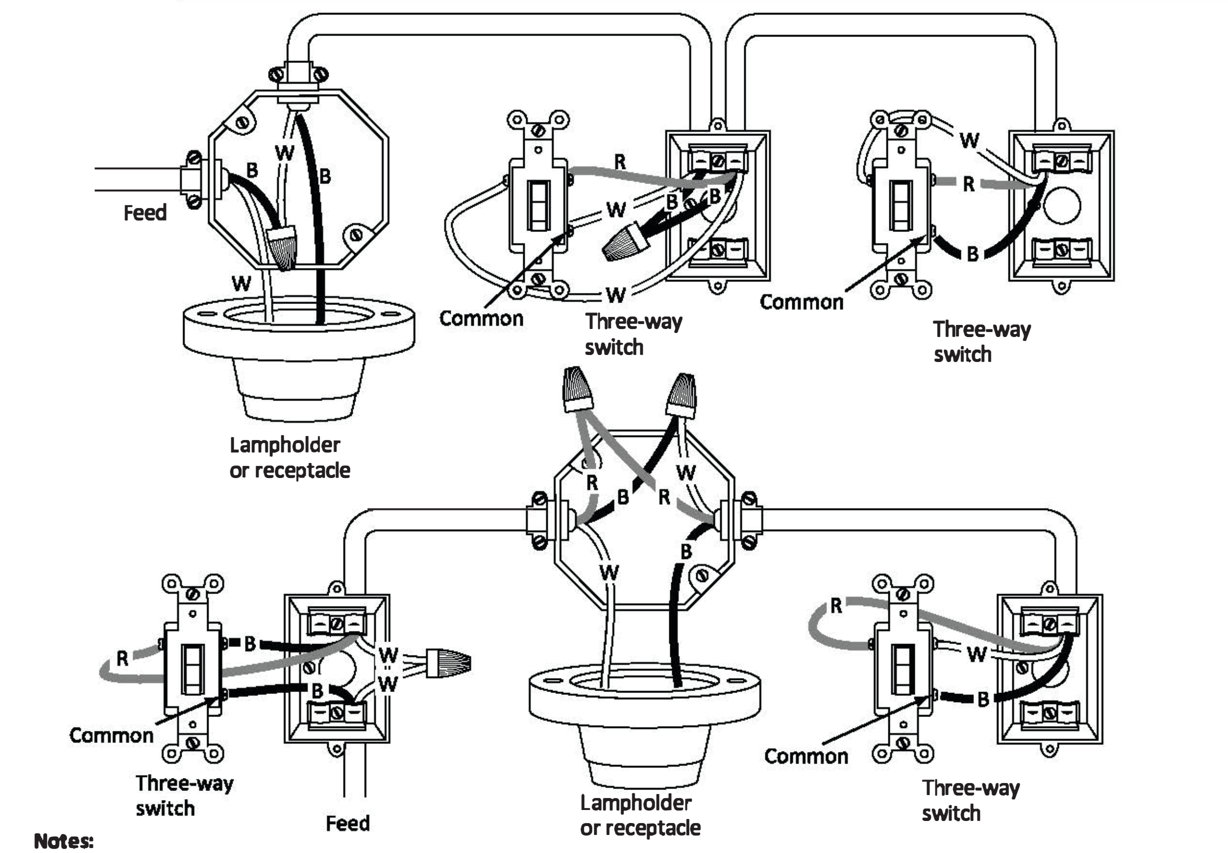
### Rule 14-602 Additional control devices not necessary

Item b) of Rule 14-010 requires that all electrical apparatus be provided with a control device capable of disconnecting all ungrounded conductors supplying the apparatus. Many small portable devices, however, are cord-connected and equipped with attachment plugs that easily provide a means of safely disconnecting the electrical equipment while under load. Rule 14-602 allows the attachment plug on a cord-connected device to be used as its disconnecting means, provided that the device is not rated more than 1500 W.

### Rule 14-604 Outlet control from more than one point

Outlets or luminaires are often controlled from more than one location (for example, a luminaire in a stairwell that is to be controlled from either floor level). Rule 14-604 requires that switches used to control outlets or luminaires from more than one point be connected so that all switching is done in the ungrounded circuit conductors only (see Figure 14-12).

**Figure 14-12**
**Typical three-way switching circuits**




**Notes:**
1) *Bonding conductors not shown.*
2) *For conductor identification, see Rule 4-030 2).*

### Rule 14-606 Panelboard overcurrent protection

Panelboards are used to supply feeders to other panelboards; to supply branch circuits to transformers; to motor, lighting, heating, and welding equipment; to various appliances; or to combinations of all of the preceding. The Rules in Section 8 or in other specific Sections of the Code are to be used to calculate the ratings of all overcurrent devices in the panelboard. Several circuits connected to a panelboard can supply loads that are not all expected to be on at the same time. This diversity allows panelboards to be protected by an overcurrent device rated at less than the sum of the ratings of all overcurrent devices in the panelboard. A panelboard's overcurrent protection device can also be "oversized" when 90% of the load it supplies is made up of motors or feeders due to the surges associated with these types of loads. In any case, the overcurrent device protecting a panelboard is not to be sized any smaller than the sum of the loads that the panelboard supplies and that will be on at the same time (see Rule 8-104).

Subrule 1) is a reflection of a general provision of Rule 14-104, which states that the rating of overcurrent devices cannot exceed the ampacity of the conductors that they protect. Subrule 1) mandates that panelboards are to be protected on the supply side by an overcurrent device rated or set not greater than the rating of the panelboard itself. Panelboards with more than 90% of overcurrent devices supplying feeders or motor branch circuits are exempt from the Subrule 1) requirement. The overcurrent protection is allowed to be either integral with (sometimes referred to as a combination panel), or directly ahead of, the panelboard, or in the primary of a transformer supplying it. In the latter case, Subrule 2) allows the installation of the overcurrent device for a panelboard to be in the primary of the transformer, but requires that the panelboard have an ampere rating not less than the primary overcurrent device rating, multiplied by the ratio of the primary to secondary voltage.

## Calculating a panelboard rating

### Example

To calculate the minimum panelboard rating, in amperes, for a panelboard protected on the primary side of a 75 kV•A, dry-type transformer, where the primary is 600 V, three-phase, 3-wire, and the secondary is 120/208 V, three-phase, 4-wire.

**Step 1**
Calculate the primary overcurrent device size for the transformer (see Rule 26-254):

Total kV•A / (primary voltage × 1.73) = 75 000 / (600 × 1.73) = 72.3 A

Rated primary current × 1.25 = 72.3 A × 1.25 = 90 A

**Step 2**
Calculate the minimum ampacity rating of the panelboard:

Primary overcurrent device size × (primary voltage / secondary voltage) = 90 A × (600 V / 208 V) = 260 A

## Calculating a primary overcurrent device rating

### Example

To calculate the maximum rating of an overcurrent device in the primary 600 V, three-phase circuit of a transformer that supplies a 200 A, 120/208 V, three-phase, 4-wire panelboard:
Panelboard rating / (primary voltage / secondary voltage) = 200 A / (600 V / 208 V) = 69.4 A

The maximum rating of the overcurrent device is 60 A, the next-lower standard rating, in accordance with Table 13.

See Table 14-1 for ratings of primary overcurrent devices for standard-rated panelboards.

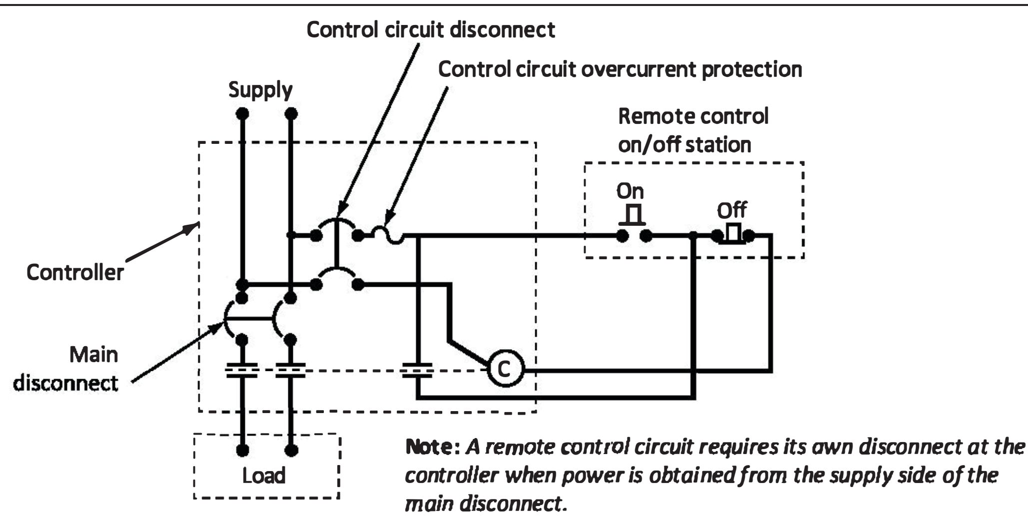
## Table 14-1
## Maximum rating of primary overcurrent devices to protect standard-rated panelboards

| | 600 V, 120/208 V, three-phase, 4-wire system | | 600 V, 120/240 V, single-phase, 3-wire system | |
|---|---|---|---|---|
| **Panel rating, A** | **Calculated rating** | **Standard rating** | **Calculated rating** | **Standard rating** |
| 60 | 20.8 | 20 | 24 | 20 |
| 100 | 34.7 | 30 | 40 | 40 |
| 125 | 43.3 | 40 | 50 | 50 |
| 200 | 69.4 | 60 | 80 | 80 |
| 225 | 78.0 | 70 | 90 | 90 |
| 400 | 138.7 | 125 | 160 | 150 |
| 600 | 208.0 | 200 | 240 | 225 |

### Rule 14-608 Remote control circuits

Electrical equipment is often provided with a means for being turned on or off from a remote location. One example is a remote push button that controls a magnetic contactor wired ahead of the equipment. The supply for this control circuit is allowed to be obtained from the same source that supplies the electrical equipment and is allowed to be tapped off either the line side or load side of the electrical equipment's disconnecting means. When control circuits extend beyond the electrical equipment's controller enclosure, Rule 14-608 requires that they be provided with a disconnecting means. Unless the controller disconnecting means also disconnects the control circuit, Rule 14-608 requires a separate control circuit disconnecting means, located at the controller (see Figure 14-13).

## Figure 14-13
## Remote control circuit




### Rule 14-610 Protection of circuits supplying cycling loads

Cycling loads of which more than 50% of the load is of a cyclical nature, such as thermostatically controlled equipment (for example, electric space heaters, clothes dryers, water heaters, and furnace fans) and intermittently self-starting equipment (for example, sump pumps or air conditioners), can cause changes in the characteristics of some fuses, leading to increased heating in the fuse to the point where its barrel is severely damaged. Despite this heating, however, the fuse might not blow, and over time, the insulation in the panelboard or switch might degrade to the point where a fault and serious arcing could occur.

Rule 14-610 requires that time-delay or low-melting-point fuses be used for cycling loads. Time-delay or low-melting-point fuses (marked D or P) and the fuses listed in Rule 14-200 are not subject to the hazards described above. The fuses listed in Item b) of Rule 14-212 have lower impedance and are less subject to overheating. They are also available with the same low-melting-point characteristics and, when used in dwelling units, are to have the same low-melting-point characteristics as outlined in Rule 14-200.

### Rule 14-612 Transfer equipment for standby power systems

Some electrical installations are equipped with standby power supplies to maintain continuity of service when the normal supply fails (for example, in hospitals). The means of transfer to the standby supply can be manual or automatic. Rule 14-612 requires that transfer equipment be designed, installed, and maintained in such a way that the inadvertent interconnection of the two power supplies never occurs during any switching operation. Requirements for automatic transfer switches are detailed in the CSA C22.2 No. 178 series of Standards. Rule 6-106 is also to be checked if the transfer equipment is installed as service equipment, and provisions of Section 84 should be met if interconnection with the power supply authority source is involved.

## Solid-state devices

### Rule 14-700 Restriction of use

Figure 14-14 shows a simplified diagram of an uninterruptible power supply (UPS) that provides uninterrupted power to a critical load when the normal power supply fails. Such systems are often used to supply power to computers and data processing equipment, which are vulnerable to fluctuations in input voltage and frequency, as well as to complete power outages. In normal operation, the rectifier keeps the battery charged, and the inverter supplies ac power to the critical load. If the normal supply fails, the battery takes over until the normal supply resumes. The solid-state transfer switch closes only if the inverter fails. UPS systems are allowed to be rated as high as 1000 kW and under battery power can sustain loads for up to 4 h.

Solid-state switches are power-isolating but not voltage-isolating devices and also have inherent resistive and capacitive leakage. Solid-state switches can fail in a short-circuit mode. Rule 14-700 accordingly requires that solid-state devices not be used as disconnecting means.

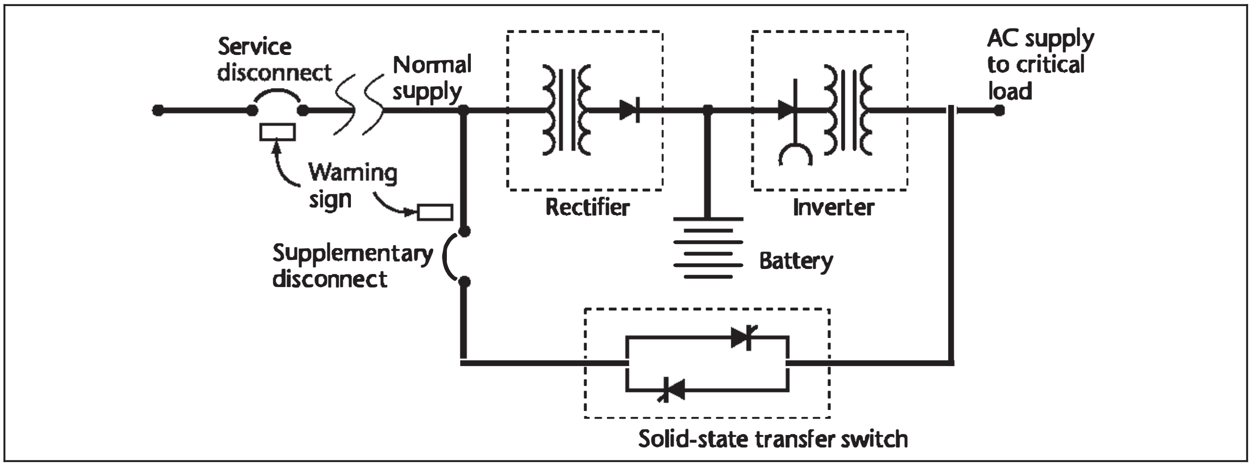
### Rule 14-702 Disconnecting means required

If the supplementary disconnect shown in Figure 14-14 were not installed and the normal supply failed, a possible hazard would exist for the personnel working on it even though the main service entrance disconnecting means has been opened. This hazard would occur if the solid-state switch fails and short-circuits, or if it allows any leakage of energy from the battery and inverter to backfeed into the normal supply.

A failure in the rectifier is not hazardous since the rectifier is fed by a transformer that prevents the dc power from feeding back.

Subrule 1) requires that, when solid-state devices are used in such a way that their leakage or failure can cause a transfer of energy between different power sources (for example, the normal supply or the battery in Figure 14-14), a supplementary disconnecting means be provided that, when opened, prevents any such transfer between the power sources.

## Figure 14-14
## Uninterruptible power supply (UPS) with supplementary disconnecting means to prevent feedback




### Rule 14-704 Warning notices required

Item a) requires that the supplementary disconnecting means required by Rule 14-702 bear a sign warning that the disconnecting means is to be opened if power fails in any power source or before servicing any part of the circuits of the other power sources. The sign is also to state that both the line and load terminals can be live, even when the disconnecting means is in the open position. Item b) requires that all other disconnecting means in the normal supply system have signs warning that other power sources exist in the system and that the supplementary disconnecting means is to be open to prevent feedback from those systems.

# Section 16 — Class 1 and Class 2 circuits

## General

Section 16 is a general Section of the Code that gives requirements for Class 1 and Class 2 circuits. Class 1 and Class 2 circuits are found in industrial instrumentation systems, building system monitors, motor controls, alarm circuits, doorbells, power door openers, thermostats, medical equipment, power supplies used to recharge batteries and laptop computers, and other similar applications. The power supply or overcurrent protection for these circuits marks the crucial difference between the conventional branch circuit and the Class 1 or Class 2 circuit. In Class 1 and 2 circuits, voltage, current, and power are limited in all parts of the circuit by the power supply. Section 16 provides requirements for power supplies, portions of the circuit beyond the power supply, and overcurrent devices to ensure the safe limitation of the voltage, current, or power used by Class 1 and Class 2 circuits.

### Rule 16-000 Scope

Subrule 1) describes the type of circuits that are defined as Class 1 and Class 2 circuits.

Class 1 and Class 2 circuits have their power supply limited by Subrule 2) of Rule 16-100 and by Rule 16-200, respectively, and are used in the following types of circuits:

- remote control circuits (any electrical circuit that controls any other circuit through a relay or an equivalent device); and
- signal circuits (any electrical circuit, other than a communication circuit, that supplies energy to a device that gives a recognizable signal, such as circuits for doorbells, buzzers, code-calling systems, signal lights, etc.).

A Class 1 circuit can also be an extra-low-voltage power circuit, such as a valve operator or similar circuit, that is neither a remote control circuit nor a signal circuit, but that operates at not more than 30 V and that is supplied by a transformer or other device restricted in its rated output to 1000 V•A [see Subrule 1) of Rule 16-100], but in which the current is not limited in accordance with the requirements for a Class 2 circuit.

A Class 2 circuit can also be a low-energy power circuit such as a circuit other than a remote control or signal circuit that has a power supply limited in accordance with the requirements for Class 2 remote control circuits (see Rule 16-200).

Class 2 power and data communication circuits connecting power sourcing equipment and powered devices are referred to by the industry as "Power Over Ethernet" (POE) (see Rule 16-300).

Some communication circuits have the power limitation characteristics of Class 2 circuits but are not considered Class 2 circuits since they carry data, voice, radio, television, and telegraph signals. To avoid confusion, Subrule 2) excludes communication circuits from the application of this Section. Circuits that form an integral part of a device, such as circuits inside computer enclosures, paging system annunciators, telephones, intercoms, or process equipment, are also excluded.

### Rule 16-002 Classifications

Class 1 and Class 2 circuits differ according to voltage, current, and power supplied either from the load side of the overcurrent protection or from a power-limiting supply. Voltage, current, and power restrictions for Class 1 circuits are specified in Rule 16-100.

Class 1 circuits can be found in industrial control installations, building monitoring systems, controls for heating and cooling equipment, emergency stop buttons, machinery guarding, etc.

Voltage, current, and power restrictions for Class 2 circuits are stated in Rule 16-200. The energy levels for Class 2 circuits are lower than for Class 1 circuits and are the same for all applications (e.g., circuits supplying relays, doorbells, buzzers, and low-power electronic equipment).

### Rule 16-004 Class 1 extra-low-voltage power circuits

Circuits that supply power at not more than 30 V are not considered a shock hazard. They are considered Class 1 because the higher power level in Class 1 circuits (up to 1000 V•A) represents a greater fire hazard than that of Class 2 circuits.

In general (except for remote control and signal circuits), Class 1 power circuits operate at 30 V or less and have their rated output restricted to 1000 V•A or less.

### Rule 16-006 Class 2 low-energy power circuits

A circuit that satisfies or exceeds the installation requirements for Class 1 circuits but is limited in energy to Class 2 circuit levels is considered to present the same limited shock and fire exposure as a Class 2 circuit, even when the circuit is used for a purpose other than remote control or signalling. Rule 16-006 allows such circuits (e.g., circuits for applications such as lighting, dish antenna rotators, and electronic equipment) to be considered Class 2 circuits.

### Rule 16-008 Hazardous locations

Hazardous locations or locations where fire or explosion is more likely to result from uncontrolled sparks and high temperatures demand stricter requirements for the installation of electrical equipment. Electrical installations conforming to the requirements of Section 16 can still present a potential source of ignition that can cause a fire or explosion in a hazardous location. Therefore, such installations in hazardous locations are also to meet the requirements of Section 18, unless such circuits are designed as intrinsically safe or non-incendive circuits (see Rule 18-064).

### Rule 16-010 Circuits to safety control devices

The requirements for the electrical installation of Class 1 circuits are more restrictive than those for Class 2 circuits. Remote-control circuits that are provided for safety are to be installed carefully to ensure that they operate properly when needed. Although the current in such circuits might be low enough to satisfy the requirements for a Class 2 circuit, Rule 16-010 requires that these circuits be installed in compliance with the stricter requirements for Class 1 circuits.

### Rule 16-012 Circuits in communication cables

Communication circuits are considered to present less of a shock and fire hazard than circuits operating at voltages and currents up to the maximum levels allowed for Class 1 circuits. Subrule 1) requires that Class 1 circuits not be run in the same cable as communication circuits in order to avoid shock or injury to people working on the communication circuits.

Subrule 2) allows Class 2 remote-control and signal circuits to form part of a cable assembly that contains communication system conductors. These Class 2 circuits are treated as communication circuits when they share a cable with a communication circuit (e.g., the cables used for intercom systems, sound systems, remote camera operations, and dish antennas). This reduces the likelihood of confusion and error on the job, thus preventing conflicts between Class 1 and Class 2 installation practices that might create a safety hazard.

Subrule 3) requires that Class 2 power and data communication circuits be installed in accordance with Rule 16-300.

## Class 1 circuits

### Rule 16-100 Limitation of Class 1 circuits

Subrule 1) requires that the maximum power supplied to a Class 1 circuit be strictly limited to prevent misapplication of the Code Rules. By definition, extra-low-voltage power circuits are not to operate at more than 30 V, and experience has shown that the 1000 V•A limit of the Code is a relatively safe power value.

Remote-control and signal Class 1 circuits, by nature of their design and use, do not require much current (typically 5 A or less). For that reason, Subrule 2) specifies a voltage limitation of 600 V, which is a common industry standard.

## Rule 16-102 Methods of installation for Class 1 circuits

Like the electrical installations consisting of power circuits, the electrical installations comprising Class 1 circuits can present a shock and fire hazard. The Code requirements for enclosures, equipment spacing, conductor ampacity, colour coding, bonding, grounding, and overcurrent protection apply equally to Class 1 circuits and power circuits. A number of exceptions are given in Rules 16-104 to 16-118.

## Rule 16-104 Overcurrent protection of Class 1 circuits

Section 14 provides Rules for determining the overcurrent protection required for branch circuits. Other Sections of the Code provide additional overcurrent protection requirements for specific types of electrical equipment. Section 26, for example, addresses overcurrent protection for transformers and capacitors, Section 28 covers specific requirements for motors, and Section 62 covers requirements for electric heaters.

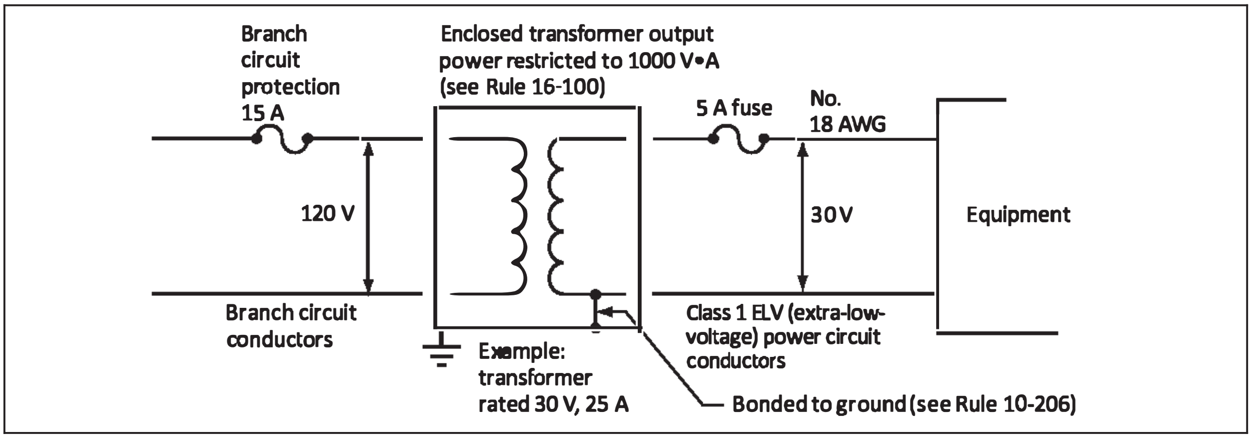
Subrule 1) requires that Class 1 circuits be treated in the same way as other electrical circuits with respect to Section 14 requirements but provides an exemption to this requirement in Item a) by recognizing that other Rules of the Code might have to be considered. Item b) also provides an exemption that specifies the respective ratings of 5 A and 10 A for No. 18 and No. 16 AWG copper conductors that extend beyond the equipment enclosure. These ratings have been found to provide adequate levels of safety in Class 1 circuit applications, even though the equipment wire ratings in Table 12 can require the use of a more conservative, lower ampacity rating. Rule 16-104 pertains to wiring extending beyond the equipment enclosure; the requirements for the wiring within the enclosure are covered in the *Canadian Electrical Code, Part II*, equipment certification Standards.

Section 26 sets out extensive requirements concerning the overcurrent protection on the primary side of a transformer, based on its rated primary current. These requirements need not apply to the primary circuit of transformers in Class 1 circuits, as the loads supplied by the transformer are normally fixed and known, and the required secondary protection provides adequate overload protection for both the primary and the secondary transformer circuits. Thus, Subrule 2) allows the overcurrent protection on the primary side of Class 1 transformers to be in the branch circuit supplying the transformer, provided that

- the Class 1 transformer is installed in a suitable enclosure (in order to prevent cross-connections with higher voltages);
- secondary overcurrent protection is installed at the secondary terminals of the Class 1 transformer; and
- adequate short-circuit protection for the Class 1 transformer is provided by the overcurrent device selected for the branch circuit supplying the transformer.

See Figure 16-1.

**Figure 16-1**
**Typical Class 1 extra-low-voltage power circuit overcurrent protection**




## Rule 16-106 Location of overcurrent devices in Class 1 circuits

A fundamental electrical safety requirement is that overcurrent protection is to be located wherever there is a reduction in conductor size; however, Rule 14-100 relaxes this general principle under certain conditions. Rule 16-106 clarifies that these Section 14 exceptions do not apply to Class 1 circuits. The overcurrent device is to be located at the point where the conductor to be protected receives its supply, and the overcurrent device is allowed to be an integral part of the Class 1 circuit's power supply.

## Rule 16-108 Class 1 extra-low-voltage power circuit sources including transformers

When installing extra-low-voltage power circuits, suitable sources are to be used to control the risk of fire. The requirements in Rule 16-108 are based on the design of extra-low-voltage transformers, including the normal internal impedances of Class 1 transformers.

A Class 1 extra-low-voltage power circuit can have more than one power supply, including transformers, batteries, and solar photovoltaic cells, which might be required when an alternative energy source or emergency standby power is used. In order to comply with the maximum power output requirements for a Class 1 circuit, Rule 16-108 requires that

- the total power output from all sources connected in the circuit not exceed 2500 V•A; and
- the open-circuit voltage multiplied by the short-circuit current of the multiple source Class 1 circuit not exceed 10 000 V•A.

## Rule 16-110 Conductor material and sizes

The Code specifies that the minimum size of copper conductor allowed is No. 14 AWG (see Rule 4-002). Since many Class 1 circuits do not require the current-handling capability of a No. 14 AWG conductor, Subrule 2) allows copper conductors with a minimum size of

- No. 16 AWG, where individual conductors are pulled into a raceway;
- No. 18 AWG, where individual conductors are laid in a raceway; and
- No. 18 AWG, for two or more conductors in an integral assembly.

**Field consideration:** Not all No. 16 and No. 18 AWG copper conductors are as strong as those for which the general Rules on wiring methods in Section 12 have been developed. Special care is to be taken during electrical installation to avoid damage to smaller-sized conductors.

## Rule 16-112 Insulated conductors for Class 1 wiring

Rule 12-102 3) identifies the various types of insulated conductors and cables, No. 14 AWG and larger, that are suitable for field installation, as well as the applications or environments in which they are suitable for use. Any insulated conductor or cable specified in Rule 12-102 3) is suitable for Class 1 circuit wiring.

Subrule 2) of Rule 16-110 allows the use of No. 18 and No. 16 AWG conductors that have not been tested for resistance to abrasion. To ensure that only approved No. 18 and No. 16 AWG conductors are used for Class 1 circuit wiring, Rule 16-112 allows the use of equipment wire (wire suitable for the internal wiring of electrical equipment – i.e., REW, SEW, SEWF, TEW, and TEWN) in accordance with Note 1 to Table 11.

**Rule 16-114 Conductors of different circuits in the same enclosure, cable, or raceway**
The general principles of the Code do not allow conductors from different sources of supply to be in the same enclosure, unless special precautions are taken (see Rules 12-904, 12-3030, and 14-414). The concern is that a person working in an enclosure supplied by more than one source might disconnect one source and mistakenly believe all parts are de-energized. Additionally, a higher-voltage source can damage the insulation on a lower-voltage source, thus creating a shock hazard or causing damage to the lower-voltage source devices or equipment.

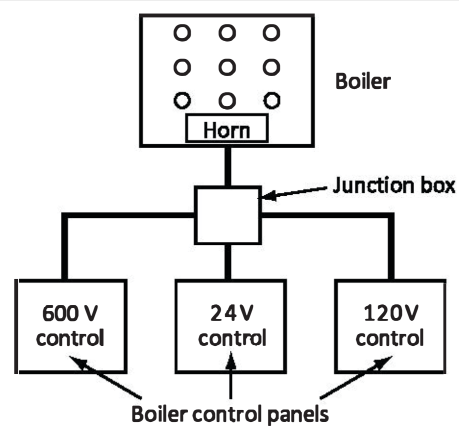
Class 1 circuits tend not to pose this kind of risk for the following reasons:
- they are used in specialized applications; and
- different circuits can be expected to serve related functions when they are grouped and are frequently de-energized as a group.

Therefore, while the Code discourages supplying a single enclosure or supplying conductors in the same raceway or cable from more than one source, Rule 16-114 allows such a practice for Class 1 circuits under certain conditions.

Class 1 circuits having different voltage characteristics are allowed to be in the same enclosure, raceway, or cable, provided that they are all insulated for the highest voltage on any conductor in the enclosure, raceway, or cable.

See Figure 16-2.

**Figure 16-2**
**Example of control circuits installed in accordance with Section 16**




**Note:** *Rule 16-114 allows the 24 V control circuit wiring to enter the junction box and share the same raceway as the 600 V and 120 V control circuits, provided that conductors insulated to 600 V are used. The 24 V circuit should be installed in accordance with the requirements for Class 1 circuits over its entire length. This might be more economical than installing the 24 V circuit as a Class 2 circuit. Where the 24 V circuit is designated as a Class 2 circuit, Rule 16-212 requires separation of the conductors from the other control circuit conductors by an acceptable barrier.*

### Rule 16-116 Mechanical protection of remote control circuits

As stated in Rule 16-010, circuits critical to life and safety are to be considered Class 1 circuits. Rule 16-102 allows Class 1 remote control circuit conductors to be installed using any appropriate wiring method contained in the Code. However, with life and safety circuits, special care is to be taken to guard against damage that might prevent a circuit from performing its function in an emergency. Rule 16-116 requires that Class 1 circuit conductors performing life or safety functions be placed in conduit or electrical metallic tubing or be provided with equivalent mechanical protection against damage and conditions such as moisture, excessive heat, and corrosion.

### Rule 16-118 Class 1 circuits extending aerially beyond a building

Although Class 1 circuits are not often used outdoors, in some installations they are to be run on the exterior of buildings and between buildings on the same site. The wiring methods for Class 1 circuits inside a building are similar to those for power circuits. Outdoor and exposed Class 1 circuits are to comply with Rules 12-300 to 12-318.

## Class 2 circuits

### Rule 16-200 Limitations of Class 2 circuits

The intent of Rule 16-200 is to limit the power available in Class 2 circuits by basing the maximum current output of a Class 2 power source on the open-circuit voltage (OCV). The rationale is that while it is recognized that transformers have a greater power output than other sources, in every case the current output of the different types of Class 2 power sources is governed by the open-circuit voltage.

Sources that can be approved as having a Class 2 output include dish antenna rotators with posistors (positive-temperature-coefficient resistors).

For circuits having open-circuit voltages up to 20 V, Item a) of Subrule 1) requires that overcurrent protection not be higher than 5 A. However, Item a) allows such overcurrent protection to be omitted when the current is supplied by:

- primary batteries consisting of one or more cells electrically connected under the same cover, with each cell producing an electrical current by an electrochemical reaction, that under short-circuit conditions will not supply a current exceeding 7.5 A after 1 min;
- transformers or other power supply devices having a Class 2 output; or
- devices that have characteristics under normal operating conditions or under fault conditions that limit the output current to 5 A and the power output to a value not exceeding 5 A × open-circuit voltage in V•A.

Item b) of Subrule 1) requires that circuits having an open-circuit voltage over 20 V but not exceeding 30 V have maximum overcurrent protection calculated by dividing 100 V•A by the open-circuit voltage. However, Item b) allows such overcurrent protection to be omitted when the current is supplied by:

- primary batteries consisting of one or more cells electrically connected under the same cover, with each cell producing an electrical current by an electrochemical reaction, that under short-circuit conditions will not supply a current exceeding 5 A after 1 min;
- transformers or other power supply devices having a Class 2 output; or
- devices that have characteristics under normal operating conditions or under fault conditions that limit the output current to a value not exceeding 100 V•A divided by open-circuit voltage.

Item c) of Subrule 1) requires that circuits having an open-circuit voltage over 30 V but not exceeding 60 V have maximum overcurrent protection calculated by dividing 100 V•A by the open-circuit voltage. However, Item c) allows such overcurrent protection to be omitted when the current is supplied by:

- transformers or other power supply devices having a Class 2 output; or
- devices that have characteristics under normal operating conditions or under fault conditions that limit the output current to a value not exceeding 100 V•A divided by open-circuit voltage.

Item d) of Subrule 1) requires that circuits having an open-circuit voltage over 60 V but not exceeding 150 V have maximum overcurrent protection calculated by dividing 100 V•A by the open-circuit voltage. Also, the Class 2 circuit is to be equipped with current-limiting means that under normal operating conditions and under fault conditions limits the output current to a value not exceeding 100 V•A divided by open-circuit voltage. Although it is potentially lethal to touch 150 V, the rationale of Item d) in allowing voltages up to 150 V is that the risk of shock exposure is limited since the use of Class 2 circuits is confined to highly specialized applications where limited power is needed.

Subrule 3) requires that a Class 2 power supply not be connected either in series or in parallel with another Class 2 power supply, since in order to limit the voltage, current, and power exposure, the power level in a Class 2 circuit is not to exceed that available from a single Class 2 power supply.

Subrule 4) allows a device having a Class 2 output to be used as a device having energy-limiting characteristics, provided that it is marked as being suitable for the purpose.

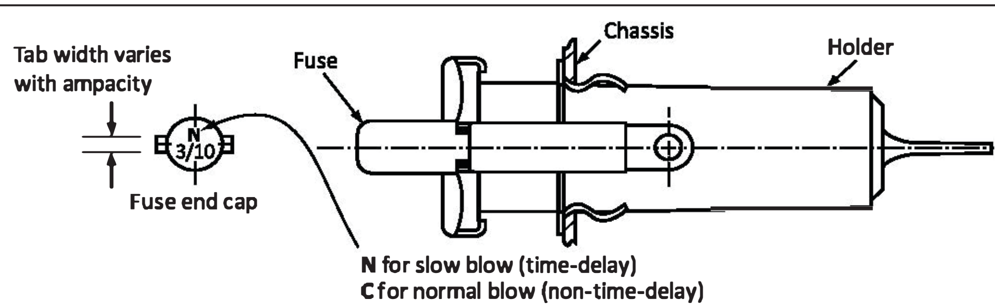
**Rule 16-202 Methods of installation on the supply side of overcurrent protection, transformers, or devices having Class 2 outputs**
The conductors and equipment on the supply side of overcurrent protection transformers or other devices having Class 2 outputs are to be installed in accordance with the wiring Rules for power circuits that are set out in other Sections of the Code.

**Rule 16-204 Marking**
Since the wiring Rules for Class 2 circuits differ from those for power wiring, the people designing, installing, inspecting, or repairing Class 2 circuits are to be able to readily confirm, through the complete life of the installation, the fact that a Class 2 supply is being used for the circuit, the electrical rating of the circuit, and the circuit's suitability to be used in a wet location when so located.

**Rule 16-206 Overcurrent protection for Class 2 circuits**
To ensure that an incorrectly rated overcurrent device is not inadvertently placed in a Class 2 circuit, Subrule 1) requires that overcurrent devices of different ratings be designed so that they are not interchangeable (see Figure 16-3).

Subrule 2) allows the overcurrent protection to be an integral part of a transformer or Class 2 supply device.

**Figure 16-3**
**Non-interchangeable-type fuse**




**Note:** *The fuses incorporate a combination of different fuse lengths and different width locking tabs on the fuse cap.*

**Rule 16-208 Location of overcurrent devices**
Rule 16-208 requires that an overcurrent device be located at the point where the conductor receives its supply. In Rule 14-100, certain exceptions to this general requirement are made for power circuits, based on various compensating safeguards. Section 16 does not provide a comparably detailed account of wiring methods for Class 2 circuits and does not make provision for compensating safeguards. The

overcurrent device for a Class 2 circuit is, in all cases, to be located where the Class 2 circuit conductor receives its supply.

**Rule 16-210 Conductors for Class 2 circuit wiring**
Conductors for Class 2 circuits, which operate at comparatively low power levels, need not be sized as large (in AWG) as the conductors for power circuits. Although conductors used in power circuits are allowed to be used in Class 2 circuits, Subrule 3) of Rule 12-102 also identifies some special conductors (e.g., LVT and ELC) that are specifically intended only for use in Class 2 circuits operating at 30 V or less. When conductors smaller than No. 14 AWG are installed in a raceway, equipment wire Types REW, SEW-1, SEWF-1, TEW, and TEWN are allowed to be used.

ELC conductors, being less robust than the other conductors specified in Subrule 3) of Rule 12-102, require special care during electrical installation and are suitable only for use in limited applications. Subrule 2) of Rule 16-210 sets limits on the use of ELC conductors in Class 2 circuits.

See Figure 16-4.

**Figure 16-4**
**Typical Class 2 cable**


Subrules 4), 5), and 6) outline the requirements for determining the minimum size of conductor that is allowed to be used in a Class 2 circuit.

Subrule 7) allows eight-conductor cables used for power and data communication circuits to be sized using Table 60.

**Rule 16-212 Separation of Class 2 circuit conductors from other circuits**
In Class 2 circuits, safety from fire and shock hazards is obtained from the power supply and the overcurrent protection provided at the power supply. The wiring methods for Class 2 circuits do not have to be as rigorous as those required for lighting, power, and Class 1 circuits; as a result, accidental contact with lighting, power, or Class 1 circuits can introduce a fire or shock hazard into a Class 2 circuit. The intent of Rule 16-212 is to prevent:

- a person working on a Class 2 circuit from inadvertently contacting a nearby energized power circuit; and
- the unintended transfer of a higher voltage to a Class 2 circuit that is not insulated to withstand such a voltage.

It is not always possible to provide a physical separation between Class 2 circuit conductors and lighting, power, or Class 1 circuit conductors (e.g., when they are installed together in outlet boxes, junction boxes, compartments, raceways, or similar fittings). Subrule 3) requires that, in such cases, an acceptable barrier be used to separate the conductors (see Figure 16-5). Specific requirements for such a barrier can vary, as determined by the local authority having jurisdiction.

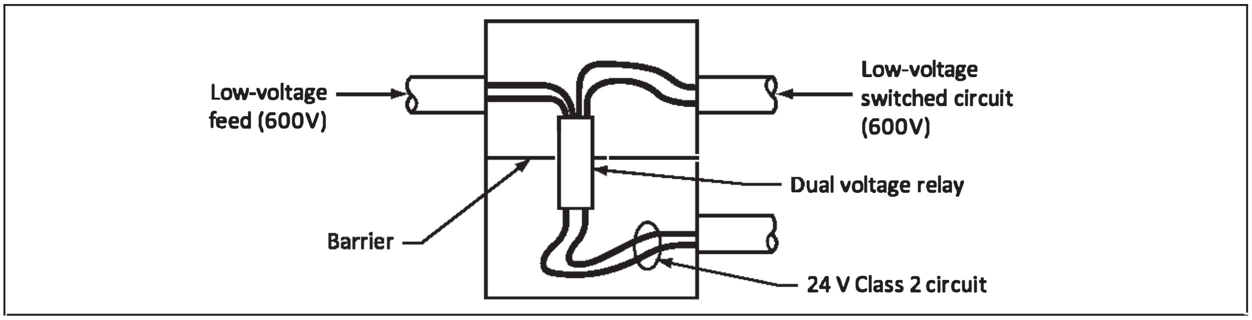
Subrule 4) allows an exemption from the separation requirements for Class 2 circuit conductors:

- when conductors of a power circuit are in the raceway or box together with Class 2 circuit conductors for the sole purpose of supplying power to Class 2 circuit conductors;
- when all conductors in that raceway (i.e., power and Class 2 circuit conductors) are insulated for the maximum voltage of any conductor in that raceway, box, or enclosure; and

- when insulated power conductors are present, no Class 2 green insulated conductors are to be present outside of a separate sheathed or jacketed cable assembly.

Subrule 5) allows an exemption from the separation requirements in Subrule 3) when electric lighting, power, and Class 1 circuit conductors are in a cable marked suitable for the application, when the Class 2 circuit conductors are intended for the supply or control, or both, of remote devices associated with the non-Class 2 conductors, and when the Class 2 conductors are insulated for the maximum voltage of any conductor in the cable.

**Figure 16-5**
**Typical barrier for Class 2 wiring**




### Rule 16-216 Penetration of a fire separation

Where Class 2 circuit conductors pass through fire separations, vertical shafts or hoistways, or ducts and plenum chambers, they are to be installed so as to have minimal effect on the building's resistance to the spread of fire and smoke. Thus, suitable fire stop systems are to be used to ensure that the fire resistance rating of the penetrated assembly is not compromised. The Code references the *National Building Code of Canada* for the construction and material requirements that apply in the case of fire separations (see Rule 2-128).

### Rule 16-222 Equipment located on the load side of overcurrent protection, transformers, or devices having Class 2 outputs

Electrical equipment operating at extra-low voltages is less likely to cause electric shock or fire hazards when there is a limited amount of power available. Class 2 circuits operating at 30 V rms (42.4 V peak) or less generally receive less attention during inspection than higher-power circuits, creating the impression that Class 2 circuits have no potential for danger and require little attention. However, Class 2 circuits and electrical equipment, even when the available power is significantly limited, can be the cause of fires where installed improperly. Item 1) a) does not mandate that electrical equipment operating at not more than 42.4 V peak and connected to the load side of the Class 2 power supply be certified (i.e., this equipment only has to be acceptable to the AHJ for the specific application).

Items 1) b) and 3) a) should be applied together, requiring electrical equipment to be certified when:
- installed in a dry or damp location;
- connected to the load side of the Class 2 power supply; and
- operating at more than
  - 42.4 V peak
  - 30 V rms sinusoidal ac;
  - 60 V continuous dc; or
  - 24.8 V peak for interrupted dc.

Item 3) b) places additional restrictions on Items 1) b) and 3) a), requiring electrical equipment to also be certified when:
- installed in a wet location;

- connected to a Class 2 circuit; and
- operating at more than:
  - 21.2 V peak;
  - 15 V rms sinusoidal ac;
  - 30 V continuous dc; or
  - 12.4 V peak for interrupted dc.

However, Subrule 2) requires that, when connected to Class 2 circuits, all lighting products, including luminaires, signs, rope lights, decorative strings and outfits, illuminated novelty items, lighting devices that incorporate light-emitting diodes (LEDs), electromedical equipment, equipment for use in hazardous locations, and thermostats incorporating heat anticipators, be certified, due to the increased risk of fire, shock, or explosion.

### Rule 16-226 Underground installations

Where Class 2 circuits are installed underground, they are to be guarded against mechanical damage during and after installation (particularly during dig-ins) and from frost-heaving damage where they enter a building, similar to a typical power circuit installation. Therefore Subrule 1) requires that the requirements of Rule 12-012 be followed. Subrules 2) and 3) give additional requirements for direct buried Class 2 circuits.

## Class 2 power and data communication circuits

### Rule 16-300 Scope

Rules 16-300 to 16-350 apply to Class 2 power and data communication circuits used in applications such as an extra-low-voltage lighting system, closed circuit television system (CCTV), wireless access point (WAP), distributed antenna system (DAS), and building automation system (BAS).

### Rule 16-310 Special terminology

A Class 2 power and data communication circuit is considered a circuit that uses a twisted pair of insulated conductors or pair of twisted pair conductors within a common cable assembly marked as being suitable for the application to transmit power from power sourcing equipment to a powered device. In the case of these circuits, more than one circuit in one cable assembly is allowed to supply one powered device.

### Rule 16-320 Equipment output limitations

A Class 2 power and data communication circuit is to be supplied from power sourcing equipment with an output limited to 100 V·A and to 60 V dc. See Rule 16-222 for operating voltage restrictions.

### Rule 16-330 Cables and conductor ampacity

Subrule 1) sets out fundamental safety criteria for the selection of conductors based on exposure to moisture, corrosive actions, temperature, degree of enclosure, and mechanical damage. This Subrule requires that the requirements in Subrule 3) of Rule 12-102 be applied in conjunction with specific conditions of use for the various types of insulated conductors and cables of a Class 2 power and data communication circuit.

Subrule 2) requires that when communication cables marked with the suffix "-LP" are used, the maximum current rating for each insulated conductor be:

- limited to the current rating marked on the cable; and
- in the case of conductors smaller than No. 26 AWG or conductors in cable bundles of more than 192 cables, permitted to be determined by a qualified person, as recognized by the regulatory authority having jurisdiction, provided that a deviation has been allowed in accordance with Rule 2-030.

Subrule 3) requires that when communication cables not marked with the suffix "-LP" are used, the maximum current rating for each insulated conductor as determined in Table 60 be based on:

- the size of the conductor;
- the cable temperature rating;

- the number of cables in a cable bundle in contact with each other; and
- the smallest conductor size and lowest temperature rating of any cable in the cable bundle.

In addition, no more than 192 cables are allowed to be bundled together, and when no more than four conductors in each cable are used to transmit power, the maximum current that each conductor is allowed to carry is to be obtained from the values listed in Table 60 multiplied by 1.4.

When connectors or components are used in the Class 2 power and data communication circuit, Subrule 4) requires that the maximum current of the insulated conductors not be more than the rating of the connectors or components to prevent overheating of the termination at the connector or component.

To prevent insulation breakdown on the insulated conductors in Class 2 power and data communication circuit cables due to ambient temperatures above 30 °C, Subrule 5) requires that the correction factors of Table 5A be applied.

Subrule 6) requires that the length of the cables used in Class 2 power and data communication circuits not cause the voltage at the point of utilization to be outside the rating or voltage tolerance of the connected powered device(s).

To avoid a buildup of heat when more than one cable bundle is installed in a ventilated and ladder-type cable tray, Subrule 7) requires that cable bundles be spaced at least 25 mm apart.

When the minimum conductor size of No. 24 AWG is used in a communication cable to supply power to communication equipment rated at 60 W or less, Subrule 8) waives the bundling requirements of Subrules 2) and 3).

To determine the maximum ampacity of an insulated conductor, Subrule 9) requires that the maximum conductor termination temperature for equipment that is not marked be considered to be 60 °C.

### Rule 16-340 Wiring method

To prevent noise and interference from being introduced into the Class 2 power and data communication circuits from other conductors in the cable assembly, Subrule 1) requires that conductors for Class 2 power and data communication circuits be used only in a common cable assembly that is marked as being suitable for the application.

Additional wiring method requirements for Class 2 power and data communication circuits are provided in the following Subrules:

- Subrule 2), which specifies that when these circuits extend beyond a building, they are to comply with the requirements in Rule 16-224;
- Subrule 3), which specifies that when conductors for these circuits are used in underground installations, the installations are to comply with Rule 12-012; and
- Subrule 4), which specifies that conductors for these circuits are not to be connected in series or parallel with other Class 2 power and data communication circuits.

### Rule 16-350 Marking

To allow for maintenance, troubleshooting, testing, and servicing, the markings to indicate the class of supply and the electrical rating of power sourcing equipment are to be permanent and readily visible for inspection after installation.

# Section 18 — Hazardous locations

Section 18 is a supplementary Section of the Code that gives additional and specific requirements for the installation of electrical equipment in hazardous locations.

Requirements for Class I, Class II, and Class III locations have been relocated to Appendix J, and requirements for explosive dust atmospheres based on IEC Zones 20, 21, and 22 are located in Section 18. The requirements are now located as follows:

- Zones 0, 1, 2, 20, 21, and 22 in Section 18; and
- Classes I, II, III, and associated Divisions in Appendix J.

Table 18, "Equipment suitable for explosive atmospheres", specifies the type of protection that is to be provided to equipment according to the different area classifications in both the Zone and Division Hazardous Area Classifications. The Table shows which types of protection for the Zone system can be used in the Division system and vice versa.

A reference to "Class I", "Class II", or "Class III" alone is intended as a general reference to the Division system for area classification. When reference is made to the Zone system for area classification, the term "Class" has no meaning.

Appendix L ("Engineering guidelines for determining hazardous area classifications") is an informative (non-mandatory) Appendix that provides guidelines to determine classifications of a hazardous area.

The intent of Appendix L is to promote awareness of the various industry codes, standards, and recommended practices that are available and can be used when performing area classification studies. These references provide extensive information on the many types of facility situations that are commonly encountered in Canadian industries where explosive atmospheres are present; however, knowledge and experience of the application of these codes, standards, and recommended practices are also needed in order to properly apply them in a given situation. Appendix L is intended to identify the most common considerations that need to be addressed when performing an area classification. It is not intended as a mandatory reference for developing area classifications.

## Scope and introduction

### Rule 18-000 Scope

The Rules of Section 18 apply in situations where there is potential for electrical equipment to ignite gases, vapours, dusts, fibres, or flyings. Section 18 provides the Rules used to classify a hazardous location based on the characteristics of the fluids being handled [for example, chemical and physical properties such as flash point, molar composition, liquid density, vapour specific gravity, lower flammable limit (LFL), upper flammable limit (UFL), mole weight, operating pressures, temperatures, flow rates, volumes, the frequency of occurrence, and the duration of hazard in the location]. These Rules can modify or supplement the general Rules of the Code.

When an area has been classified, Section 18 provides the specific Rules for the electrical installation to be used in the location. The various *Canadian Electrical Code, Part II*, Standards contain the specific requirements for certifying equipment for various locations. Many reference publications are available to assist users in the proper design, selection of equipment, installation, and operations and maintenance for electrical installations in hazardous locations (see the Appendix B Note to Rule 18-000).

It is a common misconception that only Zone equipment can be used in areas classified to the Zone system and that only Division equipment can be used in areas classified to the Division system. In fact both types of equipment can be used under either system of area classification as outlined in Table 18.

Zone-based standards require equipment to be marked with the types of protection used in its construction and the equipment protection level (EPL) that indicates the Zones where that type of equipment is allowed to be used. Equipment protection levels (EPLs) marked on equipment simplify the determination of the hazardous area classification of electrical equipment.

Equipment protection levels (EPLs) are as follows:

- **Ga** — equipment that is for use in an explosive gas atmosphere, that has a "very high" level of protection, and that is:
  - not a source of ignition in normal operation or in expected or rare malfunctions;
  - equipped with two independent means of protection;
  - safe even when two malfunctions occur independently of each other; and
  - suitable for Zones 0, 1, and 2.
- **Gb** — equipment that is for use in an explosive gas atmosphere, that has a "high" level of protection, and that is:
  - not a source of ignition in normal operation or expected malfunctions; and
  - suitable only for Zones 1 and 2.
- **Gc** — equipment that is for use in an explosive gas atmosphere, that has an "enhanced" level of protection, and that is:
  - not a source of ignition in normal operation or expected normal occurrences; and
  - suitable only for Zone 2.
- **Da** — equipment that is for use in explosive dust atmospheres, that has a "very high" level of protection, and that is:
  - not a source of ignition in normal operation, during expected malfunctions, or during rare malfunctions; and
  - suitable for Zones 20, 21, and 22.
- **Db** — equipment that is for use in explosive dust atmospheres, that has a "high" level of protection, and that is:
  - not a source of ignition in normal operation or during expected malfunctions; and
  - suitable only for Zones 21 and 22.
- **Dc** — equipment that is for use in explosive dust atmospheres, that has an "enhanced" level of protection, and that is:
  - not a source of ignition in normal operation and might include some additional protection to ensure that it remains inactive as an ignition source in the case of regular, expected occurrences (for example, failure of a lamp); and
  - suitable only for Zone 22.

Section 18 allows existing facilities employing the Division system of classification for Class I, Class II, and Class III hazardous locations to make additions, modifications, and renovations to those facilities, and to continue to operate and maintain them using the Division system. These types of facilities are required to follow the Rules in Annex J18 of Appendix J.

The Zone and Division systems of area classification provide equivalent levels of safety. The Code has been written to give preference to the Zone system of area classification, but it does not give preference to the Zone type of equipment. See Table 18 for the locations where Zone equipment is allowed to be used in Division systems and Division equipment is allowed to be used in Zone systems.

### Rule 18-002 Special terminology

The following terms are not used in Section 18 of the Code; however, they are used in the explanations provided in this Handbook:

- **Flash point** — the minimum temperature of a liquid at which sufficient vapour is given off to form an ignitable mixture with air, near the surface of the liquid or within a vessel. For example, gasoline has a flash point of –40 °C; therefore, air and gasoline can form an explosive mixture at any normal ambient temperature above –40 °C. However, diesel fuel has a flash point of 40 °C or higher and cannot form an explosive vapour unless it is heated to a temperature higher than the normal ambient temperature.

- **Fugitive emissions** — the continuous flammable gas and vapour releases from components such as pump seals, valve packing, and flange gaskets that occur during the normal operation of closed systems. These emissions are small in comparison to those that can occur as a result of equipment failures.

### Rule 18-004 Classification of hazardous locations

When it comes to the classification of hazardous locations, it is important that the work be done by qualified individuals and that the classification be documented and authenticated by the person assuming responsibility for the hazardous location classification. The Appendix B Note to Rule 18-004 3) recommends that the person taking responsibility be an engineering professional or other individual permitted to practice engineering. See the definition of *Qualified person* in Section 0.

Installations covered by the hazardous area classifications in the Scope of Section 20 are allowed by Subrule 4) to be classified in accordance with Section 20.

### Rule 18-006 Locations containing an explosive gas atmosphere

Rule 18-006 divides locations containing explosive gas atmospheres into Zones 0, 1, and 2 based on the frequency of occurrence and the duration that an explosive gas atmosphere can exist. An explosive gas atmosphere occurs when the concentration of a gas or vapour is at or above the lower flammable limit (LFL) but at or below the upper flammable limit (UFL). The presence of gases or vapours below the LFL is not evidence of a hazard if the gases and vapours do not reach concentrations at or above the LFL (for example, the area around the exterior of a spray-paint booth is sometimes a location in which there are gases and vapours below the LFL). The requirements for the three Zones are based on exposure time. The longer the exposure time, the more stringent the wiring requirements for those areas.

Section 18 specifies the explosive gas area classifications as Zone 0, Zone 1, and Zone 2. The design requirements for equipment in the *Canadian Electrical Code, Part II,* Standards are based on these area classifications. Since the areas are classified according to the frequency and duration of episodes in which there is an explosive gas atmosphere present, the area classification is allowed to be downgraded as the result of ventilation. During normal operation, most facilities continuously emit relatively small quantities of explosive gas or vapour (fugitive emissions) from valve packing, pump seals, etc. In outdoor areas above grade, these emissions are continuously diluted into the air and do not reach explosive concentrations. In enclosed spaces, if sufficient ventilation is not provided, the concentration of explosive gas or vapour resulting from fugitive emissions could gradually increase to reach explosive concentrations. If the ventilation rate is sufficient to continuously dilute the fugitive emissions to less than 25% of their lower flammable limit (LFL), adequate ventilation is deemed to be provided. In actual practice, most enclosed process buildings operate with explosive gas concentrations in the air in the range of 1% LFL.

Zone 0, Zone 1, and Zone 2, which are defined in Rule 18-002, are differentiated as follows:

- **Zone 0** areas are those areas in which explosive gas atmospheres are present continuously or are present for long periods. A Zone 0 area classification will normally result from a "continuous grade of release", which is defined by IEC documents as "a release which is continuous or is expected to occur frequently or for long periods".

  **Note:** *While there is no firm Rule relating to the length of time that explosive gas atmospheres persist within Zone 0 locations, the rule of thumb is that if the concentration of explosive gas is at or above the LFL for more than 1000 h per year, the area is Zone 0. For example, the area above flammable liquid in a vented tank is an example of a typical Zone 0 area.*

- **Zone 1** areas are those areas in which explosive gas atmospheres are likely to occur in normal operation or those areas adjacent to a Zone 0 location from which explosive gas atmospheres could be communicated. A Zone 1 area classification normally results from a "primary grade of release", which is defined by IEC documents as "a release which can be expected to occur periodically or occasionally during normal operation".

**Note:** *The rule of thumb for Zone 1 areas is that the concentration of explosive gas present is at or above the LFL for less than 1000 h but more than 10 h per year. For example, the area inside an inadequately ventilated building where natural gas is processed under significant pressure is an example of a typical Zone 1 area.*

- **Zone 2** areas are those areas in which explosive gas atmospheres are not likely to occur in normal operation and, if they do occur, they will exist for a short time only, or those areas adjacent to a Zone 1 location from which explosive gas atmospheres could be communicated. A Zone 2 area classification will normally result from a "secondary grade of release", which is defined by IEC documents as "a release which is not expected to occur during normal operation and, if it does occur, is likely to do so only infrequently and for short periods".

  **Note:** *The rule of thumb for Zone 2 areas is that the concentration of explosive gas present is at or above the LFL for less than 10 h per year. For example, the area inside an adequately ventilated building where natural gas is processed under significant pressure is an example of a typical Zone 2 area, provided that systems are in place to ensure that, if an abnormal operating event resulting in an explosive gas atmosphere occurs, the explosive gas atmosphere exists for a short time only.*
  *Basically, a Zone 2 location is a location where the release of explosive gas in explosive concentrations occurs only in abnormal conditions and the electrical equipment is only a source of ignition when the equipment is operating in an abnormal condition (producing arcs, sparks, or high temperatures under fault conditions, not normal operating conditions).*

There are a number of area classification documents available that include diagrams outlining the extent and shape of the classified area around typical facilities. When applying these typical diagrams, the designer must make certain that they properly represent the particular situation. There are also dispersion modelling programs available that predict the boundaries of the hazardous area resulting from the release of flammable fluids.

### Rule 18-008 Locations containing an explosive dust atmosphere

Rule 18-008 divides locations containing explosive dust atmospheres into Zone 20, 21, and 22 based on the frequency of occurrence and duration that an explosive dust atmosphere can exist.

The accumulation of explosive dust on electrical equipment can cause overheating because the dust layer acts as insulation. In addition, sparks or fire from the equipment can ignite the explosive dust layer or explosive dust suspended in the air. Explosive dust locations are subdivided into three zones, depending on the type and amount of dust. There are less stringent requirements for storage areas than for areas where dust-producing materials are handled or processed. Some metallic dusts, such as magnesium and aluminum, are conductive as well as explosive and require increased precautions.

Explosive dusts are divided into three Zones:

- **Zone 20** is a location in which an explosive dust atmosphere, in the form of a cloud of dust in the air, is present continuously, frequently, or for long periods of time.
- **Zone 21** is a location in which an explosive dust atmosphere, in the form of a cloud of dust in the air, is likely to occur occasionally in normal operation; and
- **Zone 22** is a location in which an explosive dust atmosphere, in the form of a cloud of dust in the air, is not likely to occur in normal operation; however, if it does occur, it will be present for a short period only.

Different types of protection apply for Zones 0, 1, and 2 and for Zones 20, 21, and 22. For example, Zones 1 and 2 use explosion-proof or flameproof "d" enclosures (for the containment of an explosion) or explosion-protected enclosures (for the prevention of an explosion); Zones 20, 21, and 22 usually require dust-tight enclosures that are constructed to minimize the entry of dusts.

Layers of dust will not explode; however, where layers of accumulated dust are present, a mechanical shock could cause sufficient dust to be thrown into the air to form an explosive mixture. If the mixture is ignited, it will cause more dust to be thrown into the air resulting in a series of explosions. Layers of dust ignited from hot surfaces can also result in explosive concentrations of dust being thrown into the air, resulting in an explosion or a series of explosions.

The minimum explosive concentration in air for a given type of dust varies depending on the particle size of the dust; however, it will be well above what is normally acceptable for industrial hygiene. For example, in *Dust Explosions in the Process Industries*, Rolf K. Eckhoff suggests the following rule of thumb: "if a glowing 25 watt light bulb is observed through 2 meters of dust cloud, the bulb cannot be seen at dust concentrations exceeding 40 g/m$^3$". For coal dust, he gives the minimum explosive concentration as 60 g/m$^3$. Therefore, while the concentration of dust in the air in most workspaces will be well below the minimum explosive concentration, disturbance of dust layers in the area can result in the attainment of the minimum explosive concentration in the immediate area of the disturbance. Housekeeping can therefore have an impact on the area classification in areas where dust is produced.

Explosive concentrations of dust resulting from normal operation exist mainly within process equipment such as mills, mixers, screens, etc. Unlike most explosive gas process equipment, which contains only fuel with no source of oxygen, process equipment containing dust also contains oxygen (air), so two of the three components required for an explosion (fuel and oxygen) are present. It is critical therefore that all possible sources of ignition be avoided.

Due to the complexity of the processes that create dust, the classification of these hazardous locations is to be determined by qualified individuals. The classification needs to be authenticated by the person assuming responsibility for the hazardous location classification. The Appendix B Note to Rule 18-004 3) recommends that the person taking responsibility be an engineering professional or other individual permitted to practice engineering. See the definition of *Qualified person* in Section 0.

### Rule 18-010 Maintenance

Electrical installations in hazardous areas possess special features specifically designed for operation in such atmospheres. To maintain safety in these areas, it is essential that throughout the life of such installations, the integrity of those special features be preserved. Unauthorized alterations or repairs are not to be made while the equipment is energized, to avoid any potential ignition of the hazardous material in the area. In addition, installations and equipment are to be maintained in their original, approved, safe condition so that they do not become possible ignition sources or cause migration of gases to a location of a lower classification.

Where it is necessary to do work on electrical equipment that may expose portions of the equipment that could ignite flammable gas or dust, "hot work" procedures are required. The following example of hot work procedures is taken from the 2009 edition of the *Alberta Occupational Health and Safety Code*.

> **Hot work**
> **169(1)** Despite any other section in this Part, an employer must ensure that hot work is done in accordance with subsections (2) and (3) if
> (a) the work area is a hazardous location, or
> (b) the work area is not normally a hazardous location but an explosive atmosphere may exist for a limited time because
> > (i) a flammable substance is or may be in the atmosphere of the work area,
> > (ii) a flammable substance is or may be stored, handled, processed or used in the location,
> > (iii) the hot work is on or in an installation or item of equipment that contains a flammable substance or its residue, or
> > (iv) the hot work is on a vessel that contains residue that may release a flammable gas or vapour when exposed to heat.

**169(2)** An employer must ensure that hot work is not begun until
(a) a hot work permit is issued that indicates
(i) the nature of the hazard,
(ii) the type and frequency of atmospheric testing required,
(iii) the safe work procedures and precautionary measures to be taken, and
(iv) the protective equipment required,
(b) the hot work location is
(i) cleared of combustible materials, or
(ii) suitably isolated from combustible materials,
(c) procedures are implemented to ensure continuous safe performance of the hot work, and
(d) testing shows that the atmosphere does not contain
(i) a flammable substance, in a mixture with air, in an amount exceeding 20 percent of that substance's lower explosive limit for gas or vapours, or
(ii) the minimum ignitable concentration for dust.

**169(3)** An employer must ensure that the tests referred to in subsection (2)(d) are repeated at regular intervals.

Maintenance of electrical equipment in hazardous locations requires an understanding of how the specific equipment is intended to function. For example, explosion-proof and flameproof enclosures are designed to contain an explosion of any gas or vapour that could enter them. The pressure of the internal explosion will force the hot gases out of the enclosures through the gaps between the covers and the bodies of the enclosures or along threads at conduit or cable entries. These gaps are very small and are referred to as flame paths. The hot gases from internal explosions are cooled as they travel through the flame paths, to the point where they will not ignite flammable gas outside the enclosure. It is extremely important that these flame paths are not damaged. If they are the damaged, their ability to cool the gases from internal explosions is compromised. When opening explosion-proof or flameproof enclosures, care is to be taken not to scratch or otherwise damage flat surfaces or threads. When closing explosion-proof or flameproof enclosures, it is important that all cover bolts are in place and properly tightened and that threaded joints are tight.

The explosion protection principles for explosive dust enclosures (enclosures used in Zones 20, 21, and 22) are different than those for Zone 0, 1, or 2 enclosures. Whereas Zone 0, 1, or 2 enclosures assume gas or vapour can enter them, and resulting internal explosions are to be contained, Zone 20, 21, or 22 enclosures are designed to prevent the entry of dust. Inspection of the enclosures should ensure that gaskets are not damaged and all fasteners are properly tightened.

The Appendix B Note to Rule 18-010 lists four references that can be used, in addition to manufacturer's instructions, for maintenance of electrical equipment in hazardous areas. IEC 60079-17 is the only one of these references that applies specifically to hazardous locations. Manufacturer's instructions (now available on most manufacturers' websites) are always to be followed as they are a part of the certification process for equipment.

## General

### Rule 18-050 Electrical equipment

Each gas (vapour) or dust has unique characteristics that are to be considered when electrical equipment for hazardous locations is being designed and installed. Gas and dusts are placed in groups with similar characteristics to facilitate the design of equipment suitable for the grouping. If gases and dusts were not grouped, it would be necessary to have a unique design for each, which would be impractical. Subrule 1) requires that electrical equipment used in hazardous locations be suitable for the specific gas, mist, or dust that will be present in the area. Explosive gas locations are characterized as Zone 0, Zone 1, or Zone 2 according to the degree of hazard, while the explosive dust locations are characterized as Zone 20, Zone 21, and Zone 22, again according to the degree of hazard.

Subrule 2) requires that equipment with a type of protection that allows it to be used in an explosive gas area classed as Zone 0, Zone 1, or Zone 2 be suitable for one of the following gas atmospheres:
- Group IIC — atmospheres containing acetylene, carbon disulphide, hydrogen, or other gases or vapours of equivalent hazard;
- Group IIB — atmospheres containing acrylonitrile, butadiene, diethyl ether, ethylene, ethylene oxide, hydrogen sulphide, propylene oxide, unsymmetrical dimethyl hydrazine (UDMH), or other gases or vapours of equivalent hazard;
- Group IIA — atmospheres containing acetaldehyde, acetone, cyclopropane, alcohol, ammonia, benzine, benzol, butane, ethylene dichloride, gasoline, hexane, isoprene, lacquer solvent vapours, naphtha, natural gas, propane, propylene, styrene, vinyl acetate, vinyl chloride, xylenes, or other gases or vapours of equivalent hazard; or
- XXXXX, where XXXXX is a chemical formula or chemical name for that specific gas or vapour.

See the 2017 edition of NFPA 497, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapours and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*. See also ISO/IEC 80079-20-1:2017, *Explosive atmospheres — Part 20-1: Material characteristics for gas and vapour classification — Test methods and data.*

Gas group marking requirements for equipment using the Division gas grouping system differ from those for equipment using the Zone gas grouping system. The Zone system has a marking system such that equipment marked for a given group is suitable for less hazardous groups. Equipment marked with Group IIC is allowed by Subrule 3) to be used in areas classified for Group IIB or IIA, and equipment marked with Group IIB is allowed by Subrule 4) to be used in areas classified for Group IIA, while equipment marked with Group IIA can be used only in areas classified for Group IIA. However, equipment using the Division gas grouping system is to be tested and marked with each group for which it is suitable. For example, equipment suitable for Groups B, C, and D is to be marked Group B, C, and D.

Subrule 5) allows equipment marked for a specific gas to be used in areas where only the specific gas is encountered. An example of this is cited in the Appendix B Note to Rule 18-050, which refers to a piece of equipment marked "IIB +H2". This equipment is suitable for applications requiring Group IIB equipment, equipment for hydrogen atmospheres, or Group IIA equipment. Also electrical equipment that is marked Group II is allowed to be installed as if it were Group IIC.

Subrule 6) requires that equipment with a type of protection that allows it to be used in an explosive dust area classed as Zone 20, Zone 21, or Zone 22 be suitable for one of the following dust atmospheres:
- Group IIIC — atmospheres containing solid particle combustible metal dust, including aluminum, magnesium, and their commercial alloys, and other metals of similarly hazardous characteristics;
- Group IIIB — atmospheres containing combustible dust other than combustible metal dust; or
- Group IIIA — atmospheres containing solid particles, including fibres, greater than 500 µm in nominal size that could be suspended in air and could settle out of the atmosphere under their own weight.

See the 2017 edition of NFPA 499, *Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*. See also ISO/IEC 80079-20-2:2016, *Explosive atmospheres — Part 20-2: Material characteristics — Combustible dusts test methods.*

Section 18 and Annex J18 allow the use of equipment using the Division four gas group system and the Zone three gas group system. The gas grouping directly relates to the equipment installed. Therefore, it is recommended that the classification of a gas for a hazardous location should be given for both systems. For example, in an area where both methane and $H_2S$ could be present in flammable concentrations, the gas grouping should be given as Gas Groups C and D and/or Gas Group IIB.

A rough comparison of the Division and Zone gas grouping systems is shown in Table 18-1.

### Table 18-1
### Comparison of Division and Zone gas groupings

| Division gas grouping | Zone gas grouping |
|---|---|
| A | IIC |
| B | IIC |
| B | IIB+H2 |
| C | IIB |
| D | IIA |

Gases are grouped according to the requirements for designing flameproof enclosures and intrinsically safe systems. In the Zone system, gases are classified into three groups: IIA, IIB, and IIC.

There are two tests that are commonly used to group enclosures:
- the maximum experimental safe gap (MESG) test — this test determines the maximum gap through a specified 25 mm long flame path that will not transmit an explosion of the test gas. It is more difficult to design enclosures for gases with low MESGs. Gases with low MESGs are, therefore, in the most hazardous group, and gases with higher MESGs are in the least hazardous group. For example, acetylene, which has an MESG of 0.37 mm, is a Group IIC gas in the Zone system, and methane, which has an MESG of 1.14 mm, is a Group IIA gas. Gases in the Zone grouping system are grouped as follows:
  - Group IIA: MESG less than 0.9 mm;
  - Group IIB: MESG equal to or greater than 0.9 mm and no greater than 0.55 mm; and
  - Group IIC: MESG greater than 0.55 mm;
- the minimum igniting current (MIC) test — this test determines the minimum current that will ignite the test gas under a specified test condition. MICs are expressed either in milliamperes or as a ratio of their minimum igniting currents to the igniting current of methane. Gases with low MIC ratios are in the most hazardous group and gases with high MIC ratios are in the least hazardous group. For example, the MIC ratio of acetylene is 0.28, while the MIC ratio of methane is 1. Gases in the Zone grouping system are grouped as follows:
  - Group IIA: MIC ratio less than 0.8;
  - Group IIB: MIC ratio equal to or greater than 0.8 and no greater than 0.45; and
  - Group IIC: MIC ratio greater than 0.45.

**Note:** *MESG values and MIC ratios are taken from IEC 60079-20-1.*

Current Canadian classifications of explosive dust atmospheres using the Division system are referred to as Class II, Group E, Group F, and Group G; and Class III. For the closest equivalency of Division and Zone dust groupings, see Table 18-2.

## Table 18-2
## Comparison of Division and Zone dust groupings

| Zone | Division |
|---|---|
| Group IIIA: combustible flyings | Class III |
| Group IIIB: non-conductive dust | Class II, Groups G and F |
| Group IIIC: conductive dust (combustible metal dust) | Class II, Group E |

### Rule 18-052 Marking

There are now two sets of hazardous location equipment standards for gas hazardous locations electrical equipment. First, there are the original CSA Group Standards that mark electrical equipment with the Class and Division in which they are acceptable for use. Second, there are the IEC-based standards that have been adopted by CSA Group that mark equipment with the types of protection used in its design. This Rule requires that the electrical equipment used in hazardous locations have markings specifying that it is suitable for the Zone in which it is installed.

Equipment protection levels (EPLs) marked on new equipment simplify the determination of the hazardous areas for which the electrical equipment is suitable. The user should be familiar with the different types of protection available for equipment. See Table 18-3.

## Table 18-3
## Equipment protection levels for Zone area classification

| Zone | Acceptable equipment protection level |
|---|---|
| Zone 0 | Ga |
| Zone 1 | Ga or Gb |
| Zone 2 | Ga, Gb, or Gc |
| Zone 20 | Da |
| Zone 21 | Da or Db |
| Zone 22 | Da, Db, or Dc |

Below is a typical marking on a piece of electrical equipment for use in a hazardous area.

**Ex de IIC T6 Gb**

where
**Ex** indicates that the equipment is explosion protected and is allowed to be used in a hazardous location.

**de** indicates the equipment's type of protection. In the example, the equipment uses flameproof "d" and increased safety "e" types of protection in its design.

**IIC** indicates that the equipment is suitable for gas group IIC. This also means that the equipment is suitable for gas groups IIB and IIA.

**T6** indicates that the maximum surface operating temperature of the equipment is less than or equal to 85 °C.

**Gb** indicates that the equipment is allowed to be used in Zone 1 classified areas (equipment that is for explosive gas atmospheres, that has a high level of protection, and that is not a source of ignition in normal operation or during expected malfunctions).

### Rule 18-054 Temperature

Ignition surface temperature is not a defined term in Section 18. CSA C22.2 60079-0 defines "ignition temperature of an explosive gas atmosphere" as the "lowest temperature of a heated surface which, under specified conditions according to IEC 60079-20-1, will ignite a flammable substance in the form of a gas or vapour mixture with air."

To prevent ignition of the explosive gas in contact with the outer surface of electrical equipment, Subrule 1) requires that the maximum surface temperature marked on equipment that is to be used in Zones 0, 1, and 2 not exceed the minimum ignition temperature for the gas in the hazardous location.

To ensure that the equipment's surface temperature is not a source of ignition in cases where the equipment is not marked with the maximum surface temperature, Subrule 2) requires that the maximum surface temperature rating for equipment that is not so marked in Zones 0, 1, and 2 be 100 °C.

In explosive dust areas, Subrule 3) requires that the maximum external surface temperature rating of equipment that is installed in Zones 20, 21, and 22 be less than the lower of the dust cloud or the dust layer ignition temperature determined for the dust in the hazardous location where the equipment is installed.

To ensure that the equipment's surface temperature does not become a source of ignition when equipment that meets the requirements of Subrules 2) and 3) of Rule 18-150 is installed in a Zone 2 area, Subrule 4) requires that the surface temperature of any point that can be in contact with the explosive gas atmosphere not exceed the minimum ignition temperature rating of the gas in the hazardous location.

### Rule 18-056 Rooms, sections, or areas

When there are separate rooms, sections, or areas within a plant, certain conditions can cause some locations to be classified differently from others, even adjacent locations. For example, if a room with a pit or depression contains a gas that is heavier than air, the pit is classified as Zone 1 because gases often settle in a pit. Similarly, if one room is well-ventilated and an adjacent room is not, a lesser classification can apply to the well-ventilated room. Rule 18-056 requires that each room, section, or area be considered a separate location in the classification of hazards.

### Rule 18-058 Equipment rooms

Where electrical equipment rooms are located within or adjacent to hazardous areas, the construction of the rooms is to be such that hazardous (flammable) materials from the hazardous areas will not enter the equipment rooms in sufficient volume to reach flammable concentrations. There are a variety of methods that can be used to prevent the passage of hazardous material from a hazardous area into a non-hazardous equipment room. These include measures such as vapour-tight walls and pressurization with clean air (see the Appendix B Note to Rule 18-062). Where equipment room doors open into hazardous areas, there are special requirements in Subrules 2) and 3) to prevent the entry of significant quantities of hazardous material into the room.

### Rule 18-060 Metal-covered cable

Mineral-insulated (MI) cable has a substantially lower breakdown voltage than cables or wires with thermoplastic or thermoset insulation. Where overhead conductors are supplying mineral-insulated cables, there is a risk of voltage surges from lightning strikes causing a failure of the mineral-insulated cable, thus producing a high-energy source of ignition. To avoid this situation, Subrule 1) requires that exposed overhead supply conductors connected to mineral-insulated cable located in a hazardous area have surge arresters installed to limit the surge voltage level to 5 kV on the cable. The Appendix B Note to Rule 18-060 1) recommends that where the overhead secondary lines exceed 90 m in length before connecting to the MI cable or where the secondary is ungrounded that the lightning arrestors include both primary and secondary devices.

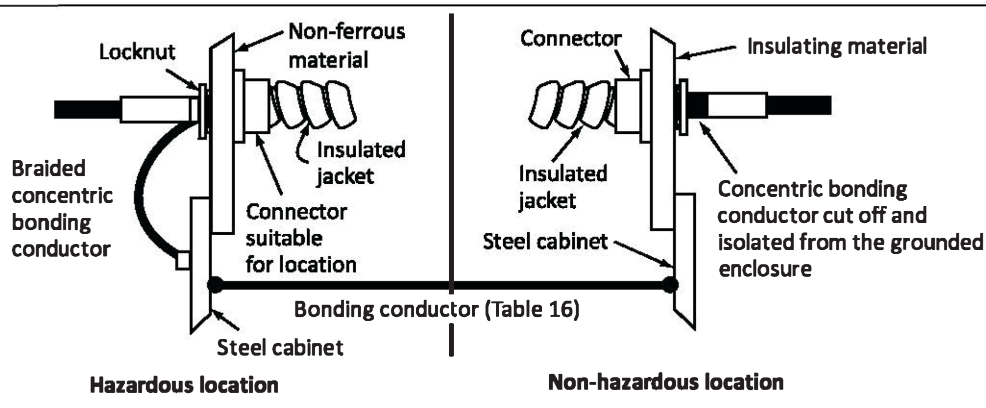
Where metal-covered (armoured and metal clad) single conductor power cables are installed, the magnetic field from the conductor will induce a voltage on the metallic armour or sheath, which in turn can cause circulating currents between the armour/sheath and metal supports, which can create a source of ignition in hazardous areas. When the metal armour/sheath is not covered by a non-metallic jacket, the armour/sheath of the single conductors must be bonded together at intervals not exceeding 1.8 m and bonded to ground. Unjacketed single-conductor metal armoured/sheathed power cables are rarely installed in hazardous areas due to the requirements for frequent bonding and sealing at the boundaries of the hazardous locations.

Single-conductor metallic armoured/sheathed power cables with insulating non-metallic jackets are to be bonded to ground at the point of termination in the hazardous area only. If they are also bonded at the other end, a circulating current will be set up in the metal armour/sheath, creating the possibility of overheating the metal armour/sheath or causing incendive sparking at the termination in the hazardous area. Users should be aware that the standing voltage-to-ground on the metal armour/sheath will be present at the unbonded end (the end isolated from ground) of the cable and could possibly result in a shock hazard.

Due to the problems associated with the safe installation of single-conductor metallic armoured/sheathed power cables in hazardous areas, three-conductor metallic armoured/sheathed power cables are most often used. The magnetic field around each conductor is cancelled out by the magnetic fields of the other two. As a result, no voltage is induced in the metallic armour/sheath of the cables.

See Figure 18-1.

**Figure 18-1**
**Bonding to ground of single-conductor PVC (insulated) jacket cable**




**Note:** *Load over* 425 A *per conductor.*

### Rule 18-062 Pressurized equipment or rooms

This Rule allows the use of a protective gas under pressure to prevent explosive or flammable atmospheres (gas and dust) from surrounding or adjacent hazardous areas from entering a protected enclosure or room. The Rule does not specify how the pressurization is to be accomplished, but the Appendix B Note to Rule 18-062 recommends three references:

- CAN/CSA-C22.2 No. 60079-2;
- NFPA 496; and
- IEC 60079-13.

This Rule waives the requirements of Rules 18-100 to 18-158 for electrical equipment located in the protected enclosure or room. However, if pressurization is lost, unprotected electrical equipment becomes a potential ignition source since the area is to be considered a hazardous location in the absence of pressurization. Continued operation of unprotected electrical equipment should therefore take place only when hot work procedures are used.

**Rule 18-064 Intrinsically safe and non-incendive electrical equipment and wiring**
Intrinsically safe and non-incendive circuits provide safety by limiting the energy available in circuits to levels below that which could ignite the gas or dust likely to be present in the area. These circuits are to be properly designed, installed, and maintained in order to provide safe operation throughout their working life. Intrinsically safe and non-incendive circuits allow for relaxation of the wiring rules as any sparking or thermal effect is not capable of an ignition of an explosive atmosphere. If the circuit is compromised (damaged) during its working life, it can present an undetected ignition source. Therefore, before intrinsically safe and non-incendive field wiring circuit designs are chosen, the designers are to be aware that their responsibility extends beyond the design of the circuits. Subrule 1) requires that a descriptive systems document, in which the items of electrical apparatus, their electrical parameters, and the electrical parameters of the interconnecting wiring are specified, be provided. See the definition of a *Descriptive system document* in Rule 18-002.

To facilitate the safe installation, verification, and ongoing maintenance of intrinsically safe and non-incendive field wiring systems, Subrule 2) requires that these circuits be installed in accordance with the descriptive system document.

To prevent transfer of energy into the intrinsically safe or non-incendive field wiring circuits from insulated conductors of any other circuit, Subrule 3) requires that no raceways, compartments, enclosures, outlets, junction boxes, or similar fittings, excluding cable trays, contain insulated conductors of intrinsically safe or non-incendive field wiring circuits with insulated conductors of any other circuit unless the conductors are separated by:
- not less than 50 mm;
- the metal armour or sheath of cable assemblies;
- a grounded metal barrier not less than 1.34 mm (No. 16 MSG) thick; or
- a non-metallic insulating material not less than 1.5 mm in thickness.

Subrule 4) allows an exemption from the requirements in Subrule 3) when the insulated conductors of different intrinsically safe or non-incendive field wiring circuits are installed in the same raceway, compartment, outlet, junction box, or multi-conductor cable provided:
- the insulated conductors of each circuit are grounded within electrically conductive shields, braids, or sheaths; or
- the insulated conductors of each circuit have insulation with a minimum thickness of 0.25 mm.

It is important that flammable fluids not migrate through the raceway or cable wiring system into a lower classified location and reach devices not suitably protected. These devices then can be a source of ignition to the migrated explosive atmosphere and can cause an explosion. Subrule 5) requires that raceways and cable systems for the wiring of intrinsically safe or non-incendive equipment in explosive atmospheres be installed (i.e., sealed) to minimize migration of flammable fluids (gas, vapour, or liquid) to other locations.

For installation, servicing, modification, inspection, repair, and testing, Subrule 6) requires that all apparatus forming part of an intrinsically safe and non-incendive system be identified as being part of an intrinsically safe and non-incendive system.

For installation, servicing, modification, inspection, repair, and testing of intrinsically safe and non-incendive field wiring circuits, Subrule 7) requires that the circuits be identified at terminals and junction locations. The identification is to conform to the identification used on the descriptive systems document.

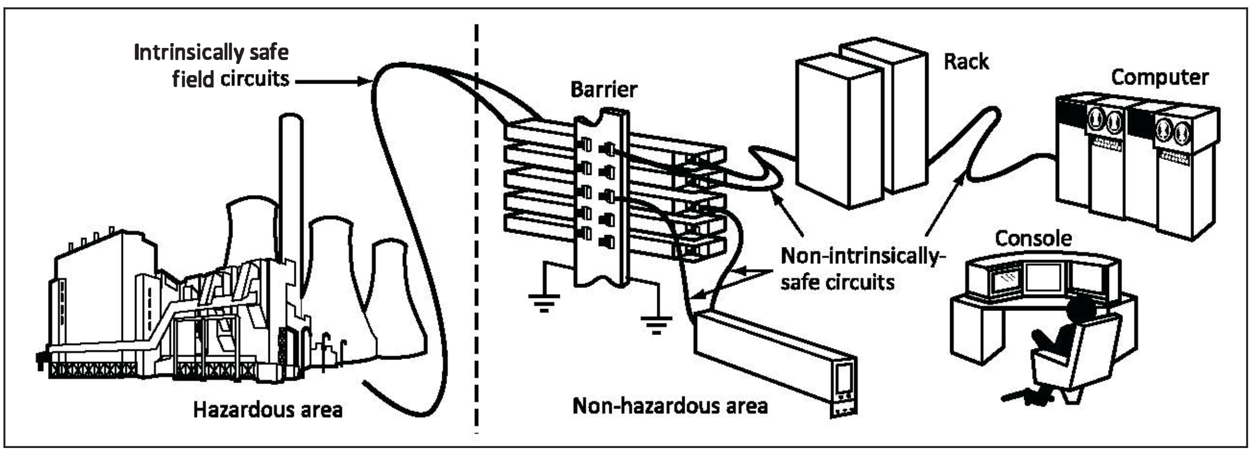
For installation, verification, and ongoing maintenance of the wiring methods, Subrule 8) requires that raceways, conductors, and cables for intrinsically safe and non-incendive field wiring circuits be identified with permanently affixed labels or be colour-coded light blue where no other cables or insulated conductors are coloured light blue.

Designers of intrinsically safe circuits should have a sound working knowledge of design, installation, and maintenance requirements. Useful information can be found in the following documents:

- Appendix F of the Code;
- ISA-TR12.2, *Intrinsically Safe System Assessment Using the Entity Concept*;
- ISA-RP12.2.02, *Recommendations for the Preparation, Content, and Organization of Intrinsic Safety Control Drawings*;
- CAN/CSA-C22.2 No. 60079-11;
- CAN/CSA-C22.2 No. 60079-0; and
- IEC 60079-14.

See Figure 18-2 for an example of an intrinsically safe control circuit.

**Figure 18-2**
**Typical intrinsically safe control circuit**




## Rule 18-066 Cable trays in explosive dust atmospheres

When cable trays are installed in explosive dust atmospheres, they are to be installed to minimize dust or fibre buildup on cables; such a buildup could negatively affect the cooling of the cables or be inadvertently blown into suspension, creating an explosive atmosphere.

## Rule 18-068 Combustible gas detection

This Rule allows equipment suitable for use in a non-hazardous area to be used in a Zone 2 hazardous area or equipment suitable for use in a Zone 2 hazardous area to be used in a Zone 1 hazardous area, where equipment suitable for the purpose is not available. The Rule requires that the equipment, during its normal operation, not produce arcs or sparks, or have surfaces hot enough to ignite the explosive gas atmosphere. Contrary to a common misunderstanding, this Rule does not change the area classification.

This is the only Rule in the Code that mandates the use of combustible gas detection. However, combustible gas detection is often used to meet the requirements of the Zone 2 definition. The Zone 2 definition requires that an explosive gas atmosphere exist only for a short time. In order for corrective action to be taken within a short time, the presence of flammable gas must first be detected. The use of combustible gas detection provides knowledge that abnormal concentrations of flammable gas are present, which then allows corrective action to be taken in a short time.

CSA C22.2 No. 152 requires that combustible gas detection devices perform under many adverse conditions, including temperature extremes, humidity, high air velocities, high gas concentrations, power fluctuations, and shock and vibration, without producing errors in excess of those allowed by the Standard. The devices are also subjected to tests involving sudden changes in gas concentration and to long-term stability tests under simulated field conditions. As a result of extensive testing and the favourable results obtained, these devices are now considered a form of protection, under the specific criteria of this Rule.

Appendix H should be consulted for application, installation, and maintenance recommendations.

The mandatory requirement for the operation of the combustible gas detection system in this Rule is intended to provide continuous monitoring of a location, with immediate detection and the activation of an alarm when an increase in the gas concentration reaches 20% of its lower flammable limit [see Item c) i)]. Also at 20% of the lower flammable limit, Item c) ii) requires that the combustible gas detection system activate additional ventilating equipment or another means that has been designed to prevent the concentration of gas from reaching the lower flammable limit.

To prevent the concentration of gas from reaching its lower flammable limit, Item c) iii) requires that the combustible gas detection system de-energize the electrical equipment in the location when the concentration of gas reaches 40% of its lower flammable limit, since additional ventilation or other means cannot control the rise in the level of concentration.

In installations where no additional ventilation or other means is provided to reduce the gas concentration, if the gas concentration reaches 20% of its lower flammable limit, Item c) iv) requires that the combustible gas detection system de-energize the equipment in the location to prevent it from becoming a possible source of ignition.

To ensure that the combustible gas system can continuously monitor the gas concentration in the area it serves, Item c) v) mandates that if the gas detection instrument fails (due to power outage, damage, inadvertent disconnection, etc.), the electrical equipment in the location will be automatically de-energized. Designers should design redundancy into the combustible gas detection system to prevent an unwanted shutdown of the electrical equipment due to a failure of the gas detection instrument.

## Rule 18-070 Flammable fluid seals

A breakdown in a seal that results in flammable fluid under pressure entering an electrical device in a hazardous location can have disastrous consequences. For example, if a flammable fluid above atmospheric pressure enters an explosion-proof enclosure, the conduit or cable seal is not rated to prevent flammable fluid from migrating through the conduit or cable into the wiring system and non-protected devices in a non-hazardous area, where it can cause an explosion.

Before applying this Rule, users should carefully read both the Rule and its Appendix B Note. See also Rule 18-002 and its Appendix B Note for definitions of cable seals, conduit seals, primary seals, and secondary seals.

**Note:** *Cable seals and conduit seals are designed to prevent the passage of explosions and are not designed to prevent the passage of flammable fluid under continuous pressure. The definition of a conduit seal states that it "minimizes the passages of gas or vapour at atmospheric pressure". An extract from the conduit sealing fitting instructions of a leading hazardous electrical equipment manufacturer notes, "by design they are not intended to prevent the passage of liquids, gases, or vapours at a continuous pressure differential across the seal. Even at differences in pressure across the seal equivalent to a few inches of water, there may be a slow passage of gas or vapour through the seal and through the conductors passing through the seal".*

Primary seals are the seals in process monitoring devices such as pressure switches, pressure transmitters, and temperature transmitters that are intended to prevent flammable process fluids from entering cable or conduit systems and migrating to less hazardous or non-hazardous areas. Subrule 1) of Rule 18-070 requires that primary seals in contact with flammable fluids (gas, vapour, or liquid):

- be installed so as to prevent migration of flammable fluid through the wiring system; and
- be used at pressures lower than the marked maximum working pressure (MWP) of the flammable fluid system.

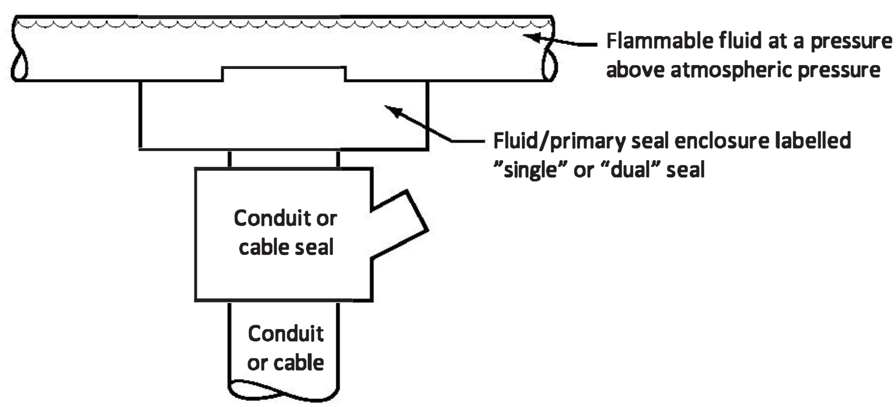
When a secondary seal is used to prevent the migration of the flammable fluid to less hazardous or non-hazardous areas due to a primary seal failure, Subrule 2) requires that the secondary seal indicate this by means of:

- design features that will make the occurrence of the primary seal failure obvious to the installation personnel; or
- marking of the secondary seal enclosure, stating that it could contain flammable fluid under pressure.

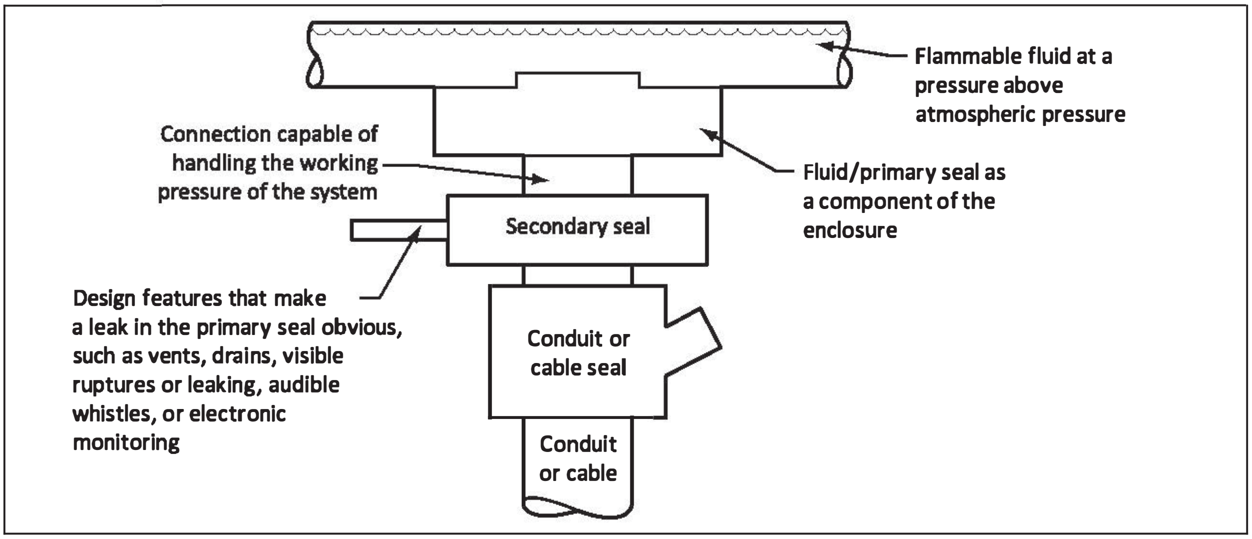
The Appendix B Note to Rule 18-070 describes three additional ways that this requirement can be met:

- The equipment nameplate is marked “single seal” or “dual seal”; the equipment complies with the requirements of ANSI/ISA 12.27.01; and the primary seal in the equipment meets the requirements of Rule 18-070 1). See Figure 18-3.
- Suitable barriers are located between the primary seal and the wiring system, such as:
  - a secondary process seal — see Figures 18-4 and 18-5; or
  - a short length of mineral-insulated cable — see Figure 18-6.
- If engineering deliberations conclude that the probability of leakage from the primary seal is negligible, the requirements of Subrule 1) of Rule 18-070 can be considered to be met. Two factors that could lead to this conclusion are an extensive history of safe operation with similar installations and the use of a primary seal with a pressure rating well in excess of the maximum working pressure. See Figure 18-7.

**Figure 18-3**
**Single or dual seal**



## Figure 18-4
## Secondary seals with design features to indicate primary seal failure




## Figure 18-5
## Secondary seals designed to contain pressure if the primary seal fails

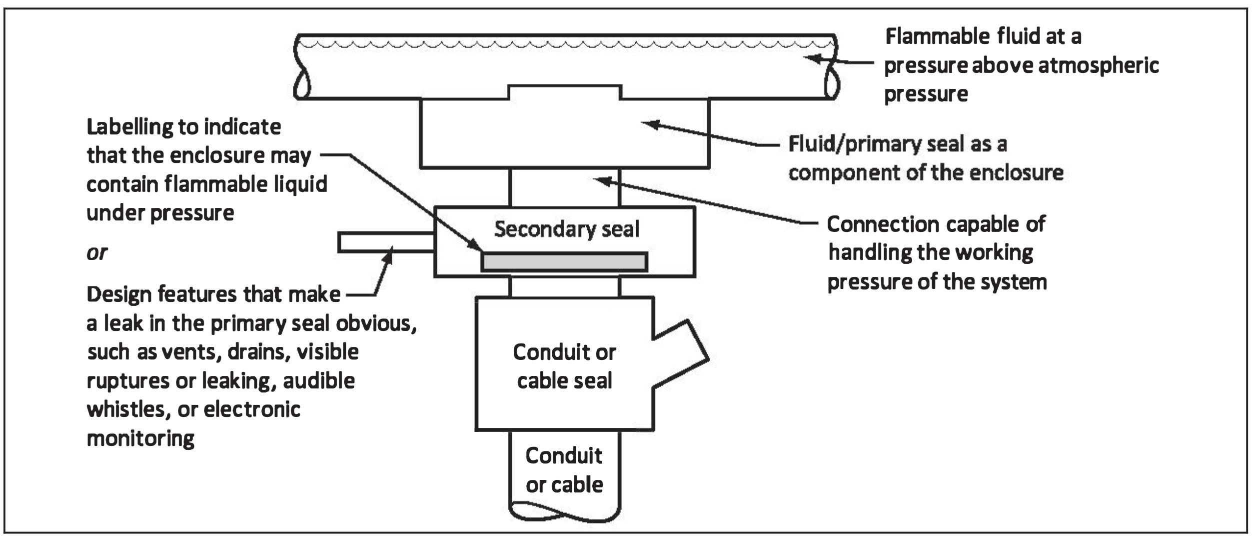


**Figure 18-6**
**Flammable fluid seal with suitable barrier to prevent gas migration**

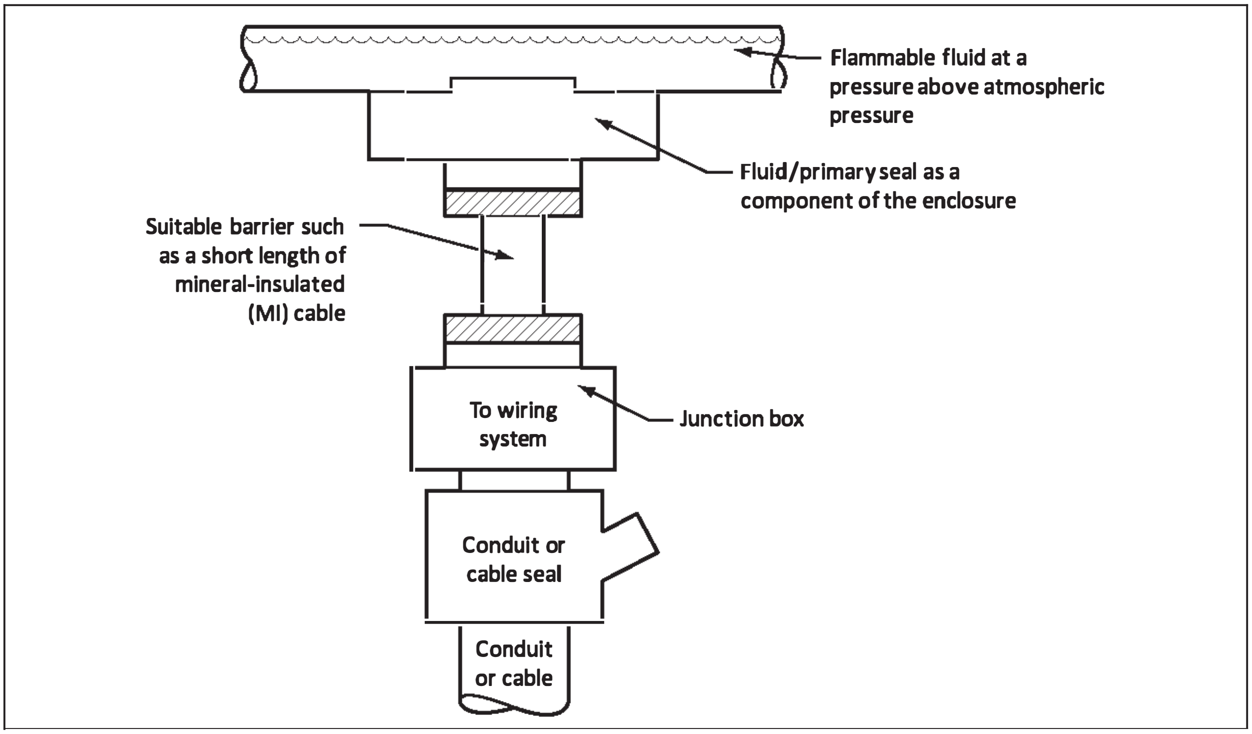
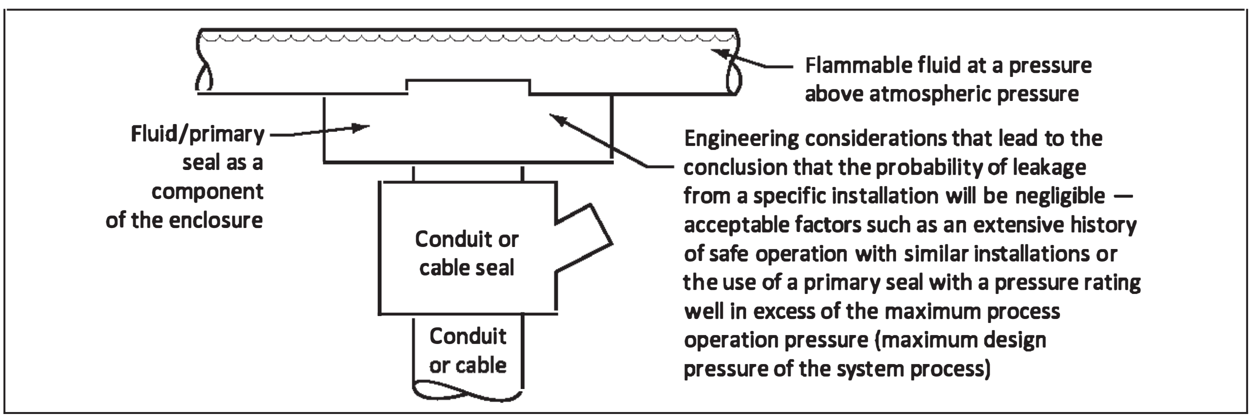



**Figure 18-7**
**Flammable fluid seal with engineering considerations**




When a secondary seal is installed, it is important that there be a means of alerting staff if there has been a failure and fluid under pressure has reached the secondary seal. If a means of indicating failure of the primary seal is not included in the design of the installation, signage is to be in place to warn staff that the enclosure could be pressurized. There is a significant hazard if staff attempt to open the enclosure between the primary and secondary seals without realizing that pressure is present. If the secondary seal remains under pressure, there is also the possibility that it will eventually fail. This could lead to an explosion.

While most installations are safe without the use of a secondary seal, it is important that an engineering evaluation reach that conclusion. If there is no engineering evaluation, a secondary seal should be installed. The requirements of this Rule are the result of a number of primary seal failures, some which have led to a loss of life.

### Rule 18-072 Bonding in hazardous locations

Proper bonding of the exposed non-current-carrying metal parts of electrical equipment, including the frames or metal exteriors of motors, fixed or portable lamps or other utilization equipment, luminaires, cabinets, cases, and conduit to a common potential (ground potential) is important for personnel safety in all areas. In hazardous areas, proper bonding will prevent the possibility of incendive arcing between components at different voltages. In addition to the bonding requirements of electrical equipment outlined in Rule 10-614, additional bonding of non-electrical process equipment can be necessary to prevent the possibility of uncontrolled static discharge. API RP 2003 (2008), *Protection Against Ignitions Arising out of Static, Lightning, and Stray Currents*, is a useful reference document in this area. In dust areas where solid material is transferred, bonding to prevent static discharge from non-electrical equipment is critical.

The bonding of exposed non-current-carrying metal parts of electrical equipment, including the frames or metal exteriors of motors, fixed or portable lamps or other utilization equipment, luminaires, cabinets, cases, and conduit to ground is to be done using:

- a bonding conductor sized by Rule 10-614; or
- rigid metal conduit with thread couplings and threaded bosses on enclosures with joints made up tight.

Subrule 2) allows an exemption from Subrule 1) where standard locknuts are used on box connectors to bond the metallic armour or raceway when the raceways or cables have an internal bonding conductor.

### Rule 18-074 Uninsulated exposed parts

To prevent any energized uninsulated exposed parts of an electrical installation or of electrical equipment such as electrical conductors, buses, terminals, or components that could cause an arc or sparking by unintentional contact with items of a different polarity, Rule 18-074 does not allow such installations or equipment in a hazardous location, unless

- they operate at less than 30 V (15 V in wet locations) and they are additionally protected by a type of protection (ia, ib, ic, or nA) suitable for the location; or
- they meet the criteria for the provisions in Subrule 2) of Rule 18-250 for electric cranes, hoists, and similar equipment in a Zone 22 location.

# Explosive gas atmospheres

## Installations in Zone 0 locations

### Rule 18-090 Equipment, Zone 0 locations

In a location that has been classified as Zone 0, an explosive gas atmosphere is present continuously or for long periods of time (e.g., over 1000 h at or above the LFL, based on the hazardous area classification). One of the most common Zone 0 locations is the atmosphere inside a flammable liquid storage tank with a vent to atmosphere.

The type of equipment protection and the type of electrical equipment that are allowed to be used in a Zone 0 location are given in Table 18.

### Rule 18-092 Wiring, Zone 0

Subrule 1) requires that the wiring for connection of equipment in a Zone 0 location be intrinsically safe.

Subrule 2) allows cables that contain one or more circuits that are not intrinsically safe and are marked with the suffix "HL" to pass through a Zone 0 location provided that:

- they pass completely through the Zone 0 location with no fittings or connections less than 300 mm beyond each boundary; and
- they are protected from mechanical damage by a raceway or other effective means within the Zone 0 area.

### Rule 18-094 Sealing, Zone 0

Subrule 1) requires that seals be installed at the boundary between Zone 0 and Zone 1 locations to prevent gas migration. An exception to the sealing requirement is allowed for a rigid unbroken conduit that passes completely through a Zone 0 location, with no fittings (breaks in the conduit run) less than 300 mm outside of the Zone 0 boundary and with termination points in non-hazardous areas.

Subrule 2) requires that seals be installed at the first termination of the cable in the Zone 0 location to prevent gas migration.

Seals at the first termination of the cable in the Zone 0 location are not required to have the explosion-proof or flameproof "d" type of protection when used in a Zone 0 intrinsically safe protected location. An intrinsically safe type of protection is not likely to have enough energy to cause an explosion in the Zone 0 location. However, Subrule 3) requires that the seals used be identified for the purpose of minimizing the passage of gas, vapours, or dusts under normal operating conditions. Like all seals in hazardous areas, they are to be accessible for installation, maintenance, testing, and replacement.

## Installations in Zone 1 locations

### Rule 18-100 Equipment, Zone 1 locations

The type of protection for equipment that is allowed to be installed in a Zone 1 location is given in Table 18.

### Rule 18-102 Wiring methods, Zone 1

Subrule 1) requires that the wiring method in Zone 1 for conduit be threaded rigid metal conduit and hazardous location cables (cables marked with the "HL" designation) with associated cable glands suitable for the application.

Cables meeting the requirements of CSA C22.2 No. 174, *Cables and cable glands for use in hazardous locations*, are acceptable for use in hazardous locations and are marked "HL". Cables approved for hazardous locations are suitable for all locations, but the termination fittings are to be suitable for the particular hazardous location. For example, in a Zone 1 or 2 hazardous location, a termination fitting entering an enclosure required to be explosion-proof or flameproof is to be a sealing-type termination fitting, whereas a termination fitting entering an enclosure not required to be explosion-proof or flameproof in a Zone 2 hazardous location is not required to be marked for Zone 2 hazardous areas. The intention of the Rule is to ensure that termination fittings in all hazardous areas are compatible with the degree of ingress protection and the explosion protection provided by the enclosure they enter. In general, the minimum requirement is weatherproof termination fittings.

The CSA Group Standard for rigid metal conduit and couplings is CSA C22.2 No. 45.1. This Standard does not require the markings for the conduit and couplings in hazardous locations. Certified rigid metal conduit and couplings are suitable for hazardous locations without specific area classification markings. For the application of Section 18, rigid metal couplings are not considered fittings.

**Note:** *When flexible connections are required in a conduit run, they are to be of o type suitable for the location. Flexible connections are to be used to connect rigid threaded metal conduit in order to avoid vibration transmission and to allow movement of the equipment at places such as motor terminals and similar equipment.*

Explosion-proof or flameproof "d" boxes, fittings, and joints are required to contain any explosion and prevent any heat or materials resulting from an interior explosion from becoming a source of ignition to a flammable gas surrounding the box, fitting, or joint. To maintain the explosion protection, Subrule 2) requires that where conduit and cable glands connect to the enclosure they do so through a threaded connection.

Where threaded joints are to be explosion-proof or flameproof "d", Subrule 3) requires that they conform to either North American tapered-type (NPT) thread forms or metric straight thread forms. Where NPT tapered threads are used, 4-1/2 fully engaged threads are required, while metric straight threads are to have a class 6g/6H tolerance (tolerance 6g/6H is defined in ISO 965-1, *ISO general purpose metric screw threads — Tolerances — Part 1: Principles and basic data)* and have at least five fully engaged threads.

Threaded connections are critical to the safety of hazardous locations for the following reasons:

- Threads that are not fully engaged can compromise the flame path making it possible for an explosion occurring within the conduit system to be transmitted to the area outside the conduit.
- Where there are not 4-1/2 fully engaged NPT tapered threads or 5 fully engaged metric straight threads, the flame path could be too short to cool the gases resulting from an internal explosion to a temperature below that which could ignite gas in the surrounding area.
- The conduit connection forms a bonding path to ground, so if the conduit connection is not tight, resistance could occur in the fault path and arcing could occur at the connection.

**Note:** *While it might not always be possible to install certain fittings without backing off, it is important to ensure that the connection is as tight as possible. Properly made conduit connections are critical to the safety of hazardous location wiring systems.*

When the thread forms of the wiring system and the equipment differ (e.g., NPT tapered threaded conduit and metric straight threaded equipment), Subrule 4) requires that suitable adapters be used.

Electrical equipment that has increased safety "e" type of protection is manufactured to prevent the ingress of materials or moisture. There are various grades of types of increased safety "e" enclosures depending on the degree of protection required. Subrule 5) requires that the wiring method used to make connections to equipment in Zone 1 locations provide a degree of ingress protection equal to that of the equipment.

To prevent tensile stress from causing damage where the hazardous location cable connects to the cable gland, Subrule 6) requires that the cables to be installed and supported in a manner that avoids tensile stress at the cable glands.

When using intrinsically safe systems designed and installed as "ia", "ib", and "ic", precautions need to be taken to preserve the intrinsic safety of the installation. Since these circuits have their energy limited so that any sparking or thermal effect will not ignite the explosive gas atmosphere, Subrule 7) allows an exemption from the wiring method requirements of Subrules 1) to 4).

### Rule 18-104 Sealing, Zone 1

Using conduit or cable seals in a hazardous location serves two purposes. The first purpose of sealing is to prevent the transmission of explosions. If two explosion-proof or flameproof "d" enclosures are joined together by a length of conduit that is not sealed, an explosion in one enclosure can cause pressurization in the second enclosure. When the explosion pressure reaches the second enclosure, the resulting explosion is more violent due to the pre-compression of the mixture, and the enclosure can rupture and transmit the explosion to the surrounding atmosphere. This effect, called "pressure-piling", is similar to the operation of a high-compression internal combustion engine. Sealing the entry into an explosion-proof or flameproof "d" enclosure (see Figures 18-8 and 18-9) prevents an explosion in the enclosure from being transmitted to the exterior explosive gas atmosphere or to another enclosure. This is of particular importance in cases where the wiring method is cable because cable cannot contain an explosion. See Figure 18-8.

The second purpose of sealing is to prevent the migration of dangerous quantities of flammable gases from one location to another. Conduit and cable seals are not completely gas-tight, but they are sufficiently tight to prevent any appreciable amount of gas from passing through at normal atmospheric pressures. They cannot be relied upon to prevent the transmission of gases under pressure above atmospheric, and other provisions are to be made to address that possibility. Such provisions are usually built into electrical equipment that is used with high-pressure flammable fluids (see Rule 18-070).

Subrule 1) requires that conduit seals be provided in conduit systems where:

- the conduit enters an explosion-proof or flameproof "d" enclosure that contains devices that could produce arcs, sparks, or high temperatures; in this case, the conduit seal is to be located as close as practicable to the enclosure or be located as marked on the enclosure being sealed, but not be located further than 450 mm from the enclosure;
- the conduit is 53 trade size or larger and enters an explosion-proof or flameproof "d" enclosure that houses terminals, splices, or taps; in this case, the conduit seal is to be located no further than 450 mm from the enclosure; or
- the conduit leaves the Zone 1 location with no box, coupling, or fitting in the conduit run between the seal and the point at which the conduit crosses the boundary line, with one exception: a rigid unbroken conduit that passes completely through a Zone 1 area with no fittings less than 300 mm beyond each boundary need not be sealed provided that the termination points of the unbroken conduit are in non-hazardous areas.

Unlike the requirement in Item c) of Subrule 1) that prohibits fittings between the seal and the boundary, Subrule 2) allows explosion-proof or flameproof "d" unions, couplings, reducers, and elbows that are not larger than the trade size of the conduit between the sealing fitting and an explosion-proof or flameproof "d" enclosure.

Subrule 3) requires that cable seals be provided:

- in a cable system where the cable enters an enclosure that is required to be explosion-proof or flameproof "d"; or
- at the cable's first termination after it enters the Zone 1 area no matter what the type of enclosure (see Figure 18-9).

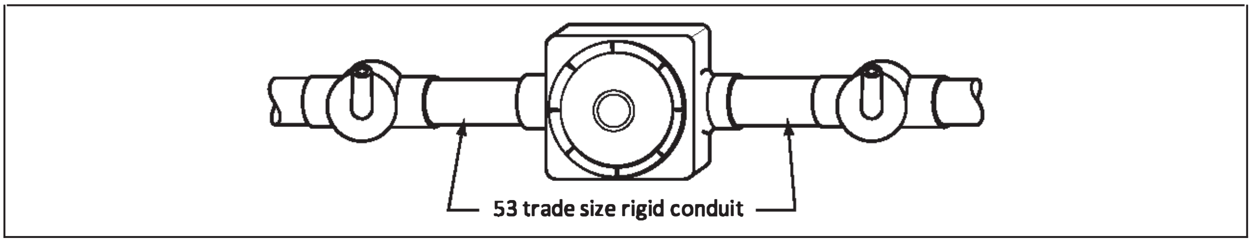
To allow secondary seals, cable seals, and conduit seals to be installed, serviced, tested, and replaced, Subrule 4) requires that they conform to the following:

- the seal is to be accessible after installation;
- no splices and taps are to be made in sealing fittings that are intended only for sealing with compound or other fittings filled with compound;
- where there is a probability that liquid or other condensed vapour could be trapped within enclosures for control equipment or at any point in the raceway system, acceptable means, such as draining fittings, are to be provided to prevent accumulation or to allow periodic draining of any liquid or condensed vapour (see Figure 18-10); and
- where there is a probability that liquid or condensed vapour will accumulate within motors or generators, joints and conduit systems are to be arranged to minimize entrance of liquid, but if a means to prevent accumulation or to allow periodic draining is judged necessary, such a means is to be provided at the time of manufacture and be deemed an integral part of the machine.

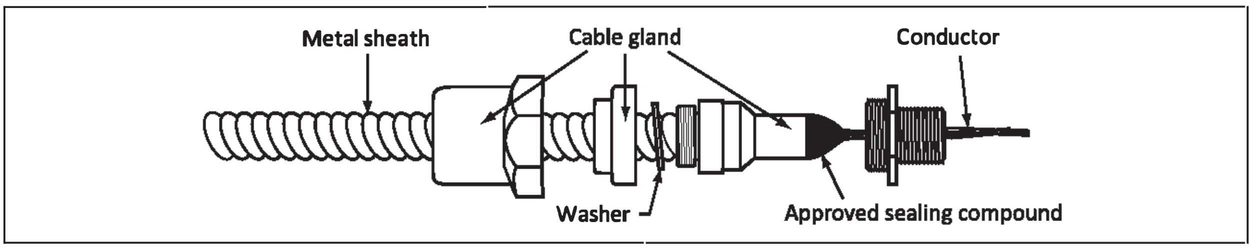
Subrule 5) allows runs of metal or non-metal cables where each cable has an outer continuous sheath that prevents the entry of gas into the cable to pass through a Zone 1 location without seals.

Metal or non-metal cables that do not have an outer continuous sheath might allow entrance of gas into the cable from a Zone 1 area, which then could migrate throughout the cable to other locations, creating an explosion hazard. Therefore, Subrule 6) requires that these types of cables be sealed at the boundary of the Zone 1 location.

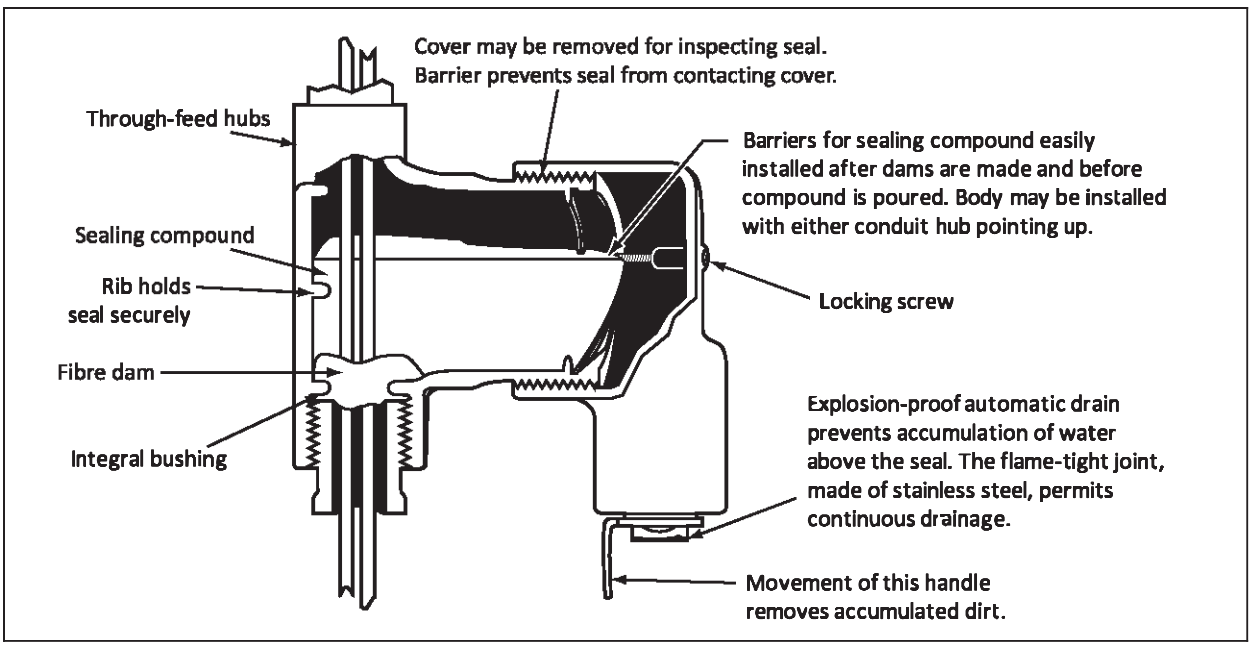
## Figure 18-8
## Explosion-proof junction boxes between horizontal seals




## Figure 18-9
## Special sealing fitting for hazardous location cables




## Figure 18-10
## Sealing fitting with provision for draining




### Rule 18-106 Motors and generators, Zone 1

Increased safety "e" motor installations are to meet the requirements for thermal protection of squirrel-cage induction motors in IEC 60079-14, *Explosive atmospheres — Part 14: Electrical installations design, selection and erection*. For the convenience of designers and users, API RP 2216 and IEEE Paper No. PCIC-97-04 are included in the Appendix B Note to Rule 18-106.

## Rule 18-108 Luminaires, Zone 1

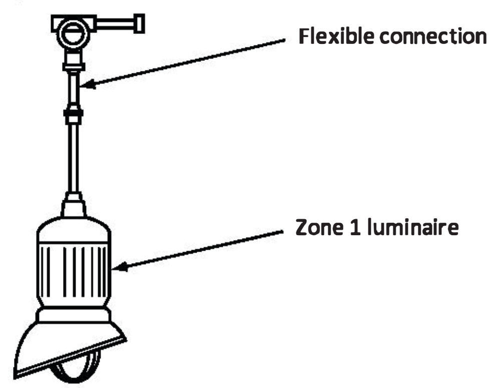
Luminaires can cause ignition in two ways: the hot lamp surface is a potential source of ignition, and if the lamp breaks, a hot filament can burn out, producing a combination of intense heat and sparking.

To prevent hot parts of a luminaire from becoming a source of ignition, Subrule 1) requires that luminaires be protected from damage by a suitable guard or by their location. Subrule 2) requires that pendant luminaires that are suspended by and supplied through threaded rigid conduit stems and threaded joints be:

- provided with set screws or other effective means to prevent loosening; and
- provided with permanent and effective bracing against lateral displacement at a level not more than 300 mm above the lower end of the stem, or provided with flexibility in the form of a fitting or flexible connector suitable for the purpose; the fitting and the connector is to be located not more than 300 mm from the point of attachment to the supporting box or fitting where the stems are longer than 300 mm. These measures are intended to prevent loosening and excessive swaying.

See Figure 18-11, which illustrates Subrule 2).

**Figure 18-11**
**Luminaires, Zone 1**




## Rule 18-110 Flexible cords, Zone 1

Rule 18-110 limits the use of flexible cords since they are not considered as safe as permanent wiring.

Subrule 1) allows flexible cords to be used for connection between a portable lamp or other portable utilization equipment and the fixed portion of its supply circuit if the flexible cord:

- is of the extra-hard-usage type;
- contains a bonding conductor;
- is provided with a sealing gland where the flexible cord enters a box, fitting, or enclosure that is explosion-proof or flameproof "d"; and
- where entering an increased safety "e" enclosure, is terminated with a suitable increased safety "e" cord connector.

Subrule 2) also allows flexible cords to be used for that portion of the circuit where fixed wiring methods cannot provide the necessary degree of movement for fixed and mobile electrical utilization equipment if the flexible cords:

- meet the requirements of Subrule 1) listed above; and
- are protected from damage by location or by a suitable guard.

# Installations in Zone 2 locations

## Rule 18-150 Equipment, Zone 2 locations

In comparison to the Rules for Zone 1 locations, the Rules for Zone 2 locations are somewhat more relaxed because the likelihood that the location will become hazardous due to the presence of a flammable gas or vapour is greatly reduced.

The type of equipment protection and the type of electrical equipment that are allowed to be installed in a Zone 2 location are given in Table 18.

Subrule 2) allows, in addition to the types of equipment and protection listed in Table 18, the following types of protection or types of equipment to be used in a Zone 2 location:

- transformers, capacitors, solenoids, and other windings that do not incorporate sliding or make-and-break contacts; heat-producing resistance devices; and arcing or spark-producing components;
- conduit and cables listed for use in a Zone 2 location [see Subrule 1) of Rule 18-152];
- non-explosion-proof or non-flameproof "d" enclosures housing:
  - non-arcing connections and connecting devices, such as joints, splices, terminals, and terminal blocks;
  - switches, controllers, and circuit breakers meeting the requirements of Subrule 1);
  - unfused isolating switches that are interlocked with their associated current-interrupting devices such that they cannot be opened under load; or
  - not more than ten:
    - sets of enclosed fuses; or
    - circuit breakers that, due to the increased arcing that would be present if the circuit breakers were used as switches to control illumination in an installation, are prohibited by Item c) iv) B) of Subrule 2) for use as switches (lighting controls) for the normal operation of lamps and luminaires but may be used as overcurrent protection for a lighting branch circuit or a fixed lighting feeder;
- the equipment used for the protection of motors, appliances, and luminaires when:
  - a standard plug or cartridge fuse is required to be placed within an explosion-proof or flameproof "d" enclosure;
  - a fuse is installed within a non-explosion-proof or non-flameproof "d" enclosure, provided that the operating element of the fuse is:
    - immersed in oil or other suitable liquid; or
    - enclosed within a hermetically sealed chamber; or
  - a fuse installed within a non-explosion-proof or non-flameproof "d" enclosure, provided that the fuse is:
    - a non-indicating type, filled, current-limiting type; or
    - an indicating, filled, current-limiting type, constructed in such a manner that the blown fuse indication does not cause the fuse body to be penetrated; or
- motors, generators, and other rotating electrical machines of the open or non-explosion-proof type that:
  - do not incorporate arcing, sparking, or heat-producing components, except where allowed by Subrule 3); or
  - incorporate arcing, sparking, or heat-producing components that comply with the requirements for equipment in a Zone 1 location (see Rule 18-100).

Depending on the environment in which they are installed, motors, generators, and other rotating electrical equipment of the open or non-explosion-proof type can have a buildup of condensation in their housings. Subrule 3) allows anti-condensation heaters in these housings to prevent the buildup of condensation provided that the heaters:

- do not use arcing or sparking component that can be a source of ignition;
- do not use temperature-limiting controls (to eliminate heater temperature runaway in the event of the failure of the controls);
- comply with the surface temperature requirements under normal operating conditions of Rule 18-054; and
- are marked by a separate nameplate on the machine (motor or generator) [see sample nameplate in the Appendix B Note to Rule 18-150 3)] with the nameplate markings including the maximum surface temperature of the heater at any point, internal or external, in degrees Celsius or the temperature code.

### Rule 18-152 Wiring methods, Zone 2

Rule 18-152 does not apply to intrinsically safe devices. Their exemption is allowed by Rule 18-064.

Subrule 1) requires that the wiring methods in Zone 2 be as follows:

- threaded rigid metal conduit;
- hazardous location cables with associated cable glands suitable for the application and marked HL;
- Type TC cable installed in cable tray in accordance with Rule 12-2202;
- armoured cable with an overall non-metallic jacket, such as TECK90, ACWU90, copper-sheathed RC90, or aluminum-sheathed RA90;
- control and instrumentation cables with an interlocking metallic armour and a continuous jacket in control circuits (Type ACIC);
- Type CIC cable (non-armoured control and instrumentation cable) installed in cable tray in accordance with the installation requirements of Subrule 2) of Rule 12-2202, where:
  - the voltage rating of the cable is not less than 300 V;
  - the circuit voltage is 150 V or less; and
  - the circuit current is 5 A or less;
- rigid RTRC Type XW conduit, provided that the:
  - boxes, fittings, and joints are specifically approved for the purpose and are marked with the suffix "-XW"; and
  - conduit is installed in industrial establishments that are not accessible to the public and where only qualified persons service the installation; or
- liquid-tight flexible metal conduit and connectors marked for heavy duty.

Explosion-proof or flameproof "d" boxes, fittings, and joints are required to contain any explosion and prevent any heat or other materials resulting from an interior explosion from becoming a source of ignition to the explosive gas surrounding the box, fitting, or joint. To maintain the explosion protection, Subrule 2) requires that where conduit and cable glands connect to these enclosures they do so through a threaded connection.

Subrule 3) specifies that where threaded joints are required to be explosion-proof, they are to be either North American tapered type thread forms (NPT) or metric straight thread forms. Where NPT tapered threads are used, there are to be 4-1/2 fully engaged threads, while metric straight threads are to have a tolerance class 6g/6H ("tolerance 6g/6H" is defined in ISO 965-1, *ISO general purpose metric screw threads — Tolerances — Part 1: Principles and basic data)* and at least five fully engaged threads.

Where thread forms differ between the equipment and the wiring system (for example, using NPT tapered threaded conduit and metric straight threaded equipment), Subrule 4) requires that suitable adapters be used.

To prevent tensile stress from causing damage where the hazardous location cable connects to the cable gland, Subrule 5) requires that the cable be installed and supported so as to avoid tensile stress at the cable glands.

Boxes and fittings in a Zone 2 location do not need to be explosion-proof or flameproof "d", unless specifically required by other Rules in Section 18, according to Subrule 6). However, since the only conduit method allowed is threaded rigid metal conduit and since it is desirable to give greater protection from ingress of moisture, it is recommended that the enclosures be designed for CSA Type 3R outdoor.

When using intrinsically safe systems designed and installed as "ia", "ib", and "ic", precautions need to be taken to preserve the intrinsic safety of the installation. Since these circuits have their energy limited so that any sparking or thermal effect will not ignite the explosive gas atmosphere, Subrule 8) allows an exemption from the wiring method requirements of Subrules 1) to 4).

The wiring method for Zone 2 takes into account the reduced presence of flammable gases or vapours in these locations. As a result, non-armoured cable such as Type TC or Type CIC (non-armoured control and instrumentation cable) is allowed to be used, provided that it is installed in a cable tray where exposure to mechanical damage is limited.

### Rule 18-154 Sealing, Zone 2

Sealing is to be provided for all conduits and cables entering or leaving an enclosure that is required to be explosion-proof, and at points where conduits or cables without a continuous metal or non-metal sheath enter or leave a Zone 2 location. In this respect, the requirements of Zone 2 are similar to those for Zone 1 locations (see Rule 18-104); the main difference is that not all boxes and devices in Zone 2 are required to be explosion-proof (see Table 18). Therefore, the number of places where sealing is to be provided is considerably reduced.

Subrule 1) requires that conduit seals be provided in conduit systems where:

- the conduit enters an explosion-proof or flameproof "d" enclosure that contains devices that might produce arcs, sparks, or high temperature. The conduit seal is to be located as close as practicable to the enclosure or as marked on the enclosure, but not further than 450 mm from the enclosure;
- the conduit leaves the Zone 2 location with no box, coupling, or fitting in the conduit run between the seal and the point at which the conduit crosses the boundary line, except that a rigid unbroken conduit that passes completely through a Zone 2 area with no fittings less than 300 mm beyond each boundary need not be sealed provided that the termination points of the unbroken conduit are in non-hazardous areas; or
- the conduit leaves a Zone 2 location outdoors, in which case Item c) of Subrule 1) allows the conduit to have breaks (fittings) in the 300 mm beyond the Zone 2 boundary, provided that a seal is located on the conduit prior to entering an enclosure or building, preventing the transmission of explosions or the migration of gas into the enclosure or building.

Unlike the requirement in Item b) of Subrule 1) that prohibits fittings between the seal and the boundary, Subrule 2) allows explosion-proof or flameproof "d" unions, couplings, reducers, and elbows that are not larger than the trade size of the conduit to be used between the sealing fitting and an explosion-proof or flameproof "d" enclosure.

When cables having a continuous metal or non-metal sheath exit a Zone 2 location and terminate in a non-hazardous location, Subrule 3) does not require seals, except in the following circumstances:

- when the cable enters an enclosure that is required to be explosion-proof; or
- when the cable terminates in a non-hazardous area with a negative atmospheric pressure greater than 0.2 kPa.

To prevent transmission of explosions where a run of conduit enters an enclosure that is required to be explosion-proof or flameproof "d", Subrule 4) requires that every part of the conduit from the seal to the enclosure comply with the Zone 1 requirements (see Rule 18-102).

When runs of cables that have a continuous outer sheath, either metallic or non-metallic, pass through a Zone 2 location where explosive gas is present only under abnormal conditions and then for a short time only, the presence of an explosive gas does not pose a risk because it cannot enter the cable and migrate to the non-hazardous location. Therefore, Subrule 5) allows these types of cables to pass through a Zone 2 location without seals at the boundary.

Since cables that do not have a continuous outer sheath made of either metal or non-metal will allow explosive gas, when present, to enter and migrate to non-hazardous locations, Subrule 6) requires that these types of cables be sealed at the boundary of the Zone 2 location.

When seals are required in a Zone 2 location, they perform similar functions and must conform to the same installation requirements as seals in the Zone 1 locations. To ensure that seals in a Zone 2 location are as effective as those in a Zone 1 location, Subrule 7) requires that the seals in a Zone 2 location comply with the Zone 1 requirements listed in Subrule 4) of Rule 18-104.

### Rule 18-156 Luminaires and portable lamps, Zone 2

Subrule 1) does not allow luminaires to be installed in unprotected areas in a Zone 2 location because of the danger of lamp breakage. A broken lamp produces a severe ignition hazard (for example, an arc produced by the burnout of a hot filament). However, luminaires that are protected from damage by suitable guards or by location are considered safe.

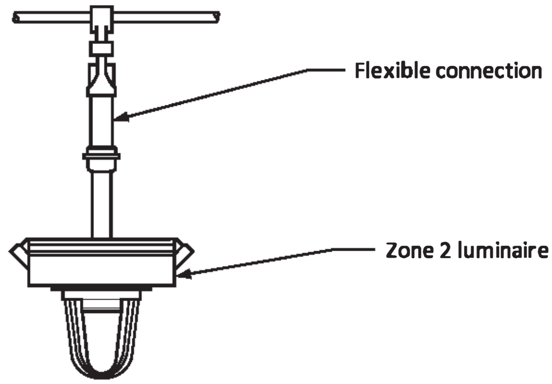
Subrule 2) requires that pendant luminaires be suspended:
- by threaded rigid conduit stems; or
- by other means specified by the manufacturer.

Subrule 3) requires that where the pendant luminaires are suspended by threaded rigid metal conduit with stems longer than 300 mm, they be provided with:
- permanent and effective bracing against lateral displacement at a level not more than 300 mm above the lower end of the stem; or
- flexibility, which is provided by a fitting or flexible connector suitable for the purpose that is positioned not more than 300 mm from the point of attachment to the supporting box or fitting.

See Figure 18-12.

Portable lamps present a great risk of being damaged and becoming an ignition source in Zone 2 locations through arcing and sparking. Subrule 4) requires that portable lamps in Zone 2 locations have the same degree of protection as those in Zone 1 locations and that they comply with the Zone 1 requirements in Subrules 1) and 2) of Rule 18-108.

**Figure 18-12**
**Pendant luminaires**




### Rule 18-158 Flexible cords, Zone 2

Subrule 1) allows flexible cords to be used for a flexible connection between permanently mounted luminaires, portable lamps, or other portable utilization equipment and the fixed portion of supply circuits. The flexible cords are to:

- be of the extra-hard-usage type;
- contain, in addition to the circuit insulated conductors, a bonding conductor;
- be provided with a sealing gland where the flexible cord enters a box, fitting, or enclosure that is required to be explosion-proof or flameproof "d"; and
- be provided with an increased safety "e" cord connector where the flexible cord enters an increased safety "e" fitting or enclosure.

Subrule 2) also allows flexible cords to be used for that portion of the circuit where fixed wiring methods cannot provide the necessary degree of movement for fixed and mobile electrical utilization equipment. Where such flexible cords are used, they are to:

- meet the requirements of Subrule 1); and
- be protected from damage by location or by a suitable guard.

## Explosive dust atmospheres

## Installations in Zone 20 locations

### Rule 18-190 Equipment, Zone 20 locations

Since Zone 20 is a location in which an explosive dust atmosphere, in the form of a cloud of dust in the air, is always expected to be present during normal operation, electrical equipment in Zone 20 is to be prevented from becoming a source of ignition. The type of equipment protection and the type of electrical equipment that are allowed to be installed in a Zone 20 location are given in Table 18.

Electrical equipment is marked with its type of protection. "Dust ignition protection by enclosure 't'" refers to a type of protection for explosive dust atmospheres where electrical equipment is provided with an enclosure providing dust ingress protection and a means to limit surface temperatures.

Equipment with dust ignition protection by enclosure "t" have one of the following levels of protection:

- ta (EPL designation — Da);
- tb (EPL designation — Db); or
- tc (EPL designation — Dc).

### Rule 18-192 Wiring methods, Zone 20

The wiring methods used in a Zone 20 location are to be able to contain a dust explosion and prevent dust migration to lower classified areas that could then ignite explosive dust accumulations. Subrule 1) requires that only threaded rigid metal conduit with a minimum of three threads of engagement as per Rule 12-1008 be used for connecting fittings or that hazardous location cables (cables marked with an HL designation) be used.

When hazardous location cables are used in a Zone 20 location, Subrule 2) requires that, in order to prevent damage to the connection at the cable gland and to make sure there is a secure connection of the cable to the equipment, the cable be installed and supported in a manner that avoids tensile stress at the cable glands.

When using threaded rigid metal conduit systems, there are many occasions where a flexible connection is required to allow for the movement, no-vibration transmission, and flexing necessitated by environmental conditions such as frost. Subrule 3) requires that where flexible connections are necessary, they be provided by:

- liquid-tight flexible metal conduit and connectors marked for heavy duty; or
- extra-hard-usage flexible cord and hazardous location cable glands.

Since oil or other corrosive conditions could enter the flexible connection over the life of the installation, Subrule 4) requires that the insulation on the conductors be suitable for the conditions or be protected by means of a suitable oil- or corrosion-resistant protective sheath over the insulation.

When using intrinsically safe systems designed and installed as "ia" or intrinsically safe equipment for Class II or Class III locations, precautions need to be taken to preserve the intrinsic safety of the installation. Since these circuits have their energy limited so that any sparking or thermal effect will not ignite the explosive dust atmosphere, Subrule 5) allows an exemption from the wiring method requirements of Subrule 1).

### Rule 18-194 Sealing, Zone 20

Where a raceway provides communication between an enclosure that is required to be dust-tight and one that is not, Rule 18-194 requires that the entrance of dust into the dust-tight enclosure through the raceway be prevented by:

- a permanent and effective seal;
- a horizontal section not less than 3 m long in the raceway; or
- a vertical section of raceway not less than 1.5 m long and extending downward from the dust-tight enclosure.

### Rule 18-196 Flexible cords, Zone 20

Where flexible cords are used, Rule 18-196 requires that they be extra-hard-usage type cords with cable glands suitable for the application.

## Installations in Zone 21 locations

### Rule 18-200 Equipment, Zone 21 locations

The type of equipment protection and the type of electrical equipment that are allowed to be installed in a Zone 21 location are given in Table 18.

### Rule 18-202 Wiring methods, Zone 21

The wiring methods required in Zone 21 are:

- threaded rigid metal conduit with a minimum of three threads of engagement required in connecting fittings; or
- hazardous location cables (cables marked with an HL designation).

Subrule 2) requires that boxes, fittings, and joints be threaded with a minimum of three threads of engagement when connected to conduit or cable glands, and boxes and fittings be suitable for use in Zone 21 locations.

When hazardous location cables are used in a Zone 21 location, Subrule 3) requires that, to prevent damage to the connection at the cable gland and to make sure there is a secure connection of the cable to the equipment, the cable be installed and supported in a manner that avoids tensile stress at the cable glands.

When using threaded rigid metal conduit systems, there are many occasions where a flexible connection is required to allow for the movement, no-vibration transmission, and flexing caused by environmental conditions such as frost. Subrule 4) requires that, where flexible connections are necessary, they be provided by:

- liquid-tight flexible metal conduit and connectors marked for heavy duty; or
- extra-hard-usage flexible cord and hazardous location cable glands.

Since oil or other corrosive conditions could enter the flexible connection over the life of the installation, Subrule 5) requires that the insulation on the conductors be suitable for the condition or be protected by means of a suitable oil- or corrosion-resistant sheath over the insulation.

When using intrinsically safe systems designed and installed as "ia" or "ib", or intrinsically safe equipment for Class II or Class III locations, precautions need to be taken to preserve the intrinsic safety of the installation. Since these circuits have their energy limited so that any sparking or thermal effect will not ignite the explosive dust atmosphere, Subrule 6) allows an exemption from the wiring method requirements of Subrules 1) and 2).

### Rule 18-204 Sealing, Zone 21

Where a raceway provides communication between an enclosure that is required to be dust-tight and one that is not, Rule 18-204 requires that the entrance of dust into the dust-tight enclosure through the raceway be prevented by:

- a permanent and effective seal;
- a horizontal section not less than 3 m long in the raceway; or
- a vertical section of raceway not less than 1.5 m long and extending downward from the dust-tight enclosure.

## Installations in Zone 22 locations

### Rule 18-250 Equipment, Zone 22 locations

The type of equipment protection and the type of electrical equipment that are allowed to be installed in a Zone 22 location are given in Table 18.

### Rule 18-252 Wiring methods, Zone 22

Rule 18-252 is essentially the same as Rule 18-202, which applies to Zone 21 locations, except that the requirements for boxes and fittings are relaxed. The wiring methods required are as follows:

- threaded rigid metal conduit with a minimum of three threads of engagement for connecting fittings;
- hazardous location cables (cables marked with an HL designation);
- Type TC cable installed in cable tray in accordance with Rule 12-2202 and enclosed in rigid conduit or another acceptable wiring method wherever it leaves the cable tray;
- armoured cable with overall non-metallic jacket, such as TECK90, ACWU90, copper-sheathed RC90, or aluminum-sheathed RA90;
- control and instrumentation cables with an interlocking metallic armour and a continuous jacket in control circuits (Type ACIC);

- Type CIC cable (non-armoured control and instrumentation cable) installed in cable tray in accordance with the installation requirements of Subrule of 2) Rule 12-2202, provided that:
  - the voltage rating of the cable is not less than 300 V;
  - the circuit voltage is 150 V or less; and
  - the circuit current is 5 A or less;
- RTRC Type XW conduit, provided that:
  - boxes, fittings, and joints are specifically approved for the purpose and are marked with the suffix " -XW"; and
  - installation is performed in industrial establishments that are not accessible to the public and where only qualified persons service the installation; or
- liquid-tight flexible conduit with fittings marked for heavy duty.

Subrule 2) requires that boxes and fittings in which taps, joints, or terminal connections are made be an Enclosure Type 4 or 5, or:
- be provided with telescoping or close-fitting covers, or other effective means to prevent the escape of sparks or burning material; and
- have no openings, such as holes for attachment screws, through which, after installation, sparks or burning material might escape, or through which exterior accumulations of dust or adjacent explosive material might be ignited.

When hazardous location cables are used in a Zone 22 location, Subrule 3) requires that, in order to prevent damage to the connection at the cable gland and to make sure there is a secure connection of the cable to the equipment, the cables be installed and supported in a manner that avoids tensile stress at the cable glands.

In threaded rigid metal conduit systems there are many occasions where a flexible connection is required to allow for the movement, no-vibration transmission, and flexing necessitated by environmental conditions such as frost. Subrule 4) requires that where flexible connections are necessary, they be provided by extra-hard-usage flexible cord and cable glands suitable for the application.

Since oil or other corrosive conditions could enter the flexible connection over the life of the installation, Subrule 4) also requires that the insulation on the conductors be suitable for the condition or be protected by means of a suitable oil- or corrosion-resistant sheath over the insulation.

When using intrinsically safe systems designed and installed as "ia", "ib," or "ic", or intrinsically safe equipment for Class II or Class III locations, precautions need to be taken to preserve the intrinsic safety of the installation. Since these circuits have their energy limited so that any sparking or thermal effect will not ignite the explosive dust atmosphere, Subrule 5) allows an exemption from the wiring method requirements of Subrules 1) and 2).

### Rule 18-254 Sealing, Zone 22

Where a raceway provides communication between an enclosure that is required to be dust-tight and one that is not, Rule 18-254 requires that the entrance of dust into the dust-tight enclosure through the raceway be prevented by:
- a permanent and effective seal;
- a horizontal section not less than 3 m long in the raceway; or
- a vertical section of raceway not less than 1.5 m long and extending downward from the dust-tight enclosure.

# Section 20 — Flammable liquid and gasoline dispensing, service stations, garages, bulk storage plants, finishing processes, and aircraft hangars

### Rule 20-000 Scope

Locations in which flammable gases or vapours are or can be present in the air in quantities sufficient to produce explosive or ignitable mixtures are classified as explosive gas hazardous locations. This Section deals with Zone 0, 1, and 2 hazardous locations as defined in Section 18.

Subrules 2) and 3) allow users to continue to apply the Division system of classification for Class I locations, where necessary, in accordance with the Rules given in Annex J20 of Appendix J.

Section 20 intends to prevent electrical installations and electrical equipment from igniting explosions and fires in areas where flammable gases (e.g., propane and compressed natural gases) are dispensed, stored, or transferred, or where flammable liquids (e.g., gasoline) are dispensed or stored, or where flammable paints or finishes are applied. It covers issues such as the degree and extent of the boundaries of hazardous locations, and the wiring methods and electrical equipment to be used. The definitions given in Section 18 apply in Section 20.

## Gasoline dispensing and service stations

Gas stations are a common hazardous location. Self-serve stations specify both public and employee safety requirements for areas where gasoline or other flammable liquids are dispensed into the fuel tanks of vehicles, as well as for the hazardous areas and wiring methods within service stations.

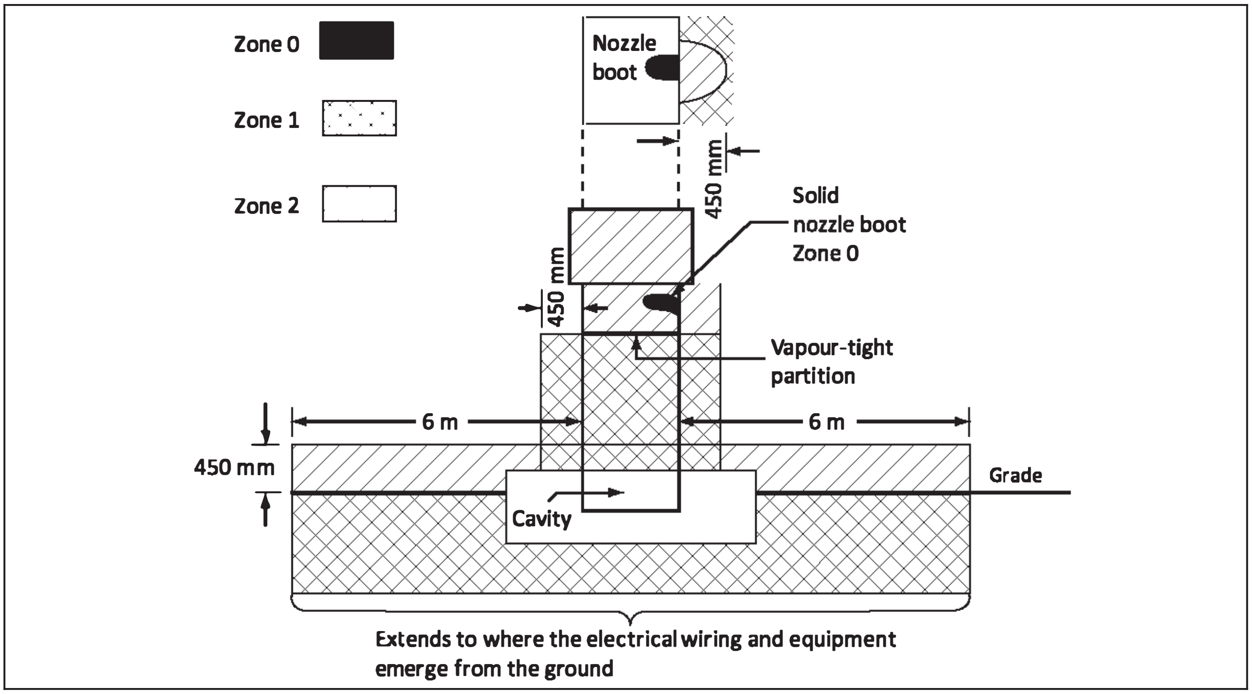
### Rule 20-004 Hazardous areas

Rule 20-004 specifies the category and boundaries of the hazardous locations, both within a gasoline dispenser enclosure and in the areas surrounding it. The extent of the boundaries and the degree (Zone 0, 1, or 2) of hazard are based on the fact that gasoline vapours are heavier than air. For example, if gasoline spills while a vehicle is being refuelled, the resulting vapour, together with gasoline vapour vented from vehicle fuel tanks, tends to stay close to the ground. Thus, the hazardous area near the ground extends farther from the dispenser than the area higher up. Any gasoline spilled during refuelling could accumulate in pits and depressions and enter the electrical system. Consequently, the space below areas subject to fuel spills is classified as a Zone 1 location.

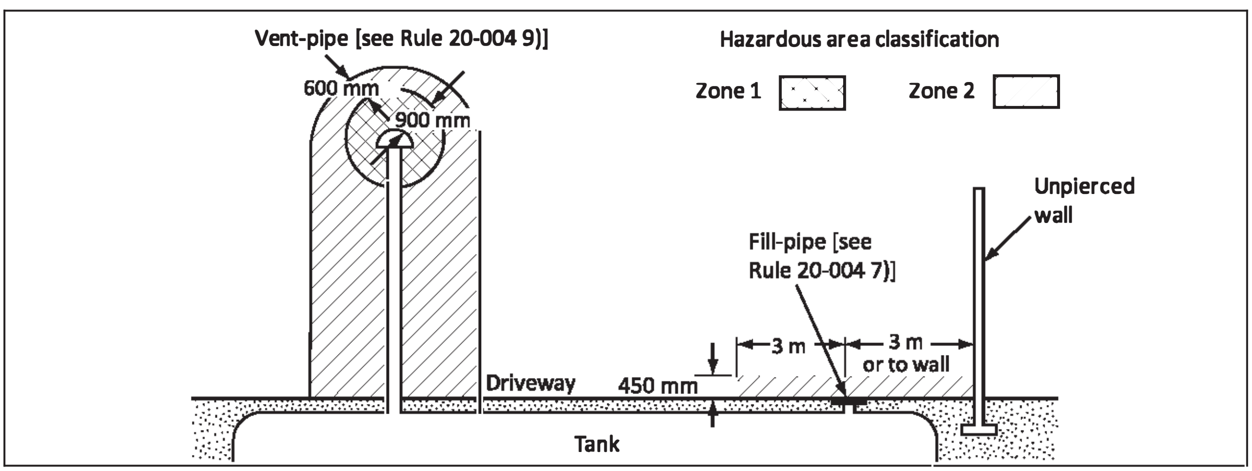
Subrule 6) requires that in an outside location, any area beyond the Zone 1 area (and in buildings not suitably cut off) within 6 m horizontally from the exterior enclosure of any dispenser be a Zone 2 location that extends to a level 450 mm above driveway or ground level. This Zone 2 location extends into a building partly located within the hazardous area, unless a solid wall cuts off or interrupts the Zone 2 location (e.g., a solid wall of the service station). The Appendix B Note to Rule 20-004 includes further information on buildings that are considered not suitably cut off.

See Figures 20-1 and 20-2.

## Figure 20-1
## Cross-sectional view of dispenser with vapour-tight partition



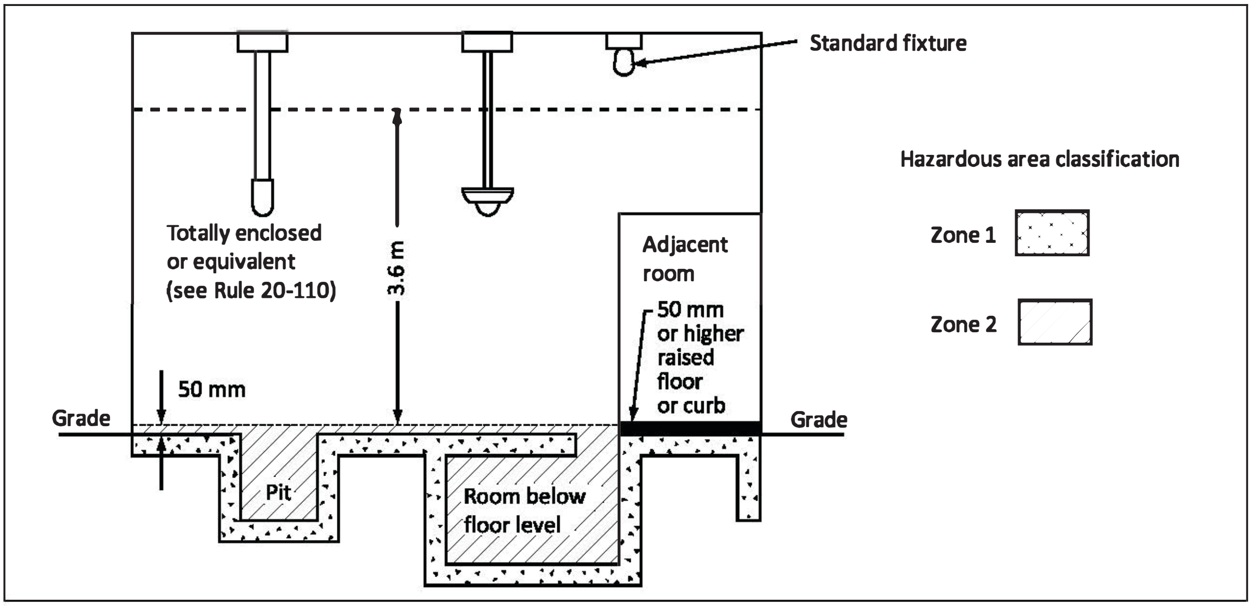

## Figure 20-2
## Gasoline storage tank installation




Areas adjacent to any tank fill-pipes are classified as hazardous because gasoline can spill during filling operations. The space around tank vent-pipes is classified as hazardous because gasoline vapours are vented from the storage tank as it is filling. If the vent-pipe discharges downward, the hazardous area extends to the ground level because the heavier-than-air vapours tend to drop to ground level. Subrule 9) classifies the hazardous areas within the vicinity of tank vent-pipes.

In service areas, including lubrication rooms of service stations, smaller quantities of gasoline spill out or leak from vehicle fuel tanks and engines, so the hazardous area extends only to a height of 50 mm above the floor. The hazardous areas in these service areas or similar buildings are classified in Subrule 10) and as shown in Figure 20-3. An exception to Item a) of Subrule 10) is allowed where adequate ventilation is provided. The ventilation can be mechanical or natural.

**Figure 20-3**
**Typical lubricating section of commercial service station**




## Rule 20-006 Wiring and equipment within hazardous areas

The type of wiring and electrical equipment required in a particular hazardous location depends on the classification of the hazardous location and the type of flammable liquid present. Where gasoline is involved, the classification is Zone 1 or Zone 2. Electrical equipment suitable for use in these hazardous areas is to be marked for use in Group IIA locations. Section 18 gives the requirements for the wiring methods and equipment that are allowed in the hazardous areas.

Where gasoline dispensers are supplied by rigid metal conduit or a cable, Subrule 2) requires that a union be provided. The union allows the dispenser to be changed (e.g., converted from full-serve to self-serve) and still maintain the integrity of the seal and the physical integrity of the conduit or cable.

When the gasoline dispensers are supplied by rigid metal conduit, in addition to the union required by Subrule 2), a flexible connection is required. The flexible connection allows for:

- vibration and movement of the dispenser without any damage being caused; and
- some movement of the dispenser if it is bumped or if the concrete base rises because of cold temperatures.

## Rule 20-008 Wiring and equipment above hazardous areas

Since gasoline vapours fall rather than rise, the space above the hazardous areas can be classified as non-hazardous, with some restrictions on the wiring and electrical equipment allowed. The restrictions are listed in Rules 20-106 and 20-110.

## Rule 20-010 Circuit disconnects

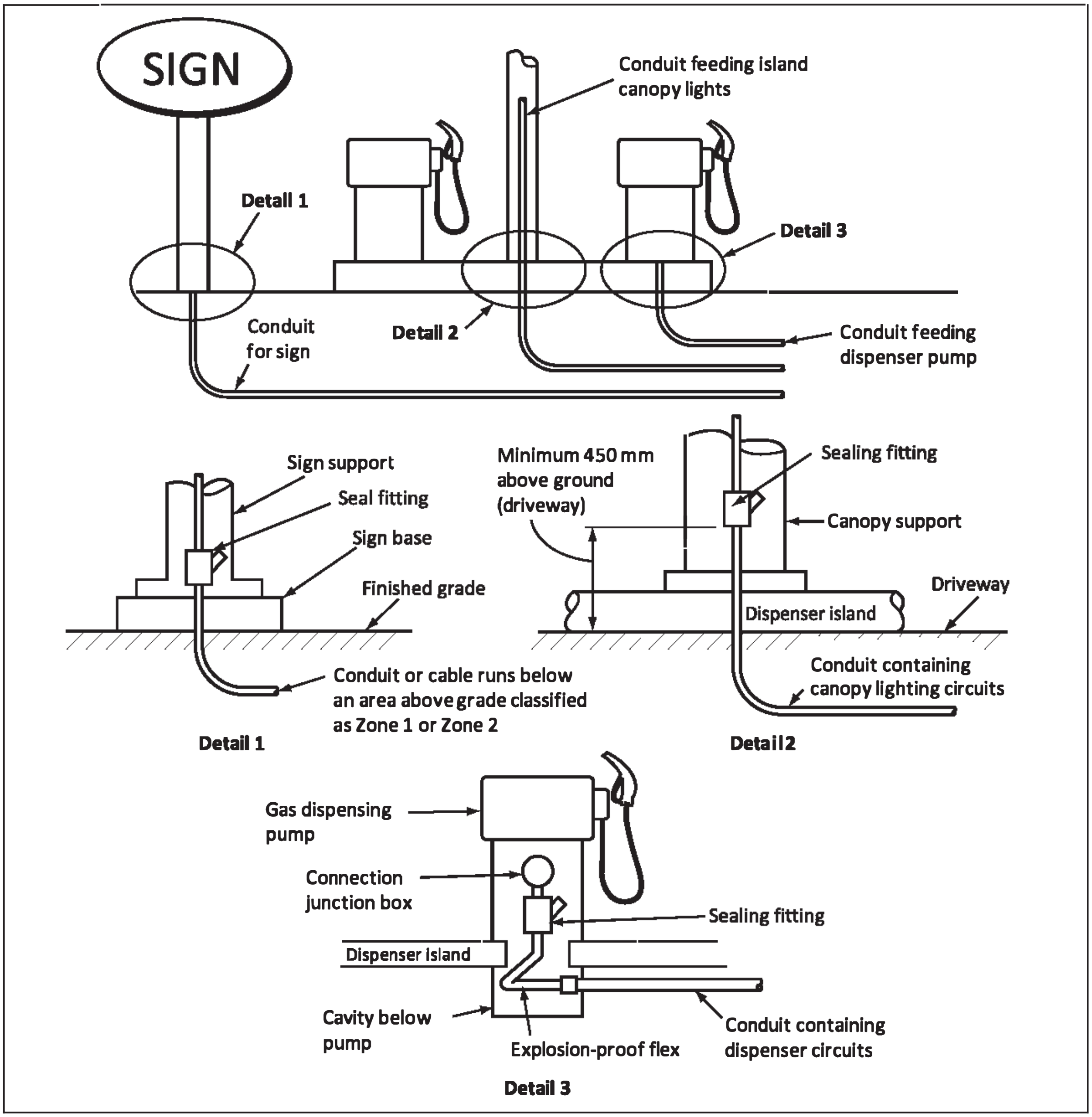
When maintenance is taking place on a gas pump, energized conductors are not to be in the vicinity of the dispenser. They would create a shock or fire hazard as any spark from the energized conductor could be a source of ignition for any gasoline vapours that might be present. Rule 20-010 requires that a disconnecting means be provided in each branch circuit leading to a dispensing pump, as well as in any circuit leading through the pump to another pump or to island lighting. Since all ungrounded conductors are to be disconnected simultaneously, a multi-phase circuit requires a multi-pole disconnecting means whereby operation of the switching mechanism de-energizes all phase conductors of the circuit at the same time.

### Rule 20-012 Sealing

In accordance with Subrule 1), sealing fittings, as required by Section 18, are to be installed in conduit entering or leaving a dispenser or the cavity below it. These fittings prevent the passage of gasoline vapours at normal atmospheric pressure or flames from an explosion inside the gas dispenser to the building where the electrical power supply originates or from one dispenser to another. Seals are also to be installed where the conduit enters or leaves the Zone 2 areas surrounding the dispenser. These seals are usually installed just above the Zone 1 area so that non-hazardous wiring methods can be used where the branch circuit originates within the building. See Figure 20-4.

When a dispenser is supplied by a cable suitable for the location, the cable is to be sealed, as required by Subrule 3) of Rule 18-104, by means of a cable gland. Subrule 2) requires that cables suitable for hazardous locations (e.g., TECK90-HL, which has a gas-/vapour-tight sheath) be sealed at the dispenser [see Subrules 5) and 6) of Rule 18-104].

**Figure 20-4**
**Sealing fittings**




## Rule 20-014 Bonding

To avert shock and fire hazards, all metal parts of dispensing pumps, raceways, and other electrical equipment are to be bonded to ground. Rule 20-014 requires that all metal parts be bonded to each other by positive metal contact or by bonding jumpers and be connected to a bonding conductor that is connected to ground. Since metal conduit underground can corrode, Section 10 requires that a separate bonding conductor be installed in the supply conduit.

## Propane dispensing, container filling, and storage

At normal pressure and temperature, propane is gaseous while gasoline is liquid. When dispensed, propane is kept in the liquid state by being stored and transferred under a pressure higher than that developed in a typical gasoline dispenser. At room temperature, the pressure inside a propane tank is about 140 psi (approximately 965.3 kPa). In the event of a fluid handling system rupture, all of the spilled liquid propane will instantly vaporize into the atmosphere, forming a flammable vapour cloud, and the entire room/area can soon become hazardous. The release of propane under pressure is quite different from a leak in a gasoline tank. It cannot be assumed that the hazardous mixture will stay close to the floor, even though propane is heavier than air.

### Rule 20-034 Hazardous areas

Bulk propane storage and distribution facilities are the most common type of propane dispensing, transferring, and storage facilities. These usually include large-volume storage tanks filled from rail cars or tanker vehicles, as well as the dispensing pumps to dispense or transfer propane to self-propelled vehicles or portable containers.

Table 63 specifies the category and the boundaries of the hazardous locations within both a container refill centre and a filling plant.

Diagram 7 illustrates the extent of the hazardous locations where a tank vehicle and a tank car are loaded and unloaded. Diagram 8 shows the extent of the hazardous locations outdoors in open air for pumps, vapour compressors, gas air mixers, and vaporizers. Diagram 9 illustrates the extent of the hazardous locations outdoors in open air for container filling areas.

### Rule 20-040 Circuit disconnects

When maintenance is being done on a propane dispensing device or pump, energized conductors are not to be in the vicinity of the dispenser. They would create shock and fire hazards as any spark from the energized conductor could be a source of ignition for any propane vapours that might be present. Rule 20-040 requires that a disconnecting means be provided in each branch circuit leading to a dispensing device and pump, as well as in any circuit leading through the pump to another pump or to island lighting. Since all ungrounded conductors are to be disconnected simultaneously, a multi-phase circuit requires a multi-pole disconnecting means whereby operation of the switching mechanism de-energizes all phase conductors of the circuit at the same time.

### Rule 20-042 Bonding

Rule 20-042 requires that all metal parts of electrical equipment and raceways be bonded to each other by positive metal contact or by bonding jumpers and be connected to a bonding conductor that is connected to the system ground, as required by Section 10.

## Compressed natural gas refuelling stations, compressors, and storage facilities

At normal pressure and temperature, compressed natural gas is lighter than air. To ensure sufficient fuel to propel a vehicle a reasonable distance, compressed natural gas is dispensed at high pressure. Compressors are used to compress the natural gas coming from a natural gas distribution system. Due to this high storage tank pressure, the rate of release of compressed natural gas is much faster than that of gasoline or propane. Compressed natural gas does not stay close to the floor because it is lighter than air, and, therefore, the entire room/area can quickly become hazardous.

### Rule 20-062 Hazardous areas

Any flammable compressed gas leak can soon become hazardous in an enclosed space because the walls will prevent clean air dilution and dispersal of the accumulated gas. Therefore, the area surrounding compressed natural gas refuelling stations, compressors, and storage facilities is classified as Zone 1. The extent of the hazardous location is based on the storage volume of natural gas (based on water capacity in litres) and the distance from the storage container, measured in metres, as indicated in Table 64.

### Rule 20-064 Wiring and equipment in hazardous areas

Section 18 gives the requirements for the wiring methods and type of electrical equipment allowed to be used in the hazardous areas specified in Rules 20-062 and 20-064. Explosion-proof electrical equipment suitable for use in these locations is to be marked for Zone 1, Group IIA, or Zone 2, Group IIA. The letter "A" refers to a group of flammable gases and vapours, including natural gas, with similar explosion characteristics for which the electrical equipment is certified (see the Appendix B Note to Rules 18-050 and 18-064).

Where compressed natural gas dispensers are supplied by rigid metal conduit, Subrule 2) requires that a flexible connection be provided to allow for vibration and limited movement of the dispenser if it is bumped or if the concrete base rises because of cold temperatures. A union is required to allow the dispenser to be changed without damaging the integrity of the seal.

### Rule 20-066 Sealing

Sealing fittings, where required by Section 18, are to be installed to prevent the passage of gases, vapours, or flames from one portion of the electrical installation to another. The requirements for seals are applied to both the horizontal and the vertical boundaries of the hazardous locations since compressed natural gas can spread into the atmosphere rapidly and in large quantities under leakage or fault conditions.

Where conduit is used to supply compressed natural gas dispensers, seals are to be used to prevent the passage of gas or flames to the building where the supply originates or from one dispenser to another.

When the compressed natural gas dispenser is supplied by a cable suitable for the location, Rule 20-066 intends that the cable be sealed by use of a cable gland as required by Subrule 3) of Rule 18-104. Cables suitable for hazardous locations (e.g., TECK90-HL, which has a gas-/vapour-tight sheath) are to be sealed at the dispenser but not at the boundary [see Subrules 5) and 6) of Rule 18-104].

### Rule 20-068 Circuit disconnects

Rule 20-068 requires that a switching means be provided in each branch circuit leading to a compressor or dispensing device, as well as in any circuit leading through the compressor to another compressor or to island lighting. Since all ungrounded conductors are to be disconnected simultaneously, a multi-phase circuit requires a multi-pole disconnecting means whereby operation of the switching mechanism de-energizes all phase conductors of the circuit at the same time.

### Rule 20-070 Bonding

Rule 20-070 requires that all metal parts of electrical equipment and raceways be bonded to each other by positive metal contact or by bonding jumpers and be connected to a bonding conductor that is connected to the system ground, as required by Section 10.

## Commercial repair garages

In commercial garages, where vehicles are serviced or repaired, gasoline, propane, or other flammable fuels can leak from vehicle fuel tanks or engines onto the floor. Other flammable liquids can also be used in servicing the vehicles. Consequently, it is necessary to specify requirements for wiring and electrical equipment both within the hazardous area and above it.

### Rule 20-102 Hazardous areas

Since the main concern in commercial garages is the possibility of gasoline spilling or leaking onto the floor in relatively small quantities, the hazardous areas are classified as Zone 2. In addition, Subrule 1) states that for each floor at or above grade, the hazardous area extends only to a height of 50 mm above floor level. To avoid any Zone 2 hazardous area classification in showrooms and other adjacent areas, they are to be:

- elevated from a service and repair area by at least 50 mm; or

- separated from a service and repair area by tight-fitting barriers such as curbs, ramps, or partitions at least 50 mm high.

Subrule 2) requires that, where flammable vapours can occupy the entire area below grade up to the outside entrance, the entire below-grade area be classed as hazardous. However, if this area is properly ventilated, with adequate mechanical or natural ventilation, the hazardous area can be reduced to just 50 mm above the floor.

Subrule 3) requires that any pit in a floor, such as an elevator pit, be a Zone 2 location extending up to 50 mm above the floor level.

### Rule 20-104 Wiring and equipment in hazardous areas

Rule 20-104 requires that the wiring and electrical equipment be installed to meet the requirements of Section 18 for Zone 2 hazardous locations.

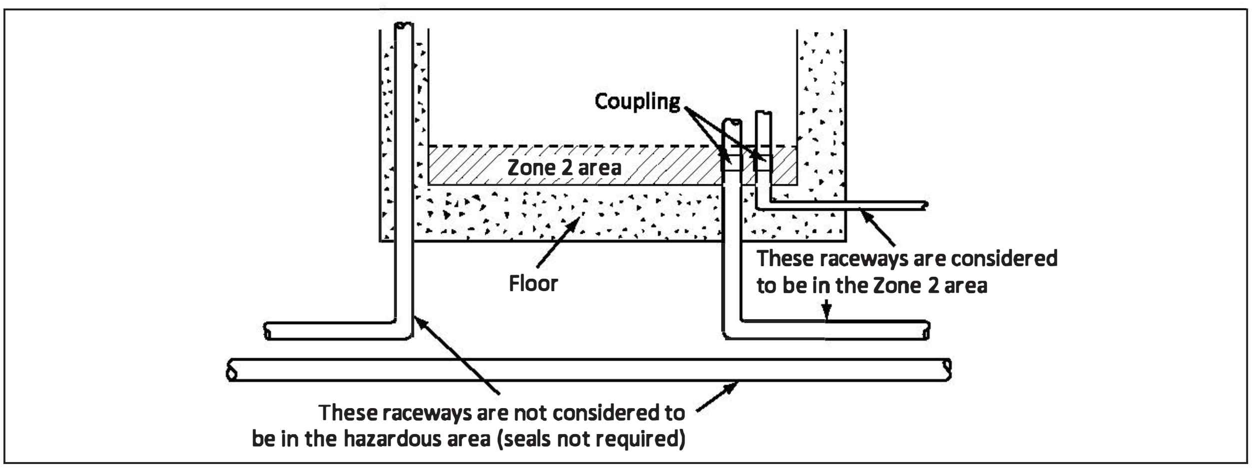
### Rule 20-106 Wiring above hazardous areas

The danger of ignition from any fixed wiring above the hazardous areas is minimal. Therefore, the fixed wiring is allowed to be of a type suitable for non-hazardous locations. However, Subrule 3) requires that any cords used to supply pendants or portable electrical equipment in the garage section be of the hard-usage type, which is less likely to break down and overload or cause an arc.

### Rule 20-108 Sealing

Seals are required to prevent flammable vapours from migrating through the conduit or cables to sources of ignition in non-hazardous areas. Where a raceway is embedded in the floor, or is below and passes up through the floor, flammable vapours can enter it. Therefore, such raceways are considered to be within the Zone 2 hazardous area and are to be sealed in accordance with Section 18 (see Figure 20-5). A seal is not required where the raceways extend unbroken through the hazardous area in compliance with Rule 18-154.

**Figure 20-5**
**Classification for raceways passing through or buried under service station floors**




### Rule 20-110 Equipment above hazardous areas

Fixed electrical equipment having make-and-break or sliding contacts and mounted less than 3.6 m above hazardous areas (such as charging panels, generators, open motors, and switches) can produce arcs and sparks or hot metal particles from abnormal operation; these can drop into the hazardous area below. Subrule 1) requires such equipment (excluding receptacles and luminaires) be either of the totally enclosed type or constructed to prevent the escape of sparks or hot particles. If such equipment is mounted 3.6 m or higher above the hazardous area, any escaping sparks or hot particles will cool or dissipate sufficiently before reaching the hazardous area; therefore, the equipment does not have to be of the totally enclosed type or constructed to prevent the escape of sparks or hot particles.

Subrule 2) allows permanently installed luminaires located over drive lanes to be of the types suitable for non-hazardous locations if they are:

- mounted at least 3.6 m above the floor level; or
- protected from mechanical damage by a guard or by location.

Since portable luminaires are not fixed in position, to prevent them from becoming a source of ignition in the hazardous area, Subrule 3) requires that they:

- be of the totally enclosed gasketted type;
- have no switch or receptacle in the lamp or handle; and
- meet the following additional requirements:
  - they be equipped with a handle, hook, and guard attached to the lampholder or handle; and
  - all exterior surfaces be of non-conducting material or protected with an insulating jacket so that no spark will occur if the luminaire comes into contact with battery terminals, wiring terminals, or other objects.

### Rule 20-112 Battery-charging equipment

Battery-charging equipment is not normally certified for hazardous locations. Arcing or sparks can occur at the battery terminals when the charger leads are being connected, and the batteries themselves can explode or short-circuit, igniting any flammable liquids on the garage floor. Rule 20-112 requires that battery chargers, their control equipment, and the batteries being charged not be located or used in the hazardous areas indicated in Rule 20-102.

## Bulk storage plants

The storage and distribution of large quantities of flammable liquids, such as gasoline, can be hazardous. Therefore, the degree and boundaries of the explosive gas hazardous locations are clearly specified. Storage and distribution facilities for materials such as gasoline and fuel oil are the most common type of bulk storage facilities for flammable liquids. These usually include large-volume storage tanks filled from rail tank cars or from tanker ships. The flammable liquid is pumped from the storage tanks through pipelines to loading facilities where tanker trucks are loaded for distribution to service stations or individual users.

### Rule 20-200 Scope

In bulk storage plants where the amount of flammable liquid in one storage tank or in a group of tanks is equal to one rail car (tank car) or more, Rules 20-202 to 20-212 apply in determining the degree and extent of the hazardous location and the type of wiring and electrical equipment to be used in these facilities. Rules 20-202 to 20-212 also cover the transfer of such volatile flammable liquids to the tanks from tanker trucks or rail tank cars or, conversely, from the tanks to tanker trucks or rail tank cars for distribution.

### Rule 20-202 Hazardous areas

Since there is some risk of leakage from pumps, meters, valves, and other equipment associated with a pipeline conveying flammable liquids (such as gasoline), the areas around these devices are to be classified. Being heavier than air, vapours concentrate near the floor or at grade level below the devices. In bulk storage plants, the classification and extent of the explosive gas hazardous location is as given in Table 69.

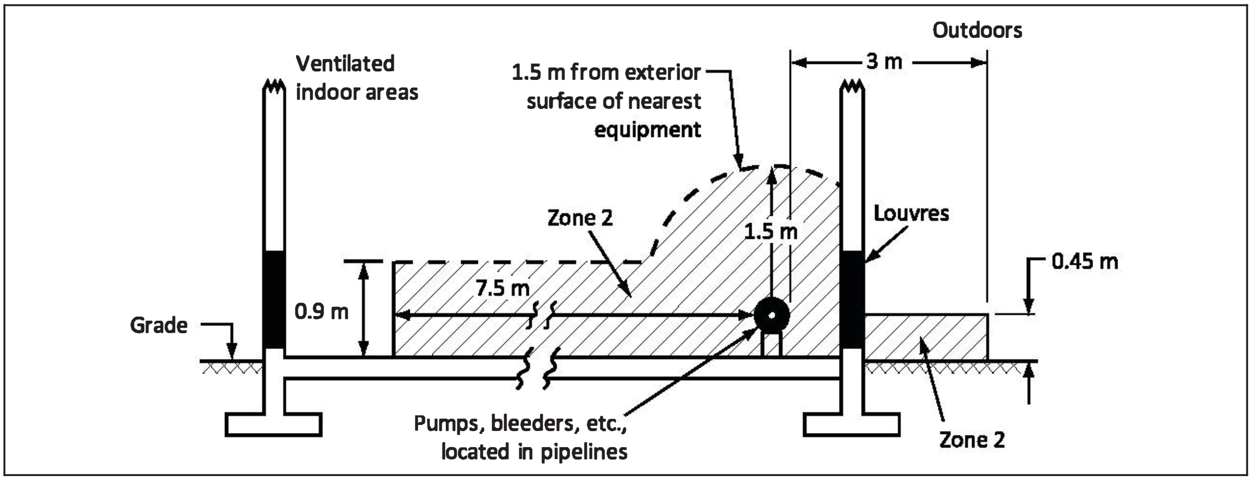
In indoor areas, the classification of the hazardous area (i.e., Zone 1 or Zone 2) depends on whether ventilation is provided. If provided, the ventilation system is to take into account the density of the vapours, and venting to the outdoors is to be unobstructed (see Figure 20-6). If the natural ventilation is inadequate, mechanical ventilation is to be provided.

In outdoor areas where similar devices are located in pipelines, the extent of the hazardous location is allowed to be reduced because the flammable vapours disperse more rapidly. See Figure 20-7.

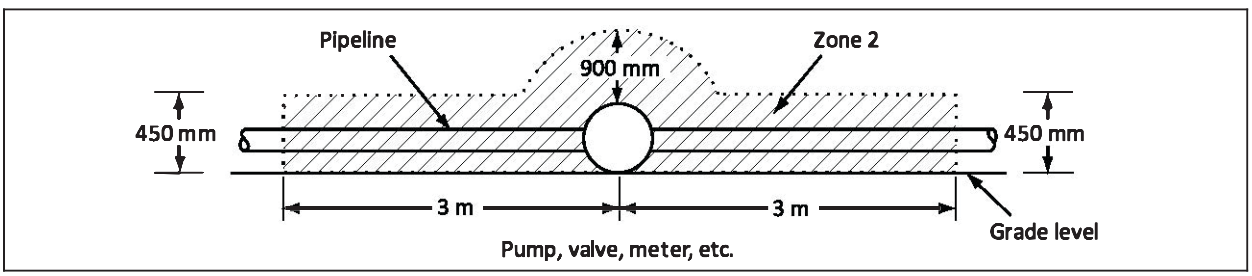
In indoor areas where flammable liquids are transferred from a storage tank to individual containers such as drums or cans:

- If no ventilation is provided, the entire room or area is to be considered a hazardous area.
- If adequate ventilation is provided, the extent of the hazardous area can be reduced to the same level as that for a similar operation conducted outdoors (see Figures 20-8 and 20-9).

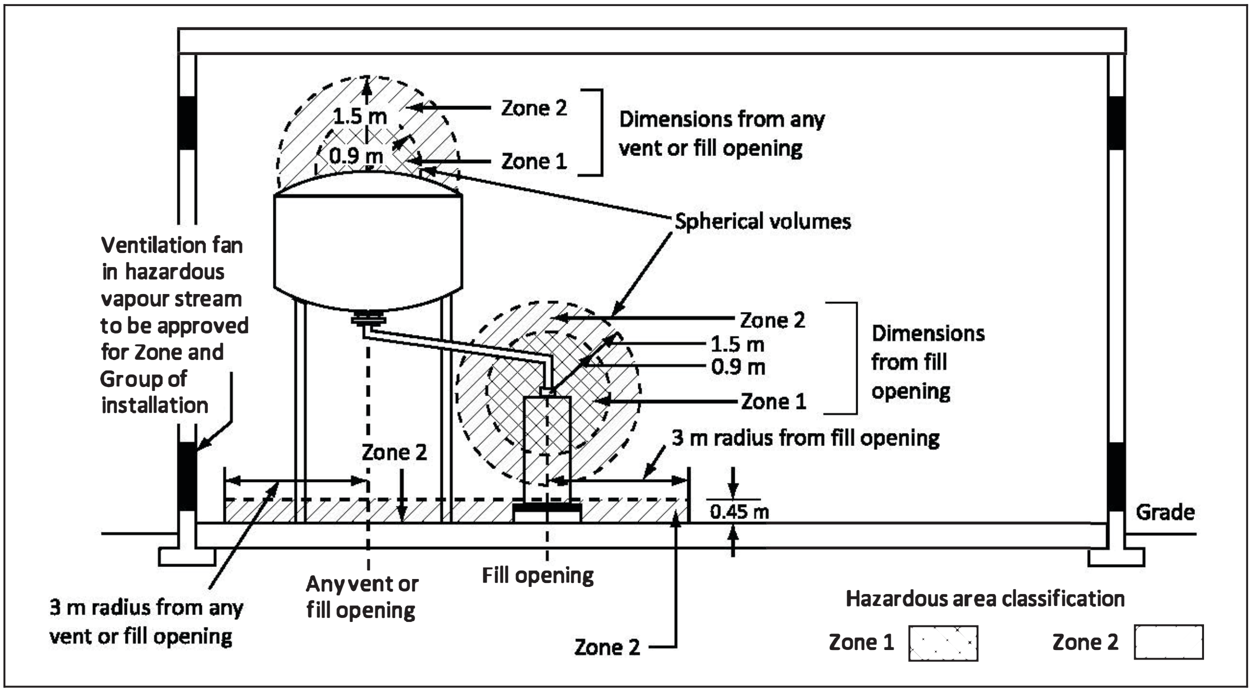
## Figure 20-6
## Ventilated indoor bulk flammable liquid storage area



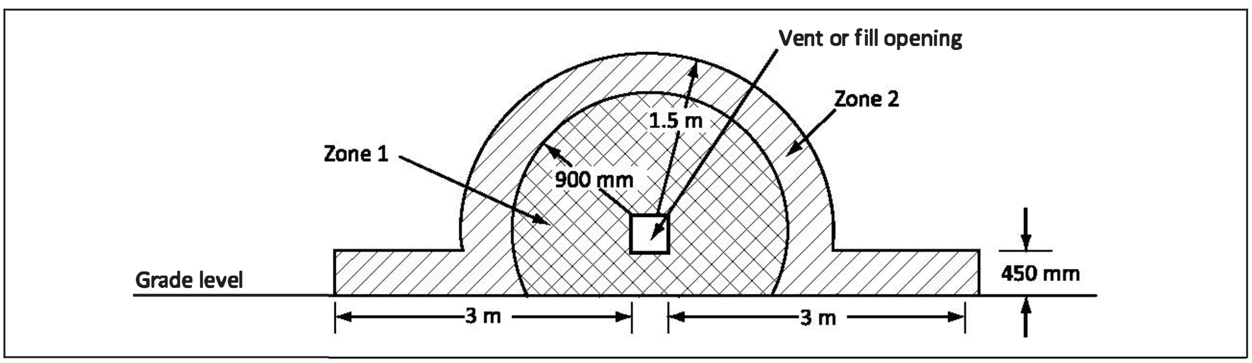

## Figure 20-7
## Outdoor bulk flammable liquid storage area



## Figure 20-8
## Ventilated indoor transfer of flammable liquids to individual containers




## Figure 20-9
## Outdoor transfer of flammable liquids to individual containers




Due to the large volume of liquid and vapour when loading and unloading tanker trucks and rail cars, these operations are almost always performed outdoors. The hazardous area is the space around the:

- dome opening in the storage tank if loading is being done through this opening; or
- vent if loading is being done through a closed connection in the dome.

Where the tanker truck or rail car is loaded or unloaded from the bottom, the area near grade level is to be considered hazardous. See Figures 20-10 to 20-12.

The internal space of tank vehicles is considered to have an explosive gas atmosphere either continuously or for long periods of time, and, therefore, the Section 18 definition of a Zone 0 location applies. There is to be no wiring or equipment in the internal space of tank vehicles, except intrinsically safe wiring and equipment as allowed in Section 18 for Zone 0 locations.

**Figure 20-10**
**Top-loading of tanker trucks and rail cars in outdoor locations**

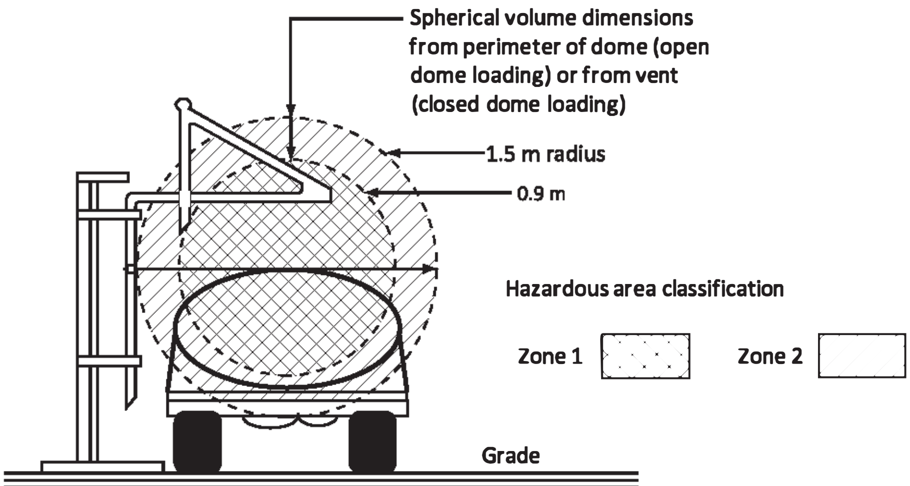



**Figure 20-11**
**Loading of rail cars and tanker trucks through dome by use of fixed connections**

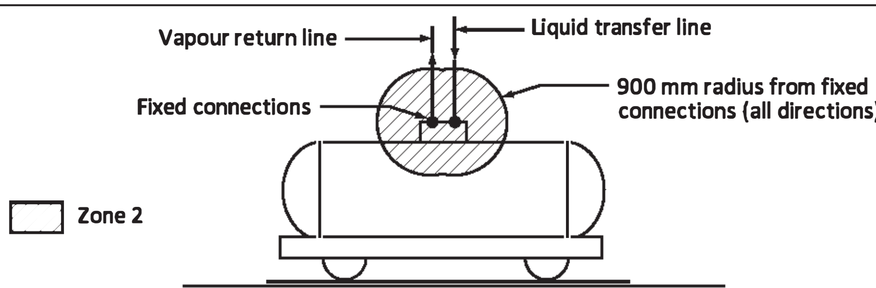
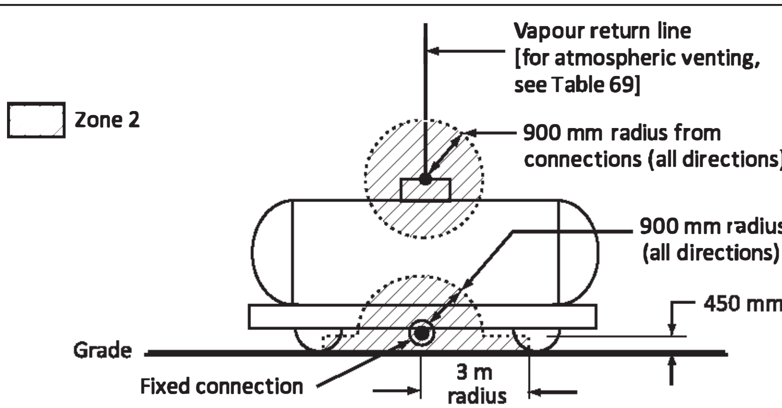



**Figure 20-12**
**Bottom-loading and unloading of rail cars and tanker trucks by use of fixed connections**

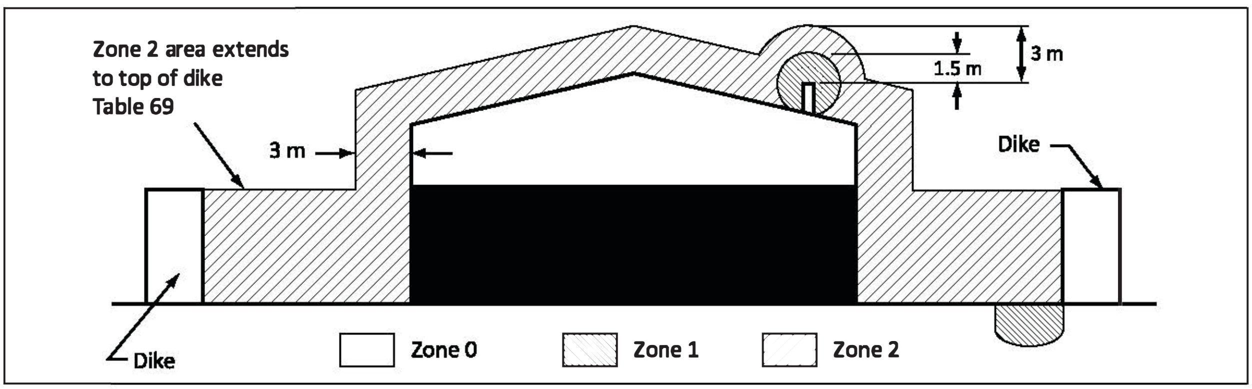


For above-ground bulk storage tanks located outdoors, which can contain many carloads of flammable liquid, the extent of the hazardous areas surrounding the vents is approximately double that for the vents on a tanker car being loaded or unloaded. This is because a larger volume of vapour is displaced through the vents as the tank is being filled. See Figure 20-13.

The vapour space above the liquid in a storage tank is considered to have an explosive gas atmosphere either continuously or for long periods of time, and, therefore, this area is classified as a Zone 0 location. No wiring or equipment is allowed in the internal space above the liquid in a storage tank, except intrinsically safe wiring and equipment as allowed in Section 18 for Zone 0 locations.

In garages where tank vehicles are stored or repaired, the hazardous area above the floor is to extend to a level of at least 450 mm. In addition, the vertical distance is to be increased or the classification changed to a Zone 1 area if this is warranted. Again, the fact that a tanker truck contains a greater volume of flammable liquid and vapour than an automobile fuel tank justifies the more restrictive requirement.

**Figure 20-13**
**Area classification around vent in bulk flammable liquid storage tank**




### Rule 20-212 Bonding

Rule 20-212 requires that all metal parts of electrical equipment and raceways be bonded to each other by positive metal contact or by bonding jumpers and be connected to a bonding conductor that is connected to the system ground, as required by Section 10.

## Finishing processes

Finishing processes (i.e., spray and other types of painting) often involve the use of flammable solvents and thinners, increasing the risk of fire and explosion. The possible ignition of deposits or residues from paints and finishes is to be considered when providing electrical safety requirements for these areas.

### Rule 20-300 Scope

Rules 20-302 to 20-308 apply to areas where paints, varnishes, lacquers, or any other flammable finishes are regularly or frequently applied to goods or materials by spraying, dipping, brushing, or other means. In addition, Rules 20-302 to 20-308 apply where flammable solvents and thinners are used in conjunction with the painting operations and where easily ignitable deposits or residues from the paints and other finishes are likely to be present.

### Rule 20-302 Hazardous locations

The principal hazards of spraying operations originate from the flammable paints or finishes, the vapours and mists generated, and the highly combustible residues that accumulate from certain finishes. Such spraying operations can be performed relatively safely in properly designed and well-ventilated spray booths. However, the interior of the spray booth and the booth exhaust ducts are to be classified as Zone 1 locations, in accordance with Subrule 1).

The hazardous areas surrounding dip tanks and their drain boards are classified as illustrated in Figure 20-14. In rooms where extensive open spraying is conducted, with or without floor-level ventilation interlocked with the spraying equipment, the hazardous areas are as indicated in Figures 20-15 and 20-16, respectively.

**Figure 20-14**
**Classification of areas surrounding a dip tank and drain board**

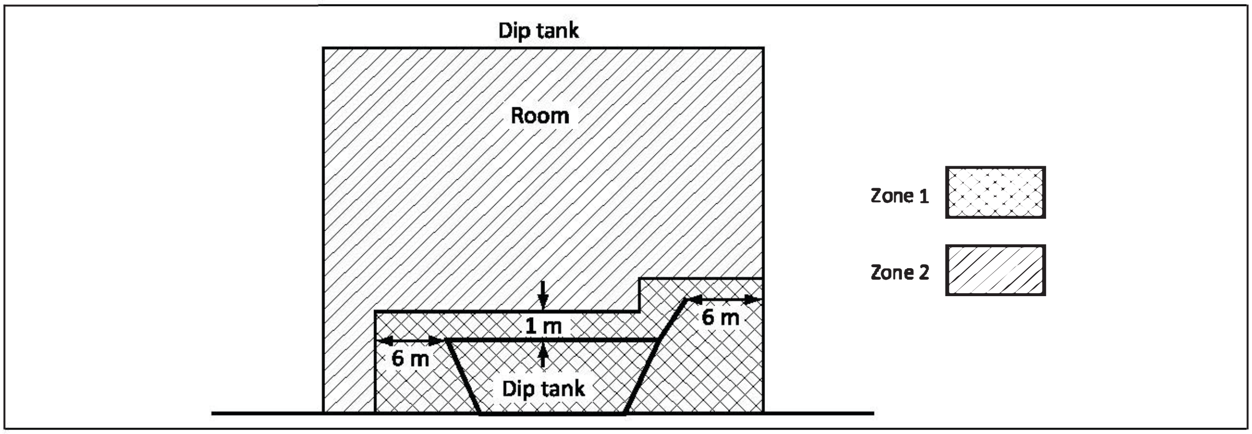



**Figure 20-15**
**Classification of area with floor-level ventilation interlocked with spraying equipment**

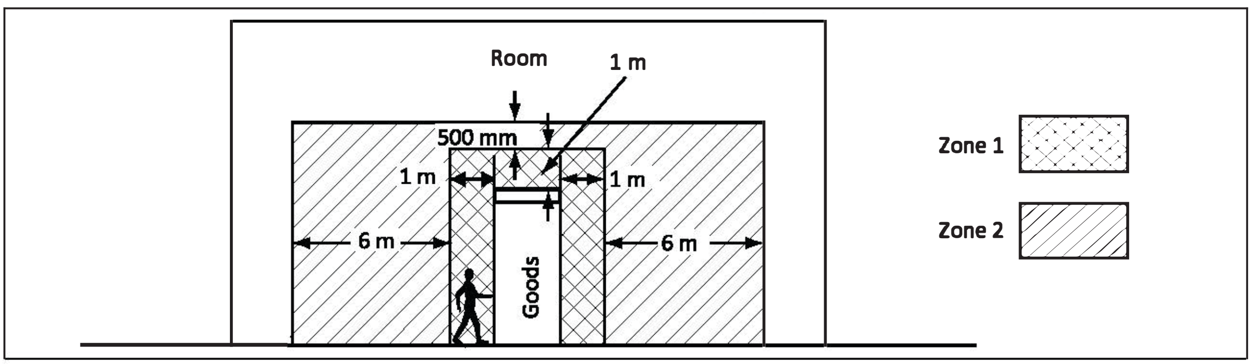
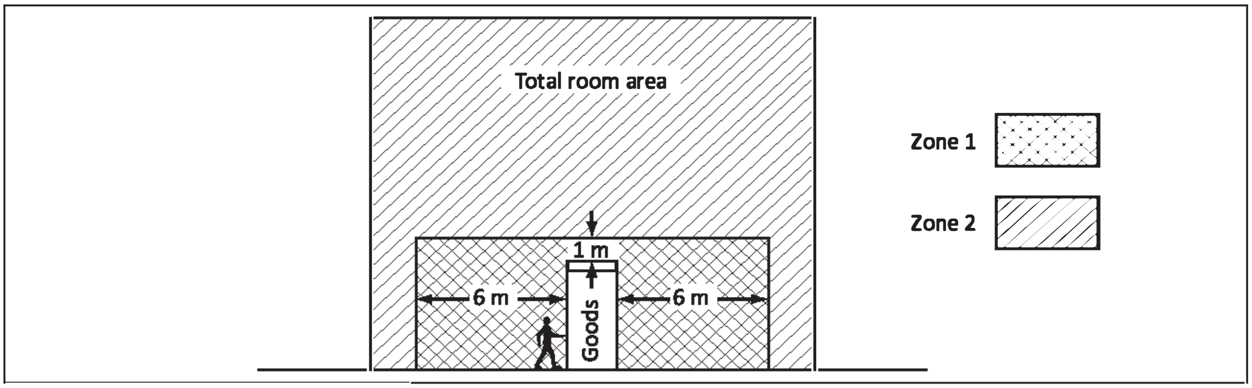


**Figure 20-16**
**Classification of areas where extensive open spraying is carried out without floor-level ventilation**




## Rule 20-306 Wiring and equipment in hazardous areas

In addition to producing vapour and mists, the spraying of flammable paints and other finishes can cause combustible materials to be deposited on nearby surfaces. Some of these materials could be ignitable at relatively low temperatures. For example, paint deposits on steam pipes, luminaires, or other hot surfaces could present a risk of ignition. Therefore, consider the maximum surface temperatures of equipment subject to residue deposits. Explosion-protected electrical equipment that is subject to the accumulation of readily ignitable deposits or residue is also to take into account surface-temperature limitations related to the residue produced. Luminaires mounted on the inside walls of a spray booth, for example, requires such consideration.

Since there is a danger of ignition from open lamps or sparking equipment, Subrule 4) prohibits portable lamps and utilization equipment (e.g., electrical tools or heaters) from being used in these locations during the operation of the finish process. If such equipment is used for repairing and cleaning the booth, the equipment is to meet the requirements for explosive gas locations since the risk of flammable materials still being present exists.

## Rule 20-308 Fixed electrostatic equipment

Rule 20-308 applies to painting or coating operations in which electrostatically charged elements are used for the atomization, charging, or precipitation of flammable materials (e.g., paints or other coatings) onto goods or articles.

Detearing refers to the removal, by electrostatic means, of excess paint from an object; it is the reverse of electrostatic paint application. Detearing is performed prior to any curing of the item. This is not solvent-based paint; it is dry powder coating material. Since the charging voltage can be in the range of 100 kV, stringent safety requirements are to be in effect in areas where these processes are performed.

The high-voltage leads supplying the electrodes or elements are to be properly supported and protected against accidental contact or grounding in accordance with Item c). An automatic means is required for grounding the electrode system to discharge any residual charge when the primary high-voltage supply is interrupted.

In the case of fixed electrostatic equipment, the charging or atomizing device is attached to a mechanical support, and the goods being painted or deteared are normally on conveyors or hangers adjacent to the high-voltage electrodes or atomizing heads. Although the articles are to be effectively bonded to the conveyor or other supports that are bonded to ground, a safe distance is also to be maintained at all times between the bonded articles and the electrodes or electrostatic atomizing heads. Item d) requires that this distance be at least twice the sparking or flashover distance between electrodes and the bonded articles being coated.

# Aircraft hangars

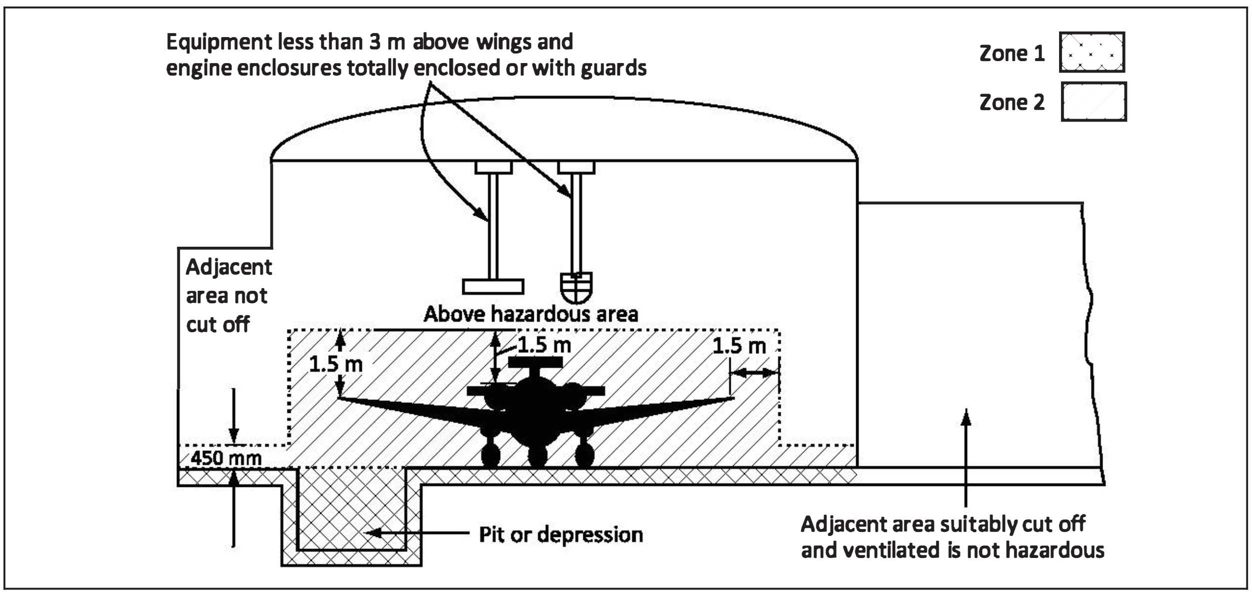
Aircraft hangars or any similar indoor areas used for storing or servicing aircraft are to have some areas inside the building classified as hazardous locations due to the presence of fuels on board the aircraft as well as the possibility of other flammable liquids being present. Since the hazardous areas surround the aircraft, aircraft parking patterns within the hangar are to be considered when the electrical systems for the hangar are being designed.

## Rule 20-402 Hazardous areas

Airplanes and helicopters generally have large volumes of flammable fuel and vapour in their tanks while they are being serviced or stored in the hangar; this fuel supplies the engines and power plants in the aircraft within the structure. Therefore, the areas surrounding the entire aircraft, and any adjacent area not suitably cut off from the hangar, are classified as hazardous locations up to a level 450 mm above the floor. Rule 20-402 requires that the hazardous areas surrounding the aircraft and within the hangar itself are to be classified as indicated in Figure 20-17.

Subrule 4) allows areas adjacent to the aircraft storage and service area that are judged to be adequately ventilated and effectively cut off from the main hangar area to be considered non-hazardous locations.

**Figure 20-17**
**Classification of areas in aircraft hangars**




## Rule 20-404 Wiring and equipment in hazardous areas

Since highly flammable fuels might leak onto and through the floor, any wiring within and below the floor is to be suitable for Zone 1 locations in accordance with Subrule 2).

Subrule 3) requires that any wiring installed in a pit be provided with drainage and not be located in the same enclosure or shaft as other services such as steam or gas lines.

## Rule 20-406 Wiring not within hazardous areas

Due to the larger volumes and greater variety of fuels used in an aircraft hangar, compared to a vehicle service station, all fixed wiring not in the hazardous areas but within the servicing and storage area of the hangar is to be installed in metal raceways or be mineral-insulated cable, armoured cable, copper-sheathed cable, or aluminum-sheathed cable. However, the wiring in adjacent rooms partitioned off from the hangar (e.g., an office with natural ventilation to the outdoors) is allowed to be installed by any method listed in Section 12 for the type of construction involved.

Where flexible cords are required for pendant luminaires, lamps, or portable lamps and electrical equipment, they are to be suitable for at least hard usage. Hard-usage-type flexible cords are less likely to break down and overheat or cause an arc after being in service for a period of time. They are to contain a bonding conductor. Suitable means are to be used to ensure continuity of the bonding conductor between the fixed wiring systems and the non-current-carrying metal parts ofthe portable lighting and equipment.

### Rule 20-408 Equipment not within hazardous areas

When a hangar is being designed, possible sources of ignition from electrical equipment located above the hazardous areas are to be considered. Subrule 1) requires that any such source of ignition (e.g., open lamps or contactors) be located at least 3 m above the aircraft wings or engine enclosures (taking into account the possible variation in the height of aircraft wings and engine enclosures). Lighting and electrical equipment less than 3 m above the aircraft storage and servicing area are to be of the totally enclosed type or are to be constructed so as to prevent the escape of sparks or hot metal particles.

### Rule 20-418 External power sources for energizing aircraft

Aircraft energizers are not normally suitable for use in Zone 2 locations; therefore, Subrule 1) prohibits fixed wiring and electrical equipment on them from being less than 450 mm above the hangar floor. For the same reason, aircraft energizers are not to be operated within the hazardous area defined in Subrule 3) of Rule 20-402.

To avoid aircraft electrical equipment damage, Subrule 3) requires that aircraft energizers have polarized power plugs and automatic controls to de-energize the output if the output voltage exceeds the safe limit of supply to the aircraft. Since flexible power cords used for this operation can be subject to damage or be run over by service vehicles, Subrule 4) requires that they be of the extra-hard-usage type, as listed in Table 11.

# Section 22 — Locations in which corrosive liquids, vapours, or excessive moisture are likely to be present

## General

### Rule 22-000 Scope

Section 22 includes additional and specific requirements for the installation of electrical equipment in locations in which corrosive liquids, vapours, or moisture exist. Section 22 is intended to minimize the detrimental effects of corrosive liquids, vapours, and moisture by requiring that electrical equipment and methods of electrical installation be appropriate for environments where such conditions are found. The requirements of Section 22 apply in particular to sewage lift and treatment plants, and supersede related requirements set out in other Sections of the Code.

### Rule 22-002 Category definitions

Rule 22-002 distinguishes between Category 1 locations, areas that contain moisture in the form of vapour or liquid, and Category 2 locations, areas that contain corrosive liquids or corrosive vapours. The Appendix B Note to Rule 22-002 lists some of the occupancies that are classified as Category 1 and Category 2 locations.

Electrical equipment and electrical installations need to meet only the requirements for the environmental conditions that they encounter. Unless a given location is considered both a Category 1 and a Category 2 location, the equipment and installation require suitability only for use in the given category.

**Note:** *Equipment suitable for Category 2 locations may be acceptable for use in a Category 1 location.*

## Equipment

### Rule 22-100 Essential equipment only

The Code does not specify in detail all the requirements that guarantee safe operation of electrical equipment. The environmental conditions in Category 1 and Category 2 locations pose hazards to electrical equipment that are too numerous to mention in any one Rule. While any electrical equipment located in a Category 1 or Category 2 location runs the risk of corrosion, it is difficult to exclude all electrical installations from such a location. Any electrical equipment that is not essential in Category 1 or Category 2 locations is to be located in a better environment (e.g., a dry location) to reduce the risk of corrosion and deterioration (see Figures 22-1 and 22-2).

Subrule 3) prohibits the use of enclosures containing moulded case circuit breakers in Category 2 locations, unless the equipment is marked for such an application. In certain environments the corrosive conditions can affect the circuit breaker enclosure, preventing the breakers from carrying their rated load and interfering with their intended safety functions. The standard enclosure surrounding the mechanism of a moulded case circuit breaker is not designed to protect the moving parts of the breaker from corrosion. When corrosion damages the moving parts of a breaker, the breaker cannot de-energize the circuit in overload and short-circuit conditions.

**Figure 22-1**
**Essential equipment in ordinary locations**

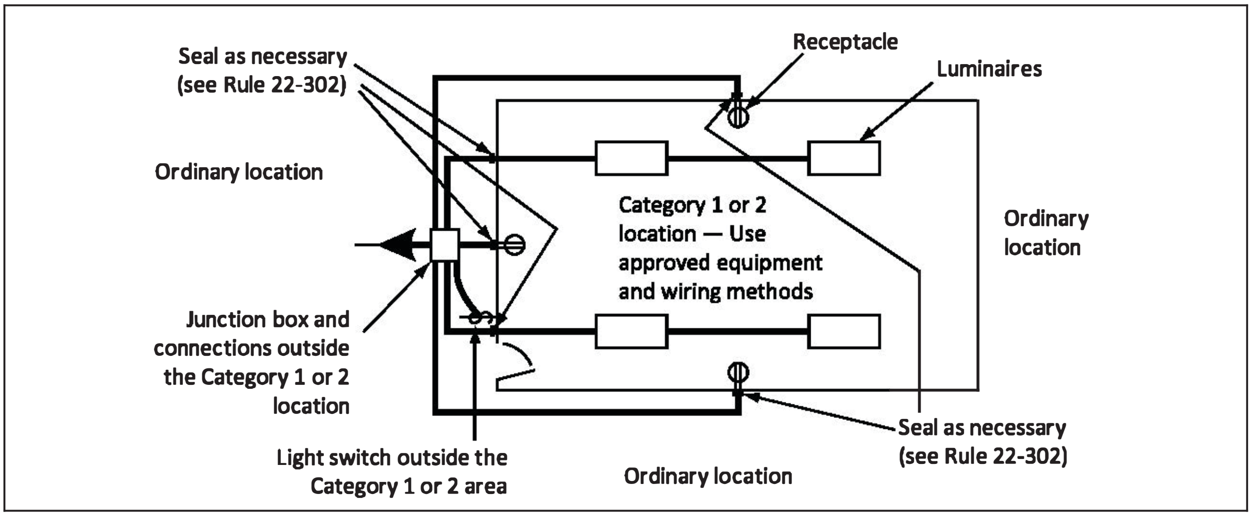
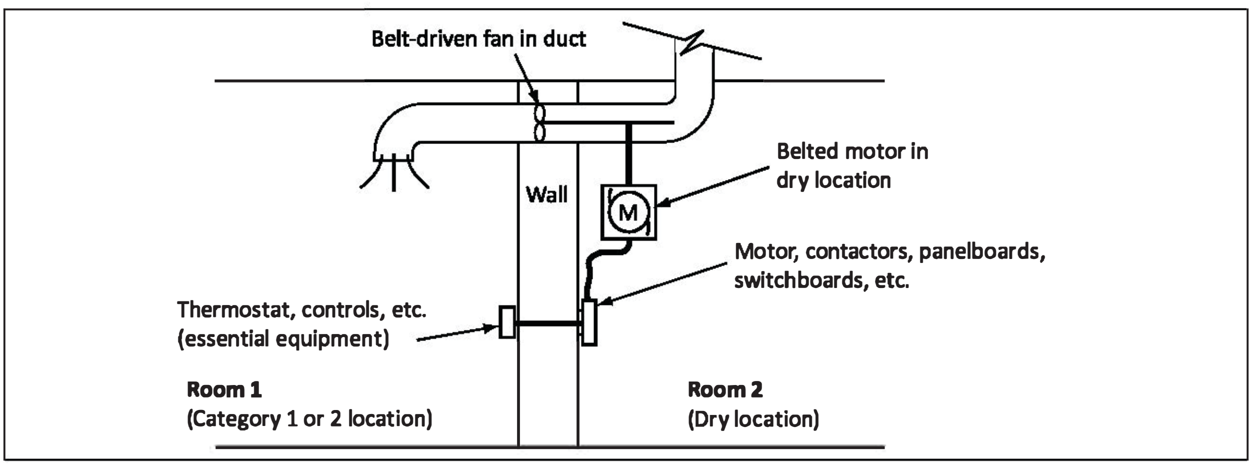



**Figure 22-2**
**Installation in ordinary locations**




## Rule 22-102 Type of construction

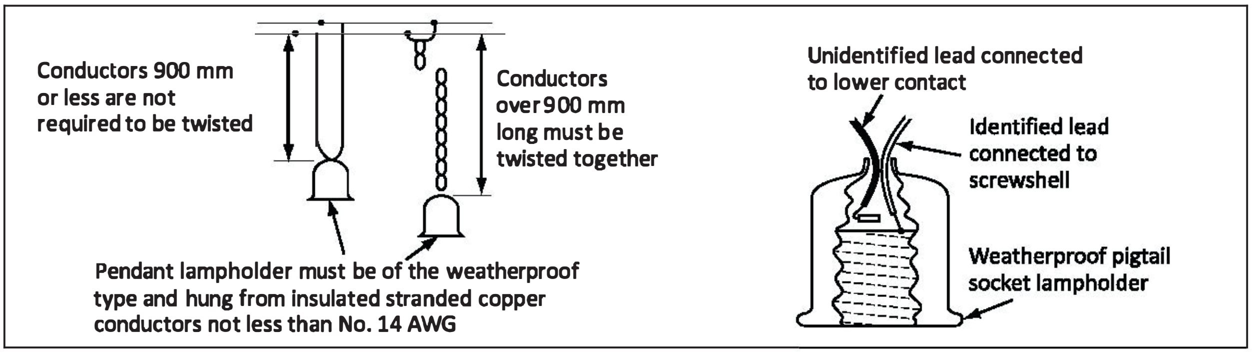
Rule 22-102 provides requirements to determine the type of enclosure, from those listed in Rules 2-400 to 2-402 and Table 65, that is appropriate for the environment. These requirements apply to submersible enclosures, enclosures protected from splashing water, and installations where water containing corrosive chemicals might degrade an enclosure and interfere with the normal operation of the components inside. For example, a number of fires caused by corroded receptacles have occurred where corrosion-resistant receptacles were not used in the wash-down areas of poultry barns and in hog-housing areas.

## Rule 22-104 Pendant lampholders

Rule 22-104 applies to pendant lampholders with weatherproof pigtail sockets (see Figure 22-3). These lampholders are used outdoors or indoors, with incandescent filament lamps, to provide permanent lighting in areas such as parking lots, and temporary lighting in new construction and similar locations. Since these lampholders are subject to mechanical damage by weather, especially wind, Rule 22-104 requires that their insulated conductors be stranded and no smaller than No. 14 AWG for flexibility and mechanical strength. Table D1 lists pendant weatherproof lampholder lead wires as TLW 600 V single insulated conductor No. 14 AWG, with flame-tested thermoplastic insulation. Insulated conductors longer than 900 mm can move under normal conditions (such as in response to air currents) and are more likely to be hooked by some moving object; therefore, they are to be twisted together for added strength (see Figure 22-3).

**Note:** *Section 30 also provides requirements related to pendant lampholders and the installation of lampholders in damp locations. See Rules 30-320, 30-608, and 30-1102. In locations where corrosive liquids, vapours, or excessive moisture are likely to be present, the requirements of Section 22 supersede those of Section 30.*

**Figure 22-3**
**Pendant lampholders**




## Rule 22-106 Luminaires

In Category 1 locations, insulated conductors can become wet, reducing the quality of the conductors' insulation. As well, impurities in the water can make the water itself a conductor. When the impure water is deposited across points having a voltage difference, shorts and electric shock hazards can occur. In Category 2 locations, corrosive liquids and corrosive vapours can degrade luminaire enclosures, components, and wiring, leading to shorts, overheating, shock, and unsafe operation.

The intention of Rule 22-106 is to require that luminaires in Category 1 locations be constructed so that water cannot enter or accumulate in them, and in Category 2 locations be enclosed, gasketted, and corrosion resistant.

## Rule 22-108 Receptacles, plugs, and cords for portable equipment

Subrule 1) a) requires that receptacles and attachment plugs for portable equipment be weatherproof, whether used indoors or outdoors, so that moisture, corrosive liquids, and corrosive vapours cannot enter the receptacle or attack the plug, causing corrosion and eventually opening or shorting of the conductors.

Subrule 1) b) requires that all metal parts of an attachment plug or receptacle that are not intended to carry current under normal operation be bonded to ground through a common bonding terminal to which the circuit bonding conductor is connected. This requirement for a bonding conductor supplements Rule 22-600, which refers to Section 10 for bonding requirements. Rule 10-408 3) and 4) allows for the bonding conductor in the cord or cable to remain unconnected from portable electric tools or appliances that are double-insulated. However, the receptacle is to be grounded, and the attachment plug, if three-prong, is to have the bonding conductor connected to the grounding terminal.

Subrule 2) requires that cords and cables for portable equipment be suitable for hard usage, be selected in accordance with Rules 12-402 1) and 12-406 1), and contain a bonding conductor to accommodate the possibility of physical abuse and deterioration from corrosion, which can lead to current leaks and shorts.

## Wiring

### Rule 22-200 Wiring method in Category 1 locations

Rule 22-200 is intended to protect exposed wiring, where practicable, from the effects of moisture and water in Category 1 locations. Subrule 1) a) requires that exposed wiring in wet locations (e.g., car washes, commercial laundries, and shower rooms) be of a type selected in accordance with Rule 12-102 3) as suitable for wet locations. Outdoor wiring exposed to the weather and/or sunlight is also required to be of a suitable sunlight-resistant type, marked "SR" (see Rule 2-134), selected in accordance with Rule 12-102 3), and installed out of reach of anyone likely to come into contact with it when standing on floors, decks, balconies, stairs, etc. (see Figure 22-4).

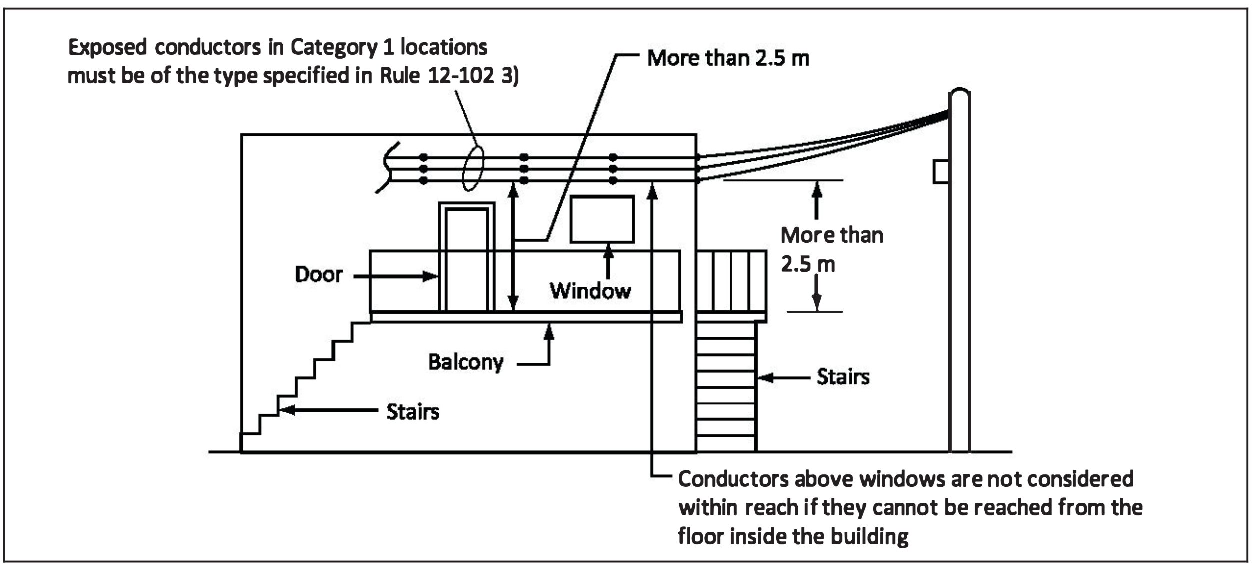
Subrules 2) and 3) require that non-metallic-sheathed cables, armoured cables, copper-sheathed cables, and aluminum-sheathed cables suitable and marked for direct burial be selected in accordance with Rule 12-102 3).

Subrule 4) prohibits the use of split knobs and cleats for wiring in Category 1 locations. Water and impurities can produce mixtures that might degrade the conductor insulation, possibly resulting in current leaks, shorts, and fire hazards.

Subrule 5) requires a 6 mm spacing between mineral-insulated cable and any wall in a Category 1 location to which it is secured, to prevent any accumulation of water and impurities between the cable and the wall that might produce a mixture, which in turn might damage the cable sheath (see Figure 22-9).

Subrule 6) requires that aluminum conductor terminations or joints be adequately sealed against the ingress of moisture by using items such as heat-shrinkable tubing, aluminum joint compound, weatherproof self-sealing tape, etc. An accumulation of moisture can weaken the non-oxidizing agents applied to terminations, resulting in terminal oxidation, overheating, and eventual failure or fire.

**Figure 22-4**
**Wiring methods in Category 1 locations (wiring to and on the outside of buildings)**




### Rule 22-202 Wiring method in Category 2 locations

Rule 22-202 is more stringent than Rule 22-200, given the more severe environmental hazards in Category 2 locations. Subrule 1) a) requires that exposed indoor or outdoor wiring in Category 2 locations have corrosion-resistant protection and be installed out of reach of people standing on floors, decks, balconies, and stairs. Subrule 1) b) requires that insulated conductors or cables run in conduit in a Category 2 location have corrosion-resistant protection, to protect against corrosive compounds that might accumulate in the conduit.

Subrule 4) imposes conditions on the use of mineral-insulated cable in Category 2 locations. Mineral-insulated cable has protection against most corrosive elements but is susceptible to oil, gasoline, and oxidizing acids such as nitric acid, sulphurous and concentrated sulphuric acid, and oxidizing salt (ferric, stannic, and mercuric salts, and substitute ammonia ions). Although mineral-insulated cable is resistant to most dry gases, it is susceptible to corrosion by wet fluorine, wet chlorine, wet bromine, wet iodine, and wet ammonia. Sulphuric compounds also have a strong tendency to attack the sheath. Also, when copper is in contact, through an electrolyte, with a metal more active in electrochemical voltage, such as aluminum, magnesium, zinc, or galvanized steel, corrosion of the metal can be stimulated, making the sheath more susceptible to cracking, especially at bends. Cracking is also more likely to occur when moisture and carbon dioxide combine with ammonia, ammonia-bearing materials (amines), or urine.

The corrosion of mineral-insulated cable can be prevented in most cases by an extruded polyethylene jacket of a black, high-density material. Subrule 4) requires that mineral-insulated cable be used only where corrosive liquids or vapours in the location cannot degrade this protective sheath. The cable sheath can deteriorate underground, especially in some types of cinder fill.

Aluminum-sheathed and copper-sheathed cable can be susceptible to corrosion in Category 2 locations if the environment contains chlorides, caustic alkalis, or vapours of chlorine or hydrochloric acid, which attack the sheath. The cable is also vulnerable to corrosion when embedded in concrete or buried directly in earth. Subrule 5) requires that aluminum-sheathed and copper-sheathed cables installed in Category 2 locations have suitable corrosion-resistant protection. In most cases, adequate protection is provided by an extruded polyethylene jacket of a black, high-density material.

Subrule 6) requires that aluminum conductor terminations or joints be sealed against the ingress of corrosive liquids or vapours. An accumulation of corrosive agents can weaken the non-oxidizing agents applied to terminals, resulting in terminal oxidation, overheating, and eventual failure or fire.

**Notes:**

**1)** *Some of the insulated conductors and cables acceptable in Category 2 locations are also acceptable in Category 1 locations; however, generally, insulated conductors and cables acceptable in Category 1 locations, unless adapted, are not approved for Category 2 locations. In Table 19, conductors and cables acceptable in Category 1 locations are not listed as "for use in Category 1 locations"; they are listed as "for use in wet locations" or "for use in damp locations." Insulated conductors and cables that are suitable for use in wet locations are also suitable for use in damp locations (see Note 5 to Table 19), but insulated conductors and cables suitable for use in damp locations are not suitable for use in wet locations, unless specifically identified as such in Table 19.*

**2)** *Certain cables and conduits can be made suitable for a Category 1 or 2 location, or both, by applying a suitable protective covering. Once the corrosive agents surrounding a particular electrical installation have been identified, installers should consult the conductor, cable, or conduit manufacturer to determine which corrosive agents might be detrimental to the cable or conduit and select the best method of protection in accordance with the Code requirements.*

### Rule 22-204 Wiring methods in buildings housing livestock or poultry

Livestock and poultry buildings are usually characterized by high moisture (due to periodic cleaning and sanitizing with water and cleaning agents) and can also be corrosive areas (due to poultry and animal excrement and the combination of corrosive particles with water). Therefore, Subrule 1) requires that wiring methods suitable for wet locations be selected in accordance with Rule 12-102 3).

Subrule 2) allows the use of NMW cable above ground and NMWU cable underground provided that the conductors are copper [see Subrule 4)]. These cables have an appropriate covering.

Subrule 3) allows an exemption from Subrules 1) and 2) where there is adequate ventilation in the building. In such a case, wiring selected in accordance with Rule 12-102 3) for use in damp locations is allowed. Adequate ventilation is considered to involve at least three air changes per hour or some form of mechanical dehumidification. Ventilation requirements for livestock buildings are covered in the *National Farm Building Code of Canada*.

Since the atmosphere in buildings housing livestock or poultry can contain corrosive elements, which can damage aluminum conductors and terminations, Subrule 4) prohibits the use of aluminum conductors and terminations.

Rodents can damage non-metallic-sheathed cable if they gain access to the cable. Subrule 5) requires that non-metallic-sheathed cable be provided with mechanical protection when
- installed in exposed locations less than 300 mm above any horizontal surface;
- installed on the side of floor joists or other structural members less than 100 mm above any horizontal surface;
- run in attics; or
- run in concealed spaces.

The Appendix B Note to Rule 22-204 5) points out that non-metallic-sheathed cable is not approved for installation in a continuous raceway system.

### Rule 22-206 Rinks

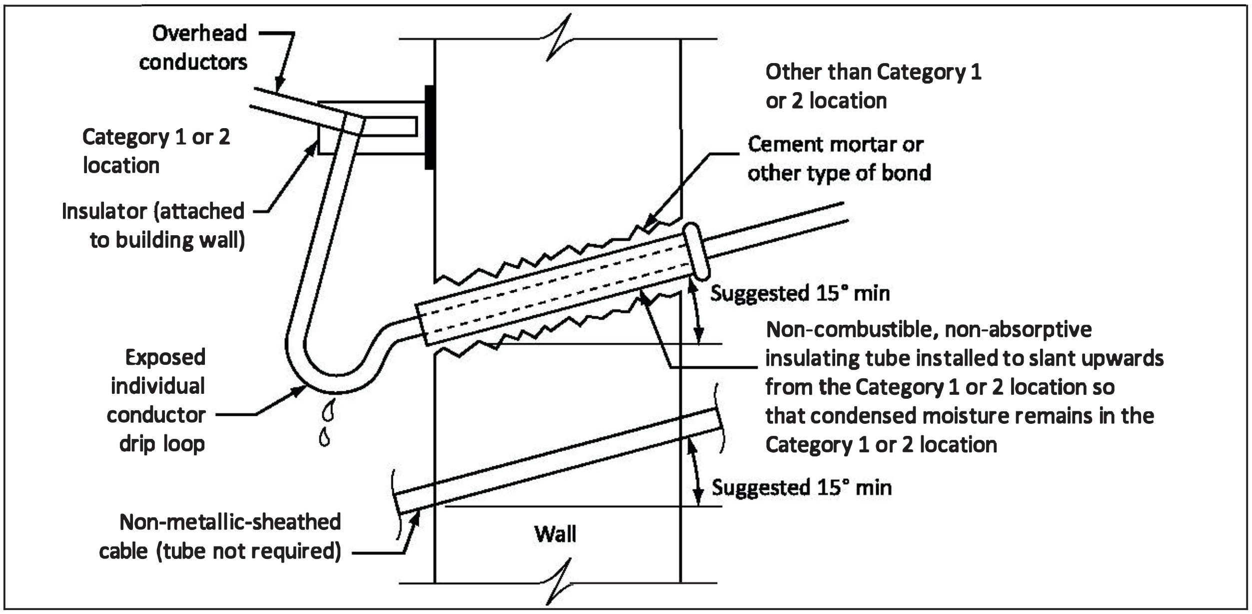
The environment in indoor rink areas can vary from wet to dry, depending on whether there is positive mechanical ventilation to reduce the moisture content. If the rink areas have at least three air changes per hour by positive mechanical ventilation, they can be regarded as dry locations. Therefore, rink areas are regarded as either wet or dry, but not damp, locations. Rule 22-206 allows insulated lighting conductors to be run in indoor rink areas as open wiring [when wiring is open, runs of single insulated conductors with no outer sheath are exposed (i.e., not concealed) and supported on insulators] in accordance with Rules 12-200 to 12-224, provided that the insulated conductors are selected in accordance with Rule 12-102 3) as suitable for wet locations. In areas that can be considered dry, such as waiting rooms, a wiring method in accordance with Section 12 is acceptable.

## Drainage, sealing, and exclusion of moisture and corrosive vapour

### Rule 22-300 Drip loops

Insulated conductors and cables that run from a Category 1 or 2 location to another location can transfer liquid or moisture that might drip on unprotected electrical wiring or equipment to the other location. Rule 22-300 requires that such wiring be installed through the intervening wall in an upward direction, and if the insulated conductors and cables are exposed, they are to pass through non-combustible, non-absorptive insulation tubes (see Figure 22-5). A drip loop is formed when the insulated conductor or cable runs down from any point of entry into a location. Without the loop, water or liquid can travel down the insulated conductor or cable and enter the other location. Proper installation prevents liquid or moisture from leaving the area of origin along exposed insulated conductors or non-metallic-sheathed cables. The insulation tubes, when used, serve as mechanical protection and prevent moisture and fire creepage to the other location.

## Figure 22-5
## Drip loop




### Rule 22-302 Drainage, sealing, and exclusion of moisture

Liquid, moisture, or vapour, whether corrosive or non-corrosive, can collect in a conduit, cabinet, or fitting, or between a conduit, cable, cabinet, or fitting and the surface that supports it. If any of these components is metal, the liquid or moisture can form a mixture with other substances (e.g., debris or the metal of the conduit, cable, or enclosure). This would eventually corrodes the materials and the conductor's insulation, causing shorts that can lead to fire or electric shock hazards. The requirements of Rule 22-302 are intended to prevent any such accumulations.

Subrule 1) a) and b) requires that any moisture be drained from the conduit through adequate sloping and suitable drain fittings (see Figures 22-6 and 22-7).

Subrule 1) c) requires that the conduit be mounted with a minimum clearance of 12 mm from the supporting surface when the conduit or supporting surface is metallic (see Figures 22-6 to 22-8).

Subrule 1) d) requires that the conduit be sealed in cases where corrosive vapour might migrate.

Moisture can be produced in a conduit, copper-sheathed cable, or aluminum-sheathed cable that leaves a warm area and enters a cooler area if the flow of warm air into the cooler area is not sealed off. Subrule 2) requires that a seal and drain fitting be installed as close as practicable to the place where the conduit or cable leaves a warm area for a cooler atmosphere. Sealing material around the cable on the warm side is intended to prevent breathing (circulation of air), which can result in condensation of moisture and corrosive vapour; the drain fitting should prevent any moisture from collecting at the seal and building up, reducing problems in the system.

Subrule 3) requires that every conduit joint in a Category 1 location be watertight. This requirement applies to conduit-to-conduit joints; connections between a conduit and an enclosure, such as a box or cabinet; and connections between a conduit and a fitting.

Subrule 4) requires that fittings and cabinets in Category 1 locations be constructed so that liquid or moisture does not enter or accumulate within electrical equipment. Fittings and cabinets are to be mounted with a clearance from the supporting surface when the cabinet, fitting, or supporting surface is metal; this is done to prevent any accumulation of water and impurities between the wall and the fittings or cabinet that might produce a corrosive mixture (see Figure 22-9).

**Figure 22-6**
**Exclusion of moisture, including drainage**

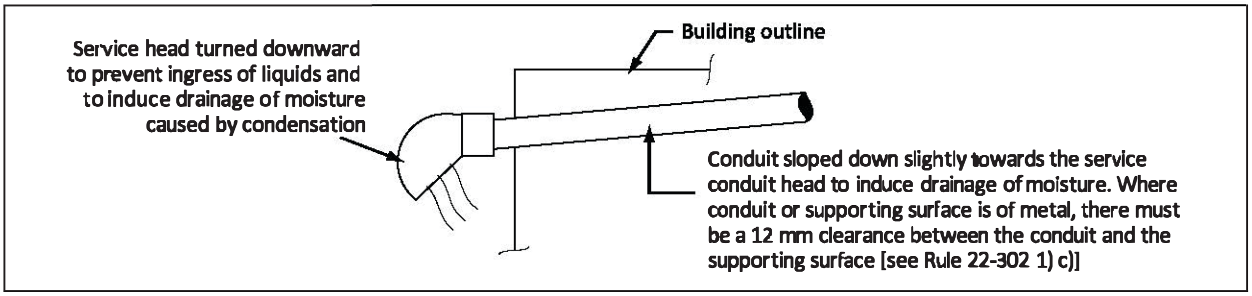



**Figure 22-7**
**Sealing or exclusion of moisture**

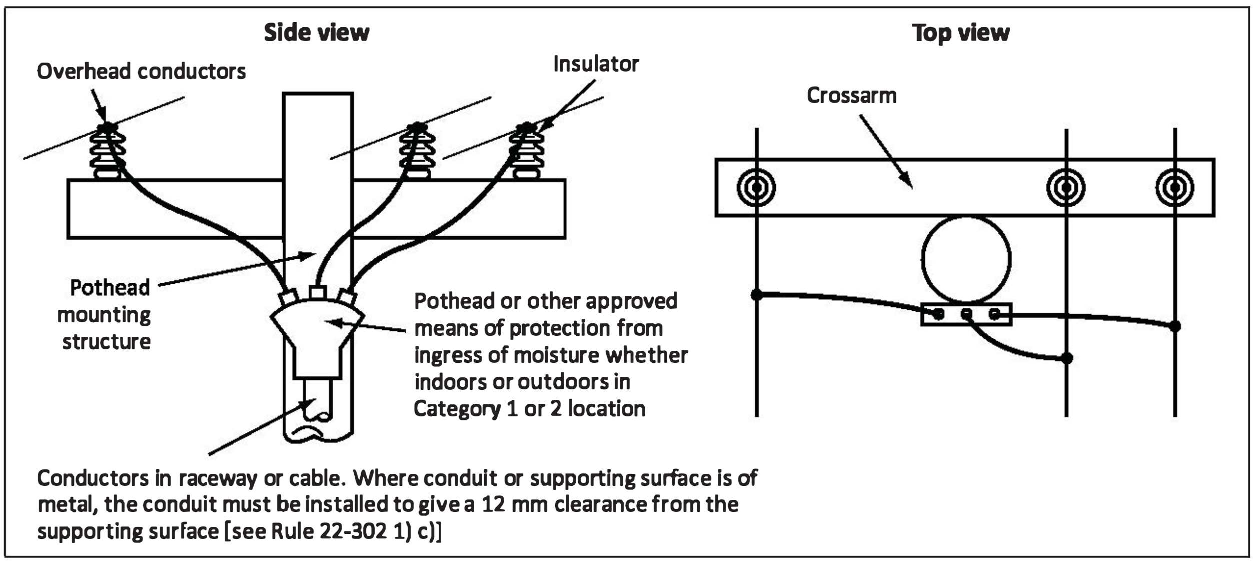


**Figure 22-8**
**Typical drainage and drain fittings**

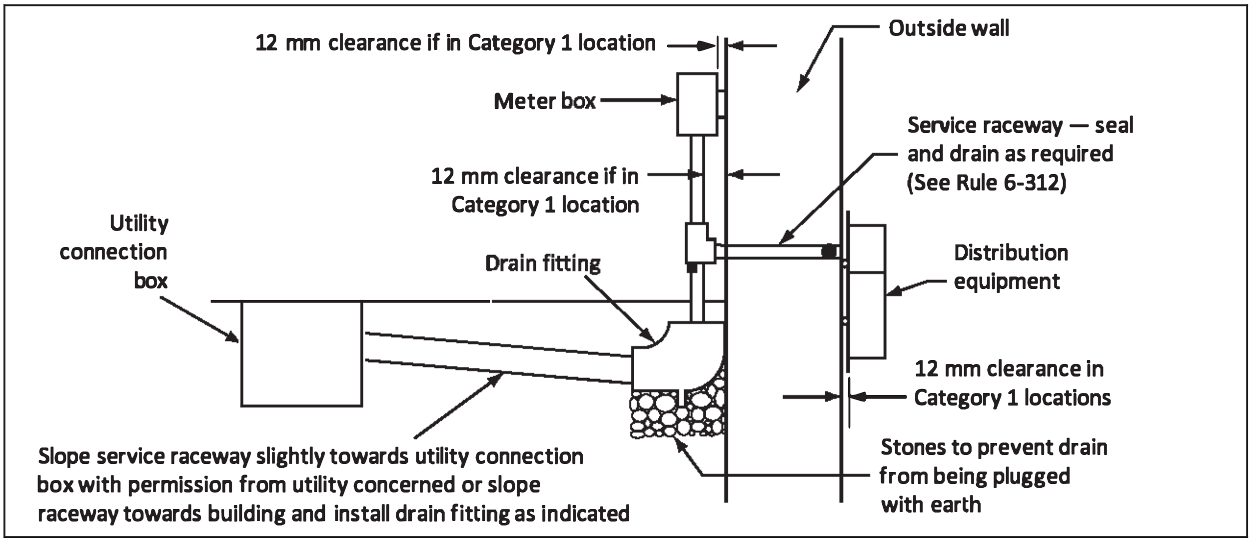
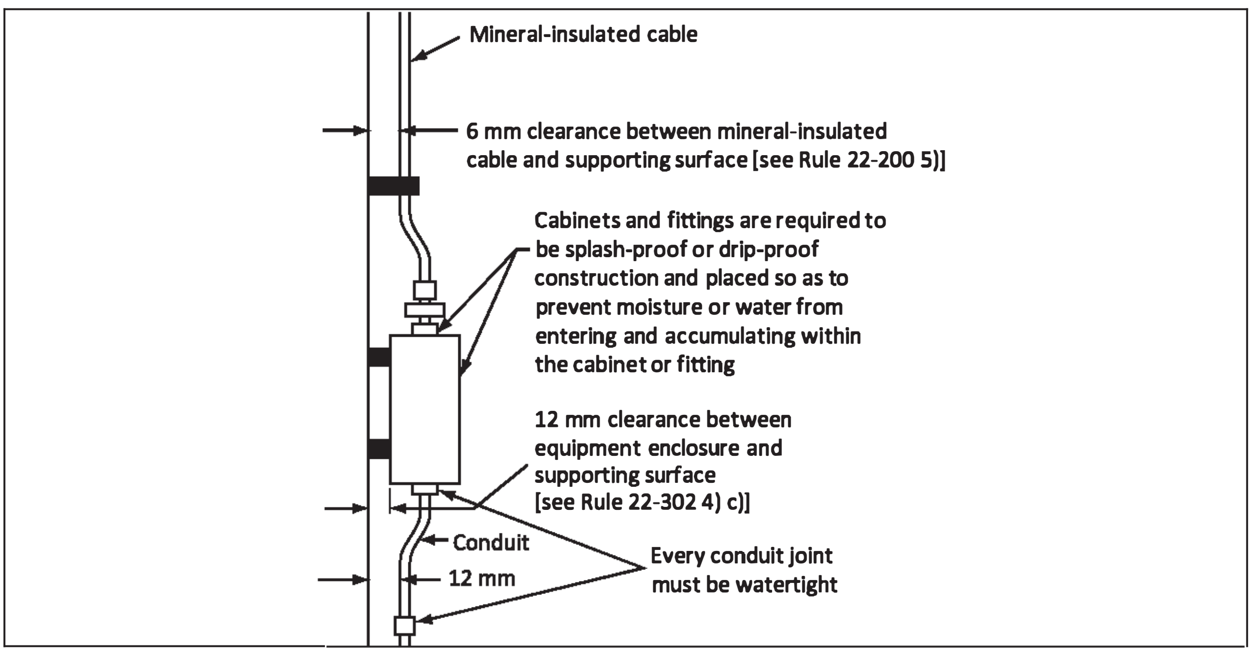



**Figure 22-9**
**Cabinets and fittings in Category 1 locations**




# Circuit control

## Rule 22-400 Circuit control

Circuits in Category 1 and 2 locations are subject to moisture, corrosive liquids, or corrosive vapours, which can eventually cause deterioration or shorting of the circuit conductors, leading to shock and fire hazards. Rule 22-400 requires that readily accessible disconnecting means be provided for all current-carrying conductors in Category 1 and 2 locations so that conductors within these locations can be easily and conveniently de-energized from a safer position outside the locations.

## Materials

### Rule 22-500 Corrosion-resistant material

Techniques used for the corrosion protection required by Rule 22-500 vary according to the environment and type of corrosive materials, and are to include

- protective coatings (e.g., zinc, cadmium, enamel, PVC jacket, or paint);
- the use of corrosion-resistant aluminum or other corrosion-resistant materials for equipment, supports, or protection; or
- the application of protective coatings to copper, as required.

## Bonding

### Rule 22-600 Exposed, non-current-carrying metal parts

Rule 22-600 requires that all exposed metal components of fixed or portable equipment in a Category 1 or 2 location that are not intended to carry current be bonded to ground, in accordance with Section 10. The grounding and bonding path is to carry away all fault currents and is to be of low enough impedance that overcurrent devices operate appropriately, by keeping the fault current time to an acceptable minimum. The grounding and bonding path is also to lead the fault current back to the supply, safeguarding people in contact with the non-current-carrying metal parts while the fault current is present.

## Sewage lift and treatment plants

### Rule 22-700 Scope

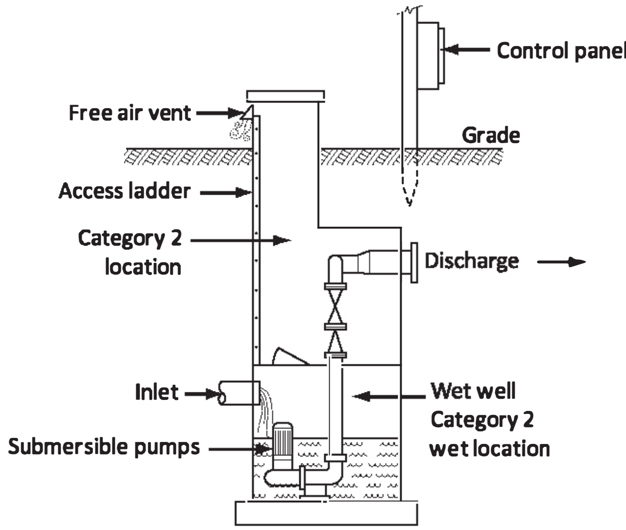
This Subsection sets out area classifications and wiring requirements for sewage handling and processing installations. In editions of the Code before 2006, sewage handling locations, and especially the wet well areas in such facilities, were simply designated Class I hazardous locations. A review of existing installations wired in accordance with the Class I and related Group requirements, however, found that in many cases corrosion had nullified the integrity of explosion-proof enclosures. Consequently, the Code now requires that sewage treatment facilities be classified for corrosive liquids and vapours, and includes Rules 22-700 to 22-710 to provide detailed requirements for such installations. These Rules do not apply to treatment facilities that are used for methane generation (to which Section 18 applies).

Sewage handling facilities are considered explosive gas hazardous locations, with appropriate designations in accordance with Section 18, due to the possibility that flammable liquids (such as oil waste, chemicals, and sewer gases) might be present in the wastewater that is treated and might create an explosive gas hazardous atmosphere, especially in the wet well. Electrical devices that can cause an open arc, spark, or high temperature during normal operation could ignite a high concentration of flammable liquids or vapours. The treatment process could also generate flammable gases (such as methane, hydrogen sulphide, and hydrogen) which in sufficient concentration can create an explosive gas atmosphere.

### Rule 22-704 Classification of areas

Subrule 1) requires that sewage lift and treatment plants be classified in accordance with Section 18 for hazardous areas and Section 22 for corrosive liquids, vapour, or moisture (see Figure 22-10). The latter classification is intended to ensure that corrosion in sewage lift and treatment plants does not degrade and ultimately defeat the explosion-proof enclosures that are provided in accordance with Section 18 requirements.

**Figure 22-10**
**Typical sewage lift station**




The following chart shows the classification of various locations in sewage lift and treatment plants.

| Location | Condition | Classification |
|---|---|---|
| Wet wells | With adequate continuous positive pressure ventilation | Category 2 location and Zone 2 |
| All below-ground locations | Suitably cut off from sewage gas locations | Category 1 location |
| All locations | Sewage gas is present in explosive concentrations | Category 2 location and Zone 1 |
| All locations | Suitably cut off from a Category 2 location and not classified as a Category 1 location | Ordinary location |
| All locations | Not suitably cut off from a Category 2 location but with adequate continuous positive pressure ventilation | Ordinary location |
| Below-ground dry well locations | With adequate heating and adequate continuous positive pressure ventilation | Ordinary location |

### Rule 22-706 Wiring methods

Rule 22-706 requires that wiring methods in hazardous locations conform to the requirements in Section 18 and the applicable Category 1 and 2 requirements of Section 22. The following are exceptions from the Section 22 requirements for wet or damp Category 2 locations:

- Rigid steel conduit or electrical metallic tubing is not to be used as it can corrode rapidly in these locations.
- Armoured, mineral-insulated, copper-sheathed, or aluminum-sheathed cable is allowed where such cable
  - is spaced 12 mm from walls;
  - has a corrosion-resistant jacket; and
  - employs cable connectors sealed to prevent the entry of corrosive liquids or vapours.
- All grounding and bonding conductors are to be insulated or protected from corrosion.

- Conduits from a wet well to an electrical enclosure are to be sealed to prevent the entry of moisture, vapour, or gases.

### Rule 22-708 Electrical equipment

Rule 22-708 requires that electrical equipment in hazardous locations conform to the requirements in Section 18 and the applicable Category 1 and 2 requirements of Section 22, with the following exceptions from the Section 22 requirements for wet or damp Category 2 locations:

- Receptacle covers are to be self-closing and have individual covers for each half of a duplex receptacle.
- Covers for lighting switches are to be weatherproof.
- Emergency lighting or control equipment is not allowed, with the exception of remote lamps.
- Heating equipment is either to be suitable for the location or installed outside the location.
- Motors are to be totally enclosed, with no dissimilar metals between the motor frame and connection box that could cause corrosion.
- Electrical equipment in wet well areas is not to contain devices that will arc or spark during normal operation.

Ventilation fans are not to be located within the wet well, and fan blades used in ventilation ducts are to be made of spark-resistant materials to prevent the buildup of a static charge on the blades that could be a point of ignition.

To prevent an explosion or fire in areas provided with continuous positive pressure ventilation, any equipment not suitable for the hazardous location is to be equipped with an automatic shutdown feature that de-energizes the equipment if there is loss of positive ventilation.

### Rule 22-710 Grounding of structural steel

To prevent voltage gradients that can cause arcs and sparks and possibly ignite accumulations of hazardous gases, Rule 22-710 requires that all structural steel installed below ground be bonded to the system ground.

# Section 24 — Patient care areas

### Rule 24-000 Scope

Section 24 includes additional and specific requirements for the installation of electrical equipment in patient care areas of health care facilities and for the installation of essential electrical systems in health care facilities. The general Rules of the Code are intended to provide a safe electrical installation environment for healthy people performing their day-to-day activities. In health care facilities, however, many patients are sedated, anaesthetized, or physically restricted, and consequently electrical installations in patient care areas need additional measures for protection against the risk of electric shock.

An increasing number of medical procedures involve intentional conductive contact between patients and medical electrical equipment. Such contact, whether it is cardiac contact, body contact, or casual contact (see the definitions in Rule 24-002), involves an inherent risk of electric shock.

The intent of Section 24 is to ensure that electrical hazards are controlled or eliminated by a combination of three means: education of the entire health care team, proper design of the health care facility's electrical system (including the design of essential electrical systems), and regular maintenance of all electrical equipment. Faults occur and people make mistakes, but if appropriate protective features are in place, a single fault is likely to present a low risk.

While Section 24 addresses the additional installation requirements applicable to patient care areas, it sets out only minimum requirements for the proper and safe design and installation of an electrical system for health care facilities. The Rules of this Section do not deal at all with the underlying principles of electrical safety in health care facilities, including patient care classification, use and control of electrical equipment, safety requirements for medical electrical systems, administration of electromagnetic emitting devices, maintenance of medical and non-medical electrical equipment, or the number, arrangement, and power supply of receptacles required for the different procedures to be performed. Users of the Code are directed to CSA Z32 for the other necessary elements of electrical safety and essential electrical systems in health care facilities. CSA Z32 also provides further precautions and inspection and testing requirements necessary for the electrical safety associated with health care provision.

## Patient care areas

### Rule 24-100 Rules for patient care areas

All patient care areas are to be designated clearly according to their intended use by the health care facility's administration. See the definition for *Health care facility administration* in Rule 24-002.
Rule 24-100 is intended to ensure that the designation of each type of patient care area accurately and clearly describes the type of care provided.

In the Code, the patient care areas are divided into three categories:

- basic care areas;
- intermediate care areas; and
- critical care areas.

Critical care areas are used for procedures in which patients are anaesthetized or are subject to cardiac contact. Only extremely small currents are allowed to pass through the heart; consequently, critical care areas are to be identified separately and receive particular attention from both designers and installers (see CSA Z32 for a more detailed discussion). Critical care areas include angiographic laboratories, cardiac care units, cardiac catheterization laboratories, emergency trauma suites, intensive care units, intensive care neonatal units, and operating rooms.

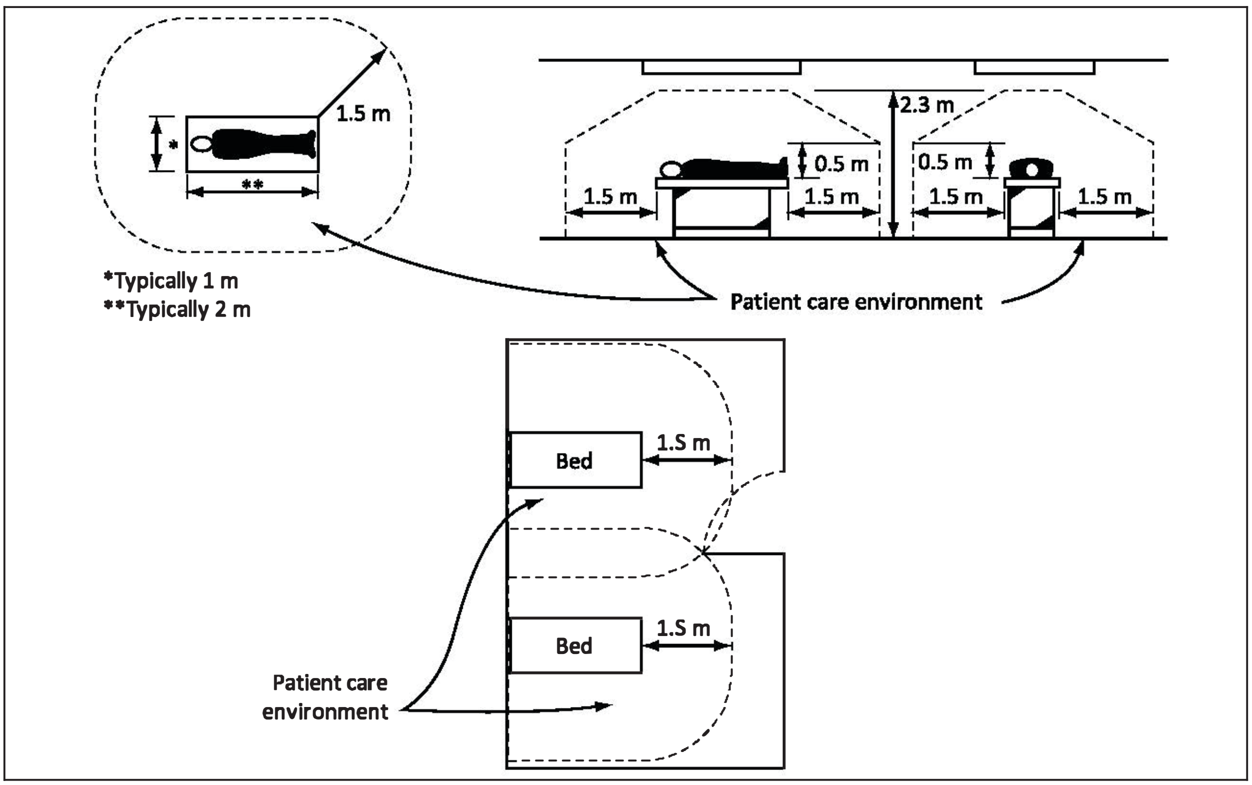
Intermediate care areas are locations in which body contact between the patient and medical electrical equipment is frequent, so attention is to be given to the performance of branch circuits during faults.

Intermediate care areas include wards, treatment rooms, and examination rooms located in general, specialty, or rehabilitation health care facilities where it is usual for a patient to have body contact with medical electrical equipment. Further examples of such areas are renal dialysis units, non-invasive electro-diagnostic areas (for ECGs, EEGs, and EMGs), patient preparation areas, physiotherapy departments, ultrasound and imaging suites, and dental clinics.

Basic care areas are those patient care areas where medical electrical equipment is not usually connected to a patient; therefore, it is unreasonable to require more than an effective connection to ground. Such areas include patient rooms in long-term care facilities and any patient rooms in general, specialty, or rehabilitation health care facilities in which body contact procedures are neither frequent nor usual. Basic care areas, even in long-term care facilities, are considered institutional occupancies, and patient care areas of such occupancies are covered by the requirements of this Section.

Within the patient care area is the patient care environment (see Rule 24-002), which is the zone used for the accommodation of a patient's bed, table, supporting mechanism, and/or treatment equipment. The dimensions of the patient care environment are shown in Figure 24-1.

**Figure 24-1**
**Patient care environment**




## Rule 24-102 Circuits in basic care areas

The need for branch circuits and receptacles in patient care areas is typically much greater than in most other locations. Users should refer to CSA Z32 for recommendations related to the minimum number of receptacles and circuits in the various patient care areas.

Subrule 1) requires that circuits for receptacles or permanently connected equipment in basic care areas be fed from a solidly grounded electrical system. This ensures that the easiest route to ground for a fault or leakage current is through a bonding conductor, not through the patient.

Overcurrent protective devices in the panelboards are to be inaccessible to patients and unauthorized personnel, which means that panelboards are frequently located some distance from their loads. Receptacles in patient care environments are to be capable of supplying 1000 to 1500 W loads with a reasonably stable voltage. Given these conditions of use, as well as the voltage drop requirements of Section 8, Subrule 2) requires that branch circuit insulated conductors be copper and not smaller than No. 12 AWG (they often need to be larger to satisfy the voltage drop requirements).

The supply to receptacles or permanently connected equipment in a patient care area is to be as free as possible from faults, voltage spikes, and electrical noise that can be introduced onto the branch circuit from non-medical or medical equipment in areas outside the patient care area. Subrule 3) requires that a branch circuit supplying receptacles or permanently connected equipment in a basic patient care area, regardless of whether the branch circuit is connected to the essential electrical system or not, supply only those devices within the patient care environment.

Subrule 4) allows the branch circuit that supplies loads in the basic care area that are described in Subrule 3) to be extended to supply loads within one additional patient care environment when the two patient care environments are adjacent to each other.

Where an electrical system in a health care facility has loads that are designated as essential, Subrule 5) requires that each patient care environment described in Subrule 3), or pair of patient care environments described in Subrule 4), be supplied by at least one branch circuit from a panelboard that is a part of an essential electrical system.

Portable medical electrical equipment does not normally operate at voltages greater than 150 volts-to-ground. In order to prevent shock hazards, Subrule 6) requires that all circuits be supplied with a voltage not greater than 150 volts-to-ground, unless they are circuits for special-purpose receptacles or permanently connected equipment.

To improve the safety and reliability of branch circuits supplying essential loads as required by CSA Z32, Subrule 7) requires that a branch circuit of an essential electrical system that supplies receptacles or permanently connected electrical equipment not be used to supply receptacles or permanently connected equipment that is not part of the essential electrical system.

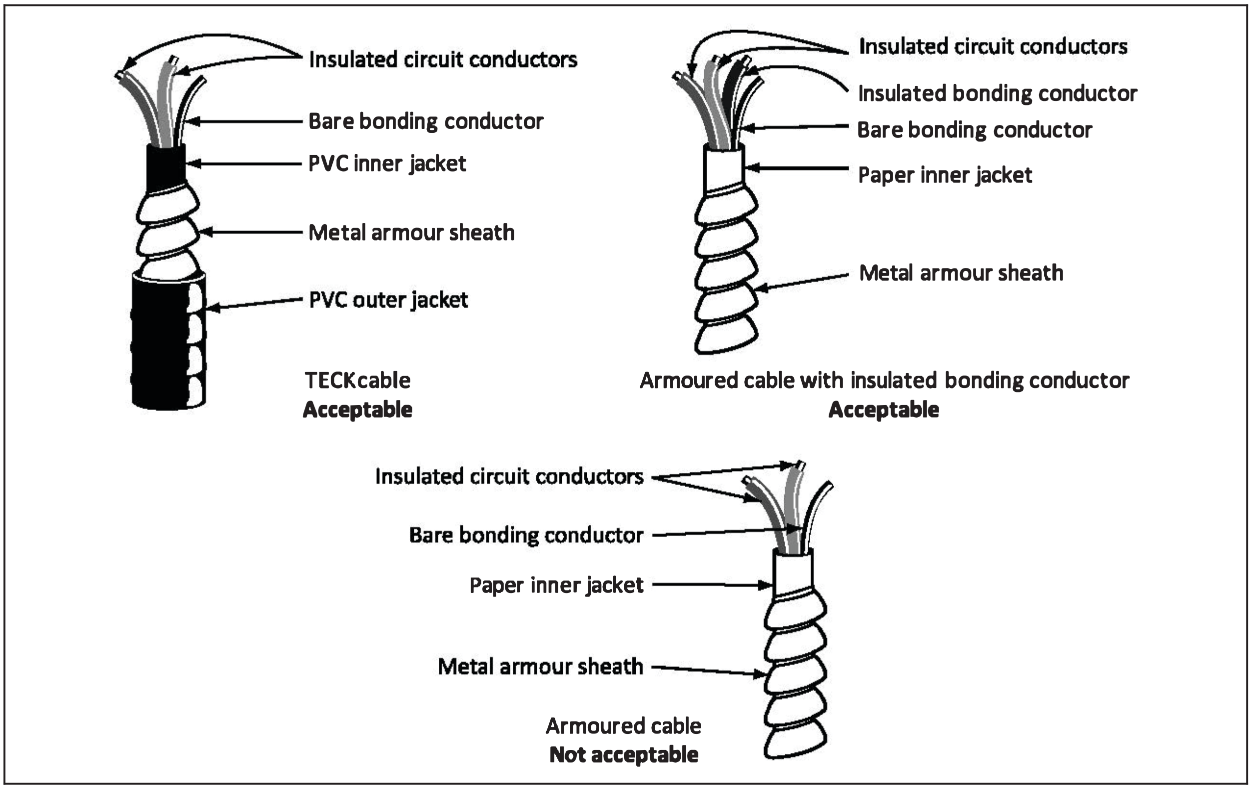
Subrule 8) requires that circuit conductors connected to communication or nurse call equipment in a patient care area be classed as Class 1 circuits in accordance with the applicable Rules of Section 16.

### Rule 24-104 Bonding to ground in basic care areas

Bonding to ground in all patient care areas limits the voltage that occurs on exposed, non-current-carrying metal parts in the event of a fault in the electrical insulation of the wiring system or in the utilization equipment; it is also intended to eliminate small but potentially hazardous voltage differences that can otherwise exist between grounded points in the vicinity of the patient.

The requirements of Subrule 1) are intended to limit voltage differences in the vicinity of the patient and minimize the risk of electric shock from breaks or high-resistance connections in the bonding conductors. The bonding conductors in metal raceways or in the metal sheath of cables are to be insulated or, if bare, run in non-metallic conduit or are to be in a cable such as TECK90 that prevents the outer metal armour or sheath from contacting the bare bond conductor in the cable (see Figure 24-2).

## Figure 24-2
## Armoured cable for use in basic, intermediate, and critical care areas




When armoured cable that contains an insulated bonding conductor along with a bare bonding conductor is used, the bare bonding conductor is to be connected to the insulated bonding conductor at both the supply and load ends.

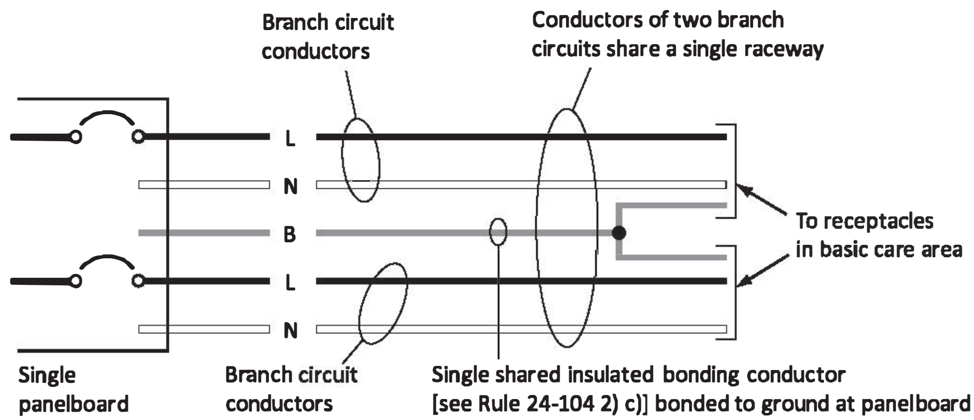
To ensure that the integrity, and the limits on the voltage drop, of the bonding conductors are maintained, Subrule 2) requires that all bonding conductors be copper and not smaller than No. 12 AWG. The bonding conductors are sized according to the requirements of Rule 10-614. The bonding conductors are to be installed according to Rules 10-610 and 10-612 and are to be run with circuit conductors in accordance with the following:

- a multi-wire branch circuit is to have its own bonding conductor; and
- a 2-wire branch circuit supplying a receptacle in a patient care area is to have its own bonding conductor.

Exemptions to the separate bonding conductor Rule for 2-wire branch circuits are allowed by Items c) and d) of Subrule 2) as follows:

- receptacles that are fed by two 2-wire branch circuits in the same raceway in the same patient care environment are allowed to share the same bonding conductor (see Figure 24-3); or
- receptacles that are installed in two adjacent patient care environments and supplied by three 2-wire branch circuits, with one of the circuits supplying receptacles in both patient care environments, are allowed to share two bonding conductors.

**Figure 24-3**
**Permissible single bonding conductor for two branch circuits**




Subrule 3) requires that the bonding conductors for receptacles, permanently connected equipment, three-phase equipment, and the non-current-carrying metal parts of communication, radio, and television equipment be terminated at the panelboard that supplies the branch circuits or on a separately installed busbar connected to the panelboard that supplies the branch circuits.

When two panelboards (one of which is an essential electrical system panelboard) supply circuits in a single patient care environment, Subrule 4) requires that the ground voltage differences between the two panelboards be minimized by bonding the panelboards together with a copper conductor sized in accordance with Rule 10-614, but in no case smaller than No. 6 AWG.

Subrule 5) is intended to ensure that under fault conditions minimal fault impedance is introduced into the fault circuit. It requires that a copper bonding conductor be installed inside the raceway, be part of the cable assembly, or be in compliance with the requirements of Rules 10-610 and 10-612 for the installation of equipment bonding conductors and sized in accordance with Rule 10-614. Installation of the bonding conductor inside the grounded metal raceway also has the benefit of introducing less noise into the circuit from outside sources.

Subrule 6) requires that each piece of three-phase equipment be bonded to ground by a copper bonding conductor that is sized in accordance with Rule 10-614, but not smaller than No. 12 AWG, and that terminates at its own terminal in the equipment and panelboard.

Subrule 7) requires that bonding conductors for communication, radio, or television equipment be sized in accordance with Subrule 6) and be either:
- connected in the communication section of the barriered and ganged metal outlet box in the patient care environment; or
- connected to the equipment bonding conductor or bonding busbar for the patient care environment as required in Subrule 3).

To clarify bonding requirements for non-electrical equipment located in a patient care environment in order to prevent shock hazards and to achieve an equipotential plane, Subrule 8) requires that exposed non-current-carrying metal parts of non-electrical equipment that could become energized in a patient care environment be bonded to ground using a copper equipment bonding conductor sized in accordance with Subrule 6) and connected to an equipment bonding conductor or bonding busbar for that patient care environment [see Subrule 3)].

When recessed and surface mounted luminaires are located more than 2.3 m above floor level, and their associated switches are located outside a patient care environment, Subrule 9) allows them to be bonded in accordance with Section 10 requirements and not the requirements of Subrules 1) and 2).

### Rule 24-106 Receptacles in basic care areas

Any interaction between the cord-connected medical electrical equipment used in one patient care environment and the cord-connected equipment intended for use in another patient care environment is to be avoided wherever possible. The intention of Subrule 1) is to reduce such interaction by effectively locating or grouping the receptacles so that those for a given patient care environment are not used inadvertently in another patient care environment.

To prevent splashing water and cleaning chemicals from contacting receptacles and creating shock hazards or premature failure of receptacles by corrosion, Subrule 2) requires that receptacles located in areas that are routinely cleaned using liquids be mounted at least 300 mm above the floor.

When receptacles are required for the use of appliances near wash basins, Subrule 3) requires that such receptacles be installed:

- within 1.5 m of the wash basin (to avoid the need for extension cords); and
- outside a bathtub enclosure or shower stall.

Such receptacles are to be protected by a Class A type GFCI, as Rule 26-704 requires that receptacles located within 1.5 m of a wash basin be protected by a Class A type GFCI.

Housekeeping electrical equipment is not serviced, tested, or checked as frequently or as fully as medical electrical equipment. It frequently generates electrical noise and has a leakage current greater than that acceptable in a patient care area. For these reasons, Subrule 4) requires that receptacles for housekeeping and other non-medical loads be clearly identified for their intended purpose.

Hospital-grade receptacles require highly reliable components and construction, and are manufactured to a higher standard than other types of receptacles. Subrule 5) requires that all 15 A and 20 A non-locking receptacles be hospital grade. An exception is made for the receptacles specified in Subrule 3) that are installed adjacent to wash basins since they have ground fault protection.

**Note:** *Receptacles that are marked as hospital grade are to be identified by a green dot on the receptacle face, which is visible after the cover plate has been installed. The Appendix B Note to Rule 24-106 5) clarifies that it is not intended by this Rule to mandate installation of hospital-grade receptacles in washrooms and bathrooms contained within patient care areas.*

Health care facility staff are to be able to identify readily and consistently, from one health care facility to another, receptacles that are to remain energized during a supply failure (i.e., those that are supplied from an essential electrical system circuit). Subrule 6) requires that such receptacles be coloured red.

Subrule 7), along with the requirements of CSA Z32, does not allow the use of isolated ground type receptacles in basic care areas.

### Rule 24-108 Other equipment in basic care areas

Rule 24-108 allows the installation of appropriate electrical signalling equipment, which is placed at useful heights inside the stalls and enclosures, so that patients can call for help if necessary.

### Rule 24-110 Circuits in intermediate and critical care areas

CSA Z32 provides recommendations regarding the minimum number of receptacles and circuits usually needed in the various patient care areas. In intermediate and critical care areas, either a grounded or an isolated system is allowed to be used. Consult CSA Z32 regarding the relative merits of each system.

Procedures in intermediate and critical care areas frequently involve body or cardiac contact, and the electrical equipment connected to one branch circuit is to be as protected as possible from the effects of a fault on another circuit. Rule 24-110 allows the use of a solidly grounded system or an isolated system for supply of branch circuits in intermediate and critical areas. However, each branch circuit in these areas, except those circuits that supply multiphase equipment, is to be a 2-wire circuit and each is to have its own bonding conductor, except where isolated 2-wire circuits meeting the requirements of Rule 24-200 are used.

**Rule 24-112 Bonding to ground in intermediate and critical care areas**
Subrule 1) requires that intermediate and critical care areas meet the same bonding-to-ground requirements as those specified for basic care areas in Rule 24-104, whether they are supplied from a solidly grounded or an isolated system.

Subrule 2) recognizes that bonding methods can vary (e.g., some bonding conductors for an area can terminate at a grounding bus and others at the panelboard).

**Rule 24-114 Receptacles in intermediate and critical care areas**
Receptacles in intermediate and critical care areas are to meet the requirements in Rule 24-106 for basic care areas. Isolated systems provide protection from electric shock without reducing the line voltage to ground on the isolated system to 50% of the supply voltage and without disconnecting receptacles from their supply (as in the case of a GFCI). To avoid performance and operational problems, Item b) is intended to ensure that staff can readily identify receptacles that are connected to isolated systems (see Rules 24-200 to 24-208).

**Rule 24-116 Receptacles subject to standing fluids on the floor or drenching of the work area**
Standing fluids on the floor or drenching of the work area can create potentially hazardous safety conditions since people can become the path for the ground fault current. Rule 24-116 is not intended to apply to routine housekeeping procedures and incidental spillage of liquids.

Item a) requires that receptacles protected by a Class A GFCI be used in locations within a patient care area where standing fluids on the floor or drenching of the work area can create potentially hazardous safety conditions and when the interruption of power to the receptacles due to the activation of a GFCI is allowed by health care facility administration. When such power interruption to the receptacles is not allowed, Item b) requires that these receptacles be supplied by an isolated system.

## Isolated systems

An isolated system is an electrical distribution system in which no circuit conductor is connected directly to ground. An isolated system is used to eliminate outside influences (such as circulating ground currents and stray signals or frequencies in the grounding or power systems) from entering the system.

A well-designed and properly installed solidly grounded distribution system provides satisfactory protection from electric shock. If Class A GFCIs are included, circuits of a solidly grounded system provide excellent protection from electric shock but with the potential risk of an interruption to the supply. Isolated systems provide good protection from electric shock without the inconvenience and other problems that result from an interruption to the supply. Although the possibility of a person receiving an unintentional electric shock from a properly grounded system is extremely remote, such a possibility is even more unlikely in an isolated system.

In a typical solidly grounded system, there is a voltage difference of 120 V between the live conductor and ground. In a comparable isolated system, there is a voltage difference of 120 V between the two branch circuit conductors, but because neither conductor is connected to ground (except through the very high impedance of the conductor insulation), only a small charging current can flow from the conductor to ground, and the effective voltage-to-ground is 120 V / 2 = 60 V.

The electrical distribution equipment for a solidly grounded system typically requires less space and is less expensive than that of an isolated system. This difference in cost is offset to some extent by the less frequent circuit testing required by isolated systems.

The decision to use a solidly grounded system, an isolated system, or a combination of both systems (in larger areas containing several rooms and patient care environments) is to be made jointly by the provincial or federal health care authorities having jurisdiction, the health care facility administration, and the professional engineer responsible for the electrical design of the facility.

### Rule 24-200 Rules for isolated systems

Rules 24-202 to 24-208 govern the electrical installation of isolated power systems in intermediate and critical care areas. There is usually little need to use an isolated system to supply fixed lighting and other permanently connected equipment, although in some situations where a surgical light will be adjusted from time to time by the surgeon, consider using an isolated supply.

Wiring for solidly grounded and isolated systems is to be kept separate to avoid the possibility of an improper cross-connection and to prevent reactive coupling between the two systems. Reactive coupling occurs when the conductors of a solidly grounded system and those of an isolated system are run in a common raceway, resulting in a transfer of energy from one system to the other. This transfer of energy is caused by mutual inductance between the two electric circuits.

Isolated ground receptacles and isolated systems are commonly confused. The use of isolated ground receptacles with isolated systems is not normally required, but it is not prohibited. While Rule 24-200 allows the connection of permanently connected luminaires and other electrical equipment to an isolated system, it neither requires nor recommends the use of isolated ground receptacles with an isolated system.

### Rule 24-202 Sources of supply

Regardless of the means of supply selected, there is not to be a conductive connection between the normal building electrical system, whether grounded or ungrounded, and the isolated system intended for use in a patient care area [see Subrule 1) of Rule 24-202].

To minimize the possibility of a hazard to patients during medical procedures where more than one single-phase isolated power system serves a single patient care environment, the maximum voltage rise at the U-slot of any receptacle in a single patient care environment is to remain at a safe level during an electrical fault, and the bonding conductor is to be able to carry the anticipated fault current safely. The intent of Subrule 2) is to limit the voltage rise on the grounding buses of each isolated electrical system in a patient care environment by bonding all grounding buses together. Subrule 2) also ensures that electrical faults can be cleared quickly by requiring that bonding conductors:

- be made of copper;
- have a total impedance of the bonding connections to a maximum of 0.2 Ω; and
- not be smaller than allowed by Rule 10-614.

## Rule 24-204 Single-phase isolated circuits

CSA Z32 includes the following definitions:

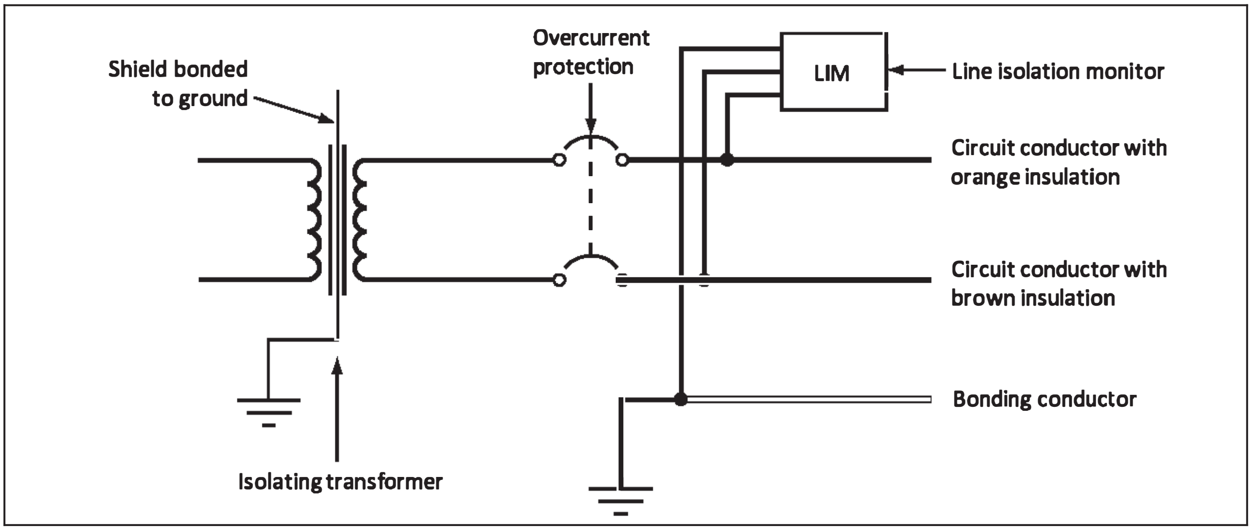
> **Hazard index** — for a given set of conditions in an isolated power system, the current, expressed in milliamperes and consisting of resistive and capacitive leakage and fault currents, that would flow through a low impedance if the low impedance were to be connected between either isolated conductor and ground.
>
> **Note:** *The hazard index with one isolated conductor connected to ground is not necessarily the same as the hazard index with the other isolated conductor connected to ground; of the two, the higher hazard index governs.*
>
> **Maximum hazard index** — the hazard index of an isolated system with all permanently connected equipment switched on, as read on the line isolation monitor.
>
> **System hazard index** — the hazard index of an isolated system with all permanently connected equipment switched off and the line isolation monitor and all cord-connected equipment disconnected.
>
> **Total hazard index** — the hazard index of an isolated system with all appliances connected, including the line isolation monitor.

The hazard index of an isolated system is never to be greater than 2 mA. An index of 2 mA limits the leakage current of the system to 1 mA when all the utilization equipment is connected to it. The line isolation monitor introduces an equal current, bringing the total to 2 mA. To achieve such a low hazard index, the leakage current of the isolated system alone should be in the vicinity of 0.25 mA. A system with such a small leakage current is usually small; isolated systems typically have a capacity in the range of 5 kV•A to 7.5 kV•A. Also, isolated systems must use conductors with special insulation to maintain the isolation in the raceways.

Isolated circuits are to be kept totally separate from other branch circuits and made easily recognizable to maintenance personnel. Across Canada, orange and brown insulation is used on conductors in single-phase isolated circuits for easy identification.

Subrule 2) covers requirements for single-phase isolated circuits (see Figure 24-4).

**Figure 24-4**
**Single-phase isolated circuit**




Isolated systems provide protection from electric shocks when both conductors are isolated from ground, so health care facility staff must be alerted if anything reduces this isolation. A reduction in isolation is usually due to the connection of a faulty piece of electrical equipment to the system. Subrule 5) requires the use of a line isolation monitor (LIM) to provide this necessary warning. A LIM is a device that measures and displays the total hazard index of an isolated electrical system and provides a warning when the index reaches a pre-set limit. The LIM is to be installed where it is visible to the staff using the isolated system. A LIM will alert staff using the isolated system. A LIM is a device that measures and displays the total hazard index of an isolated electrical system and provides a warning when the index reaches a pre-set limit. A LIM should be provided to alert staff that a first fault has occurred and that the system has become a grounded one capable of producing significant arcs. A LIM will sound an alarm when a first fault develops in any branch circuit of the isolated electrical system or in equipment plugged into the system.

Subrule 6) requires that the impedance to ground be measured using acceptable techniques. The 200 000 Ω requirement is intended to limit the system leakage current. CSA Z32 covers methods for verifying the impedance to ground of an isolated system.

Since the leakage current is to be small, each isolated system is to have circuit conductors of short lengths to limit capacitive leakage and for ease of service, maintenance, and testing. The area such conductors can serve is limited.

## Rule 24-206 Individually isolated branch circuits

Occasionally, the need arises for a single outlet supplied by an isolated system. Under such circumstances, the cost of a LIM and an isolated distribution centre might not be warranted. If a LIM is not provided, however, the impedance to ground of the circuits is to be tested at regular intervals and maintenance procedures are to be instituted for the system and the electrical equipment connected to it, as necessary, to limit the hazard index to 2 mA. Rule 24-206 provides an exemption from the requirements for an overcurrent device and a LIM in the case of a single-phase isolated system supplying only one load by means of a one branch circuit.

## Rule 24-208 Three-phase isolated systems

Instability can occur when wye-connected, three-phase systems with isolated (ungrounded) neutrals have unbalanced loads. Consequently, Rule 24-208 restricts the use of such systems so that they only supply permanently connected electrical equipment having a balanced three-phase load or special-purpose receptacles in which the loads are strictly controlled and limited to avoid an unbalance in the system. Item a) ii) requires that the special-purpose receptacles be provided only in anaesthetizing locations or patient care environments and be connected so that only one receptacle can be energized at any one time.

**Note:** *General-use receptacles have uncontrolled loads, allowing the inadvertent application of widely unbalanced loads.*

## Essential electrical systems

In certain areas of a health care facility, an interruption of power to the electrical system can endanger patients' lives or adversely impact the effective operation of the health care facility. An essential electrical system (see definition in Rule 24-002) is needed since it has the capacity to restore and sustain a supply of electrical energy to specified loads in the event of a loss of the normal supply of energy, without interrupting the effective care of patients. This Subsection sets out the requirements for installing an essential electrical system in a health care facility. CSA Z32 provides further recommendations related to its design, installation, use, and maintenance.

### Rule 24-302 Circuits in essential electrical systems

Rule 24-302 describes the three types of circuits used in an essential electrical system (see Rule 24-002):

- the vital branch, used when the circuits require power restoration within 10 s;
- the delayed vital branch, used when the circuits require power restoration within 2 min; and
- the conditional branch, used when the circuits require power restoration by emergency service within 24 h (for non-critical loads such as ventilation, lighting, and pumping).

Such circuits are designated essential by the health care facility administration since these circuits are necessary to the life safety systems described in Section 46, the care of the patient, and the effective operation of the health care facility. CSA Z32 provides full descriptions of vital, delayed vital, and conditional branches and provides a complete listing of those essential electrical system loads and branches that are to have access to an emergency supply. Essential electrical system circuits are to be installed in a manner that minimizes the risk of damage from a fault in the normal circuits. Subrule 3) requires the complete separation of the essential electrical system circuits from the non-essential electrical system circuits. Subrule 4) also clarifies that separation of life safety system circuits required by Rule 46-108 is not necessary when such life safety system circuits function as a part of the essential electrical system in a health care facility, provided that:

- all overcurrent devices of the essential electrical system are selectively coordinated; or
- the vital branch and delayed vital branch of the essential electrical system are kept entirely separate from the conditional branch.

### Rule 24-304 Transfer switches

A transfer switch connects the essential electrical system to the emergency power supply whenever there is a disruption in the normal power supply to the essential system. Certain types of transfer switches (e.g., a closed transition switch) can allow an essential electrical system supplied by the emergency power source to unexpectedly energize a de-energized distribution line while utility personnel are working on it. Therefore, the supply authorities are to be satisfied with the type of transfer switch connected to their systems.

Once the loads of the essential electrical system are connected to the emergency supply, these loads are not to be disconnected until the normal supply is restored. Occasionally, automatic devices fail. In such an instance, essential electrical system loads can be manually transferred to the emergency supply. Subrule 3) provides the requirements for manual transfer switches.

Vital and delayed vital branches are to be connected to the emergency supply more quickly than is possible by means of a manual transfer switch. Subrule 4) requires that automatic switches be used for such circuits.

Subrule 5) permits conditional branches, which have a much longer period for transfer to the emergency supply, to use either automatic or manual transfer switches.

### Rule 24-306 Emergency supply

To be completely reliable, an emergency supply is to function in all emergencies, not just during unexpected interruptions to the normal supply. An emergency supply is to deliver power continuously during natural disasters (e.g., storms, floods, fires, and earthquakes) when all community supplies of electricity, water, and fuel are cut off, either accidentally or intentionally. Item a) of Rule 24-306 requires that one or more generators be used as the emergency power supply source for the loads of the essential electrical system.

The intention of Rule 24-306 is to ensure that the power supply to a health care facility is as reliable as possible under all operating conditions and that the installation complies with the requirements of CSA Z32 for the arrangement and redundancy of the generator sets.

Clause 6 of CSA Z32 provides criteria for sizing the emergency generators and for determining their redundancy. CSA Z32 also states that the emergency generators are to comply with CSA C282.

Rule 24-306 b) requires that the emergency power supply be installed on the health care facility premises and located in a service room or enclosure in accordance with CSA C282.

# Section 26 — Installation of electrical equipment

## General

### Rule 26-002 Connection to identified terminals or leads

The use of ac systems incorporating a neutral conductor is quite common. Section 10 requires that such systems be grounded, and Section 4 requires that a grounded circuit conductor be identified (usually with a white or grey covering). In 2-wire circuits, the grounded conductor is often referred to in the field as the neutral conductor.

Ensuring that a particular part is connected to the grounded conductor can be important in the connection of some electrical equipment. For example, with a luminaire incorporating a screwshell lampholder, the grounded conductor is to be connected to the screwshell to eliminate the possibility of someone receiving an electric shock while changing a lamp bulb. The lead connected to the screwshell is to then be identified and connected to the identified or grounded conductor of the branch circuit. To minimize the possibility of someone receiving an electrical shock when touching the equipment, Rule 26-002 requires that electrical equipment be properly connected by connecting the identified conductor to the identified terminal or lead.

### Rule 26-004 Equipment over combustible surfaces

Some pieces of electrical equipment are designed to be mounted on a floor. If that equipment has an open bottom and the floor has a combustible surface, then the floor surface can then be subjected to arcing or sparking under fault conditions through the open bottom. Equipment mounted on a floor is acceptable only if the floor surface is covered with non-combustible material, due to it presenting a hazard if the floor surface is combustible.

The certification requirements for electrical equipment state that equipment that is to be mounted directly over combustible surfaces does not require any additional protection, unless the equipment bears a cautionary marking clearly indicating that additional protection is necessary. If equipment has an open bottom, or if there is a mark indicating that additional protection is required, a steel plate is to be installed between the equipment and the combustible floor surface.

### Rule 26-006 Installation of ventilated enclosures

When installed inside an enclosure, certain types of electrical apparatus can generate a significant amount of heat that can damage the apparatus or reduce its life expectancy. One way of keeping the heat buildup at a satisfactory level is to ventilate the enclosure. Keeping the ventilation open to airflow is also a certification requirement for these ventilated enclosures. Rule 26-006 requires that enclosures that are to be ventilated to avoid overheating not be installed in a way that restricts the necessary ventilation.

### Rule 26-008 Sprinklered equipment

Some parts of buildings are equipped with sprinklers, with sprinkler heads installed to ensure that any fire in that room cannot spread to other parts of the building. In an electrical equipment vault or room that contains sprinklers, water from an operating sprinkler head must not be allowed to get into the electrical equipment. Therefore, Rule 26-008 requires that water following a direct line-of-sight path from the sprinkler head not be allowed to strike live parts within the enclosure through ventilation openings in the sides and tops of electrical equipment, and water accumulating on the top of the equipment not flow into the interior through significant openings (for example, ventilation openings, openings around bus duct entries, and dry-type armoured cable connectors). Bolts and seams do not present significant openings. In all other cases, Rule 26-008 requires that non-combustible hoods or shields be provided over the equipment. See Figures 26-1 and 26-2.

As the Appendix B Note to 26-008 states, the intent of Rule 26-008 can be met through the use of weatherproof equipment.

Although Rule 26-008 applies only to electrical equipment in electrical equipment vaults or rooms, following its intent for electrical equipment in all sprinklered areas of a building can reduce potential damage to electrical equipment caused when a live sprinkler head is activated.

**Figure 26-1**
**Protective shields over equipment**

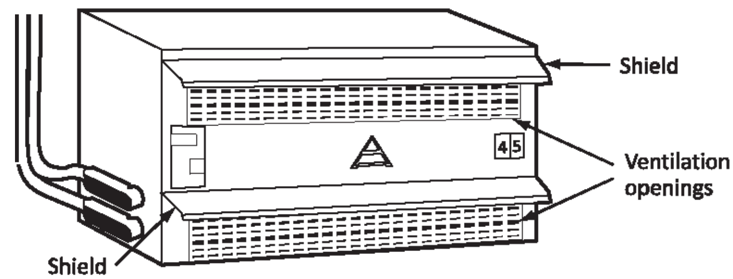
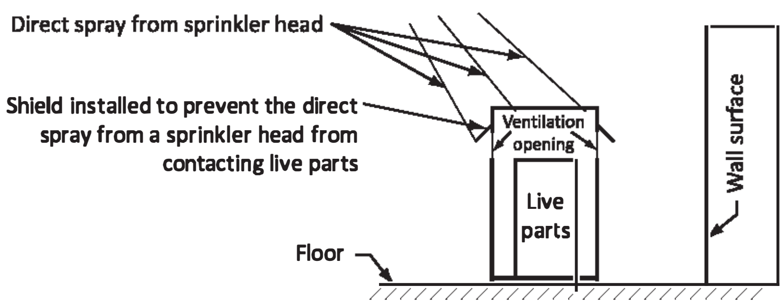



**Figure 26-2**
**Protective shields for electrical equipment**




## Rule 26-010 Outdoor installations

To prevent shock hazards, Rule 26-010 requires that electrical apparatus installed outdoors be properly bonded to ground and guarded against accidental contact by suitable fencing or outdoor enclosures such as the casing of an outdoor air conditioner compressor unit.

## Rule 26-012 Dielectric liquid-filled equipment — Indoors

In many cases, electrical equipment such as transformers, capacitors, and motor starters are immersed in a dielectric liquid (insulating liquid) and are installed indoors. Leakage of this dielectric liquid from the equipment into the building or sewer system presents an environmental and fire hazard. When electrical equipment contains larger quantities of liquid (over 23 L of liquid in one tank or over 69 L in a group of tanks), the environmental and fire hazards becomes significant, so Subrule 1) requires that such equipment, when located indoors, be located in an electrical equipment vault.

Subrule 2) gives the requirements for the service room where dielectric liquid-filled electrical equipment containing 23 L of liquid or less in one tank, or 69 L or less in a group of tanks are installed.

Subrule 3) allows a dielectric liquid-filled motor starter to have the quantities of dielectric liquids specified in Subrules 1) and 2) doubled.

Subrule 4) allows an exception from the requirements of Subrule 2) for capacitors that contain flammable liquids of 14 L or less in each tank: they are not required to be installed in an electrical equipment vault or in a service room, provided that:

- a metal pan or concrete curbing that is capable of collecting and retaining all the liquid of the tank or tanks is installed;
- no other dielectric liquid-filled electrical equipment nor any combustible surface or material is within 4.5 m unless segregated by fire-resisting barriers, with metal-enclosed equipment considered as providing segregation; and
- each capacitor tank is provided with overcurrent protection to minimize rupture of the case.

Subrule 5) allows an exception from the requirements of Subrule 1) for dielectric liquid-filled equipment located indoors with more than 23 L of liquid in one tank or more than 69 L in a group of tanks, provided the following additional conditions are met:

- the equipment is protected from mechanical damage either by location or guarding;
- the equipment contains a non-propagating liquid having a flash point of 275 °C or higher;
- for equipment other than transformers, a means of absorbing gases generated by arcing inside the case, or a pressure relief device is provided;
- for transformers with ratings exceeding 25 kV•A at 25 Hz or exceeding 37.5 kV•A at 60 Hz, a means of absorbing gases generated by arcing inside the tank, or a pressure relief vent is provided; and
- where transformers exceeding 25 kV•A at 25 Hz or exceeding 37.5 kV•A at 60 Hz are rated at 15 000 V or more, the service room is accessible only to authorized persons.

The Appendix B Note to Rule 26-012 states that dielectric liquid-filled circuit breakers or switches should have their vents piped directly to an outside area in accordance with the manufacturer's instructions or recommendations. A table and diagrams illustrating the separation requirements of Subrule 2) are also provided.

### Rule 26-014 Dielectric liquid-filled equipment — Outdoors

When outdoor dielectric liquid-filled electrical equipment containing more than 46 L in any one tank or a total of 137 L in a group of tanks fails under certain conditions of fault, the dielectric liquid can burn in the air. This burning liquid, as well as any leaking dielectric liquid, might reach the building, causing problems for:

- people in the building;
- people evacuating the building; and
- the building itself.

The location of outdoor dielectric liquid-filled electrical equipment is to be:

- accessible to firefighting operations;
- accessible to authorized personnel who are responsible for servicing and maintaining the equipment; and
- inaccessible to unauthorized personnel to keep them from contacting the equipment.

Therefore, Subrule 1) requires that when dielectric liquid-filled equipment is installed outdoors it not be located within 6 m of:

- any combustible surfaces or material on a building;
- any door or window; or
- any ventilation inlet or outlet.

Subrule 2) gives the requirements for measuring the 6 m distance in Subrule 1). The distance is to be the shortest line-of-sight distance from the face of the container containing the dielectric liquid to the building or part of the building.

When the 6 m distance from the building cannot be maintained, Subrule 3) allows the equipment to be installed at a distance less than 6 m from the building, provided that a wall or barrier made with fire-resisting surfaces or material that prevents burning liquid from contacting the building is constructed between the building and the equipment. This barrier is in addition to the normal enclosure for the equipment.

## Isolating switches

### Rule 26-100 Location of isolating switches

An isolating switch is a non-load break switch intended for isolating either a circuit or a piece of equipment from its source of supply. It is not intended either to establish or to interrupt the load current in any circuit. Subrule 1) allows isolating switches to be installed in locations that require the use of a hook stick to operate the switches, provided that unauthorized personnel cannot gain access to the switches.

Subrule 2) requires that isolating switches be marked to show their purpose. An exception to the marking requirement is allowed when the isolated switches are:
- located or guarded from access by unauthorized personnel; or
- interlocked to prevent inadvertent operation under load.

## Circuit breakers

### Rule 26-120 Indoor installation of circuit breakers

Many of the larger indoor circuit breakers are immersed in a dielectric liquid. In such cases, the degree of fire hazard is related to the quantity of dielectric liquid used. Subrule 1) requires that the requirements of Rule 26-012 be applied to circuit breakers, as well as to any other type of dielectric liquid-filled electrical equipment. If a circuit breaker is installed in an electrical equipment vault, it is to be mounted so that the circuit breaker itself is on the inside of the vault and only the operating handle is exposed on the outside of the vault. Subrule 2) requires that the circuit breaker be operable without opening the door of the vault.

## Fuses and fusible equipment

### Rule 26-140 Installation of fuses

A fuse is expected to operate under either overload or short-circuit conditions. Items a) and b) require that:
- their operation not cause any injury to people;
- their operation not cause damage to property;
- their operation not cause damage other electrical equipment; and
- they be capable of being readily inserted and removed from the fuseholders.

In low-voltage installations, the fuses are typically located in either an externally operated switch or a panelboard. For high-voltage installations, refer to the appropriate Rules in Section 36.

### Rule 26-142 Fusible equipment

Tables 1 to 4 list the allowable ampacities for copper and aluminum insulated conductors. When the single conductor or single-conductor cable is in free air, using Tables 1 and 3, it is assigned a higher ampacity. Even when the insulated conductor is in a raceway or cable, using Tables 2 and 4, it is assigned a slightly higher ampacity if its insulation is rated at 90 °C rather than 60 or 75 °C.

When the insulated conductors supplying fusible electrical equipment are allowed to carry higher currents, an increased heating effect occurs inside the equipment enclosure. Zinc-link fuses, usually referred to as standard or code fuses and now known as Class H fuses, are an additional source of heat, and the combined heat can cause a premature failure of the equipment. Therefore, Rule 26-142 requires that, if higher ampacities are allowed, Class H fuses with a low melting point designated by the marking D or P on the label be used, or that fuses that do not generate as much heat, such as Class CA, CB, CC, G, J, K, L, R, T, or HRCI-MISC fuses, be used.

# Capacitors

### Rule 26-200 Capacitors exempted

Rule 2-024 requires that all electrical equipment be approved, which means that individual pieces of equipment are to be certified by an accredited certification organization. The certification process is a means of ensuring that capacitors included as a component part of an apparatus operate safely.
Rule 26-200 therefore states that the requirements of Rules 26-202 to 26-222 do not apply to capacitors that are included as component parts of factory-assembled electrical equipment or to surge protective capacitors.

### Rule 26-206 Grounding of capacitors

When de-energized, capacitors are to automatically drain their stored charge within a specific period of time (see Rule 26-222). In this process the bonding circuit not only carries fault current but also must carry the discharge current for the time it takes the capacitor to discharge the stored charge. To allow the bonding circuit to carry the fault current or discharge when required, Rule 26-206 requires that non-current-carrying metal parts of capacitors be bonded to ground.

### Rule 26-208 Conductor size for capacitors

When capacitors operate on an energized ac system, a surge of current occurs as the capacitor plates are charged and discharged. Since the polarity of the capacitor plates changes every half-cycle, there is a small continuous surge on the capacitor's supply conductors as long as the capacitor is energized.

All capacitors are manufactured with a tolerance of 0% to +15%, so that a capacitor can actually draw a current equivalent to 115% of its rating. In addition, the current drawn by a capacitor varies directly with the line voltage, and any variation in the line voltage from a pure sine waveform causes the capacitor to draw an increased current. Thus, the current to a capacitor can amount to 135% of the rated current of that capacitor. Subrule 1) requires that the conductors of capacitor feeder circuits and branch circuits have an ampacity not less than 135% of the rated capacitor's current. See Table 26-1.

Sometimes it might be necessary to supply more than one capacitor from a single branch circuit, in which case the requirements of Rule 14-100 do not normally allow the size of the branch circuit conductors to be decreased. Since the load is fixed, however, Subrule 2) allows the overcurrent device protecting the branch circuit supplying the two or more capacitors to protect the tap conductors, provided that the tap conductors:

- are not greater than 7.5 m in length;
- have an ampacity equal to the requirement of Subrule 1) for the capacitor each tap conductor feeds; and
- are not less than one-third the ampacity of the feeder conductor (the conductor supplying the tap conductors).

Overloads on the taps are unlikely, and the overcurrent devices sized to protect the branch circuit continue to provide short-circuit protection for each tap conductor.

### Rule 26-210 Overcurrent protection

Individual capacitor overcurrent protection or the single protection of a capacitor bank is typically used. This involves coordinating the time-current (i.e., tripping) characteristics of the overcurrent protection with those of the capacitor with respect to the bursting caused by the generation of gas pressure under fault conditions. In selecting the protection, it is necessary to consider the available fault current of the circuit and the proper connection of the capacitors in the circuit (i.e., whether in parallel, series-parallel, Y-connected with a floating neutral, etc.). Improper capacitor connections can also cause overvoltage on adjacent units upon failure of a unit.

Rule 26-210 requires that the overcurrent protection be set as low as practicable without causing nuisance tripping of the overcurrent device, but not exceed 250% of the capacitor's rated current for feeders or branch circuits supplying capacitors (Table 26-1). See the Appendix B Note to Rule 26-210 for further information.

**Table 26-1**
**Method to determine the maximum overcurrent device size and the minimum conductor size for a capacitor or capacitor bank installation**

| Step | Method |
|---|---|
| 1 | From the capacitor's nameplate or using the following formula, determine the capacitor's rating (FLC) or capacitor bank in amperes:<br>For single-phase<br>$I = (kVARS \times 1000) / E_{line}$<br>For three-phase<br>$I = (kVARS \times 1000) / (E_{line} \times 1.73)$ |
| 2 | Calculate the maximum calculated overcurrent device ampere rating by multiplying the capacitor's rating (FLC) in amperes (see Step 1) × 250% (2.5). (See Rule 26-210.) |
| 3 | Using manufacturer's tables, determine the size of the standard rated overcurrent device.<br>**Note:** *The standard size of the overcurrent device is equal to or less than the calculated value in Step 2.* |
| 4 | Calculate the minimum conductor ampacity by multiplying the capacitor's rating (FLC) in amperes (see Step 1) × 135% (1.35). (See Rule 26-208.) |
| 5 | Determine the minimum conductor size from Tables 1 to 4, taking into account:<br>• the conductor's material (copper or aluminum); and<br>• the installation method (i.e., free air, raceway, multi-conductor cable, or direct buried). |

### Rule 26-212 Disconnecting means for capacitor feeders or branch circuits

Subrule 1) requires that anyone servicing a capacitor be able to safely disconnect it from its feeder or its branch circuit and do so without interrupting other loads.

Similar to the requirement for motors in Rule 28-604, Subrule 2) requires that the disconnecting means for capacitor feeder and branch circuits be within sight of, and not more than 9 m from, the capacitor unless the disconnecting means can be locked in the open position.

Due to the stored energy in a capacitor, Subrule 3) requires that a warning notice be affixed to the disconnecting means used on circuits having capacitors only, stating that:

- the circuit has capacitors; and
- a waiting period of 5 min is necessary when the circuit is opened to allow the automatic discharge function of the capacitor time to discharge the stored energy, after which the capacitors is to be discharged by grounding the capacitor before handling

### Rule 26-214 Rating of the disconnecting means for capacitor feeders or branch circuits

To prevent heat buildup in the disconnecting means, Rule 26-214 requires that the disconnecting means for a capacitor feeder or branch circuit have a continuous rating of not less than 135% of the rated current of the capacitor.

### Rule 26-216 Rating of contactors for capacitor feeders or branch circuits

Item a) of Rule 26-216 requires that when contactors are used for the switching of capacitors, the current rating of the contactor be equal to or greater than the minimum conductor ampacity rating for the capacitor (greater than 135% of the current rating of the capacitor).

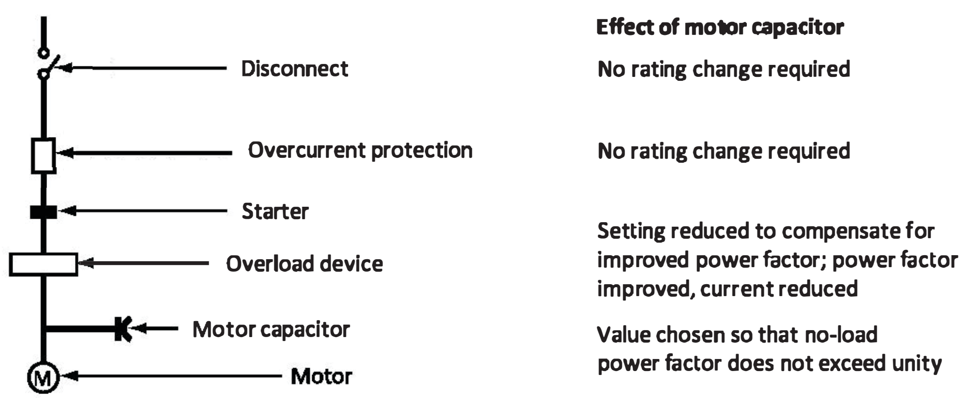
Due to heat dissipation, extra capacity is required if the contactor is of the enclosed type. Item b) requires that, when enclosed-type contactors are used for the switching of capacitors, the current rating of the contactor be equal to or greater than 150% of the capacitor's current rating.

### Rule 26-218 Special provisions for motor circuit capacitors

Motors are inductive loads and capacitors can be used to correct the power factor. To improve the power factor of an entire plant, a large central bank of capacitors can be provided. The most effective power factor correction, however, is obtained when individual capacitors are connected directly to the terminals of the motor or the load terminals of the motor starter or controller. In some cases, some relaxation of the general Rules is allowed. In others, the requirements are more restrictive. For example, if the capacitor is connected on the load side of the overload device, the line current is reduced due to the improved power factor; therefore, the rating or setting of the overload device is not to be as high as allowed by the Rules in Section 28, which are based on the rated full load current of the motor. See Figure 26-3.

Subrule 2) recognizes that special provisions are appropriate where a capacitor is provided for an individual motor. The intent is to prohibit the connection of capacitors on the load side of the motor overload device if the motor is subject to unusual switching service such as plugging, rapid reversals, and jogging. Under this kind of service, the overvoltage and the overtorque produced by the residual voltage on the capacitor can result in failure of the motor windings or the motor shaft.

**Figure 26-3**
**Power factor correction on load side of motor overloads**




**Note:** *The motor must not be subjected to star-delta starting, auto-transformer starting, or switching service such as plugging, rapid reversals, reclosings, jogging, or other similar operations that generate overvoltage and overtorques.*

### Rule 26-222 Drainage of stored charge of capacitors

When in use, capacitors build up a stored charge. Upon disconnection from its source of supply, a capacitor holds that charge for a period of time. As a result, people servicing the electrical equipment can receive a severe shock or the equipment can be damaged, unless some means is provided for draining off the stored charge from the capacitor. Subrule 1) requires that there be a means of draining the stored charge or residual voltage left when the capacitor is de-energized.

Subrule 2) requires that the stored or residual voltage be reduced to the following:

- for low-voltage capacitors (750 V or less), 50 V or less within 1 min; or
- for high-voltage capacitors (over 750 V), 50 V or less within 5 min.

Subrule 3) requires that the discharge circuit be:

- connected permanently to the terminals of the capacitor bank; or
- automatically connected to the capacitor when it is de-energized.

In either case, Subrule 4) requires that the discharge circuit not be switched or connected to the capacitor by manual means.

Subrule 5) provides an exception that allows the discharge circuit to be connected directly to capacitors for motors, transformers, or other equipment where this equipment provides a suitable discharge path without going through a switch or overcurrent device.

## Transformers

### Rule 26-240 Transformers — General

Rule 26-240 describes the types of transformers covered by this Subsection and establishes requirements for the enclosures for transformers, conductor entry into the transformer enclosure, mechanical protection, and the air space surrounding dielectric liquid-filled transformers.

"Transformer" as defined in Item a) of Subrule 1) is a single-phase transformer, a polyphase transformer, or a bank of two or three single-phase transformers connected to operate as a polyphase transformer.

There are numerous unit substations being designed, constructed, and installed as complete integrated assemblies that are approved in accordance with CSA SPE-1000. Item b) of Subrule 1) defines "unit substation" as an integrated unit consisting of one or more transformers, disconnecting means, overcurrent devices, and other associated equipment, each contained in a suitable enclosure designed and constructed to restrict access to live parts.

Transformers such as those used to supply Class 2 circuits (for example, doorbell transformers) and ballasts in electric-discharge luminaires are not covered in this Subsection.

Subrule 2) requires that live parts not be exposed unless the transformers are accessible only to authorized personnel. In other words, transformers are to have all live parts enclosed, unless they are isolated by:

- elevation;
- location in a lockable transformer vault; or
- being surrounded by a suitable fence (for example, chain link) (see Rules 26-300 to 26-324).

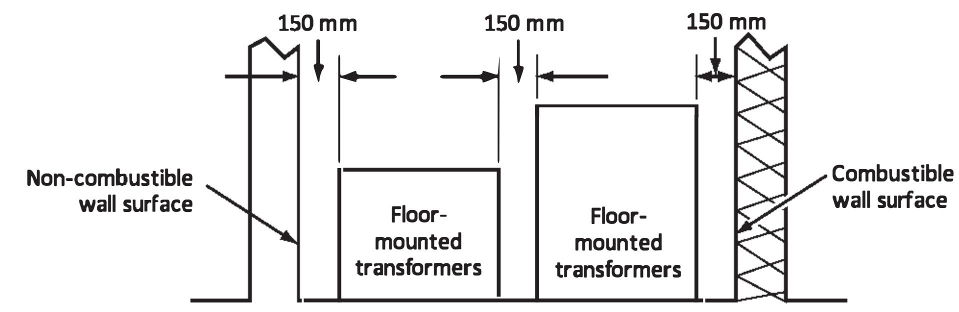
Subrule 3) recognizes that the temperatures in the enclosure of an air-cooled (dry-type) transformer can exceed 30 °C, and the surface temperatures of the core-and-coil assemblies can exceed 90 °C. If the conductors or cables enter the transformer enclosure through the top, the conductor's or cable's insulation can fail due to the heat buildup at the top of the transformer. Therefore, conductors and cables used to connect air-cooled (dry-type) transformers are not allowed to enter the transformer enclosure through the top, unless the transformer is marked to allow top entry.

Subrule 4) requires that transformers be protected from mechanical damage (for example, by ensuring that motor vehicles do not accidentally bump into and damage a transformer located outdoors near a driveway or a loading platform).

Subrule 5) is an installation requirement for the air space surrounding dielectric liquid-filled transformers. The purpose of this requirement is to ensure adequate air circulation around the transformers and any adjacent combustible and non-combustible wall surfaces. Therefore, Subrule 5) requires an air space of 150 mm between dielectric liquid-filled transformers, and between the transformers and adjacent surfaces of combustible material. This air space allows air circulation to keep the dielectric material from overheating. See Figure 26-4. (For the required air space around a dry-core, open-ventilated-type transformer, see Rule 26-246.)

**Note:** *When the transformers are mounted on combustible surfaces, the requirement of Rule 26-004 is to be met.*

**Figure 26-4**
**Clearances for oil-filled transformers**




## Rule 26-242 Outdoor transformer and unit substation installations

Outdoor transformers and unit substations can present:

- a fire hazard to combustible materials on the building;
- a shock hazard to people who come in contact with them; or
- an environmental hazard if they are dielectric liquid-filled.

To prevent these hazards Subrule 1) requires that the transformers and unit substations installed outdoors:

- be installed in accordance with Rule 26-014 if they are dielectric liquid-filled;
- have the bottom of their platform not less than 3.6 m above ground if they are isolated by elevation;
- have the entire installation surrounded by a suitable fence in accordance with Rules 26-300 to 26-324 if they are not isolated by elevation or housed in suitable enclosures; and
- have conspicuously posted, suitable warning signs indicating the highest voltage employed, except where there is no exposed live part.

Field experience with dielectric liquid-filled pad-mounted transformers has shown that a reduction of the 6 m distance from combustible surfaces or materials required in Rule 26-014 can be allowed. Subrule 2) therefore allows dielectric liquid-filled pad-mounted distribution transformers, either by themselves or forming part of a unit substation, to be installed:

- 3 m from a combustible surface or material; and
- a minimum of 6 m from any window, door, or ventilation inlet or outlet.

Subrule 2) also allows an exemption from the 3 m and 6 m distances where:

- a wall or barrier with non-combustible surfaces or material is constructed between the pad-mounted transformer and any such window, door, or ventilation inlet or outlet. This wall or barrier protects these openings against the possibility of being sprayed by burning liquid from a failed transformer; or
- the transformer is equipped with an integral current-limiting device and a pressure relief device, and sufficient space is available to gain entrance to the transformer and to do work around the transformer such as painting, attaching slings for removal, etc. The required working spaces are at least 3 m on the access side of the transformer, and on all other sides, 1 m for three-phase transformers and 0.6 m for single-phase transformers.

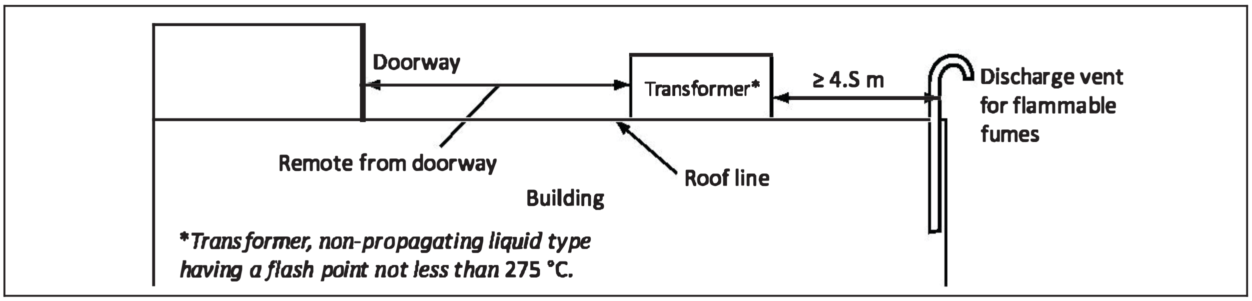
## Rule 26-244 Transformers mounted on roofs

If a dielectric liquid-filled transformer case ruptures, the presence of the liquid can present an additional hazard to the building since it can collect or pool on the roof. The degree of that hazard depends on the flammability of the liquid. Rule 26-244 establishes additional requirements for a dielectric liquid-filled transformer installed on the roof of a building.

Subrule 1) requires that dielectric liquid-filled transformers mounted on a roof be installed in an electrical equipment vault and not be supported by combustible construction. The rationale is that a fire inside the building can weaken the structure, causing the transformers to crash through the roof and substantially increase the fire load.

Subrule 2) states that a vault is not required when the liquid used in the transformer is the non-propagating type with a flashpoint equal to or greater than 275 °C. The transformer is to be located so that it is not placed adjacent to doors or windows, or within 4.5 m of discharge vents for combustible materials or gases (see Figure 26-5). See the Appendix B Note to Rule 26-244 2) for assistance in determining how the liquid in the transformer is to be classified.

**Figure 26-5**
**Transformer mounted on roof**

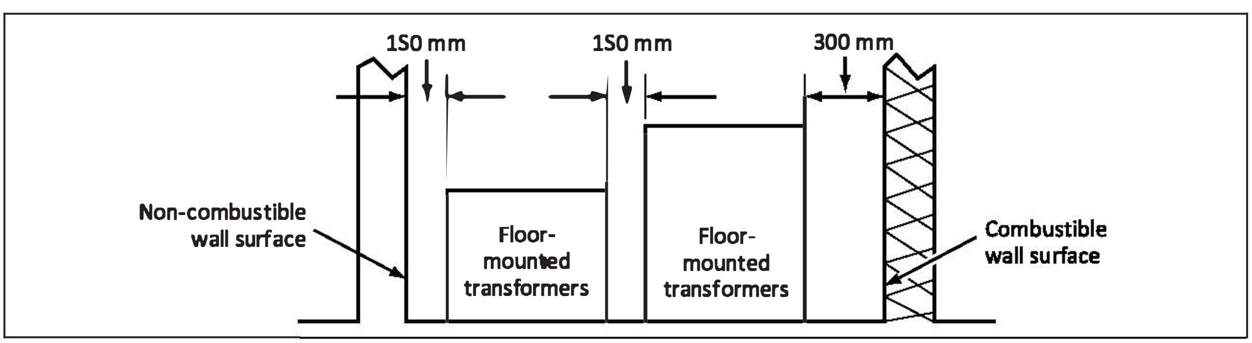



### Rule 26-246 Dry-core, open-ventilated-type transformers

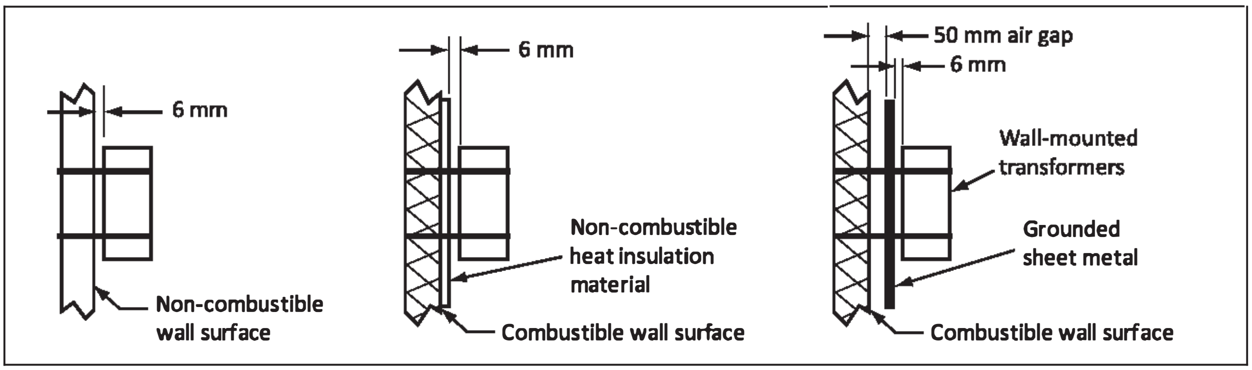
Since fully loaded dry-core transformers can produce a substantial amount of heat, these types of transformers are not to be mounted too close together or to surrounding surfaces, which would overheat both the transformers and surrounding combustible surfaces. See Figures 26-6 and 26-7.

Rule 26-246 requires that dry-core, open-ventilated-type transformers be installed in such a way that air can move freely around the transformers and any heat transferred to adjacent surfaces will be insufficient to heat the surfaces above their auto-ignition temperature values. Rule 26-246 also requires that transformers other than the sealed type be placed where they are not subject to damage by water [see Subrule 5)].

**Figure 26-6**
**Clearance for floor-mounted dry-core transformers**



## Figure 26-7
## Clearances for wall-mounted dry-core transformers




### Rule 26-248 Disconnecting means for transformers

To service power and distribution transformers safely and without interruption of other loads, it is essential to have a disconnecting means that enables the transformer to be isolated from the supply without disconnecting any other loads from the same supply. For that reason, Rule 26-248 requires that a disconnecting means be provided on the line side of each power and distribution transformer.

A transformer is always interposed between a primary (upstream) source of energy and a secondary or downstream load that makes use of the transformer's energy. Therefore, the impedance rating of a transformer is the impedance to the flow of current from source to load. The higher that impedance, the greater the voltage drop across the transformer for a given load current. When a fault occurs on the secondary of the transformer, the fault current flow from the source decreases as the transformer's impedance increases. The impedance rating in percentage is similar to the percentage voltage drop associated with the flow of current in a circuit.

"Inrush current", "energizing current", and "starting surge" refer to the maximum, instantaneous input current drawn by a piece of electrical equipment when first turned on. For example, incandescent light bulbs have high inrush currents until their filaments warm up and their resistance increases. Alternating current electric motors and transformers can draw several times their normal full-load current when first energized, for a few cycles of the input waveform. The selection of overcurrent protection devices such as fuses and circuit breakers is made more complicated when high inrush currents have to be tolerated. The overcurrent protection must react quickly to overload or short-circuit faults but should not interrupt the circuit when the (usually harmless) inrush current flows.

When a transformer is first energized, an inrush current approximately 10 to 50 times higher than the rated transformer current can flow for several cycles. For large transformers, the inrush current can last for several seconds. The high currents occur to energize the transformer core. The steady-state magnetizing current for a transformer is very low, but the momentary current when it is first energized can be quite high.

These inrush currents can cause interaction problems with other loads in a facility or on the power system (voltage sags that can trip or freeze loads). Protection devices can misinterpret these events as fault currents if the devices are not properly coordinated. Coupled with the tendency of other constant power devices to increase current to make up for the reduced voltage, the inrush current could cause protection devices to trip. Energizing a transformer is further complicated by harmonics in the inrush current, which can excite system resonances and cause dynamic overvoltage. In addition to being a high current, the transformer energizing current is full of harmonics. Both even and odd harmonic components occur when a transformer is energized, and they can excite system resonances, resulting in dynamic overvoltages.

## Rule 26-250 Overcurrent protection for power and distribution transformer circuits rated over 750 V

Overcurrent devices located on the secondary side of a transformer do not protect the transformer against a short-circuit condition that could occur on the primary windings. Consequently, protection is required on the primary side. The multiplier (correction factor) used to size the maximum individual overcurrent device is usually provided on the primary side, and the multiplier (correction factor) value varies, depending on whether a fuse at 150% (1.5) of the rated primary current or a circuit breaker at 300% (3.0) of the rated primary current is used. The difference in this rating is based on the difference between the operating characteristics of fuses and circuit breakers. In the case of fuses, when the calculated maximum primary fuse rating (rated primary current × 1.5) does not correspond to a standard rated fuse, Subrule 2) allows rounding up to the next higher value, to avoid nuisance tripping caused by the energizing (inrush) current. Rule 26-250 describes the types and ratings of overcurrent (short-circuit) protection for high-voltage power and distribution transformers (see Figure 26-8). Subrules 3) and 4) list those special circumstances in which an individual overcurrent device in the primary circuit of the transformer is not required. See Examples below.

### Example 1A — Sizing overcurrent protection using a fuse and minimum primary and secondary conductor ampacity for high-voltage transformers

**Question**

Determine the rating of the primary fuse and the minimum ampacity rating of the primary and secondary conductors for a 5 MV•A dry-type transformer with a primary of 27.6 kV and a secondary of 13.8 kV, three-phase.

**Answer**

1) Determine the primary current of the transformer:
   (MV•A × 1 000 000) / ($E_{line}$ × 1.73) = (5 × 1 000 000) / (27 600 × 1.73) = 104.7 A
2) Determine the secondary current of the transformer:
   (MV•A × 1 000 000) / ($E_{line}$ × 1.73) = (5 × 1 000 000) / (13 800 × 1.73) = 209.4 A
3) Determine the maximum calculated fuse rating [see Item a) of Subrule 1) of Rule 26-250]:
   Primary current × 1.5 = 104.7 × 1.5 = 157.1 A [see Subrule 1) of Rule 26-256]
4) Determine standard rated fuse size – 150 A (from manufacturer)
5) Minimum primary conductor ampacity [see Subrule 1) of Rule 26-256]:
   Primary current × 1.25 = 104.7 × 1.25 = 130.9 A
   However, Subrule 5) of Rule 26-256 applies. Therefore, the minimum primary conductor ampacity must be equal to or greater than 150 A (rating of primary fuse)
6) Minimum secondary conductor ampacity [see Subrule 2) of Rule 26-256]:
   Secondary current × 1.25 = 209.4 × 1.25 = 261.8
   However, Subrule 5) of Rule 26-256 applies. Therefore, the minimum secondary conductor ampacity must be equal to or greater than the:
   Standard rated primary fuse size × (primary to secondary voltage ratio)
   = 150 × (27.6 / 13.8) = 300 A

**Note:** *Subrule 2) of Rule 26-250 allows the primary fuse to be rounded up to the next higher standard rating when 150% of the rated primary current of the transformer does not correspond to the standard rating of fuses. When Subrule 2) of Rule 26-250 is applied, Subrule 5) of Rule 26-256 must also be taken into consideration. In the example above, Steps 4 to 6 would change, as follows:*

*4) Determine standard rated fuse size – 175 A (from manufacturer)*

*5) Minimum primary conductor ampacity:*
*According to Subrule 5) of Rule 26-256, the minimum primary conductor ampacity must be equal to, or greater than, 175 A.*

*6) Minimum secondary conductor ampacity [see Subrule 5) of Rule 26-256]:*
*Standard rated primary fuse size × (primary to secondary voltage ratio)*
*= 175 × (27.6 / 13.8) = 350 A*

## Example 1B — Sizing overcurrent protection using a circuit breaker and minimum primary and secondary conductor ampacity for high-voltage transformers

**Question**

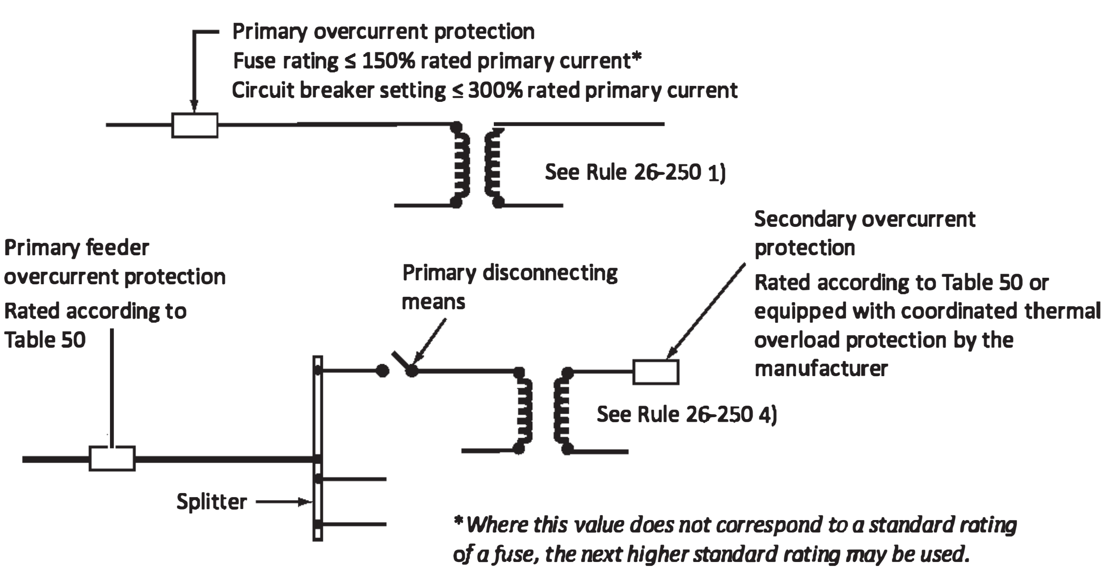
Determine the rating of the primary circuit breaker and the minimum ampacity rating of the primary and secondary conductors for a 5 MV•A dry-type transformer with a primary of 27.6 kV and a secondary of 13.8 kV, three-phase.

**Answer**

1) Determine the primary current of the transformer:
   (MV•A × 1 000 000) / ($E_{line}$ × 1.73) = (5 × 1 000 000) / (27 600 × 1.73) = 104.7 A
2) Determine the secondary current of the transformer:
   (MV•A × 1 000 000) / ($E_{line}$ × 1.73) = (5 × 1 000 000) / (13 800 × 1.73) = 209.4 A
3) Determine the maximum calculated circuit breaker rating [see Item b) of Subrule 1) of Rule 26-250]:
   Primary current × 3.0 = 104.7 × 3 = 314.1 A [see Subrule 1) of Rule 26-256]
4) Determine standard rated circuit breaker size – 300 A (from manufacturer)
5) Minimum primary conductor ampacity [see Subrule 1) of Rule 26-256]:
   Primary current × 1.25 = 104.7 × 1.25 = 130.9 A
   However, Subrule 5) of Rule 26-256 applies. Therefore, the minimum primary conductor ampacity must be equal to, or greater than, 300 A (the rating of primary circuit breaker).
6) Minimum secondary conductor ampacity [see Subrule 2) of Rule 26-256]:
   Secondary current × 1.25 = 209.4 × 1.25 = 261.8
   However, Subrule 5) of Rule 26-256 applies. Therefore minimum secondary conductor ampacity must be equal to, or greater than:
   Standard rated primary overcurrent device × (primary to secondary voltage ratio)
   = 300 × (27.6 / 13.8) = 600 A

**Note:** *Subrule 2) of Rule 26-250 does not allow the primary circuit breaker to be rounded up to the next higher standard rating when 300% of the rated primary current of the transformer does not correspond to the standard rating of circuit breaker.*

## Figure 26-8
## Overcurrent protection for transformers rated over 750 V



### Rule 26-252 Overcurrent protection for power and distribution transformer circuits rated 750 V or less, other than dry-type transformers

The requirements of Rule 26-252 for low-voltage other than dry-type transformers are similar to those of Rule 26-250 for high-voltage transformers. In Subrule 1), however, fuses and circuit breakers use the same multiplier (correction factor) of 150% of the rated primary current of the transformer unless otherwise stated in Subrules 2) to 6).

Subrule 2) allows the multiplier (correction factor) used to determine the maximum rating of the primary overcurrent device (fuse or circuit breaker) to vary with the transformer's rated primary current as follows:

- Where the rated primary current is 9 A or more, the multiplier is 150% (1.5).
- Where the rated primary current is less than 9 A, the multiplier is 167% (1.67).
- Where the rated primary current is less than 2 A, the multiplier is 300% (3.0).

In the case of both fuses and circuit breakers, when the multiplier to determine the maximum rating of the primary overcurrent device is 150% (1.5) and the calculated maximum primary fuse or circuit breaker rating (rated primary current × 1.5) does not correspond to a standard rated fuse or circuit breaker, Item a) of Subrule 2) allows rounding up to the next higher value, to avoid nuisance tripping caused by the energizing (inrush) current.

Subrule 3) allows the overcurrent protection for a feeder or branch circuit to be used as the overcurrent device specified by Rule 26-252. However, remember that Rule 26-248 requires that the disconnecting means for a transformer be installed in the primary circuit of the transformer.

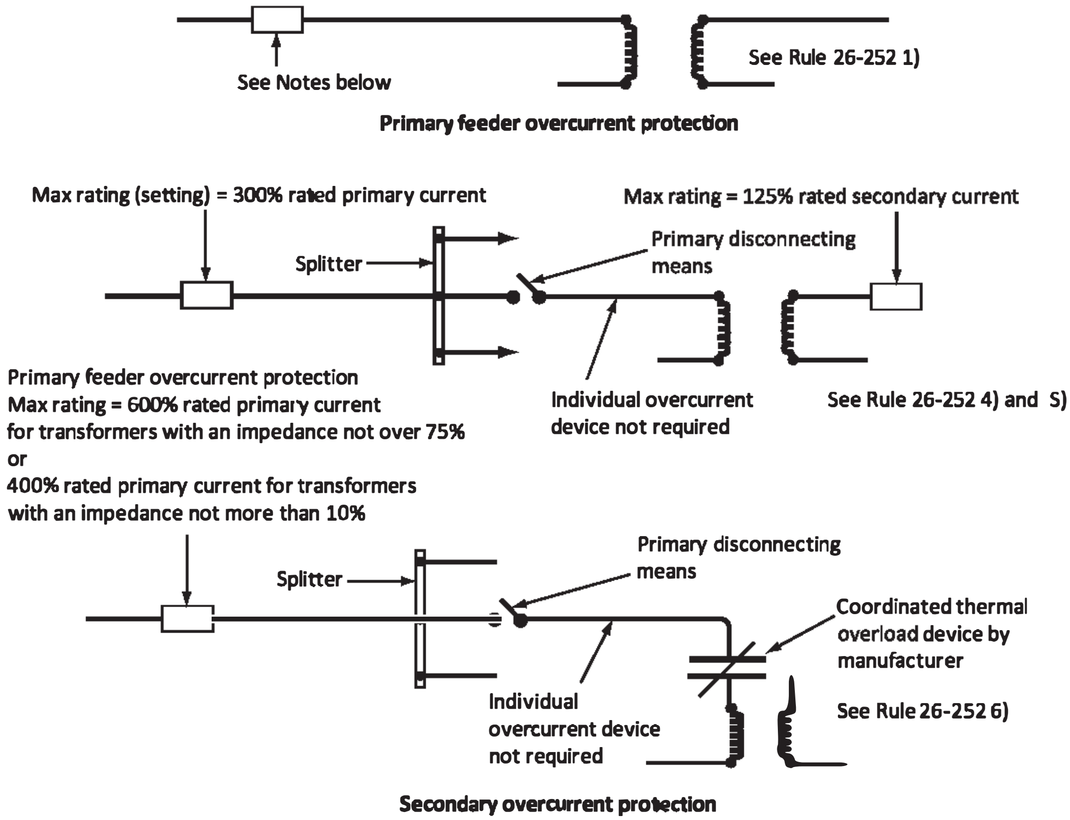
Where a transformer has overcurrent protection on the secondary side that is rated or set at not more than 125% of the rated transformer's secondary current, Subrule 4) does not require individual overcurrent protection on the primary side, provided that the primary feeder overcurrent device is rated or set at not more than 300% of the rated primary current of the transformer.

Where the secondary current of the transformer is 9 A or more, and 125% of the secondary current required in Subrule 4) does not correspond to a standard rating of a fuse or nonadjustable circuit breaker, Item a) of Subrule 5) allows the next higher standard rating to be used in the secondary.

When the transformer's secondary current is less than 9 A, to size the secondary overcurrent device required in Subrule 4), Item b) of Subrule 5) allows the multiplier (correction factor) to be to a maximum of 167% of the rated secondary current.

As with high-voltage transformers, individual overcurrent devices are not mandatory in the primary circuit, and higher ratings are permitted ahead of the transformer when there is acceptable protection on the secondary side of the transformer. Subrule 6) specifies the requirements for transformers equipped with coordinated thermal overload protection by the manufacturer. See Figure 26-9.

## Figure 26-9
## Overcurrent protection (for transformers rated 750 V or less and other than the dry type)




**Notes:**

1) *Individual primary overcurrent protection rating (setting) ≤ 150% rated primary current where primary current is 9 A or more. Where this value does not correspond to a standard rating of an overcurrent device, the next higher standard rating may be used.*
2) *Individual primary overcurrent protection rating (setting) ≤ 167% rated primary current, where the primary current is less than 9 A.*
3) *Individual primary overcurrent protection rating (setting) ≤ 300% rated primary current, where the primary current is less than 2 A.*

### Rule 26-254 Overcurrent protection for dry-type transformer circuits rated 750 V or less

Low-voltage dry-type transformers usually do not have the overload capability of dielectric liquid-filled transformers. As a result, lower maximum overcurrent values are required for dry-type transformers. The multiplier (correction factor) used to determine the maximum rating of the primary overcurrent device (fuse or circuit breaker) for low-voltage dry-type transformers is 125% (1.25). When the secondary conductor of a low-voltage dry-type transformer has a minimum rating of 125% of the rated secondary current of the transformer, it is considered to be protected by the overcurrent device sized in accordance with Rule 26-254 1).

In the case of both fuses and circuit breakers, when the multiplier to determine the maximum rating of the primary overcurrent device is 125% (1.25) and the calculated maximum primary fuse or circuit breaker rating (rated primary current × 1.25) does not correspond to a standard rated fuse or circuit breaker, Subrule 3) allows rounding up to the next higher value. This is allowed to avoid nuisance tripping caused by the energizing (inrush) current.

Care is to be taken in selecting the overcurrent protection device values to ensure that the device is not tripped by the inrush current of the transformer when the transformer is energized. The Appendix B Note to Rule 26-254 suggests that to avoid this nuisance operation, the overcurrent device interrupting characteristics should be able to carry:

- 12 times the transformer rated primary full-load current for 0.1 s; and
- 25 times the transformer rated primary full-load current for 0.01 s.

See Figure 26-10 and Example 1.

### Example 1 — Sizing overcurrent protection and minimum primary and secondary conductor ampacity for low-voltage dry-type transformers

**Question**

Determine the rating of the primary fuse or circuit breaker and the minimum ampacity rating of the primary and secondary conductors for a 60 kV•A dry-type transformer with a primary of 600 V, three-phase, 3-wire, and a secondary of 120/208 V, three-phase, 4-wire.

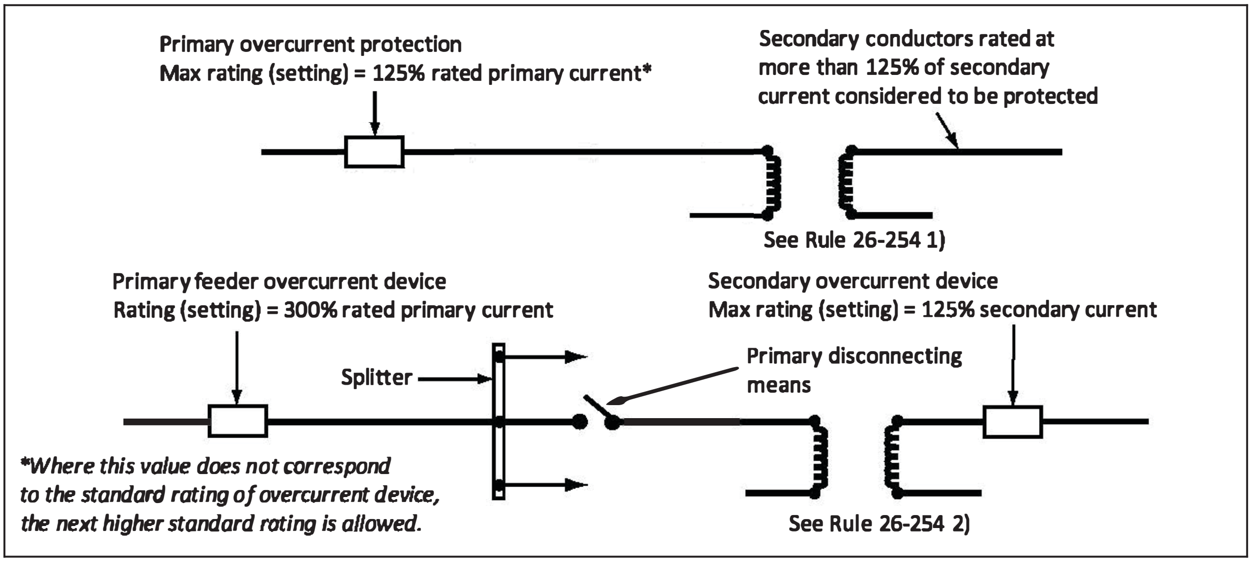
**Answer**

1) Determine the primary current of the transformer:
   $(kV\bullet A \times 1000) / (E_{line} \times 1.73) = (60 \times 1000) / (600 \times 1.73) = 57.8$ A
2) Determine the secondary current of the transformer:
   $(kV\bullet A \times 1000) / (E_{line} \times 1.73) = (60 \times 1000) / (208 \times 1.73) = 166.7$ A
3) Determine the maximum calculated fuse or circuit breaker rating [see Subrule 1) of Rule 26-254]:
   Primary current × 1.25 = 57.8 × 1.25 = 72.3 A
4) Determine the standard rated fuse or circuit breaker size – 70 A (from manufacturer)
5) Minimum primary conductor ampacity [see Subrule 1) of Rule 26-256]:
   Primary current × 1.25 = 57.8 × 1.25 = 72.3 A
6) Minimum secondary conductor ampacity [see Subrule 2) of Rule 26-256]:
   Secondary current × 1.25 = 166.7 × 1.25 = 208.4

**Notes:**

1) *Subrule 1) of Rule 26-254 states that the primary overcurrent device is considered capable of protecting secondary conductors rated at 125% or more of the rated transformer's secondary current.*
2) *Subrule 3) of Rule 26-254 allows the primary device to be rounded up to the next higher standard rating when the value not exceeding 125% of the rated primary current of the transformer does not correspond to the standard rating of the overcurrent device.*
   *When Subrule 3) of Rule 26-254 is applied, Subrule 5) of Rule 26-256 must also be taken into consideration. In the example above, Steps 4 to 6 would change, as follows:*
   *4) Determine the standard rated fuse or circuit breaker size – 80 A (from manufacturer)*
   *5) Minimum primary conductor ampacity:*
   *According to Subrule 5) of Rule 26-256, the minimum primary conductor ampacity has to be equal to, or greater than, 80 A*
   *6) Minimum secondary conductor ampacity [see Subrule 5) of Rule 26-256]:*
   *Standard rated primary overcurrent device × (primary to secondary voltage ratio)*
   *= 80 × (600 / 208) = 230.4 A*

**Figure 26-10**
**Overcurrent protection for dry-type transformers rated 750 V or less**




## Rule 26-256 Conductor size for transformers

Subrules 1) and 2) require that both the primary conductors (supplying the transformer) and the secondary conductors (connected to the secondary side of the transformer) are to be sized not less than 125% of the primary and secondary current ratings of the transformer.

Subrule 3) allows an exception to Subrules 1) and 2) for obtaining the minimum primary and secondary conductor size by using the demand load being placed on the conductors, provided that the overcurrent device protecting the conductors is sized by the demand load in accordance with Rules 14-100 and 14-104.

Where the transformer overcurrent protection is selected in accordance with Subrules 1) and 2) of Rule 26-250 for high-voltage transformers, or Subrule 3) of Rule 26-254 for low-voltage dry-type transformers, Subrule 4) requires that the primary and secondary conductors connected to the transformer be protected by overcurrent protection devices selected in accordance with Rules 14-100 and 14-104. See Examples 1A and 1B in Rule 26-250 and Example 1 in Rule 26-254.

**Note:** *Subrule 4) of Rule 26-256 does not apply to low-voltage dielectric liquid-filled transformers.*

Subrule 5) gives the requirements for sizing the primary and secondary conductors where multi-voltage rating transformers are being used. The minimum size of primary and secondary conductors is to be determined by using the utilization voltage of the primary and secondary circuits to obtain the primary and secondary current rating. This value is multiplied by 125%.

See Table 26-2.

## Table 26-2
## Sizing of transformer equipment*

| Type of equipment | Calculation of ampacity | CE Code reference |
|---|---|---|
| **Primary windings** | | |
| Single-phase primary windings | kV•A × 1000, divided by the primary line-to-line volts | |
| Three-phase primary windings | kV•A × 1000, divided by (the primary line-to-line volts × 1.73) | |
| **Secondary windings** | | |
| Single-phase secondary windings | kV•A × 1000, divided by the secondary line-to-line volts | |
| Three-phase secondary windings | kV•A × 1000, divided by (the secondary line-to-line volts × 1.73) | |
| **Overcurrent devices** | | |
| For high-voltage power and distribution transformers — all types, maximum size | For fuses:<br>1.5 × the transformer's rated primary winding current†<br>For circuit breakers:<br>3 × the transformer's rated primary winding current | 26-250 1) |
| For low-voltage other than dry-type transformers, maximum size | For fuses and circuit breakers for transformers with a primary winding current of 9 A or more:<br>1.5 × the transformer's rated primary winding current‡<br>For fuses and circuit breakers for transformers with a primary winding current less than 9 A:<br>1.67 × the transformer's rated primary current<br>**Exception:**<br>For fuses and circuit breakers for transformers with a primary winding current of less than 2 A:<br>3 × the transformer's rated primary winding current | 26-252 |
| For low-voltage dry-type transformers | 1.25 × the transformer's rated primary current‡ | 26-254 |
| **Minimum size conductors** | | |
| | For the primary line:<br>1.25 × the rated primary current<br>For the secondary line:<br>1.25 × the rated secondary current | 26-256 |

** A disconnecting means is to be provided in the primary circuit of each transformer or each bank of transformers operating as a group to supply the required system's electrical characteristics.*
*† if this value does not correspond to a standard rating of fuse, the next higher standard rating is allowed.*
*‡ if this value does not correspond to a standard rating of fuse or circuit breaker, the next higher rating is allowed. If the secondary conductors or equipment that is connected to the secondary of the transformer is less than 1.25 × the transformer's rated secondary current, secondary overcurrent protection must be provided.*

### Rule 26-258 Transformer continuous load

The intent of this requirement is to provide coordination between loads connected to a transformer's secondary and the rating of the transformer circuit (i.e., the rating of the transformer's overcurrent protection device and the ampacity of transformer's conductors). When determining compliance with the requirements of Rule 8-104 for continuous loads, it is not the rating of the transformer that is used, but rather the load connected to the transformer secondary. For the purpose of the transformer's overcurrent protection and conductor size selection in accordance with Rules 26-250 to 26-256, the continuous load, as determined from the calculated load connected to the transformer secondary, is not to exceed the values specified in Subrule 5) or 6) of Rule 8-104. When an overcurrent protection device rated for continuous operation at 80% is installed in the transformer circuit when free air rated single conductors are being used, a derating of 70% would be used to determine the amount of continuous plus non-continuous loads that could be connected to the overcurrent device [see Item b) of Subrule 6) of Rule 8-104].

### Rule 26-260 Overcurrent protection of instrument voltage transformers

Rule 26-260 prescribes appropriate overcurrent protection for instrument voltage transformers (see also the Appendix B Notes to Rule 26-260).

The purpose of installing primary fuses between the power lines and instrument voltage transformers is to protect the power system from possible destructive arcing due to breakdown of the transformer's insulation. These fuses are to have adequate interrupting capacity for the system to which they are connected.

### Rule 26-262 Marking of transformers

Rule 26-262 specifies the information that is to be listed on the nameplate of each transformer so that the appropriate installation Rules can be applied.

### Rule 26-264 Auto-transformers

Auto-transformers are transformers in which part of the primary and secondary windings is common to both the primary and secondary circuits. The use of an auto-transformer makes it possible to use a piece of electrical equipment rated for a particular voltage when that particular voltage is not readily available from the supply authority. Auto-transformers require little physical space and are quite economical and efficient.

However, an auto-transformer does not provide electrical isolation between its windings (primary and secondary) as a power or distribution transformer does; if the neutral side of the input is not at ground voltage, the neutral side of the output will not be either. A failure of the insulation of the windings of an auto-transformer can result in full input voltage being applied to the output. Also, if a fault occurs between windings that are common to both the primary and secondary circuits, a higher voltage might be applied to the lower voltage circuit, damaging equipment or injuring people. As a result, Subrule 2) requires that auto-transformers be used only on interior wiring systems or circuits used only for motor purposes unless:

- the interior wiring system supplying the auto-transformer (primary circuit) has an identified grounded conductor connected to the identified grounded conductor of the secondary (Figure 26-11);
- the auto-transformer is used for starting or controlling an induction motor; or

  **Note:** *Subrule 3) allows the auto-transformer to be installed either in the starter/controller's enclosure or separately.*
- the circuit the auto-transformer supplies is contained in the enclosure/equipment that houses the auto-transformer.

For example, if a building has a 120/208 V, three-phase supply, but there is a need to provide for a piece of electrical equipment rated at 240 V, an auto-transformer can fulfill this need as shown in Figure 26-12.

**Figure 26-11**
**Connection to auto-transformer**

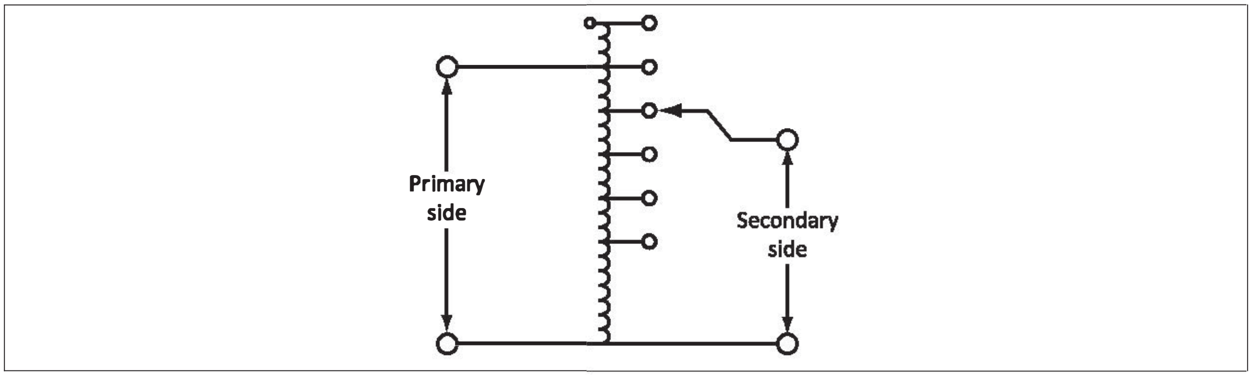
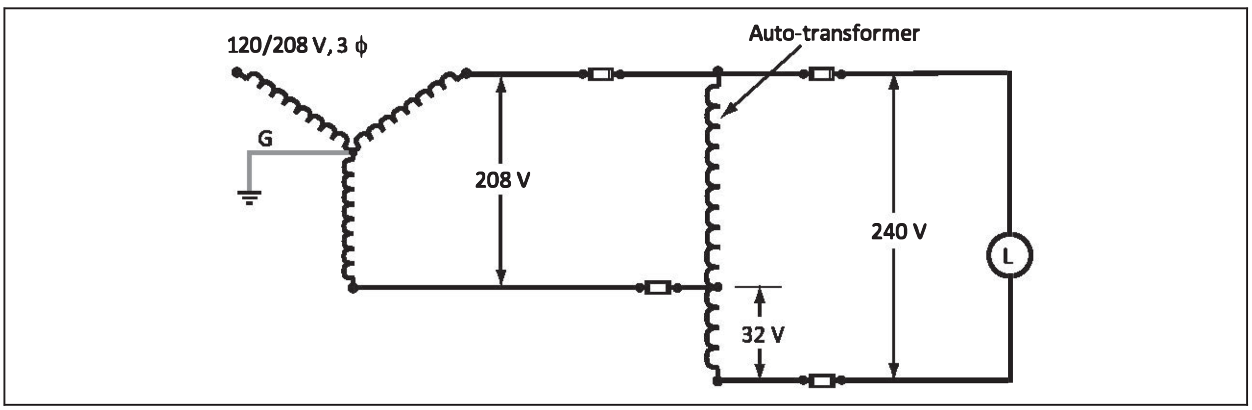



**Figure 26-12**
**Circuitry for an auto-transformer used to derive a 240 V system from a 208 V supply**




## Rule 26-266 Zero sequence filters

Zero sequence filters are zigzag or otherwise wound transformers used in a three-phase, 4-wire system to control unbalanced loads that are caused by loads having non-linear voltage-current characteristics (harmonics). In these installations, the neutral conductor can carry more current than the unbalanced current from other ungrounded conductors of normally balanced circuits of single-phase, 3-wire, and three-phase, 4-wire systems. As the Appendix B Note to Rule 26-266 indicates, the current in the neutral conductor can be three times the current flowing in the phase conductor. If the neutral conductor is not sized to carry this current, it can cause serious heating problems in equipment and conductors.

Subrule 3) requires that the phase/ungrounded conductors to the filter have a minimum ampacity rating of 125% (1.25) times the rated primary current of the filter, while Subrule 4) requires that the neutral conductor have a minimum ampacity rating of 125% (1.25) times the rated neutral current of the filter.

The installation of a zero sequence filter is designed to reduce the current in the neutral conductor by cancelling the multiples of the third harmonic current (from non-linear loads), which are causing the heating in the neutral. When a zero sequence filter is installed in an electrical circuit, it can increase the single phase-to-ground fault current to 1.5 times the available phase-to-phase fault current, which is to be considered when selecting the overcurrent device under Rule 14-012. If the overcurrent protection opens the circuit to a zero sequence filter, it might go unnoticed for a long enough period to allow overheating and damage to occur and to reduce the life expectancy of the electrical equipment and conductors. Therefore, Subrule 6) requires that the overcurrent device be equipped with an integral device that energizes a signal or alarm when the overcurrent protection protecting the zero sequence filter opens. See Figure 26-14.

Zero sequence (harmonic) filters can be installed at the service entrance, on feeders, or at the loads (see Figure 26-13).

**Figure 26-13**
**Location of harmonic filters**

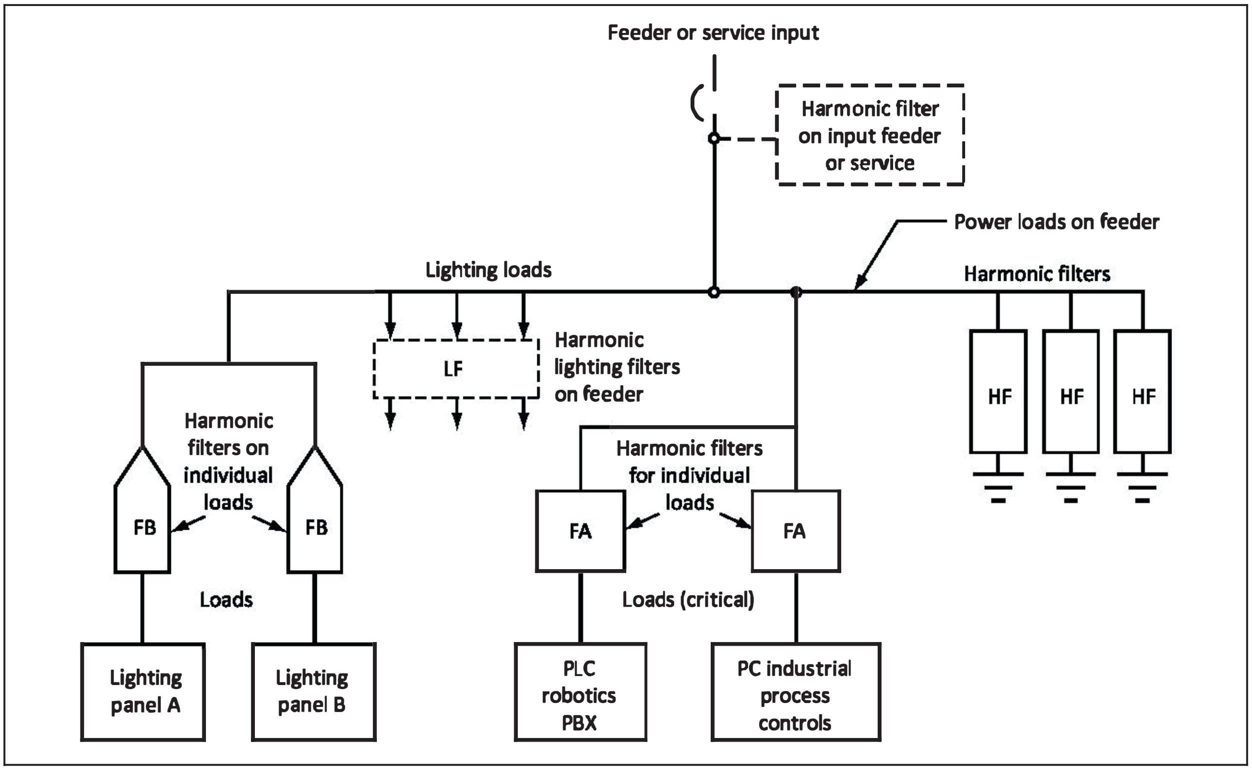
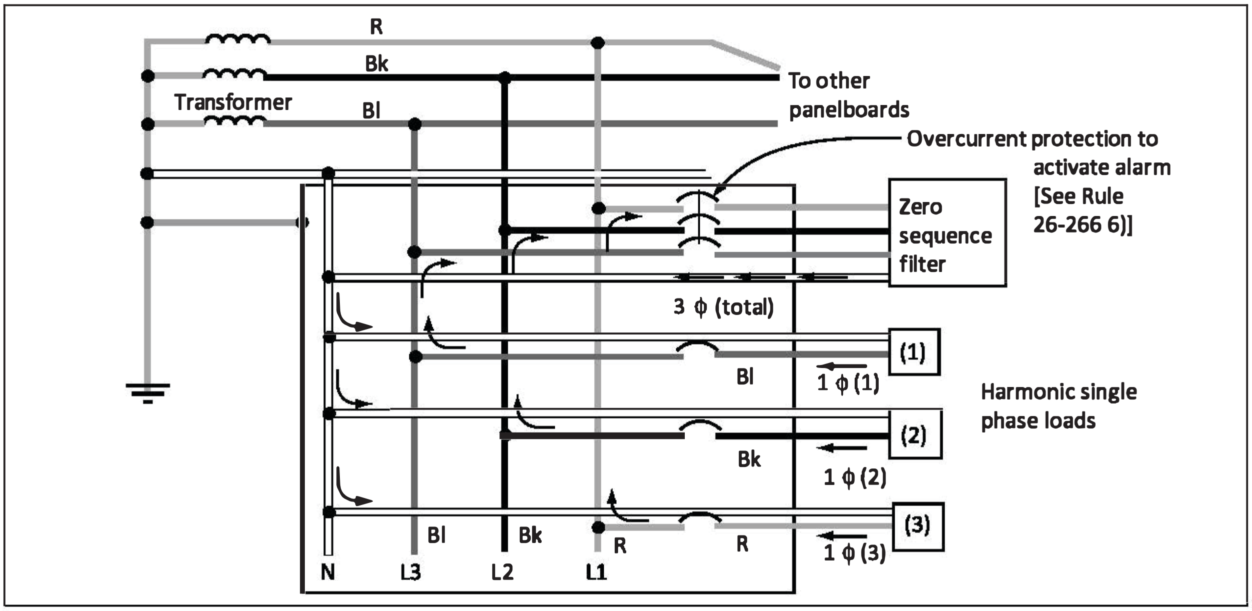


**Figure 26-14**
**Zero sequence filter connection**



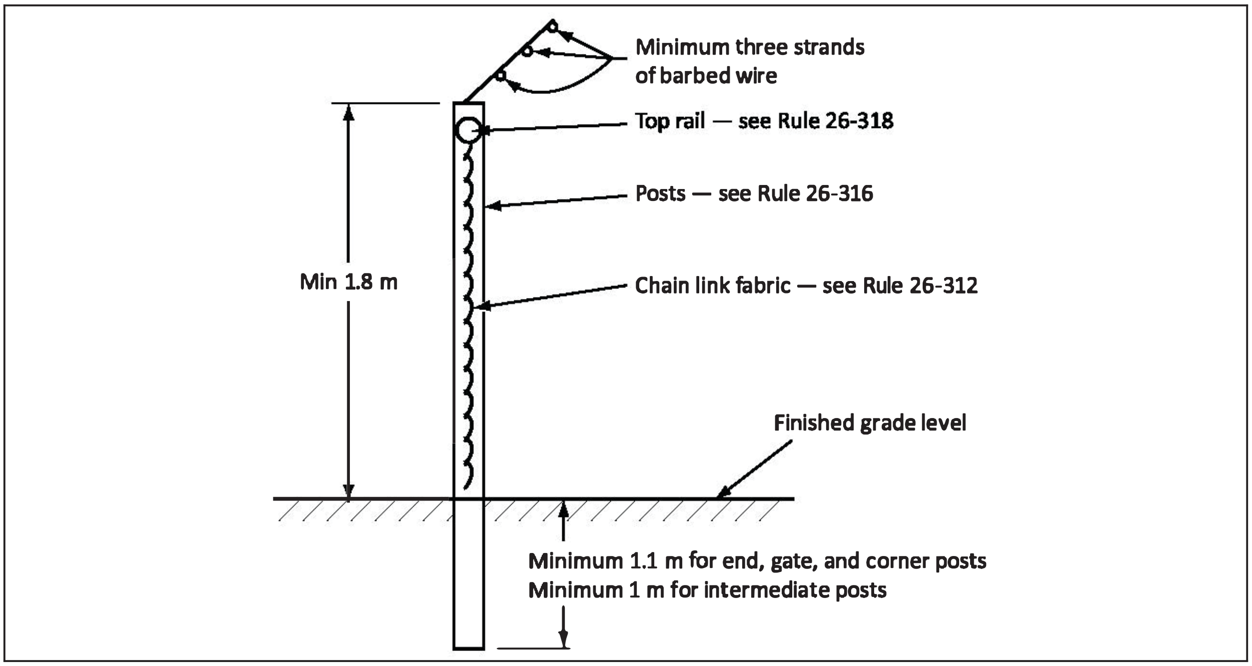

# Fences

**Rules 26-300 to 26-324**

To minimize liability and the risk of dangerous contact or approach by people or objects, fences are used outdoors to guard electrical equipment in high-voltage substations. Rules 26-300 to 26-324 give the requirements for such fences (see Figure 26-15). Although the Code recognizes the use of wooden fences, wood is not advisable since it does not stand up to the elements as well as chain-link fencing materials.

Figure 26-15 shows a typical application of metal fences that comply with the Rules of Section 26.

## Figure 26-15
## Metal fences



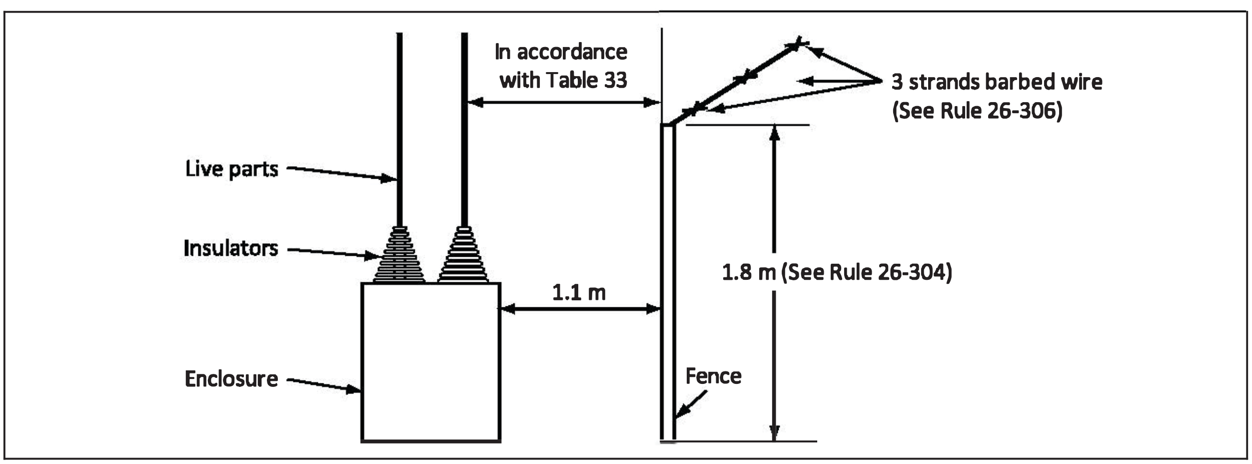

### Rule 26-302 Clearance of equipment

Rule 26-302 sets out the minimum clearance between electrical equipment and the fence as follows:

- for unguarded live parts based on the system voltage, see Table 33;
- for an enclosure containing live parts, a minimum of 1.1 m; and
- for working on equipment, enough to ensure adequate working space (taking into account the extended space needed for draw-out type equipment) and the opening of enclosure doors.

See Figure 26-16.

## Figure 26-16
## Clearances from fencing



### Rule 26-306 Barbed wire

To keep people from climbing over the fence, Rule 26-306 requires that the fence be topped with not less than three separate strands of barbed wire extending at an angle from the top of fence.

## Electrical equipment vaults

### Rule 26-350 General

Many of the larger units of electrical equipment (for example, transformers and capacitors) are filled with a dielectric liquid. Depending on the quantity of liquid involved, the equipment might need to be located in an electrical equipment vault as specified in Rule 26-012.

Rules 26-350 to 26-356 refer the designer to the requirements of the *National Building Code of Canada* and other appropriate Sections of the Code; these include Section 36 for high-voltage installations.

### Rule 26-354 Electrical equipment vault construction

The *National Building Code of Canada* requires that a vault be separated from the remaining parts of the building by a fire separation of solid masonry or concrete construction with a fire-resistance rating of not less than 3 h. This rating is allowed to be reduced to 2 h, however, if the vault is provided with an automatic fire-extinguishing system. The *National Building Code of Canada* also establishes requirements for explosion-relief devices, types of doors, ventilation, drainage, etc. (see the Appendix B Note to Rule 26-354).

### Rule 26-356 Illumination

Rule 26-356 requires that:

- there be adequate lighting in the vault;
- it be possible to service the luminaires without endangering personnel; and
- a grounding type receptacle be conveniently located so that servicing personnel have a place to plug in their portable tools and equipment.

## Cellulose nitrate film storage

### Rule 26-360 General

Rules 26-360 to 26-368 apply to any portion of a building in which cellulose nitrate film is stored.

### Rule 26-362 Equipment in film-vaults

To eliminate potential sources of ignition in film-vaults, such as sparks and heating, Rule 26-362 prohibits the installation of any electrical equipment in film-vaults other than what is necessary for fixed lighting

### Rule 26-364 Wiring methods in film-vaults

Nitrocellulose-based films are highly flammable and decompose over time into a combustible and poisonous gas. To slow the possible migration of such gases and to prevent the spread of fire or heated gases to other rooms or film-vaults through raceways, Rule 26-364 requires that the wiring methods in film-vaults be threaded rigid metal conduit, cables marked for use in a hazardous location (marked with an HL designation), or armoured cable with an overall non-metallic jacket, such as TECK90, ACWU90, copper-sheathed RC90, or aluminum-sheathed RA90. The migration of gases and fire is also prevented by running conduit only from luminaires to switches located outside film-vaults. There is to be no wiring run directly from one vault to another. The conduit is to be sealed near the switch with a fitting and sealing compound marked for Zone 2, Group IIA, or for Class I, Division 2, Group C (see Rule 18-154 or J18-154). These types of seals and compounds prevent gas migration and the spread of fire or heat through the conduit.

### Rule 26-366 Luminaires in film-vaults

Luminaires installed in film-vaults are to be:

- marked for use in Zone 2 locations;
- marked for use in Class I, Division 2, locations;
- marked as non-incendive;

- marked as providing a method of protection "n" (non-sparking); or
- equipment permitted in Zone 1.

### Rule 26-368 Circuits in film-vaults
Luminaires are a potential heat source that can cause the ambient temperature in the film-vault to increase to a level above the normal ambient temperature but below the ignition temperature of the nitrocellulose-based film. This can cause the film to start to decompose, which can rapidly increase the temperature inside the vault to the ignition temperature. The lighting circuits are to be controlled by double-pole switches located outside of the film-vault so that all conductors, including the grounded/identified conductor, are disconnected when the switch is open. Also, the switches are to be provided with a red pilot lamp that lights up to indicate when the switch is closed, which monitors the operation of the luminaires from outside the film-vault. These additional requirements are necessary to avoid any arcing or heating that could occur in the film-vault under fault conditions in the circuit (shorts or grounds) and during servicing of the luminaires.

## Lightning arresters

### Rule 26-400 Use and location of lightning arresters
A lightning strike can cause extensive damage to electrical circuitry and equipment. A direct hit can be devastating, but even a nearby strike can induce a voltage of several thousand volts in power lines. In areas where lightning disturbances are common, lightning arresters that are capable of draining off any such surges to ground, thereby protecting the equipment, are to be installed.

### Rule 26-402 Indoor installations of lightning arresters
To prevent fire and shock hazards from lightning arrester installations, Rule 26-402 requires that they be located:

- away from unprotected equipment;
- away from passageways/corridors;
- away from combustible materials in or on buildings; and
- in separate areas that conform to the requirements of vaults when the arrester contains oil.

### Rule 26-404 Outdoor installations of lightning arresters
To prevent fire and environmental hazards, lightning arresters containing oil and installed outdoors are to have:

- draining means, such as ditches and drains; or
- absorbing means, such as a suitable depth of cinders or other absorbing materials, covering the arrester area.

### Rule 26-406 Choke coils for lightning arresters
A choke coil is inductance used in a circuit to present a high impedance to frequencies, thereby appreciably limiting or suppressing the flow of ac or pulsating dc. To allow the choke coil to operate without being damaged by a lightning strike, the arrester is to be connected between the supply and the choke coil.

### Rule 26-408 Connection of lightning arresters
Due to the high voltages involved, Rule 26-408 requires that the path to ground be as short and straight as practicable. The aim is to keep the current from "jumping" from one object to another, as every time it jumps, extensive damage can result. Since the surge is directed to follow a predetermined low impedance path, that path is to be kept as far as possible from the regular electrical equipment to minimize any possible damage. The lightning arrester is also to be connected by, at a minimum, a No. 6 AWG copper conductor.

### Rule 26-410 Insulation of lightning arrester accessories
To prevent the current from jumping from the conductor to ground or from the conductor to the lightning arrester accessories, the insulation is to have the same voltage rating as other parts of the circuit.

# Low-voltage surge protective devices

## Rule 26-420 Low-voltage surge protectors

A transient voltage surge is a momentary voltage surge on a signal or power line that lasts for a short time (less than a half-cycle). It can produce false signals or triggering impulses and cause insulation or component breakdown and failures.

High-voltage spikes or transient voltage surges in electrical installations are caused by factors such as switching of high-voltage lines, variable frequency drives, and electronic switching. These high-voltage spikes can damage devices/components used in today's electrical equipment by exceeding their voltage rating, even though the duration of the voltage spike is short. Lightning surge suppressors have been used successfully for many years to prevent damage to electrical installations from direct and indirect lightning strikes, but they do not operate fast enough to prevent damage or disturbances from transient voltage surges.

Low-voltage surge protective devices or transient voltage surge suppressors are surge suppression products designed to repeatedly suppress transient voltage surges on 50 and 60 Hz power circuits on low-voltage systems (i.e., those not exceeding 750 V). To prevent a fire hazard inside a building due to damage to the low-voltage surge protector or to the conductors feeding it, overcurrent protection is necessary when low-voltage protectors are installed inside a building.

To enable low-voltage surge protectors to divert the damaging high-voltage spikes or transient voltages to ground, the impedance of the conductors feeding the low-voltage surge protector are to be kept to a minimum. The conductors between the equipment being protected and the low-voltage surge protector should be kept as short and as straight as possible. The manufacturer's specifications should be consulted for the maximum length of conductors.

The CSA C22.2 No. 269 series of Standards covers five types of surge protective devices as described in Table 26-3.

**Table 26-3**
**Five types of surge protective devices**

| Type | Intended application and environment |
|---|---|
| 1 | • Permanently connected between the secondary of the service transformer and the line side of the service equipment overcurrent device, as well as the load side, including watt-hour meter socket enclosures, and is intended to be installed without an external overcurrent protective device.<br>• Category A, B, and C exposure environments. |
| 2 | • Permanently connected on the load side of the service equipment overcurrent device.<br>• Category A and B exposure environments. |
| 3 | • Cord-connected or direct-plug-in type, not intended for permanent connection.<br>• Intended to be connected at a minimum conductor length of 10 m from the electrical service panel to the point of utilization.<br>• Category A* exposure environments. |
| 4 | • A component assembly forming part of a Type 1, 2, or 3 SPD.<br>• Not intended for field installation. |
| 5 | • A discrete component such as an MOV, gas tube, or avalanche diode.<br>• Not intended for field installation. |

** Type 3 surge protective devices that have been subjected to the nominal discharge current test in CSA C22.2 No. 269.3 are suitable for use in Category B exposure environments*

The following are tips for using transient voltage surge suppressors:

- The suppressors should have leads of minimal length to avoid parasitic inductance [current in a circuit due to some unintentional cause such as inequalities of temperature or composition (resistance)] and minimize the clamping voltage (a feature of a wave that holds the voltage or current to a specified level).
- Locate overcurrent devices upstream from the suppressor and in series with the protected load.
- Locate the protected power cords far away from unprotected power cords.
- Bunch the power cords in zigzag fashion to minimize the pickup of electromagnetic radiation.
- Noise attenuation of suppressors might not be necessary if the protected equipment has been designed to operate in a noisy environment.
- Separate data lines from ac power cords to avoid the coupling of transient voltages from one to the other.
- Use suppressors at subpanels to block transient voltages generated on a branch circuit from the other branch circuits.
- If the low-voltage suppressor is installed as built-in equipment protection, request information on the suppressor's rating to ensure that it is adequate for the intended environment.
- Mount the low-voltage suppressor in a suitable enclosure since a failure or a suppression of voltage spikes can cause arcs to be discharged.
- Base the decision to use a low-voltage suppressor on economics (i.e., weigh the cost of potential damage against the cost of the suppressor).

## Storage batteries

### Rule 26-500 Scope

Rule 26-500 establishes the appropriate requirements for storage battery installations and differentiates between the wiring requirements for the batteries (Rules 26-502 to 26-512) and the wiring requirements for the other electrical equipment in the room such as luminaires and ventilating fans (Rule 26-514).

### Rule 26-502 Special terminology

A *storage battery* is made up of rechargeable cells; the number of cells depends on the total voltage required. Each cell consists of a positive and negative plate mounted in a container filled with an electrolyte. A common type of storage cell is the lead-acid type (for example, a car battery), which uses a sulphuric acid solution as the electrolyte. Another common type of storage cell is the alkali type, which uses an alkaline solution as the electrolyte.

### Rule 26-504 Location of storage batteries

Some storage batteries are rather small (for example, those used in an automobile or in individual unit equipment for emergency lighting). Rules 26-500 to 26-514, however, refer to the larger electrical installations that use a large number of cells to achieve the voltage and ampacity required, such as:

- large uninterruptable power supplies (UPSs); and
- large storage battery installations that could be used with alternative energy sources such as wind or solar.

Not only do exposed live parts present a shock hazard to an unsuspecting person, but the electrolyte can be very corrosive. For these reasons, Rule 26-504 requires that such cells be located in a room or enclosure accessible only to authorized personnel.

### Rule 26-506 Ventilation of battery rooms or areas

Rule 26-506 deals with two factors: ventilation and temperature. When some batteries are being charged, explosive gas (hydrogen) is produced; sufficient ventilation is to be provided to prevent an accumulation of this gas to an explosive concentration. See the Appendix B Note to Rule 26-506 for the formula from IEEE 484 for determining the rate of ventilation required and a sample calculation using the formula.

The second factor covered by Rule 26-506 is temperature. If it is too cold, the electrolyte could freeze, damaging the containers and ultimately allowing corrosive liquids to escape. The freezing point of the electrolyte varies, depending on the state of charge of the battery, but, as noted in the Appendix B Note to Rule 26-506, batteries should not be located where the temperature is likely to fall to below –7 °C. In addition, Subrule 2) requires that temperatures not exceed 45 °C because heat causes a shedding of active materials from the plates. This eventually forms a sediment buildup in the bottom of the container or case and can short-circuit the plates and the cell.

### Rule 26-508 Battery vents

During charging, storage batteries produce hydrogen. Since mixtures of oxygen and hydrogen are highly explosive, Subrule 1) requires that each vented cell be equipped with a flame arrester to prevent destruction of the cell due to the ignition of gases within the cell by an external spark or flame. Sealed cells are to be equipped with pressure release vents, in accordance with Subrule 2), to prevent the excessive accumulation of gas pressure, which could cause the cell to explode.

### Rule 26-510 Battery installation

Battery cells are usually mounted on racks, which saves floor space and facilitates servicing and maintenance. Rule 26-510 provides the basic requirements for the proper placement of batteries. Since the cells might be relatively heavy and the electrolyte is quite corrosive, Rule 26-510 requires that the racks be very secure, stable, and protected against corrosion. The other requirements establish good installation practices.

### Rule 26-512 Wiring to batteries

Subrule 1) requires that the wiring used for the interconnection of cells and for connecting the batteries to other electrical equipment be made using:

- bare conductors;
- open wiring;
- flexible cord; or
- mineral-insulated, copper-sheathed, or aluminum-sheathed cable designed or treated to make it corrosion-resistant.

Where the wiring is installed in rigid conduit or electrical metallic tubing, Subrule 2) requires that:

- it be made of corrosion-resistant material or protected from corrosion (by coating);
- it be sealed at the ends to prevent corrosion of the raceway by electrolyte entering the raceway by means of spray or creepage;
- a glazed insulated bushing be installed at the end of the raceway to prevent damage to the conductors' insulation where they exit the raceway;
- a minimum of 300 mm of free conductor be left for connection to the battery/cell terminations; and
- the raceway termination be at least 300 mm above the highest battery/cell termination to help prevent the entrance of electrolyte.

### Rule 26-514 Wiring methods and installation of equipment in battery rooms

The electrolyte used in batteries is quite corrosive, and hazardous gases are produced during the charging process. Given the required ventilation for battery rooms, however, moisture is not an issue in such locations. Rule 26-514 requires that electrical wiring other than that associated with the batteries be installed in accordance with the requirements for a dry location.

Only electrical equipment essential for the area is to be located in battery rooms, so:

- lighting switches should be located outside the area; and
- thermostats with capillary tubes should be used with the thermostat outside and the capillary tube inside the battery room.

## Resistance devices

### Rule 26-550 Location of resistance devices

Rules 26-550 to 26-554 provide general requirements for field applications of resistance devices. No longer commonly used, these devices limit the amount of current that can flow in a branch circuit, both under normal operating conditions and under short-circuit conditions.

Since resistance devices, including the leads to the resistance elements, produce heat during operation, Rule 26-550 requires that they be kept away from adjacent combustible material to reduce the fire risk.

### Rule 26-552 Conductors for resistance devices

The insulation on the conductors supplying the resistance elements is subjected to heating during the operation of the devices. Therefore, unless the conductors connecting the device and the controllers are used for infrequent motor starting, Rule 26-552 states that their insulation must be suitable for the condition of use [see Subrule 3) of Rule 12-102] with a temperature rating of no less than 90 °C. Also, where the voltage between any two insulated conductors is not greater than 75 V and the insulated conductors have a fire-retardant insulation or outer jacket, the conductors are permitted to be grouped together.

## Panelboards

### Rule 26-600 Location of panelboards

Panelboards contain overcurrent devices that protect the branch circuits against overload and short-circuit, and serve as a disconnecting means for the branch circuits. Panelboards are to be located in areas where they are not subject to damage or abuse and where they are readily accessible when necessary.

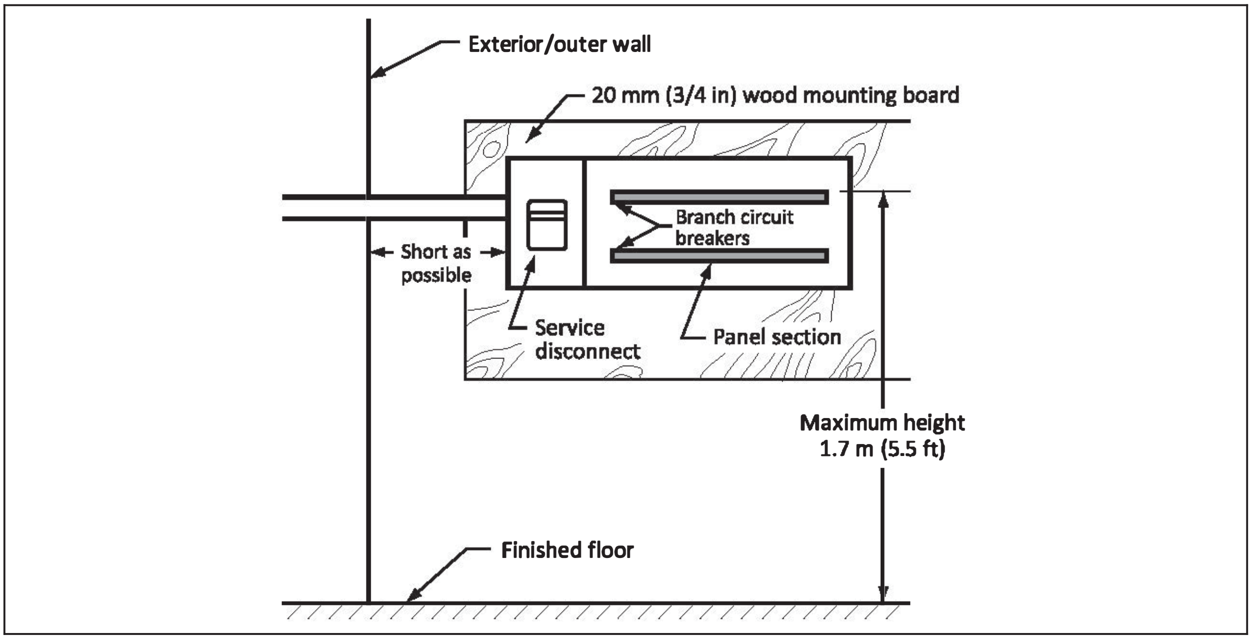
Subrule 1) requires that a panelboard be located so that it can be readily reached when necessary. A panelboard is not to be located, for example:

- in a cupboard or clothes closet where articles piled up in front interfere with access and constitute a fire hazard;
- in coal bins where the dust can cause short-circuiting in the panel due to tracking;
- in bathrooms where there is a shock hazard, as well as deterioration from the moisture;
- in stairways where accessibility is poor;
- in high ambient temperature rooms where nuisance tripping of the overcurrent devices can occur, as well as deterioration of the conductor's insulation from heat;
- in dangerous or hazardous locations where there is the risk of explosions or fires; or
- in similarly adverse locations.

Subrule 2) requires that the height of the panelboard in dwelling units be such that there is a maximum distance of 1.7 m to the floor from any operating handle of an overcurrent device to allow easy access to the branch circuit overcurrent devices and to the branch circuit directory and other operational information (see Figure 26-17).

If the dwelling unit has a barrier-free design, the *National Building Code of Canada* and the local codes should be consulted for the maximum mounting height of the panelboard. See also CSA B651.

**Figure 26-17**
**Typical panelboard installation**




### Rule 26-602 Panelboards in dwelling units

When an existing single dwelling unit is converted into a structure containing an accessory suite(s), major modifications to the electrical system are often required to ensure that the occupants of the dwelling unit have complete control over all of their branch circuits. Rule 26-602 does not require an individual panelboard for the branch circuits in each suite, provided that the suites have been created by subdividing a single dwelling unit and the individual suites are not individually metered for power consumption.

Subrule 1) requires that a panelboard be installed in every dwelling unit to allow occupants control over the branch circuits in their unit, except for dwelling units that:

- are not individually metered for electrical power consumption; and
- have been created by subdividing a single dwelling.

If any overloads or faults occur in a particular dwelling unit, the occupants of other dwelling units are not to be affected. Subrule 2) requires that each dwelling unit have its own supply and disconnecting means so that no other dwelling unit is affected if the supply to the panelboard is disconnected, even temporarily to allow servicing of electrical equipment.

## Branch circuits

### Rule 26-650 Special terminology

Circuit breakers and fuses used for branch circuit protection in dwelling units are designed to open automatically in order to protect circuit conductors from damage from excessive current flow, which causes heating or short-circuit conditions. The response time of these circuit breakers and fuses is determined only by the magnitude and duration of the circuit overcurrent condition. This response is sufficient to protect the circuit conductors if the circuit conductor integrity has been maintained. Once this integrity has been compromised through deteriorated insulation or broken conductors, electrical arcs can occur. Plasma-flame temperatures associated with these arcs can exceed 20 000 °C.

An AFCI device recognizes the current or voltage (or combination of current and voltage) characteristics associated with these arcing faults and opens the circuit when an arc fault is detected. It is intended to mitigate the effects of arcing faults (for example, high temperatures) that might pose a risk of smoke or fire. However, it is not intended to detect glowing connections. If an AFCI device is intended to perform other functions such as overcurrent protection, ground fault circuit interruption, or any combination of these functions, it is also to comply with the relevant requirements of the specific CSA Group Standards for the devices that perform those additional functions.

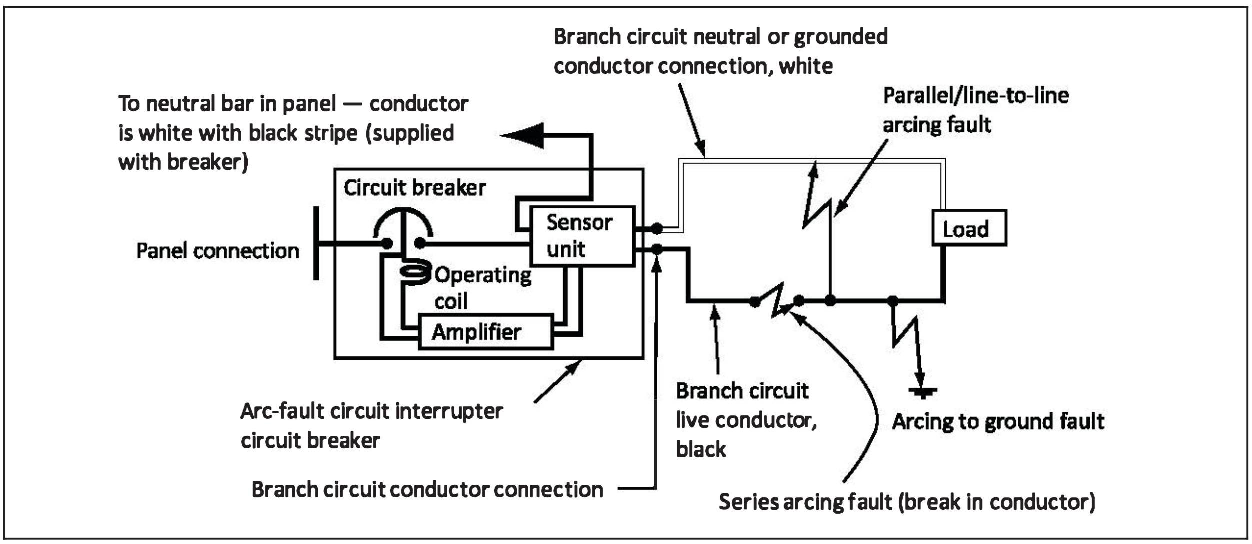
The intent of Rules 26-652 to 26-656 is to provide both series (also called low level) and parallel (also called high level) arc-fault protection downstream from the panelboard through the entire branch circuit wiring including the cord sets and power-supply cords connected to the outlets.

The following definitions apply:

*Arc-fault protection* — a means of recognizing characteristics unique to both series and parallel arc faults and de-energizing the circuit when an arc fault is detected.

*Combination-type arc-fault circuit interrupter* — a device that provides both series and parallel arc-fault protection to the entire branch circuit wiring including cord sets and power supply cords connected to the outlets, against the unwanted effects of arcing. See Figure 26-18.

**Figure 26-18**
**Combination-type arc-fault circuit interrupter (AFCI)**




*Outlet branch-circuit-type arc-fault circuit interrupter* — a device that provides both series and parallel arc-fault protection to downstream branch circuit wiring, cord sets, and power-supply cords against the unwanted effects of arcing and also provides series arc-fault protection to upstream branch circuit wiring.

### Rule 26-652 Branch circuits for residential occupancies

Rules 26-652 to 26-656 require that each residential occupancy have a sufficient number of branch circuits to meet the needs of the electrical appliances normally used in the occupancy and to supply the receptacles required by Rule 26-720. It can be argued that limiting the number of outlets on a branch circuit is unnecessary since if an overload occurs the overcurrent device operates. However, when fuses regularly blow or circuit breakers trip, people tend to defeat the safety feature provided by overcurrent devices, creating a hazard. As a result, the Code limits the number of outlets allowed to be connected to a circuit. [For an example, see Subrule 1) of Rule 8-304.]

Rule 26-652 provides details on the branch circuit requirements for receptacles in a residential occupancy, which includes dwelling units and single dwellings. Where the requirements apply only to a dwelling unit, they are discussed in Rule 26-654.

Item a) requires that a separate branch circuit for every refrigerator be installed in the kitchen. Some refrigerators draw a relatively high current, and plugging in another appliance on the same circuit can cause the overcurrent device to open. If this goes unnoticed, there is no electrical hazard, but the food in the refrigerator can spoil. A special recessed receptacle designed to supply an electric clock can be connected on the circuit with the refrigerator, as the current draw from an electric clock is negligible.

Item b) requires that a laundry room or a space where the complete plumbing is installed to accommodate a washing machine be provided with an individual branch circuit for receptacles installed for the use of washing machines, gas clothes dryers, irons, and similar appliances that could be used in these locations.

An individual branch circuit for the receptacles is to be installed in utility rooms to allow the use of freezers and other high-wattage appliances, in accordance with Item c).

Item d) requires that a separate branch circuit be provided for the receptacle installed in the enclosure for a built-in microwave oven since a microwave oven is a high-wattage appliance.

Since a central vacuum system is a high-wattage appliance, Item e) requires that a separate branch circuit supply the receptacle to avoid unnecessary opening of the overcurrent device.

When CSA configuration 5-20R receptacles are installed in residential occupancies, Item f) requires that the branch circuit ampere rating be a minimum of 20 A. Rule 14-600 also requires that the overcurrent protection not exceed the ampere rating of the receptacle.

When the *National Building Code of Canada* requires that receptacles be provided for use with electric vehicle (EV) supply equipment [see Item n) of Rule 26-720], Item g) requires that each receptacle be supplied by a separate branch circuit.

**Note:** *Rule 86-306 requires that the receptacle for EV supply equipment be a 5-20R and the branch circuit have a minimum of a 20 A rating. For example, if an apartment building (residential occupancy) has five receptacles for EV supply equipment, there would have to be a minimum of five 125 V, 20 A branch circuits (one for each receptacle).*

### Rule 26-654 Branch circuits for dwelling units

Rule 26-654 details the specific circuit requirements for dwelling units, which are required to ensure the safe use of electrical appliances.

Outlets or electrical equipment in a particular dwelling unit are to be connected to the panelboard in that dwelling unit (as required by Rule 26-602); the intent of Item a) is to enable occupants to control and have access to their panelboard.

A variety of high-wattage appliances are used simultaneously in kitchens. Item b) requires that at least two 15 A multi-wire or 20 A branch circuits supply the 5-15R split or 5-20R receptacles located along the kitchen counter work surface. The maximum number of receptacles is two 5-15R split receptacles on each multi-wire branch circuit or two 5-20R receptacles on each 20 A branch circuit, with no other outlets connected to that circuit.

Where there is limited counter space, Item c) requires that only one 5-15R split or 5-20R receptacle be supplied from a separate branch circuit. This recognizes that the smaller counter space makes it impractical to use many appliances at one time.

Where 5-15R split or 5-20R receptacles are installed for people with disabilities in accordance with Item d) of Rule 26-720, Item d) allows them to be connected to the 15 A multi-wire or 20 A branch circuits required by Item b). In this situation, there can be four 5-15R split or 5-20R receptacles on the same branch circuit: two receptacles on the wall behind the counter, and two in the front edge of the counter directly ahead of the receptacles on the wall.

### Rule 26-656 Arc fault protection of branch circuits for dwelling units

The intent of combination arc-fault protection is to provide both series (also called low level) and parallel (also called high level) arc-fault protection downstream from the panelboard through the entire branch circuit wiring, including cord sets and power supply cords connected to the outlets. Item a) requires that all branch circuits supplying 125 V receptacles rated 20 A or less be protected by a combination-type arc-fault circuit interrupter (AFCI). See Figure 26-18.

Item a) also exempts the branch circuits supplying 125 V receptacles rated 20 A or less from the requirements of a combination-type arc-fault circuit interrupter protection in the following locations:

- in each bathroom or washroom with a wash basin(s) within 1 m of the basin, provided that no other receptacles are connected to these circuits;
- in kitchens designed for use by persons with disabilities that have receptacles installed in the side of the counter work surfaces;
- in kitchens, for the refrigerator(s);
- in kitchens, for the 5-15R split or the 5-20R receptacles that are required along the wall at the counter working surfaces;
- in kitchens, for the 5-15R split or the 5-20R receptacles that are required at each permanently fixed island counter work surfaces with a continuous long dimension of 600 mm or greater and a short dimension of 300 mm or greater;
- in kitchens, for the 5-15R split or the 5-20R receptacles that are required at each peninsular counter space with a continuous long dimension of 600 mm or greater and a short dimension of 300 mm or greater; or
- for a single receptacle for a sump pump where:
  - the receptacle is labelled in a conspicuous, legible, and permanent manner identifying it as a sump pump receptacle; and
  - the branch circuit does not supply any other receptacles.

Item b) exempts the entire branch circuit from a combination type arc-fault protection where:

- an outlet branch-circuit-type arc-fault circuit interrupter is installed at the first outlet on the branch circuit; and
- the wiring method for the portion of the branch circuit between the branch circuit overcurrent device and the first outlet consists of metal raceway, armoured cable, or non-metallic conduit or tubing.

Item c) states that where one or more 125 V receptacles rated 20 A or less are added to an existing branch circuit that is not provided with arc-fault protection, the entire branch circuit need not be provided with combination type arc-fault protection, where an outlet branch-circuit-type arc-fault circuit interrupter is installed at the first added receptacle to the existing branch circuit.

## Receptacles

### Rule 26-700 General

To avoid misapplication, standardization and general requirements are necessary for the electrical installation of receptacles. Subrule 1) requires that receptacle configurations be in accordance with Diagrams 1 and 2. If the voltage that is supplying a receptacle and the ampacity of the branch circuit to which it is connected are known, portable equipment can be readily matched up with an appropriate branch circuit.

Subrule 2) requires that the electrical installation of receptacles match the voltage and ampere rating requirements given in Diagrams 1 and 2. For example, a conventional 15 A non-locking receptacle rated 125 V uses parallel blades, whereas those rated at 250 V have tandem blades.

Receptacles on the same premises are allowed to be connected to circuits having different voltages, frequencies, or types of current (ac or dc) not listed in Diagrams 1 and 2. Subrule 3) requires that these receptacles be designed so that attachment plugs used on such circuits are not interchangeable.

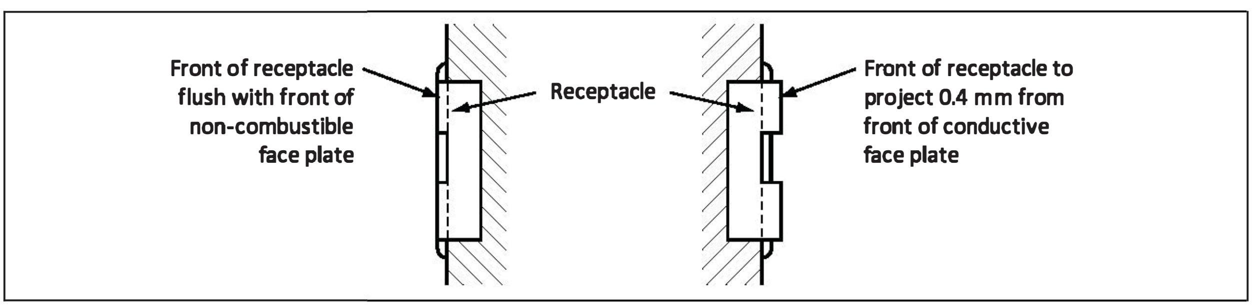
To prevent a shock hazard from contact with exposed terminals on receptacles, Subrule 4) requires that receptacles with exposed terminals be used only in fittings, metal troughs, and similar devices, which shield the exposed terminals from contact.

To avoid problems from spilled substances, cleaning equipment, etc., when receptacles are installed in floors, Subrule 5) requires that the receptacles be installed in floor boxes. These boxes are either raised above the floor or are flush with the floor and equipped with special covers designed to restrict water and dust from contacting the receptacles.

When receptacles rated 30 A or more are installed facing down, the weight of the cord and attachment plug used exerts a steady pull on the receptacle jaws. When this effect is enhanced by any vibration, the plug slowly moves outward and the contact surfaces are reduced. Such a condition at first causes the contacts to heat up, then slowly causes the receptacle jaws to deteriorate, losing their retention ability. This can cause the contact surface to heat up, creating a possible fire hazard. To prevent unintentional detachment when receptacles rated 30 A or more are installed facing downward, Subrule 6) requires that these receptacles be provided with a locking or latching means.

To ensure that an attachment plug makes a solid connection to the receptacle, Subrule 7) requires that it be possible to fully insert the attachment plug [i.e., the receptacle face is to be flush with or project from the face plate (cover plate)]. If a metal or conductive face plate is used, the receptacle is to project a minimum of 0.4 mm to prevent faults caused by attachment plugs with exposed bare terminal screws coming in contact with the metal cover plate, which is usually bonded to ground through the receptacle. See Figure 26-19. Although new attachment plugs are not allowed to have exposed terminal screws, they are found on many older attachment plugs still in use. Openings around receptacles or covers are to be filled to prevent a 6.75 mm rod from entering.

**Figure 26-19**
**Receptacle face plates**




### Rule 26-702 Bonding of receptacles

As noted in Diagrams 1 and 2, all receptacles are required to have a grounding pin. However, many older electrical installations still have ungrounded receptacles. When an ungrounded receptacle becomes defective, it is to be replaced with the grounded type since the others are no longer available. If the grounding terminal is not effectively connected to ground, it creates a false sense of security. Some portable equipment is bonded to ground for safety reasons, and if the grounding terminal is not bonded to ground, the safety feature is lost. Normally, a bonding conductor is run with the branch circuit conductors, but in situations such as this, Subrule 1) allows it to be connected to a local ground and specifies the methods allowed.

When an existing ungrounded receptacle has to be replaced and there is no grounding means in the existing receptacle's enclosure, Subrule 2) allows the use of grounding type receptacles protected by a Class A type ground fault circuit interrupter.

To limit potential shock hazards, Subrule 3) requires that a bonding conductor not be extended from any receptacle protected by a GFCI of the Class A type to any other outlets when the GFCI of the Class A type is used under Subrule 2) to replace the ungrounded type receptacles since the receptacle protected by the GFCI is not grounded.

### Rule 26-704 Protection of receptacles by a ground fault circuit interrupter of the Class A type

To prevent shock hazards where CSA configuration 5-15R or 5-20R receptacles are located within 1.5 m of sinks (for example, in the case of wash basins with drain pipes), bathtubs, or shower stalls, Rule 26-704 requires that these receptacles be protected by a Class A GFCI. Receptacles are exempt from this requirement if:

- they are for a stationary appliance designated for the location; and
- the receptacle is located behind the stationary appliance so that it is not accessible for use with general-purpose portable appliances.

For additional information, see the Appendix B Note to Rule 26-704.

### Rule 26-706 Tamper-resistant receptacles

A significant number of electrical shock incidents occur when children insert conductive objects into electrical receptacles. Tamper-resistant receptacles are designed to prevent contact with live electrical contacts when an object other than a plug is inserted into one of the receptacle slots. In one design used, the slots for the ungrounded (live) conductor and the grounded (identified) conductor are closed by shutters that must open simultaneously. Unless insert pressures from the two blades of the male plug cap are simultaneously applied equally against each shutter, the shutters will not open. These receptacles are called tamper-resistant receptacles and marked "TAMPER RESISTANT" or "TR".

Subrule 1) requires that all receptacles of CSA configuration 5-15R and 5-20R be tamper-resistant when they are installed in:

- childcare facilities;
- guest rooms and guest suites of hotels and motels; or
- preschools and elementary education facilities;

When receptacles of CSA configurations 5-15R and 5-20R are for dedicated stationary appliances or installed over 2 m from the floor or finished grade, they are inaccessible to children. Subrule 2) provides an exemption to Subrule 1) where the receptacles are located 2 m above the floor or finished grade or located behind dedicated stationary appliances (for example, washing machines, microwaves) and are not accessible for general use.

### Rule 26-708 Receptacles exposed to the weather

Receptacles provided on the outside of buildings that are exposed to the weather are generally used for outdoor appliances that typically get used when the weather is good. The "Wet Location Only When Cover Closed", weatherproof covers or the equivalent, when required to be used on these receptacles, only keep the moisture from entering the enclosure (device box) and/or the receptacle when the appliance plug is not inserted into the receptacle (i.e., when the cover is closed). The reality is that there are many instances where these receptacles are used for items that remain unattended for long periods, such as automobile heaters, electric vehicle charging stations, seasonal decorative lighting, etc. In such cases, the appliance plug remains inserted in the receptacle, which leaves the weatherproof cover open exposing the receptacle to all types of weather conditions. When used in this fashion, there is a risk that long-term exposure to moisture can cause the receptacle to corrode, and if the receptacle is equipped with GFCI protection, that protection might malfunction creating a fire and shock hazard.

In some cases, these receptacles can be installed where they are protected from the weather (for example, under an eave or an overhang). If the face of the receptacle is likely to be exposed to the weather (rain or snow), Subrule 1) requires that a wet location cover plate marked for extra duty be used.

CSA C22.2 No. 42.1 has additional testing requirements for wet locations receptacle covers suitable whether or not a plug is inserted into the receptacle. Receptacle covers meeting these requirements are rated and marked "Extra-Duty".

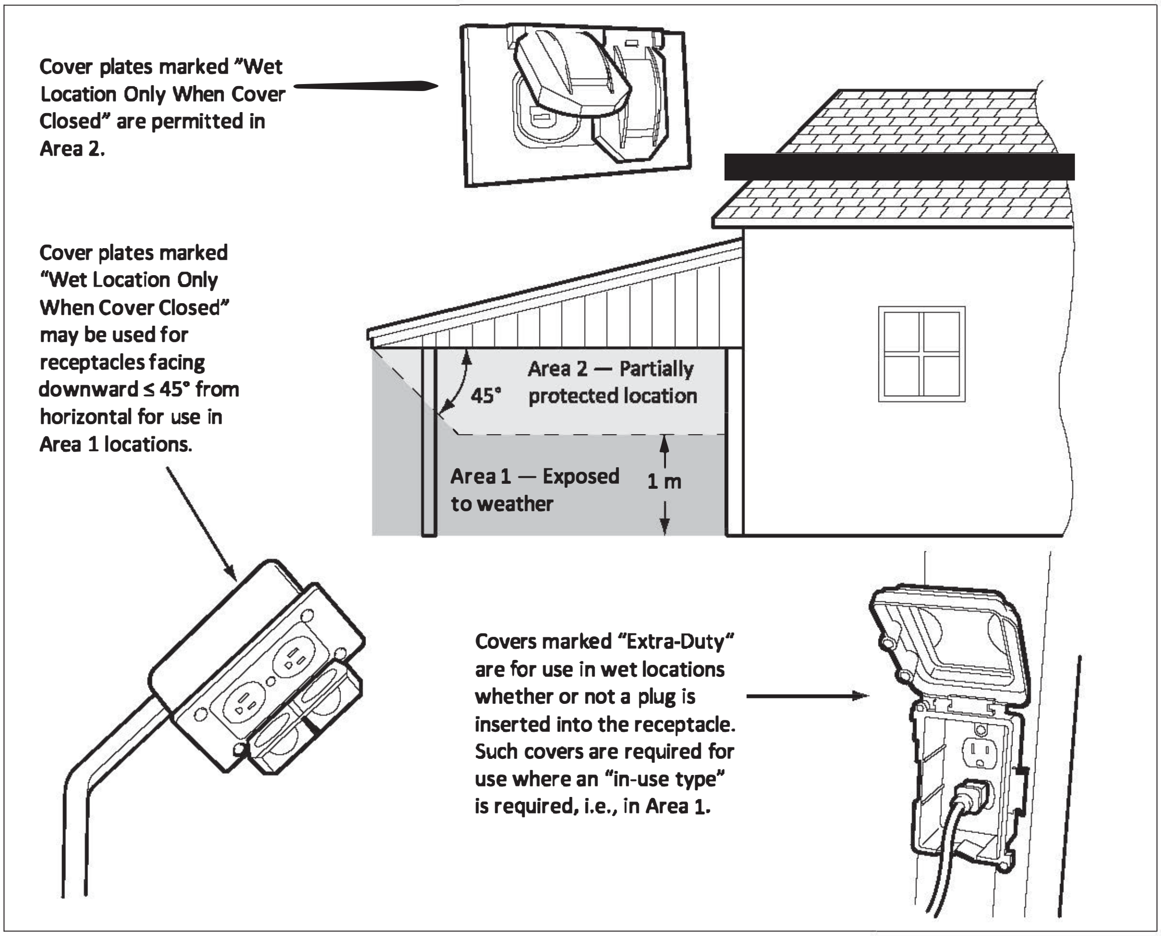
To prevent moisture from entering the enclosure (device box), Subrule 2) requires that the covers for receptacles of CSA configurations 5-15R, 5-20R, 5-20RA, 6-15R, 6-20R, and 6-20RA that are exposed to the weather be for wet locations, whether or not a plug is inserted into the receptacle, and are to be marked "Extra duty", with the marking visible after installation. See Figure 26-21.

Subrule 3) allows the covers for receptacles of CSA configurations 5-15R, 5-20R, 5-20RA, 6-15R, 6-20R, and 6-20RA to be marked, "Wet Location Only When Cover Closed", or the equivalent when:

- installed facing downward at an angle of at least 45° or less from the horizontal; or
- installed at least 1 m above finished grade or floor level and not in a wet location.

See Figure 26-20.

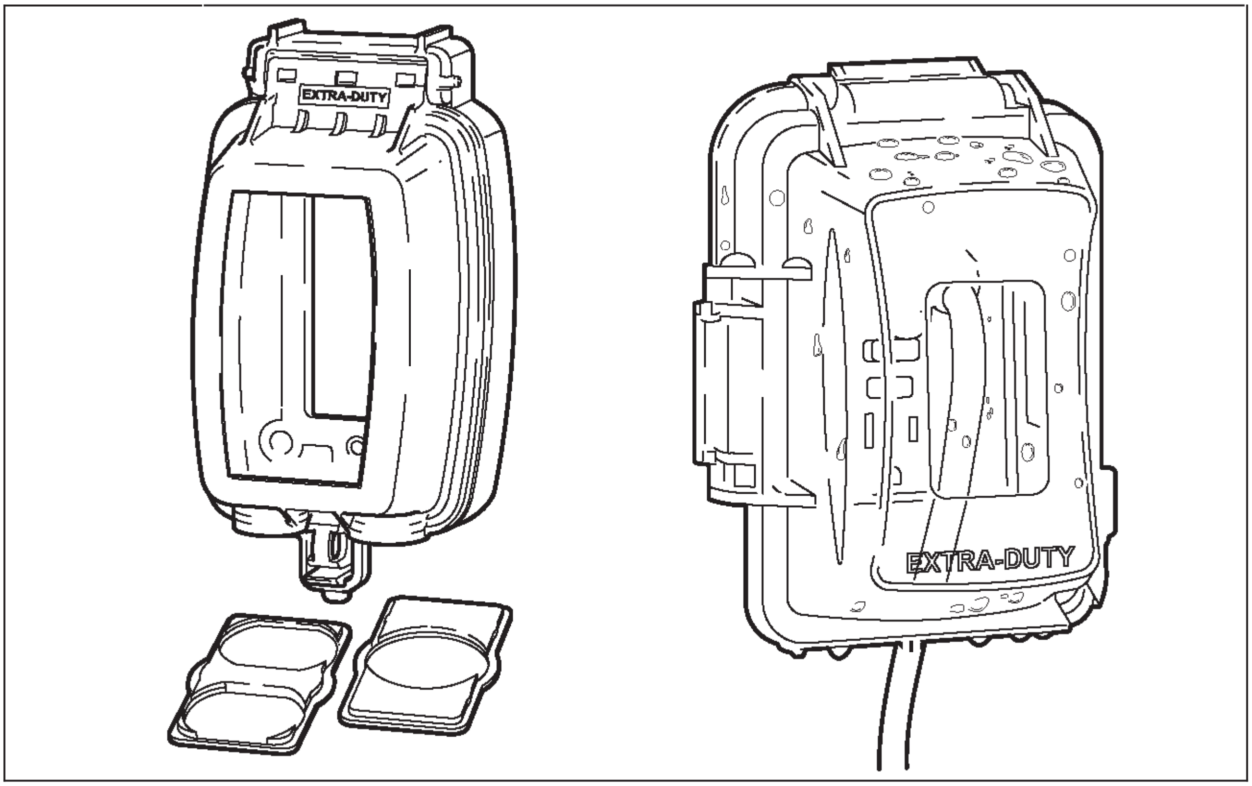
**Figure 26-20**
**Location of wet location cover plates**




If a duplex receptacle is installed in a surface-mounted outlet box, Subrule 4) requires that the cover plate be held in place by four screws or the equivalent. If a single mounting screw is used, objects can catch on the edge of the cover, and it can be pulled away from the box, breaking the weatherproof seal.

When, due to exposure to weather, wet location cover plates are used in flush-mounted outlet boxes, Subrule 5) requires that the covers be fitted to make a proper weatherproof seal. Therefore, if a duplex receptacle is installed in a flush-mounted outlet box installed in accordance with Rule 12-3016, the cover can be held in place by a single screw (in the centre of the cover).

**Figure 26-21**
**Wet location cover plate with extra-duty marking**




### Rule 26-710 Receptacles for maintenance of equipment located on rooftops

Rule 2-316 requires that, in other than dwelling units, a receptacle be provided for maintenance of rooftop equipment, such as heating, ventilating, air conditioning, and dust-extracting equipment. Rule 2-316 requires that these receptacles be installed as follows:

- They are to be CSA configuration 5-20R receptacles, in order to provide the extra capacity for equipment required to maintain the rooftop equipment.
- They are to be supplied by a separate branch circuit that does not supply any other outlets or equipment, to prevent nuisance circuit interruptions.
- All receptacles are to be protected by a Class A type ground fault circuit interrupter, to provide shock protection.
- They are to be mounted a minimum of 750 mm above the finished roof, to prevent inaccessibility due to snow buildup on the roof.
- They are to be located within 7.5 m of the rooftop electrical equipment, to provide power for maintenance equipment that can be reached by using a standard length (approximately 10 m) extension cord.
- They are to be protected from mechanical damage that could result from activities being performed on the roof.
- When exposed to the weather, they are to have wet location cover plates marked for extra duty.

## Receptacles for residential occupancies

### Rule 26-720 General

This Subsection provides the requirements for receptacles in residential occupancies, dwelling units, and single dwellings. When electricity was first used in the home, its purpose was to provide fixed lighting; receptacles were not needed. As various types of home electrical appliances became available, one receptacle installed per room was deemed sufficient. Frequently, however, the one receptacle was not in the location where the occupant needed it, and it emerged that many household fires were caused by the misuse and overuse of extension cords, as occupants ran undersized cords under carpets, linoleum, or wallpaper. This Subsection intends to reduce the hazardous use of extension cords and ensure the safe use of electrical appliances.

Rules 26-720 to 26-726 give the requirements for receptacles in residential occupancies, dwelling units, and single dwellings, with the intent of reducing the hazards of extension cords and electrical appliances.

Rule 26-720 deals with receptacles in "residential occupancies", a term that includes dwelling units and single dwellings. Where the requirements apply only to a dwelling unit or single dwelling, they are detailed in the specific Rule (Rules 26-724 and 26-726, respectively). See Section 0 for definitions of "dwelling unit", "single dwelling", and "residential occupancy".

Rule 26-720 provides details for all the locations in residential occupancies where receptacles are required. Item a) defines "finished wall" to clarify the placement of general-use receptacles in the subsequent Items. For example, when basement walls are insulated and require a wall finish material to protect the integrity of the wall insulation (and the wall finish material is not within 450 mm of the floor), the area is not deemed a finished wall for the purposes of Rule 26-720. See Table 26-4.

Item b) recognizes an exception to the general requirement for a CSA configuration 5-15R receptacle, as shown in Diagram 1, and allows a 5-20R receptacle to be connected to a 20 A branch circuit. See also Item l) for the requirements for a central vacuum. This 5-20R receptacle accepts either a 15 or 20 A, 125 V attachment plug and is supplied from a 20 A circuit.

Item c) prohibits the mounting of receptacles face up in a work surface in kitchen or dining areas, to avoid electric shock and fire hazards from liquids that are spilled on, or used to clean, kitchen counters or dining area work surfaces.

Item d) recognizes the installation of 15 A split or 5-20R receptacles on the side of a kitchen counter work surface that is designed for people with disabilities (see Figure 26-22). The installation of these additional receptacles, however, does not mean that Item d) iii) of Rule 26-724 requiring receptacles in the wall behind the counter work surfaces is waived.

Item e) requires a single duplex 5-15R or 5-20R receptacle of the tamper-resistant type in each of the following locations:

- in a space where the complete plumbing is installed for a washing machine;
- in a laundry room, in addition to the receptacle for the washing machine, to provide for other laundry-associated equipment such as an iron;
- in a utility room, to provide power for tools or other equipment used to service equipment installed there; and
- in an unfinished basement area, to provide power for equipment/appliances used in this area by the occupant.

**Note:** *Receptacles dedicated to stationary appliances (for example, a washing machine) that are rendered inaccessible for general use by being behind the stationary appliance or those located above 2 m from the floor or finished grade are not required to be tamper-resistant [see Subrule 2) of Rule 26-706].*

## Table 26-4
## Method of determining the layout of receptacles in finished walls

**Step 1**
Identify any unusable wall spaces around the perimeter of the room or area.

**Step 2**
Measure the first 1.8 m from the start of a finished wall at the floor line along the perimeter of the usable wall space, to determine where the first receptacle should be. It can be located anywhere within the first 1.8 m.

**Step 3**
From the location of the first receptacle, measure 3.6 m along the floor line of the wall perimeter. The second receptacle can be located anywhere within the 3.6 m distance from the first receptacle.

**Step 4**
Repeat Step 3 until the end of the perimeter of the finished wall has been reached.

**Step 5**
The last receptacle in the series must be within 1.8 m of the end of the finished wall.

Item f) requires that a receptacle be located within 1 m of the wash basin in each bathroom or washroom with a wash basin(s). Item f) also applies to a bedroom with a wash basin, which is included in the definition of washroom in Section 0. The 1 m measurement is based on the normal cord length found on washroom-type appliances, which can range from 1.2 to 2 m in length.

Item g) requires that receptacles in bathrooms be located not less than 500 mm, and preferably 1 m, from the bathtub or shower stall to avoid shock hazards for people bathing, showering, or contacting electrical appliances or receptacles.

Item h) requires that receptacles not be placed in a cupboard, cabinet, or similar enclosure, but outlines exceptions such as receptacles that are allowed to be placed in a cupboard. These exceptions are as follows:

- when the receptacle is an integral part of a factory-built enclosure;
- when the receptacle is for use with an appliance that is suitable for installation within the enclosure (for example, garbage disposal);
- when the receptacle is for a microwave oven;
- when the receptacle is for a cord-connected range hood; or
- when the receptacle is for a cord-connected combination microwave oven/range hood fan.

When installation of a receptacle is allowed in a cupboard, cabinet, or similar enclosure, Item i) requires that the receptacle be de-energized unless the door remains in the fully opened position. An exception is made for cord-connected dishwashers, in-line water heaters, garbage disposal units, and other similar appliances. The intent of Item i) is to avoid a situation in which an appliance is plugged into a receptacle and someone damages the cord while trying to close the cupboard door, or a cooking or heating appliance is plugged in and left on with the cupboard door closed, thus creating possible a fire hazard.

Item j) specifies that none of the following are to be used as substitutes for the receptacles required by Rule 26-720:

- receptacles that are part of luminaires or appliances such as ranges that are equipped with an integral receptacle;
- receptacles located inside cabinets or cupboards, as permitted by Item h); or
- receptacles located more than 1.7 m above the floor.

The *National Building Code of Canada* requires that most rooms in a residential occupancy be provided with a luminaire controlled by a wall switch. Item k) allows the luminaire to be omitted, however, provided that the room has a receptacle controlled by the wall switch. The rationale is that a lamp plugged into one-half of the receptacle functions the same way as a luminaire, while the half that is unswitched is used in the customary way and meets the intent of Item a) of Rule 26-724.

In many new residential occupancies, an exhaust duct is installed for a central vacuum system even though there is no intention to install a complete central vacuum system at that time. Unless a receptacle is installed at the time of the building construction, the occupant often uses extension cords rather than going to the expense of installing a branch circuit and receptacle. For this reason, Item l) requires that at least one receptacle be provided for each cord-connected central vacuum system where the complete duct for the system is installed.

Item m) requires the installation of receptacles in public corridors and public stairways in buildings of residential occupancies (for example, apartment buildings). These enable service and maintenance equipment (for example, portable tools and vacuum cleaners) to be used without the need for long extension cords. One receptacle is to be installed for every 10 m, or fraction of 10 m, of corridor and stairway length.

When the *National Building Code of Canada* requires that receptacles be provided for use with electric vehicle (EV) supply equipment, Item o) requires that these receptacles, as specified in Rule 86-306, be provided for car spaces in garages or carports serving buildings of residential occupancies. The Appendix B Note to Rule 26-720 n) is intended to recognize a need for an additional EV charging infrastructure in residential occupancies only in those cases when such an EV charging infrastructure is mandated by the provincial/territorial building codes or local building or zoning regulations. Local building or zoning bylaws should be consulted for EV charging infrastructure requirements and for the number of dedicated receptacles for EV supply equipment as a percentage of the total car spaces in a residential occupancy.

### Rule 26-722 Protection of residential occupancy receptacles installed outdoors by a ground fault circuit interrupter of the Class A type

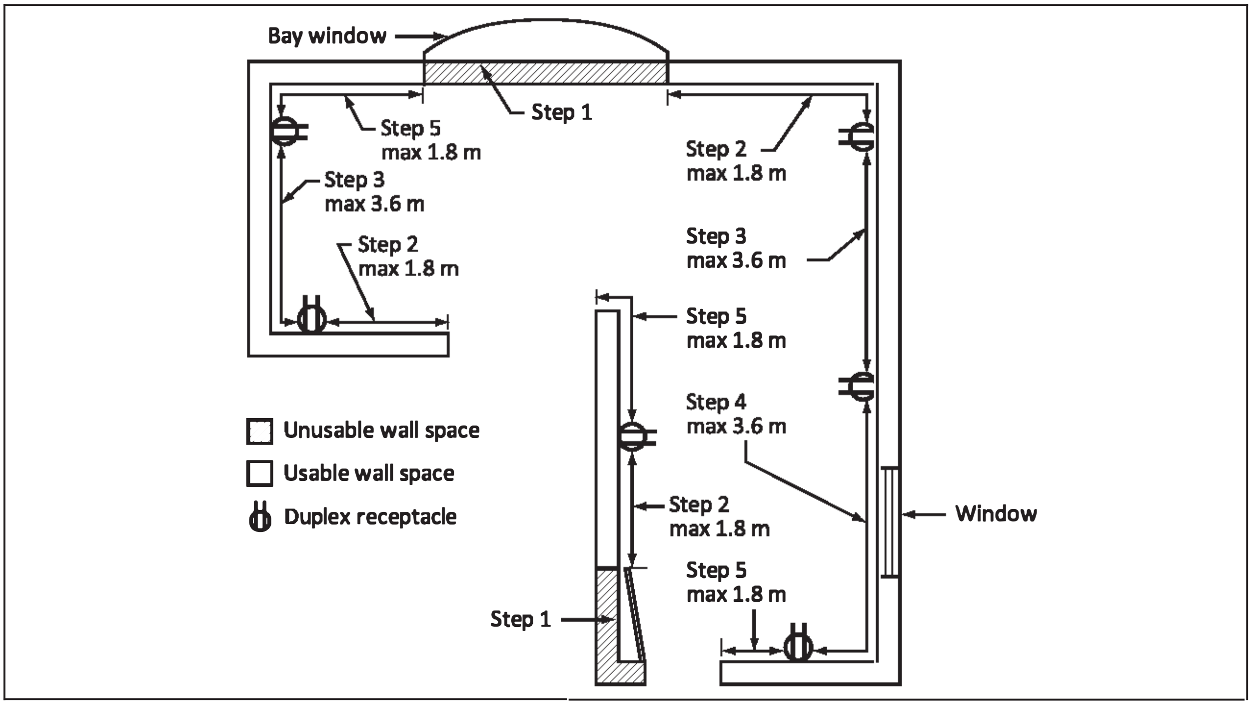
Rule 26-722 requires that all receptacles installed outdoors of residential occupancies, and within 2.5 m of finished grade, be protected with a Class A GFCI. The intent of this Rule in the Appendix B Note is to include all receptacles located on buildings or structures associated with the residential occupancy, such as garages, carports, sheds, and receptacles on posts or fences, etc., in the requirement for Class A GFCI protection.

Receptacles for automobile heaters are exempt from this requirement, provided that installations are in conformance with Rule 8-400. Also the Appendix B Note further intends that Class A GFCI protection is not intended to apply to receptacles in parking lots of apartment buildings that are installed solely for use as automobile heater receptacles.

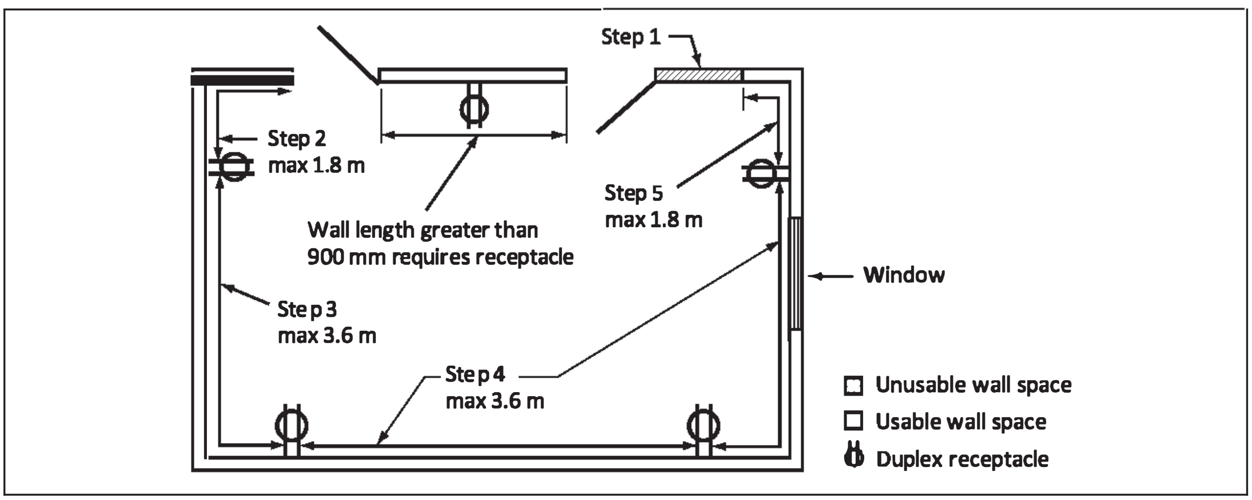
### Rule 26-724 Receptacles for dwelling units

Rule 26-724 provides details for all the locations in dwelling units where receptacles are required. The intent is to ensure that an adequate number of receptacles are installed throughout the dwelling unit to facilitate the use of electrical appliances and to minimize the use of extension cords. For clarification of the term “usable wall space”, see Item c). See Figures 26-22 to 26-24.

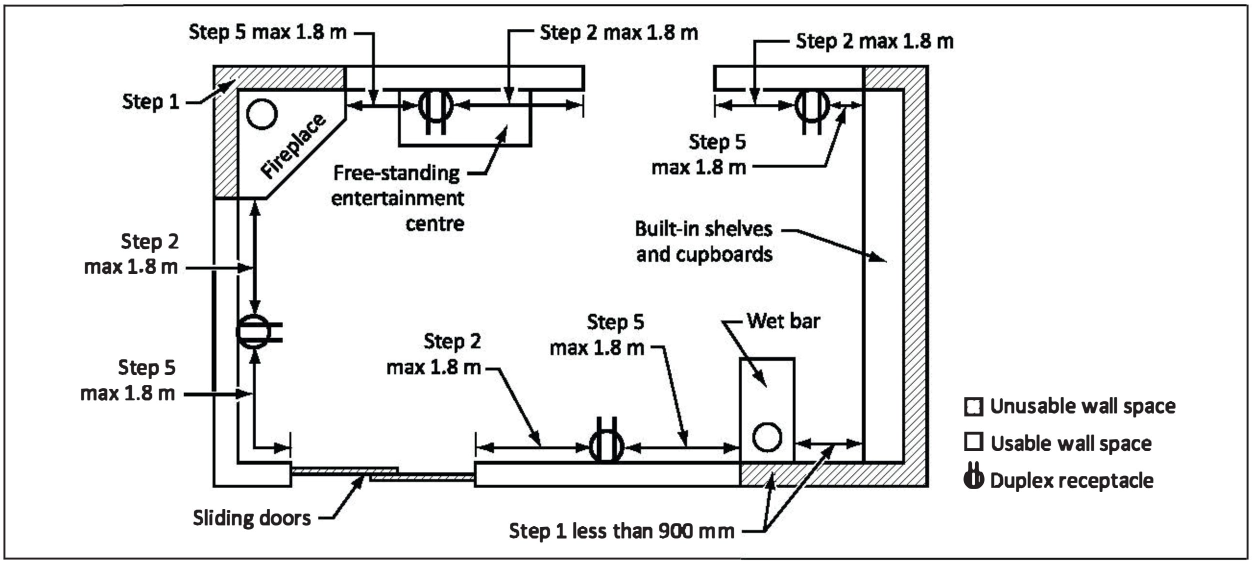
## Figure 26-22
## Receptacle layout — Living and dining room




## Figure 26-23
## Receptacle layout — Bedroom



## Figure 26-24
## Receptacle layout — Recreational room

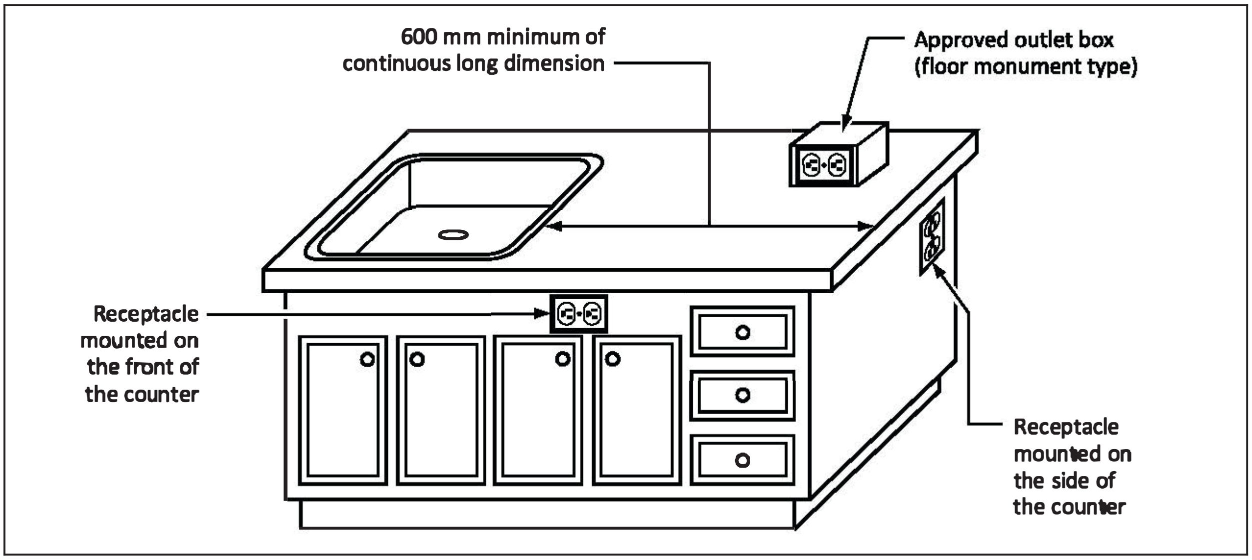



Not every finished wall space is suitable for placing appliances; consequently, Item c) has excluded the requirement for receptacles on all finished wall spaces less than 900 mm wide as measured along the floor line. Doorways, the area behind the door when the door is fully open, windows extending to the floor, fireplaces, and any other similar permanent installation are not deemed usable wall space and are not required to have receptacles.

Item d) outlines the following requirements for receptacles in kitchens of dwelling units:

- one receptacle for each refrigerator;
- one receptacle for each free-standing gas range
  - where the gas supply piping or a gas connection outlet has been provided;
  - located behind the intended gas range;
  - mounted not more than 130 mm from the floor; and
  - as close as possible to the midpoint of the intended wall space for the gas range as measured along the floor line of the wall space;
- a sufficient number of receptacles (15 A split or 20 A T-slot) along the wall behind counter work surfaces (excluding sinks, built-in equipment, and isolated work surfaces less than 300 mm long at the wall line) so that no point along the wall line is more than 900 mm from a receptacle measured horizontally along the wall line (see Table 26-5 and Figure 26-27);
- when there is a permanently fixed island counter space (see Figure 26-25) with a continuous long dimension of 600 mm or greater and a short dimension of 300 mm or greater, at least one 15 A split or 5-20R receptacle; and
- in a dining area forming part of a kitchen, a sufficient number of duplex receptacles installed on the remaining finished walls, in accordance with Item a). (See Table 26-4.)

## Figure 26-25
## Permanently fixed island counter




## Table 26-5
## Method of determining the layout of receptacles on kitchen counter work surfaces

(See Figures 26-26 and 26-27.)

**Step 1**
Determine any unusable wall space along the wall line of the kitchen counter work surface.

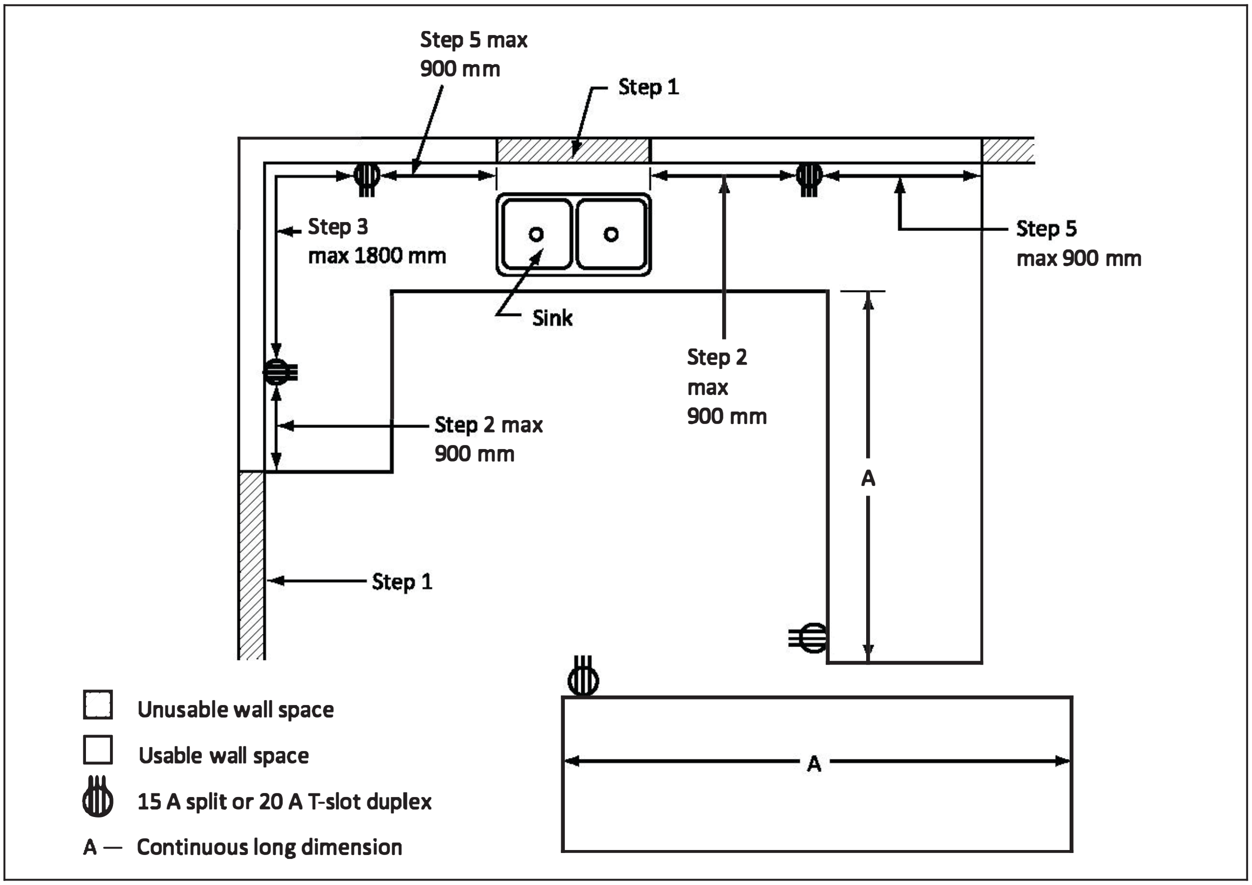
**Step 2**
Measure the first 900 mm from the beginning of the counter work surface at the wall line, along the perimeter of the counter. The first receptacle can be located anywhere within this 900 mm length.

**Step 3**
From the first receptacle, measure 1800 mm along the counter at the wall line. The next receptacle can be located anywhere within this 1800 mm distance from the first receptacle.

**Step 4**
Repeat Step 3 until the end of the perimeter of the counter work surface is reached. (It should be noted, however, that few kitchens have an uninterrupted usable wall space greater than 3.6 m. In most cases, one can proceed directly to Step 5.)

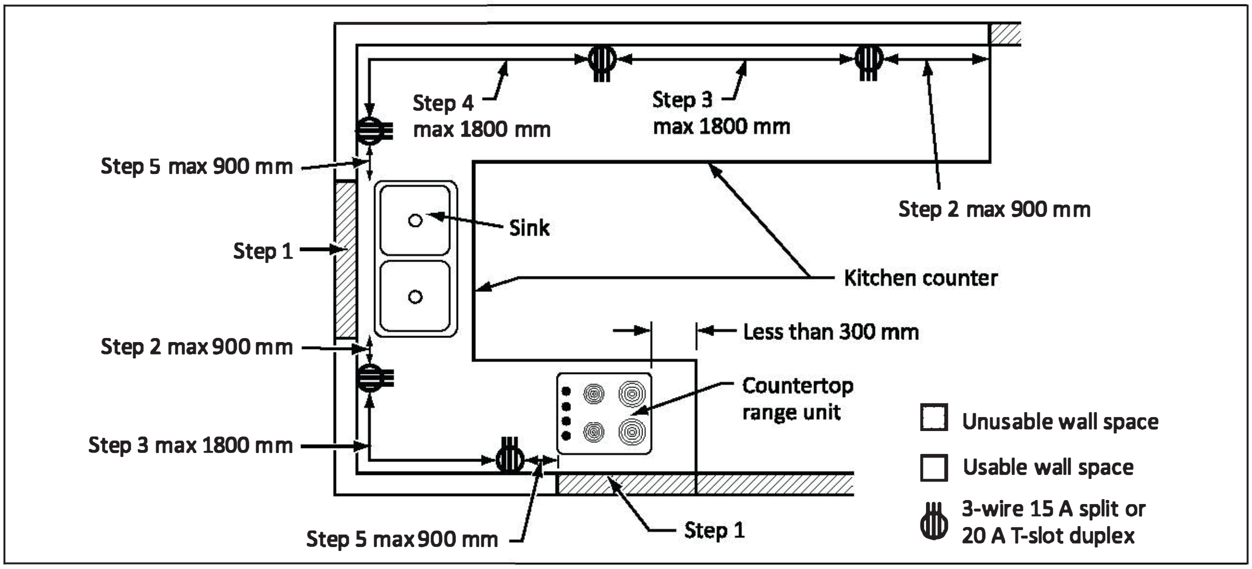
**Step 5**
The last receptacle, as located in accordance with Step 3 or Step 4, must be within 900 mm of the end of the counter.

**Figure 26-26**
**Receptacle in peninsular counter area**



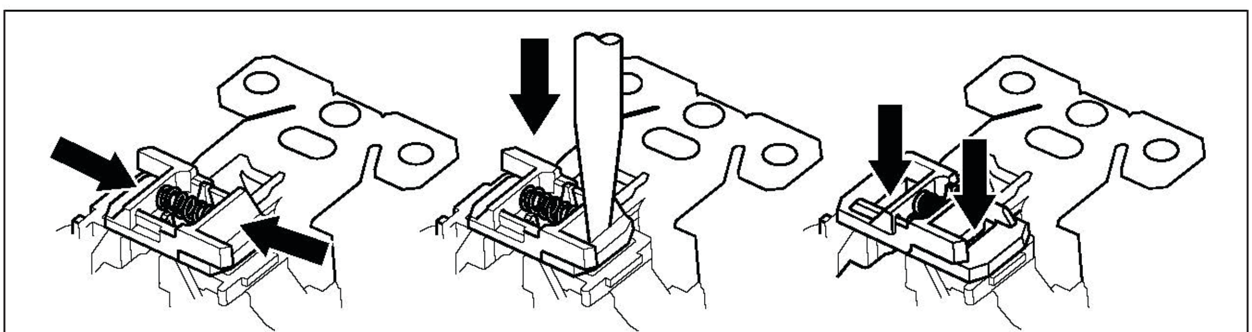

Since areas behind and directly in front of the kitchen sink are subject to water splashing, Item e) prohibits installation of receptacles in these locations. Other water-related hazards include the risk of attachment cords lying or falling in the water or attachment plugs being inserted and removed by people with wet hands. See Figure 26-27.

**Figure 26-27**
**Receptacles in a kitchen**




A significant number of electrical shock incidents occur when children insert conductive objects into electrical receptacles. Most of these incidents take place in living and sleeping areas of the home. Tamper-resistant receptacles are designed to prevent contact with live electrical contacts when an object other than a plug is inserted into one of the receptacle slots. In one design used, the slots for the ungrounded (live) conductor and the grounded (identified) conductor are closed by shutters that are to open simultaneously. Unless insert pressure from the two blades of the male plug cap are simultaneously pressed equally against each shutter, the shutters will not open. See Figure 26-28.

**Figure 26-28**
**A typical tamper-resistant receptacle**




### Rule 26-726 Receptacles for single dwellings

Single dwellings often have a yard or garden, and many gardening tools are electrically operated. To facilitate the use of electrical equipment outdoors, Item a) requires that a receptacle be located in a readily accessible location outside every single dwelling. The receptacle is to be located at a height where it can be reached without the use of a ladder or chair. See Figure 26-29 and the Appendix B Note to Rule 26-726 for recommendations for locating outdoor receptacles.

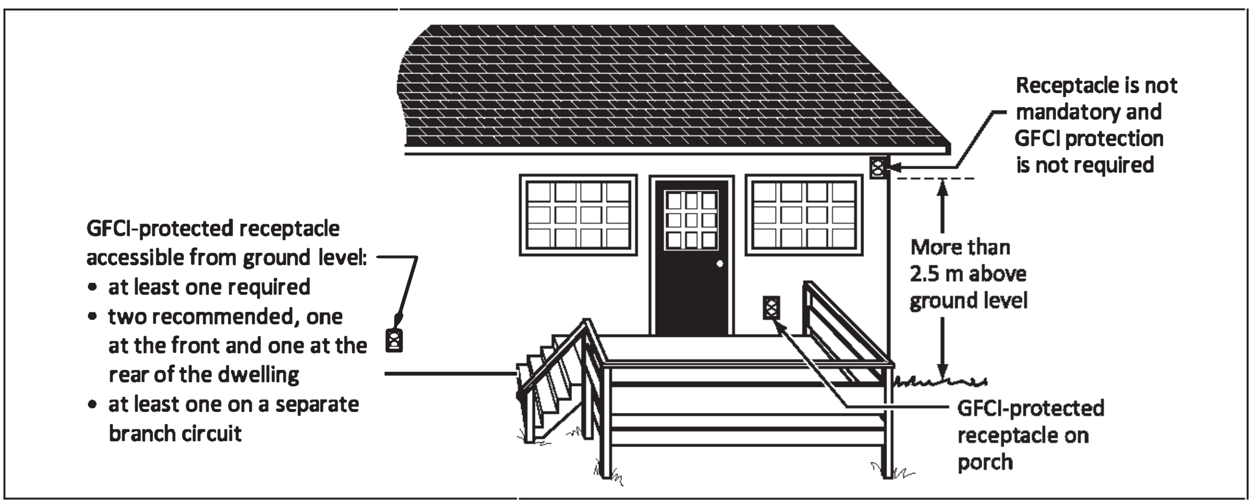
Item b) requires that at least one duplex receptacle be provided for each car space in a garage or carport of a single dwelling.

When electrical equipment is used outdoors, the possibility of a severe electric shock is present if the equipment becomes wet or damaged. Rule 26-722 requires that all receptacles for single dwellings installed outdoors and located within 2.5 m of ground or grade level be protected by a Class A GFCI. An exception to the GFCI requirement is allowed for outdoor receptacles used to plug in vehicle heaters, as specified in Rule 8-400. Providing a receptacle outdoors ensures that cords are not run through doors or windows and that the receptacle used is protected by a GFCI.

Outdoor receptacles mounted more than 2.5 m from the ground are not required to have GFCI protection since they have typically been provided to facilitate the connection of decorative lighting. These receptacles are unlikely to be used for appliances such as barbecues, lawn mowers, hedge clippers, or similar outdoor apparatus that are connected while the operator is in contact with the ground.

Automobiles are usually equipped with an electric block heater or a similar device intended to prewarm the engine under winter conditions. For this purpose, Item b) requires that at least one duplex receptacle be provided for each car space in a garage or carport of a single dwelling.

**Figure 26-29**
**Outdoor receptacle requirements**




Electric overhead garage door openers are very popular in garages of single dwellings. Item c) requires that a receptacle be installed within 1 m of each cord-connected overhead garage door opener.

**Note:** *When determining the location of the receptacle for an overhead garage door opener, the installer needs to determine both the type of opener and the type of garage door being used.*

## Electric heating and cooking appliances

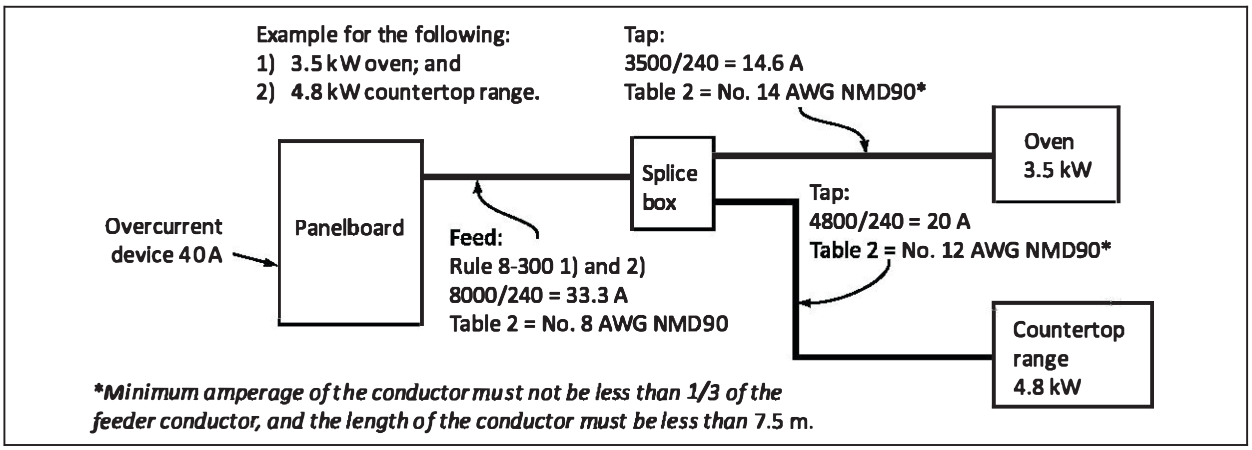
### Rule 26-742 Separate built-in cooking units

A standard electric range has four surface elements, one or two ovens, and a total rating typically less than 16 kW. Subrule 1) of Rule 8-300 specifies how to determine the size of the branch circuit to feed such a range (a 40 A branch circuit is used for a standard range). Under Subrule 2) of Rule 8-300, two or more separate built-in cooking units may be considered one range, provided that the circuit is designed as if it feeds one range with more than one separate cooking unit. The circuit is then split or tapped at the load end with a supply to each of the separate cooking units. Rule 26-742 allows the circuit overcurrent device sized by Subrule 1) of Rule 8-300 to protect each separate cooking unit under the following conditions:

- the length of the tap conductor from the connection to the supply to each separate cooking unit is not more than 7.5 m;
- the ampacity rating of the tap conductor to each separate cooking unit is not less than the rating of the separate cooking unit it supplies; and
- the individual tap conductor's ampere rating is not less than one-third of the rating of the overcurrent device protecting the supply to the range.

See Figure 26-30.

**Figure 26-30**
**Tap conductor sizing for separate built-in cooking units**




## Rule 26-744 Supply connections for appliances

Subrule 1) states that for electric heating and cooking appliances, there is to be only one point of connection for supply. If these appliances need servicing, the power is to be turned off so that the servicing can be carried out safely.

However, some permanently connected appliances are provided with multiple points of supply as allowed by the applicable safety standard for electrical equipment and are marked accordingly. To allow this, Subrule 1) refers to an exemption in Subrule 10) to allow for multiple point of supply for one heating and cooking appliance.

All new electric ranges and clothes dryers come equipped with an appropriate cord and attachment plug that enables them to be plugged safely into the receptacle without the need to hire qualified personnel. This makes it easier to move these appliances for servicing, cleaning, redecorating, etc.

The concept of cord-connected, relatively high-wattage appliances has been so well received by both homeowners and inspection departments that Subrule 8) allows similar connections for appliances other than ranges and dryers, when deemed appropriate.

Subrule 10) allows more than one branch circuit to be supplied to heating and cooking appliances when:

- they are permanently connected with multiple points of connection;
- they are marked accordingly; and
- their connection to the different branch circuits conforms to Rule 14-414.

### Rule 26-746 Appliances exceeding 1500 W

It is acceptable to supply a number of appliances rated 1500 W or less from a single branch circuit. If the appliance exceeds 1500 W, however, Subrule 1) requires that there be a separate branch circuit solely for the supply of that particular appliance. Sometimes, another appliance might need to be added, particularly with older electrical installations, but the electrical system does not accommodate another branch circuit. For that reason, Subrule 1) also recognizes that two or more separate built-in cooking units can be connected to the same branch circuit even if it is not sized for the total connected load, provided that the branch circuit is properly sized and protected for each appliance and that the appliances are controlled by:

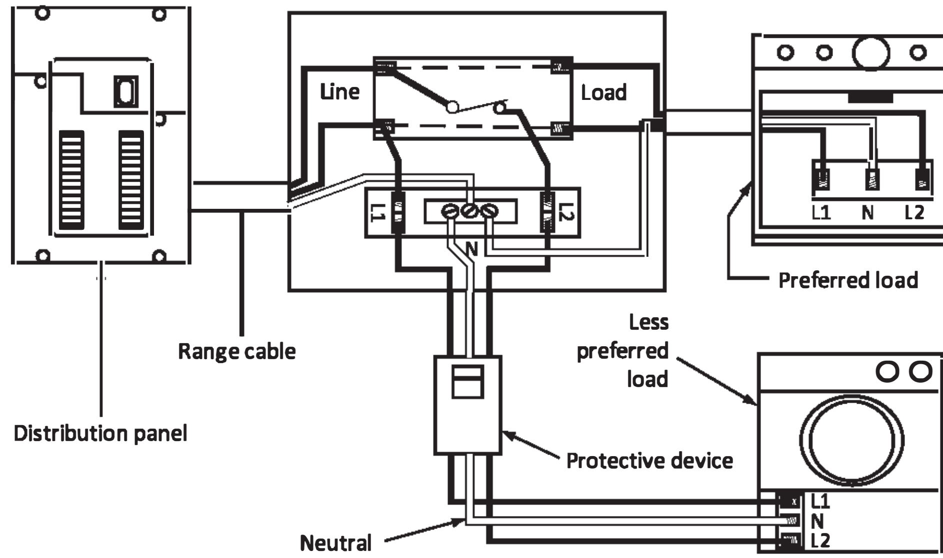
- a multiple-throw manually operated device that will allow only one such appliance to be energized at one time; or
- an automatic device that will limit the total load to a value that will not cause operation of the overcurrent devices protecting the branch circuit.

For example, a manufacturing plant uses a heating appliance rated at 32 A connected to a 40 A circuit. If a different piece of electrical equipment that also has a rating of 32 A is occasionally used, the second piece of equipment can be connected to this branch circuit by using a double-throw switch. This allows only one piece of equipment to be used at any one time. If the supply circuit is sized appropriately, the branch circuit cannot be overloaded, and the particular piece of equipment in use at any particular time is properly protected.

Using the example of an older home with a relatively small service and distribution panelboard that does not have provisions for the required branch circuit for a new clothes dryer, Item b) of Subrule 1) would allow the installation of a "load miser" (see Figure 26-31) that is connected in the range branch circuit and acts as an automatic double-throw switch. In this scenario, the range is considered the preferred load. If the dryer is operating and the occupant attempts to use the range, once the current drain on the range reaches the limit of the branch circuit, the less preferred load (the dryer) is automatically "dumped" until the use of the preferred load (the range) is discontinued. Then the less preferred load (the dryer) is automatically re-energized.

Subrule 2) requires that every electric heating and cooking appliance have an indicating switch, either in the branch circuit or on the appliance. An indicating switch is one that visually shows whether the switch is in an ON or OFF position. If there is more than one individual heating element and each element is controlled by its own switch (for example, an electric range in which each element has its own switch), no main switch needs to be provided. Up to 30 A, an attachment plug and receptacle are an acceptable means for disconnecting the power to an appliance.

**Figure 26-31**
**Use of a load miser**




**Notes:**
1) *The load miser is temperature-compensated and is unaffected by changes in ambient temperature.*
2) *The load miser is calibrated to dump the less preferred load at a predetermined level and is sealed before shipment.*
3) *Because the load-dumping switch is single-pole, it is necessary to follow the wiring diagram closely to avoid backfeeding any motors in the appliances.*

### Rule 26-748 Signals for heated appliances

In many commercial and industrial applications, heated appliances such as soldering irons, glue pots, and clothes/fabric irons are used. Fires can occur if these appliances are left energized for a long time, especially in areas that might be unattended for extended periods. Therefore, some visual means of advising the usual occupants of the area that such appliances have been left on is required. Item a) recognizes a simple wall switch with a red pilot light as an acceptable means.

### Rule 26-750 Control of ventilation of commercial cooking equipment

Other codes and regulations specify when and how commercial cooking equipment is to be ventilated. For example, the *National Building Code of Canada* requires that systems for the ventilation of restaurant and other commercial cooking equipment be designed, constructed, and installed to comply with NFPA 96. It is not uncommon for fires to occur at such locations, and an operating fan can worsen the situation. People working around such electrical equipment are to be able to turn such a fan off, so the intent of Rule 26-750 is to ensure that the control for the fan motor of a ventilation system for commercial cooking equipment can be easily reached in an emergency, even during a fire.

## Heating equipment

### Rule 26-802 Mechanical protection of cables

Cables used with fuel-burning electrical equipment are to be adequately protected from mechanical damage. Although Section 12 contains the requirements for the various wiring methods, Rule 26-802 repeats the requirement, specified in Rule 12-518 for non-metallic-sheathed cable, that cables are to be protected from mechanical damage when they are within 1.5 m from the floor.

### Rule 26-804 Fuel burner safety controls

Some of the basic requirements for fuel burner safety control circuits are specified in CSA C22.2 No. 3. The addition of other controls in the safety control circuits can create a safety hazard if these controls fail, thus negating the safety effect provided by the safety control circuits.

The intent of Rule 26-804 is to minimize the interposing of other controls in the safety control circuits. Rule 26-804 requires that the safety controls for gas- and oil-fired equipment be installed in accordance with CSA C22.2 No. 3, while the Appendix B Note to Rule 26-804 lists the requirements from CSA C22.2 No. 3 pertinent to installation of the safety control circuits.

### Rule 26-806 Heating equipment rated 117 kW and less

Due to the importance of heating equipment in a building, Subrule 1) requires that any electrical power necessary to operate the electrical equipment associated with heating equipment rated 117 kW and less be obtained from a single branch circuit used for no other purpose, regardless of the total load. Gas-fired water heaters (for example, high-efficiency gas hot-water heaters) are exempted from this requirement by Subrule 3).

Subrule 2) allows exceptions for some auxiliary types of electrical equipment, such as an electronic air cleaner on a forced air system to improve air quality or a circulating pump on a hot-water system that is provided to improve the operation of the system.

Subrule 4) allows the tap conductor supplying associated equipment for the heating equipment to be without overcurrent protection when the associated equipment is essential to the operation of the heating equipment (for example, a circulating pump is essential to a hot-water boiler). Subrule 4) also allows the overcurrent protection to be installed in the tap conductor for essential associated equipment provided that the control circuit for the heating equipment de-energizes (shuts down) the heating equipment when the associated equipment fails to function. An example is a water flow switch in the control circuit of a hot-water boiler that shuts down the boiler when there is a lack of water flow.

Subrule 5) requires that the branch circuit have a suitable disconnecting means that can be reached in an emergency without the necessity of going near the furnace.

## Pipe organs

### Rule 26-900 Installation of electrically operated pipe organs

In a pipe organ, compressed air is directed into tuned pipes to produce sound. The mechanism of the organ consists of three parts: the sound-producing apparatus, which includes the pipes; the wind supply; and the controls, which include one or more keyboards. With an electrically operated pipe organ, the wind supply comes from a blower driven by an electric motor. Usually, the blower motor is in a location remote from the organ console. Some visual means of indicating that the motor is operating is therefore required.

In some installations, a few racks of pipes are arranged in a decorative pattern and exposed to view, but usually many more pipes are installed in a loft directly behind the decorative pipes. This situation requires some form of illumination to allow servicing of the equipment.

## Submersible pumps

### Rule 26-950 Special terminology

The following definitions apply only to Rules 26-950 to 26-956:

A *deep well submersible pump* is a submersible pump for use in a well casing or a similar protective enclosure. It uses the casing or enclosure for mechanical protection for the cable between the pump and the well head.

A *submersible pump* is a pump-motor combination in which the enclosed electrical equipment and the supply connection wiring method are intended to operate submerged in water.

### Rule 26-952 General

The deep well type is to be installed and connected in accordance with Rule 26-954 and the manufacturer's instructions, and the submersible type, in accordance with Rule 26-956 and the manufacturer's instructions. In keeping with the definition for submersible pump given in Rule 26-950, many sump pumps and sewage pumps are classified as submersible pumps.

### Rule 26-954 Deep well submersible pumps installed in wells

Conventional wiring methods listed in Section 12 are used from the main distribution panelboard to the well head. From the well head down to the pump, however, specific wiring methods suitable for the application that are detailed in Item a) are required. For deep wells, the cable going down the well to the discharge pipe is to be supported at a spacing no greater than 3 m [see Item b)]. Without such support, the weight of the cable puts too much strain on the connectors at the well head. To ensure that electrical equipment is properly bonded to ground, a separate bonding conductor is usually provided. When a metal discharge pipe is continuous from the pump to the well head, however, Item d) allows the discharge pipe to ground the pump when it is connected to the equipment bonding conductor at the well head.

### Rule 26-956 Submersible pumps installed in bodies of water

Submersible pumps installed in bodies of water present a potential shock hazard to persons who are in, or in contact with, that body of water. For that reason, installation safety requirements are to be provided to limit the hazard to people in the water and to limit access to the pump.

Installing submersible pumps in bodies of water is allowed. If the voltage exceeds 150 volts-to-ground, however, Subrule 2) requires that:

- a deviation under Rule 2-030 be obtained;
- the electrical installation be maintained by qualified electrical maintenance staff;
- the voltage not exceed 5.5 kV; and
- the area around the pump be protected from access by the public by fencing, cribbing, or isolation and so marked.

If the operating voltage does not exceed 150 volts-to-ground, Rule 26-956 requires that GFCI protection be installed to protect the branch circuit supplying the pump.

A faulty pump can pose a hazard by establishing a voltage gradient in the water in the vicinity of the pump. Although the amount of current involved might be small, it can prove fatal to anyone in the water nearby. Installing a Class A GFCI is impractical since it is too sensitive. Therefore, a ground fault circuit interrupter that opens the branch circuit within 2.7 s if the ground fault current exceeds 10 mA is acceptable. Since even this small current presents a shock hazard, especially to infants, it is advisable to limit access to the pump area. Where the pump voltage exceeds 150 volts-to-ground, Subrule 2) d) requires that fences or cribbing and suitable warning signs be provided to control access to this area.

## Data processing

### Rule 26-1000 Permanently connected data processing units

Today's computers contain and process large amounts of information, and the loss of the use of this electrical equipment, even for relatively short periods, can create major problems. By prohibiting these branch circuits from supplying other electrical equipment, the chances of faults or overloads causing a disruption of service is lessened. While Rule 26-1000 applies only to permanently connected units, it is also a good practice to follow with cord-connected computers.

# Section 28 — Motors and generators

## Scope

**Rule 28-000 Scope**
Section 28 includes additional and specific requirements for the installation, protection, and control of electric motors, generators, and hermetic, semi-hermetic, and non-hermetic refrigerant motor-compressors.

The principal components and requirements for motor installation are summarized in Figures 28-1 and 28-2, which provide an overview of the supply to a motor control centre typically used to feed the individual motors in a multiple-motor installation.

**Figure 28-1**
**Single-motor installation**

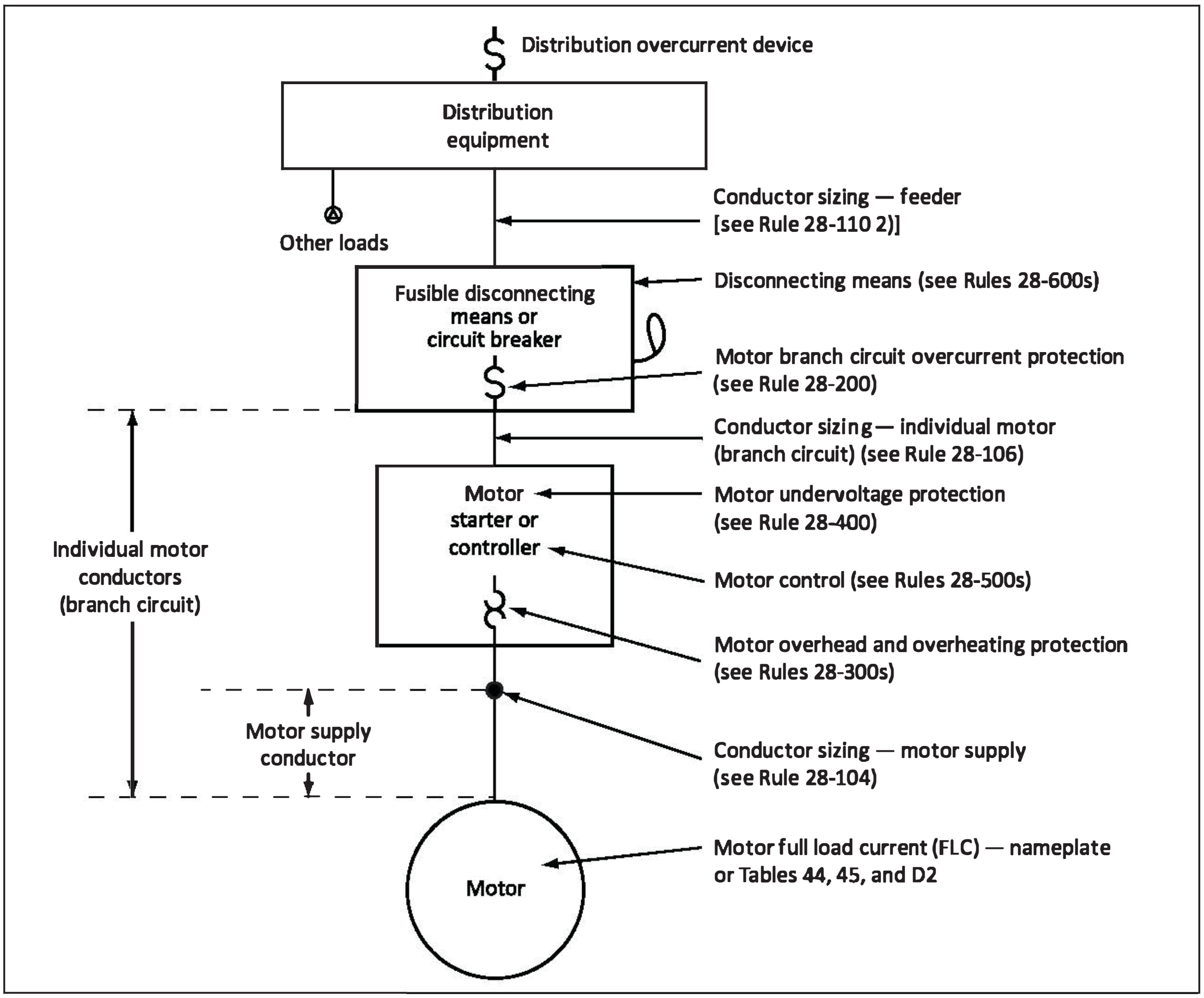
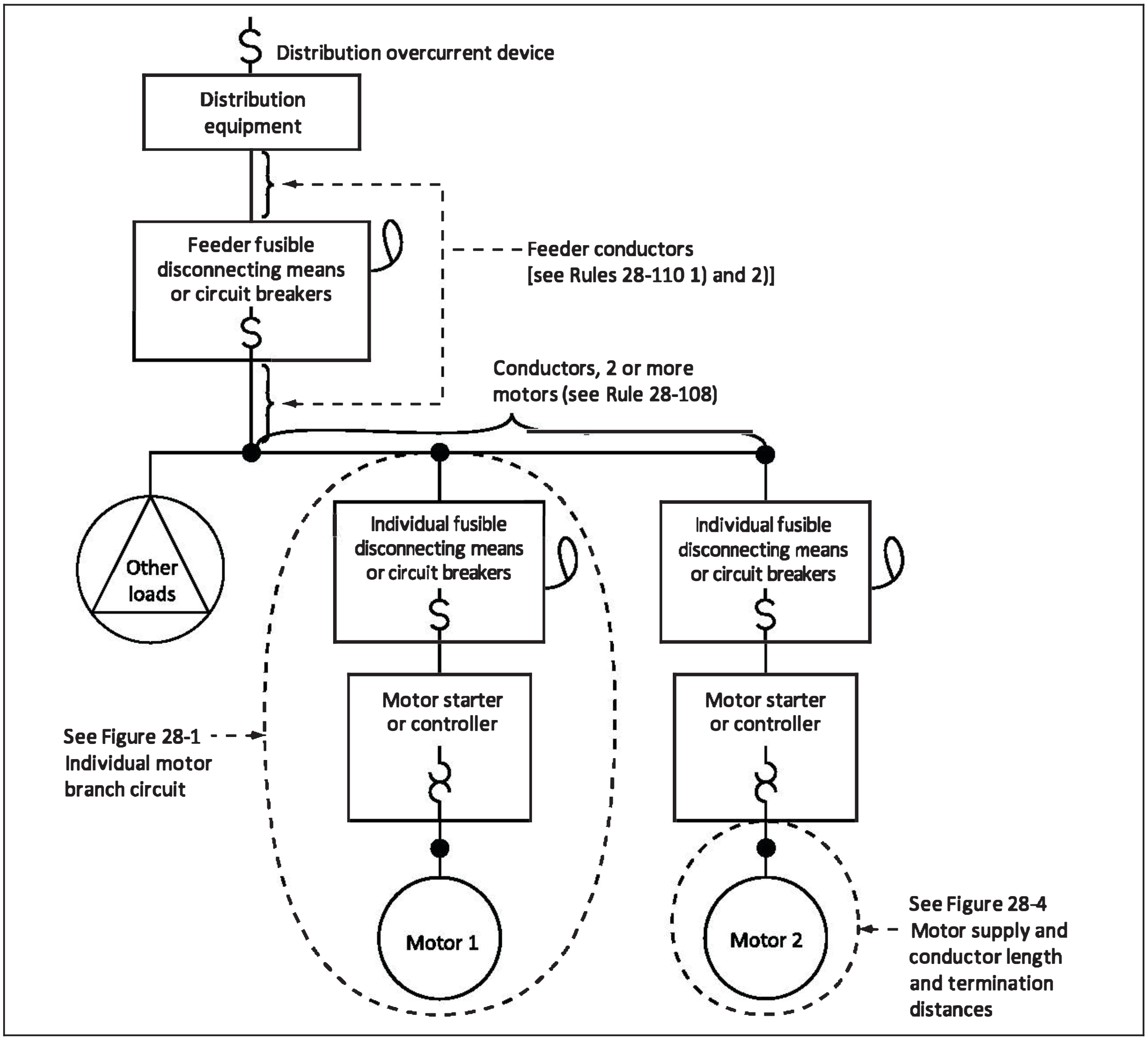


**Figure 28-2**
**Multiple-motor installation**




## General

### Rule 28-010 Special terminology

The terms listed and defined in Rule 28-010 apply only to Section 28. They refer to electrical characteristics of motors, compressors, and generators, some of which are specified on the device's nameplate (see Figure 28-3).

The term *refrigerant motor-compressor* is used in connection with air conditioner or refrigeration compressors, which have a number of types and special characteristics.

The *locked rotor current* (LRC) *rating* of an ac motor or compressor can also be described as the maximum current that the motor or compressor requires from the electrical system when

- it is starting from a standstill position; or
- the shaft fails to rotate due to a mechanical fault, while energized.

In the field, *rated load current* (RLC) *rating* is applied to motor-compressors as it describes the full load current that an air conditioner or refrigerant motor-compressor takes from the electrical system when

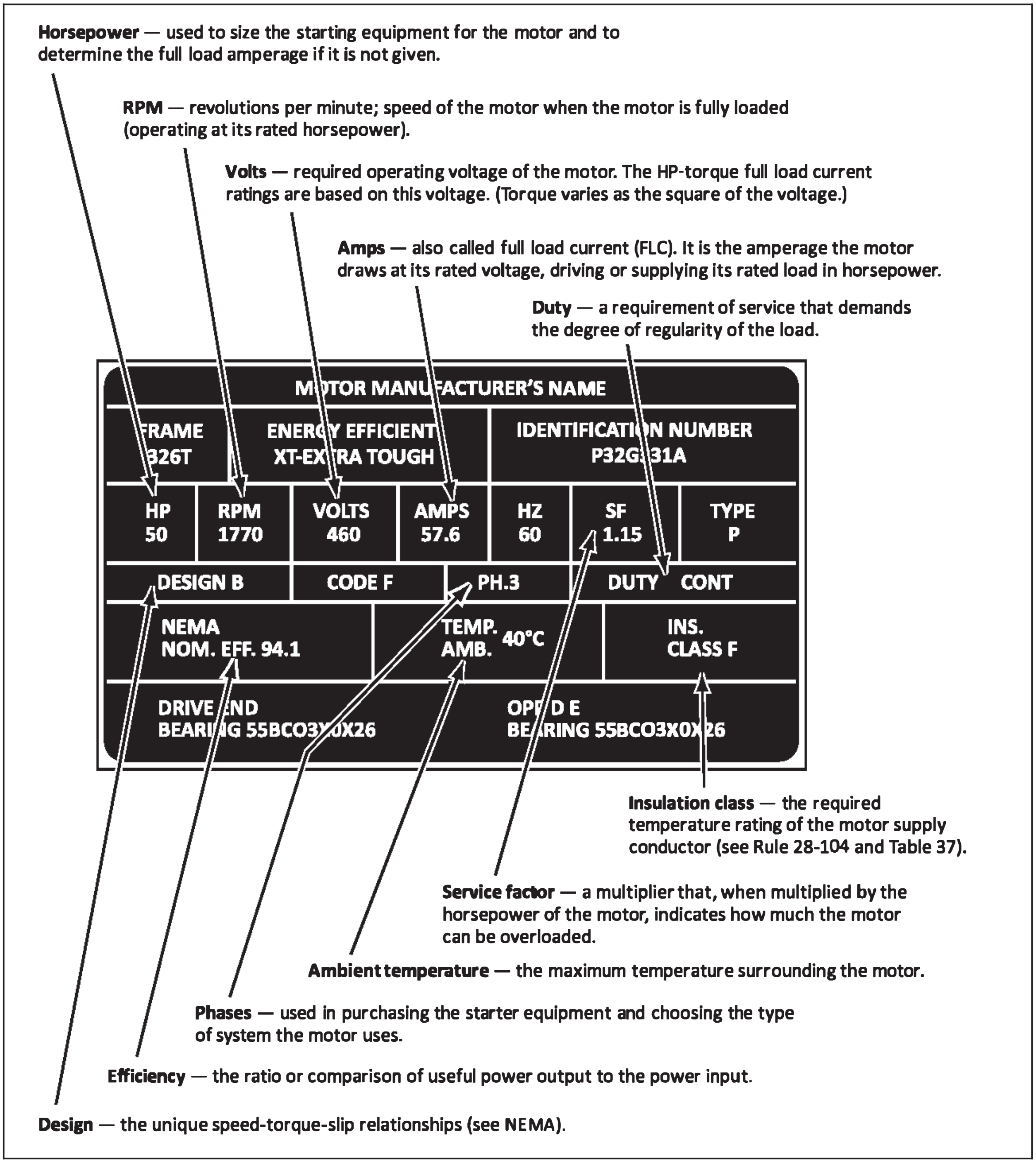
- the motor-compressor is delivering its rated mechanical load [usually expressed in horsepower (hp)]; and
- the electrical installation is delivering the required nameplate voltage to the motor-compressor's terminals.

Although not defined in the Code, full load current (FLC) has meaning similar to rated load current (RLC) when used in relation to motors and generators. In the field, RLC and FLC are used to determine quickly how the motor or compressor is operating under load. If the equipment is drawing more than its nameplate current, it is usually because it is rotating more slowly than its nameplate revolution per minute (rpm) value, either because of low voltage at its terminals or because it is delivering more horsepower than the design intended (i.e., it is mechanically overloaded).

*Continuous duty service* and *non-continuous duty service* are terms used to describe the operational characteristics of the load that a motor is required to handle. The distinction is essential in determining the minimum size of conductor required to deliver current to the motor. When the type of duty service is not specified on the equipment nameplate, the accepted practice in the field is to treat the motor as continuous duty service equipment.

*Service factor* (SF) refers to a value used to determine the maximum rating of the overload current or excessive current protection for a motor. The SF specified on the nameplate indicates the degree of overload, whether mechanical or due to low supply voltage, that the motor has been designed to handle.

## Figure 28-3
## Nameplate terminology




### Rule 28-014 Methods of guarding
Rule 28-014 describes various methods of guarding motors. Rules 28-012 and 28-014 relate only to exposed live or energized parts; other hazards that can be posed by rotating equipment (for example, control, isolation, and moving parts) are covered by other Rules in the Code and by company, local, provincial, or federal regulations or standards.

### Rule 28-016 Ventilation

Subrule 1) requires that the ambient air temperature surrounding a motor not exceed 40 °C for motors 1 hp and larger and 30 °C for fractional horsepower motors. If motors are installed and used in areas where the ambient temperature exceeds the designed temperature rating due to poor ventilation or other causes, the motor can become a fire or shock hazard, and its life expectancy can be reduced.

Where adequate ventilation cannot be provided, Subrule 2) requires that motors specifically designed for higher ambient temperatures be used. These motors are to be appropriate for such use and marked to indicate the ambient temperature at which they can be used.

In areas where proper ventilation and cooling are prevented by an accumulation of dust or flying materials on the motor, Subrule 3) requires that a suitable type of enclosed motor be used to prevent the motor from overheating. See also Rules 28-314 to 28-318 regarding overheating protection.

## Wiring methods

### Rule 28-100 Stationary motors

Stationary motors are to be connected to the electrical system using wiring methods listed in Sections 12 and 36 depending on the voltage rating of the motor. However, motors are allowed to be supported by or mounted on pads or springs to reduce noise and vibration transmission to other parts of a building or structure. The Appendix B Note to Rule 28-100 recommends that when rigid conduit, EMT, or other rigid wiring methods are used to make connections to the motor, a flexible fitting is to be inserted between the rigid conduit and the motor connection box to prevent vibration transmission and damage to the rigid conduit, other rigid wiring arrangements, or parts of the building or structure.

### Rule 28-102 Portable motors

Flexible cords used to supply portable motors (i.e., motors that are not fixed in position) can be subject to severe usage, such as

- being dragged or moved along rough, dirty, uneven, or wet surfaces;
- flexing;
- vibration; and
- mechanical injury from being walked on or driven over by machinery.

Rule 28-102 requires that flexible cords supplying motors have a serviceability rating of extra-hard usage in damp or dry locations.

An exception to this requirement is allowed when the motor is part of a factory-assembled device and the rating of the flexible cord is covered by the Standard for the specific equipment.

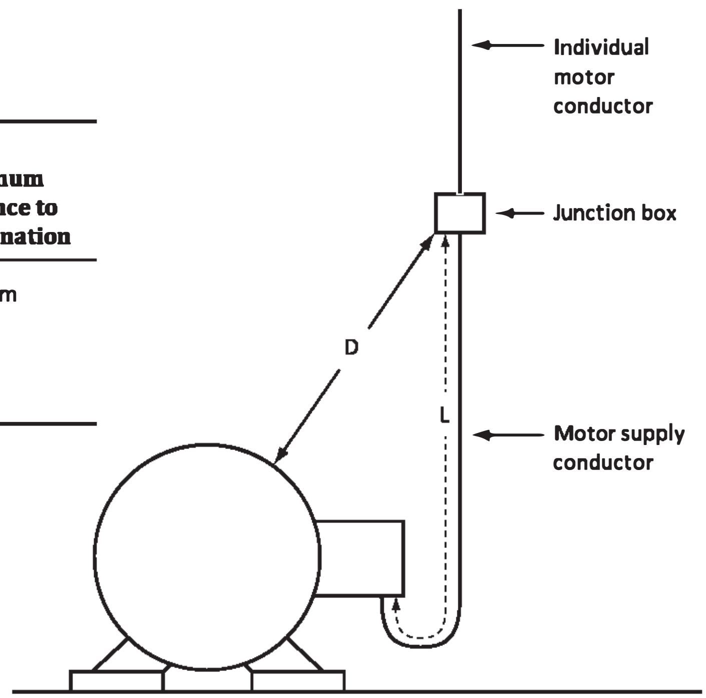
### Rule 28-104 Motor supply conductor insulation temperature rating and ampacity

Motor supply conductors (see Figure 28-4) are the conductors that enter a motor connection box to supply electrical energy to a motor. They are to satisfy the following requirements:

- the conductors' ampacity rating is to be sufficient to handle the motor's full load current;
- the conductor's ampacity rating is to be based on the conductor's insulation temperature rating being 75 °C even though a higher insulation temperature rating is required;
- the conductors are to act, to some degree, as a heat sink for the motor connection box;
- the conductors' insulation temperature rating is to be suitable for the motor's insulation class and type of enclosure as listed in Table 37 unless marked otherwise; and
- the conductors' insulation temperature rating is to be suitable for the ambient temperature surrounding the motor.

## Figure 28-4
## Motor supply conductors

| Motor size | L<br>Minimum length of conductor | D<br>Minimum distance to termination |
|---|---|---|
| Less than 100 hp | 1.2 m | 600 mm |
| 100 hp or larger | 1.2 m | 1.2 m |




The motor supply conductor's temperature rating depends on the motor's insulation class, the ambient temperature surrounding the motor, and the type of motor enclosure [for example, totally enclosed non-ventilated, open ventilated, or totally enclosed fan cooled (TEFC)].

The motor's insulation class is based on the temperature of the motor's windings, which is the hottest area in the motor. There are four standard motor temperature ratings (described in *Canadian Electrical Code, Part II* Standards):

- Class A (105 °C);
- Class B (130 °C);
- Class F (155 °C); and
- Class H (180 °C).

The insulation on a motor's winding conductor is to be resilient since the conductor heats and expands as the motor is operated. Different parts of a motor are made with different materials, which expand at different rates. The winding insulation is a form of plastic, so it becomes more brittle with time and repeated heating and cooling cycles. If the temperature inside the motor is increased, the life expectancy of the winding insulation is reduced. When the winding insulation becomes brittle, it develops fine cracks and exposes the conductor to contaminants (for example, dirt, moisture, or any conducting material). The current in the winding conductors can flow across the insulation (tracking), resulting in insulation damage. This damage allows more current to flow as the tracking across the insulation reduces the impedance of the winding insulation, leading to a complete insulation breakdown.

The minimum ampacity of motor supply conductors is based on a conductor insulation temperature rating not exceeding 75 °C, as required by Subrule 1) c).

The connection box attached to the motor housing is smaller than the junction or outlet boxes used in accordance with the wiring methods covered in Section 12 of the Code. The connection box experiences the same temperatures found inside the motor. Since the supply conductors entering the motor connection box are not only to supply the motor with the required power but also help to dissipate the temperatures inside the connection box, Subrule 1) a) requires that the minimum insulation temperature rating for conductors entering the motor connection box be based on the motor's insulation class (specified on the motor's nameplate), and the enclosure type listed in Table 37. Subrule 1) b) requires that when the ambient temperature surrounding the motor exceeds 30 °C, the minimum insulation temperature rating selected from Table 37 is to be increased by the difference between 30 °C and the ambient temperature. Selecting the correct motor supply conductor's insulation temperature rating and increasing it where the motor is used in ambient temperatures above 30 °C prevents the insulation from being damaged by heat buildup in the motor connection box, provided that the motor is operating under normal conditions in an environment for which it has been designed.

**Table 28-1**
**Method to determine the minimum insulation temperature rating for a motor supply conductor**

| Step | Method |
|---|---|
| 1 | Note the insulation class of the motor, as specified on the motor's nameplate or by the motor manufacturer. |
| 2 | Note if the motor enclosure is totally enclosed, and if so, whether it is non-ventilated or ventilated. |
| 3 | On the basis of the insulation class (see Step 1) and the motor enclosure (see Step 2), select the minimum insulation temperature rating from Table 37. |
| 4 | Determine the ambient temperature of the location where the motor is to be used. If the ambient temperature is above 30 °C, increase the insulation temperature rating chosen in Step 3 by adding the difference between the ambient temperature and 30 °C. |

Subrule 2) allows an exception to Subrule 1) for Class A insulated motors, which operate at a lower temperature. The motor supply conductors for Class A motors do not have to act as a heat sink and can run at a warmer temperature than the conductors for motors in other insulation classes. Subrule 2) allows the ampacity of supply conductors for Class A motors to be based on an insulation temperature rating of 90 °C, provided that 90 °C rated insulation is used for the motor supply conductors.

To allow motor supply conductors with a higher insulation temperature rating to act as a heat sink and to prevent the heat from damaging the insulation of the motor's branch circuit conductors which are allowed to be set at a lower insulation temperature rating, Subrule 3) requires that

- the supply conductors have a minimum length of 1.2 m; and
- the conductors terminate at a specified minimum distance from the motor (see Figure 28-4).

### Rule 28-106 Insulated conductors — Individual motors

The minimum ampacity of the branch circuit insulated conductors for a single motor is determined by

- the motor's full load current (FLC), as determined from the motor's nameplate or by using the motor's type (dc or ac: if ac the number of phases is also to be used), horsepower rating, and voltage rating in manufacturer's charts or Code tables (Table D2 for dc motors, Table 44 for three-phase ac motors, and Table 45 for single-phase ac motors); and
- whether the motor is rated for continuous or non-continuous duty service, as specified on the motor's nameplate.

For a continuous duty service rated motor, Subrule 1) requires that the minimum ampacity of a branch circuit insulated conductor be calculated by multiplying the full load current of the motor by 1.25 (125%).

For a non-continuous duty service motor, Subrule 2) requires that the minimum ampacity for an insulated branch circuit conductor be calculated by multiplying the motor's full load current by the demand factor from Table 27.

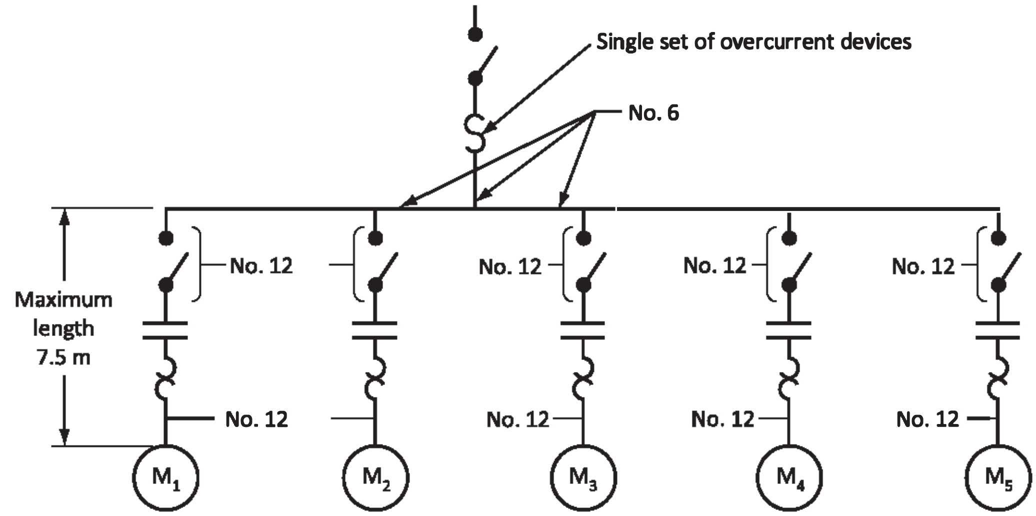
The demand factor from Table 27 is determined by

- the motor's service classification as specified on the nameplate (i.e., short-time, intermittent, periodic, or varying duty); and
- the motor's time rating as specified on the nameplate.

Where more than one motor is supplied by a single set of overcurrent devices (see Figure 28-5), Subrule 3) requires that the ampacity of the tap conductors to each motor be at least equal to the ampacity of the branch circuit insulated conductor (feeder) meeting the requirements of Rule 28-108 for a branch circuit insulated conductor supplying two or more motors. However, Subrule 3) allows an exception to be made if the individual motor conductors

- are sized for each individual motor on continuous or non-continuous duty service;
- have an ampacity equal to or greater than one-third of the ampacity of the branch circuit insulated conductor; and
- are 7.5 m or less in length.

## Figure 28-5
## Tap conductors to more than one motor




| No. | Duty service | FLC | Minimum branch circuit ampacity | Minimum conductor size (see Table 2) |
|---|---|---|---|---|
| $M_1$ | Continuous | 9 | 9 × 1.25 = 11.25 | No. 14* |
| $M_2$ | Continuous | 12 | 12 × 1.25 = 15 | No. 14* |
| $M_3$ | Continuous | 6 | 6 × 1.25 = 7.5 | No. 14* |
| $M_4$ | Non-continuous, short time, 30 minute rating | 11 | 11 × 1.5 = 16.5 | No. 12* |
| $M_5$ | Non-continuous, varying, 15 minute rating | 5 | 5 × 1.2 = 6 | No. 14* |

Minimum motor branch circuit conductor size = 2 or more motors
Minimum ampacity = (12 × 1.25) + 9 + 6 + 16.5 + 6 = 52.5 A [Rule 28-108 1) c)]
Minimum conductor size (in conduit) = No. 6* (Table 2)
Ampacity of a No. 6 in conduit = 55 A
Minimum individual motor branch circuit conductor amperes = 1/3 of 55 A = 18.3 A
Minimum individual motor branch circuit conductor size = No. 12
* *Since the motor's equipment does not have a marked conductor termination rating and the equipment is rated 100 A or less, Rule 4-006 2) a) requires that the 60 °C column of Table 2 be used.*

### Rule 28-108 Insulated conductors — Two or more motors

The minimum ampacity of a circuit's insulated conductors supplying a group of two or more motors is determined from the following:

- the full load current (FLC) of each motor;
- whether each motor is used for continuous or non-continuous duty service;
- for non-continuous duty service motors, the minimum ampacity of the individual branch circuit conductor supplying the motor; and
- the number of motors that are in operation at the same time.

The minimum ampacity of the circuit's insulated conductor where there are two or more continuous duty service motors is calculated by adding 125% of the largest full load current (1.25 × FLC) to the sum of the remaining full load currents of motors that are operating at the same time. It is not 125% of the sum of the full load currents of each motor. It is assumed that the motors do not all start at the same time. If they did, the starting surge, which lasts for only a very short duration, would not cause significant heating of the insulated conductors.

The minimum ampacity of the circuit conductor where there are two or more non-continuous duty service motors is calculated by adding together the minimum branch circuit insulating conductor ampacities for all the non-continuous duty service motors that are in operation at the same time.

The minimum ampacity of the circuit's insulated conductor where there are continuous and non-continuous duty service motors is calculated by adding 125% of the FLC for the largest continuous duty motor to the sum of FLCs of the remaining continuous duty service motors that are operating at the same time, and then adding the sum of the minimum branch circuit insulated conductor ampacities for all the non-continuous duty service motors that are operating at the same time.

Subrule 2) allows the size of the circuit's insulated conductors supplying a group of motors to be reduced when the motors' control circuits are interlocked to prevent all the motors in the group from operating at the same time. The intention is to allow the ampacity of the circuit's insulating conductor feeding the group of motors to be determined by the subgroup of motors having the largest rating when operating at the same time.

Subrule 3) allows the application of demand factors based on load diversity (i.e., the specific characteristics of the motor loading by the motors connected to the circuit's insulated conductor), to allow a more realistic sizing of the insulated conductor. An example of load diversity is the switching of motors or motor loading that occurs on a circuit during a manufacturing process. In such cases, a lower feeder ampacity involves no reduction in safety since

- Rule 28-204 4) requires that the feeder protective devices not have a higher rating than the circuit's insulated conductor (feeder) ampacity; and
- the circuit's insulated conductors need only be sized for the maximum demand that can be placed on them.

When the sizing of insulated conductors is reduced in accordance with Subrule 3), the overcurrent protection is not to be greater than that required by Rule 28-204 using the reduced circuit's insulated conductor (feeder) ampacity.

## Rule 28-110 Feeder conductors

Insulated feeder conductors are the conductors that run between the overcurrent device at the source of supply and the branch circuit overcurrent device(s), as is the case for a panel or motor control centre. Insulated feeder conductors are to have an ampacity high enough to supply the loads without exceeding the temperature rating of the conductors' insulation and termination points. See Table 28-2.

Subrule 1) requires that feeders supplying both motor loads and other types of loads be sized by adding the sum of the other types of loads to

- the minimum ampacity of the branch circuit's insulated conductor, where a single motor is connected (see Rule 28-106); or
- the minimum ampacity of the circuit's insulated conductor, where two or more motors are connected (see Rule 28-108).

## Table 28-2
## Method to determine the feeder's minimum insulated conductor size for motors and non-motor loads

| Step | Method |
|---|---|
| 1 | Determine the motor's contribution to the feeder for<br>• an individual continuous duty motor;<br>• an individual non-continuous duty motor;<br>• two or more continuous duty motors;<br>• two or more non-continuous duty motors; or<br>• a combination of continuous duty motors and non-continuous duty motors.<br>See Rules 28-106 and 28-108. |
| 2 | Using the appropriate Sections and their Rules, determine the total contribution of any other non-motor loads to the feeder's minimum ampacity. |
| 3 | Calculate the minimum ampacity of the feeder's insulated conductor by adding the motor's and/or motor-compressor's minimum ampacity contribution (Step 1) to the total calculated minimum ampacity of the other non-motor loads (Step 2). |
| 4 | Determine the minimum size of the feeder's insulated conductor using the minimum ampacity rating calculated in Step 3 and the appropriate ampacity Table from the Code based on the wiring method being used. |

When a tap conductor is used from a feeder to a single set of overcurrent devices that protect a motor circuit only, Subrule 2) sets out requirements for the unprotected tap conductor. See Table 28-3 for requirements.

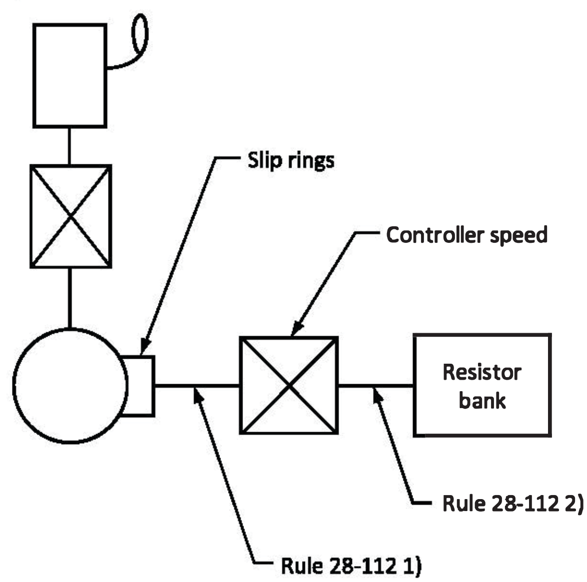
## Table 28-3
## Method to determine the tap conductor's minimum ampacity from a feeder to a single set of overcurrent devices protecting the motor's branch circuit insulated conductor

| Type of tap conductor | Calculation of ampacity | Code reference |
|---|---|---|
| Tap conductors for motor circuits | | |
| Tap conductors over 7.5 m in length | The same ampacity as the feeder conductor | Rule 28-110 2) |
| Tap conductors that are 3 m or less in length and that are enclosed in metal | When the tap conductor feeds a single continuous duty service motor:<br>FLC × 1.25 | Rules 28-106 1) and 28-110 2) |
| | When the tap conductor feeds more than one continuous duty service motor:<br>FLC of the largest motor × 1.25, plus the combined FLCs of the remaining motors in operation at the same time | Rules 28-108 1) and 28-110 2) |
| Tap conductors that are 7.5 m or less in length and that are not enclosed in metal | Tap conductor amps = feeder conductor amps divided by 3 | Rule 28-110 2) b) |

### Rule 28-112 Secondary insulated conductors

A wound rotor induction motor is a variable-speed ac motor that operates on the same principles as the squirrel-cage motor but differs in construction. The rotor in a squirrel-cage motor is made up of shorted bars, while the rotor in a wound rotor motor consists of windings that terminate at slip rings on the motor shaft. This allows the speed of the motor to be varied. The slip rings connect the rotor windings to an external resistance bank; by varying the resistance, the motor's torque-speed characteristics can be changed. In a wound rotor motor operating at full speed, the external resistance is shorted out, and the motor works in the same way as a typical squirrel-cage motor. The branch circuit insulated conductors for a wound rotor motor are sized using the same method as that for squirrel-cage motors (see Figure 28-6).

**Figure 28-6**
**Wound rotor motor — Branch circuit and secondary conductors**




For a continuous duty service motor, Subrule 1) a) requires that the minimum ampacity of the insulated conductors supplying the secondaries (the resistor bank) of a wound rotor motor be determined by multiplying the full load current of the secondary by 1.25. Subrule 1) b) requires that, for a non-continuous duty service motor, the percentage of the rated full load current as specified on the nameplate [or specified in Table 27 using the motor's service classification (i.e., short-time, intermittent, periodic, or varying) and the motor's time rating, specified on the nameplate] be multiplied by the secondary current to determine the minimum size of the secondary conductor.

Secondary conductors are the insulated conductors that connect the slip rings in a wound rotor motor to the external resistance bank. Their minimum ampacity is a percentage of the secondary circuit's full load current, as determined by the duty classification of the external resistance bank (see Table 28).

## Overcurrent protection

Overcurrent protection is designed to de-energize a circuit, cutting off the electrical supply when the connected load allows more current to flow through the circuit than the design intended (sometimes called "excessive current"). Overcurrent protection also de-energizes a circuit when the connected load has been shorted out or bypassed, leaving only the small resistance/impedance of the conductive path that is shorting out the load. This condition causes a large, rapid current flow that can damage an electrical installation and cause a fire.

Motors impose special demands on circuits, and overcurrent protection is to be modified accordingly. During motor starting, the inrush current is approximately six times the motor's full load current. Although this initial inrush current lasts for a short time, overcurrent protection devices sometimes respond to the inrush current as if it were a short-circuit and de-energize the circuit. This is called nuisance tripping. To prevent motors from causing nuisance tripping when starting, the Code allows overcurrent devices to be oversized with a current rating larger than the ampacity rating of the circuit's insulated conductors or the connected equipment. Short-circuit protection is still provided even when the overcurrent device is rated at a maximum of 300% of the insulated conductors' or equipment's ampacity rating. However, these oversized overcurrent devices no longer provide protection against the excessive current caused by an overload. To protect the motor from excessive current, Rules 28-300 to 28-318 regarding overload and overheating protection apply.

**Rule 28-200 Branch circuit overcurrent protection**

Rule 28-200 requires that each ungrounded or live conductor of a branch circuit supplying a single motor be protected from short-circuit faults by a standard-rated overcurrent device (i.e., a fuse or circuit breaker), and that the maximum rating of the overcurrent protection be a percentage of the single motor's full load current. The rating varies according to the type of overcurrent device, whether the system is ac or dc, the number of phases, the type of starting, and the type of motor, as shown in Table 29. The method in Table 28-4 is to be used to determine the maximum rating of an overcurrent device for individual motors. Table D16 may also be used.

## Table 28-4
## Method to determine the maximum overcurrent device size for an individual motor (other than a refrigerant motor-compressor)

| Step | Method |
|---|---|
| 1 | Determine the motor's full load current (FLC). |
| 2 | Determine the type of overcurrent device used to protect the motor. |
| 3 | Determine whether the motor operates on ac or dc. If it operates on ac, go to Step 4.<br>For a dc motor not protected by an instantaneous-trip (magnetic type) circuit breaker:<br>• In Row 6 of Table 29, find the demand factor for the motor's FLC based on the types of overcurrent device selected in Step 2.<br>• Using the FLC determined in Step 1, calculate the maximum overcurrent device size.<br>• Using the overcurrent device's manufacturer's tables, select the maximum standard rated overcurrent device that is closest to, but does not exceed, the calculated maximum overcurrent device size.<br>For a dc motor using an instantaneous-trip (magnetic type) circuit breaker:<br>• for a dc motor rated 50 hp or less, multiply the FLC by 2.5 (250%); and<br>• for a dc motor over 50 hp, multiply the FLC by 2.0 (200%). |
| 4 | Determine whether the ac motor is 1-phase or 3-phase. If it is a 3-phase motor, go to Step 5.<br>For all types of 1-phase ac motors not protected by an instantaneous-trip (magnetic type) circuit breaker:<br>• In Row 1 of Table 29, find the demand factor for the motor's FLC based on the type of overcurrent device selected in Step 2.<br>• Using the FLC determined in Step 1, calculate the maximum overcurrent device size.<br>• Using the overcurrent device's manufacturer's tables, select the standard-rated overcurrent device that is closest to, but does not exceed, the calculated maximum overcurrent device size.<br>For 1-phase ac motors using an instantaneous-trip (magnetic type) circuit breaker:<br>• multiply the FLC by 13.0 (1300%); or<br>• multiply the locked rotor current (LRC) by 2.15 (215%). |

*(Continued)*

## Table 28-4 (Concluded)

| Step | Method |
|---|---|
| 5 | For 3-phase (multi-phase) ac motors, determine the motor type. If it is a squirrel-cage or synchronous type, go to Step 6.<br>For 3-phase wound rotor motors not protected by an instantaneous-trip (magnetic type) circuit breaker:<br>• In Row 5 of Table 29, find the demand factor for the motor's FLC based on the type of overcurrent device selected in Step 2.<br>• Using the FLC determined in Step 1, calculate the maximum overcurrent device size.<br>• Using the overcurrent device's manufacturer's tables, select the standard-rated overcurrent device that is closest to, but does not exceed, the calculated maximum overcurrent device size. |
| 6 | For 3-phase squirrel-cage and synchronous motors, determine the starter or controller type. If it is an auto-transformer or a star-delta type, go to Step 7.<br>For 3-phase ac motors using full-voltage (across-the-line) and resistor reactor starters or controllers and not protected by an instantaneous-trip (magnetic type) circuit breaker:<br>• In Row 2 of Table 29, find the demand factor for the motor's FLC based on the type of overcurrent device selected in Step 2.<br>• Using the FLC determined in Step 1, calculate the maximum overcurrent device size.<br>• Using the overcurrent device's manufacturer's tables, select the standard-rated overcurrent device that is closest to, but does not exceed, the calculated maximum overcurrent device size.<br>For 3-phase ac motors using an instantaneous-trip (magnetic type) circuit breaker:<br>• multiply the FLC by 13.0 (1300%); or<br>• multiply the locked rotor current (LRC) by 2.15 (215%). |
| 7 | For 3-phase squirrel-cage and synchronous motors using auto-transformer or star-delta starters or controllers, determine if the FLC is over 30 A. If the FLC is over 30 A, go to Step 8.<br>For 3-phase ac motors using auto-transformer or star-delta starters or controllers with a FLC not more than 30 A and not being protected by an instantaneous-trip (magnetic type) circuit breaker:<br>• In Row 3 of Table 29, find the demand factor for the motor's FLC based on the type of overcurrent device selected in Step 2.<br>• Using the FLC determined in Step 1, calculate the maximum overcurrent device size.<br>• Using the overcurrent device's manufacturer's tables, select the standard-rated overcurrent device that is closest to, but does not exceed, the calculated maximum overcurrent device size.<br>For 3-phase ac motors using an instantaneous-trip (magnetic type) circuit breaker:<br>• multiply the FLC by 13.0 (1300%); or<br>• multiply the locked rotor current (LRC) by 2.15 (215%). |
| 8 | This Step is for 3-phase squirrel-cage and synchronous motors using auto-transformer and star-delta starters or controllers with a FLC over 30 A.<br>For 3-phase ac motors using auto-transformer and star-delta starters or controllers with a FLC over 30 A and not being protected by an instantaneous-trip (magnetic type) circuit breaker:<br>• In Row 4 of Table 29, find the demand factor for the motor's FLC based on the type of overcurrent device selected in Step 2.<br>• Using the FLC determined in Step 1, calculate the maximum overcurrent device size.<br>• Using the overcurrent device's manufacturer's tables, select the standard-rated overcurrent device that is closest to, but does not exceed, the calculated maximum overcurrent device size.<br>For 3-phase ac motors using an instantaneous-trip (magnetic type) circuit breaker:<br>• multiply the FLC by 13.0 (1300%); or<br>• multiply the locked rotor current (LRC) by 2.15 (215%) |

## Determining the maximum overcurrent device size when the overcurrent device sized by Table 28-4 will not allow the motor to start

**Step 1**

Determine the motor's full load current (FLC):
- as specified on the motor's nameplate (the preferred value);
- as stated for that model number by the motor's manufacturer; or
- as stated in the Code (Table 44 for three-phase ac motors, Table 45 for single-phase ac motors, and Table D2 for dc motors).

**Step 2**

Determine the type of overcurrent device used: time-delay fuse, non-time-delay fuse, inverse-time circuit breaker, instantaneous-trip (magnetic type) circuit breaker, or self-protected combination motor controller.

**Note:** *Where instantaneous-trip circuit breakers are used, see Rules 28-200 2) d) and 28-210 to determine the maximum rating. Where self-protected combination motor controllers are used, see Rules 28-200 2) e) and 28-306 to determine the maximum overcurrent device's rating.*

**Step 3**

Determine whether the motor operates on alternating current or direct current. If it is an ac motor, go directly to Step 4.
For a dc motor:
- In Row 6 of Table 29, find the demand factor for the motor's full load current appropriate for the type of overcurrent device selected.
- Using the FLC determined in Step 1, calculate the maximum overcurrent device size.
- Using the overcurrent device manufacturer's tables, select the standard-rated overcurrent device that is closest to, but does not exceed, the calculated maximum size.

**Step 4**

Determine whether or not the ac motor is a single-phase motor. If it is not a single-phase motor (i.e., a two- or three-phase motor), go directly to Step 5.
For a single-phase motor:
- In Row 1 of Table 29, find the demand factor for the motor's full load current appropriate for the type of overcurrent device selected.
- Using the FLC determined in Step 1, calculate the maximum overcurrent device size.
- Using the overcurrent device manufacturer's tables, select the standard-rated overcurrent device that is closest to, but does not exceed, the calculated maximum size.

**Step 5**

Determine whether the multi-phase ac motor is a squirrel-cage or synchronous motor or a wound rotor motor. If it is a wound rotor motor, go directly to Step 7.
Determine whether the squirrel-cage or synchronous motor uses full-voltage (across-the-line) resistor and reactor starting, auto-transformer starting, or star delta starting. If the motor uses auto-transformer starting or star delta starting, go directly to Step 6.
For a squirrel-cage or synchronous multi-phase ac motor with full-voltage (across-the-line) resistor and reactor starting:
- In Row 2 of Table 29, find the demand factor for the motor's full load current appropriate for the type of overcurrent device selected.
- Using the FLC determined in Step 1, calculate the maximum overcurrent device size.
- Using the overcurrent device manufacturer's tables, select the standard-rated overcurrent device that is closest to, but does not exceed, the calculated maximum size.

**Step 6**
For a multi-phase squirrel-cage or synchronous motor that uses auto-transformer starting or star delta starting, determine whether the motor's FLC is more or less than 30 A.
For a motor with an FLC of 30 A or less:
- In Row 3 of Table 29, find the demand factor of the motor's full load current appropriate for the type of overcurrent device selected.
- Using the FLC determined in Step 1, calculate the maximum overcurrent device size.
- Using the overcurrent device manufacturer's tables, select the standard-rated overcurrent device that is closest to, but does not exceed, the calculated maximum size.

For a motor with an FLC greater than 30 A:
- In Row 4 of Table 29, find the demand factor of the motor's full load current appropriate for the type of overcurrent device selected.
- Using the FLC determined in Step 1, calculate the maximum overcurrent device size.
- Using the overcurrent device manufacturer's tables, select the standard-rated overcurrent device that is closest to, but does not exceed, the calculated maximum size.

**Step 7**
For a wound-rotor type:
- In Row 5 of Table 29, find the demand factor of the motor's full load current appropriate for the type of overcurrent device selected.
- Using the FLC determined in Step 1, calculate the maximum overcurrent device size.
- Using the overcurrent device manufacturer's tables, select the standard-rated overcurrent device that is closest to, but that does not exceed, the calculated maximum size.

Subrule 2) d) requires that where instantaneous-trip circuit breakers use a magnetic trip only (i.e., no thermal unit), the requirements of Rule 28-210 be used to size the maximum branch circuit overcurrent protection.

Subrule 2) e) allows the use of self-protected combination motor controllers for providing motor branch circuit overcurrent protection provided that they comply with the requirements of Rule 28-500. In CSA C22.2 No. 14, a motor controller that has non-replaceable or integral discriminating overload and short-circuit current sensors, and is provided with one or more sets of contacts where the contacts cannot be isolated for separate testing, is considered to be a self-protected combination motor controller Type E. A controller comprised of a magnetic or solid-state motor controller coupled with a Type E controller is considered to be a self-protected combination motor controller Type F. If individual components can be shipped separately, the self-protected combination motor controller is required to be additionally marked "COMBINATION MOTOR CONTROLLER WHEN USED WITH…" or "SELF-PROTECTED COMBINATION MOTOR CONTROLLER WHEN USED WITH…". Line side terminal components may also be required in order to fulfill the terms of certification. Due to their integral construction, self-protected combination motor controllers are selected primarily on the basis of the overload protection requirements for the circuit.

In a case where the maximum overcurrent device size, calculated on the basis of the individual motor's full load current and the demand factor of Table 29, is less than 15 A, Subrule 3) a) allows the overcurrent protection to be rated at 15 A.

Subrule 3) b) requires that the maximum rating of an overcurrent device protecting a branch circuit supplying two or more motors not exceed the values listed in Rule 28-206.

In some situations, even when overcurrent devices are over-sized in accordance with the requirements of Subrule 3) and Table 29, the specific application, environment, types of load, or electrical system can still lead to nuisance tripping during starting, with the overcurrent device responding to the inrush current as a fault. In such cases, Subrule 4) allows the rating of the overcurrent protection to be increased more than Table 29 allows. Subrule 4) specifies the maximum rating or setting of the overcurrent protective device being used to protect the motor branch circuit. See the method in Table 28-6.

Subrule 5) requires that where a thermal magnetic circuit breaker is used as the overcurrent protection for a motor branch circuit, the rating of the breaker is not to exceed the values specified in Rule 28-210.

### Rule 28-202 Overcurrent protection marked on equipment

The requirements for branch circuit overcurrent protection set out in Rule 28-200 apply to a wide range of motors and installations. However, some motor control equipment is designed and constructed to have overcurrent tripping characteristics requiring settings that differ from the provisions of Table 29. In such cases, the maximum rating of the overcurrent protection is marked on the motor controller nameplate, and the rating is not to be exceeded, even if a higher rating is determined by applying Rule 28-200.

### Rule 28-204 Feeder overcurrent protection

Where a feeder circuit supplies branch circuits to motors, the overcurrent protection for the feeder is usually chosen on the assumption that the motors supplied by the feeder do not all start at the same time. The rating of the feeder's overcurrent device is to be kept as low as possible to prevent any overheating and fire hazard, but is not to be so low that nuisance tripping occurs at motor start-up.

Subrule 1) provides a method for determining the maximum rating of a feeder's overcurrent device on the basis of the following:

- the type of overcurrent device used to protect the feeder [for example, non-time-delay fuse, time-delay fuse, inverse-time circuit breaker, or instantaneous trip (magnetic-type) circuit breaker];
- the highest calculated overcurrent device rating, determined in accordance with Rule 28-200, for a motor supplied by the feeder; and
- the full load current ratings of all other motors in operation at the same time connected on the feeder.

**Note:** *When one or more of the motors on the feeder is a refrigerant motor-compressor, the multiplier for determining the maximum calculated overcurrent protection rating for non-time-delay fuses, time-delay fuses, and inverse-time circuit breakers is the same. The multipliers are 50% of the locked rotor current (LRC) or the rated load current (RLC) × 6.0 × 0.5. The method is given in Rule 28-708.*

## Table 28-5
## Method to determine the maximum standard overcurrent device for a group of two or more motors in operation on a feeder

| Step | Method |
|---|---|
| 1 | Calculate the maximum calculated overcurrent device's rating for the type of overcurrent device used to protect the feeder for each motor that will be in operation on the feeder.<br>**Note:** *When one or more of the motors on the feeder is a refrigerant motor-compressor, calculate the maximum calculated overcurrent protection using the method in Rule 28-708:*<br>*Maximum calculated overcurrent protection = (RLC × 6.0 × 0.5 ) or (LRC × 0.5)* |
| 2 | Determine which calculated overcurrent device's rating is the largest for any motor in the group in Step 1 that will be in operation on the feeder. |
| 3 | Add the value of the largest calculated overcurrent device's rating from Step 2 to the sum of the full load current (FLC) of all other motors that will be in operation on the feeder. |
| 4 | Using the overcurrent device's manufacturer's tables, select the standard-rated overcurrent device size that is closest to, but does not exceed, the maximum rating from Step 3. |

In installations where two or more motors are expected to start at the same time, a feeder overcurrent device selected in accordance with Subrule 1) might trip, due to the combined starting inrush current of the motors, and prevent all the motors on the feeder from starting. For such cases, Subrule 2) gives the method for calculating an increased maximum overcurrent device size but limits any such increase to not more than 300% of the ampacity rating of the feeder's insulated conductors, to avoid losing short-circuit protection on the feeder's insulated conductors.

The allowable increase is calculated by adding the full load currents of all the motors that start simultaneously and treating the total as the full load current of a single motor, whose starting surge is assumed to be equal to the sum of the starting surges of the individual motors. When determining which motors might start simultaneously, it is important to consider not just normal operating conditions but also the conditions that exist after a sustained power interruption.

The maximum allowable increase in the rating of the feeder overcurrent protection is based on the number of motors connected to the feeder that start simultaneously and on the type of overcurrent protection that is used to protect the feeder.

## Table 28-6
## Method to determine the maximum standard overcurrent device size for a feeder where simultaneously-starting motors trip the overcurrent device calculated from Rule 28-204 1)

| Step | Method |
|---|---|
| 1 | Determine the full load current (FLC) of all motors that will be in operation on the feeder that are required to start simultaneously. |
| 2 | Add together the FLCs of all the motors that are to start simultaneously. |
| 3 | Determine the FLC of each motor that will be in operation on the feeder but will not be starting simultaneously with any other motor. |
| 4 | Calculate the maximum calculated overcurrent device's rating for the type of overcurrent device used to protect the feeder for each motor in Steps 2 and 3. |
| 5 | Determine the largest calculated overcurrent device rating for any motor of the group in Step 1 that will be in operation on the feeder. |
| 6 | Add the value of the largest calculated overcurrent device rating from Step 5 to the sum of the FLCs of all other motors from Steps 2 and 3 that will be in operation on the feeder. |
| 7 | Using the overcurrent device's manufacturer's tables, select the standard-rated overcurrent device size that is closest to, but does not exceed, the maximum rating from Step 6.<br>**Note:** *This value cannot exceed 300% of the ampacity of the feeder conductor.* |

Subrule 3) requires that when motor loads are combined with other loads, they are to be treated separately and added together to determine the maximum overcurrent protection required for the feeder. (See Table 28-7).

# Table 28-7
## Method to determine the maximum standard overcurrent device size for a feeder supplying both motor and other loads (non-motor)

| Step | Method |
|---|---|
| 1 | Calculate the maximum overcurrent device rating for each motor and/or motor-compressor connected on the feeder (Rule 28-200).<br>**Note:** *When calculating the maximum overcurrent device rating of individual motors connected to the feeder, the calculation should be made using the values for the same type of overcurrent protective device as that protecting the feeder.* |
| 2 | From the values calculated in Step 1, determine which type of overcurrent device used to protect the motor feeder has the largest calculated rating. [See Rule 28-204 1).] |
| 3 | Determine the total continuous and non-continuous loads of the other non-motor loads connected to the feeder. |
| 4 | Add together the maximum calculated overcurrent protection rating (Step 2) to the maximum calculated load from Step 3. |
| 5 | Using the overcurrent device's manufacturer's tables, select the standard-rated overcurrent device size that is closest to, but does not exceed, the maximum rating from Step 4. |

Subrule 4) requires that when the feeder's insulated conductor ampacity is reduced by applying the demand factors allowed by Rule 28-108 3), the rating or setting of the overcurrent device on the circuit is to be limited to the insulated conductor ampacity. In determining the maximum rating or setting of the feeder overcurrent protection, the exemptions noted in Rule 14-104 and Table 13 are allowed to be applied.

**Determining the maximum rating of a feeder's overcurrent device (see Figure 28-7)**

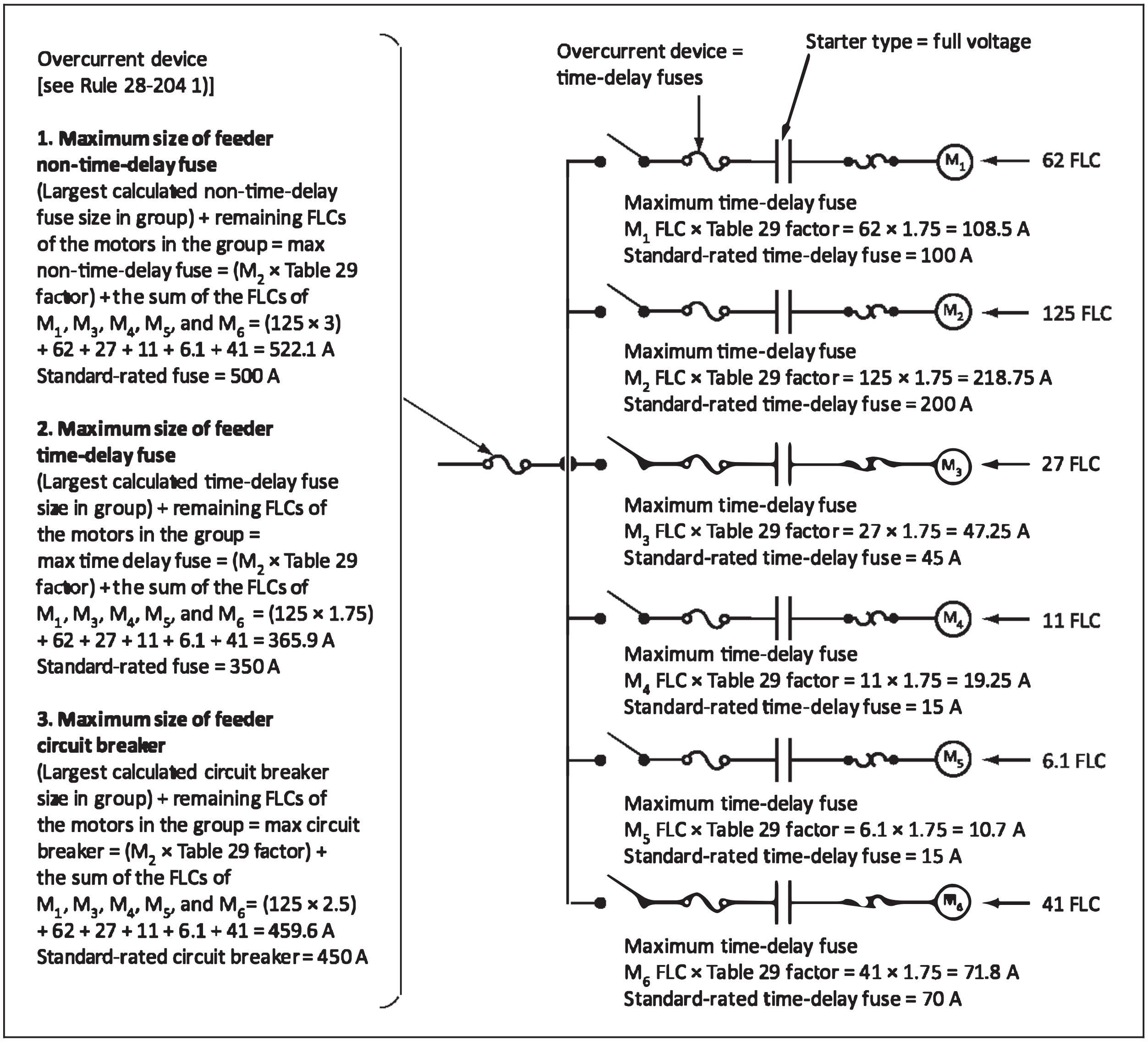
**Step 1**
Calculate the overcurrent device rating required for each motor, in accordance with Rule 28-200, using Table 29.

**Step 2**
Determine which motor has the highest calculated overcurrent protection rating.

**Step 3**
Add the value determined in Step 2 to the sum total of the full load currents of the remaining motors in operation at the same time. This is the maximum calculated value of the feeder overcurrent device.

**Step 4**
Use the overcurrent device manufacturer's tables to select the standard-rated overcurrent device that is closest to, but does not exceed, the maximum calculated size from Step 3.
Figure 28-7 provides sample calculations for a feeder circuit supplying six motors, each with full-voltage starting and protected by a time-delay fuse. The calculations show the maximum allowable ratings for a non-time-delay fuse, a time-delay fuse, and a circuit breaker in the feeder circuit.

## Figure 28-7
## Sample calculations — Maximum overcurrent device size for a feeder circuit




### Rule 28-206 Grouping of motors on a single branch circuit

Grouping two or more motors on a single set of overcurrent devices is considered safe if any of the following conditions required by Rule 28-206 is satisfied:

- the circuit is limited to a maximum of 15 A;
- control equipment suitable for group fusing is used;
- special electrical equipment built to contain a fault is used; or
- a deviation is allowed in accordance with Rule 2-030 for the grouping of motors for a coordinated drive on a single machine.

### Rule 28-208 Size of fuseholders

Fuseholders are to be able to accommodate the fuses selected by sizing overcurrent protection in accordance with the motor's full load current and Table 29 or D16. However, conditions in a specific installation can require the use of smaller fuses and associated fuseholders. Rule 28-208 lists the conditions for the use of such fuseholders.

### Rule 28-210 Instantaneous-trip circuit breakers

Instantaneous-trip circuit breakers do not have an overload feature (for example, a thermal trip unit); therefore, Rule 28-210 requires that these circuit breakers be used only as part of an approved combination starter or controller that includes an overload device. The overload device is intended to protect the motor at up to 10 times the motor's full load current, so the instantaneous-trip circuit breaker, which provides short-circuit protection, may be set at up to

- 13 times the motor's full load current; or
- 2.15 times the motor's locked rotor current.

A motor's locked rotor current is typically six times the motor's full load current. However, certain types of motors (for example, energy-efficient motors) have higher locked rotor currents that must be considered when selecting the rating or setting of instantaneous-trip circuit breakers. The Appendix B Notes to Rule 28-210 and 28-210 a) provide additional information.

To determine the maximum rating of an instantaneous-trip circuit breaker for a dc motor, Rule 28-210 bases the locked rotor current multiplier on the horsepower rating of the dc motor.

### Rule 28-212 Semiconductor fuses

Under fault conditions, restricting the short-circuit energy by means of a high-speed fuse/semiconductor-type fuse is essential to the protection of power electronic devices in the system.

Variable frequency drives, adjustable speed drives, soft starters, and other power electronic devices are common in motor circuits. These power electronic devices are much more sensitive to the damaging effects of short-circuit currents and, therefore, require a level of protection that is not provided by circuit breakers or conventional fuses.

Semiconductor fuses are components recognized in accordance with CAN/CSA-C22.2 No. 248.13 and provide short-circuit protection, but they are not to provide overload protection. Rule 28-212 requires that in cases where power electronic devices are used in a solid-state motor controller system, semiconductor fuses are allowed to be used

- in addition to the protection determined by Rule 28-200 1) (the full load current multiplied by the Table 29 factor); and
- provided that the semiconductor fuses are integral to the controller.

## Overload and overheating protection

Rules 28-300 to 28-318 specify when overload and overheating protection is required; the types of overload protection that can be used, along with the number, location, and rating or setting of overloads; and the requirements for the disconnection of overload protection during start-up.

Rules 28-200 to 28-212 allow the oversizing of overcurrent protection so that motors can start without nuisance tripping. The advantages of preventing nuisance tripping is to be balanced against the potential damage that excessive current might cause to the motor conductors, control equipment, disconnecting means, and motor. If the rating of overcurrent protection is significantly increased, protection against excessive current, or overload, is to be assigned to another device.

During an overload, conductors and equipment handle more current than their design allows. The amount of excess current is limited, however, since the load (a motor or motor group) is still connected in the circuit. (In contrast, in the case of a short-circuit, the load has been shorted out.) As a result, an overload takes longer than a short-circuit to cause damage or fire, making it possible to use a slow-acting overload device that allows a motor's inrush current to pass through without detecting it and consequently de-energizing the circuit. The overload device detects the excess current flow (which lasts longer than the inrush current) and de-energizes the circuit before the excess current develops enough heat that can damage the motor, motor conductors, and associated equipment.

## Rule 28-300 Overload protection required

Rule 28-300 requires that branch circuit insulated conductors and control equipment for each motor are to be protected from excessive current conditions that can cause fire hazards and damage to the motor windings, motor conductors, and associated equipment.

Rule 28-308 sets out exceptions to this general requirement for situations where power demands are relatively low and/or special design features provide protection against overloading hazards.

## Rule 28-302 Types of overload protection

Overload devices are responsive to motor currents and operate in accordance with predetermined current and time limits. These devices can be either integral with or separate from the motor. Subrule 1) a) allows the separate overload device to be used as both short-circuit and excessive current protection. Subrule 1) b) requires that the overload device that is integral with the motor be responsive to the motor current or to the motor current and temperature buildup inside the motor, as well as protect the branch circuit insulated conductors and control equipment.

If fuses are used as the overload device, Subrule 2) requires that they be time-delay-type fuses that do not trip on the start-up inrush current.

## Rule 28-304 Number and location of overload devices

For proper protection, all ungrounded conductors to motors are to have overload protection. The minimum number of overload devices required in the individual motor branch circuit is determined by the number of phases (see Table 25). For single-phase motors, where time-delay fuses are used as overload protective devices, Subrule 1) requires that one overload device be installed in each ungrounded conductor.

Subrule 2) requires that unless a deviation has been allowed in accordance with Rule 2-030, where current-responsive devices are used for the overload protection of three-phase motors, the devices are to have three current-responsive elements that are to be

- connected directly in the motor's circuit insulated conductors; or
- fed by two or three current transformers that are connected so that all three phases are protected.

## Rule 28-306 Rating or trip selection of overload devices

An overload device provides protection by de-energizing the circuit when the current that the motor is drawing from the circuit, after the starting inrush current has dropped, continuously exceeds the motor's design rating (the full load current specified on the nameplate). An overload device that immediately and automatically cuts off any current supply exceeding the motor's full load current can interfere with the normal operation of the motor, as the current draw typically varies and can exceed the design rating. Motors are often subject to excessive mechanical loading and/or system voltage sags and draw more current from the supply in order to develop the increased horsepower required to keep operating. Motors with a marked service factor greater than 1.0 are designed to handle overloading of the motor for short periods of time. The service factor (SF) is an indication of how much overload a motor can withstand, without overheating or otherwise damaging the motor, when operating at rated voltage frequency and ambient. For example, the standard SF for open drip-proof (ODP) motors is 1.15. This means that a 10-hp motor with a 1.15 SF could provide 11.5 hp when required for short-term use. Some fractional horsepower motors have higher service factors, such as 1.25, 1.35, and even 1.50. In general, it is not a good practice to size motors to operate continuously above rated load in the service factor area.

To select the maximum rating or setting of overload protection, both the motor's full load current and the motor's service factor are to be considered. The service factor determines the maximum allowable percentage increase of the motor's nameplate current rating that is used to determine the maximum rating or setting of the overload protection.

Subrule 1) requires that overload devices that are responsive to the motor's nameplate current rating be used.

If a fixed type is being used, it is to have a maximum rating of

- 125% (1.25) of the full load current rating of a motor having a marked service factor of 1.15 or greater; or
- 115% (1.15) of the full load current rating of a motor that does not have a marked service factor or where the marked service factor is less than 1.15.

If an adjustable type is being used, it is to be set to trip at not more than the following:

- 125% (1.25) of the full load current rating of a motor having a marked service factor of 1.15 or greater; or
- 115% (1.15) of the full load current rating of a motor that does not have a marked service factor or where the marked service factor is less than 1.15.

(See Table 28-8).

**Table 28-8**
**Method to determine the maximum rating or setting of the overload protection device**

| Step | Method |
|---|---|
| 1 | Determine the motor's full load current (FLC) using the FLC that is given on the motor's nameplate. |
| 2 | Determine the service factor of the motor given on the motor's nameplate. |
| 3 | Calculate the maximum rating or setting of the overload device using the following:<br>• if the service factor of the motor is 1.15 or higher, calculate the maximum ampacity of the motor's overload by multiplying the motor's FLC (from Step 1) by 1.25; or<br>• if the service factor of the motor is less than 1.15 or is not given, calculate the maximum ampacity of the motor's overload by multiplying the motor's FLC (from Step 1) by 1.15.<br>**Note:** *Remember the service factor is not the multiplier, it only determines the multiplier.* |

In certain applications such as wye-delta or auto-transformer reduced voltage starting, the overload protection installed does not carry the total FLC given on the nameplate. Subrule 2) requires that for servicing, maintenance and troubleshooting, the percentage of the motor's nameplate FLC used to determine the overload protection be marked on the starter in the manufacturer's overload selection table.

### Rule 28-308 Overload protection not required

Rule 28-308 specifies that the requirements for overload protection are allowed to be waived when the motors are as follows:

- a manually started motor rated at 1 hp or less that is continuously attended while in operation, and that is
  - protected by a branch circuit overcurrent protection device rated or set at not more than 15 A; or
  - on an individual branch circuit that has overcurrent protection determined by Table 29 [Rule 28-200 3) a)] and that is so positioned that it can be readily determined from the starting location that the motor is running;
- an automatically started motor having a rating of 1 hp or less forming part of an assembly equipped with other safety controls that protect the motor from damage due to stalled rotor current and on which a nameplate, located so that it is visible after installation, indicates that such protection features are provided; or
- a motor that conforms with CSA C22.2 No. 77.

Motors with inherent overheating protection that are marked as impedance protected "ZP" and thermally protected "TP" are also exempt.

**Note:** *CSA C22.2 No. 77 applies to ac and dc motors with inherent overheating protection designed for use in installations allowed by the Code. CSA C22.2 No. 77 covers motors*

a) *with a voltage rating not exceeding 600 V and with a protective device connected in the motor circuit;*
b) *having impedance protection with a voltage rating not exceeding 600 V; and*
c) *with a voltage rating not exceeding 5000 V and with a protective device connected in an external control circuit with a voltage rating not exceeding 600 V.*

### Rule 28-310 Shunting of overload protection during starting

In some cases, it is impractical to have an overload device in the control circuit that remains operative during the starting period. For example, a motor having a manual reduced-voltage starter might trip the protection every time the motor starts if the increased duration of a starting current causes the maximum rating of the overload device to be exceeded. In such circumstances, Rule 28-310 allows the overload device to be connected in the run control circuit, provided that the starter cannot be left in the start position. In such an installation, the overcurrent device in the power circuit serves as a backup to protect the equipment during the starting period.

### Rule 28-314 Overheating protection required

An overheated motor can cause a fire or shock hazard, so Rule 28-314 contains a general requirement for overheating protection. Specific exemptions are covered in Rule 28-318.

### Rule 28-316 Types of overheating protection

Motors that are required to have overheating protection are to have integral overheating protection that responds to both motor current and temperature or to motor temperature only, as required by Rule 28-316. Thermally protected motors (marked TP) have built-in sensors that detect when a motor's temperature exceeds the design temperature limit and disconnects the power to the motor. Where a deviation is allowed, Rule 28-316 also allows for designs in which the temperature sensor activates a warning signal, rather than disconnecting the power to the motor. Impedance-protected motors (marked ZP) are inherently protected from overheating. By design, such motors have sufficient impedance to limit the continuous current that the motor draws from the supply.

### Rule 28-318 Overheating protection not required

Rule 28-318 does not require overheating protection in some specific applications and in installations where protection is obtained by other means. Environmental conditions are a critical factor in determining whether or not overheating protection is to be installed. However, if the ambient temperature in the location of the motor installation does not exceed the ambient temperature where the motor's overload devices are located by more than 10 °C, the overload devices alone are allowed to be used instead of providing overheating protection. Other conditions, such as airborne dust, are also to be considered. Dust can settle on and cling to a motor's surface, preventing the motor's heat from dissipating, and in this case overheating protection would be required.

In installations where no overload protection is required by the Code, no overheating protection is required.

## Undervoltage protection

A reduction in the supply voltage to a motor, called undervoltage or low voltage, can cause a motor to overheat; the motor and then the cooling fans associated with the motor slow down, so that the motor can develop the horsepower required by the connected load, reducing heat dissipation. When the motor rpm is decreasing, the motor is also drawing more current from the supply, which also causes the internal temperature of the motor to increase. The Code generally requires that motors be supplied with protective devices that disconnect the power to the motor when undervoltage occurs. An exception is allowed where it is evident that an undervoltage condition poses no hazard (for example, where the motor has been designed for applications in which it is required to operate under varying voltage conditions). If this is the case, the voltage range in which the motor can operate is to be specified on the nameplate.

### Rule 28-400 Undervoltage protection required for motors

Two types of protection are available: low-voltage protection (3-wire control, undervoltage protection) and low-voltage release (2-wire control, undervoltage release). Figure 28-8 shows the main differences in design.

Low-voltage protection (3-wire control) is designed to have the starter drop out when there is a voltage failure and not pick up automatically when voltage returns to normal. The control circuit is completed through a STOP button and also through a holding contact on the starter (see Figure 28-8). When the starter drops out, the holding contact opens, breaking the control circuit until the START button is pressed. Three conductors lead from the pilot device to the starter. Low-voltage protection is typically associated with a START-STOP momentary contact push-button station, the most common means of providing this type of control.

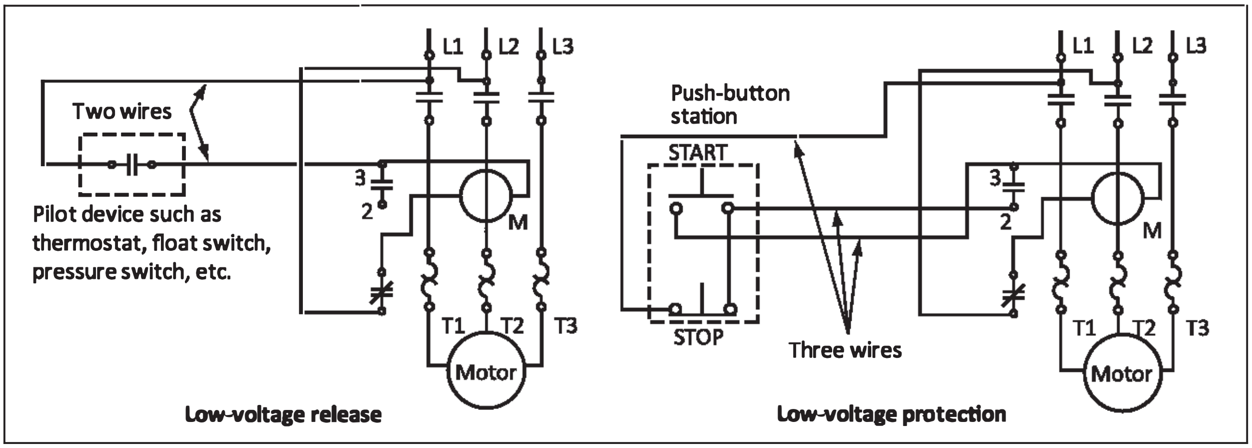
Low-voltage release (2-wire control) is designed to have the starter drop out when there is a voltage failure and pick up again as soon as voltage returns to normal (see Figure 28-8). The pilot device is unaffected by the loss of voltage, and its contact remains closed, ready to carry current as soon as line voltage returns to normal. Low-voltage release is typically associated with an automatic pilot device (for example, a limit switch, thermostat, or float switch) that opens and closes a control circuit by means of a single contact. Two conductors lead from the pilot device to the starter.

The main distinction between the two types of protection is that undervoltage release maintains the coil circuit through the pilot switch contact, while undervoltage protection maintains the circuit through a STOP contact on the push-button station and an auxiliary contact (called a holding, maintaining, or sealing contact) on the starter.

The designations 2-wire and 3-wire describe only the simplest applications of the two types. In some systems, there might actually be more conductors leading from the pilot device to the starter, but the basic principles of a 2-wire or 3-wire control still apply.

Low-voltage protection with a manual restart is to be used in installations where the automatic restarting of motors and/or machinery can cause damage to machinery or injury to personnel. Examples include punch presses, cut-off saws, drill presses, and conveyor systems. If the motor or machinery can be restarted automatically with no hazard, Item b) allows the motor to be protected by low-voltage release. This allows the motor to restart automatically when the voltage returns to a safe operating value, as is necessary for equipment such as air compressors, water pumps, and heating and air-conditioning equipment.

**Figure 28-8**
**Low-voltage release and low-voltage protection**




## Control

Starters and controllers are devices specifically designed to modify the characteristics of the current in a motor installation (for example, reversing, jogging, and reduced-voltage starters) or to interrupt the current (for example, starting and stopping controllers), to govern the operation of the motors in various kinds of machinery.

### Rule 28-500 Control required

Subrule 1) requires that all motors are to be provided with a starter or controller for starting and stopping the motor. The starter or controller is to have a rating in horsepower equal to or greater than the motors to which it is connected, so that it can handle the in-rush current when the motor contacts close or the generated current when the motor contacts open.

A motor starter or controller controls the operation of the motor and is not required to be a disconnecting means that opens all the ungrounded (live) conductors feeding a motor. For example, a single-phase, line-to-line voltage motor requires only one ungrounded conductor to be switched to control it. Therefore, Subrule 2) allows a controller not to have to open (i.e., disconnect) all the ungrounded conductors supplying the motor unless it also serves as the disconnecting means for a motor.

Subrule 3) lists the applications where a motor starter rated in horsepower as per Subrule 1) is not required as the currents it has to switch will not pose an arcing hazard.

### Rule 28-502 Control location

Rule 28-502 requires that the operation of a starter or controller be controlled either manually or by remote control devices in such a way that the motor or machinery can be operated safely at all times. Exposed live parts and moving parts can pose a safety risk and are to be guarded to prevent people from coming in contact with them. Where such guarding cannot be provided, Item b) requires that control devices be provided at each danger point to allow the motor or machinery to be stopped in an emergency.

In locating controls and providing guarding, all applicable occupational health and safety regulations are also to be considered.

### Rule 28-504 Starters having different starting and running positions

Certain types of starters and controllers (for example, soft start, wye-delta, or reduced-voltage starters) have different starting and running positions. Leaving the starter or controller in the starting position can damage the starter, the motor, or both. Consequently, Rule 28-504 requires that starters or controllers not be left in the starting position under normal operating conditions.

### Rule 28-506 Grounded control circuit

In a control circuit in which the power is supplied by a grounded system, faults might cause the control circuit wiring to give a false signal that can cause the motor to start or that might defeat or short out safety devices, causing the motor to start unexpectedly or preventing it from being stopped.
Rule 28-506 requires that the control circuit be arranged so that an accidental ground does not affect the starting or stopping of the motor.

The control circuits for remote and/or signal devices installed outside the controller are generally one of two types: grounded control circuits or ungrounded control circuits. In a grounded control circuit, one line is grounded and the other line is protected by an overcurrent device sized in accordance with Rule 14-100 e) or Section 16. The overcurrent device is allowed to be omitted when the requirements of Rule 14-100 e) are met. Any remote and/or signal device installed outside the controller is to be connected on the ungrounded side of the coil.

In an ungrounded control circuit, both lines are protected by an overcurrent device sized in accordance with Rule 14-100 e) or Section 16. Once again, the overcurrent device is allowed to be omitted when the requirements of Rule 14-100 e) are met. This type of control circuit allows the remote and/or signal devices to be connected on either side of the coil without causing the motor to start or preventing the motor from being stopped by an accidental ground in one of the control circuit conductors.

## Disconnecting means

### Rule 28-600 Disconnecting means required

To ensure the safety of those working on a motor branch circuit, a motor starter or controller, or a motor, Subrule 1) requires that each motor branch circuit, each motor starter or controller, and each motor be provided with a separate disconnecting means to isolate the equipment and the branch circuit from all electrical energy. Subrule 2) allows one disconnecting means to serve more than one function, so an installation consisting of a motor, motor controller, and motor branch circuit is allowed to have only one disconnecting means provided that it meets the requirements of Rule 28-604 (see Figure 28-9).

### Rule 28-602 Types and ratings of disconnecting means

For the purpose of safety, Subrule 1) d) requires that a disconnecting means open all ungrounded conductors simultaneously and also be capable of safely opening the motor circuit while the motor is under load. As a result, the disconnecting means is to either have a horsepower rating equal to or greater than the rating of the connected motor or be capable of safely making and breaking the locked rotor current of the connected motor.

The rating of the disconnecting means for the motor, motor starter, or controller is to be the same as that for the motor branch circuit [see Subrule 1)], although some exceptions to this requirement are set out in Subrule 3).

Subrule 3) a) allows 3-phase motors rated over 100 hp and other than 3-phase motors rated over 50 hp to use an isolating or general-use switch as a disconnecting means for a motor, motor starter, or controller when the switch

- is lockable in the open position;
- is marked as required by Rule 26-100 2); and
- has a minimum current rating of 115% of the motor's full load current (1.15 × FLC).

Subrule 3) b) allows a manual across-the-line type of motor starter that has been designed, certified, and marked as "Suitable for Motor Disconnect" to serve as both the motor starter and disconnecting means for

- a single motor, when it has a horsepower rating not less than the connected motor;

- a group of motors, when it has
  - a minimum horsepower rating not less than the largest connected motor; and
  - a minimum current rating not less than 115% of the full load current of the largest connected motor plus the sum of the full load currents of all the other motors in the group that may be in operation at the same time; or
- a motor or group of motors contained in equipment such as an air-conditioning, refrigeration, or heating unit when
  - the equipment does not contain overcurrent protection, and the starter is rated in accordance with the minimum horsepower rating of the single motor; or
  - the current rating for a group of motors not less than 115% of the full load current of the largest connected motor plus the sum of the full load currents of all the other motors in the group that may be in operation at the same time.

Subrule 3) c) allows the disconnecting means for a portable motor and its starting and control equipment to be a cord set when the cord set
- has a minimum current rating not less than the minimum ampacity of the conductors allowed for the motor branch circuit or tap in which they are connected and is used only as an isolating means and not to interrupt current; or
- is used for a single-phase portable motor rated at 1/3 hp or less, connected by means of a receptacle and attachment plug rated not in excess of 15 A, 125 V [see Rule 28-500 3) a)];

Subrule 3) d) allows the disconnecting means to be the draw-out feature of a high-voltage motor starter or controller of the draw-out type, which complies with Rule 14-010 b), provided that it is used only as an isolating means and is not used to interrupt current. A draw-out circuit breaker has two parts: the base, which is bolted and wired to the frame, and the actual breaker, which slides into and electrically mates with the base. This allows the unit to be replaced without the need to turn off the power feeding the breaker. The load is to be turned off in order to test or remove the unit.

As a safety feature, these units are interlocked to automatically turn the power off just before removal of the breaker begins. By design, it is necessary to turn off only the circuit breaker's load to remove the breaker. This method of mounting allows a single breaker to be disconnected from the power supply (i.e., it does not require that all the power be disconnected from all the breakers installed in the larger enclosure, such as a motor control centre).

There are various designs used to facilitate the "racking-in" (installation) and "racking out" (withdrawal) of the draw-out-type circuit breakers. Some utilize some form of jacking screw to initially move and thus electrically disengage the breaker, then use a travelling trolley type of hoist (somewhat like a small boat winch) to support the breaker during removal and reinstallation. A transient supporting device is necessary as these large (in terms of physical size) breakers are too heavy and too bulky to be safely moved into and out of position by one person.

Subrule 3) e) allows the disconnecting means for a single-phase motor to be a manually operated general-use ac switch that has a current rating not less than 125% of the full load current of the motor and that need not be horsepower rated, provided that it complies with the requirements of Rule 14-510.

Subrule 3) f) allows a fused or unfused motor-circuit switch to be used as a disconnecting means for a group of motors supplied by single circuit and allows the minimum rating of the switch to be not greater than that required to accommodate the proper rating of fuse, when the switch has
- a horsepower rating not less than that of the largest motor in the group; and
- a current rating not less than 115% of the full load current of the largest motor in the group plus the sum of the full load currents of all the other motors in the group that may be in operation at the same time.

To ensure that a disconnecting means operates as required to de-energize circuits and maintain a de-energized condition, the disconnecting means is to be designed and installed for direct, manual operation. Subrule 4) prohibits the disconnecting means from being operated electrically, either automatically or by remote control (for example, lock-off stop buttons).

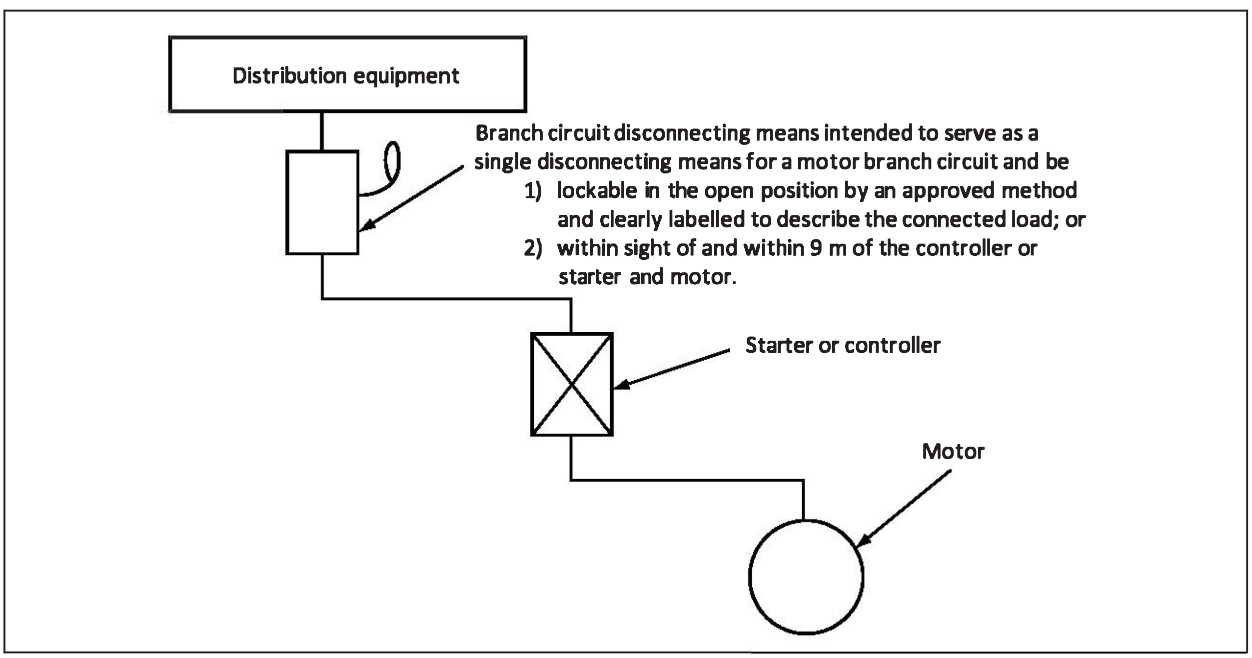
Condensation can be produced in a conduit that leaves a warm area and enters a cooler area, if the flow of warm air into the cooler area is not sealed off. Subrule 5) requires that an enclosure containing disconnecting means for air-conditioning, refrigeration, and heating units that is located outdoors be suitable for the environment. Where conduit is used as part of the wiring methods to the disconnecting means located in the enclosure, the conduit is to be drained and sealed. A seal and drain fitting is to be installed as close as practicable to the place where the conduit leaves a warm area for a cooler atmosphere. Sealing material in the conduit on the warm side is intended to prevent breathing (circulation of air), which can result in condensation of vapour, and the drain fitting will allow any condensate from collecting at the seal. Rule 22-302 gives other requirements for draining and sealing the conduit.

### Rule 28-604 Location of disconnecting means

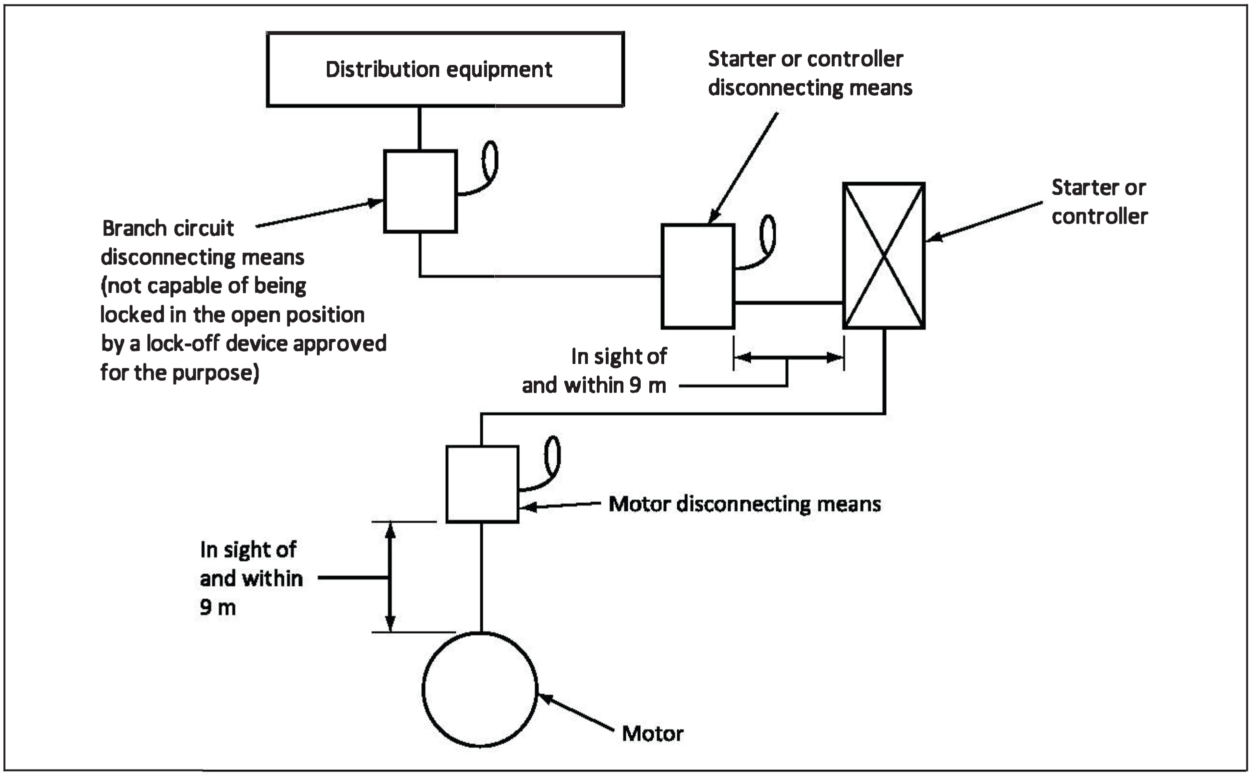
Subrule 1) requires the motor branch circuit disconnecting means to be located at the distribution centre (i.e., the source of supply for the circuit) and allows it to serve as the single disconnecting means when

- it is within sight of and within 9 m of the motor or machinery driven by the motor, and the motor starter or controller; or
- it has locking provisions capable of keeping it locked in the open position and is labelled with the loads connected to it (see Figure 28-10).

**Figure 28-9**
**Disconnecting means serving motor and starter or controller**



## Figure 28-10
## Disconnecting means — Placement and location



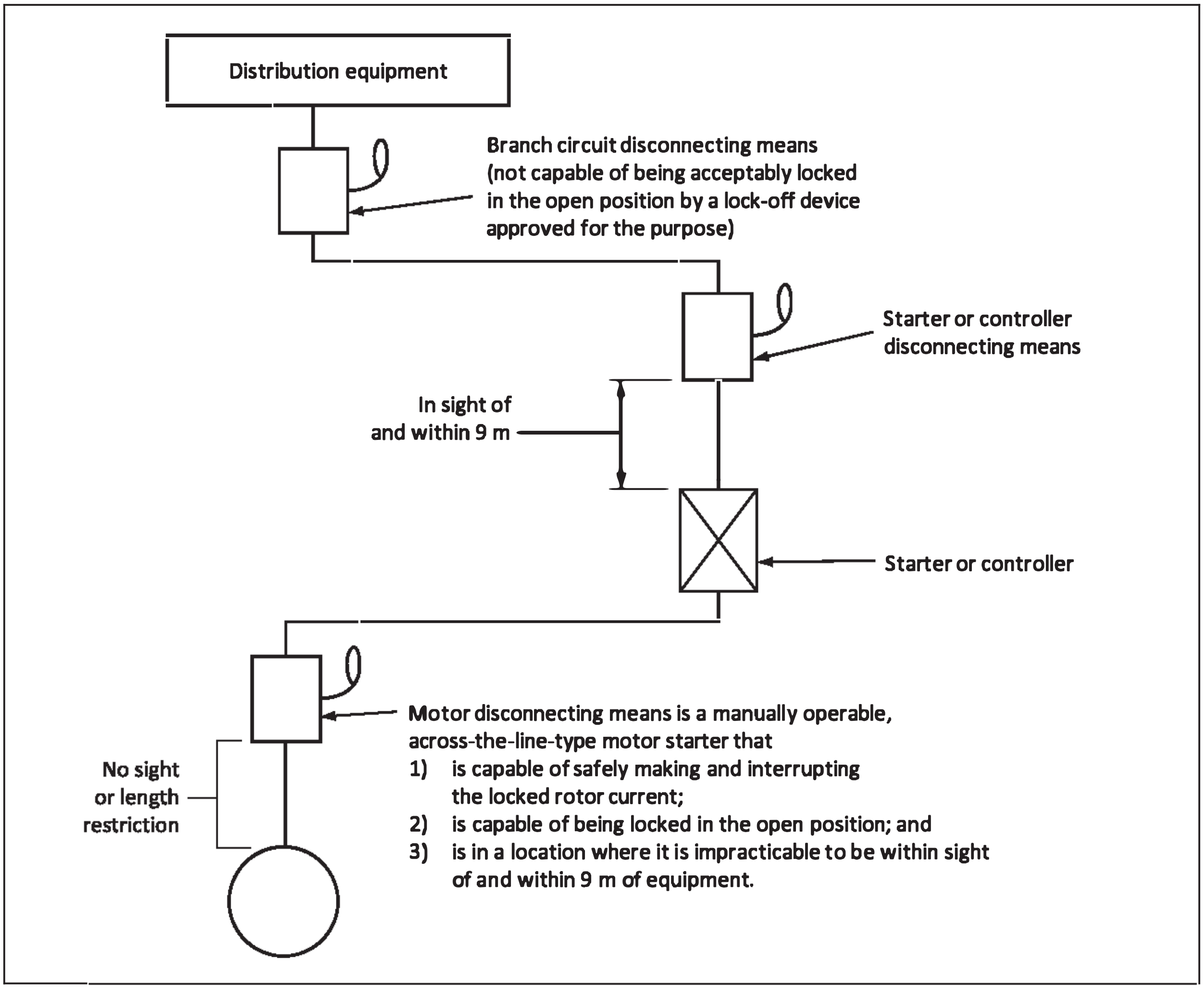

In some installations, a number of small motors are fed from a distribution panelboard (i.e., the enclosure for the branch circuit disconnecting means). In this type of installation, each motor and each starter/controller cannot be locked in the open position, and the disconnecting means will not be within sight of and within 9 m of the equipment. In such cases, Subrule 3) then requires a separate disconnecting means to be located within sight of and within 9 m of the motor and motor's starter or controller (see Figure 28-9).

When the branch circuit disconnecting means cannot be acceptably locked in the open position, Subrule 4) gives an exemption from the Subrule 3) requirement that the disconnecting means for a motor or group of motors on a single branch circuit be in sight of and within 9 m of the motor or motors. Subrule 4) allows the disconnecting means to be located out of sight of, and more than 9 m away from, the motor or motors if the disconnecting means is

- a manually operable across-the-line type of motor starter;
- capable of making (closing) and interrupting (opening) the locked rotor current of the connected load;
- capable of being locked in the open position; and
- in a location where it is clearly impracticable to locate it within sight of and within 9 m of the motor or motors [for example, a hazardous location or a Category 1 or 2 location (see Rule 22-100)]. See Figure 28-11.

**Note:** *Any other type of disconnecting means would have to be located within sight of and within 9 m of the motor or group of motors unless the branch circuit disconnecting means is capable of being acceptably locked in the open position.*

## Figure 28-11
## Disconnecting means located out of sight of equipment




Special requirements apply to the disconnecting means for air-conditioning and refrigeration equipment. Many refrigerants are harmful to the environment if they leak from equipment. Consequently, it is necessary to be possible to shut down such equipment as quickly as possible. Air-conditioning equipment is usually located on roofs, at grade level, or in other hard-to-reach locations. Service people working on air conditioning need to be able to energize and de-energize the equipment for testing, servicing, and making repairs. Having the disconnecting means located out of sight of and/or any considerable distance from the equipment can create both a safety hazard for service personnel and an environmental hazard. As a result, Subrule 5) requires that the disconnecting means for air-conditioning and refrigeration equipment and compressors be located within sight of and within 3 m of the equipment.

Subrule 6) requires that the disconnecting means be readily accessible or operable by an external means (for example, a hook stick) that is readily accessible.

For safe servicing of portable motor-driven machinery, the disconnecting means is to be located on the portable machine and is to be accessible to the operator, in accordance with Subrule 7).

# Refrigerant motor-compressors

Because of their design and special function, motor-compressors have features and requirements that differ from those of the squirrel-cage, wound rotor, or synchronous motors covered in Rules 28-012 to 28-604. The principal differences are summarized in Table 28-9.

**Table 28-9**
**Comparison of squirrel-cage, wound rotor, or synchronous motors, and refrigerant motor-compressors**

| | Squirrel-cage, wound rotor, or synchronous motors | Refrigerant motor-compressors |
|---|---|---|
| **Ratings** | • Rated in full load amperes (FLC)<br>• Locked rotor current (LRC) rating not required<br>• Horsepower (hp) rating required | • Rated in rated load current (RLC)<br>• Locked rotor current (LRC) rating required: LRC = RLC × 6 [see Rule 28-704 1)]<br>• Horsepower (hp) rating required |
| **Conductor size** | For an individual continuous duty service motor: 1.25 × FLC (see Rules 28-106 to 28-110) | For an individual continuous duty service motor: 1.25 × RLC (see Rules 28-106 to 28-110) |
| **Sizing overcurrent device** | Determined in accordance with Rule 28-200 and Table 29, for single motors, depending on whether the overcurrent device is<br>• a non-time-delay fuse;<br>• a time-delay fuse; or<br>• a circuit breaker.<br>If the motor does not start, the overcurrent device size may be increased to<br>• 2.25 × FLC for time-delay fuses; and<br>• 4.0 × FLC for non-time-delay fuses [see Rule 28-200 4)] | Determined, in accordance with Rule 28-708, as 50% of the locked rotor current (LRC), regardless of the type of overcurrent device. If the motor-compressor does not start, the overcurrent device size may be increased to 65% of the locked rotor current (LRC). |
| **Sizing overload device** | Determined in accordance with Rule 28-306, depending on the motor's service factor, as follows:<br>• 1.25 × FLC when the service factor is 1.15 or higher; and<br>• 1.15 × FLC when the service factor is less than 1.15 or is not given. | Determined in accordance with Rule 28-710 as follows:<br>• 1.4 × RLC for overload devices; and<br>• 1.25 × RLC for Type D fuses. |
| **Disconnecting means** | Be in accordance with Rule 28-604 1); required to be within sight of and within 9 m of the motor, unless the motor branch circuit disconnecting means can be acceptably locked in the open position. | Be in accordance with Rule 28-604 5); always required to be within sight of and within 3 m of compressor. |

### Rule 28-700 Rules for refrigerant motor-compressors

Refrigerant motor-compressors, including hermetic refrigerant motor-compressors and semi-hermetic motor-compressors use the refrigerant from the compressor to cool the motor and can have higher horsepower ratings than normal. Rules 28-702 to 28-714 are needed to ensure the safety of such equipment.

### Rule 28-704 Horsepower rated equipment

Horsepower rated equipment is sometimes used to control a motor-compressor, so the horsepower ratings are to be related to the rated load current and locked rotor current of the motor-compressor. When these values are not available, Subrules 1) and 2) require that the locked rotor current be determined as six times the rated load current and the rated load current be determined for 3-phase and 1-phase ac by using the horsepower ratings in Table 44 or 45 respectively. (See Table 28-10).

### Rule 28-706 Insulated conductor ampacity

The required minimum ampacity for insulated conductors supplying a motor-compressor is determined in the same way as that for a standard motor: 125% of the motor-compressor's rated load current (1.25 × RLC). Refrigerant motor-compressors always have a continuous duty service rating.

Where two or more motor-compressors are connected on the same conductor, the insulated conductor's minimum ampacity is determined by adding 125% of the largest motor-compressor's rated load current (1.25 × RLC) to the sum of the rated load currents of any other motor-compressors that are in operation at the same time. (See Rule 28-108 and Table 28-10).

### Rule 28-708 Overcurrent protection

For a motor-compressor, Subrule 1) requires that the maximum size of the overcurrent protection be calculated as 50% of the locked rotor current (0.5 × LRC), which is the same as 300% of the rated load current (3.0 × RLC). If an overcurrent device sized at 50% of the rated load current does not allow the motor-compressor to start, the value is allowed to be raised to 65% of the locked rotor current (0.65 × LRC).

Where two or more motor-compressors are connected on the same overcurrent device, the maximum overcurrent device rating is determined by adding the highest calculated overcurrent device rating for any motor-compressor in the group to the sum of the rated load currents of all the other motor compressors that can be in operation at the same time (similar to Rule 28-204).

For motor compressor circuits, the type of device used to provide the overcurrent protection does not affect these calculations. (See Table 28-10).

### Rule 28-710 Overload protection

Unlike standard motors, motor-compressors do not have service factors and are designed to be protected by an overload relay set at not more than 140% of the rated load current (1.40 × RLC). When devices other than overload relays are used, such as fuses, Item b) does not allow the maximum rating to be greater than 125% of the rated load current (1.25 × RLC). Assemblies that include overload protection have been tested and need no further overload protection. (See Table 28-10).

## Table 28-10
## Method to determine the minimum insulated conductor ampacity, the maximum rating or setting of the overload device, and the maximum size of the standard overcurrent device for refrigerant motor-compressors

| Step | Method |
|---|---|
| 1 | Determine the motor-compressor's rated load current (RLC) by using<br>• the motor-compressor's nameplate;<br>• information from the manufacturer using the motor-compressor's model number; or<br>• one of the following tables from the Code:<br>– Table 44 for 3-phase ac motor-compressors;<br>– Table 45 for 1-phase ac motor-compressors; or<br>– Table D2 for dc motor-compressors. |
| 2 | Determine the motor-compressor's locked rotor current (LRC) by<br>• using the motor-compressor's nameplate; or<br>• multiplying the RLC times 6 (see Rule 28-704). |
| 3 | Calculate the minimum ampacity of the motor-compressor's insulated conductor by multiplying the RLC times 1.25 (see Rule 28-706). |
| 4 | Determine the minimum insulated conductor size of the motor-compressor by using the motor-compressor's minimum ampacity rating from Step 3 and the appropriate ampacity Tables from the Code based on the wiring method being used. |
| 5 | Calculate the maximum rating or setting of the overload protection:<br>• If an overload relay is being used, multiply the RLC from Step 1 times 1.4.<br>• If another type of overload device is being used, such as time-delay fuses, multiply the RLC from Step 1 times 1.25 (see Rule 28-710). |
| 6 | Calculate the overcurrent device's maximum rating by<br>• multiplying the LRC from Step 2 times 0.5; or<br>• multiplying the RLC from Step 1 times 6 times 0.5 (see Rule 28-708). |
| 7 | Using the overcurrent device's manufacturer's tables, select the overcurrent device size that is closest to, but does not exceed, the maximum rating from Step 6. |

### Rule 28-712 Control equipment
Control equipment for a motor-compressor is to have ratings suitable for use with the motor-compressor and is also to have a marked interrupting capacity, or equivalent, that is equal to the locked rotor current rating, so that it can safely open the motor-compressor circuit's insulated conductors. The control equipment is also to meet the requirements for standard motors in Rules 28-500, 28-502, and 28-506.

### Rule 28-714 Disconnecting means
The minimum rating of the disconnecting means for a single motor-compressor or for one or more motor-compressors plus other loads is determined in the same way as that for a single standard motor or for one or more standard motors plus other loads (see Rule 28-602).

## Multi-winding and part-winding-start motors

### Rule 28-800 Rules for multi-winding and part-winding-start motors
Multi-winding and part-winding-start motors have special winding configurations that allow them to obtain different speeds or use different supply voltages. Rules 28-802 to 28-812 ensure the safe installation and operation of these motors.

### Rule 28-802 Permanent connection

If the winding configurations of a multi-winding motor are fixed (a permanent configuration), the motor must comply only with the requirements for standard motors provided in Section 28.

### Rule 28-804 Conductor sizes

The full load current for multi-winding motors varies, depending on the winding configuration and type of motor used. In a part-winding-start motor, both windings are connected in parallel in the run position.

The supply circuit's insulated conductors for the controller are sized as 125% of the largest full load current (FLC) of any winding configuration used for a multi-winding motor or part-winding-start motor (1.25 × largest FLC) (see Rule 28-106). The circuit's insulated conductors between the controller and motor connection box are sized as 125% of the largest full load current of any winding or winding configuration that they supply (1.25 × largest FLC).

### Rule 28-806 Overcurrent protection

Subrule 1) requires that the supply's insulated conductors to the controller of a multi-winding or part-winding-start motor have overcurrent protection sized in accordance with Rule 28-200 and use the full load current of the largest winding configuration provided by the controller.

When the insulated conductors are installed between the controller and the motor, overcurrent protection is required to be installed and sized by using the requirements of Subrule 1) and the full load current of the largest winding configuration supplied by insulated conductor. Subrule 2) allows this overcurrent protection to be omitted where the overcurrent protection rating on the supply side of the controller protects it.

An exception is made in Subrule 3) for part-winding-start motors only, to allow a single set of overcurrent devices on the supply side of the controller to protect both windings (start and run) instead of a set of overcurrent devices on the supply side and load side of the controller. It also allows that if a single set of overcurrent devices are time-delay fuses, the maximum rating is not to exceed 150% of the full load current (1.5 × FLC).

### Rule 28-808 Overload protection

The winding configurations of a multi-winding motor can have different full load currents, and proper overload protection is to be provided for each one. Subrule 1) requires that the maximum rating of the overload protection not exceed 125% of the full load current of the winding configuration that it protects (1.25 × FLC).

In a part-winding-start motor, where the total motor current is usually split equally between the starting and running windings, separate overload protection for each winding configuration is not required according to Subrule 2) if the overload protection

- is located in the starting winding;
- de-energizes both windings; and
- is selected in accordance with the manufacturer's recommendation.

### Rule 28-810 Controls

Multi-winding motors and part-winding-start motors are to meet the general requirements for control equipment, the location of control equipment, and the use of grounded control circuits set out in Rules 28-500, 28-502, and 28-506. Rule 28-810 adds the following requirements for controllers that are not for use with a given multi-winding motor or part-winding-start motor:

- For a multi-winding and a part-winding-start motor in which each winding configuration can have a different full load current, the motor controller is to be large enough for the horsepower rating (or the locked rotor current rating) of the largest winding configuration. To avoid damaging the motor or controllers, interlocks are to be added as required to prevent the simultaneous operation of controllers that are not intended to operate at the same time.

- For a part-winding-start motor in which the motor current is unevenly divided between the starting and running windings, separate controllers for the starting and running windings are required. These controllers are to have a horsepower or locked rotor current rating at least equal to that of the motor, unless they are marked for use with that motor.

## Protection and control of generators

### Rule 28-900 Disconnecting means required for generators

A generator is both a source of electrical energy to its connected downstream loads and a consumer of electrical energy for its various protection and control systems. For individuals who, as part of their duties, work around generators, Subrule 1) requires that a separate disconnecting means be provided for each generator (source of electrical energy) and for each circuit supplying protective and control devices required for the operation of the generator (electrical energy supplied to the generator).

The disconnecting means required by Subrule 1) is required by Subrule 2) to disconnect the generator and all protective and control devices from the circuits connected to the generator.

Subrule 3) allows an exemption from the required disconnecting means when the generator is
- constructed with an integral disconnecting means that meets the requirements of Subrule 2) by disconnecting the generator and all protective and control devices from the circuits connected to the generator; or
- provided with the disconnecting means required by CSA C282.

### Rule 28-904 Generator not driven by electricity

When a generator (usually a portable generator) that is not driven by electricity supplies a 2-wire grounded system, Rule 28-904 requires a protective device that opens both lines for the safety of the electrical equipment and personnel; the reason is that the prime mover of the generator when not electrically driven is not interlocked with the operation of the protective device.

### Rule 28-906 Balancer sets

To supply a 3-wire system, 2-wire dc generators can be operated in conjunction with a balancer set to obtain a neutral. If an imbalance in the load occurs, it is the balancer set that is overloaded and not the main generator. Rule 28-906 requires that protective devices be installed to disconnect the complete system in the event of a severe imbalance.

### Rule 28-908 Three-wire dc generators

Where a 3-wire dc generator is used, an imbalance in the load can occur between the neutral and either side of the line. Subrule 1) requires that a tripping element of the circuit breaker be connected in each of the line leads or armature leads to detect the maximum current available. A 2-pole circuit breaker with two tripping elements or a 4-pole circuit breaker connected in the main and equalizer leads with two tripping elements is to be provided

Subrule 2) requires that the circuit breaker used for overcurrent protection be tripped by the entire armature current.

Subrule 3) requires that there be one tripping element in each armature lead, and that it be connected so that it is activated by the entire armature current [see Subrule 2)].

# Section 30 — Installation of lighting equipment

### Rule 30-000 Scope

Section 30 is a supplementary Section of the Code that gives additional and specific requirements for the electrical installation of lighting equipment.

## General

### Rule 30-102 Voltage

Rule 30-102 requires that lighting equipment in dwelling units be connected to branch circuits supplied from voltages not exceeding 150 volts-to-ground. Typically, 120/240 V single-phase or 120/208 V three-phase, four-wire systems are used. Lighting equipment in other than dwelling units, however, is allowed to be connected to circuits supplied from 277/480 V or 347/600 V systems.

### Rule 30-104 Protection

Proper overcurrent protection is necessary for the various types of lighting equipment and the different sizes of lampholders. Rule 30-104 is a general Rule for both indoor and outdoor lighting. Its intent is to control damage in the event of a fault on a lighting branch circuit by limiting to 15 A the size of overcurrent protection for luminaires, lampholders, and lighting tracks in dwelling units (see Table 30-1). For installations other than in dwelling units, the overcurrent protection is allowed to vary from 15 A to 40 A depending on the input voltage and the type of luminaire [see Items b) to d)].

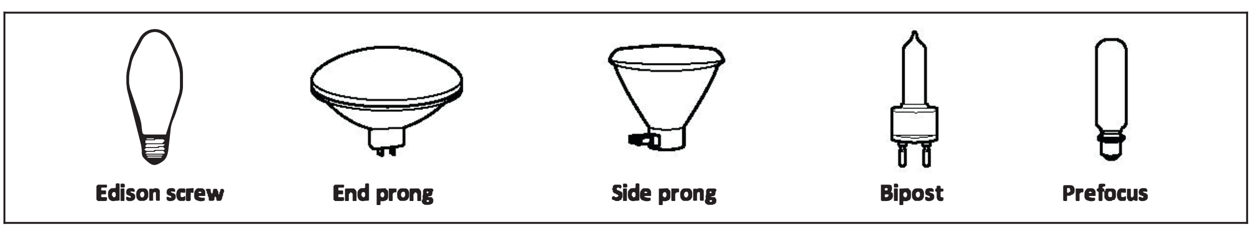
The Appendix B Note to Rule 30-104 states that for the application of the Rule, mogul base includes Edison screw, end prong, extended end prong, side prong, bipost, and prefocus types (see Figure 30-1).

### Rule 30-106 Overcurrent protection of high-intensity discharge lighting equipment

The combined mutual heating effect of the ballast, the overcurrent devices, and the supply conductor terminations when installed in the same enclosure can adversely affect the operation of the electrical equipment. Special design and testing of the high-intensity lighting assembly is required so that adequate space and ventilation is provided for the fuseholders and the rating of the overcurrent protection is properly selected.

When overcurrent protection is provided in a high-intensity discharge (HID) luminaire or in a separate ballast box, Rule 30-106 requires that the combination of the HID luminaire and overcurrent devices, or the separate ballast box and overcurrent devices, be approved for the purpose and be so marked.

**Figure 30-1**
**Samples of bulbs intended for connection to different types of incandescent mogul base lampholders**



## Table 30-1
## Overcurrent protection

| Occupancy type — Dwelling units only | | |
|---|---|---|
| **Maximum branch circuit overcurrent protection rating** | **Maximum branch circuit voltage rating** | **Additional requirements** |
| 15 A | 120 V | All luminaires, lampholders, and track lighting |
| **Occupancy type — Other than dwelling units** | | |
| **Maximum branch circuit overcurrent protection rating** | **Maximum branch circuit voltage rating** | **Additional requirements** |
| 20 A | Does not exceed 347 V | All luminaires, lampholders, and track lighting |
| 15 A | Exceeds 347 V | All luminaires, lampholders, and track lighting |
| 40 A | Does not exceed normal system voltage of 347/600 V | Luminaires and lampholders with mogul base type lamps |
| | Does not exceed 120 V | High-intensity discharge (HID) luminaires |
| | Does not exceed 240 V | Tungsten halogen luminaires with double-ended lampholders |
| | Does not exceed 120 V | Luminaires provided with integral overcurrent device rated at not more than 15 A |

### Rule 30-108 Overcurrent protection for arc lamp luminaires
An overcurrent device is to be provided for each arc lamp or series of lamps.

### Rule 30-110 Polarization of luminaires
The screwshell of a lamp can be touched by someone changing the lamp while it is energized and still connected to the screwshell of the lampholder. A shock hazard can exist if the screwshell of the lampholder has a voltage-to-ground. A shock can also occur under a fault condition in which the screwshell is not bonded to ground separately when supplied from an isolated (2-winding) type of transformer or ballast.

Rule 30-110 requires that screwshells of lampholders that are part of a luminaire be connected to the identified or grounded conductor of the electrical system supplying the luminaire. An exception is allowed when a luminaire is approved and has some means to prevent people from accidentally contacting bare live parts while inserting or removing lamps.

Where luminaires are supplied by 208 V, 240 V, 480 V, and 600 V branch circuits that do not incorporate an identified or grounded circuit conductor, an isolating (2-winding) type of transformer or ballast is to be used and the screwshells separately bonded to ground.

### Rule 30-112 Bonding of lighting equipment

Non-current-carrying metal parts of luminaires and associated electrical equipment under fault conditions can become a shock hazard to people contacting the lighting equipment. To avoid this hazard, Rule 30-112 requires that all non-current-carrying metal parts be bonded to ground as required in Section 10.

## Location of lighting equipment

### Rule 30-200 Near or over combustible material

Storing combustible material too close to certain types of luminaires creates a fire hazard. The stored materials can also restrict heat dissipation and limit access to, or otherwise interfere with the operation of, the integral switches of luminaires or lampholders.

Subrule 1) requires that luminaires installed where combustible material is likely to be stored be provided with shades or guards of a type that prevents the combustible material from being exposed to a temperature above 90 °C. Subrules 2) and 4) add further requirements for these luminaires by:

- not allowing them to have integral switches, which could ignite the combustible material due to arcing that occurs during operation [Subrule 2)]; and
- not allowing exposed insulated conductors since the insulation could break down causing a fire hazard [Subrule 4)].

Subrule 3) requires that each luminaire be controlled by an individual wall switch when it is installed over combustible material. An individual switch allows each luminaire to be turned off when it is not required, which reduces the fire hazard potential. Maintenance and repair work can also be done without the need to turn off other lights in the area, which would leave the area in complete darkness. However, when the luminaires are located at least 2.5 m above the floor or are located or guarded so that the lamp cannot be easily removed or damaged, a wall switch is allowed to control more than one luminaire.

### Rule 30-202 In show windows

Combustible merchandise is often displayed in show windows and showcases. Given the increased ambient temperature caused by the intensity of lighting used and the sunlight shining through the windows, special precautions are necessary so that any fault that occurs in a luminaire or lampholder does not allow hot particles to fall on combustible materials in the show windows.

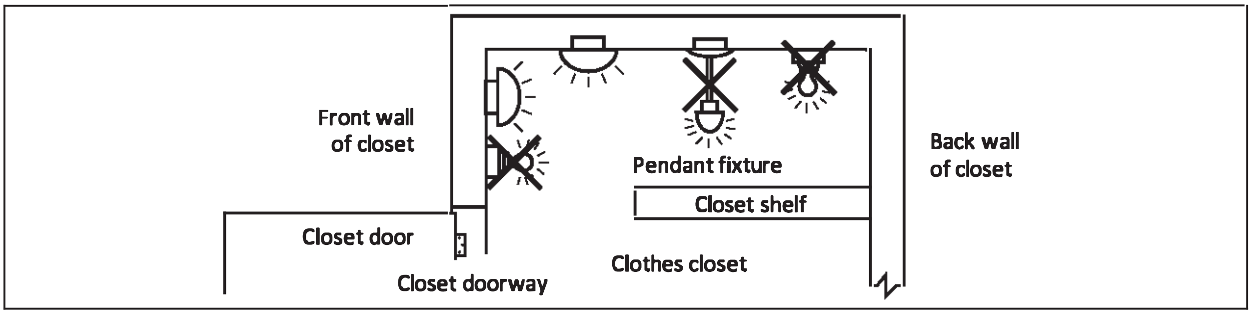
Recognizing the exposure of showcases to high heat and ultraviolet rays, Subrules 1) and 2) of Rule 30-202 require that all conductors and equipment wire, other than that used for chain suspension-type luminaires or cable lighting systems, be concealed and that lampholders not have a paper or fibre lining. Flexible cord and equipment wire supplying permanently installed luminaires in showcases is also to be concealed in suitable raceways or enclosures, in accordance with Subrule 3).

### Rule 30-204 In clothes closets

A fire hazard can be created if combustible material on the shelves of a clothes closet is piled too close to a closet lampholder or luminaire of the bare lamp type (i.e., a luminaire without a globe or enclosure surrounding the lamp). To avoid a fire hazard in a closet, Subrule 1) requires that luminaires installed in a clothes closet be located on the ceiling or on the front wall of the closet above the door. By not locating luminaires above a shelf, contact is avoided with combustibles that can be placed there (see Figure 30-2). When a luminaire is located on the trim or sidewall of the doorway, it is to be suitable for mounting in that location.

To prevent the lamp (heat source) from coming in contact with combustible materials that might be in the closet and thus creating a potential fire hazard, Subrule 2) requires that pendant, suspended, or bare lamp-type luminaires and lampholders not be located inside a clothes closet.

**Figure 30-2**
**Luminaires in clothes closet**




## Installation of lighting equipment

### Rule 30-302 Supports

Luminaires and lampholders are usually mounted on walls and ceilings. To prevent damage to the luminaire and lampholder, to protect people or items of property under the luminaire or lampholder, and to prevent potential fire hazards, Subrule 1) of Rule 30-302 requires that the connection of the luminaire to the insulated conductors of the building's electrical system and the attachment of the luminaire to the building's structure be adequate for the weight of the luminaire plus other forces that can be placed on the luminaire during the lifetime of its installation. These other forces include vibration, air movement, integral switching devices that control the luminaire, lamp changes, and accidental contact by people or objects. Luminaires come in many different shapes, dimensions, and weights, so it is necessary to specify different methods of support, according to the weight and dimensions of the luminaire.

Subrule 2) prohibits a luminaire that weighs more than 2.7 kg, or exceeds 400 mm in any dimension, from being supported by the screwshell of the lampholder. The lampholder screwshell is not designed to withstand such forces and might separate.

Subrule 3) requires that a wall-mounted luminaire that weighs 13 kg or less be supported directly on a wall outlet box attached to the building structure or by a wall outlet box attached to a bar hanger. This support is not to be attached only to wall coverings, sheeting, or cladding but is to go through the wall covering, sheeting, or cladding to be attached to the structural wall members.

Subrule 4) requires that a ceiling-mounted luminaire weighing 23 kg or less be supported on a ceiling outlet box attached directly to the building structure. A bar hanger is also allowed to be used to attach a ceiling outlet box to the building structure when the luminaire weighs 23 kg or less.

Subrule 5) requires that the wall-mounted luminaires weighing more than 13 kg or ceiling-mounted luminaires weighing more than 23 kg be supported independently of the outlet box or be supported by a suitable fixture hanger with an integral outlet box.

For the purposes of Rule 30-302, outlet boxes are defined as boxes that use 8/32 machine screws to attach luminaires, lampholders, covers, plaster rings, extension rings, etc. The 8/32 machine screws are usually installed in the outlet box when the outlet box is purchased. Device boxes are boxes that hold a device (for example, a switch, receptacle, fire alarm pull station, or cover) by means of 6/32 machine screws that come with the device, not with the device box, at the time of purchase.

Experience has shown that when PVC material softens, due to exposure to the higher temperature produced by luminaires, the posts or inserts holding the screws can loosen and fall out, causing the luminaire to drop. Some manufacturers have produced luminaires with an integral box made of a polymeric material other than PVC and with hubs designed to receive rigid PVC conduit, when rigid PVC conduit is the wiring method being used. Subrule 6) requires that only rigid PVC boxes that are marked as being suitable for the support of a luminaire be used to support a luminaire.

### Rule 30-304 Outlet boxes to be covered

Joints, splices, and connections of conductors are subject to failure (for example, through vibration, they can loosen and come apart, causing arcing or a short-circuit). They are therefore required to be contained in suitable enclosures to prevent any molten particles from igniting combustible material in the event of a failure. Rule 30-304 requires that an outlet box cover, luminaire-canopy, or other suitable device be used to maintain the integrity of an outlet box used with the luminaire.

### Rule 30-306 Wiring space

Subrule 1) of Rule 30-306 requires adequate space for insulated conductors and connections in a luminaire-canopy and outlet box to prevent mechanical damage during the electrical installation or maintenance of luminaires. Precautions are also necessary so that heat generated by the luminaire does not cause overheating of the conductors' insulation in the outlet box.

### Rule 30-308 Circuit connections

The connections between the luminaire's insulated conductors and the branch circuit's insulated conductors, as well as the bonding connections, are to be accessible for inspection. Subrule 1) requires that luminaires be installed so that the connections to the branch circuit and bonding connections can be inspected without disconnecting the wiring.

Removing a luminaire weighing more than 4.5 kg to inspect the connections is not practical. Subrule 2), therefore, requires that luminaires weighing more than 4.5 kg be installed so that the luminaire supports do not have to be removed to conduct the necessary inspection.

Branch circuit conductors that extend into a ballast compartment are subjected to the increased temperature generated by the ballast and are to be suitable for use at the temperature involved. Subrule 3) requires that the temperature rating of the insulation of insulated conductors within 75 mm of the ballast be a minimum of 90 °C.

Accidents and casualties involving electricians and other service people who perform maintenance on live fluorescent luminaire ballasts are frequently reported across the country. This is because of the highly disruptive nature of the power interruption to the fluorescent luminaires in the areas where they are working. To provide safe conditions for maintenance of fluorescent luminaires when the ballast is connected to circuits exceeding 150 volts-to-ground, Subrule 4) requires that the connection to each fluorescent luminaire utilizing double-ended lamps be made by one of the following methods:

- using mated separable wire connectors, which safely disconnect all conductors of the luminaire from branch circuit conductors simultaneously when separated;
- connecting the attachment plug of a luminaire equipped with an external power supply cord to a receptacle;
- connecting the female connector of an external cord to the male connector of a luminaire equipped with an integral inlet; or
- permanently connecting the branch circuit insulated conductors to the terminals of a luminaire through a disconnecting means that simultaneously opens all conductors supplying the ballast(s) or drivers when access to the ballast or driver compartment is made.

### Rule 30-310 Luminaire as a raceway

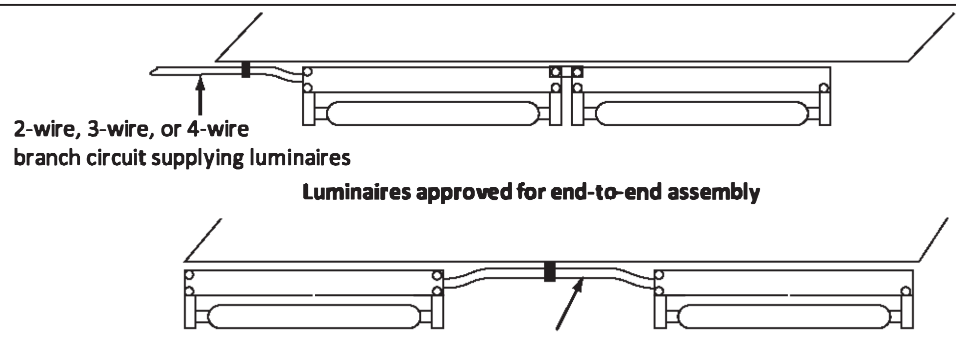
A luminaire is not necessarily designed to be used as a raceway, but Rule 30-310 provides for incorporating a raceway into the design of a luminaire (see Figure 30-3). The heat generated by the ballasts is to be considered when selecting the type of insulated conductor.

Subrule 1) requires that branch circuit insulated conductors be run only through those luminaires that have a raceway incorporated as part of the luminaire. An exception is luminaires that are marked suitable for continuous row mounting. The insulated conductors of a 2-wire, 3-wire, or 4-wire branch circuit supplying these luminaire types are allowed to be run through the luminaires.

Recognizing that ballasts inside the luminaires are a source of heat, Subrule 2) requires that the insulated conductors supplying these types:

- have a voltage rating not less than 600 V to guard against the higher voltage of the secondary of the ballast;
- have a temperature rating not less than 90 °C to guard against insulation deterioration due to high temperature; and
- be selected in accordance with:
  - Subrule 3) of Rule 12-102 for conductors run in raceways; and
  - Subrule 1) of Rule 12-402 for flexible cords that are suitable for use in the location (i.e., No. 14 AWG and larger) and do not extend beyond the luminaire in raceways that are longer than 2 m in length.

**Figure 30-3**
**Luminaires as a raceway**




### Rule 30-314 Minimum height of low luminaires

Lamp filaments or other live parts can be exposed when damage occurs to a luminaire, causing a shock or fire hazard. Subrule 1) requires that a readily accessible luminaire located less than 2.1 m above the floor be protected from mechanical damage, unless it is located where it is not subject to damage. Subrule 2) allows a short, flexible drop light or luminaire located less than 2.1 m above the floor to be used in place of a rigid luminaire, but it still requires mechanical protection for the luminaire.

### Rule 30-316 Luminaires exposed to flying objects

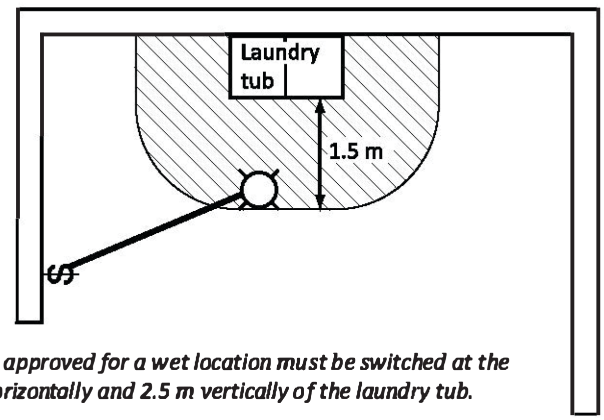
To prevent damage from flying objects (for example, basketballs), Rule 30-316 requires that luminaires installed in gymnasiums or similar locations have metal reflectors designed to protect the lamps or that they be protected by metal screens, armoured glass, or suitable plastic material. The reflectors or guards used are to be strong enough to withstand the impact of the objects used in the area. The reflectors or guards are not to obstruct ventilation of the luminaire.

### Rule 30-320 Lighting equipment in damp locations or near grounded metal

People run the risk of receiving a severe shock if they touch a faulty lampholder or luminaire while they are either in a damp location or in contact with grounded equipment or a grounded surface. Where an integral switch is used, take precautions to ensure that in the event of a fault, voltage is not transferred to the operating means of the switch.

Subrule 1) requires that luminaires in damp locations or near grounded equipment or surfaces be controlled by a wall switch (see Figure 30-4). Subrule 2) provides an exception that allows a luminaire marked for use in damp or wet locations to have an integral switch.

**Figure 30-4**
**Lighting equipment in damp locations**




**Note:** *A luminaire not approved for a wet location must be switched at the wall if within 1.5 m horizontally and 2.5 m vertically of the laundry tub.*

### Rule 30-322 Totally enclosed gasketted luminaires

Since totally enclosed gasketted luminaires can operate at higher temperatures than ventilated types of luminaires, they present a fire hazard when mounted on a combustible ceiling. Rule 30-322 requires that totally enclosed gasketted luminaires mounted on a ceiling of combustible material be of a type approved for the purpose and so marked.

## Wiring of lighting equipment

### Rule 30-404 Conductor insulation

Rule 30-404 requires that insulated conductors used for the connecting of luminaires be at least No. 18 AWG for mechanical strength and have insulation rated for at least the voltage involved and not less than the maximum operating temperature of the luminaire.

### Rule 30-406 Arrangement of exposed wiring on suspended luminaires

Special requirements are necessary for exposed wiring on suspended luminaires so that the wiring is not damaged by the weight of the luminaire or movable parts do not place excessive tension on the wiring or on the connections.

### Rule 30-408 Wiring of ceiling outlet boxes

The insulated conductors in ceiling outlet boxes are subjected to an increased operating temperature due to the additional heat from the luminaire mounted on the box. This can cause the conductor's insulation to deteriorate. Subrule 1) requires that all branch circuit insulated conductors installed in a ceiling outlet box on which a luminaire is, or might be, installed have insulation rated for at least 90 °C. An exception to the 90 °C insulation rating is allowed when the insulated conductors are installed in a box in a wet location and the cables used are types NMW or NMWU.

Subrule 2) requires that the maximum ampacity of these insulated conductors not exceed what is allowed for 60 °C insulated conductors. The purpose of this requirement is to reduce the heat from insulated conductors carrying the higher currents allowed at the higher insulation temperature ratings.

### Rule 30-410 Wiring of show window luminaires

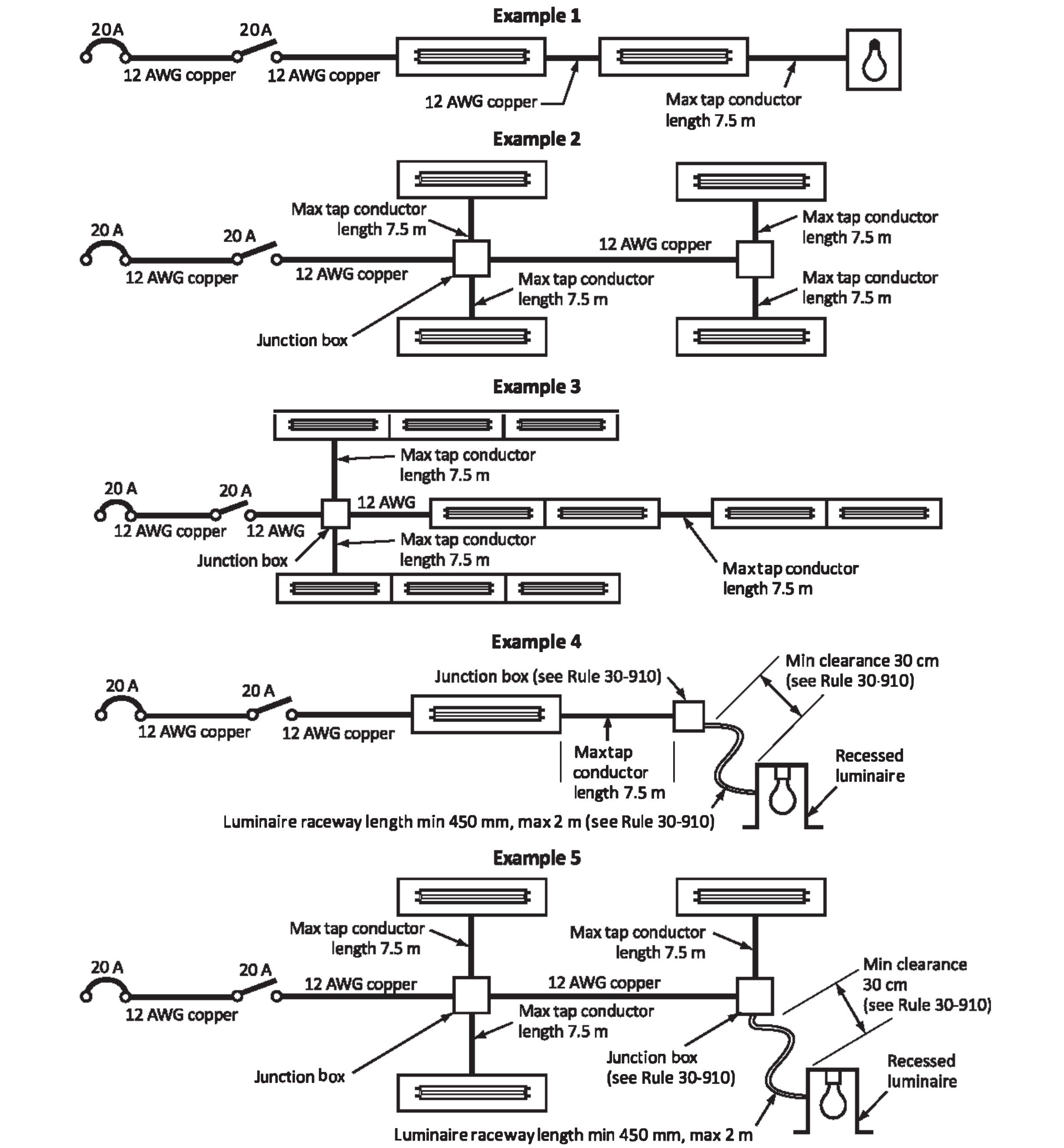
When luminaires are located close together to achieve high intensity lighting in a confined space, such as a show window, the operating temperature is dramatically increased. Consequently, select the insulated conductors in accordance with Subrule 1) of Rule 12-402, with a temperature rating of not less than 125 °C.

### Rule 30-412 Tap connection conductors

The conductors in any electrical system are normally reduced in size and ampacity the farther downstream they are from the power source. They are always to be large enough to safely carry the current required by the load they supply. Size reductions of insulated conductors in distribution systems usually occur in switchboards and panelboards or at splitters; generally, the upstream overcurrent device is too large to protect the smaller insulated conductor from overload or short-circuit. While the simplest solution is to provide a suitably sized fuse or circuit breaker ahead of the smaller conductor, this can be inconvenient or prohibitively expensive. In certain circumstances, the smaller conductor or tap can safely carry a fault current for the time it takes the overcurrent protective device to trip.

In lighting branch circuits, Rule 30-412 allows a copper insulated tap conductor to be sized no smaller than No. 14 AWG and to be used as a tap conductor from a 20 A branch circuit to feed single luminaires or end-to-end mounted luminaires. The No. 14 AWG insulated tap conductor is not to be longer than 7.5 m and the ampacity rating of the luminaire(s) connected to it are to be equal to or less than the rating of the insulated tap conductor. See Figure 30-5.

## Figure 30-5
## Examples of tap conductors




**Notes:**

1) *Where the fixture is used as a raceway, the maximum length of the tap conductor must include that portion inside the fixture.*
2) *Fixtures used as a raceway must conform to Rule 30-310 1).*
3) *The minimum tap conductor size is the larger of either No. 14 AWG or the size providing an ampacity not less than the rating of the luminaire(s) it serves.*

# Luminaires in buildings of residential occupancy

## Table 30-2
## Summary of lighting requirements

| Location | Lighting requirements |
|---|---|
| Lighting of entrances of residential occupancies<br>Rule 30-500 | – An exterior luminaire controlled by a wall switch located inside the building is required at every entrance |
| Luminaires in dwelling unit rooms such as kitchens, bedrooms, living rooms, utility rooms, dining rooms, bathrooms, water closet rooms, laundry rooms, vestibules, hallways, and finished basements<br>Rule 30-502 | – A luminaire controlled by a wall switch is required<br>– Bedrooms and living rooms are exempt from having a luminaire controlled by a wall switch if a receptacle controlled by a wall switch is provided<br>– The requirements of Rule 30-204 prohibit<br>– installing pendant or suspended types of luminaires in clothes closets<br>– using the bare lamp type of luminaires in clothes closets |
| Stairway lighting in residential occupancies<br>Subrule 1) of Rule 30-504 | – All stairways are to be illuminated for safety to prevent falls, accidents, etc. |
| Stairway lighting (other than basement stairs) in residential occupancies<br>Subrule 2) of Rule 30-504 | – When the stairway has four or more risers, the lighting is to be controlled by 3-way switches at the head and foot of the stairway |
| Basement stairway lighting in residential occupancies<br>Subrule 3) of Rule 30-504 | – Stairway lighting for basements or cellars that do not contain a finished area or room, or that lead to an outside entrance or built-in garage and that do not serve more than one dwelling unit, are allowed to be controlled by a single switch located at the head of the stairs |
| Unfinished basements in residential occupancies<br>Subrule 1) of Rule 30-506 | – One luminaire is required for each 30 $m^2$ (or fraction of 30 $m^2$) of floor area in unfinished basements |
| Unfinished basements in residential occupancies<br>Subrule 2) of Rule 30-506 | – The luminaire that is located nearest the basement stairs is to be controlled by a wall switch |
| Storage rooms in residential occupancies<br>Rule 30-508 | – One luminaire is required in each storage room |
| Garages and carports in residential occupancies<br>Rule 30-510 | – A luminaire is required in an attached, built-in, or detached garage or carport<br>– The luminaire is to be controlled by a wall switch near the doorway |

**Note:** *The requirements in Section 30 for the installation of lighting in a residential occupancy are harmonized with those of Part 9 of the* National Building Code of Canada. *Installers can consult Rules 30-500 to 30-510, as summarized in this Table, for assistance in complying with both the building and electrical codes. See Appendix G of the* Canadian Electrical Code *for the applicable clauses in the* National Building Code of Canada.

### Rule 30-500 Lighting equipment at entrances

Inadequate illumination is a safety issue in and around a residential occupancy. In order to ensure stable footing and prevent falls, adequate illumination is required. Outside lighting is considered a good burglar deterrent, and it assists the homeowner in determining that no one is lurking around the property. Rule 30-500 requires that illumination be provided at each entrance to a residential occupancy with a control inside the building.

### Rule 30-502 Luminaires in dwelling units

Rule 30-502 covers the general areas inside a dwelling unit: kitchens, bedrooms, living rooms, utility rooms, dining rooms, bathrooms, water closet rooms, laundry rooms, vestibules, and hallways. Subrule 1) requires that each of these areas have a luminaire controlled by a wall switch. Subrule 2) exempts bedrooms or living rooms from having a luminaire controlled by a wall switch if a receptacle controlled by a wall switch is provided.

The switch locations for luminaires are not to require the occupant to travel to the other end of the hallway or room to operate the switch. Similarly, where an area has multiple entrances, the use of 3- and 4-way switches enables the luminaires to operate independently at each entrance without the occupant having to move around in the dark looking for the switch.

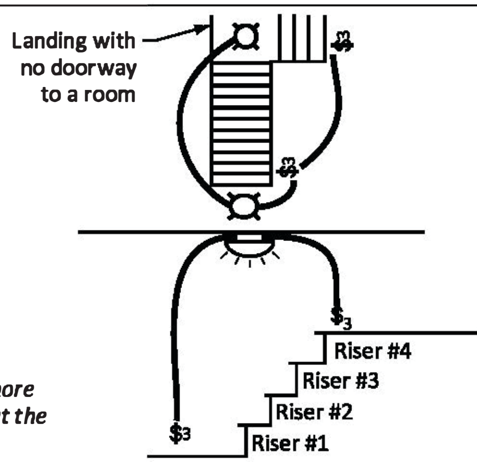
### Rule 30-504 Stairways

Illumination of stairs is necessary for safety. Subrule 1) requires that every stairway in a residential occupancy be illuminated. When the stairway has four or more risers, the lighting is to be controlled by 3-way wall switches located at the head and foot of the stairway in accordance with Subrule 2). See Figure 30-6.

Subrule 3) allows an exception for a 3-way wall switch at the foot of the stairs for basements that do not contain a finished area, do not lead to an outside entrance or built-in garage, and do not serve more than one dwelling unit. The lighting for such stairways is allowed to be controlled by a single switch located at the head of the stairs. The assumption is that people will not stay in the basement area since it is not finished, and since they cannot use another exit to leave.

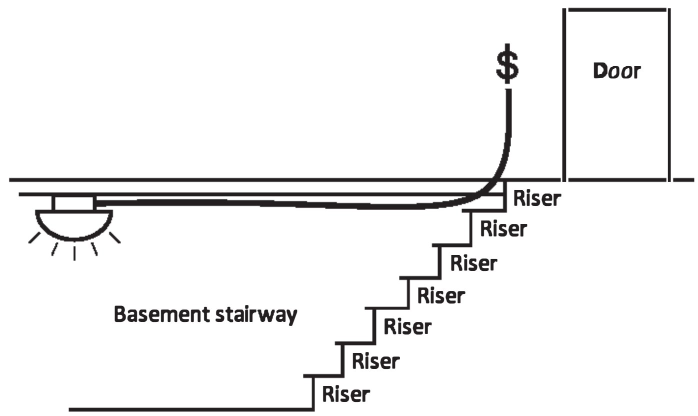
Basements are often finished after the original construction of a building. If provision for a 3-way switch is installed at the time the building is constructed, it simplifies the conversion from a single-pole to a 3-way switch. See Figure 30-7.

**Figure 30-6**
**Stairways**




**Note:** *Stairways with four or more risers require 3-way switches at the top and bottom of the stairs.*

**Figure 30-7**
**Basement stairways**




**Note:** *If the basement has a finished area, an exit to the outside or to a built-in garage, or leads to another dwelling unit, 3-way switches are required at the head and foot of the stairway.*

### Rule 30-506 Basements
Rule 30-506 provides requirements for basement lighting related to the basement floor area in unfinished basements (finished areas come under the requirements of Rule 30-502). A luminaire is to be provided for each 30 m² or fraction of 30 m² of floor area. The basement luminaire located nearest to the stairway is to be controlled by a wall switch located at the head of the stairs (see Rule 30-504).

### Example
An unfinished basement has a floor area of 66 m². What is the minimum number of luminaires required to illuminate the unfinished basement area?

Minimum number of luminaires = unfinished basement floor area, m²/30 (the maximum area for one luminaire)

= 66/30 = 2.2

Because any fraction in the result requires an additional luminaire, 3 luminaires are required.

### Rule 30-510 Garages and carports
Subrule 1) requires that luminaires be installed in garages and carports.

Subrule 2) requires that switches be located beside any door leading to the dwelling or to the outside. Luminaires mounted on a wall or located above an area not normally occupied by a parked vehicle, however, are allowed to have an integral switch.

Subrule 3) requires that the integral switch be accessible to an adult of average height.

Subrule 4) exempts the carport from having its own luminaire when the required luminaire at the dwelling unit entrance (see Rule 30-500) illuminates the carport.

## Lampholders

### Rule 30-600 Connections to lampholders
The screwshell of a lamp, as well as that of a lampholder, can be touched easily by someone changing lamps. In a grounded system, Rule 30-600 requires that the screwshell of a lampholder be connected to the identified/grounded insulated conductor to avoid a shock hazard.

### Rule 30-602 Switched lampholders used on unidentified circuits

When a lampholder is supplied from a 2-wire branch circuit in which both conductors are ungrounded, both conductors are to be disconnected by a double-pole switch that opens both conductors simultaneously. This prevents a shock hazard if someone touches the screwshell of the lamp or the lampholder.

### Rule 30-604 Luminaires with pull-type switch mechanisms

If a fault occurs in the integral switch of a lampholder, the pull-chain can become energized. Precautions are necessary to reduce the possibility of someone touching metal parts that can be energized as a result of a fault. This can be achieved by using insulating pull cords and insulating links in the metal chain or by the special design of the lampholder switching mechanism.

### Rule 30-608 Pendant lampholders

Pendant lampholders can be subject to considerable movement during normal use, and during insertion and removal of lamps. The cables on some pendant lampholders are designed and tested to be able to support the weight of the lampholder and the lamp and are to be able to withstand movement at the temperatures involved without damage.

Subrule 1) requires that pendant lampholders with permanently attached leads, for other than festoon wiring, be hung from separate stranded rubber- or thermoplastic-insulated cables connected directly to the branch circuit conductors. The cables supporting the lampholder are to be supported independently of the circuit conductors (for example, through the use of a strain relief device).

Subrule 2) requires that pendant cables used for mogul-base or medium-base screwshell lampholders be not smaller than No. 14 AWG in order to handle the mechanical and electrical stress of movement, weight, and temperature. An exemption from the minimum No. 14 AWG conductor size is given in Subrule 3), which allows pendant cables used for intermediate or candelabra-base lampholders to be not smaller than No. 18 AWG.

When pendant cables connected to the lampholder are longer than 900 mm, Subrule 4) requires them to be twisted together to provide greater strength to support the lampholder, as well as to keep the pendant cables together.

## Electric-discharge lighting systems operating at 1000 V or less

### Rule 30-702 Oil-filled transformers

Oil-filled transformers are subject to leakage and under certain conditions can create a fire hazard. They have restrictive installation requirements. Rule 30-702 requires that oil-filled transformers not be used for electric-discharge lighting systems operating at 1000 V or less.

### Rule 30-704 DC equipment

If a luminaire designed for ac connection is connected to a dc supply, overheating can occur, resulting in a fire hazard. Rule 30-704 requires that luminaires used on dc branch circuits be so marked.

### Rule 30-706 Voltages — Dwelling units

The occupants of dwelling units are not always aware of the hazards involved when changing lamps on luminaires with exposed live parts. A severe shock hazard can exist where the luminaire's open-circuit voltage exceeds 300 V in dwelling units. An exemption is allowed where there are no live parts exposed during the installation or removal of the lamps.

### Rule 30-708 Auxiliary equipment

The auxiliary electrical equipment for electric-discharge lighting equipment is a source of heat and can cause a fire if not properly installed. The secondary conductors are often energized at a voltage that is higher than the supply voltage. Precautions are therefore necessary to prevent a shock hazard as well as to ensure proper operation of the lamps.

### Rule 30-710 Control
Electric-discharge luminaires are an inductive load with a lagging power factor; therefore, the switches used are to be capable of interrupting this type of load.

### Rule 30-712 Branch circuit capacity
Using the ampere rating of the units to calculate the total load of a branch circuit supplying luminaires with ballasts and similar electrical equipment is more accurate than using the lamp wattage. A mutual heating effect exists between branch circuit conductors and overcurrent devices when placed in a panelboard; under certain conditions, this effect can cause premature operation of the overcurrent devices when they are loaded in excess of 80% of the rating.

## Electric-discharge lighting systems operating at more than 1000 V

### Rule 30-802 Voltages — Dwelling units
The occupants of a dwelling unit are not always aware of the shock hazards involved in the operation and maintenance of lighting systems in which the open-circuit voltage exceeds 1000 V. Rule 30-802 requires that the lighting systems operating at more than 1000 V not be installed in dwelling units.

### Rule 30-804 Control
In addition to ensuring that the switches are capable of interrupting the type of lighting load involved, it is important to ensure that the lighting equipment is not inadvertently energized while someone is servicing the electrical equipment. Subrule 1) requires that electric-discharge luminaires and lamp installations operating with electrical equipment having an open-circuit voltage of more than 1000 V be controlled either individually or in groups by an externally operated switch or circuit breaker that opens all ungrounded branch circuit conductors.

Subrule 2) requires that the switch or circuit breaker location be in sight of the luminaires or be capable of being locked in the open position.

Subrule 3) gives requirements for the switch that is used to control these luminaires.

### Rule 30-810 Transformers — Secondary connection
Subrule 1) allows for connecting the high voltage windings of transformers operating at more than 1000 V to form a midpoint-grounded transformer to limit the line to ground voltage to 7.5 kV to prevent insulation damage.

Subrule 2) requires that the grounded end (the midpoint) of the high-voltage windings be connected to the enclosure using an insulated stranded copper conductor not smaller than 14 AWG.

### Rule 30-814 Wiring method
A high-voltage conductor acts like one side of a capacitor. As the length of the conductor increases, particularly in a metal raceway, an excessive voltage can build up and break down the insulation of the conductor.

Rule 30-814 gives the installation requirements for the maximum length in a metallic and non-metallic raceway, as well as the type of cable to be used. These requirements are the same as the requirements in Section 34 for signs and outline lighting as neon supplies use luminous-tube sign cable.

### Rule 30-816 Transformer loading
The length and diameter of electric-discharge lamps affect the characteristics of the load. As the load on the high-leakage reactance type of transformer used for this type of lighting is increased, the secondary voltage increases. Therefore, overloading the transformer causes an overvoltage. Rule 30-816 requires that the lamps be designed in such lengths and diameters that they do not cause a continuous overvoltage on the transformer.

### Rule 30-818 Lamp supports
For safe and reliable operation, lamps need proper support. Rule 30-818 requires that lamps operating at more than 1000 V be supported on suitable insulating material that maintains sufficient clearance

between the lamps and grounded metal parts. For further details, see Section 34 and CAN/CSA-C22.2 No. 207.

## Recessed luminaires

### Rule 30-900 General

Because heat is not dissipated from recessed luminaires as rapidly as from other types of luminaires, higher operating temperatures result. This necessitates special installation methods to prevent hazards including the potential for the overheating of adjacent combustible materials.

### Rule 30-902 Spacings for Non-IC type luminaires

To avoid the overheating of combustible construction adjacent to the recessed luminaire, Rule 30-902 requires that every recessed luminaire enclosure marked "Type Non-IC" (not intended for insulation contact) be installed with at least 13 mm clearance from combustible material, except at the points of support. The mounting means and method of mounting are part of the certification of the recessed luminaire, and this information is to be provided with the installation instructions included with the recessed luminaire. Also, to prevent overheating of the recessed luminaire, Rule 30-902 also requires that it be at least 76 mm from thermal insulation.

### Rule 30-906 Luminaires designed for thermal insulation contact

Recessed luminaires can become overheated when blanketed with thermal insulation. However, recessed luminaires that have been designed and tested for safe operation when blanketed with thermal insulation are available. Some of the luminaires marked for this use include a thermal protective device to ensure that the maximum allowed temperature cannot be exceeded. These are marked "Type IC".

Other types for this use are marked "Type IC, inherently protected". These luminaires are allowed to be in contact with combustibles and insulation and are designed not to exceed the maximum allowable temperature under any conceivable condition, including overlamping and overinsulating. See Rule 30-002 for the definitions of the various types of recessed luminaires.

### Rule 30-908 Luminaires designed for non-combustible surfaces contact only

Where a recessed luminaire is marked for a specific purpose, Rule 30-908 intends to clarify the importance of such a marking, stressing that a recessed luminaire marked for installation on a non-combustible surface cannot be installed on a combustible surface. Since this type of recessed luminaire runs at a higher temperature than the other types of recessed luminaires, failure to comply with this requirement presents a fire hazard.

### Rule 30-910 Wiring of recessed luminaires

Heat is not dissipated from recessed luminaires as rapidly as from other types of luminaires, which results in a higher operating temperature. To provide for this, the insulation on the conductors is to be suitable for the temperature to which it is exposed, and the method of electrical installation is to allow heat to be dissipated along the high-temperature insulated conductors before the point at which they are connected to the branch circuit insulated conductors.

Subrule 1) requires that the insulation on conductors used for connecting recessed luminaires be rated for at least the temperature to which it is exposed. When the branch circuit insulated conductors meet this requirement, Subrule 2) allows them to be run directly to the recessed luminaire.

Subrule 3) intends that tap connection insulated conductors extend at least 450 mm, but not more than 2 m, to allow for heat dissipation from the recessed lampholder and to limit the length of the high-temperature equipment wire that is not designed to be field installed into raceways. Also, the conductors are to terminate in an outlet box located not less than 30 cm from the recessed luminaire, in accordance with Subrule 4).

The outlet box required by Subrule 3) is required by Subrule 4) to be mounted within 35 cm of the opening for the luminaire.

To access this outlet box through the opening for the recessed luminaire, Subrule 5) requires that the opening be at least a circle of 180 $cm^2$ (i.e., the area of a circle having a diameter of 15 cm), with no dimension smaller than 15 cm. See Figure 30-9.

When the recessed luminaire opening is smaller than 15 cm in any direction, Subrule 6) requires that access to the outlet box be through another opening that is not less than a square or rectangle of 400 $cm^2$ (i.e., the area of a 20 cm square or a 22 cm diameter circle) with no dimension less than 20 cm.

When the supply connection box (the outlet box) is an integral (built-in) part of the luminaire, Subrule 7) requires that the box be:

- accessible in accordance with Rule 12-3014; and
- accessed through the opening for the luminaire.

The recessed luminaire in this application is to meet the following requirements:

- the electrical components of the luminaire are to be capable of being removed through the opening for service;
- the components are to include ballasts, transformers, thermal protectors, and conductor connections in the supply connection box; and
- the cover of the supply connection box is to be capable of removal by hand tool, held below the ceiling.

Subrule 8) requires that the supply connection box that is an integral part of the recessed luminaire not have insulated branch circuit conductors pass directly through the junction box due to accessibility unless the luminaire is marked as suitable for the purpose.

### Rule 30-912 Wiring of recessed fluorescent luminaires

When recessed fluorescent luminaires are installed in a suspended ceiling that creates a plenum or hollow space, wiring to the luminaire is not required to meet the requirement of Subrule 3) of Rule 12-010 provided that:

- the luminaire is supplied by a flexible cord not exceeding 3 m in length and terminated with an attachment plug;
- the flexible cord is rated for at least 90 °C; and
- the flexible cord is selected in accordance with Subrule 1) of Rule 12-402 for:
  - hard usage where the supply voltage does not exceed 300 V; or
  - extra-hard usage where the supply voltage does not exceed 750 V.

**Figure 30-8**
**Access to branch circuit connections**

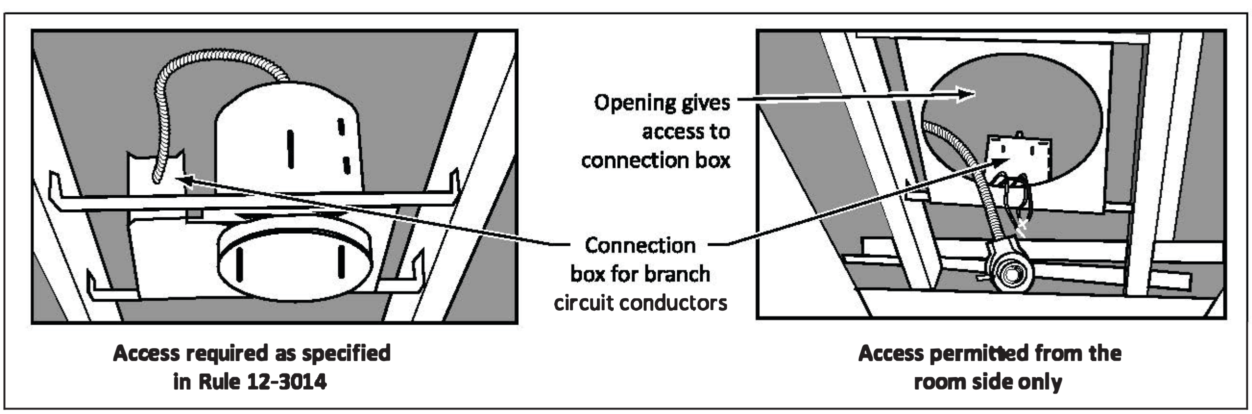
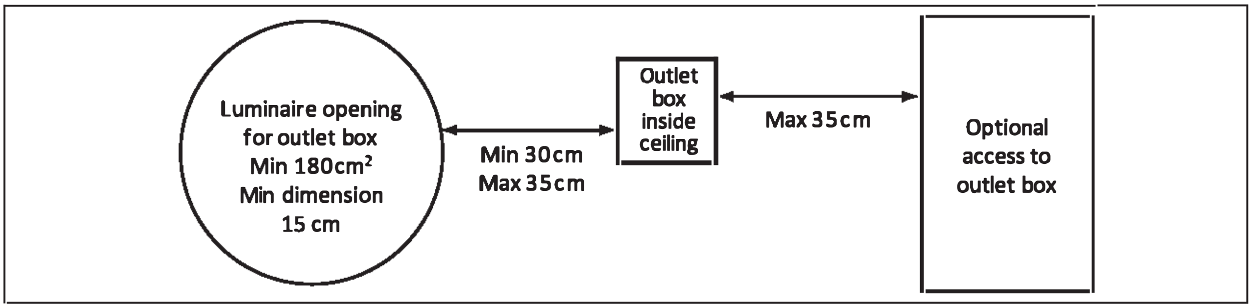


**Figure 30-9**
**Wiring of recessed luminaires — Access to outlet box**




## Permanent outdoor floodlighting installations

### Rule 30-1000 General

Where lighting equipment is located outside a building, the potential for a fire hazard is not as serious as indoors; consequently, some of the general Rules for lighting equipment can be relaxed. Rules 30-1002 to 30-1030 apply to the installation of permanent outdoor floodlights when protection of the electrical installation and prevention of electric shock are the primary concerns and the possibility of a fire hazard is a secondary concern.

### Rule 30-1002 Service equipment

Service equipment for outdoor floodlighting installations is similar to that for other electrical installations, and the same installation requirements apply.

### Rule 30-1004 Wiring methods — Underground

Special requirements are necessary for the wiring method and type of conductors when wiring is run underground. Subrule 1) requires that wiring underground be run:

- in rigid steel or rigid aluminum conduit;
- in non-metallic underground conduit;
- in mineral-insulated cable, aluminum-sheathed cable, or copper-sheathed cable; or
- as cable selected in accordance with Rule 12-102 3) as being suitable for direct earth burial. Where a deviation under Rule 2-030 has been granted, cables selected in accordance with Rule 12-102 3) for service entrance below ground are allowed.

Subrule 2) requires that insulated conductors installed in conduit be selected in accordance with Rule 12-102 3) as being suitable for use in wet locations.

Subrule 3) requires that cables buried directly in the earth be installed in accordance with Rule 12-012.

Subrule 4) requires that suitable corrosion-resistant protection be provided for aluminum-sheathed cable, aluminum conduit, copper-sheathed cable, and also for mineral-insulated cable if used where materials that contact the cable can have a deteriorating effect on the sheath.

### Rule 30-1006 Wiring methods on poles

Provisions are necessary to allow workers to climb poles to service and re-lamp floodlights without risk of contacting exposed live parts. Subrule 1) requires that all the electrical wiring and electrical equipment on the pole be controlled by a switch that can be locked in the OFF position. A sign is to be posted on the pole to warn people not to climb the pole until the switch is off or unless all insulated conductors and live parts, except pole-top wiring, are guarded in one of the following ways:

- the insulated conductors are run in rigid or flexible metal conduit, or as mineral-insulated cable, or are run up the centre of steel, aluminum, or hollow concrete poles;
- the insulated conductors, cables and live parts are kept at least 1 m from the climbing steps or ladder; or

- barriers are provided between the ladder and the insulated conductors or live parts to prevent the likelihood of contact by the climber.

Subrule 2) requires that insulated conductors and cables running up the centre of poles be supported to prevent damage to the insulated conductors or cables inside the pole and to prevent undue strain where they leave the pole.

Insulated conductors, cables, and grounding conductors are to be equipped with a covering that provides mechanical protection when run vertically within 2.5 m of locations accessible to unauthorized personnel, in accordance with Subrule 3).

When the grounding conductors from lightning arresters are installed on wood poles, Subrule 4) requires that the protective covering specified in Subrule 3) be wood moulding or other insulating material of equivalent protection to reduce the shock hazard when a lightning arrester is conducting energy.

### Rule 30-1008 Disconnecting means at individual poles

On individual poles with no more than two fuses on a single-phase and three fuses on a three-phase system, Rule 30-1008 does not require a disconnecting means ahead of the inline fuseholder on individual poles when the:

- fuseholder is a weatherproof type;
- fuseholder has load-breaking capability;
- maximum number on any one pole is two on a single-phase system and three on a three-phase system;
- fuseholder is constructed and connected so that in the open position, there are no exposed live fuse parts; and
- load is connected between the live insulated conductor and the identified insulated conductor to prevent a shock hazard from a backfeed.

### Rule 30-1010 Overcurrent protection of pole-top branch circuits

Overcurrent protection for outdoor floodlighting installations can be much larger than that normally allowed for indoor lighting equipment. For this type of lighting, the fire hazard is a secondary concern and the overcurrent protection is required only in the event of a severe fault, rather than for the protection of the individual luminaires and their supply conductors. For this reason, Rule 30-1010 allows pole-top branch circuits to be provided with overcurrent protection rated or set at not more than 100 A.

### Rule 30-1012 Pole-top branch circuit wiring

Where the wiring method used does not provide protection from contact with live parts, other provisions are necessary to allow workers to climb the poles without risk of contact with exposed live parts. With the exception of the floodlight luminaire leads, Rule 30-1012 requires that the pole-top branch circuit wiring:

- be run as lead-sheathed cable, or as rubber- or thermoplastic-insulated moisture-resistant types of insulated conductors installed in rigid conduit;
- be mineral-insulated cable, copper-sheathed cable, or aluminum-sheathed cable; or
- when a deviation has been allowed under Rule 2-030, be run as insulated or uninsulated exposed wiring, provided that:
  - the wiring is supported on suitable insulators;
  - the wiring is controlled by a switch that can be locked in the OFF position; and
  - a prominent sign is posted on the pole to warn against climbing the pole until the switch is off.

### Rule 30-1014 Joints

Joints and splices are also to be accessible for maintenance and inspection. Therefore, Subrule 1) allows exposed taps and joints to be made at pole-top, provided that the joint or tap is given insulation equivalent to that of the insulated conductors to prevent a shock hazard.

Subrule 2) does not allow joints and splices to be concealed within conduit runs, as the joints and splices are not accessible for maintenance and inspection.

### Rule 30-1016 Location of transformers

Transformers are to be located so that exposed live parts are accessible only to authorized personnel. When transformers are mounted on floodlight poles, Item a) requires that all live parts be guarded as specified in Rule 30-1006. When they are located on poles, the bottom of the transformer is to be at least 5 m above locations accessible to unauthorized personnel [see Item b)]. When transformers are located on platforms on the ground, Item c) requires that they be completely enclosed to prevent access by unauthorized personnel or that they be surrounded by a fence that complies with the requirements of Rules 26-300 to 26-324.

### Rule 30-1018 Overcurrent protection of transformers

Overcurrent protection of transformers is necessary to protect transformers against the possibility of damage and faults, as well as to reduce the fire hazard in the event of a fault. Rule 30-1018 requires that overcurrent protection be provided for transformers as specified in Section 26.

### Rule 30-1020 Switching of floodlights

The requirements for switches controlling a floodlighting installation as set out in Rule 30-1020 are:

- when installed on the primary side of a transformer feeding a floodlighting installation, the switch is to be capable of making and interrupting the full load on the transformer to prevent damage to the switch when being operated;
- when installed on the secondary side of a transformer feeding a floodlighting installation, the switch is to have a minimum current rating not less than 125% of the ampacity of the floodlighting being controlled;
- the switch is to be capable of being operated without exposing the operator of the switch to the danger of exposed live parts by operating them by remote means or by the use of guarding; and
- the switch is to be lockable in the OFF position to prevent the floodlighting installation from being energized when work is being done on the installation or for unauthorized uses.

### Rule 30-1022 Grounding of circuits

Grounding is required to limit the voltage-to-ground and to reduce the possibility of accidents in the event of lightning and some types of electrical equipment failure. Subrule 1) requires that branch circuits supplying permanent outdoor floodlighting installations be supplied from a solidly grounded system.

Subrule 2) allows an exemption from Subrule 1), when the floodlighting circuits are operating at voltages above 300 V and supplied from an ungrounded or impedance grounded system.

Subrule 3) allows the grounded circuit conductors of a floodlight installation when solidly grounded in accordance with Subrule 1) to be connected to the grounded circuit conductor that is used to connect to the solidly grounded system to the grounding electrode.

### Rule 30-1024 Bonding of non-current-carrying metal parts

To prevent shock hazards, Subrule 1) requires that all exposed non-current carrying metal parts of electrical equipment and exposed metal parts of non-electrical equipment of permanent outdoor floodlighting installations be bonded to ground when they are located within 2.5 m of finished grade or in locations where unauthorized persons can stand and contact the non-current carrying metal parts. The separate bonding conductor is to be sized using Rule 10-614.

To create an equipotential plane so that the possibility of a potential difference between metal parts is minimized, Subrule 2) requires that all non-current carrying metal parts of electrical permanent outdoor floodlighting equipment installed at the top of a pole be bonded together. Also when the metal parts are within reach of any grounded metal at the pole, they are to be grounded. Subrule 2) also exempts isolated metal parts, such as crossarm braces, bolts, insulator pins, and the like at the top of the pole from the bonding requirement.

### Rule 30-1026 Material for grounding and bonding conductors

The material used for grounding conductors is to be suitable for the purpose. Rule 30-1026 requires that a system grounding conductor be an insulated or bare copper, aluminum, or other acceptable material, as specified in Rule 10-112. The material for conductors used for bonding electrical equipment is to be as specified in Rule 10-610.

### Rule 30-1028 Installation of lightning arresters

Lightning protection for floodlighting installations can be provided by using methods similar to those used for other electrical installations. When lightning arresters are installed, Rule 30-1028 requires that they be installed as specified in Rule 10-108. A common grounding conductor and one grounding electrode is allowed to be used for grounding the primary and secondary neutral conductors as well as the lightning arresters.

### Rule 30-1030 Climbing steps

Permanent climbing steps are required for maintenance purposes but are not to be located so close to the ground that unauthorized personnel are tempted to climb the poles. When it is necessary to climb the pole to replace lamps, Rule 30-1030 requires that permanent climbing steps be provided, but the lowest permanent step is not to be located less than 3.7 m above any location accessible to unauthorized personnel.

## Exposed wiring for permanent outdoor lighting

### Rule 30-1102 Conductors

Insulated conductors are to be suitable for the environmental conditions involved. Rule 30-1102 requires that the conductors be stranded copper not smaller than No. 12 AWG to allow for movement and the increased mechanical strength required for use in this application. The insulated conductors are to be one of the following, as applicable:

- suitable for exposed wiring where it is exposed to the weather in accordance with Rule 12-102 3);
- a rubber-insulated type suitable for exposed wiring where exposed to the weather in accordance with Rule 12-102 3), when lampholders are of a type that punctures the insulation and makes contact with the insulated conductors; or
- a moisture-resistant rubber-insulated type suitable for exposed wiring where it is exposed to the weather in accordance with Rule 12-102 3), if cabled together and used with messenger cables.

### Rule 30-1104 Use of insulators

Suitable support is necessary to carry the weight of conductors and lampholders as well as to insulate the conductors from conducting surfaces.

### Rule 30-1106 Height of conductors

Insulated conductors, cables, and lamps are to be located at a reasonable height above grade to prevent damage to the electrical installation. Rule 30-1106 requires that the lowest part of the insulated conductors, cables, and the lamps in parking lots, used car lots, drive-in establishments, and similar commercial areas be maintained at least 4 m above grade. When the insulated conductors, cables, or lamps are above a thoroughfare or driveway, increase this clearance to at least 5 m due to the varying height of vehicles.

### Rule 30-1108 Spacing from combustible material

Rule 30-1108 gives the requirements for insulated conductor and lampholder clearances from combustible material as it is necessary to reduce the risk a fire hazard from the heat of the lamps or under fault conditions.

### Rule 30-1110 Spacing of conductors

Spacing between insulated conductors is necessary to prevent abrasion and subsequent damage, unless the insulated conductors are secured to and supported by a messenger cable.

### Rule 30-1112 Lampholders

Lampholders need to be designed for exposure to the weather and be connected in a way that provides safe and satisfactory operation. Subrules 1) and 2) of Rule 30-1112 require that the lampholders be a weatherproof type that have permanently attached leads or that have terminals of a type that punctures the insulation to make contact with the insulated conductors. When a cable assembly is used, Subrule 3) requires that lampholders with permanently attached leads have the connections to the branch circuit conductors staggered to minimize the potential of shorting between two connection points.

### Rule 30-1114 Protection of lampholders

Overcurrent protection is required for protection of the lampholders in the event of a fault. The setting of the overcurrent protection is allowed to be higher than that for equivalent lampholders located indoors where the possibility of a fire hazard exists. Rule 30-1114 states that unswitched-type lampholders rated for at least 660 W and used for incandescent lamps are allowed to be connected to branch circuits protected by overcurrent devices rated or set at not more than 30 A. This is an exception to the 15 A and 20 A limitations of Rule 30-104. Since the lampholders are located outdoors, the buildup of heat is less likely.

### Rule 30-1116 Use of messenger cables

Additional means are necessary to support the weight of the insulated conductors and the lampholders with permanently attached leads and to eliminate sag when the span exceeds 12 m. The additional support is also necessary to reduce the movement of the assembly when the lampholder terminals puncture the insulation.

Subrules 2) and 3) require the messenger cable to be securely attached at each end, grounded in accordance with Section 10, and have the insulated conductors feeding the lampholders permanently attached.

### Rule 30-1118 Construction of messenger cables

The messenger cables are to have sufficient mechanical strength to carry the weight of the insulated conductors, the lampholders, and extra loading due to ice and wind loads at the desired sag. Subrules 1) and 2) require that messenger cables be made of galvanized steel with a coating of not less than 45 g/m$^2$, copper-coated steel, or stainless steel and be of stranded construction with no fewer than 7 strands. The messenger cables are to have an actual strength that is not less than 3 times the calculated maximum working load, including ice loading and wind loading, but in no case are the individual strands allowed to be less than 1.17 mm in diameter for galvanized or copper-coated wire or less than 1.11 mm in diameter for stainless steel wire, in accordance with Subrule 3).

### Rule 30-1120 Branch circuit loading and protection

Overcurrent protection is required to safeguard lampholders in the event of a fault. The total load on a branch circuit is to be limited to reduce any excess heating that the mutual heating effect of the branch circuit conductors can produce. Overcurrent devices in a panelboard can prematurely trip when exposed to excess heat from the connected branch circuit conductors.

## Extra-low-voltage lighting systems

### Rule 30-1200 Rules for extra-low-voltage lighting systems

Rules 30-1202 to 30-1208 give the requirements for extra-low-voltage (30 V or less) lighting systems.

### Rule 30-1202 Sources of supply

Extra-low-lighting systems supplied from branch circuits with voltage ratings at values 150 volts-to-ground or less could pose a shock hazard if the electrical insulation intended to prevent this hazard fails. Isolated systems offer protection from electric shock as they have no reference to ground. There is no direct connection from the primary to the secondary windings of the isolation transformer. The electrical shock hazard is further prevented in that faults occurring outside the isolated 30 V system do not have a grounding path to follow to the 30 V system, as those conductors are not permitted to be grounded. Also, by not grounding the isolation transformer secondary, the voltage-to-ground is only one-half of the secondary voltage (for example, 15 V for a 30 V secondary).

### Rule 30-1204 Installation of landscape lighting systems

Extra-low-voltage lighting systems are exempt from Rule 12-402 3), which prohibits the permanent attachment of flexible cords to structural members, due to the reduced potential of a shock hazard when using extra-low-voltage lighting systems.

### Rule 30-1206 Installation of cable lighting systems

Since bare or insulated conductors can be used on the extra-low-voltage portion of cable lighting systems, Rule 30-1206 requires that, to prevent shock hazards, cable lighting systems not be installed in bathrooms. They are, however, allowed in dry locations. To eliminate any fire and shock hazards, the cables of the extra-low-voltage portion are to be installed according to the specified criteria in Rule 30-1206.

The cables that are part of extra-low-voltage circuits are part of an approved system. The manufacturer provides the requirements for the minimum spacing and the support of the cables. Requirements for cable spacing are detailed in the manufacturer's instructions supplied as part of a certified system.

### Rule 30-1208 Installation of cabinet and undercabinet lighting systems

Cabinet and undercabinet lighting systems are supplied as a complete system, including a Class 2 power supply, luminaires, wiring harness, and connectors, and are intended for surface or recessed mounting under a shelf or similar structure or in an open or closed cabinet. The wiring methods specified in Section 12 for flexible cords cannot be strictly applied to these installations. Rule 30-1208 recognizes the unique wiring method required by cabinet and undercabinet lighting systems and therefore relaxes the limitations placed on flexible cords in Rule 12-402 3). Rule 30-1208 also recognizes that the Class 2 power supply does not present a fire or shock hazard and that connections can be made outside an outlet box, provided that they are not subject to damage from equipment normally found in a cupboard or on a kitchen counter. (See Rule 16-200 for more information on Class 2 circuits.)

# Section 32 — Fire alarm systems, smoke and carbon monoxide alarms, and fire pumps

## Rule 32-000 Scope

Section 32 includes additional and specific requirements for the installation of fire alarm systems, permanently connected smoke and carbon monoxide alarms, and fire pumps as specified by the *National Building Code of Canada*. Section 32 does not specify where and when fire alarm systems, smoke and carbon monoxide alarms, and fire pumps are to be provided, as these requirements are mandated by the *National Building Code of Canada*. However, Section 32 specifies how the various pieces of approved equipment are to be connected electrically, describes acceptable wiring methods, and lists the appropriate size and type of conductors. The Rules are intended to prevent fire or shock hazards and to ensure that the fire alarm system equipment covered by this Section is installed in accordance with installation standard CAN/ULC-SS24 and that fire pumps are installed in conformance with NFPA 20. As the Appendix B Note to Rule 32-000 indicates, consult CAN/ULC-S524 for further information on the installation of fire alarm systems and NFPA 20 for further information on the installation of fire pumps.

Subrule 2) notes that Section 32 supplements and in some cases amends other general provisions of the Code. For example, the Section 12 requirements for wiring methods also apply to fire alarm systems, unless Section 32 specifically modifies the Section 12 requirements.

Every fire alarm system required by the *National Building Code of Canada* is subject to the provisions of Section 32. For instance, the *National Building Code of Canada* requires that fire alarm systems installed in high buildings to be provided with a two-way voice communication capability (for example, emergency telephones) and loudspeakers. Although the *National Building Code of Canada* refers to this as a voice communication system, this voice communication system is an integral part of the required fire alarm system; it is not considered an electrical communication system, as covered by Section 60. Such voice communication systems are to be installed in accordance with CAN/ULC-S524 and wired in conformance with Section 32.

## Fire alarm systems

A complete fire alarm system may consist of the following components:

- manual and automatic alarm-initiating devices, which activate the fire alarm system when an incendiary situation occurs;
- audible (and visual where required by the *National Building Code of Canada*) signal devices, which are intended to warn building occupants that a fire has possibly broken out and that evacuation of the building is or could be required;
- a control unit, which consists of a central processing unit (CPU) for alarm-initiating device circuits, signal circuits, and ancillary or auxiliary functions;
- an annunciator panel, which indicates to firefighters, supervisors, and maintenance personnel the location of the fire or trouble;
- a central alarm and control facility (CACF), which activates auxiliary functions such as the operation of smoke control and smoke venting and the operation of the voice communication system; and
- end-of-line devices, for electrical supervision (see Figure 32-1 and Handbook Commentary on Rule 32-106).

## Rule 32-100 Conductors

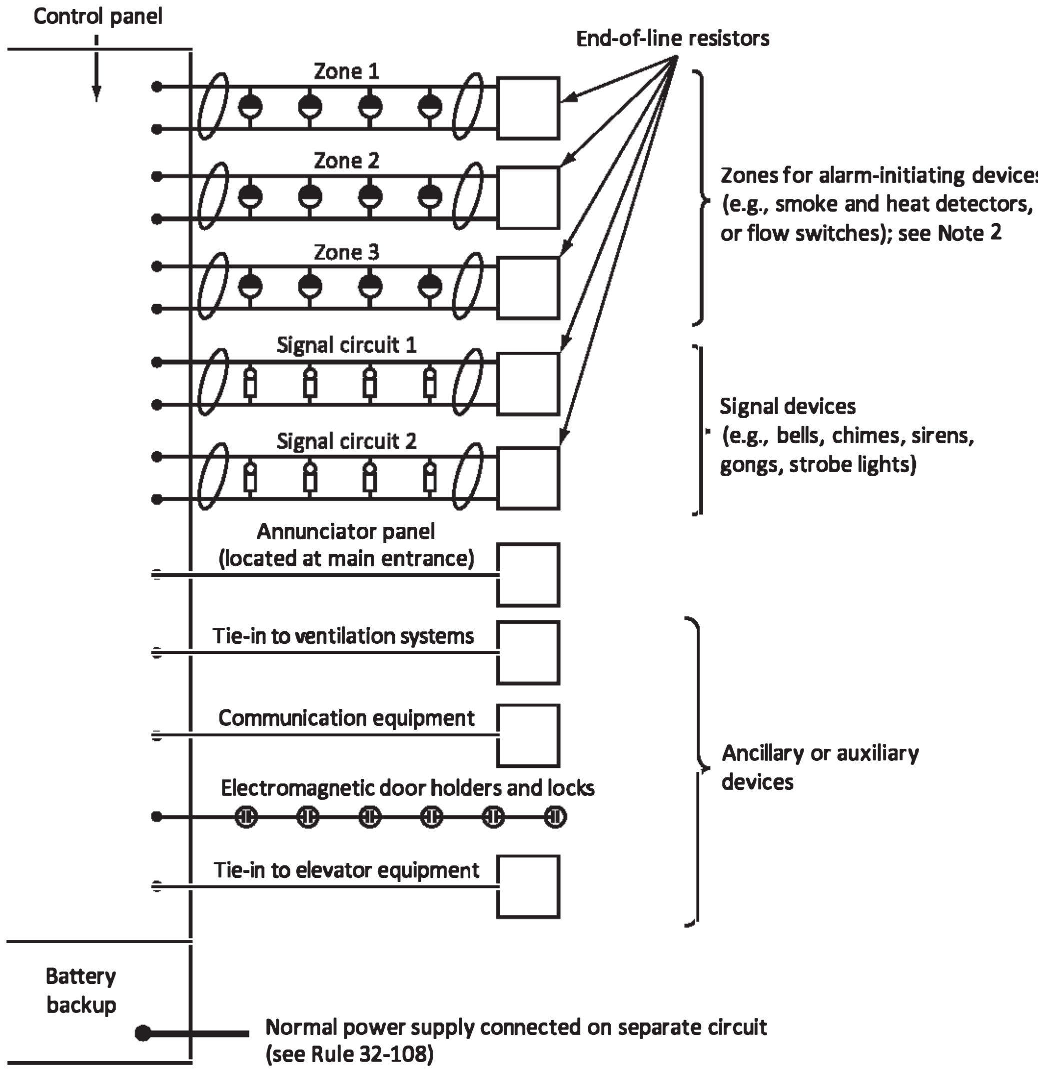
Conductors are to be reliable and adequate for the purpose of fire alarm systems. Fire alarm systems range from simple, single-zone systems to highly sophisticated addressable systems, in which an actuated device sends a signal to the control unit indicating the exact address/location of the fire initiating signal. When selecting the type of conductor or cable to be used (for example, shielded or non-shielded, twisted pairs or individual conductors pulled or laid in a raceway, minimum size, length restrictions), consult the system manufacturer for recommendations.

Fire alarm system conductors carry signals using a small amount of current (typically less than 20 A) at a voltage level of 30 V or less. Subrule 1) requires that conductors be made of copper as the conductors are usually smaller than No. 14 AWG. This ensures that they are capable of carrying the signals required by the fire alarm system, taking into consideration voltage drop over long runs of conductor, flexibility, and provides low-impedance terminations.

Fiber-optic communication is a method of transmitting information from one place to another by sending pulses of light through an optical fiber. The optical fibers transmit modulated light patterns that are encoded and decoded by terminal equipment. They do not transmit electrical voltages or currents, nor are they affected by electrical contact or induction. Subrule 2) allows the use of optical fiber cables to transmit signals between control units and transponders of a fire alarm system as described in CAN/ULC-S524.

Proper termination of the conductors is important, especially where stranded conductors are used. A conductor connected by a single fine strand might be capable of carrying the current used for the supervisory signal, but when the system is activated, the conductor has to carry a higher current. The strand can burn off, reducing the effectiveness of the system. The requirements of Subrule 3) address the fact that strands not properly confined at their termination point can come in contact with other conductors or termination points, causing incorrect operation of the system.

## Figure 32-1
## Components of a typical fire alarm system




**Notes:**

**1)** *End-of-line resistors are located in a separate box, visible from the floor, after the last signal or alarm-initiating device or are located in the control panel.*

**2)** *Flow switches, smoke detectors, and heat detectors cannot be in the same zone with other detectors.*

Subrule 4) stipulates minimum sizes for conductors, depending on the installation method used. In addition to carrying an electrical current, the conductors are to have sufficient strength to withstand, without damage, the forces normally applied during installation and periodic testing. Conductors that are laid, rather than pulled, into a raceway are allowed to be slightly smaller. Similarly, if a number of conductors are bundled into a cable assembly, smaller individual conductors are allowed since the assembly provides the additional strength needed to withstand the stress of being pulled into a raceway.

Subrule 5) requires that the insulation on the conductors be suitable for the application, environment, and system voltage, and be selected in accordance with Rule 12-102 3) for conductors No. 14 AWG and larger, and Rule 12-122 1) for conductors smaller than No. 14 AWG.

## Rule 32-102 Wiring method

A fire alarm system is part of a building's life safety system. The conductors of the fire alarm system are to have sufficient sizing and installation methods to ensure the system can effectively detect potential fires and warn people when necessary. Subrule 1) requires that the fire alarm conductors be

- installed in a metal raceway of the totally enclosed type;
- incorporated in a cable having a metal armour or sheath;
- installed in rigid non-metallic conduit; or
- installed in electrical non-metallic tubing only when the tubing is encased or embedded in at least 50 mm of masonry or poured concrete.

Subrule 2) allows an exception to these requirements for buildings of combustible construction, which, in accordance with the *National Building Code of Canada*, are smaller buildings. In such buildings, non-metallic sheathed cable is allowed to be used, provided that the combustible jacket of this cable is marked FT1 for flame spread rating.

Subrule 3) requires that fire alarm conductors be kept independent of all other wiring and electrical equipment, except where connections are made to

- the electrical supply for the system;
- signal devices or systems;
- ancillary devices that minimize the spread of fire and damage (for example, magnetic door holders for fire doors, intake fan shutdowns), facilitate safe evacuation (for example, activation of emergency lighting, elevator recall), and contact the fire department or monitoring company; and
- communication circuits connected to a central monitoring system conforming to ULC 5561 for transmission of alarm signals to the fire department.

The separation of fire alarm system conductors minimizes the possibility of a fault involving other circuits and equipment adversely affecting the operation of the fire alarm system.

Conductors used as part of a fire alarm system to transmit signals to the central monitoring station are considered to be communication conductors. Subrule 4) states that the installation requirements of Section 60 apply only where such conductors extend beyond the building. For example, when the fire alarm system notifies the fire department that a signal has been initiated, the conductors and wiring methods used between the fire alarm control unit and the transmitter (for example, an automatic dialer) are to conform to Section 32. However, conductors between the transmitter and the central monitoring station (in addition to being communication conductors in accordance with Section 60) are part of communication channels in accordance with ULC S561. The provisions of ULC 5561 are to be consulted for selection of communication lines between a transmitter and a central monitoring station.

Since different circuits in a fire alarm system can have different voltage characteristics, Subrule 5) requires that the conductors in a raceway or cable be insulated for the highest voltage present on any of the conductors in the raceway or cable. This prevents electrical energy from the conductors of one circuit affecting the conductors of another circuit creating operational problems.

## Rule 32-104 Equipment bonding

To eliminate shock hazards and circulating ground currents, and to ensure the intended operation of a fire alarm system by recognizing ground faults and providing necessary trouble signals, Subrule 1) requires that all non-current-carrying metal parts be bonded to ground. If the conductors are installed in a metal raceway or a cable having a metal armour or sheath, it is simple to provide this bonding. However, if a non-metallic wiring system is used (for example, a cable with a non-metallic sheath or conductors installed in rigid non-metallic conduit), Subrule 2) requires that a separate bonding conductor, sized in accordance with Rule 10-614 1), be provided in the cable or conduit.

### Rule 32-106 Electrical supervision

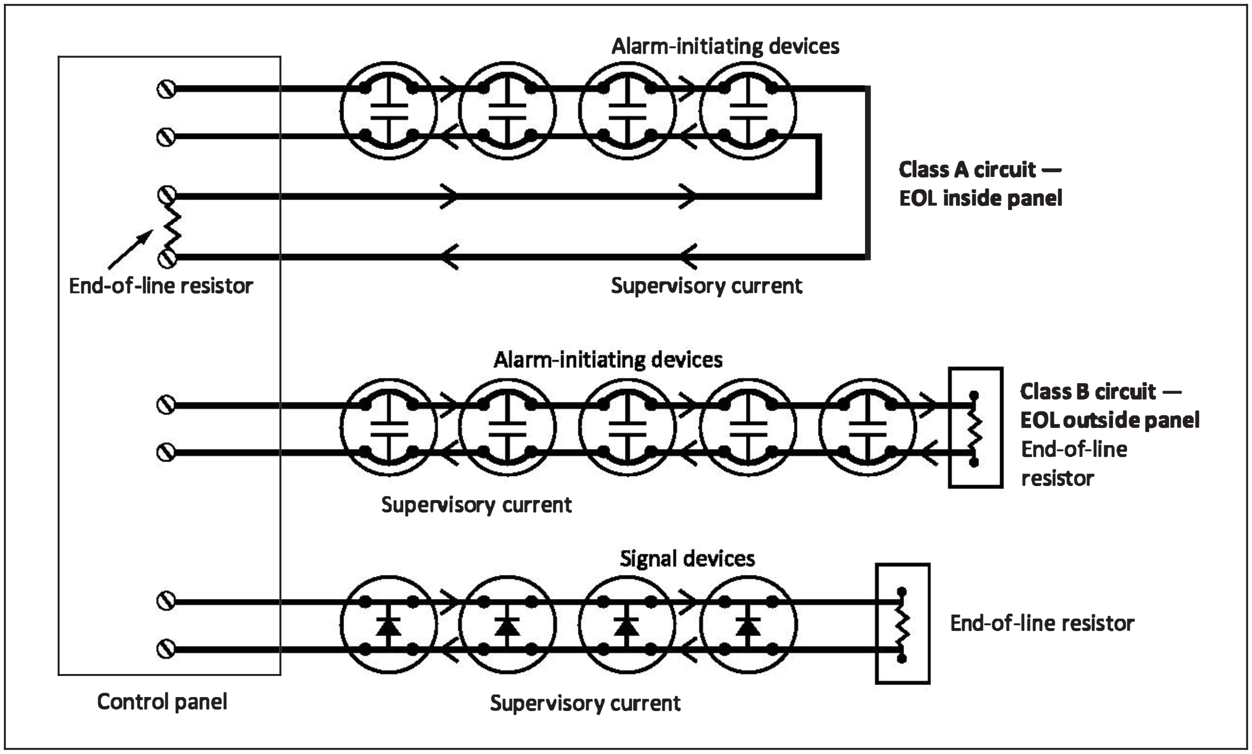
The *National Building Code of Canada* and CAN/ULC-S524 require that a fire alarm system have electrical supervision (i.e., the fire alarm system monitors itself for faults, such as open circuits and ground faults, and for supervisory conditions on a sprinkler system that can prevent proper operation of the system). An open circuit fault condition occurs when the total resistance of the circuit exceeds 10 000 Ω or as defined by the manufacturer. A ground fault condition occurs when the resistance to ground of any conductor in the circuit is less than 10 000 Ω or as defined by the manufacturer. An open tamper switch prevents a sprinkler system from proper operation. All such trouble and supervisory conditions should be indicated on the fire alarm system annunciator.

While many systems can be used to provide this supervision, the two most widely used are based on conventional field devices and active field devices. A conventional field device is usually connected to the control unit on a wiring circuit shared with other devices; thus, any information regarding a change in status (for example, fire alarm detection or signalling) can come from any of the devices on the circuit. The control unit cannot identify the detection or signalling device that is directly affected (unless there is only one device on the circuit). Supervised circuits are closed-loop circuits through which a small supervisory current is made to flow at all times. The level of supervisory current is controlled by the end-of-line device, which is usually a resistor.

The control panel monitors the supervisory current. Any change in its value indicates trouble, whether it is a ground fault or an open circuit (i.e., system failure), or the operation of an alarm-initiating device caused by a possible fire (i.e., proper system operation). A ground fault is detected by the control panel when the amount of current coming back to the panel is less than the amount of current flowing out on the circuit (for example, a certain amount of current is going to ground). An open circuit is registered when current is flowing out from the panel, but no current is flowing back to the panel due to a break in a conductor. In either case, the control panel responds with a trouble signal.

A properly operating alarm-initiating device shorts out the end-of-line device, and the maximum current allowed for the circuit flows out, with the same amount returning to the panel. When an alarm-initiating device is activated, the polarity on the signal circuit is reversed, allowing the current to flow through the signal device and causing it to operate. The control panel responds appropriately by activating signalling devices. In the non-operational mode, the polarity allows a diode in the signal device to block the supervisory current from flowing through and activating it. See Figure 32-2.

**Figure 32-2**
**Typical supervised alarm-initiating and signal circuits using end-of-line resistors**




In such a system, fire alarm initiating devices and audible signalling devices are to have dual terminals or dual splice leads so that if they are removed from the circuit or if a conductor comes off its terminal, the circuit opens and a trouble signal is initiated (see Figure 32-2).

Addressable fire alarm systems use active field devices that can be uniquely identified, as each sends a distinctive signal to the control unit to indicate its location and operating status. Each device can be programmed to operate (or switch off) or to change operating parameters (for example, the operating location) independently of the other devices that share the circuit. Active field devices can be connected with other devices, components, and the control panel by means of a 2-wire circuit. Some active field devices use a data communication link to communicate with the control panel, transponders, and other devices. If the unique signal from an active field device is not received by the control panel (for example, as a result of open circuits or grounds), the control panel activates the appropriate trouble signal.

In some applications, the signals and alarms operate in response to fires that can damage the lines to or from the devices; if only one circuit is used to operate the system, this might render it inoperable. When the system is required for the safety of people in a building, a separate redundant circuit following a different path is required by the national fire code, ULC standards, and other regulatory authority requirements.

## Rule 32-108 Power supply

Fire alarm systems are required by the *National Building Code of Canada* to have an emergency power supply. Subrule 1) requires that the power supply to a fire alarm system be a separate circuit that does not supply power to any other electrical equipment.

Subrule 2) requires that where a fire alarm system includes more than one control unit or transponder, the circuit supplying power to each control unit or transponder be a separate branch circuit.

Subrule 3) requires that the overcurrent devices and disconnecting means supplying power to the fire alarm system be clearly identified. The disconnecting means is to be coloured red and is to be lockable in the ON position to reduce the likelihood of inadvertently disconnecting the fire alarm system.

## Smoke and carbon monoxide alarms

**Rule 32-200 Installation of smoke alarms and carbon monoxide alarms in dwelling units**
Permanently connected smoke alarms conforming to CAN/ULC-S531 and permanently connected carbon monoxide alarms conforming to CSA 6.19 are installed in each dwelling unit when required by the *National Building Code of Canada* (see Tables 32-1 and 32-2).

Except as permitted by Item e), Item a) permits smoke and carbon monoxide alarms to be supplied by a lighting branch circuit or a branch circuit with a mix of lighting and receptacles. If an overcurrent device on the circuit trips and cuts off power to the alarm, it can be noticed more readily because the lights or other devices on the circuit will not be working. The Appendix B Note to Rule 32-200 a) stresses, however, that the Code does not intend to permit smoke and carbon monoxide alarms to be connected to a circuit that supplies receptacles only. In such a case, there might be no visual indication (as no lights are connected to the circuit) when the circuit is de-energized.

To eliminate the possibility of inadvertently disconnecting or switching off the alarm, Item b) prohibits any disconnecting means between the smoke or carbon monoxide alarm and the overcurrent device that protects the branch circuit.

Depending on the size of and number of stories in the dwelling unit, more than one smoke and carbon monoxide alarm can be required, in which case the *National Building Code of Canada* requires that the smoke alarms be interconnected. The *National Building Code of Canada* does not prohibit the interconnection of smoke alarms with carbon monoxide alarms. Item c) requires that the wiring method used to connect smoke and carbon monoxide alarms and the interconnection between smoke alarms, carbon monoxide alarms, or smoke and carbon monoxide alarms and their associated equipment are to comply with the wiring requirements in Rules 32-100 and 32-102.

Item d) allows Class 2 wiring methods to be used to interconnect smoke and carbon monoxide alarms and their associated equipment in buildings of combustible construction, provided that

- the smoke and carbon monoxide alarm circuit uses a Class 2 power supply; and
- the conductors are installed in accordance with Rules 12-506 to 12-524.

Item e) allows an exemption from Item a) when a smoke alarm or a combination of a smoke alarm and carbon monoxide alarm has an integral battery that is used as a secondary power supply.

## Table 32-1
## Smoke alarm requirements

| Location | Requirement | Circuitry |
|---|---|---|
| All floor levels | Smoke alarms are to be installed on each floor level (including basements), that is 900 mm or more above or below an adjacent floor level. Each bedroom is to be protected by a smoke alarm either in or outside the bedroom. A smoke alarm outside a bedroom is to be installed within 5 m of the bedroom door. This measurement is to be made along the corridors and through the bedroom door, not through walls or openings in walls.<br><br>The maximum distance between smoke alarms on the same floor in rooms other than bedrooms is 15 m. This measurement is to be made along corridors and through doorways, not through walls or openings in walls.<br><br>Smoke alarms are to be installed on the ceiling or near the ceiling.<br><br>(See Article 9.10.19 of the *National Building Code of Canada*.) | Smoke alarms are to be installed in any lighting branch circuit or any branch circuit which has both lighting and receptacles.<br><br>Smoke alarms are not to be connected to circuits that are protected by an AFCI or GFCI unless the smoke alarm or combination smoke alarm and carbon monoxide alarm has an integral battery that is used as a secondary power supply [see Rule 32-200 e)]<br><br>No switches or disconnecting means are allowed to be installed between the smoke alarm(s) and the overcurrent device for the branch circuit (see Article 9.10.19 of the *National Building Code of Canada*).<br><br>When more than one smoke alarm is required, alarms are to be interconnected so that the actuation of one alarm causes all the alarms in the dwelling unit to sound (see Article 9.10.19 of the *National Building Code of Canada*).<br><br>Battery backup is recommended (or may be required by some local building by-laws). |

**Table 32-2**
**Carbon monoxide (CO) alarm requirements**

| Location requirements | Circuitry |
|---|---|
| A CO alarm is to be mounted at the manufacturer's recommended mounting height or, if that height is not available, on or near the ceiling of a room or area in a dwelling unit containing a solid-fuel-burning appliance (see Article 6.9.3 of the *National Building Code of Canada*).<br><br>If a unit/suite in a residential occupancy contains a fuel-burning appliance or shares a wall with a storage garage, a CO alarm is to be located inside each bedroom or outside each bedroom within 5 m of each bedroom door, measured following corridors and doorways (see Article 9.32.3.9 of the *National Building Code of Canada*). | CO alarms may be installed in any lighting and receptacle branch circuit, except for circuits that supply kitchen counter and dining area receptacles, refrigerators, outlets in a garage, and outdoor receptacles (see Rules 26-650 to 26-656 and the requirements of the *National Building Code of Canada*).<br><br>In accordance with the *National Building Code of Canada*, CO alarms must not be connected to circuits that are protected by an AFCI or GFCI or to circuits that only supply receptacles.<br><br>No switches or disconnecting means are allowed to be installed between the CO alarm(s) and the overcurrent device for the branch circuit (see Article 9.32.3.9 of the *National Building Code of Canada*).<br><br>When required by the *National Building Code of Canada*, a CO alarm must have an audible alarm (see Article 9.32.3.9 of the *National Building Code of Canada*). |

## Fire pumps

Fire pumps are usually installed in a building to maintain required water pressure in sprinkler and standpipe systems during their use as fire suppression systems in the event of a fire emergency. Rules 32-300 to 32-312 cover requirements for conductors; wiring methods to fire pumps; dedicated fire pump service boxes; fire pump disconnecting means; and overcurrent protection in both the normal and emergency power supplies and transfer switches.

### Rule 32-300 Conductors

A fire pump is part of the building's life safety equipment intended to sustain the operation of the required fire protection system. The conductors from the emergency power source feeding the fire pump are to be reliable, protected against exposure to fire, and of sufficient size to allow the pump to operate under overcurrent conditions. Rule 32-300 requires that these conductors have a minimum ampacity of 200% of the motor's full load current rating. A jockey pump, which is mentioned in Item a) ii), is a water pump that maintains the pressure in a system until the fire pump is activated. See Table 32-3.

## Table 32-3
## Method to determine the minimum conductor ampacity from the emergency power source to a fire pump installation

| Step | Method |
|---|---|
| 1 | Determine the full load current of each load in amperes. |
| 2 | Add all the loads together from Step 1. |
| 3 | Calculate the minimum conductor ampacity by multiplying the total load in amperes from Step 2 by 2.0. |
| 4 | Using the Code ampacity Table appropriate for the wiring method, determine the minimum conductor size. |

### Rule 32-302 Wiring method

As part of a building's fire suppression system, a fire pump system provides adequate water pressure for sprinkler systems, standpipes, and hose systems that operate to control a fire. Thus, the fire pump conductors need to be protected physically and electrically from exposure to fire and mechanical damage so that the pump functions even in severe conditions. Rule 32-302 requires physical protection such as metal-enclosed wiring methods, non-metallic wiring methods when enclosed in 50 mm of masonry or poured concrete, and underground installation. This is similar to the requirements for fire alarm systems in Rule 32-102 and for emergency systems in Rule 46-108.

The Appendix B Note to Rule 32-302 states to consider the location, routing, and design of the wiring to minimize hazards that can cause failure due to explosion, flooding, fire, ice, vandalism, and other adverse external conditions that can impair the function of a fire pump. The Note also recommends that, where possible, cables supplying power to fire pumps be located underground.

### Rule 32-304 Service box for fire pumps

During a fire, a fire pump is to continue to operate without being affected or interrupted by faults occurring in other equipment and wiring systems in the building. Subrule 1) allows the dedicated supply service for the fire pump, usually from a different distribution system than that supplying the main service. A service box is an approved assembly consisting of a metal box or cabinet that is separately constructed so that it is capable of being locked or sealed. Service boxes contain either service fuses and a service switch or a circuit breaker, and are of a design that allows the switch or circuit breaker to be manually operated when the box is closed. Subrule 2) allows the fire pump dedicated service box to be in a location remote from the main supply service box in the building. This allowance might be necessary to enable the fire pump service box to be located close to the fire pump controller or to provide for a situation in which the location of the fire pump supply service is different from the main service. See Rule 6-102 2) and 3) for the requirements.

### Rule 32-306 Disconnecting means and overcurrent protection

The *National Building Code of Canada* and NFPA 20 contain provisions for the location of disconnecting means and for the type and rating of overcurrent protection for fire pump feeders. Consult these documents to ensure that there is no difference between these provisions and Rule 32-306, as the revision dates of the three codes vary. Figure 32-3 illustrates a typical installation.

Subrule 1) requires that only a circuit breaker capable of interrupting the fire pump circuit be allowed between the normal power supply service box and the fire pump controller, or between the main circuit breaker of the emergency generator and the fire pump transfer switch. This circuit breaker is to be labelled in a conspicuous, legible, and permanent manner identifying it as the fire pump disconnecting means.

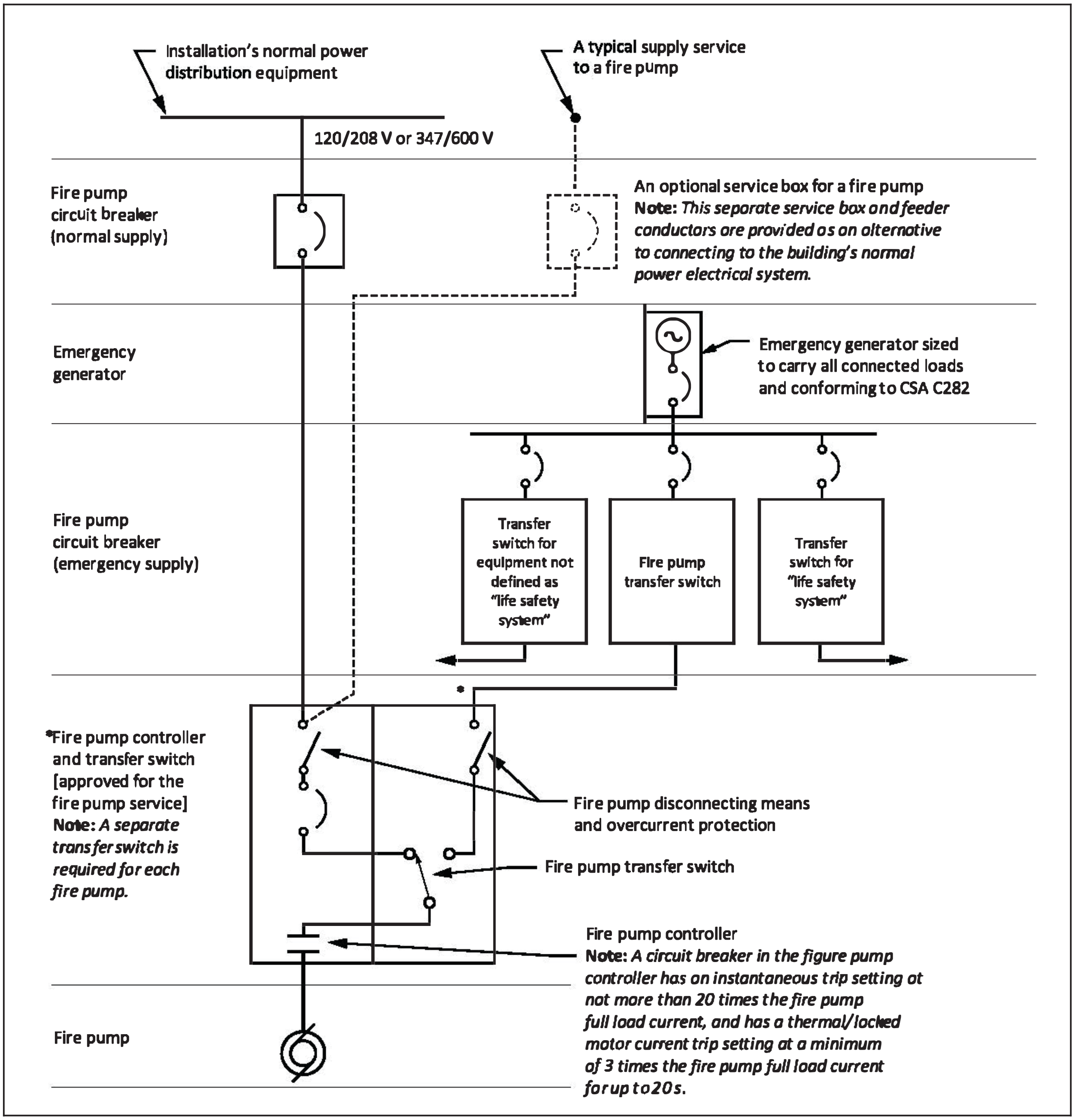
Subrule 2) requires that the circuit breaker in Subrule 1) identified as the fire pump disconnecting means be lockable in the closed (ON) position.

Subrule 4) requires that the rating or setting of the overcurrent protection device in the circuit breaker installed between the normal power supply service box and the fire pump controller is set or rated to carry the locked rotor current of the fire pump indefinitely.

Subrule 5) requires that the rating or setting of the overcurrent protection device in the circuit breaker installed between the main breaker of the emergency generator and the fire pump transfer switch be set or rated not less than the overcurrent protection provided integral with the fire pump transfer switch. This is to ensure that the overcurrent protection device does not trip before the protection in the fire pump transfer switch.

To coordinate requirements between the generator main circuit breaker and the circuit breaker in the fire pump transfer switch supplied from the emergency power source, Subrule 6) allows the feeder that is installed between the emergency generator and the fire pump transfer switch to bypass the generator main circuit breaker and be connected directly to the emergency generator.

**Figure 32-3**
**Typical disconnecting means and overcurrent protection for fire pumps**

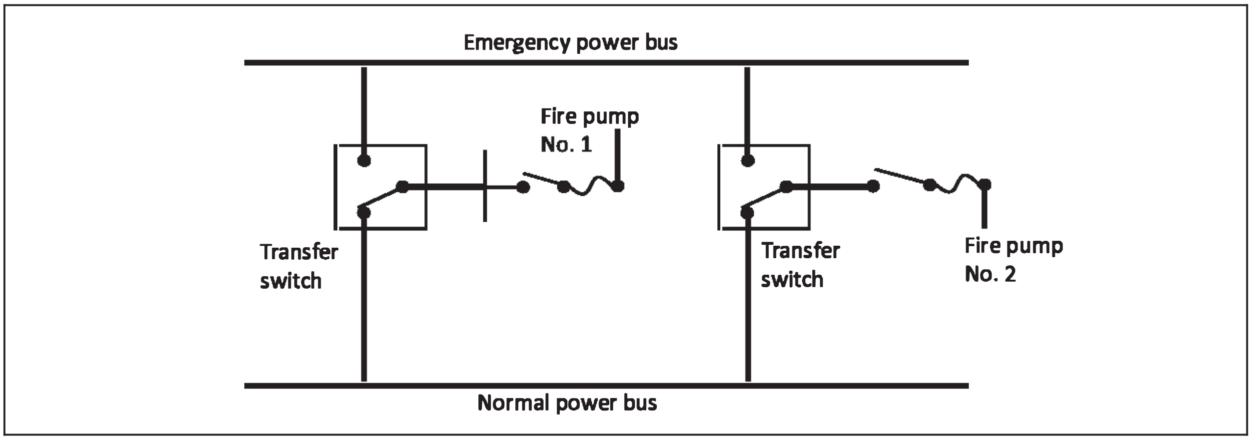



## Rule 32-308 Transfer switch

NFPA 20 requires a dedicated fire pump transfer switch specifically designed, constructed, tested, and marked for fire pump service. This NFPA 20 requirement is reflected in Rule 32-308.

On a site having more than one fire pump that is required to be supplied by emergency power, Subrule 2) requires that a transfer switch be provided for each fire pump and located in accordance with Subrule 1). This requirement provides an additional backup (i.e., if the transfer switch fails for one fire pump, the other fire pump(s) can still function). See Figure 32-4.

**Figure 32-4**
**Transfer switches for fire pumps**




## Rule 32-310 Overload and overheating protection

A fire pump operates in response to a fire and is to maintain operation for as long as possible, even if it results in overheating. Rule 32-310 allows a fire pump installation to omit the overload or overheating protection that is normally required by Rules 28-300 and 28-318.

## Rule 32-312 Ground fault protection

Although ground fault, overload, and overheating protection are safety concerns, the continued operation of fire pumps takes precedence during a fire emergency. While sprinkler systems are operating or firefighters are using hose lines connected to standpipes, spraying water can cause leakage currents in the wiring associated with the fire pump. If the branch circuits supplying the installation have ground fault protection, the power to the pump can be interrupted. Rule 32-212 prohibits such protection for fire pump circuits.

The Appendix B Note to Rule 32-312 defines a fire pump circuit, for purposes of this Rule, as the circuit supplied from either of the following:

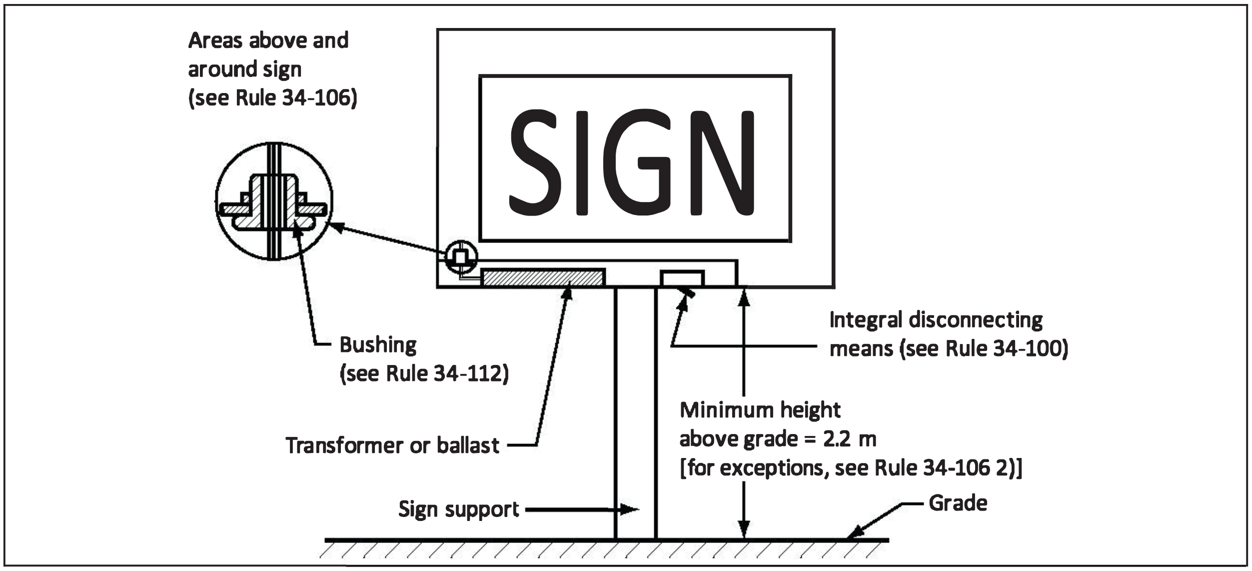
- the emergency power source referred to in Rule 32-300; or
- a separate service box, in accordance with Rule 32-304, to fire pump equipment.

# Section 34 — Signs and outline lighting

### Rule 34-000 Scope

Section 34 includes additional and specific requirements for signs and outline lighting (see Section 0, Definitions). A typical sign installation and its parts are shown in Figure 34-1.

**Figure 34-1**
**Typical sign installation**




### Rule 34-002 Special terminology

The following definitions apply to Section 34 only:

*GTO sleeving* is a flexible polymeric sleeve permitted by the Code to enclose high-voltage cable operating at not more than 7500 volts-to-ground, provided that the combination of cable and sleeving is installed within a raceway. GTO sleeving itself must not be used as a raceway for electrical conductors and cables because it has not been tested and evaluated by an accredited certification organization for this purpose.

*Neon supply* is the standardized term that covers both neon transformers and electronic neon power supplies.

## General requirements

### Rule 34-100 Disconnecting means

Signs and outline lighting require periodic maintenance. To ensure that the equipment can be worked on safely, as required by Rule 2-304, a disconnecting means that facilitates the de-energization of the equipment is essential.

The requirements for the location of the disconnecting means are similar to those for motors in Rule 28-604, except that a disconnect integral with the sign or outline lighting may be used. Subrule 2) allows the disconnecting means to be located out of the line of sight or more than 9 m from the sign when the disconnecting means can be locked in the open position.

### Rule 34-102 Rating of disconnecting means and control devices

The switches and controls required to interrupt the inductive load of the neon supply, transformers, or ballasts must be designed for the application or must have a current rating not less than twice the current rating of the neon supply, transformers, or ballasts being controlled. Such a rating ensures that the devices can safely interrupt the inductive loads associated with this type of equipment.

### Rule 34-104 Thermal protection

Ballasts for fluorescent lamps, with the exception of the simple reactance type, are subject to overheating under certain conditions of fault and can cause a fire. To ensure that the temperature rise on ballasts that supply fluorescent lamps for signs and outline lighting is maintained at a specified safe value, Rule 34-104 requires the use of thermally protected ballasts (which are labelled "Thermally Protected") unless simple reactance-type ballasts are used. A simple reactance-type ballast provides the proper starting and operating electrical condition for the operation of fluorescent, neon, or high-intensity discharge (HID) lamps. The reactance (which is through an inductor) limits the power available to the lamp with only minimal power losses, while the voltage spike to strike the arc in the lamp is produced when current through the inductor is rapidly interrupted.

### Rule 34-106 Location

Subrule 1) gives the general requirements for locating indoor and outdoor signs and outline lighting (see Figure 34-1). Sufficient clearances are required from overhead conductors such as electrical and communication utility conductors to:

- prevent persons working on the signs and outline lighting from coming in contact with them;
- ensure the installation will not interfere with the normal operational requirements for the overhead conductors; and
- prevent persons or vehicles from contacting the electrical components of the sign.

Subrule 2) allows an exemption from the minimum mounting height of Subrule 1) when the sign or outline lighting is free-standing, located indoors, installed in show windows, or installed in similar locations.

### Rule 34-110 Bonding

Because conductive non-current-carrying parts of signs and outline lighting, and the non-electrical equipment to which signs are mounted, can become energized during fault conditions, they must be bonded to ground to prevent possible shock hazards. However, subassemblies of signs and outline lighting supplied by a remote Class 2 power supply with an output voltage not exceeding 30 V do not pose a hazard and therefore are not required to be bonded to ground.

It is very unlikely that small conductive parts of signs or outline lighting attached to a building and illuminated from the rear, or any grille work that is spaced a reasonable distance from neon tubing, could become energized. Therefore, Rule 34-110 exempts such parts, including metal wire-ties securing neon tube supports, from bonding requirements.

### Rule 34-114 Fuseholders and flashers

Fuseholders, flashers, and other components must be installed in electrical enclosures suitable for the purpose. The enclosures must be able to contain molten particles in the event of a fault. For maintenance purposes, enclosures must be accessible without the need to remove obstructions or dismantle the sign.

## Enclosures

### Rule 34-200 Enclosures

Neon supplies, switches, timers, relays, sequencing units, and similar devices are to form part of an assembly or be enclosed in a suitable electrical enclosure.

The Appendix B Note to Rule 34-200 provides more detailed information on the design requirements for these enclosures, including the following recommendations:

- enclosures should be constructed to prevent the escape of flames or any burning or molten material, and where they house a transformer, neon supply, or other components, enclosures should be marked as specified in Section 2;

- metal enclosures should not be less than 0.68 mm thick (No. 22 MSG) and, at the point where the supply connections are made, should not be less than 1.34 mm thick (No. 16 MSG); and
- openings for ventilation should not present a shock hazard and should be at least 100 mm from live parts.

The Appendix B Note recommends that in order to prevent the overheating of the components inside an enclosure that contains neon supplies, such an enclosure have a volume three times the volume of the transformer and/or the internal box.

## Neon supplies

### Rule 34-300 Maximum secondary voltage for neon supplies

Intense electric fields or electrically charged air molecules can be produced at the surfaces of bare or insulated conductors and other live components of high-voltage systems. This phenomenon is called the "corona effect". If the difference in polarity between the fields or charged air molecules and the circuit conductors and components increases sufficiently, a corona discharge can occur, causing a loss of energy in high-voltage conductors and a breakdown of the conductors' insulation. This can lead to other problems such as short-circuits or arcing.

The corona effect is directly proportional to the voltage and the distance between conductors or between conductors and ground. As a consequence, Rule 34-300 places limitations on the maximum value of the open-circuit voltage and the volts-to-ground for neon supplies.

### Rule 34-302 Secondary-circuit ground fault protection

Electronic power supplies do not follow the ideal conversion from rms or effective voltage to peak voltage of 1.414 times the rated secondary open-circuit voltage.

A form of protection over and above the normal overcurrent devices is required to prevent a potentially hazardous condition on the high-voltage secondary circuits. Therefore, all neon supplies must be provided with secondary-circuit ground fault protection, unless:

- the secondary is isolated from the primary, and the secondary open-circuit voltage is limited to 6000 V or less; and
- the transformers are constructed at the factory with internal porcelain or glass secondary housing for connecting the neon tubing so that no field wiring of the secondary is required.

### Rule 34-304 Open-type neon supplies

On some neon supplies, the open core-and-coil windings, when not installed in their own enclosure, are not protected against the absorption of moisture caused by temperature changes, high humidity, and similar conditions. Such neon supplies must be used only in dry locations.

### Rule 34-306 Neon supplies for damp or wet locations

Where neon supplies are used in damp or wet locations, either in indoor installations (for example, car washes) or outdoors, they must be approved for the environmental conditions.

**Note:** *The Section 0 definition of "outdoor location" should be consulted, along with the Note to the definition in Appendix 8, which states that "Locations that are sheltered from the weather are not considered outdoor locations". An outdoor location is one that is exposed to the weather, and a neon supply installed in such an area must be approved for an outdoor location. Where the neon supply is located outdoors but protected from the weather, a wet or damp location type would be required.*

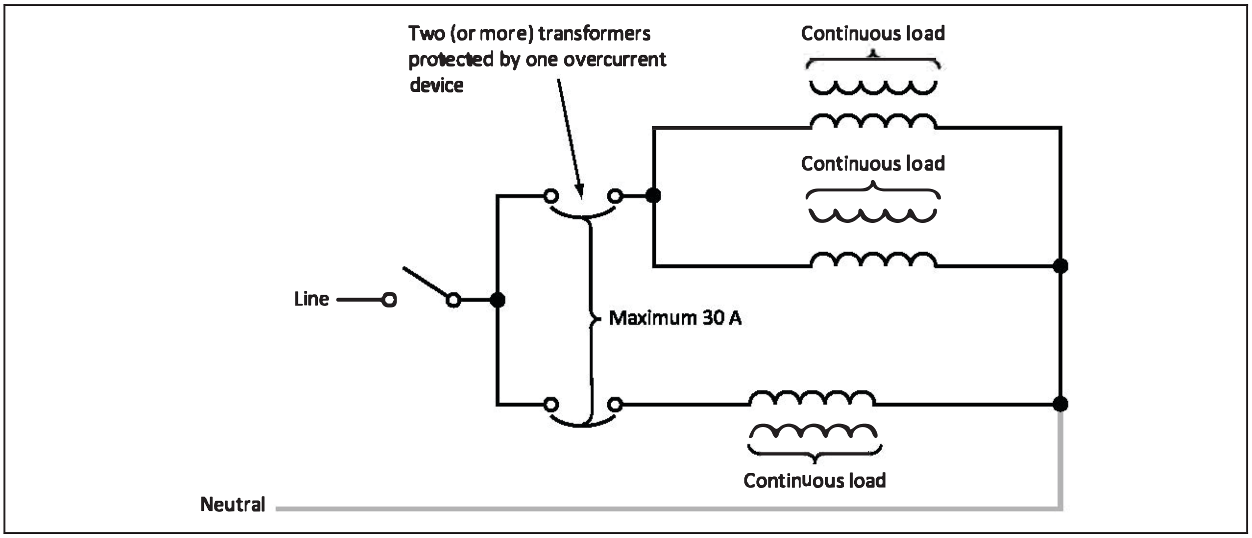
### Rule 34-310 Neon supply overcurrent protection

Overcurrent protection is required for each neon supply, both to limit possible damage to the supply and to prevent a fire hazard in the event of a fault. Many neon supplies cannot operate on a 15 A circuit, so the overcurrent protection may be rated as high as 30 A.

However, two or more transformers may be protected by a single overcurrent device (see Figure 34-2), provided that the load, rated as a continuous load, does not exceed the limitations of Rule 8-104. For example, if the 30 A breaker shown in Figure 34-2 has a continuous operation rating of 80%, the maximum connected load would be 30 × 0.8 = 24 A in accordance with Item a) of Subrule 6) of Rule 8-104.

Additional overcurrent devices for individual protection of neon supplies may be placed either inside or outside the sign structure; if they are exposed to the weather, they must be approved for such exposure.

**Figure 34-2**
**Transformer overcurrent protection**




### Rule 34-312 High-voltage output connection

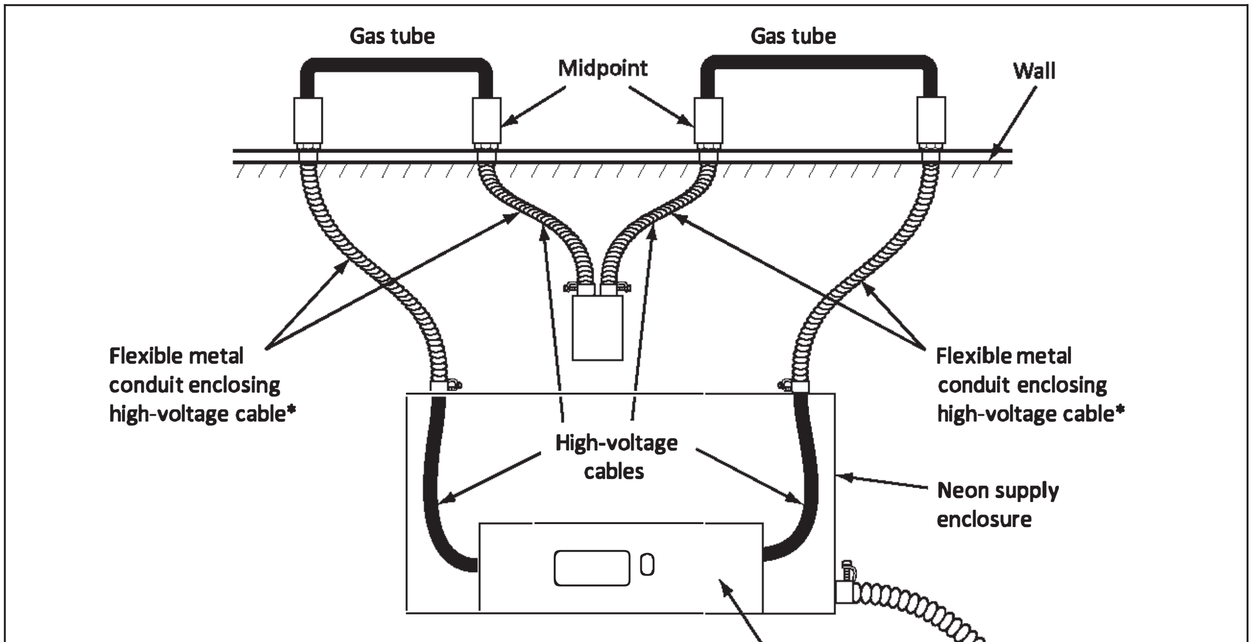
Connecting neon supplies in series or in parallel can exceed the voltage limits or circumvent the secondary circuit's ground fault protection. Therefore, Rule 34-312 does not permit the high-voltage windings of neon supplies to be connected in parallel or in series under any conditions.

## Wiring methods

### Rule 34-400 High-voltage wiring methods

The corona effect is produced when two wires or other conductors having significantly different voltage values are placed near each other, or when high-voltage conductors are placed near ground. The corona effect can cause high-voltage cable to become hazardous when run on, in, or through partitions, walls, floors, or ceilings, or run in flexible non-metallic conduit in contact with conducting or combustible material. Figure 34-3 shows a typical installation for a through-wall sign that complies with the wiring methods prescribed in this Rule.

**Figure 34-3**
**High-voltage wiring for a through-wall-type sign**




* *Bonding conductor not required in flexible metal conduit or liquid-tight flexible metal conduit [see Rule 34-110 1)]*

Subrule 1) requires that high-voltage cables be installed in neon supply enclosures, sign enclosures, and a specified group of conduits and raceways. Subrule 2) gives requirements for liquid-tight flexible conduit used to enclose high-voltage cable.

Although there is no potential on the midpoint return of the neon tube circuit, Subrule 3) requires that only high-voltage cable be used because failure in a neon tube creates a high-voltage condition at the midpoint.

Subrule 4) requires that bends in the high-voltage cables be in conformance with the minimum bending radii detailed in Table 15. Note these high-voltage cables are non-shielded cables. The minimum required bending radius is seven times the cable diameter, as specified in Table 15.

To prevent damage that could be caused by the corona effect, Subrule 5) specifies the minimum separation between high-voltage cables when they are installed in non-metallic conduit.

Subrule 6) gives the requirements for cable installations used for the wiring of signs and outline lighting when it is run exposed.

Subrule 7) requires that high-voltage conductors for secondary wiring associated with field-wired signs and outline lighting be at least No. 18 AWG. Smaller conductors cannot be relied upon for sufficient mechanical strength.

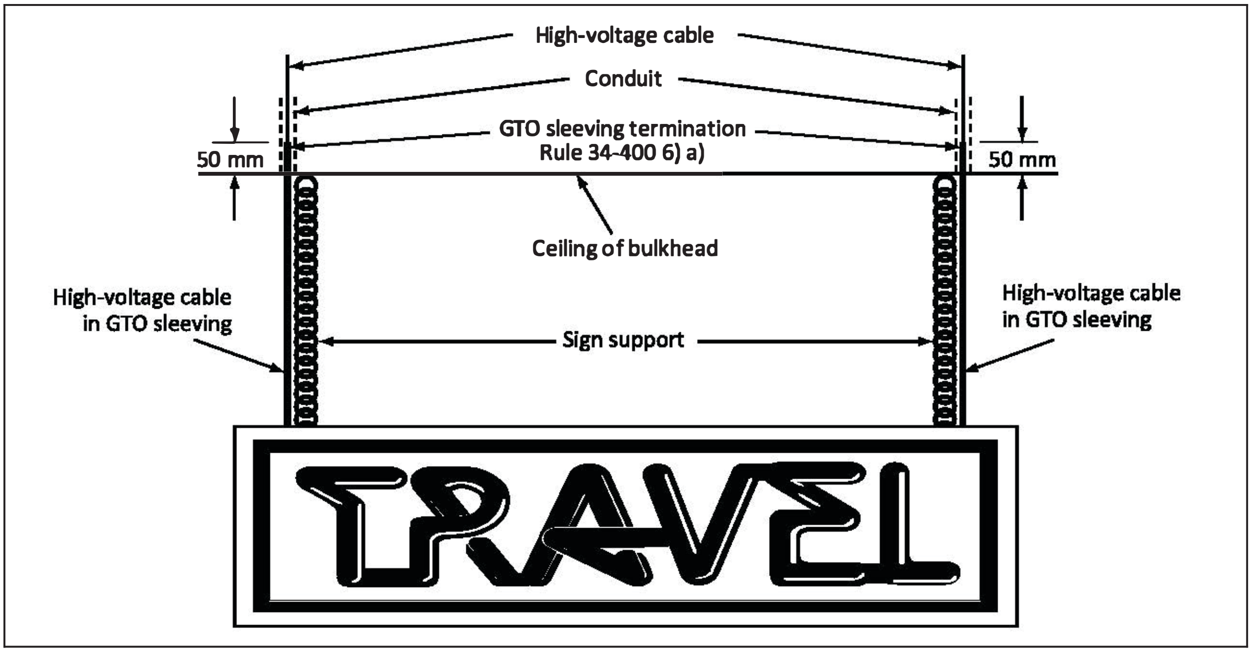
Subrule 8) intends to reduce even further the possibility of failure in the high-voltage conductor due to the corona effect by requiring that only one high-voltage cable be installed in a conduit.

Subrule 9) requires that where high-voltage cable enters or leaves conduit in a damp or wet location, the conduit ends be watertight. Preventing moisture from entering and travelling through conduits to electrical equipment attached to the conduits further reduces the potential for a corona discharge.

## Rule 34-402 High-voltage cables in show windows and similar locations

Rule 34-402 describes the specific exemptions from the wiring requirements given in Rule 34-400 that apply to high-voltage cables that are run outside raceways to supply power to hanging signs in show windows and similar locations (see Figure 34-4). Under no circumstances are high-voltage cables to be used to support a sign or any part of a sign.

**Figure 34-4**
**Show window sign (high-voltage conductor not exposed)**




## Rule 34-404 Length of high-voltage cable from neon supplies

The length of a high-voltage cable must be limited because the cable acts like one side of a capacitor; as the length of cable increases, particularly in a metal raceway, excessive voltage can build up, breaking down the insulation on the cable. Subrule 1) limits the length of high-voltage cable to 6 m in metal raceways and 16 m in non-metallic raceways. Subrule 2) requires that all other lengths of cable in the circuit be kept as short as practicable, in order to reduce the capacitive charge effect.

## Rule 34-406 Connections of high-voltage cables

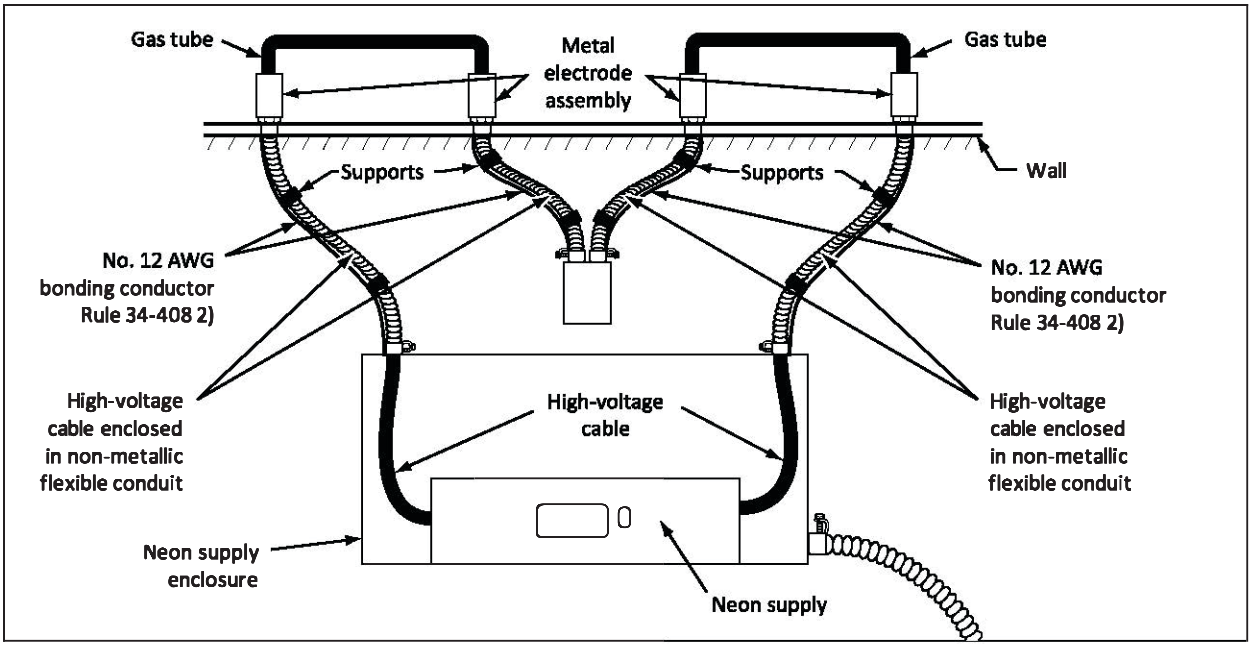
The configurations of neon tubing for signs and outline lighting vary considerably. To accommodate this variety, while still maintaining a high level of safety for people and property, Rule 34-406 specifies accessibility and equipment requirements for connecting high-voltage cables to neon tubing, both inside and outside a building.

To ensure that proper terminations can be made without making sharp bends or damaging the cable insulation, Rule 34-406 requires that a minimum length of insulated cable be left outside the raceway; the length varies according to whether the location is dry or damp/wet.

## Rule 34-408 Bonding of metal electrode assembly housing and metal parts

The short-circuit current on the secondary of a neon supply is limited by design, and thus the maximum fault current is limited to no more than the short-circuit current. Because this current rarely exceeds 100 mA and never exceeds 1 A, the normal bonding requirements in Section 10 may be relaxed. Thus, Subrule 1) allows flexible metal conduit with connectors that ensure a positive bonding connection to serve as the bonding means for a metal electrode assembly housing (see Figure 34-3). Where non-metallic conduit is used instead of flexible metal conduit, Subrule 2) requires that a bonding conductor at least No. 12 AWG be installed on the exterior of the non-metallic conduit to reduce the capacitive charge and the corona effects (see Figure 34-5).

**Figure 34-5**
**Bonding requirements for enclosing high-voltage cable in non-metallic flexible conduit for metal electrode assembly housing**



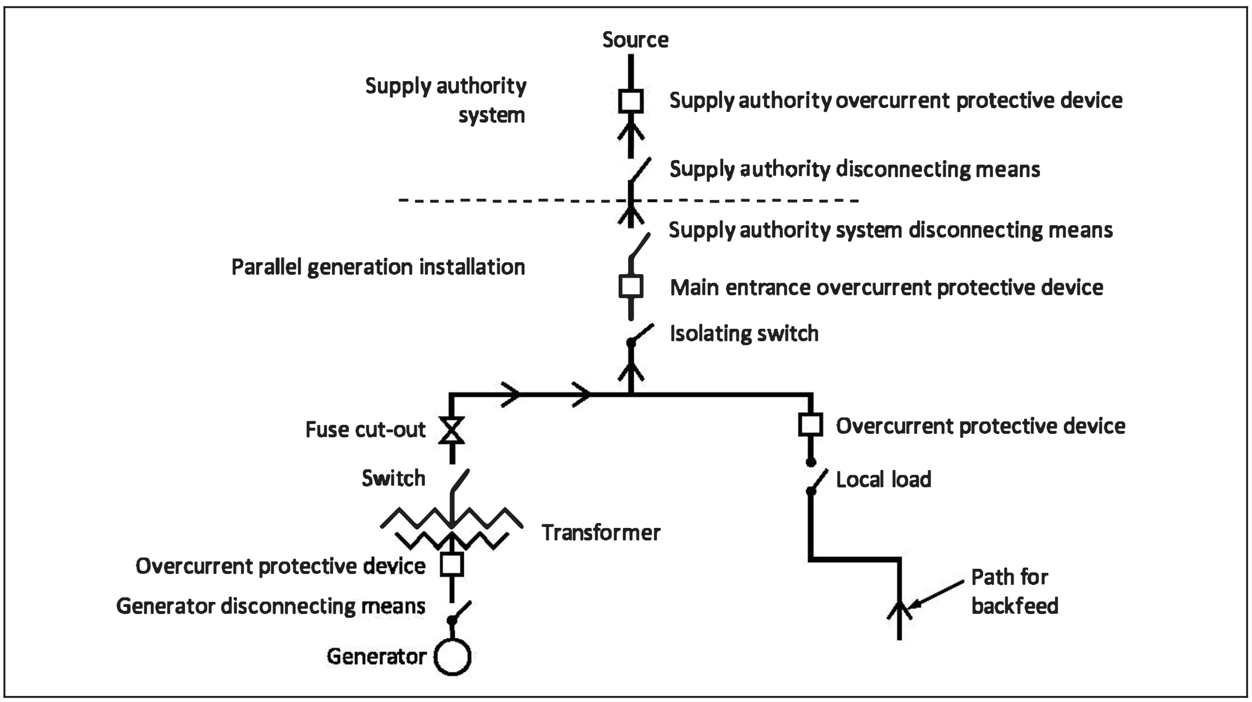
# Section 36 — High-voltage installations

Section 36 includes additional and specific requirements for electrical installations operating at voltages above 750 V. Particular care is to be taken when operating electrical power systems at voltages above 750 V. A person can suffer a lethal shock or burn without coming into direct contact with an energized high-voltage conductor since

- an arc can strike through free air or along the surface of certain materials. Significant arcing can also occur when a circuit carrying only small amounts of load current (under 100 A) is interrupted by a device not equipped with an arc-extinguishing mechanism (for example, when a fuse is tripped due to a ground fault or when an isolating switch is switched under load);
- dangerous voltages can be applied on non-current-carrying metal surfaces when a phase-to-ground fault occurs, unless proper steps are taken to bond these parts to ground; and
- energy released at the point of a fault is often sufficient to be highly destructive. When a fault occurs between two live conductors, or between a live phase conductor and ground, the energy released almost instantly vaporizes the materials involved. The rapid expansion of this vaporizing material causes it to be expelled violently, resulting in serious or fatal burns to anyone in its path.

Hazards to personnel and electrical equipment can also be caused by a backfeed on high-voltage and/or low-voltage systems. (See the definition of *backfeed* in Section 0 of the Handbook and Figure 36-1.)

**Figure 36-1**
**Backfeed (feedback)**




## General

### Rule 36-000 Scope

All high-voltage installations are to comply with Section 36 requirements. Since the requirements of Section 36 can affect the design and layout of the installation as well as the proper selection of components and equipment, the supply authority and inspection department are to be consulted in advance.

It should also be noted that most authorities having jurisdiction require the involvement of a professional engineer in the design of HV installations. Consultation with the relevant AHJ administering the adopted Code is essential.

Factory-assembled electrical equipment can also perform some of the equipment functions covered by requirements in Section 36. Such equipment does not fall within the scope of this Section. These assemblies are approved in accordance with the applicable safety Standards of the *Canadian Electrical Code, Part II*. The Appendix B Note to Rule 36-000 4) refers in particular to gas-filled high-voltage switchgear and control-gear enclosures, which in some cases are not subject to regulation or inspection by local boiler and pressure vessel authorities. The Appendix B Note lists CSA Group engineering Standards that govern the design, construction, testing, inspection, and certification of these enclosures.

## Rule 36-002 Special terminology

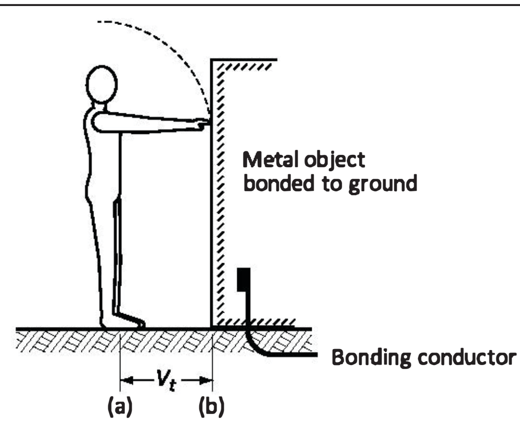
The terms defined in Rule 36-002 apply only to Section 36.

In a high-voltage installation that receives power at voltages above 750 V, the actual utilization voltage required by at least some of the loads is almost always lower than the supply voltage, necessitating the installation of transformer, switching, and protective electrical equipment. An assembly of such equipment can be located outside (in a switch yard) or inside a building, or both. This assembly constitutes a *station*.

Voltage gradients can occur across normally non-current-carrying surfaces during energized conductor-to-ground faults. *Touch voltage* refers to the potential difference between a grounded metal structure and a point on the earth's surface at a distance equal to a person's normal maximum horizontal reach (see Figure 36-2).

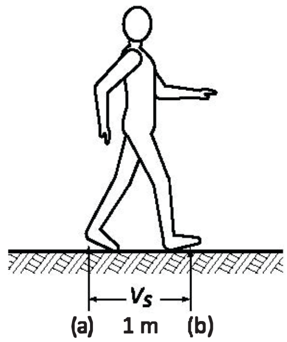
*Step voltage* refers to the potential difference between two points on the earth's surface separated by one pace (assumed to be 1 m) in the direction of the maximum voltage gradient (see Figure 36-3). Conditions such as *step voltage* can sometimes also be calculated if the resistance of the earth is known.

**Figure 36-2**
**Touch voltage**




**Note:** *$V_t$ = touch voltage [the potential difference between point (a) on the earth's surface and the surface of a metal object bonded to ground at point (b)].*

## Figure 36-3
## Step voltage




**Note:** *$V_S$ = step voltage [the potential difference between points (a) and (b) on the earth's surface* 1 m *apart in the direction of maximum voltage gradient].*

# Wiring methods

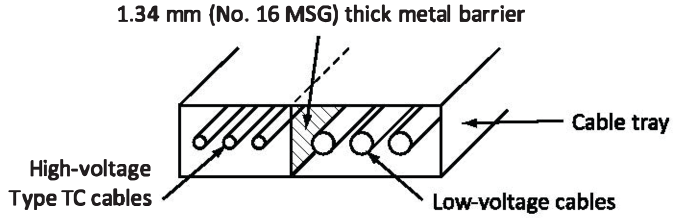
### Rule 36-100 Conductors

Since conductors operating at high voltage can pose a threat to human life, some type of protective barrier is to be provided. This barrier can take the form of a physical separation (for conductors run in free air), a structural barrier (for example, an equipment vault or service room), or a metal covering bonded to ground. A metal covering bonded to ground is preferred because any discharge is conducted safely to ground.

Rule 36-100 requires that high-voltage conductors, with certain exceptions set out in Subrule 1), be enclosed in metal bonded to ground (see also Rules 36-300 to 36-312). As specified in Subrule 2), insulated conductors or cables installed in metal conduit, electrical metallic tubing, metal-enclosed busways, cables with metal sheaths, steel wire armour, and interlocking armour, and Type TC cables installed in cable trays in accordance with Rule 12-2202 are considered to be suitable for HV installation.

Subrule 3) allows high-voltage Type TC cables to be run in the same cable tray as low-voltage insulated conductors or cables only if they are separated by a No. 16 MSG metal barrier (see Figure 36-4).

## Figure 36-4
## Separation of high- and low-voltage conductors




Where high-voltage insulated conductors or cables are encased or embedded in concrete or masonry, Subrule 4) requires that permanent markers be set in the walls, floors, or ceilings at intervals not exceeding 3 m. The Appendix B Note to Rule 36-100 4) defines the design criteria for these markers.

Subrule 6) requires that high-voltage service conductors have at least the mechanical strength of No. 6 AWG hard-drawn copper to withstand the stresses of the installation.

### Rule 36-102 Radii of bends

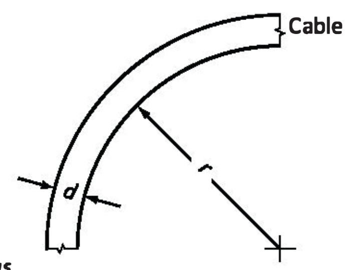
Materials used in high-voltage conductors and the insulation surrounding them do not possess unlimited ductility and can suffer damage if bent beyond certain limits. The conductor itself can be reduced in cross-section area, resulting in a reduction in its capacity, and the integrity of the insulation surrounding the conductor can be impaired if it is stretched or compressed too much.

Rule 36-102 requires compliance with the minimum allowable bending radii provided in Table 15 of the Code for various sizes and types of high-voltage cable. By applying Table 15 requirements for bending radii, the installed cables are not overstressed at the bends.

The bending radius is measured at the innermost surface of the bend. For example, the minimum radius allowed for a 50 mm lead-covered cable is 600 mm (12 × 50 mm). Note that this minimum radius should be applied to the finished installation and during the handling and installation of the cable.

See Figure 36-5.

**Figure 36-5**
**Bending radius for high-voltage cable**




**Note:** $r = d \times k$
*where*
$r$ = *minimum allowable bending radius*
$d$ = *overall diameter of the cable*
$k$ = *multiplying factor from Table 15 (determined by the type of cable)*

### Rule 36-104 Shielding of thermoset insulated conductors

The purpose of shielding (see the definition of *shielding* in Section 0 of the Handbook) is to conduct any leakage current safely to ground. Where insulated conductors are terminated, special care is to be taken to minimize the possibility of leakage along the surface of the insulation. Current leakage can produce tracking (the carbonization of minute particles) on hydrocarbon-based materials, resulting in failure of the insulation. The Appendix B Note to Rule 36-104 sets out recommendations for terminations and joints.

Rule 36-104 is intended to guard against physical damage to, or deterioration of, thermoset insulation material to prevent hazards resulting from partial or complete failure of the insulation. The voltage limits specified reflect the various degrees of protection inherently provided by the environment in which the conductors are installed.

Subrule 1) requires that thermoset insulated conductors be provided with shielding where the phase-to-phase voltage exceeds 2000 V. Subrules 2) to 4) specify various exemptions.

Subrule 2) exempts thermoset insulated conductors from the shielding requirement if

- they are installed underground in raceways or are directly buried;
- they operate at not more than 3000 V phase-to-phase; and
- their insulation or non-metallic jacket, if provided, is of the ozone- and discharge-resistant type.

Subrules 3) and 4) exempt thermoset insulated conductors in more fully protected environments from the metal shielding requirement under prescribed conditions.

Subrule 5) requires that all metal protective coverings and fittings be bonded to ground [see Rule 10-606 and Item e) i) of Subrule 2) of Rule 36-308].

### Rule 36-106 Supporting of exposed conductors

In a high-voltage system, very high currents (amounting to thousands of amperes) flow when a short-circuit occurs. This fault current creates powerful electro-magnetic fields that alternately attract and repel adjacent current-carrying conductors. Unless the exposed conductors are securely held in place, the mechanical forces can move them close enough to unenergized surfaces to draw an arc and, in the worst case, cause the support to fail. The mechanical forces generated are a function of the magnitude of the short-circuit current. Although it is not explicitly stated in Rule 36-106, the supply authority should be consulted to determine the maximum available short-circuit current (or maximum amount of power in MVA) from the supply system (at present and in the future) so that insulating supports of appropriate mechanical strength can be selected and the maximum spacing of supports along the exposed conductor can be determined.

### Rule 36-108 Spacing of exposed conductors

Where exposed single, bare and insulated, conductors run in free air or other bare live parts are supported and are installed in free air without the benefit of metal shielding, the gap separating them from each other and from other adjacent surfaces serves as the primary insulating medium. The impurities in the insulation material used on conductors will cause a very small amount of current leakage along the length of insulated conductor [150 m (500 ft) of insulated conductor run along a grounded surface will leak 1 mA]. As the system voltage increases, this leakage current can present a shock hazard. A key purpose of the insulation is to prevent the migration of any fault along the conductors by blocking the path of ionized gases to bare conductors or parts. Thus, the voltage rating of the insulation is only one concern.

Subrule 1) therefore makes no distinction between insulated and uninsulated conductors in setting out spacing requirements between conductors and other bare live parts, citing the requirements of Tables 30 and 31, which both refer only to bare conductors. When insulated conductors are used, the values in Tables 30 and 31 apply to the distance between the conductors themselves, without taking into account the thickness of the insulation.

Subrule 2) allows the spacing to be reduced from the requirements in Tables 30 and 31 when the terminal spacing at the apparatus or devices they are being connected to is less than the Table spacing. However, the spacing is to be increased to the required Table 30 and 31 values by the first support beyond the termination.

### Rule 36-110 Guarding of live parts and exposed conductors

In high-voltage electrical installations, an insulating covering alone is not considered adequate because partial discharge (corona) can occur on or along the surface of the material. Rule 36-110 is intended to take into account the need to guard exposed live parts. This need is addressed by a number of elevation and clearance requirements in Tables 32 to 34. When applying these Tables to a given installation, the proper voltage class is to be selected. When voltage levels are increased, the spacing is to be increased as well. The nominal system voltages listed in the Tables are phase-to-ground for grounded systems and phase-to-phase for ungrounded systems.

High-voltage conductors in free air require greater clearances to minimize the possibility of partial discharge or of an arc being struck. For voltages higher than those listed in Tables 30 to 34, the supply authority and the inspection department should be consulted.

### Rule 36-112 Terminating facilities

Rule 36-112 requires that proper terminating facilities be provided in accordance with the recommendations of the cable manufacturer. Where a live conductor is exposed (for example, at the end of a cable), the voltage gradient from the live part out to and along the outer surface of the insulating material is sometimes suffiicient to cause a partial discharge (corona). The presence of moisture or other contaminants on that surface can substantially increase the level of this discharge.

If the material is hydrocarbon-based, the discharge can produce tracking, a path of carbonized particles along the surface of the material. In time, this carbonized track might no longer offer sufficient electrical resistance to the voltage across it, and a flashover to ground can occur.

### Rule 36-114 Joints in sheathed cables

The integrity of the bonding path provided by the metal sheath of a cable is not to be impaired at breaks where splices or taps are made. Rule 36-114 requires that suitable hardware be provided so that joints or splices have the same mechanical strength and electrical continuity as the cable. This ensures the mechanical and electrical integrity of the cable and its devices throughout its length.

### Rule 36-116 Elevator shafts

High-voltage equipment located in elevator shafts is susceptible to damage from falling objects. Such damage can make high-voltage insulated conductors or cables extremely dangerous to elevator maintenance and inspection personnel. If a high-voltage insulated conductor or cable failure occurs in an elevator shaft, flames or toxic gases are likely to be carried upward by the chimney effect common in hoistways. Rule 36-116 prohibits the installation of high-voltage insulated conductors or cables in elevator shafts unless they are installed in conduit that is embedded in the masonry walls of the hoistway. The conduit is to be surrounded by at least 50 mm of masonry or concrete for the entire length of its run.

### Rule 36-118 Conductors over buildings

To eliminate associated hazards to people and property, high-voltage conductors are not to be installed over buildings.

## Control and protective equipment

### Rule 36-200 Service equipment location

Rule 36-200 requires that electrical service equipment be installed in a location that complies with the requirements of the supply authority. The qualified supply authority personnel terminate the supply service conductors in the service entrance compartment, and the location of the service entrance equipment is to be acceptable to the supply authority. These requirements of the supply authority usually stipulate that the location

- be readily accessible only to authorized personnel; and
- allow for the safe isolation of the premises when necessary.

Service equipment for a station served by a high-voltage supply is to be located in a building or in an outdoor switch yard. The higher the voltage, the less practical it is to accommodate the electrical equipment inside a building because of the higher cost of switchgear, equipment, the construction requirements for the electrical vault or a service room, and the difficulty of providing for future expansion or equipment replacement. Whether indoors or outdoors, the equipment is to be located at the first practical point on the premises nearest to the high-voltage supply to allow easy access for all concerned parties (i.e., the supply authority, the customer, and other authorized personnel), and to limit the length of high voltage service conductors in the buildings, considering that such supply service conductors might not have adequate overcurrent protection on the supply side. Since this often requires experienced judgment, the supply authority is to be involved.

In an emergency, such as a fire or explosion, authorized personnel are to have unimpeded access to the high-voltage equipment so that as much of the premises as possible can be isolated. Locating service electrical equipment in a uniform way from site to site makes it easier for the equipment disconnecting means to be found quickly in an emergency. Uniform service equipment location also facilitates the safe maintenance or alteration of a system.

### Rule 36-202 Rating and capacity

The high levels of energy that can be unleashed during a short-circuit on a high-voltage system dictate the application of stricter criteria so that safety is maintained. Circuit breakers, switches, and fuses are to be of the correct type and rating because they are to be capable of carrying (or limiting) a fault current for the maximum expected duration of the fault (short-time current rating). Devices intended to interrupt a short-circuit are to also have the necessary interrupting capacity. In some cases, the current-limiting characteristic (maximum let-through current) of a device is also important because downstream equipment might not have adequate short-time ratings to withstand a fault.

Rule 36-202 is intended to minimize the possibility of catastrophic failure resulting from the improper application of station components. It requires that all equipment used in the high-voltage portion of a station be appropriate for the specific conditions that exist and the phenomena that can occur. Circuit-breaker ratings [momentary and short-time current, interrupting capacity and clearing times, and voltage withstand BIL (basic insulation levels)] are to be adequate, and continuous current ratings are to reflect the anticipated loads. Switches (whether of the isolating type or the load-interrupting type) are not to be subject to duty that they are incapable of handling. Fuses are to have the necessary interrupting capacity and, when required, are to be of the current-limiting type.

Coordination with the supply authority's protective device settings also ensures that a fault occurring in an installation is cleared by local protective devices rather than those at the utility substation.

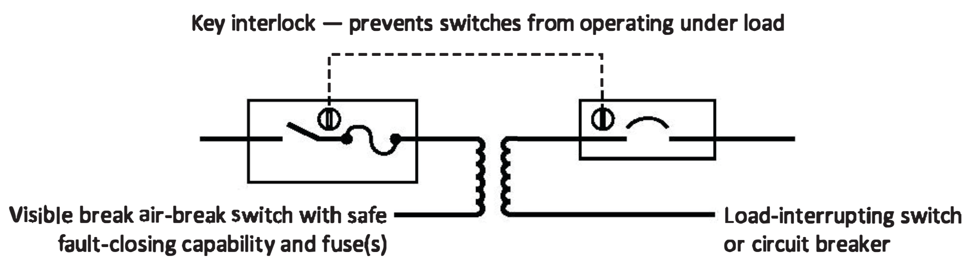
### Rule 36-204 Overcurrent protection

Subrule 1) requires that each circuit in a high-voltage electrical installation be equipped with an appropriate type of overcurrent device.

In installations where fuses are used, no voltage can be present and no current flowing when the fuses are inserted or removed. Preceding them by a visible break load-interrupting device provides this assurance. If there is a fault on the system, the load-interrupting device is to be capable of closing without danger to the operator. When outdoor, aerially mounted horn-gap switches are used, the primary safeguard for the person operating the switch is the vertical clearance. Some of these switches are capable of interrupting only the magnetizing current of the transformer they supply and are to be interlocked with a fully rated secondary interrupting device to prevent on-load operation.

Rule 36-204 allows some flexibility in selecting protective and switching components that are suited to the electrical installation and do not compromise the requirement for safe operation. Subrule 1) requires safe fault-closing capability from all circuit breakers and load-interrupter switches. Item c) of Subrule 1) is intended to prevent these devices from being operated under load (see Figure 36-6). Subrule 2) restricts access to fuses to authorized personnel because it is not always possible to physically interlock access to fuses with an isolating device.

**Figure 36-6**
**Typical overcurrent protection with key interlock**




### Rule 36-206 Indoor installation of circuit breakers, switches, and fuses

When a short-circuit occurs, the arc energy released is sufficient to raise the temperature of the material involved (conductor, insulation, or combustible liquid) to a high level in a fraction of a second. The ensuing rapid expansion of these arc products results in their being expelled, often violently, from the fault location. If they come into contact with combustible material, that material will most likely be set on fire. Additional precautions are necessary when any of the electrical equipment is dielectric liquid-filled (for example, transformers, capacitors, or circuit breakers) since the volume of hot or burning products is likely to be much greater.

To ensure that every electrical installation takes into account the destructive nature of high-energy short-circuits, Subrule 1) requires that devices such as circuit breakers, fuses, and switches operating at high voltage be isolated from combustible materials. The devices are to be of an enclosed type approved for the purpose or enclosed in a room of non-combustible construction. Due to the added hazards, dielectric liquid-filled equipment installed indoors is also to meet the requirements of Rule 26-012. The Appendix B Note to Rule 26-012 recommends that the gas relief vents for such equipment be connected to an outside area.

### Rule 36-208 Interlocking of fuse compartments

Most high-voltage fuses for indoor use are of the barrel type. These fuses are inserted into or removed from fuseholders by grasping the body of the fuse, and force is often required. This is not to be attempted when the circuit might be energized and when exposed bare live parts are close by. Aside from the shock hazard, there is the danger that a significant arc might occur that endangers the serviceperson and creates a fire hazard. To prevent the servicing of fuse compartment components when all parts inside are not safely de-energized, Rule 36-208 requires that the compartment door or cover be physically interlocked with an associated isolating or disconnecting means.

### Rule 36-210 Protection and control of instrument transformers

Rule 36-210 is intended to minimize the risk of serious faults developing from an insulation failure in a voltage transformer. Subrule 1) requires compliance with the overcurrent protection requirements of Rule 26-260 to reduce the probability that an insulation failure in a voltage transformer will propagate a fault to the supply conductors.

Subrule 2) allows flexibility in selecting a suitable disconnecting means. Manufacturers of high-voltage metal-enclosed and metal-clad switchgear usually incorporate a suitable disconnecting means, but designs can vary considerably.

### Rule 36-212 Outdoor installations

Rule 36-212 requires that field-assembled switches and fuses having exposed live parts be installed in a manner appropriate to their intended application, particularly with respect to preventing flashovers. The devices are to have the spacings indicated in Table 35 of the Code, in accordance with their voltage insulation level and operating characteristics.

Devices incorporating exposed live parts mounted on insulated supports (for example, porcelain insulators) are to be surrounded by free air to maintain the integrity of their insulation. Consequently, the phase-to-phase spacing of exposed live parts is critical. Minimum spacing is to take into account the possibility that foreign objects (for example, birds or squirrels) might effectively reduce the free-air separation to the point where an arc will be drawn. The spacing is also to be wide enough that, if a foreign object causes an arc to be struck and then falls away, the arc will not be sustained through the ionized air. During their operation, some devices emit ionized gases that can sustain an arc. Such devices require additional precautions. Table 35 of the Code addresses this by providing two ranges of values.

Horn-gap switches are non-load-breaking high-voltage switches designed to break the arc from the primary excitation current of a transformer when the secondary is open (load not connected). Subrule 2) requires that horn-gap switches be mounted in the horizontal position since the arc that is drawn as the contacts part is magnetically forced away from the contacts. This arc is not to strike in the direction of adjacent conductors or grounded parts of the structure. Horn-gap switches are operated through a mechanical linkage extending downward towards or near ground level and are to have provision for locking in the open position.

### Rule 36-214 Disconnecting means

The disconnecting means is the key element in the safe operation of a high-voltage power distribution system. It is necessary for it to be possible to isolate all or any portion of a high-voltage installation. Subrule 1) requires that disconnecting means be provided at each entrance to a building as well as at each connection to a branch circuit; to electrical equipment such as transformers, motors, electric furnaces or boilers; and to any other connected loads. This ensures that all conductors and apparatus within a building can be de-energized without having to physically trace all insulated conductors or cables to their source, which can be vital during an emergency in the building. The disconnecting means on the high-voltage conductors entering a building from a station is to be a load-breaking device installed

- inside the building at the entry of the conductors; or
- in the outdoor supply station that can be tripped or operated from inside the building.

Subrule 2) requires that the disconnecting means be capable of operation under load and that it incorporate a means of visibly verifying that the contacts are in the open position. Where a circuit breaker that is not of the draw-out type or a load-break switch is used that does not have contacts visible in the open position, a group-operated isolating switch is to be provided on the supply side that

- offers means for visible inspection of all contacts in both open and closed positions;
- is interlocked so that it cannot be operated under load; and
- has positive position indicators.

The requirement for a disconnecting means also applies to downstream conductors feeding other circuits or connected apparatus.

In some electrical installations, two or more sets of insulated conductors or cables are arranged to feed a commonly connected set of loads or branch circuits (for example, in a double-ended substation). In such cases, backfeed from one station is possible, either directly or through the portion of the station operating at low voltage. When this possibility exists, Subrule 3) requires that the visible isolation specified in Subrule 2) be provided on both sides of the load-breaking switch or circuit breaker. A sectionalizing (tie) switch or circuit breaker is also to have the same protection.

## Grounding and bonding

### Rule 36-300 Material and minimum size of grounding conductors and ground grid conductors and connections

As stated in Subrule 1), bare copper is the preferred conductor material due to its high and uniform conductivity as well as its resistance to many types of corrosion. However, Subrule 2) recognizes that the use of conductor material other than copper is sometimes more practical.

Subrule 1) specifies various minimum bare copper conductor sizes since the conductor is to be thermally and mechanically capable of carrying the maximum anticipated fault current without damage, and the voltage drop along the conductor is to be kept within acceptable limits during an energized conductor-to-ground fault. Other conditions (for example, anticipated lightning disturbances and sustained system-neutral currents) can also influence the determination of conductor size. These considerations are taken into account in the conductor sizes listed in Table 51, referenced in Subrule 1).

To comply with Item c) of Subrule 2) and the Appendix B Note to Rule 36-300, the material and devices used are to be certified to CSA C22.2 No. 41.

### Rule 36-302 Station ground electrode

Subrule 1) requires that every outdoor station operating at high voltage be connected to a station ground electrode that meets the requirement for maximum allowable resistance described in Rule 36-304. Subrule 1) requires that a station ground electrode consist of a minimum of four driven ground rods spaced at least the rod length apart and, where practicable, located adjacent to the equipment to be grounded. The driven ground rods are required to be manufactured and certified to CSA C22.2 No. 41. It is intended that the designer of the station ground electrode verify for each installation that the selected diameter and length of the ground rods are sufficiently in contact with the surrounding soil to comply with the station ground resistance requirements of Rule 36-304.

The requirements of Items b) and c) of Subrule 1) are intended to minimize any voltage differences between the ground grid conductor and the surface of the earth or any metal objects during transient circuit conditions (see Figures 36-7 and 36-16).

Item b) of Subrule 1) gives the required maximum burial depth of the ground grid conductors below the surface of the rough station grade and the minimum depth of the of the ground surface covering layer placed on top of the rough station grade. See Figure 36-8.

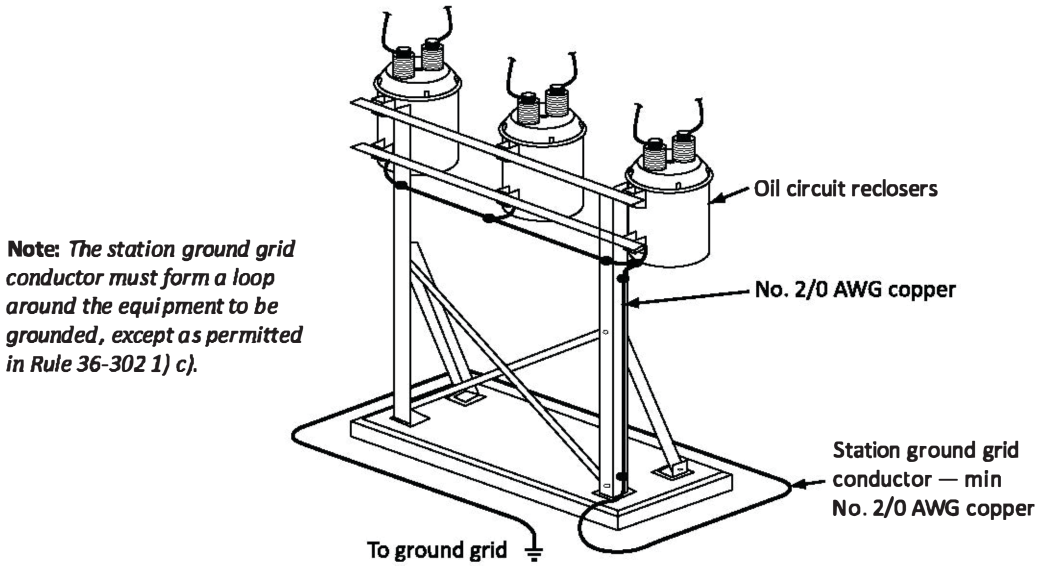
Item c) of Subrule 1) requires that buried ground grid conductors be connected to all non-current-carrying metal parts of equipment and structures, and that they form a loop around the equipment, which is then connected to the station ground electrode to protect people from lethal shocks by keeping touch and step voltages within acceptable limits. The loop is to go around the equipment to be grounded (see Figure 36-7) with the following exemptions:

- a portion of the loop can be omitted where an obstacle such as a wall prevents a person from standing on the corresponding side or sides of the equipment; and
- 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 (see Figure 36-10).

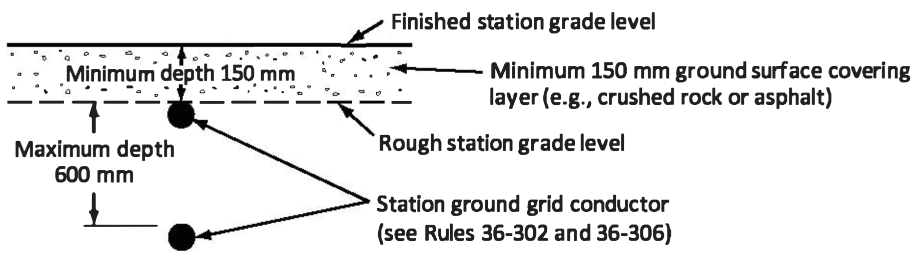
Subrule 2) addresses site conditions in which the ground rods required in Subrule 1) cannot be used by allowing an alternative type of buried ground electrode to be employed where appropriate. The Appendix B Note to Rule 36-302 2) recommends that any station grounding system design that does not use ground rods as specified by the Rules be documented and signed by an engineer, in addition to being subject to acceptance in accordance with Rule 2-030.

Subrule 3) provides requirements for installing a station ground electrode that conforms to Items a) and b) of Subrule 1) of Rule 36-302 in a remote location when soil or other conditions at the station (for example, high soil resistivity) make it impractical to locate the grounding electrode at the station as described in Item a) of Subrule 1) of Rule 36-302. In such cases, it is required that two grounding conductors of a minimum of No. 2/0 AWG copper connect the ground electrode to the station equipment in such a way that if one grounding conductor or ground electrode is damaged, no single metal structure or equipment frame could become isolated (see Figure 36-9).

## Figure 36-7
## Station ground loop

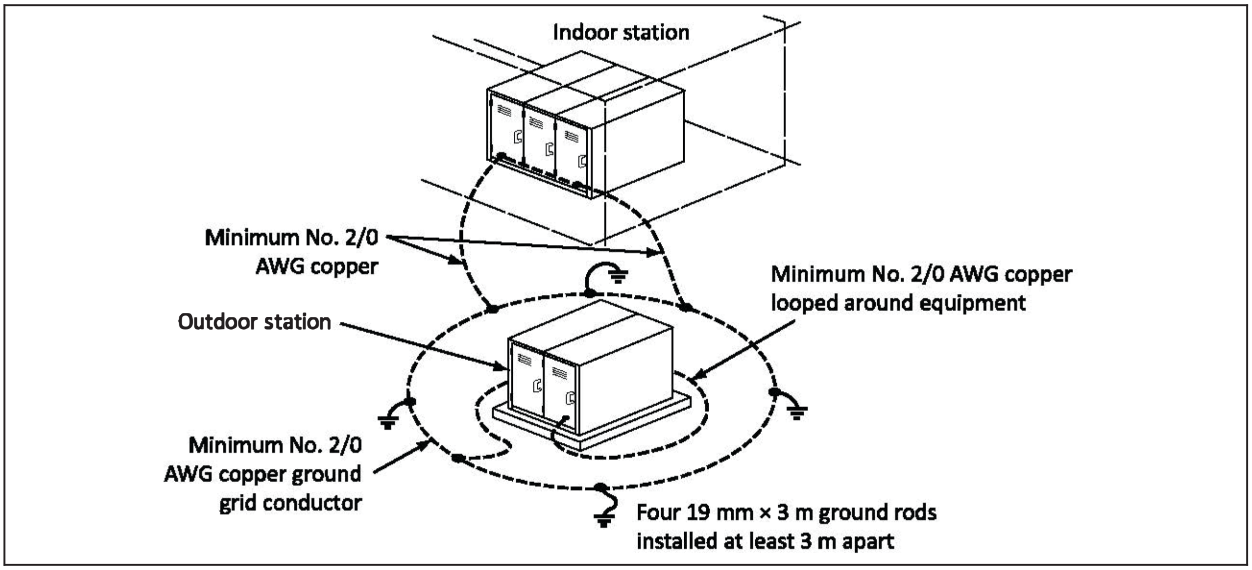



## Figure 36-8
## Burial depth of station ground grid conductor




Subrules 4) and 5) require that all metal non-current-carrying parts of an indoor station be bonded together with a copper conductor of at least No. 2/0 AWG and connected to the station ground electrode (see Figure 36-9). Subrule 4) is intended to ensure that all objects in an indoor station are maintained at the same potential as the station ground electrode, or as close to it as practical. The requirement in Subrule 5) for a No. 2/0 AWG copper conductor is intended to minimize voltage drop along the conductor in the event that it is required to carry fault current.

## Figure 36-9
## Grounding inside and outside equipment to remote grounding grid electrode




The reinforcing steel members (rebar) in building foundations can be effective grounding conductors because the concrete usually assumes the resistivity of the surrounding soil, as long as no insulating barrier (for example, a plastic sheet between the concrete and earth) prevents moisture from penetrating the concrete. Subrule 6) allows the use of the rebar of a building's foundations and concrete platforms as part of the station ground electrode design, which has proven to be effective in reducing station ground resistance. See Figure 36-10.

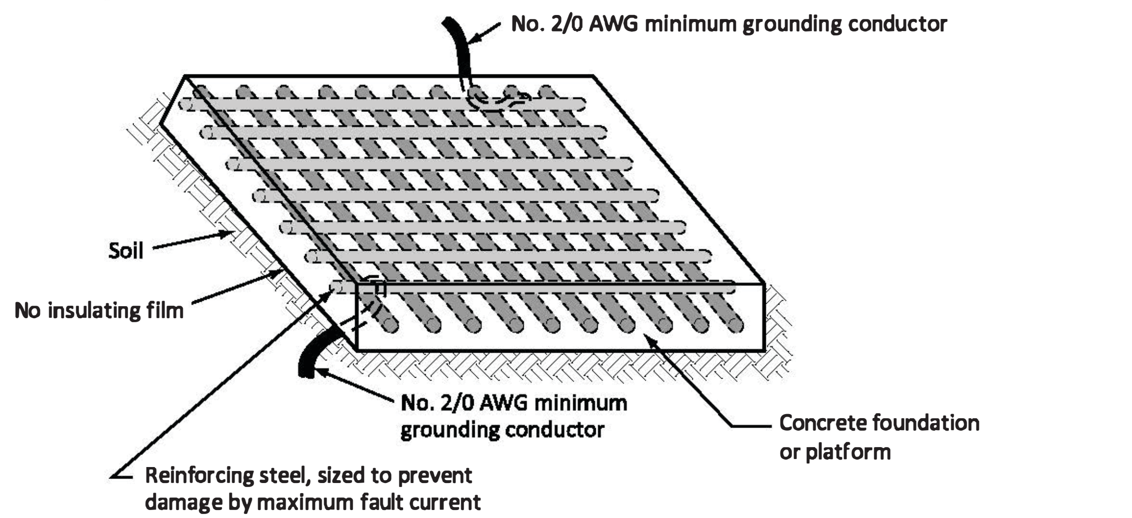
The Appendix B Note to Rule 36-302 6) refers to IEEE 80 for guidance on sizing conductors to prevent thermal damage to the rebar during fault conditions.

### Rule 36-304 Station ground resistance

Limiting the potential (voltage) rise of a station ground grid to a safe value under all conditions can be an engineering challenge since the resistance of the station ground electrode is never zero. In the worst case, the available fault current is very high and the resistance of the soil is high. If the potential rises on the station ground grid under fault conditions, lightning strikes, or surges, then the people, equipment, non-current- carrying exposed metal, etc., in the station and its immediate vicinity are all at the same potential (for example, birds on an energized wire) and are vulnerable if they contact something that is not at the same potential.

To protect operators and others from harmful voltages that can appear on surfaces bonded to ground when a high-current fault occurs, such voltages are to be held to acceptable levels by the resistance of the station ground electrode. Subrule 1) requires that this resistance be such that the maximum available ground fault current injected into the ground by the station ground electrode, or the maximum station fault current multiplied by the ground resistance, does not permit the potential (voltage) to rise above a maximum of 5000 V on all parts of the station ground grid. When determining the ground resistance, Subrule 1) requires that all the soil conditions that exist in practice (for example, wet, dry, and frozen conditions) be taken into consideration. In practice, the tests need to be repeated for all soil conditions and monitored periodically. When, under special conditions, the 5000 V maximum cannot be reasonably achieved, Subrule 1) allows the voltage rise to be increased to the maximum insulation level of the communication equipment (for example, equipment used to monitor and operate equipment from a remote location), subject to a deviation that has been allowed in accordance with Rule 2-030.

## Figure 36-10
## Using rebar in a grounding system




While Subrule 1) limits the ground potential rise, Subrule 2) requires that the step and touch voltages not exceed the values listed in Table 52 of the Code. This requirement applies to areas at the edge of, within, and around the station ground electrode, including all metallic structures that are electrically connected to the station (see Rule 36-308).

Subrule 3) specifies that if a station ground electrode design has been developed in accordance with CEA 249 D541 [cited in the Appendix B Note to Rule 36-304 3)] and the parameters used in the design have been validated, the electrode design is deemed to meet the requirements of Subrules 1) and 2).

After the completion of each station, Subrule 4) requires the verification (or testing and commissioning of a high voltage station by qualified persons) that the station ground electrode resistance does not exceed the permissible resistance specified in Subrule 1). This ensures that if a fault occurs, personal safety is not compromised.

Subrule 5) gives requirements concerning the ground surface covering layer and the uniformity of the materials used throughout a station. If different materials are used for the ground surface covering, a safety hazard can result if there are different touch and step voltages in different areas of the station. The ground surface covering layer is to extend 1 m beyond the station ground electrode area on all sides. Given that the station ground electrode area is to be a minimum of 1 m outside the station fence, the ground surface covering layer is to extend 2 m outside the station fence (see Figure 36-20).

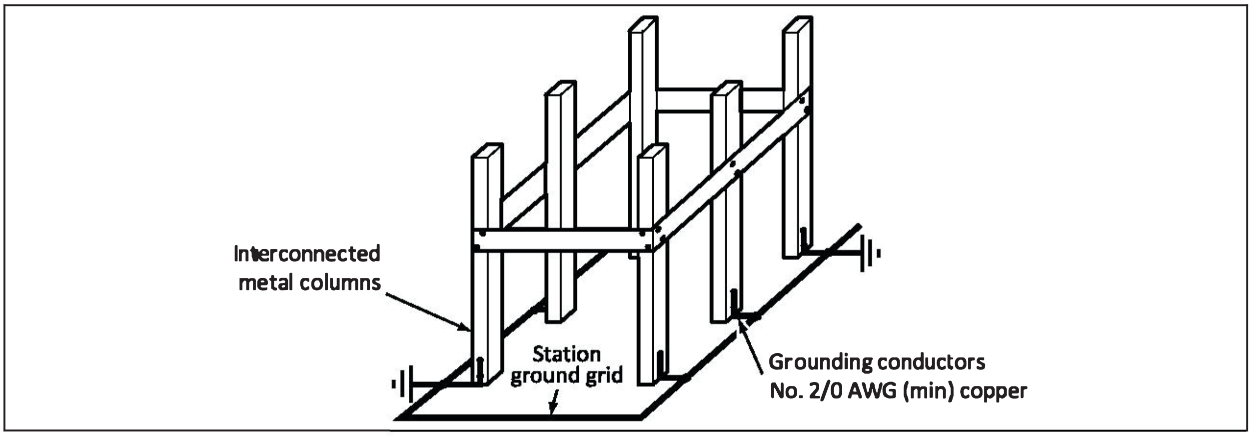
### Rule 36-308 Connections to the station ground electrode

Any non-current-carrying metal object, unless grounded to the station ground electrode, can experience a rise in voltage (potential) to ground or to other nearby objects, either because of induction or because of voltage gradients created by the passage of high fault currents to ground. Subrule 1) requires that all non-current-carrying metal equipment and structures be grounded by connection to the station ground electrode.

Since these items are not all of the same nature or size, different means are required to connect them to the station ground electrode. Rule 36-308 covers many such means. The intent is always to maintain each item at the same voltage (potential) relative to all the others and to the earth.

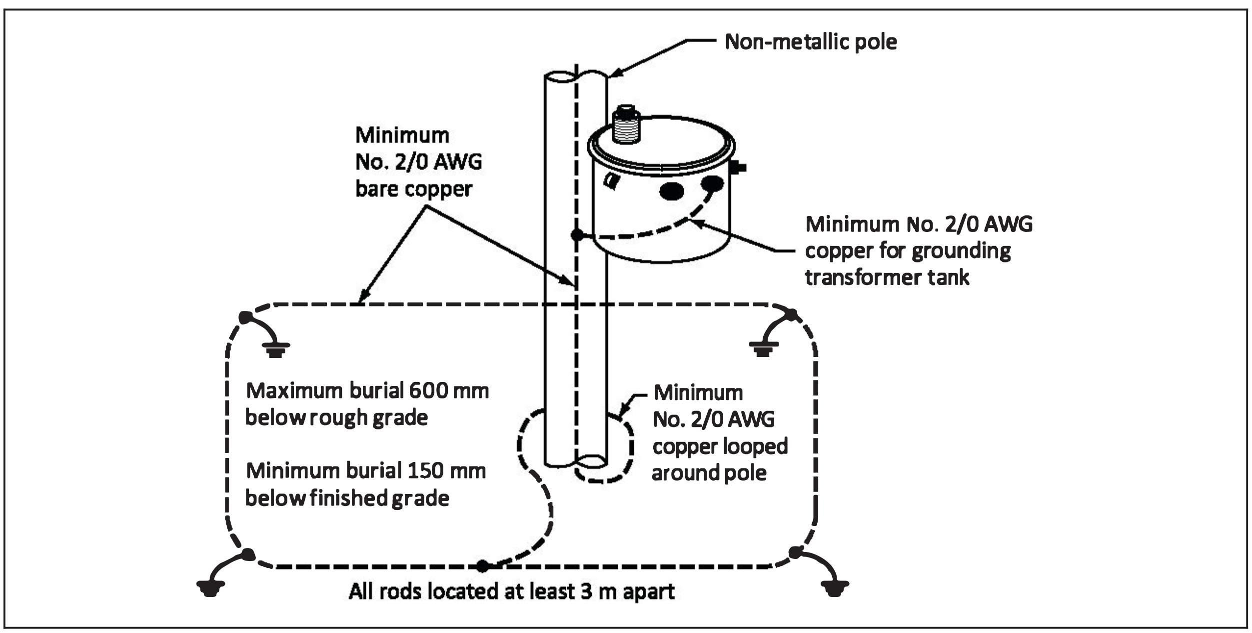
Subrule 2) addresses a variety of structural features, apparatus, and equipment. Item a) of Subrule 2) is intended to prevent unwanted currents from flowing through metal structures, such as single columns or pedestals and single- and multi-bay structures, when a voltage gradient exists between the bases of two or more columns. Each column or bay, whether by itself or forming a part of a multi-bay structure, is to be grounded at each column by a conductor of at least No. 2/0 AWG copper (see Figure 36-11).

## Figure 36-11
## Connections to station ground electrode — Supporting columns




Metallic structures or the metallic devices mounted on non-metallic structures are not to be used as a conductor to ground. Item b) of Subrule 2) requires that all metallic non-current-carrying parts mounted on such structures be individually grounded (see Figure 36-12). This is optional, however, in the case of single-pole isolating switches or fuse cut-outs mounted on a non-metallic structure (typically, a wooden pole). The metal base of these devices is usually elevated well beyond a touch distance and therefore does not constitute a hazard.

## Figure 36-12
## Grounding pole-mounted equipment

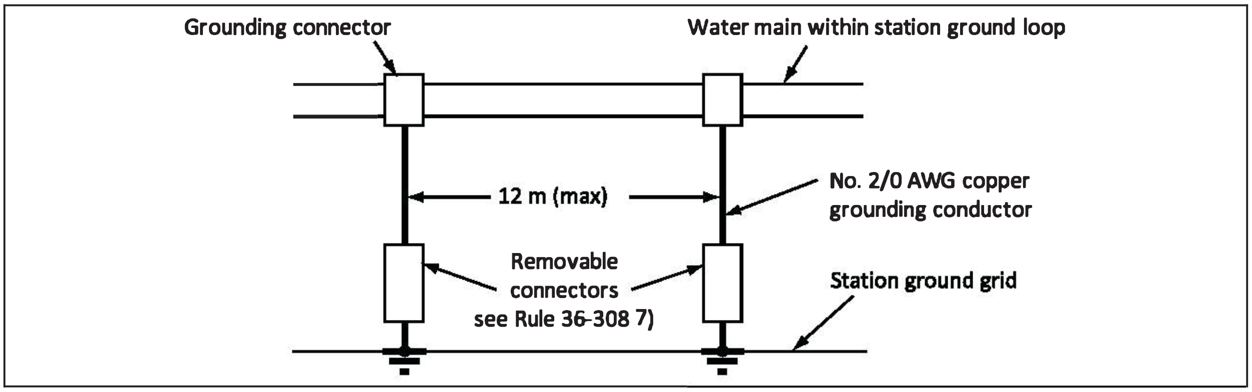


Lightning arrester grounding paths are to be of low impedance to reliably carry off the high current and variable frequencies characteristic of lightning discharges. Item c) of Subrule 2) requires that these conductors be

- at least No. 2/0 AWG copper;
- as straight and short as possible to keep the inductance to a minimum; and
- connected to the metal potheads, cable shielding, or cable sheaths where the arrester protects a high-voltage cable and sheath.

As voltage gradients can exist along the path of a water main, the main is to be bonded to ground at intervals along its length. Item d) of Subrule 2) requires that a metal water pipe be grounded at intervals of 12 m or less to prevent unwanted currents from flowing through the pipe (see Figure 36-13).

**Figure 36-13**
**Connections to station ground electrode — Water main**



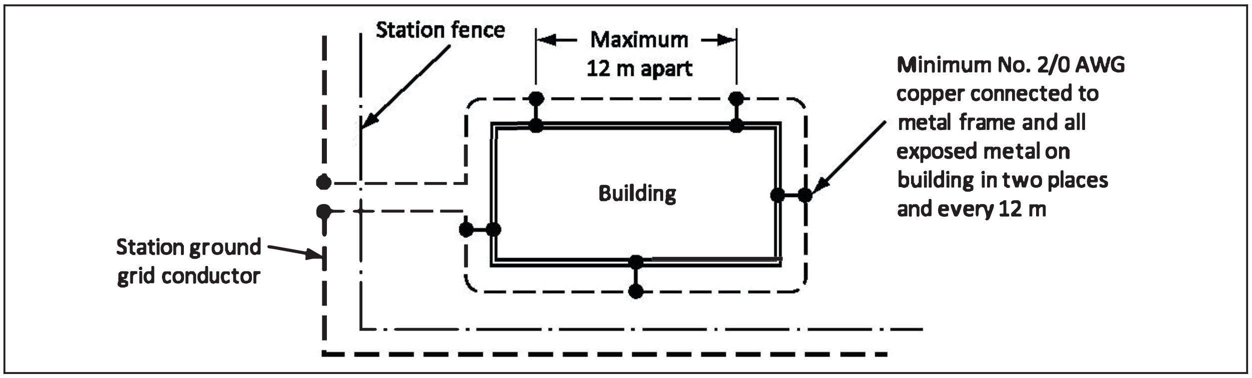

The non-current-carrying parts of metal equipment such as cable sheaths, potheads, raceways, pipe work, screen guards, meters, instruments, and exposed metal work on buildings are to be grounded to the station ground electrode in accordance with Item e) of Subrule 2) (see Figure 36-14). Item e) of Subrule 2) allows the use of smaller grounding conductors than those specified elsewhere in Subrule 2) since the apparatus involved is less susceptible to excessive transient voltage and is often too small to accommodate a connection to a No. 2/0 AWG copper conductor. The intent, however, is still to keep the touch voltage to a minimum.

Item f) of Subrule 2) requires insulated rail joints at the point at which any rail spur enters the station (see Figure 36-15). This is intended to prevent an elevated ground grid voltage from being propagated along the steel rails of railway spur tracks beyond the boundary of the station ground electrode area and to limit the tolerable values of step and touch voltages to those given in Table 52.

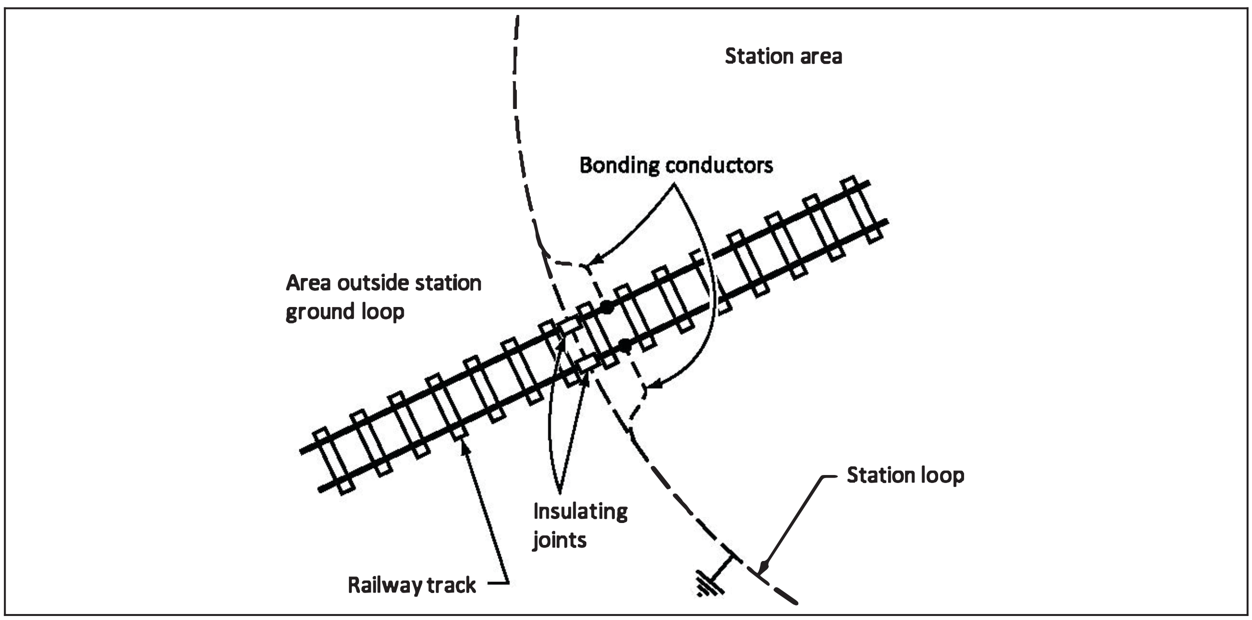
When it can be shown that touch and step voltages around a building are within the acceptable limits set out in Table 52, Subrule 3) waives the requirement for a buried loop [see Item c) of Rule 36-302 1)].

Subrule 4) requires that an overhead ground wire entering the station be connected to the station grounding electrode by at least a No. 2/0 AWG copper conductor, bare or insulated, to protect against dangerous voltages during transient circuit conditions. Such a connection is intended to decrease the fault current injected into the ground by the station during a fault, which is likely to reduce the ground potential rise.

## Figure 36-14
## Grounding of exposed metal work on buildings




## Figure 36-15
## Connections to station ground electrode — Railway tracks



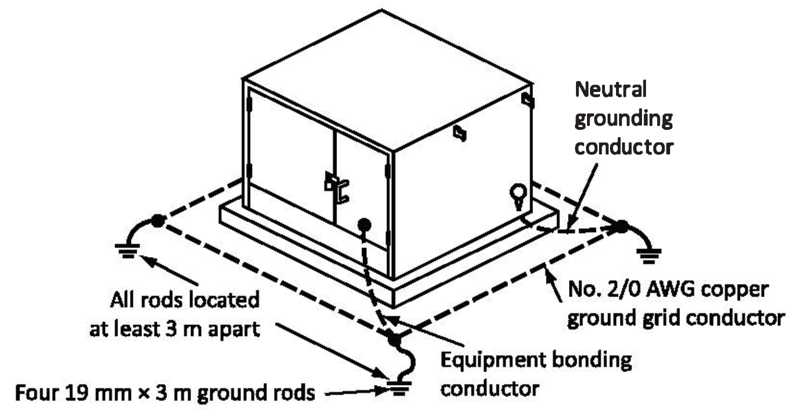

Subrule 5) requires that the grounding conductor on a grounded neutral system have an ampacity not less than the line neutral conductor. The grounding conductor is to be capable of carrying normal full-load current continuously in case of a discontinuity or an opening in the neutral conductor.

Item a) of Subrule 6) requires that the transformer neutral on a grounded system be connected to the station ground electrode by a second grounding conductor in addition to the one required by Item b) i) of Subrule 2). This conductor is to be not less than No. 2/0 AWG copper and is to have sufficient ampacity to carry the maximum ground fault current of the transformer as specified in Table 51 (see Figure 36-16).

An exception to the No. 2/0 AWG requirement in Item a) of Subrule 6) is allowed for the grounding of low-voltage secondary neutrals, provided that they are sized in accordance with the requirements in Section 10 and are suitable for the maximum ground fault current on the transformer secondary.

The Appendix B Note to Rule 36-308 6) recommends that in a solidly grounded system, the secondary grounding conductor not be less than No. 2/0 AWG and that those systems using a neutral resistance or impedance grounding device be sized in accordance with Section 10.

**Figure 36-16**
**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.*

## Rule 36-310 Gang-operated switch handle grounds

A malfunction in the operation of an exposed switch mounted on an open structure can easily result in a line-to-ground fault. The passage of fault current down the supporting structure or the mechanical linkage to the switch-operating handle at ground level can create a significant rise in the touch and step voltage (potential) at that location.

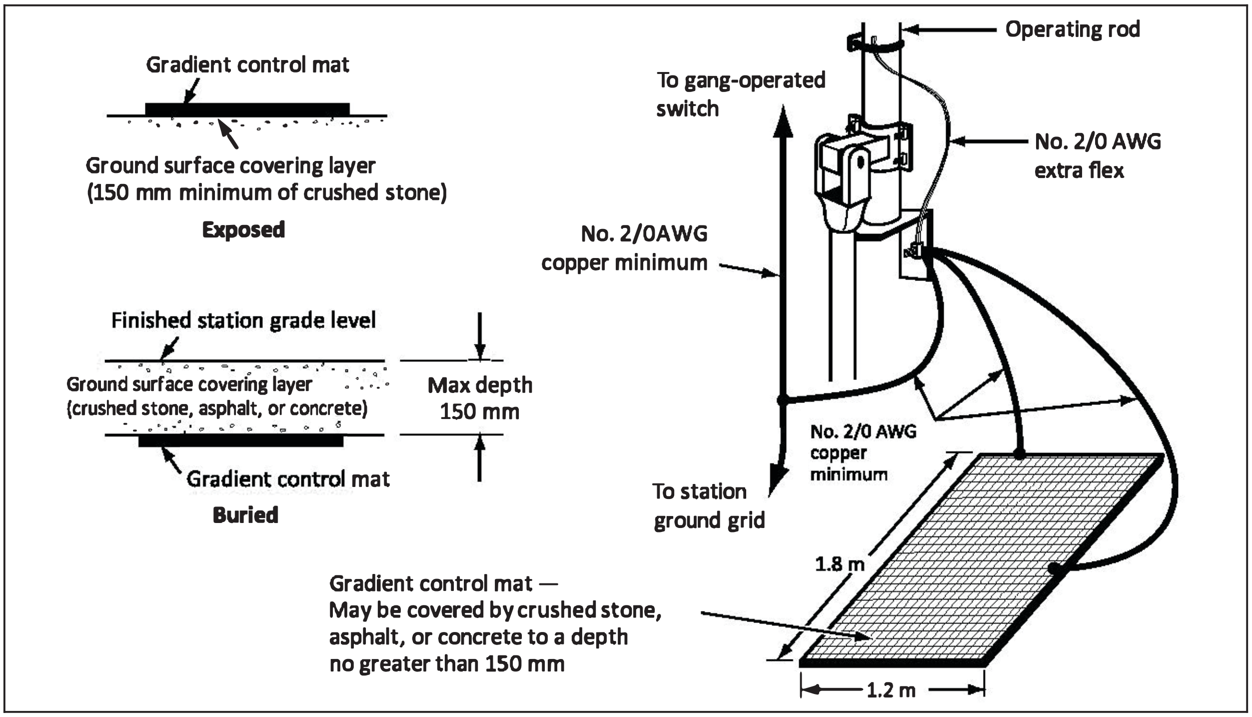
Grounding the handle of a non-enclosed gang-operated switch (i.e., a multiple-pole switch) with a minimum No. 2/0 AWG grounding conductor connected to the station ground electrode, as required by Subrule 1), is intended to minimize the ground potential rise. Depending on the type of operating mechanism, the grounding method used is to be

- a multi-revolution grounding device (a device that ensures electrical continuity between the moving mechanism controlling the gang-operated switch and the connection to ground); or
- a combination of extra-flexible conductor, braid, and/or stranded conductor grounding the operating shaft.

Grounding the handle is not always sufficient to ensure operator safety. The voltage gradient across the ground surface in the immediate vicinity of the point of entry of the fault current can be substantial, and touch and step voltages can exceed the values permitted by Table 52. Subrule 2) gives requirements for installing and grounding a gradient control mat for the operator to stand on when operating the switch. This ensures that the operator is always at essentially the same voltage (potential) as the handle and prevents the operator from becoming part of the current path to earth (see Figure 36-17).

IEEE 80, IEEE 837, CSA C22.2 No. 41, and CEA 249 D541 provide technical information that will assist the designer in ensuring that safety issues are properly addressed in the design of a gradient control mat.

## Figure 36-17
## Grounding of gang-operated switch handle

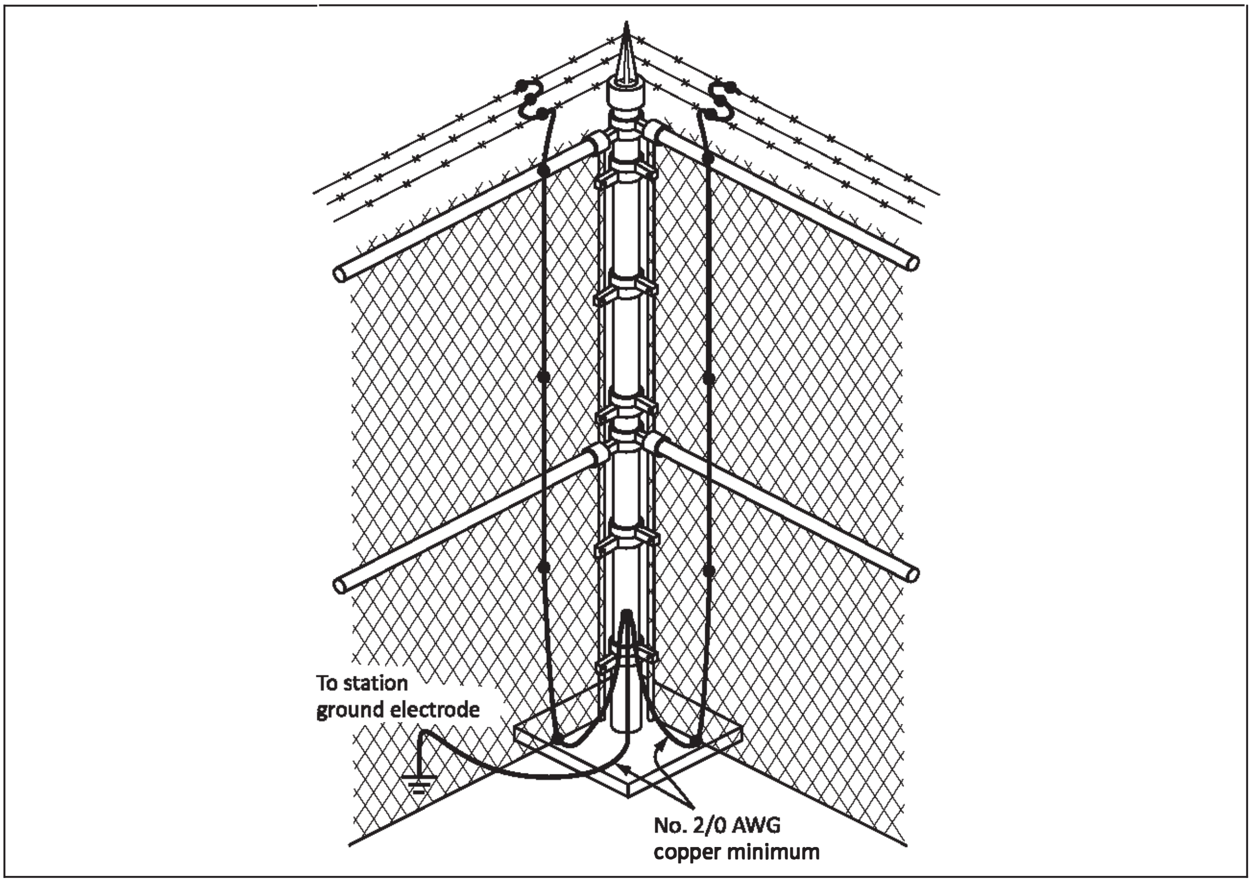



### Rule 36-312 Grounding of metallic fence enclosures of outdoor stations

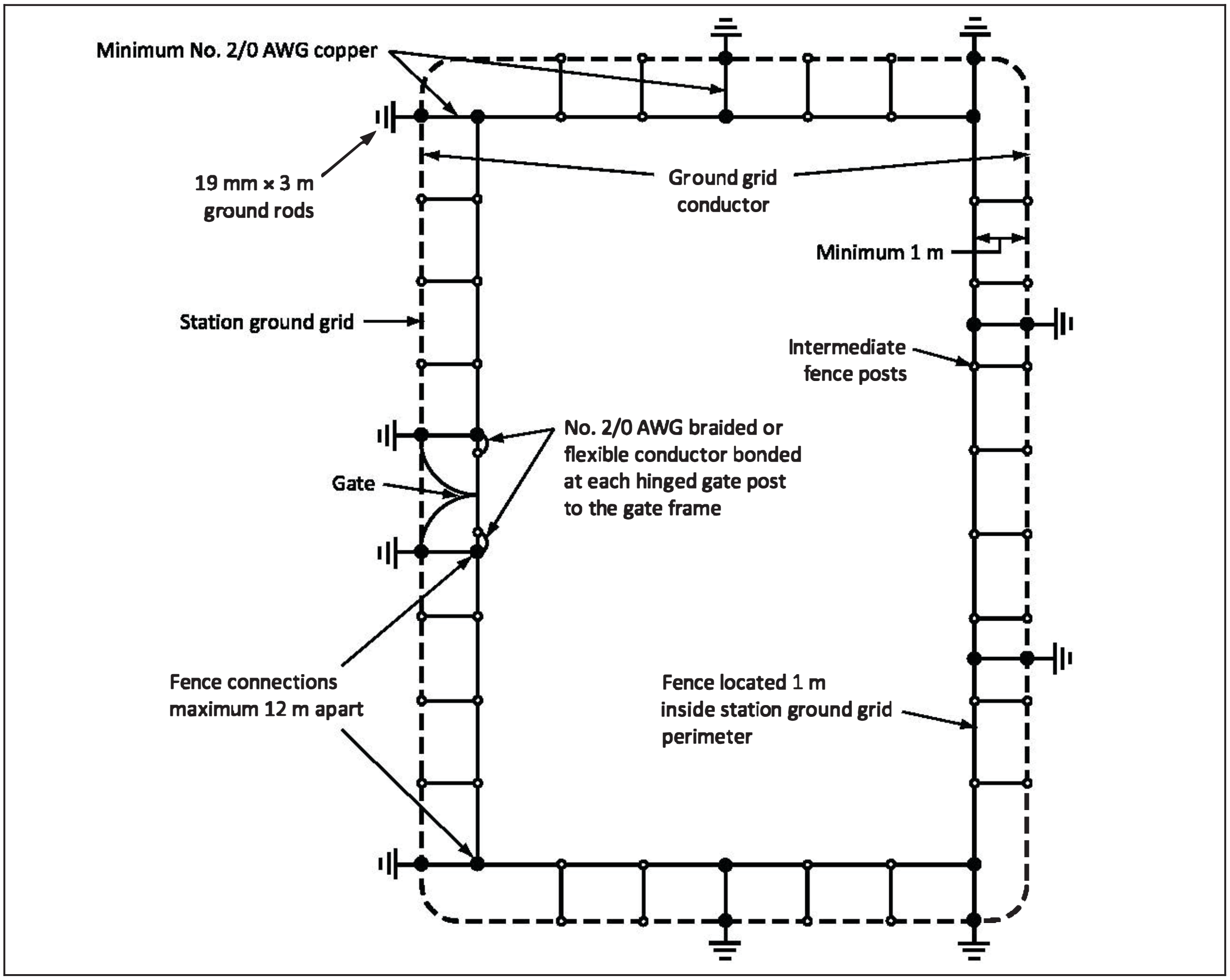
Rule 36-312 adds to the requirement in Subrule 1) of Rule 36-308 for grounding of non-current-carrying metal parts in or around a station operating at high voltage. The fence is typically a metallic structure located within the area of the station ground electrode. The station ground electrodes underlying the station provide safe touch and step voltages throughout the entire station area. The fence is to be located so that it cannot be contacted by a person standing outside the station ground electrode area.

Subrule 1) requires that the metallic fence enclosure of outdoor stations be located a minimum of 1 m inside the perimeter of the station ground electrode area. The grounding system for the fence is specified in Subrules 2), 3), and 4) (see Figures 36-18 and 36-19).

## Figure 36-18
## Grounding at corner post

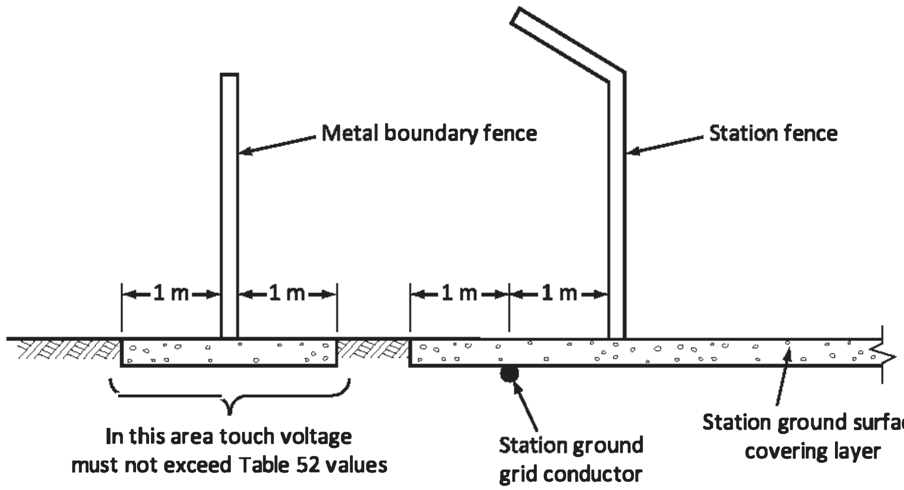


## Figure 36-19
## Fencing inside ground grid electrode area




Subrule 5) requires that when there is a metal boundary fence in proximity to the station fence, the touch voltages within 1 m of the boundary fence are not to exceed the limits in Table 52 (see Figure 36-20).

# Figure 36-20
# Boundary fence and station fence




**Note:** *When the touch voltage exceeds Table 52 values, the boundary fence must be bonded to the station fence every 12 m by a minimum No. 2/0 AWG copper conductor.*

# Section 38 — Elevators, dumbwaiters, material lifts, escalators, moving walks, lifts for persons with physical disabilities, and similar equipment

## Rule 38-001 Scope

Section 38 includes additional and specific requirements for the installation of electrical equipment and wiring for the transportation devices covered by ASME A17.1/CSA B44 and CSA B355. These Standards specify the safety and operational requirements for elevators, dumbwaiters, material lifts, escalators, moving walks, and lifts for persons with physical disabilities. The Code addresses fire and shock hazards, and maintenance and operational requirements related to the installation and electrical connection of these devices.

## Rule 38-002 Special terminology

New technology expands on the traditional use and meaning of "controller", as microprocessors and other microelectronics allows control functions to be physically distributed in different locations. Micro-technology, which introduces new safety considerations, typically operates at low voltage levels and at power levels that are measured in microwatts and milliwatts.

This Rule has definitions for *motor controller*, *operating device*, and *signal equipment*, which apply only to Section 38.

## Rule 38-003 Voltage limitations

Staff who are not skilled in working with electrical equipment often operate transportation equipment devices covered in Section 38, while staff trained to service only the devices covered in this Section maintain this equipment. Therefore, voltage in machine rooms and cars of elevating devices is limited to 750 V or less.

The Appendix B Note to Rule 38-003 references CSA B44.1/ASME A17.5 for guidance on voltage limitations within equipment.

## Rule 38-005 Working clearances

Working clearances around electrical equipment in elevating devices must be large enough to allow maintenance, servicing, and troubleshooting to be performed safely and quickly. The clearances required by Rule 2-308 may be relaxed under the conditions specified in Rule 38-005. With the reduced working clearances and spaces, the hazards of contacting live equipment is greatly increased when examinations, adjustments, servicing, and maintenance are carried out. Therefore, Subrule 2) sets out the requirements for electrical equipment installed with the reduced working clearances and spaces.

## Rule 38-011 Insulation and types of conductors

For safety, and fire and smoke protection, all conductors and cables used for elevating devices, except travelling cables, must

- be selected in accordance with Rule 12-102 3), Rule 12-122 1), Rule 12-402 1), and/or Rule 12-406 1) for the applicable conditions of use;
- have an insulation voltage rating greater than or equal to the circuit voltage of any other conductor in the enclosure, cable, or raceway; and
- meet the general flame spread requirements of Rule 2-130 for cables and Rule 2-132 for raceways.

Travelling cables used as flexible connections between the car or counterweight and the raceway must be selected in accordance with Rule 12-406 1) or be of other types approved for the purpose.

## Rule 38-012 Minimum size of conductors

The control and operation of elevating devices, as well as the associated lighting, emergency communication, and various signalling devices, depend on the continued integrity of the travelling cables. The travelling cables provide connections between moving parts and between moving parts and fixed equipment for the safe operation of the elevating equipment, and in particular the safety of the individuals using the equipment. Subrule 1) specifies the minimum sizes of conductors for travelling cables to guard against breaking of the conductor or damage to the insulation on the conductor due to flexing and to provide protection from electrical disturbances, such as a voltage drop, that might cause a stall, false signals, or loss of lighting.

Microelectronic circuits, which consist of an assembly of discrete electrical components connected in an extremely small and compact form, operate only with very small currents ordinarily carried by relatively small conductors. As part of a travelling cable, however, the microelectronic circuit conductors must be large enough to withstand the mechanical stress of flexing and be sized larger than strictly required for the current levels involved.

When the wiring method used for conductors involves fastening them to the hoistway or to fixed pieces of the elevating equipment or structure, vibration and flexing are not a concern, and the higher level of mechanical strength provided by larger conductor sizes is not necessary. In these cases, Subrule 2) allows the minimum size of conductor to be reduced to No. 26 AWG copper.

## Rule 38-013 Ampacity of feeder and branch-circuit conductors

The drive motors used in elevating devices typically have a non-continuous duty cycle. At any given time, an elevating device can be running fully loaded, running with no load, or resting. The current that the motor draws from the line might exceed the nominal nameplate value for short periods of time (such as when an elevator or escalator is fully loaded with people). There are also operational periods when the current levels are below the nameplate value (such as when an elevator or escalator is running with no load), as well as periods when no current is drawn (such as when an elevator is waiting at a floor level).

The heating of motor conductors depends on the root-mean-square (rms) or effective current value, which is specified by the nameplate current rating of the motor controller. The rms or effective current value is the amount of alternating current (ac) that produces the same heating effect as that produced by an equal amount of direct current (dc). For an ac sine wave form, the rms value is equal to 0.707 times the peak or maximum current value.

The elevator manufacturer considers the design or application and selects the size, type, and duty cycle (the ratio of full-load to no-load to at-rest operational cycles) of the motor. These duty cycles determine the nameplate current rating of the associated motor controller. The Appendix B Note to Rule 38-013 2) a) refers to the values in Table 27, which are based on the classifications of service and the time ratings for the non-continuous duty motors.

In some elevators, a motor-generator set supplies power to the driving motor of the elevator machinery. In such cases, the nameplate current rating of the motor-generator set is used to determine the ampacity of the driving-motor supply conductors.

Rule 38-013 also notes those factors that must be considered along with the nameplate rating when determining the minimum ampacity of conductors for
- a single motor;
- a single motor controller;
- a single power transformer; and
- more than one motor, motor controller, or power transformer.

## Rule 38-014 Feeder demand factor

A feeder that supplies several cars and that has an operational cycle of an irregular nature is unlikely to require the sum total of all the equipment's nameplate currents simultaneously; this reduces the potential heating of the feeder conductor. The factors in Table 62 may be used to adjust the feeder ampacity requirements for elevator equipment, taking into account the number of elevators connected to the feeder. These factors, which are based on an operational cycle of half-time load, half-time no load, correlate the current values for multiple intermittent duty cycle applications with the values for continuous duty cycle applications (see Section 28).

### Rule 38-015 Motor controller rating

Motor controllers for elevator motors do not differ from controllers for other motor applications and must meet the rating requirements of Subrule 1) of Rule 28-500. In some installations, such as adjustable speed drive systems, the motor controller limits the power available to the motor. In this case, the elevating device does not require the full nameplate current of the driving motor to be used. Where the motor controller limits the power and is marked "power limited", Rule 38-015 permits the use of a controller with a rating lower than the motor's nameplate rating. The amount of reduction of the controller rating allowed will depend on the application.

### Rule 38-021 Wiring methods

Rule 38-021 sets out requirements for wiring methods, conductors, and cables that are used in the installation of electrical equipment and devices in elevators, escalators, and lifts for persons with physical disabilities. It requires that wiring methods, conductors, and cables

- not be exposed to mechanical damage; and
- be made of non-metallic material or provided with non-metallic outer jackets meeting the flame spread rating (FT) required by the *National Building Code of Canada* (see Rules 2-130 and 2-132 of the *Canadian Electrical Code, Part I*).

The Appendix B Note to Rule 38-021 1) a) ii) explains that certain electrical protective devices required by ASME A17.1/CSA B44 and CSA B355 can result in a direct life hazard and recommends that Class 1 wiring methods be used even where the circuit has the characteristics of a Class 2 circuit (see Rule 16-010).

### Rule 38-022 Branch circuits for car lighting, receptacles, ventilation, accessories, heating, and air conditioning

To avoid safety hazards and discomfort, passengers in elevator cars should not be deprived of light, heat, or cooling due to power interruptions related to equipment and devices not located on the elevator car. Subrule 1) requires that at least one branch circuit be provided solely for the car lights, receptacles, auxiliary lighting power source, accessories, and ventilation on each car.

As heating and cooling loads are typically larger, Subrule 2) requires that each heating and cooling unit installed on an elevator car have its own branch circuit.

Subrule 3) requires that the overcurrent protective devices for these branch circuits be located in the elevator machine room or control room/machinery space or control space so that they are readily accessible for quick and convenient elevator maintenance but inaccessible to unauthorized personnel.

### Rule 38-023 Branch circuits for machine room or control room/machinery space or control space lighting and receptacle(s)

To prevent nuisance tripping of the lighting and receptacle(s) in the machine room or control room/ machinery space or control space, Subrule 1) requires that the lighting and receptacle(s) be supplied by a separate branch circuit with its own overcurrent device. This helps to prevent hazards related to moving around operating equipment or resetting a tripped circuit in the dark. Nuisance tripping of the overcurrent device is also prevented by the Subrule 2) requirement that GFCI-type overcurrent devices not be used to protect the lighting branch circuit.

For the safety and convenience of people maintaining or servicing equipment, Subrule 3) requires a lighting switch at the point of entry to the machine room or control room/machinery space or control space.

Subrule 4) requires that at least one 5-15R duplex receptacle be provided for the use of people servicing or maintaining the installation in each machine room or control space.

The Appendix B Note to Rule 38-023 references ASME A17.1/CSA B44 and CSA B355 for determining the minimum illumination levels for elevators, escalators, and lifts for people with disabilities.

### Rule 38-024 Branch circuit for hoistway pit lighting and receptacles

Subrule 1) requires a separate branch circuit for the lighting located in the hoistway pit to prevent nuisance tripping of the lighting branch circuit, a hazard associated with moving around operating equipment or resetting a tripped circuit in the dark. For the same reason, Subrule 2) requires that GFCI-type overcurrent devices not be used to protect the lighting branch circuit. Rule 38-085 provides additional information on ground fault protection for receptacles in pits and hoistways.

Subrule 3) requires that a lighting switch be located at the point of entry of a hoistway pit to ensure safety and accessibility for people maintaining or servicing equipment in this area.

Subrule 4) requires that at least one 5-15R duplex receptacle be provided in the hoistway pit to use during servicing or maintenance of the installation.

The Appendix B Note to Rule 38-024 references ASME A17.1/CSA B44 for determining the minimum illumination levels for hoistway pits.

### Rule 38-025 Branch circuits for other utilization equipment

Rule 38-025 requires that a separate branch circuit supply any electrical equipment not identified in Rules 38-022 to 38-024 that is located on elevator cars and in the machine room, control room, machinery space, control space, or hoistway pit. Overcurrent devices for such branch circuits must be located in the machine room, control room, machinery space, or control space so that service and maintenance personnel can easily locate and gain access to the devices.

### Rule 38-034 Supports

Rule 38-034 specifies requirements for the support of cables or raceways in hoistways, escalators, moving walk wellways, and the hoistway or runway for a material lift or a lift for persons with physical disabilities. This is to prevent mechanical damage to the cable or raceway and interference with the moving parts of the elevating devices.

### Rule 38-035 Auxiliary gutters

An auxiliary gutter is a raceway consisting of a sheet metal enclosure used to supplement the wiring space of electrical equipment and to enclose interconnecting conductors. When an auxiliary gutter is used as part of the supply installation for elevating devices, the requirements of Rules 12-1900 to 12-1904 apply.

### Rule 38-036 Grouping of conductors

When conductors associated with different systems (for example, power supply, control circuits, communications systems) are grouped in the same cable or raceway, consider the following factors:

- the space in hoistways and machine rooms is confined;
- elevator equipment is maintained and serviced by trained elevator technicians; and
- the operation of elevators involves the control of motors, movement of the car, indicating lights (signals), lighting, telephones, and other accessories, and all these circuits are contained in the hoistway and machine room.

Taking into account these factors, and to prevent the migration of voltage from one system's conductors to another's, Rule 38-036 requires that conductors of different systems that are run in the same raceway or travelling cable be provided with insulation suitable for the maximum voltage rating of any conductor in the raceway or travelling cable. Where the voltage rating of the insulation of some of the conductors located in the cables or raceways is not high enough or in cases where cables with higher ratings are not available, other separation methods must be employed (such as multi-channel raceways – see Rule 12-904).

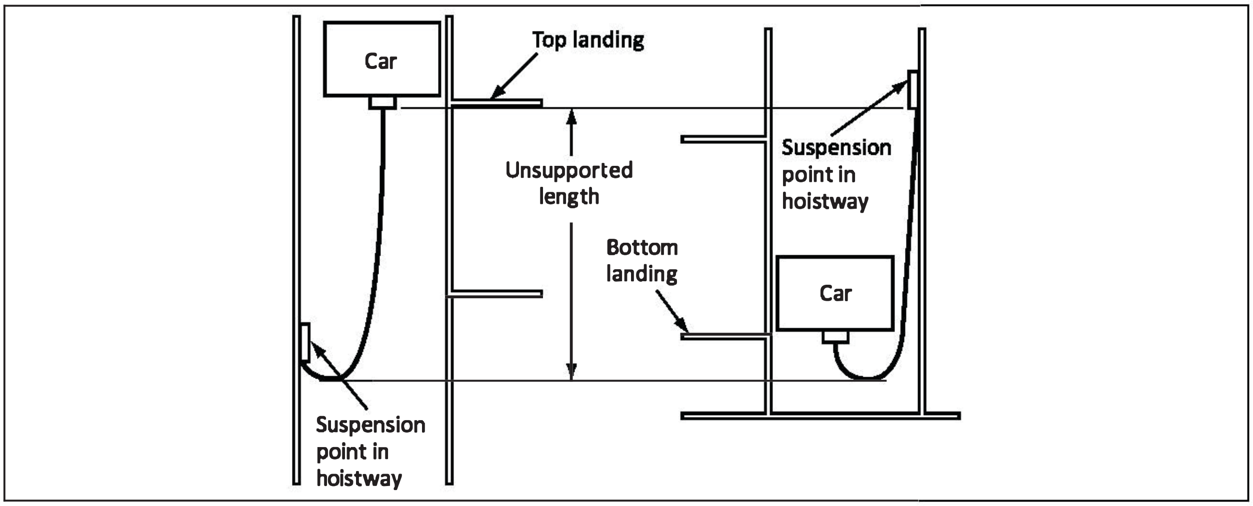
### Rule 38-037 Wiring in hoistways, machine rooms, control rooms, and machinery spaces and control spaces

To prevent other building systems from interfering with the operation of elevating devices and to keep unauthorized personnel out of hoistways, runways, machine and control rooms, machinery and control spaces, and escalator wellways, Rule 38-037 requires that only the conductors associated with the operation of elevating devices be allowed in these areas. An exception is allowed in accordance with Rule 2-030 and explained in Rule 12-014.

### Rule 38-041 Suspension of travelling cables

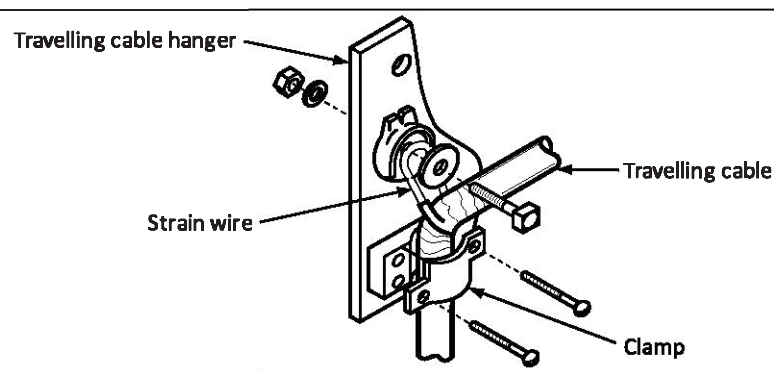
Elevator travelling cables are fastened at one end to the underside of the elevator car and at the other end to the hoistway structure or counterweight, and hang in a loop in the hoistway (see Figure 38-1).

**Figure 38-1**
**Elevator's travelling cable system**



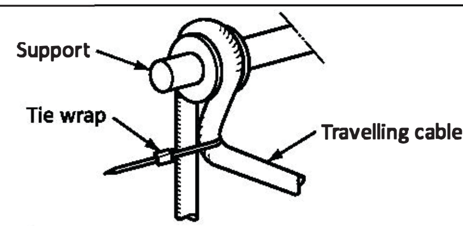

The fastenings should be designed to reduce strain on the individual conductors in the travelling cable. When the car is at the lowest landing, if the unsupported length of cable (as defined in the Appendix B Note to Rule 38-041) from the hoistway to the fastening at the underside of the car (that is, the lowest point of the loop) exceeds 60 m, the steel support filler (that is, strain wire) in the cable must be used to support the weight of the cable (see Figure 38-2).

**Figure 38-2**
**Travelling cable support — Strain wire**



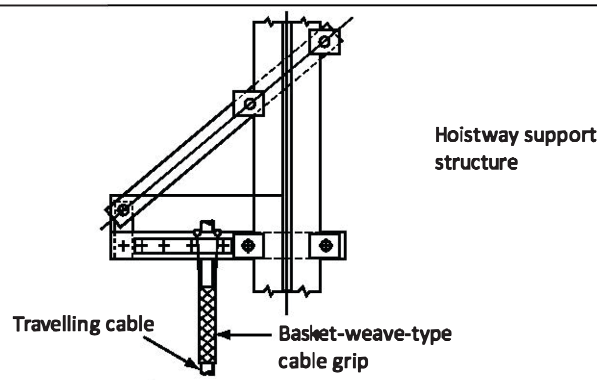

For unsupported lengths less than 30 m, Item b) of Subrule 2) permits the weight of the cable to be supported by simpler methods, such as looping the cable around a support (see Figure 38-3).

**Figure 38-3**
**Travelling cable support — Simple loop**




Alternatively, Item c) of Subrule 2) permits lengths of up to 60 m to be supported by a means that automatically tightens around the cable when tension is increased, such as the basket-weave-type cable-gripping device (see Figure 38-4).

**Figure 38-4**
**Travelling cable support — Cable-gripping means**




### Rule 38-051 Disconnecting means

Service personnel must have a ready means of interrupting all the supply circuits to electrical equipment for normal servicing, maintenance, and installation, as well as in emergency situations. Rule 38-051 requires that a plainly marked disconnecting means that can disconnect all ungrounded conductors supplying power to elevator or escalator motors, control circuits, and motor ventilation be located in the machine or control room or space. A similar disconnecting means must be provided for the lighting, ventilation, and air conditioning in each car.

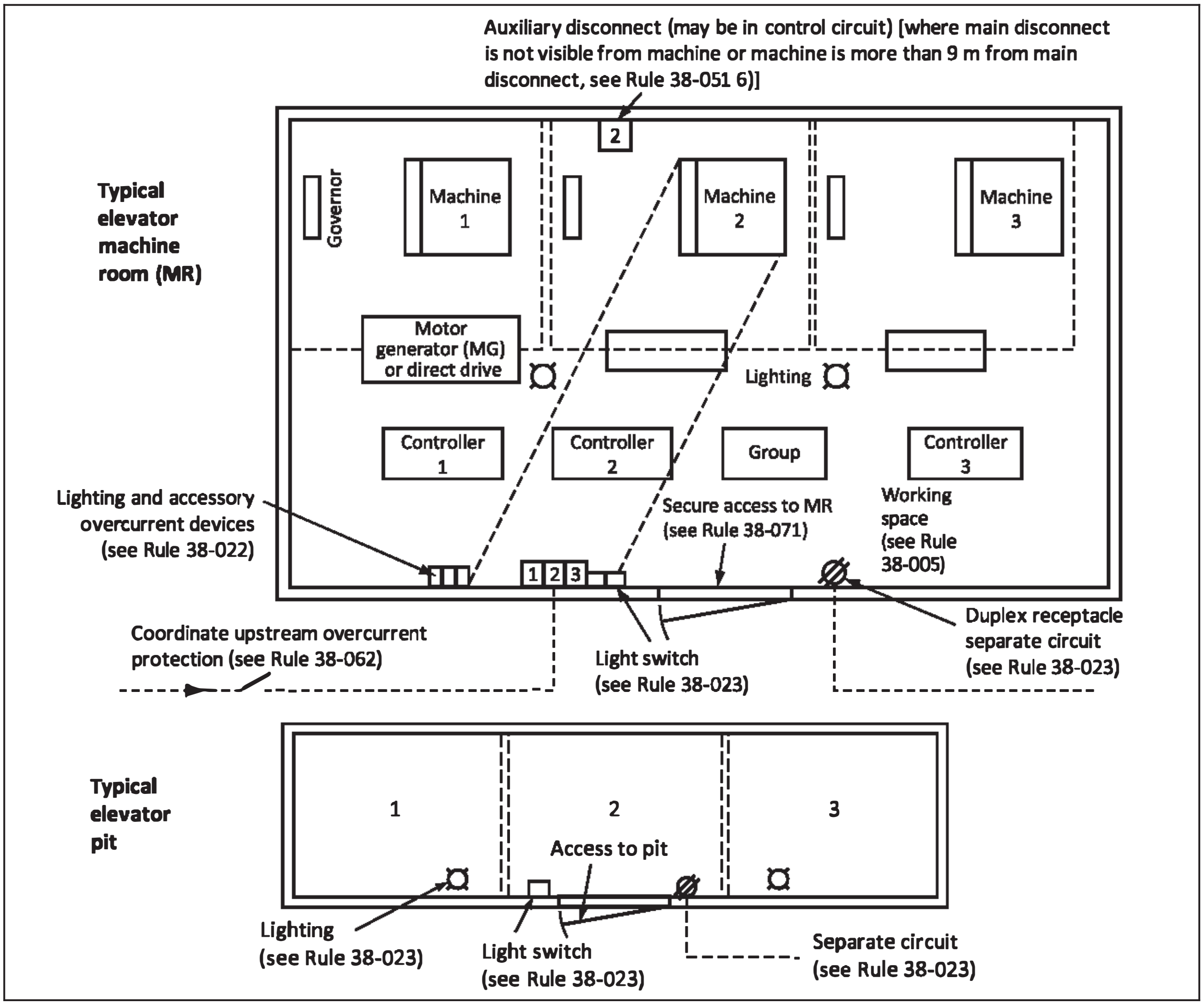
Subrule 6) requires that the disconnecting means be visible and readily accessible at the entrance of the machinery area so that in an emergency there is no confusion or loss of time in opening the proper circuits. The disconnecting means must also be capable of being locked in the open position to prevent it from being unintentionally closed while the equipment is serviced.

In large machine rooms with multiple machines and controllers, additional switches are sometimes required to protect elevator service personnel.

Subrule 6) also requires that in cases where the disconnecting means for elevator or escalator motors, control circuits, and motor ventilation is not visible from the motor controller(s) or is located more than 9 m from the motor controller(s), additional manually operated disconnect switches be installed adjacent to the remote equipment (see Figure 38-5).

Additional requirements for the disconnecting means are covered in Subrules 3), 8), 9), 10), 12), and 13).

## Figure 38-5
## Typical machine room layout




### Rule 38-062 Selective coordination

When an electrical fault such as a short-circuit or excessive current occurs, the overcurrent protection directly ahead of the fault should be the only device that trips. If a fault bypasses the first upstream overcurrent protection and causes a device further upstream to trip, problems in circuits or equipment not related to the fault can occur, creating a safety hazard or inconvenience. Rule 38-062 requires that overcurrent devices be coordinated so that a fault on a circuit causes only the first overcurrent device upstream from the fault to trip.

### Rule 38-081 Bonding of raceways to cars

To avoid shock hazards and circulating ground currents, metal raceways and metallic-sheathed cables attached to cars must be bonded to the metal parts of the car that they contact.

### Rule 38-082 Bonding of equipment

To avoid shock hazards and circulating ground currents, the frames of all motors, generators, machines, controllers, and the metal enclosures for all electrical equipment in or on the car or in the hoistway must be bonded to ground in accordance with Section 10.

### Rule 38-083 Bonding of non-electric elevators

To avoid shock hazards and the buildup of static electrical charges from the movement of the car in the elevator shaft, the metal frame of the car of a non-electric elevator, where it is normally accessible to people, must be bonded to ground in accordance with Section 10.

### Rule 38-085 Ground fault circuit interrupter protection for personnel

To protect maintenance and service personnel from shock hazards while working on elevating devices, Subrules 1) and 2) require that all 125 V, single-phase receptacles be protected by a Class A GFCI. An exception is permitted by Subrule 3) in cases where a single receptacle is used to feed a permanently installed sump pump.

For safety reasons, Rules 38-023 and 38-024 require that lighting in machine rooms, control rooms/ machinery spaces, control spaces, and hoistway pits not be protected by a GFCI. Since the lighting and receptacles are usually on the same branch circuit, a circuit-breaker-type GFCI does not satisfy Code requirements. Receptacles with built-in GFCI protection are permitted as an alternative.

### Rule 38-091 Emergency power

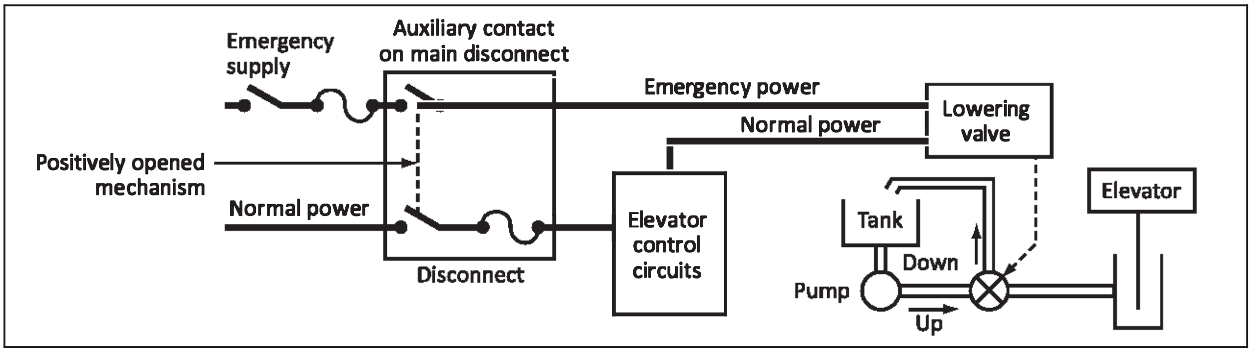
ASME A17.1/CSA 844 allows the operation of elevators on emergency power to facilitate the rescue of passengers during a power failure and for use by firefighters and other emergency personnel. Subrule 1) makes a similar allowance for emergency operation.

Subrules 2) and 3) address the operation of regenerative power systems under emergency conditions. Such systems are modelled on the concept of an elevator system in which energy storage is used to reduce net energy usage over a given time period. An ascending elevator uses energy as it needs help from the motor. A descending elevator yields potential energy that can either be dissipated as heat or, in a regenerative system, be recovered as electricity. Contemporary elevator systems use a variable-speed drive to capture regenerated energy for use in the elevator or in other parts of the building, thus reusing energy that would typically go to waste. Regenerative power systems can also condition the recovered power and feed it into the building's electrical distribution system, offsetting the costs of purchasing power from the utility's grid system.

Subrule 2) requires that a means be provided in a regenerative elevator system either to absorb the regenerative power or to prevent the regenerative power from causing the elevator to overspeed. This means can be the power system itself or an emergency or standby power generator. If the prime mover is sufficiently large, it can be a separate load bank provided by the emergency or standby generator system. Other building loads can be considered to be the required absorption means, provided that the loads are automatically connected to the emergency or standby power source, cannot be inadvertently disconnected, and are large enough to absorb the regenerative energy without causing the elevator to overspeed (for example, by exceeding the smaller of the governor's tripping speed or a speed in excess of 125% of the elevator's rated speed). Subrule 3) specifies requirements intended to ensure that such systems operate in the event of a power failure.

Hydraulic elevators can be lowered by opening a control valve in the hydraulic system. An emergency power control circuit must be provided to open this valve when the main power fails. In these circumstances, opening the disconnect is interpreted as a power failure, and the emergency power control circuit causes the car to automatically move down. To prevent this potentially hazardous operation, Subrule 5) requires that the main disconnect be equipped with an auxiliary contact that is positively opened mechanically (for example, opening is not solely dependent on springs) and opens the additional power source when the main disconnecting means is open (see Rule 38-051 and Figure 38-6).

## Figure 38-6
## Emergency power — Hydraulic elevator



# Section 40 — Electric cranes and hoists

## Rule 40-000 Scope

Section 40 includes additional and specific requirements for electric cranes and hoists.

Electric cranes, hoists, and monorails are assembled and erected at construction sites, in plants, or elsewhere and are considered to be "field certified equipment". The extensive and often complex electrical work involved in assembling the on-site components is covered by CSA Group Standards such as CSA C22.2 No. 33, *Construction and Test of Electric Cranes and Hoists* and CSA B167, *Overhead cranes, gantry cranes, monorails, hoists, and jib cranes*, which give the requirements for the installation of electrical equipment and electrical components installed on the equipment.

Section 40 is intended to apply only to the electrical installation between the crane or hoist and the installation's electrical services, such as supply conductors and main contact conductors (the stationary conductor supplying power to the movable collectors).

## Rule 40-002 Supply conductor sizes

The manufacturers of cranes, hoists, and similar electrical equipment recognize the economic advantages that can be derived from using smaller, cheaper, non-continuous duty motors, rated for 60-min, 30-min, or 15-min work periods, where work load and duty cycle conditions allow. Non-continuous duty service motors are capable of operating efficiently and without undue stress for the relatively short periods required by the intermittent work cycles typical of this type of equipment.

To determine the minimum calculated motor conductor ampacity for non-continuous duty motors, use the method shown in Rules 28-106 and 28-108.

Use Table 58, which specifically applies to cranes and hoists, to establish minimum conductor size, rather than the broader requirements of Tables 2 and 4.

Table 58 applies to conductors in cables or raceways that supply main contact conductors or are directly connected to cranes and hoists. In Table 58, the Code recognizes that installation conditions such as ambient temperature, the number of wires in a raceway or cable, and the duty cycles of motors can vary greatly. The Notes to Table 58 give the requirements for these conditions which must be taken into consideration when using the Table.

## Rule 40-004 Conductor protection

Potential hazards to electrical conductors in industrial locations are increased when the equipment is directly connected to the feeders. Although direct connection eliminates the potential hazard of contact with exposed main contact conductors, equipment connected in this way has an "umbilical cord" cable or feeder that follows the moving equipment throughout the extent of its run, requiring a great degree of flexibility in the cable. The cable must also be supported so that it can stretch out to the full extent of the equipment's run and then return, coiled or looped, as the equipment returns to or passes its point of connection. The direct-connection flexible cable can easily traverse and droop into open spaces over work locations. Thus, it is essential that the flexible cables used for this purpose must be of the type listed in Subrule 2) and that the cable installation be equipped with a take-up device(s) to supply adequate tension on the cable and allow it to extend or contract when required to easily traverse the required area and not droop into open spaces over work locations.

## Rule 40-006 Overcurrent protection

Cranes, hoists, and monorails have widely varying electrical loads. They can incorporate a number of motors of various sizes, as well as brakes, transformers, lighting, controls, and communication systems. Overcurrent protection for these pieces of equipment is required to be the same as for other electrical installations covered in the Code. See the 200-series of Rules in Section 28 for determining overcurrent protection.

When the equipment has loads in addition to motors, it might be necessary to use conductors larger than those required by the motors. Rule 14-104 should be applied when selecting overcurrent devices for such applications.

### Rule 40-008 Disconnecting means

It should be possible to shut off the electrical supply to any crane, hoist, or monorail quickly in emergencies and when necessary for servicing or maintenance. The disconnecting means must

- open all ungrounded conductors simultaneously;
- be positioned so that it is in sight of the connection to the main contact conductors or the direct connection to equipment it serves; and
- be accessible from the ground or floor area directly below where the equipment operates (see Figure 40-1).

**Note:** *Some crane and hoist installations are fed by main contact conductors that extend over long distances. In such cases, it might not always be possible to locate the disconnect means where it is in sight of the equipment at all times. For the purpose of Rule 40-008, main contact conductors are considered to be an integral part of the equipment. The point at which the feeders connect to the main contact conductors is considered equivalent to the point at which a direct-connection cable connects to the equipment. One of these connecting points must be visible from the disconnect means.*

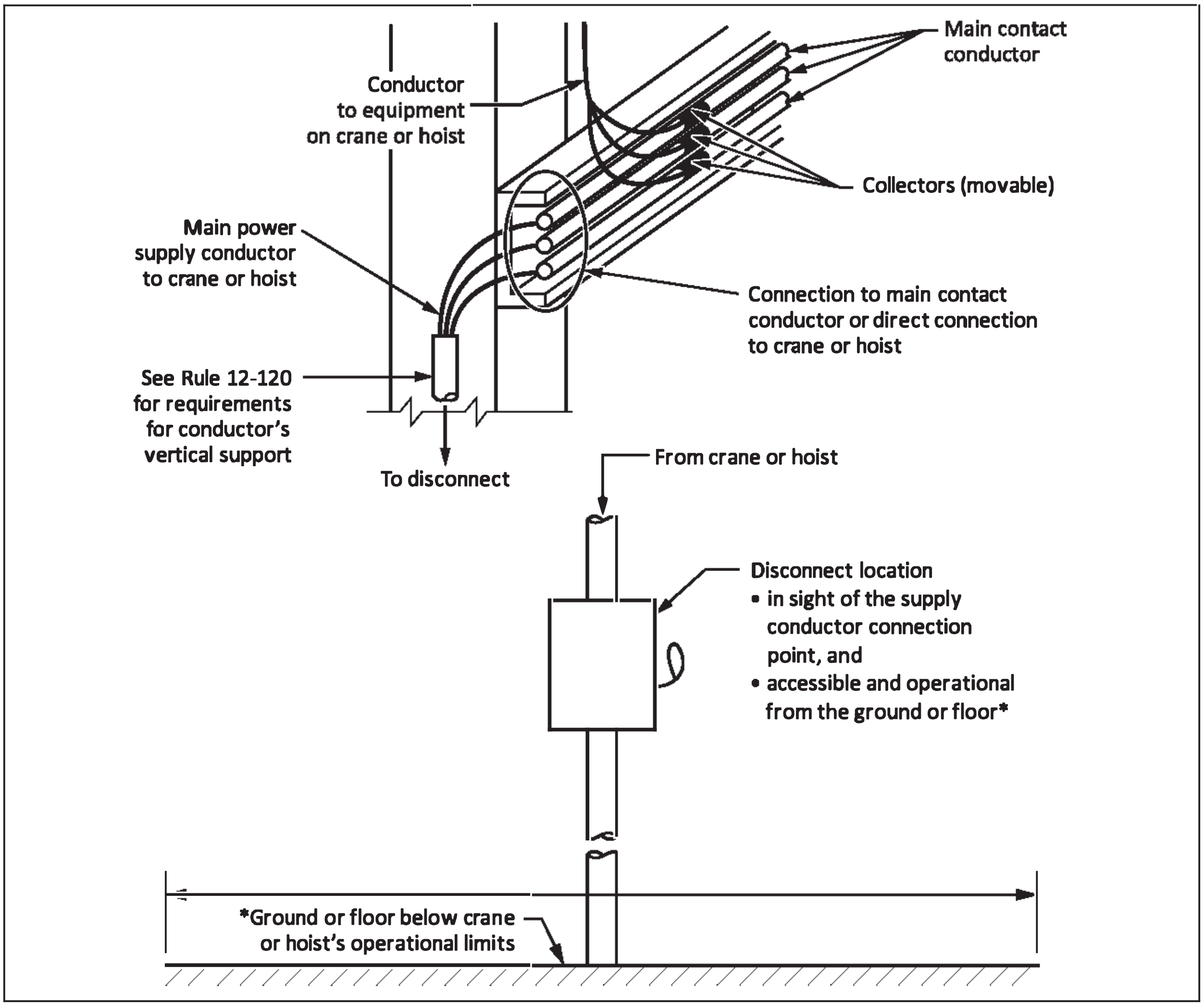
### Rule 40-010 Main contact conductors

Main contact conductors transfer electrical energy from the power supply conductors of the crane or hoist through collectors that run along the length of the main contact conductor, in order to supply energy to the crane or hoist components (see Figure 40-1). Main contact conductors can be either wires or rigid conducting materials. Their function subjects them to friction caused by the physical work stresses between the contact conductors and the collectors. Where wire conductors are used, their size, the materials from which they are manufactured, and the spacing between their supports all require consideration.

Subrule 1) gives the requirements for minimum ampacity rating, minimum size of copper or aluminum conductors, and the requirements for the length of the conductors.

Subrule 2) permits the use of bare, solid, hard-drawn copper or aluminum wires as main contact conductors. The conductors may also be fabricated of steel or any other conductive metal in the form of T-rails and other rigid shapes, angles, and tees for directional changes.

## Figure 40-1
## Supply for crane or hoist




### Rule 40-012 Spacing of main contact conductors

Bare main contact conductors rely on air space for insulation between phases and between phases and ground. The materials and installation methods used must be such that the contact conductors maintain their required spacing when subjected to forces, pressures, and stresses caused by the movement of the collectors along their length.

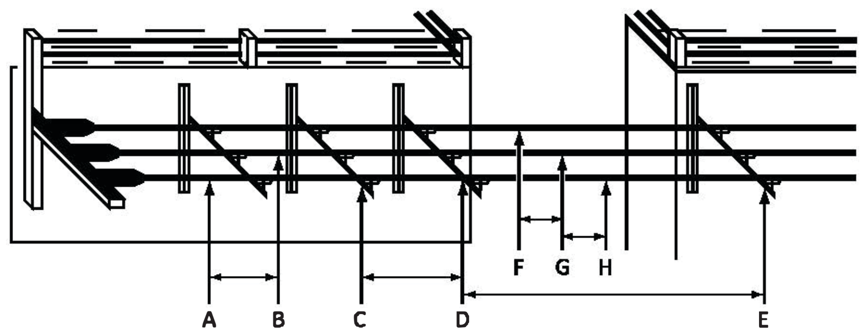
Rule 40-012 gives the requirements for minimum separation (centre to centre), the maximum limit of displacement, and minimum clearances.

### Rule 40-014 Supporting of main contact conductors

The current-collecting devices used in various types of travelling contacts are designed to apply mechanical pressure to maintain contact with the bare main contact conductor. This pressure tends to move the contact conductors from their normal place between supports. Such movement must be kept within established tolerances. Thus, the bare main contact conductors must be mounted and their rigidity ensured so that any possible displacement along the entire run of the contact conductor does not cause the distance from the centre of one phase conductor to the centre of neighbouring phase conductors, or to ground, to be less than the spacing required for safe insulation.

The minimum required spacing is given in Rule 40-014 and shown in Figures 40-2 and 40-3.

## Figure 40-2
## Support of bare main contact conductor wires

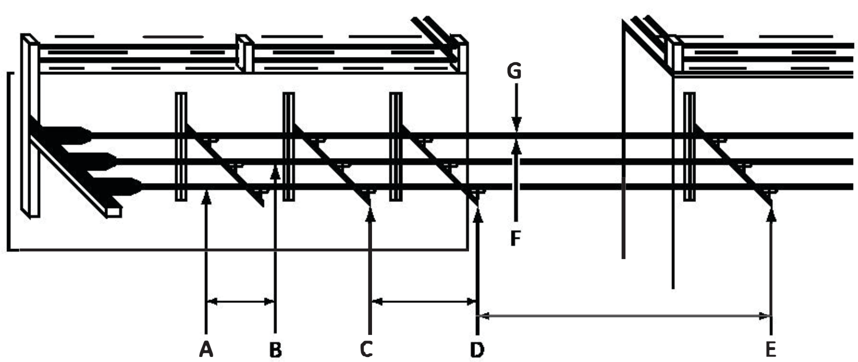



Space (A–B) between bare main contact conductors, see Rule 40-012 1)
Distance (C–D) between bare main contact conductor supports, see Rule 40-014 1)

**Example:**
Where the conductors are to be installed in the horizontal plane and are for other than a monorail hoist, the minimum clearance between the contact conductors (F–G, G–H), where the support distance (D–E) is 9 m, is calculated as follows:

Minimum clearance = [the support distance (m) / 6] × [minimum spacing from Rule 40-012 1) a) i), mm]
= 9 / 6 × 150
= 1.5 × 150
= 225 mm

## Figure 40-3
## Support and size of rigid main contact conductors




Space (A–B) between rigid main contact conductors ≥ 25 mm [see Rule 40-012 2)]
Distance (C–D) between rigid main contact conductor supports < 80 times the vertical dimension (F–G) of the rigid main contact conductor [see Rule 40-014 2)]
**Example:**
Distance (C–D) or (D–E) ≤ 4.5 m [see Rule 40-014 2)]
Where distance (D–E) is 4.5 m, the vertical dimension (F–G) of the rigid main contact conductor ≥ (4.5 × 1000) / 80 = 56.3 mm

### Rule 40-016 Joints in rigid contact conductors

The principal intent when connecting two lengths of rigid main contact conductors is to have the same conductivity as the conductors being joined so that no temperature rise greater than might be expected under normal operating conditions occurs at the joint or at any point along the entire length of the conductor.

### Rule 40-018 Use of track as a conductor

Monorails, tramrails, and cranes often move horizontally on steel wheels that are on or in contact with steel tracks, similar to railway cars and tracks. The weight of the monorail, tramrail, or crane on the track, along with the metal-to-metal contact between the wheel and the track, provides an excellent electrical connection. Where it can be done safely, the equipment can use the track as one of the main contact conductors or as a supply circuit conductor to reduce costs. Such a design requires no contact conductor, supports, collectors, or related materials.

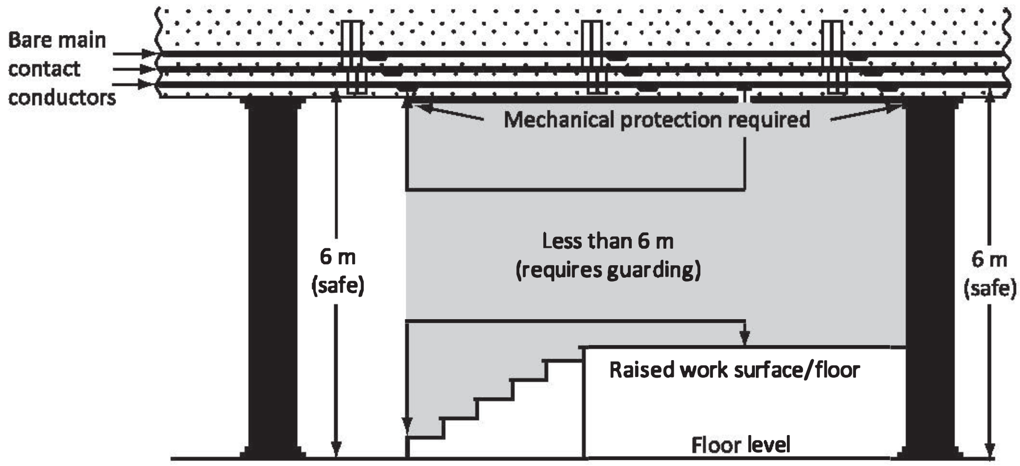
Where the track is used as a main contact conductor, the following installation requirements apply:

- Power to the equipment must be supplied through an isolating transformer so that the equipment's electrical supply is isolated from the building's electrical system. This allows, for example, the secondary of the isolated transformer to be configured as a three-phase ungrounded delta system that would allow one of the phase conductors to be the grounded track without affecting the equipment's operation. For safety reasons (i.e., to reduce the risk of shock or arc flash), this allowance (i.e., the use of the track as a conductor) is limited to one piece of equipment (for example, monorail, tramrail, or crane).
- The voltage must be limited to 300 V between phases. When one phase of a three-phase ungrounded delta is grounded, the line-to-ground voltage on the remaining two ungrounded phases increases to full line voltage, but no overcurrent device trips as there is not a complete fault path (see explanation in Subsection 10-300).
- The rail serving as the contact conductor must be effectively bonded to ground, preferably at the transformer, and have additional grounding provided by the fittings used for the suspension or attachment of the rail to the building structure.

### Rule 40-020 Guarding of contact conductors

Exposed, bare contact conductors pose a shock hazard as the effects of accidental contact by people or other conductive objects can be severe. The use of enclosed contact assemblies is highly recommended, but this is not always practical. Where bare contact conductors are installed, they must be located to provide the highest possible degree of safety. In some installations, it is not possible to locate bare contact conductors far enough from traffic areas to consider the installation safe. In such installations, a suitable, reliable guard must be designed and installed to ensure that no person or object, under any circumstances, can accidentally touch the conductors. It is often sufficient to elevate the bare contact conductors far enough above the work surface to keep them out of reach. A clearance of 6 m above the work area surface is considered sufficient to provide a practical margin of safety (see Figure 40-4).

**Figure 40-4**
**Guarding of bare contact conductors**




## Rule 40-022 Contact conductors not to supply other equipment

The modified requirements for feeders and main contact conductors for electric cranes, hoists, and monorail installations are due to the short work cycles that typically characterize the use of such equipment. These requirements do not extend to other unrelated electrical equipment. All other equipment must conform to the applicable Sections of the Code where specific service factors and conditions of use are taken into account.

## Rule 40-024 Bonding

Providing and maintaining good bonding conditions throughout the entire system is the only way to ensure safety. Rules 10-700 and 40-018 apply to all such installations, except where the rail or track is deliberately energized for use as a contact conductor. For this exception, Rule 40-018 takes precedence as the conductive parts in question can no longer be regarded as the non-electrical equipment referred to in Rules 10-600 to 10-614 and 10-700 to 10-708.

The Appendix B Note to Rule 40-024 1) stresses that contact between wheels and tracks cannot always be relied upon for bonding to ground, especially where paint, grease, or other insulating material might affect conductivity. In these locations, a separate bonding conductor is to be provided.

# Section 42 — Electric welders

## General

### Rule 42-000 Scope

Section 42 includes additional and specific requirements for the installation, protection, and control of electric welders.

Welders are generally classed as arc welders or resistance (spot) welders. Arc welders can be of the transformer type, the motor-generator type, or the resistance type. Arc welding joins two pieces of metal using the metal of a flux-coated wire rod. The rod melts while being used as an electrode to strike an arc. Resistance welders join two pieces of metal by making the metal of each piece molten at the point of application of the welding electrodes (or points), causing fusion.

### Rule 42-002 Special terminology

The definitions in Rule 42-002 apply only to Section 42. The terms refer to the electrical characteristics of a welder that are normally specified on its nameplate.

Welders are provided with different taps and control settings for the user to adjust the current draw from the electrical supply for different applications, materials, and environments. The current flow from the supply is the *actual primary current* of the welder.

Most welders are not operated continuously, so there are periods of time during a welding job when the welder is not drawing current from the electrical installation (such as while changing a wire rod). The ratio between the time the welder draws current under load and the time of a complete welding cycle is the *duty cycle* (sometimes referred to as the "time rating"). When the welder is not drawing current during the welding cycle, the heat from the supply current flow has a chance to dissipate, reducing the amount of heat that can build up. The duty cycle ratio, expressed as a percentage, may be used to reduce the ampacity rating of the insulated supply conductors.

The minimum insulated conductor size and the maximum rating of the overcurrent protection for a welder must be calculated on the basis of the welder's *rated primary current*, which is normally specified on the nameplate of the welder. The *rated primary current* can also be determined by the following formulas:

Rated primary current, single-phase = (Nameplate kV•A rating × 1000) / rated primary voltage

or

Rated primary current, three-phase = (Nameplate kV•A rating × 1000) / (rated primary voltage × $\sqrt{3}$ )

### Rule 42-004 Receptacles and attachment plugs

Portable welders are connected to the electrical supply by means of a receptacle and attachment plug. Rule 14-600 requires that the maximum overcurrent protection for a receptacle not exceed the ampere rating of the receptacle. During start-up of the welding process, however, welders have a high short-duration inrush current. To prevent nuisance tripping of the overcurrent protection during start-up, Rule 42-004 permits the overcurrent protection for a welder receptacle to exceed the receptacle's rated ampacity by a multiple determined by the type of welder. The ampacity of the welder's supply cable determines the minimum ampere rating of the receptacle.

## Transformer arc welders

Requirements for insulated supply conductor sizing, overcurrent protection, and disconnecting means for transformer arc welders are set out in Rules 42-006 to 42-010.

### Rule 42-006 Supply conductors

To size the insulated supply conductors for a single welder, a correction factor, which is determined by the duty cycle, is applied to the rated primary current of the welder.

The duty cycle for each welder is a specification by the manufacturer that defines the number of minutes in a 10-min period during which a welder can safely produce a particular welding current. This means that a 75 A welder with a 20% duty cycle must be rested for at least 8 min after 2 min of continuous welding.

Use the calculated minimum ampacity, the type of insulated conductor, and the wiring method to determine the minimum insulated conductor size. The process is described in Tables 42-3 and 42-4, using the demand factors given in Tables 42-1 and 42-2.

**Table 42-1**
**Demand factor for conductor sizing — Transformer arc welder**

| Duty cycle | 100 | 90 | 80 | 70 | 60 | 50 | 40 | 30 | 20 |
|---|---|---|---|---|---|---|---|---|---|
| Demand factor | 1.00 | 0.95 | 0.89 | 0.84 | 0.78 | 0.71 | 0.63 | 0.55 | 0.45 |

**Table 42-2**
**Demand factor for determining welder's contribution to feeder ampacity**

| Welder's calculated conductor ampacity | Demand factor |
|---|---|
| Largest | 1.00 |
| Second-largest | 1.00 |
| Third-largest | 0.85 |
| Fourth-largest | 0.70 |
| All remaining | 0.60 |

**Note:** *A high duty cycle is a long continuous welding process with very short rest periods between welding cycles. Where the welding process makes this type of cycle unlikely, a lower demand factor can be used.*

### Table 42-3
### Process for calculating the minimum insulated supply conductor size for an individual transformer arc welder

| Step | Method |
|---|---|
| 1 | Obtain the rated primary current for the transformer arc welder (see the welder's nameplate, or calculate it using the kV•A and primary voltage ratings specified on the welder's nameplate). |
| 2 | Obtain the duty cycle specified on the welder's nameplate. |
| 3 | Obtain the duty cycle factor from Subrule 1) of Rule 42-006 or Table 42-1.<br>**Note:** *if the welder's time rating is 1 h, the duty cycle factor is 0.75 [see Item b) of Subrule 1) of Rule 42-006].* |
| 4 | Determine the minimum insulated supply conductor ampacity by multiplying the duty cycle factor (from Step 3) by the rated primary current (from Step 1). |
| 5 | Select the minimum conductor size from the Code's ampacity Tables (see Section 4 for method). |

### Table 42-4
### Method for calculating the minimum insulated circuit conductor size for two or more transformer arc welders connected on the same circuit

| Step | Method |
|---|---|
| 1 | Calculate the minimum insulated supply conductor ampacity for each transformer arc welder connected to the feeder (see Table 42-3 for the method to use to determine the minimum individual welder's insulated conductor ampacity). |
| 2 | Calculate each welder's contribution to the circuit conductor's ampacity by multiplying each calculated welder's insulated supply conductor ampacity by the demand factor [see Subrule 2) of Rule 42-006 or Table 42-2]. |
| 3 | Determine the minimum calculated insulated circuit conductor's ampacity by adding together all the minimum calculated insulated supply conductor ampacities for each welder connected to the circuit. |
| 4 | Select the minimum insulated circuit conductor size from the Code's ampacity Tables (see Section 4 for method). |

### Rule 42-008 Overcurrent protection for transformer arc welders
During start-up, welders draw a high short-duration inrush current. To prevent nuisance tripping of the transformer arc welder's overcurrent protection device during start-up, Subrule 1) permits the maximum rating of the overcurrent protection device to be 200% of the rated primary current of the welder.

However, Subrule 1) allows the standard rated overcurrent device protecting the welder's supply conductors, calculated according to Subrule 2) methods, to also protect the welder. When the welder's supply conductors' maximum standard rated overcurrent device will not allow the welder to operate, for example during the start-up in-rush current, the welder's supply conductors' ampacity will need to be increased to accommodate the required higher rated welder's overcurrent protection.

Subrule 2) requires that the maximum calculated rating of the overcurrent protection to protect the insulated supply conductors not exceed 200% of their ampacity as determined from the Tables in the

Code and the requirements of Subrule 1) of Rule 42-006. If a standard rated overcurrent device equal to the minimum insulated supply conductor ampacity is not available, Item a) of Subrule 2) allows either the next higher standard rated overcurrent device or the next higher rating to be used if the lower rating results in repeated tripping.

For example, if a transformer arc welder has a rated primary current at 600 V, 1-phase, of 41.7 A, with a duty cycle of 30%, the maximum calculated rating of the transformer arc welder's overcurrent protection device would be 41.7 × 2 = 83.4 A or an 80 A standard rated overcurrent protection device. The insulated supply conductor would require an overcurrent protection device with a maximum rating calculated as follows:

- minimum conductor ampacity = 41.7 × 0.55 = 29.4 A [Subrule 1) of Rule 42-006];
- insulated supply conductor size = #12 RW75XLPE (Table 2 ampacity – 25 A); and
- maximum calculated rating of the overcurrent protection device 25 × 2 = 50 A [Subrule 2) of Rule 42-008] and a maximum standard rated overcurrent protection of 50 A.

In the above example, the transformer arc welder's overcurrent protection device at 80 A would not protect the insulated supply conductors. The welder's overcurrent protection device would have to be reduced to 50 A or the insulated supply conductor size increased to a No. 8 RW75XLPE.

The process is described in Tables 42-5 and 42-6, using the demand factors given in Tables 42-1 and 42-2.

## Table 42-5
## Calculating the maximum standard rated overcurrent protection for an individual transformer arc welder and the insulated supply conductors

| Step | Method |
|---|---|
| 1 | Calculate the maximum calculated rating of the overcurrent protection device required to protect the insulated supply conductors feeding a transformer arc welder by multiplying the individual welder's insulated conductor ampacity (see Table 42-3 and the Code's ampacity Tables) × 2.0 [see Subrule 2) of Rule 42-008]. |
| 2 | Determine the maximum standard rated overcurrent protection device using the calculated overcurrent protection device rating from Step 1 and the manufacturer's tables.<br>**Notes:**<br>**1)** *The next higher rating or setting of standard rated overcurrent protection device may be used when either:*<br>a) *the calculated overcurrent protection device rating from Step 1 does not correspond to a standard rating [see Item a) of Subrule 2) of Rule 42-008]; or*<br>b) *the setting determined in accordance with Step 2 causes frequent nuisance tripping of the overcurrent protection device [see Item b) of Subrule 2) of Rule 42-008].*<br>**2)** *The overcurrent protection device is not permitted to be larger than the maximum standard rated overcurrent protection device protecting the transformer arc welder (see Steps 3 and 4).* |
| 3 | Calculate the maximum calculated overcurrent protection for an individual transformer arc welder by multiplying the rated primary current of the welder × 2.0 [see Subrule 1) of Rule 42-008]. |

*(Continued)*

### Table 42-5 (Concluded)

| Step | Method |
|---|---|
| 4 | Determine the maximum standard rated overcurrent protection device using the calculated overcurrent protection from Step 3 and manufacturer's tables.<br>**Note:** *If this value does not correspond to a standard rated overcurrent protection, go to the next lower standard rated overcurrent protection device (round down).* |
| 5 | Determine if the transformer arc welder has a disconnecting means that is an integral part of the welder.<br>If "YES", Rule requirements are met.<br>If "NO", provide a disconnecting means in the supply connection to the transformer arc welder. The disconnecting means can be either a switch or circuit breaker sized to accommodate the maximum overcurrent protection device sized by Rule 42-008. |

### Table 42-6
### Process for calculating the maximum standard rated overcurrent protection for two or more transformer arc welders connected on the same circuit

| Step | Method |
|---|---|
| 1 | Determine the largest standard rated overcurrent protection device required to protect an individual transformer arc welder that is connected on the circuit (see Table 42-5). |
| 2 | Calculate the maximum calculated overcurrent protection device required to protect the circuit by adding to the rating of largest overcurrent protection device determined from Step 1 to the minimum calculated supply conductor ampacities for all other welders connected on the circuit. |
| 3 | Determine the maximum standard rated overcurrent protection device using the calculated overcurrent protection from Step 2 and manufacturer's tables:<br>• if it matches a standard rating, use the matching overcurrent protection; or<br>• if this value does not correspond to a standard rated overcurrent protection, go to the next lower standard rated overcurrent protection device (round down). |

### Rule 42-010 Disconnecting means

To protect the operator and make the welding equipment safe for repair, maintenance, or adjustment, disconnecting a welder from its source of supply is necessary. On many transformer arc welders, the disconnecting means is an integral part of the welding equipment; where this is not the case, one must be provided. On a single welder, the disconnecting means may be combined with the overcurrent device in a single unit mounted at the welder. If a circuit breaker is used as a switch to turn the welder off and on, the circuit breaker must be approved and marked "SWD".

## Motor-generator arc welders

### Rule 42-012 Conductors, protection, and control of motor-generator arc welders

Motor-generator arc welders are driven by electric motors. Motor generators are used to minimize electrical interference on other electrical equipment in the installation caused by operational characteristics of arc welders (for example, harmonics and current surges). Consequently, requirements for disconnecting means and overcurrent protection are given in the applicable Rules of Sections 4 and 28. In Section 28, the 200-series Rules provide requirements for motor overcurrent devices, and the 600-series Rules deal with motor disconnecting means. These Rules should be used for sizing overcurrent protection and locating the disconnecting means for motor-generator welders.

Sizing insulated supply conductors for motor-generator welders is slightly different from sizing insulated conductors for transformer arc welders. While the calculations are similar to those described in Rule 42-006, different duty cycle factors are involved (see Table 42-7).

**Table 42-7**
**Demand factors for conductor sizing — Motor-generator welders**

| Duty cycle | 100 | 90 | 80 | 70 | 60 | 50 | 40 | 30 | 20 |
|---|---|---|---|---|---|---|---|---|---|
| Demand factor* | 1.00 | 0.96 | 0.91 | 0.86 | 0.81 | 0.75 | 0.69 | 0.62 | 0.55 |

** For motor-generator welders having a time rating of 1 h, the demand factor is 0.80.*

## Resistance welders

Resistance welding is the coordinated application of electric current and mechanical pressure, in the proper magnitudes and for a precise period of time, to create a coalescent bond between two base metals. Welding electrodes conduct the electric current to the base metals as they are forged together. The major forms of resistance welding are spot, seam, and projection welding. Resistance welders are operated either manually or automatically.

### Rule 42-014 Supply conductors for resistance welders

Spot welders use the current to weld metals together in just one location or spot and thus draw current for a shorter period than seam welders. Seam welders join metals together along a seam that runs the length of a piece of work, as in the case of welding together piping or ductwork. Because seam welders draw current for a longer period, consider the type of resistance welder when determining the minimum conductor size required to avoid overheating of the conductor.

Insulated supply conductors for a single resistance welder are sized by applying a correction factor to the welder's rated primary current. This correction factor is determined by the type of resistance welder, its duty cycle, and whether it is manually or automatically operated. The calculated minimum ampacity and the given type of insulated conductor and wiring method are used in conjunction with the Code's ampacity Tables (see Tables 1 to 4) to determine the minimum insulated conductor size. The process is described in Tables 42-9 and 42-10, using the demand factors given in Table 42-8.

**Table 42-8**
**Demand factor for conductor sizing — Resistance welder**

| Duty cycle | 50 | 40 | 30 | 25 | 20 | 15 | 10 | 7.5 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| Demand factor | 0.71 | 0.63 | 0.55 | 0.50 | 0.45 | 0.39 | 0.32 | 0.27 | 0.22 |

## Table 42-9
## Process for calculating the minimum insulated supply conductor size for an individual resistance welder

| Step | Method |
|---|---|
| 1 | Determine whether or not the resistance welder is a seam resistance welder (for use in Step 4). |
| 2 | Determine whether or not the resistance welder is operated manually (for use in Step 4). |
| 3 | Determine the rated primary current, based on the welder's kV•A and primary voltage rating, as specified on the nameplate. |
| 4 | Determine the minimum insulated supply conductor ampacity by using Method A, Method B, or Method C.<br>**Method A:**<br>Use Method A if the seam resistance or individual resistance welder is automatically fed and is operated at different times at different values of the rated primary current:<br>• Minimum calculated insulated supply conductor ampacity = rated primary current × 0.70 [see Item a) of Rule 42-014].<br>**Method B:**<br>Use Method B if the individual resistance welder is manually fed and is operated at different times at different values of the rated primary current:<br>• Minimum calculated insulated conductor ampacity = rated primary current × 0.50 [see Item b) of Rule 42-014].<br>**Method C:**<br>Use Method C if the individual resistance welder is operated at known and constant values of the rated primary current and duty cycle:<br>• Minimum calculated insulated conductor ampacity = rated primary current × demand factor [see Item c) of Rule 42-014 or Table 42-8 above]. |
| 5 | Select the minimum conductor size from the Code's ampacity Tables (see Section 4 for method). |

## Table 42-10
## Process for calculating the minimum insulated circuit conductor size for two or more resistance welders connected on the same circuit

| Step | Method |
|---|---|
| 1 | Calculate the minimum insulated supply conductor ampacity for each welder type listed in Items a), b), and c) of Rule 42-014 that is connected to the circuit using the following formula:<br>Rated primary current × demand factor [see Items a), b), and c) of Rule 42-014 or Step 4 in Table 42-9]. |
| 2 | Add together the minimum calculated ampacity for each welder's insulated supply conductor connected to the circuit (see Step 1). |
| 3 | Add together the minimum calculated insulated supply conductor ampacity for all other welder types that are connected to the circuit and are not covered in Items a), b), and c) of Rule 42-014. |

*(Continued)*

## Table 42-10 (Concluded)

| Step | Method |
|---|---|
| 4 | Determine the total insulated supply conductor ampacity of all other welder types by multiplying the total from Step 3 by 0.6. |
| 5 | Calculate the minimum insulated conductor ampacity for the circuit conductor by adding the total calculated insulated supply conductor ampacities from Step 2 and from Step 4. |
| 6 | Select the minimum conductor size from the Code's ampacity Tables (see Section 4 for method). |

**Rule 42-016 Overcurrent protection**

Resistance welders have an inrush current of longer duration than transformer arc welders. Inrush current occurs when the welding tips or electrodes conduct the electric current through the base metals when they are forged together during the welding process. To prevent nuisance tripping, the ampacity rating of the branch circuit and the feeder overcurrent protection is allowed to be increased to 300% of the ampacity of the branch circuit and feeder insulated conductor. The process is described in Tables 42-11 and 42-12, along with Table 42-9.

## Table 42-11
## Process for calculating the maximum standard rated overcurrent protection device for an individual resistance welder and the insulated supply conductors

| Step | Method |
|---|---|
| 1 | Calculate the maximum calculated rating of the overcurrent protection device required to protect the insulated supply conductors feeding a resistance welder by multiplying the individual welder's insulated conductor's ampacity (see Table 42-9 and the Code's ampacity Tables) × 3.0 [see Subrule 2) of Rule 42-016]. |
| 2 | Determine the maximum standard rated overcurrent protection device using the calculated overcurrent protection device rating from Step 1 and the manufacturer's tables.<br>**Notes:**<br>**1)** *The next higher rating or setting of standard rated overcurrent protection device may be used when either:*<br>a) *the calculated overcurrent protection device rating from Step 1 does not correspond to a standard rating [see Item a) of Subrule 2) of Rule 42-016]; or*<br>b) *the setting determined in accordance with Step 2 causes frequent nuisance tripping of the overcurrent protection device [see Item b) of Subrule 2) of Rule 42-016].*<br>**2)** *The overcurrent protection device is not permitted to be larger than the maximum standard rated overcurrent protection device protecting the resistance welder (see Steps 3 and 4).* |
| 3 | Calculate the maximum calculated overcurrent protection for an individual resistance welder by multiplying the rated primary current of the welder × 3.0 [see Subrule 1) of Rule 42-016]. |

*(Continued)*

### Table 42-11 (Concluded)

| Step | Method |
|---|---|
| 4 | Determine the maximum standard rated overcurrent protection device using the calculated overcurrent protection from Step 3 and manufacturer's tables.<br>**Note:** *If this value does not correspond to a standard rated overcurrent protection, go to the next lower standard rated overcurrent protection device (round down).* |
| 5 | Does the resistance welder have a disconnecting means that is an integral part of the welder?<br>If "YES", Rule requirements are met.<br>If "NO", a disconnecting means is to be provided in the supply connection to the resistance welder. The disconnecting means can be either a switch or circuit breaker sized to accommodate the maximum overcurrent protection device sized by Rule 42-016. |

### Table 42-12
### Process for calculating the maximum standard rated overcurrent protection for two or more resistance welders connected on the same circuit

| Step | Method |
|---|---|
| 1 | Determine the largest standard rated overcurrent protection device required to protect an individual resistance welder that is connected on the circuit (see Table 42-11). |
| 2 | Calculate the maximum calculated overcurrent protection device required to protect the circuit by adding to the rating of the largest standard overcurrent protection device determined from Step 1 to the minimum calculated insulated supply conductor ampacities for all other welders connected on the circuit. |
| 3 | Determine the maximum standard rated overcurrent protection device using the calculated overcurrent protection from Step 2 and manufacturer's tables.<br>**Note:** *If this value does not correspond to a standard rated overcurrent protection, go to the next lower standard rated overcurrent protection device (round down).* |

#### Rule 42-018 Control of resistance welders
To protect the operator, to make it safe to change tips or welding electrodes, and to allow repair, maintenance, or adjustment, it must be possible to disconnect a resistance welder from its source of supply.

An individual resistance welder's control or disconnecting means may be a switch or circuit breaker in the supply circuit that isolates the welder and control equipment from the welder's supply circuit.

#### Rule 42-020 Nameplate data for resistance welders
Resistance welders, like any other piece of electrical equipment, must have a nameplate with specific information on electrical characteristics to ensure that the welder is installed, maintained, repaired, replaced, and operated within its design limits.

# Section 44 — Theatre installations

## Scope

### Rule 44-000 Scope

Section 44 includes additional and specific requirements for electrical installations, whether permanent or temporary, in buildings or parts of a building that are used for live performances or motion picture presentations.

## General

### Rule 44-100 Travelling shows

Electrical equipment used by travelling shows — often subject to rough usage — is typically adapted to meet specific needs. It might be handled, especially in a smaller organization, by people not qualified to install or service electrical equipment. By requiring a permit, Rule 44-100 requires that a qualified person be responsible for confirming that the installation of the electrical equipment meets Code requirements. The permit process also ensures that the local inspection department is aware of the event before its first performance.

### Rule 44-102 Wiring method

To prevent damage from the installation methods used to supply mobile lighting and other electrical equipment used on the set or stage, or during the performance, Subrule 1) of Rule 44-102 requires that all wiring be enclosed in metal.

However, to minimize potential damage and shock hazards due to moving elements, Items a) and b) of Subrule 1) allow the use of temporary wiring and flexible cords that are necessary to meet the production needs of different shows and performances.

To reduce tripping hazards and damage due to moving equipment, Subrule 2) prohibits the use surface raceways on the stage area.

### Rule 44-104 Number of conductors in raceways

To prevent injury to conductor insulation, Rule 44-104 requires that conductors used in raceways be easy to install and withdraw, and have enough space for heat to dissipate.

### Rule 44-106 Aisle lights in moving picture theatres

Low-wattage lamps are used to light theatre aisles so patrons can safely reach and leave their seats without significantly disrupting the screen or stage display or disturbing other audience members. Rule 44-106 allows up to 30 aisle-light outlets to be supplied by a single branch circuit, provided that a mechanical limitation or its equivalent is used to ensure that the lamp size is 25 W or less.

## Fixed stage switchboards

### Rule 44-200 Stage switchboards to be dead front

To protect operators from electrical shock hazards, Rule 44-200 requires that operational surfaces of a switchboard be of the dead-front type, which has no exposed live parts (in other words, something needs to be removed to expose the live parts). To prevent falling objects from damaging the switchboard, a metal guard or hood must be used that extends the full length of the switchboard and completely covers the space between the switchboard and the wall.

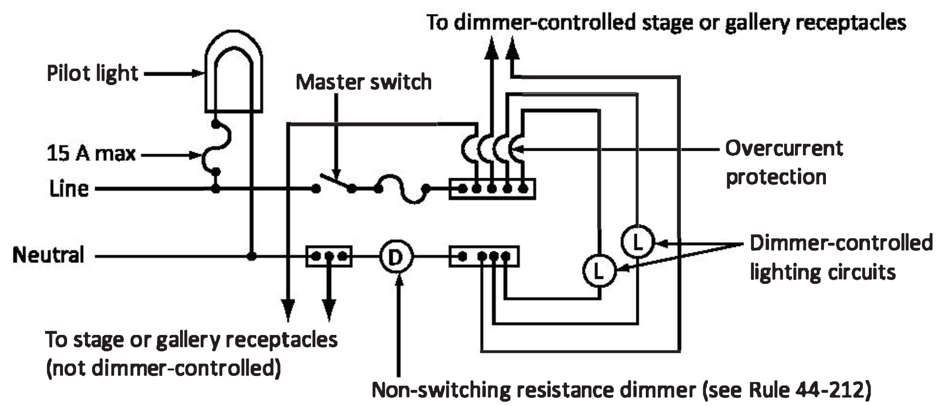
### Rule 44-204 Switches

To prevent operators from coming into contact with live switch components in a switchboard, the switches must be of the enclosed type. It must also be possible to operate them externally by a switch or lever that is accessible when the enclosure door is shut.

### Rule 44-206 Pilot lamp on switchboards

To provide illumination inside the fixed stage switchboard to aid in inspecting and servicing the components inside the switchboard enclosure, an independent pilot lamp must be installed inside the switchboard enclosure and connected to the main supply circuit (see Figure 44-1). [This is similar to the requirement in Subrule 2) of Rule 26-900 for pipe organs.] The power to the pilot lamp must remain on while the switchboard is live, even when the master controls are off or no loads are currently connected to the switchboard. The pilot lamp must be on an independent circuit that is connected ahead of the master switch on the switchboard. It must be protected by an overcurrent device rated no higher than 15 A and cannot share the lighting circuit overcurrent protective devices in the switchboard since the pilot lamp is connected on the line side of the master switch. The pilot lamp's condition should not be used as the only indication that the switchboard is de-energized/dead, as the pilot lamp bulb could be burned out and the switchboard still energized.

**Figure 44-1**
**Typical fixed stage switchboard circuit**




### Rule 44-208 Fuses
To facilitate quick replacement, fuses must be of the plug or cartridge type, have the correct ampacity rating, and be installed in a fuseholder. Each fuseholder must be enclosed in order to maintain electrical isolation from other fuseholders and other components of the switchboard. This will contain any associated arcing or flashing that could result when interrupting fault current and will prevent a shock hazard to the operator or service personnel.

### Rule 44-210 Overcurrent protection
To protect electrical equipment, devices, outlets, and ungrounded circuit conductors fed from the switchboard from short-circuits or overloads, all ungrounded conductors leaving the switchboard must be protected by an overcurrent device.

A fixed stage switchboard controls the operation of lighting levels required for the theatre's production (stage and/or gallery receptacles and other luminaires). These luminaires are frequently rated 5 kW and 10 kW and are connected to stage and gallery receptacles, which are often supplied from dimmers rated at 100 A. For luminaires having an input voltage of not more than 120 V that might have to be controlled by one dimmer, Subrule 2) allows an exemption from the branch circuit overcurrent protection requirements of Items c) and d) of Rule 30-104, up to a maximum of 100 A (the rating of the dimmer). This exemption is allowed because of the number and wattage of the luminaires and because each luminaire has an individual overcurrent protection device that is connected to the single dimmer. This exemption is similar to the exemption in Rule 30-1010 for pole-top branch circuits for permanent outdoor floodlighting installations. For conductor sizing, see Subrule 2) of Rule 44-216.

### Rule 44-212 Dimmers
Dimmer circuit switches must be disconnected on the supply side when they are in the open position to ensure that each dimmer and the branch circuits that it controls are dead.

Non-switching dimmers such as resistive dimmers may be connected in the neutral conductor, provided that the neutral is grounded.

All current-carrying components of dimmers must be enclosed or otherwise arranged or protected to prevent accidental contact with live parts.

### Rule 44-216 Conductors

A resistive dimmer dissipates heat from any current not used by the lamps that the dimmer controls. Subrule 1) requires that the conductors used for resistive and transformer-type dimmer switches be capable of withstanding the high temperatures that are commonly generated.

Stranded conductors tend to compress when fastened by pressure terminals. The vibration of dimmer components can also loosen or break strands of the stranded conductors within the terminals, generating heat and increasing the risk of arcing. Subrule 4) requires that wire strands be soldered together before being fastened under a clamp or binding screw.

## Portable switchboards on stage

### Rule 44-250 Construction of portable switchboards

To protect personnel from contact with live components, portable switchboards must be placed inside a suitable enclosure. The enclosure may be arranged so that it is open during operation, but no live components should be exposed in this position, except for dimmer faceplates.

### Rule 44-252 Supply for portable switchboards

Portable switchboards are sometimes located in high-traffic areas, with people passing by and/or moving equipment. The switchboards might also have to be moved from place to place. To accommodate a wide range of possible conditions of use, Subrule 1) requires that the feeder cables for portable switchboards be of the extra-hard-usage type (for example, Types S, SO, and ST) and suitable for damp or dry locations.

Subrule 1) also requires that the supply cables terminate within the switchboard enclosure, in an enclosed, externally operated, fused master switch. This provides a means for all components inside and outside the enclosure to be de-energized before reconfiguring and connecting load circuits. Subrule 2) requires a pilot light to indicate that the fused master switch is energized regardless of whether it is switched on or off.

## Fixed stage equipment

Fixed stage equipment refers to the footlights, border lights, and proscenium sidelights that previously were permanently installed in theatres. Such luminaires are now used only as portable equipment and are covered by CSA C22.2 No. 166.

### Rule 44-300 Footlights

Because footlights are typically installed directly on, or recessed in, the floor of the stage, Rule 44-300 requires that footlight wiring be protected from damage using rigid metal conduit, electrical metallic tubing (EMT), or a metal trough. When rigid metal conduit or EMT is used to route the wiring for footlights, each lampholder must be installed in an individual outlet box that is part of the conduit or EMT installation. This ensures the continuity of the rigid metal conduit or EMT and prevents shock hazards.

### Rule 44-302 Metal work

The metal used in the construction of permanent and portable footlights, border lights, proscenium sidelights, and strip lights must be thick enough to maintain structural rigidity and to protect the lights and their components from damage. Rule 44-302 sets out the minimum thicknesses for various applications.

### Rule 44-304 Clearances at terminals

Arcing between lampholder terminals and a metal trough in which footlight wiring is run can present a fire hazard. Rule 44-304 specifies a minimum spacing of 13 mm between lampholder terminals and a metal trough. This clearance is not required where all footlight wiring is installed in a rigid metal conduit or an EMT system, as any arc is contained by the metal conduit or EMT system.

### Rule 44-306 Mechanical protection of lamps in borders, etc.

The lamps used in border lights, proscenium lights, and strip lights are fragile and generate a significant amount of heat. The construction of these luminaires must provide adequate mechanical protection for the lamps, protecting them from impact and preventing them from accidentally touching scenery, drapery, and other combustible materials.

### Rule 44-308 Suspended luminaires

Border and strip lighting units are heavy and can pose a safety risk when suspended over the heads of performers, technical personnel, and others. Such units must be mounted so that their mechanical and electrical integrity is ensured under normal working conditions.

### Rule 44-310 Connections at lampholders

Lampholders are subject to vibration when they are moved and when they are physically knocked or hit during storage, installation, or operation. Rule 44-310 requires that the supply conductors to lampholders be fastened to terminals in such a way that they cannot vibrate or twist free. This is achieved by soldering the terminal points or by using connections such as solderless crimp connectors or self-locking pressure connectors.

### Rule 44-312 Ventilation for mogul lampholders

The lamps used in mogul lampholders generate a significant amount of heat. These luminaires must be constructed to allow the heat to dissipate quickly so that external surfaces do not create a fire hazard. This is accomplished by using a double-wall construction designed to allow adequate cooling.

### Rule 44-318 Pendant lights rated more than 100 W

Lamps rated higher than 100 W are more susceptible to damage than lower-wattage lamps because their larger glass envelopes do not have as much structural rigidity. Rule 44-318 requires the use of mesh lamp guards to protect these lamps from direct impact and to contain glass shards if a lamp shatters or explodes.

### Rule 44-320 Cable for border lights

Flexible cord or cable used for border lights must be the extra-hard-usage type and suitable for damp or dry locations (for example, Types S, SO, and ST).

Subrule 2) requires that the cable support points be located overhead so that strain-relief devices are not subject to lateral motion, which can damage the cable and cause failure of the strain-relief device.

Subrule 3) requires that the cable be fully supported so that the terminals or binding posts of border lights do not bear any weight, ensuring that all connections maintain their electrical and mechanical integrity.

### Rule 44-322 Wiring to arc pockets

Arc pockets are receptacles designed to supply power to carbon-arc direct-current lighting fixtures. Such luminaires are no longer in general use. Because arc pockets need to be moved easily for spotlight movements or situations, they cannot be attached directly to rigid metal conduit or EMT. When such conduit or tubing is used to wire arc pockets, it must be terminated approximately 300 mm from the pocket, with the wiring continued by means of flexible metal conduit. Leave sufficient slack to allow the luminaire to move easily in the desired directions.

### Rule 44-324 Receptacles in gallery pockets

To facilitate the use of specialized, high-capacity electrical equipment in the gallery pockets, at least one receptacle of 30 A or higher must be provided in each pocket.

### Rule 44-328 Curtain motors

Curtain motors must be of the enclosed type to prevent foreign matter from entering into motor components and creating an electrical, mechanical, and/or heat hazard.

### Rule 44-330 Flue damper control

Flue dampers are doors located in the loft above the scenery and stage. In normal operation, these doors are to be held in a closed position by either electrical or mechanical means. In the case of fire, the doors are released, allowing smoke to exit through the loft space. When they are held in a closed position by an electrical device, flue dampers must be arranged to release (open) automatically when power is interrupted, either intentionally by a switch that opens the branch circuit or accidentally by a general loss of power. The flue damper control device must be designed to operate indefinitely at full rated voltage and must be located in a protective enclosure in the loft near the flue dampers.

At least two release switches must be installed: one at the electrician's station and the other at a location acceptable to the authority having jurisdiction (see Rule 28-604). These release switches must be protected from accidental operation by a self-closing cover.

## Portable stage equipment

### Rule 44-350 Fixtures on scenery

To prevent shock or fire hazards, all electrical fixtures mounted on scenery must be secure. Supply cables must be of the hard-usage type and selected in accordance with Rule 12-402 1) or Rule 12-406 1) to prevent damage when scenery is moved. Where fixtures have stems, the stems must be carried through the scenery and terminate with a bushing in order to protect the insulation of the cable.

### Rule 44-352 String or festooned lights

Joints in the wiring of string or festooned lights must be staggered to prevent adjacent conductor joints from contacting each other and possibly causing a short-circuit. To prevent a fire hazard, Rule 44-352 requires the use of lamp guards so that lamps do not come in contact with combustible lampshades.

### Rule 44-354 Flexible conductors for portable equipment

Flexible cords

- used for arc lamps;
- installed in bunches (fastened together); or
- for use with other portable equipment

must be approved for extra-hard usage and selected in accordance with Rule 12-402 1) or Rule 12-406 1) to ensure protection from mechanical damage. Where separate miscellaneous portable devices are used and the conditions of use are such that the flexible cords are not exposed to severe mechanical injury, flexible cord types approved for other than hard usage and selected in accordance with Rule 12-402 1) or Rule 12-406 1) may be used. In many cases, deciding whether the requirement can be relaxed depends on expert opinion. It is advisable to consult the authority having jurisdiction prior to installation.

### Rule 44-356 Portable equipment for stage effects

Portable electrical equipment for special stage effects must be considered acceptable for the specific purpose by the authority having jurisdiction. It must be located so that flames, sparks, or hot particles cannot come into contact with combustible materials.

# Section 46 — Emergency power supply, unit equipment, exit signs, and life safety systems

### Rule 46-000 Scope

Section 46 applies to:

- specific requirements for the emergency power supply to the electrically connected life safety systems that are mandated by the *National Building Code of Canada* to be provided with emergency power;
- the installation of emergency power supply sources, including unit equipment for emergency lighting; and
- the requirements for installation of electrically connected exit signs and electrical connections between the emergency power supply and the life safety systems described by this Section.

When the *National Building Code of Canada* requires that, in the event of a failure of the normal supply, certain equipment in a building (life safety systems as defined by this Section) be provided with an emergency power supply source, compliance with the requirements of this Section becomes mandatory.

Life safety systems include emergency lighting and fire alarm systems that are required by the *National Building Code of Canada* to have an emergency power supply from batteries, generators, or a combination thereof. Electrical equipment for building services, such as fire pumps, elevators, smoke venting fans, smoke control fans, and dampers that are required by the *National Building Code of Canada*, must have an emergency power supply provided by an emergency generator. These life safety systems are mandated by the *National Building Code of Canada* to facilitate:

- early warning of the fire condition;
- fire suppression, smoke venting, and smoke control; and
- safe egress of the building's occupants in the event of a fire or other emergency.

Section 46 does not determine where or when emergency power supply or life safety systems are required; such requirements are mandated by the *National Building Code of Canada*. The *National Building Code of Canada*'s requirements include, but are not limited to, the following (see Appendix G):

- exits and public corridors in buildings are to have a specified level of illumination; and
- when the regular power supply to a building is interrupted, an emergency power supply is to be automatically available to maintain the required levels of illumination for a specified period of time. This time period can vary, depending on the type of building and its occupancy.

The *National Building Code of Canada* also requires that an emergency power supply be provided by an emergency generator that conforms to CSA C282. The emergency power provided by the generator, supplies equipment such as elevators, smoke control and smoke venting fans in high buildings, and electrically connected fire pumps where fire pumps are required for operation of fire suppression systems.

## General

### Rule 46-100 Capacity

Emergency power supply and unit equipment must be capable of performing their intended function when required. The *National Building Code of Canada* places different operational requirements for the emergency power supply's performance (from 30 min to 2 h). The applicable *National Building Code of Canada* provisions must be assessed in this regard. These requirements vary according to the type and occupancy of a building. Rule 46-100 requires that an emergency power supply or unit equipment be of adequate capacity and rating to address the specific needs of any given building or type of occupancy (for example, how much lighting is to be provided, where it is required, how long it is to be capable of operating).

Appendix G provides cross-references between specific Rules of Section 46 and Articles of the *National Building Code of Canada*.

### Rule 46-102 Instructions

In accordance with the applicable Standards for emergency power supplies and Standards for central battery systems, unit equipment, and emergency generators, testing is required. Specific forms or instructions for such tests are provided by these Standards. The *National Building Code of Canada* references these Standards as mandatory documents with which emergency power supply sources are to comply in their design, construction, and testing.

### Rule 46-104 Maintenance

Batteries are to be kept in proper condition and fully charged. Required maintenance typically includes maintaining proper fluid levels and keeping the batteries constantly charged by means of automatic chargers. Review product Standards and manufacturer's instructions for this purpose.

### Rule 46-106 Arrangement of lamps

Although a single emergency lamp might provide the illumination required in a specific area by the *National Building Code of Canada*, the failure of that one lamp could leave the area in total darkness. Rule 46-106 requires that at least two lamps be used in an area so that if one fails the area is still illuminated.

Subrule 2) clarifies that the circuit supplying emergency lighting is not to supply any other lamps or appliances as this might interfere with the operation of the emergency system and compromise safety.

### Rule 46-108 Wiring method

Subrule 1) states that the following insulated conductors be installed in accordance with the requirements of Subrule 2):

- insulated conductors and cables run between the emergency power supply and the life safety system;
- insulated conductors and cables run between the emergency power supply and the exit signs; and
- insulated conductors and cables run between the unit equipment's (emergency power supply) and remote lamps.

**Note:** *These requirements are intended to reduce the likelihood that a fault on electrical equipment not associated with emergency systems will interfere with their operation.*

Subrule 2) requires that these insulated conductors be installed in:

- metal raceways of the totally enclosed type;
- a cable having a metal armour or sheath;
- rigid non-metallic conduit; and
- electrical non-metallic tubing when the tubing is encased or embedded in at least 50 mm of masonry or poured concrete.

Subrule 3) relaxes the requirements in Subrule 2) when these insulated conductors are used in buildings of combustible construction (the definition of a combustible building is found in the *National Building Code of Canada* — a combustible building is typically a smaller building). It allows the use of non-metallic sheathed cable that conforms to Rules 12-506 to 12-520 or of a totally enclosed non-metallic raceway. Whichever method is chosen, the appropriate FT1 flame spread rating is required.

Wiring methods are a particular concern in high buildings, where more extensive provisions are needed for operation of life safety systems. The Appendix B Note to Rule 46-108 directs a Code user to the *National Building Code of Canada* requirements for providing fire protection for electrical insulated conductors and cables used in conjunction with emergency equipment in high buildings. These requirements are intended to prevent faults on non-emergency equipment from adversely affecting the operation of mandatory emergency equipment. For example, Article 3.2.7.10 of the *National Building*

*Code of Canada* mandates protection of insulated conductors between the emergency power supply and life safety systems against exposure to fire for at least 1 h.

Subrule 4) requires that the installation of insulated conductors and cables run between the *National Building Code of Canada* required emergency power supply and the *National Building Code of Canada* required electrically connected exit signs or life safety systems be kept entirely independent of all other wiring and not be installed in luminaires, raceways, boxes, cabinets, or unit equipment containing other wiring, including wiring to other loads connected to the emergency power supply. Exceptions are allowed where the insulated conductors are required to enter transfer switches or to enter exit signs and emergency lights that are fed from two sources (normal and emergency).

Subrule 5) states that insulated conductors and cables between the emergency power supply and other equipment that is not a part of a life safety system are not to enter a luminaire, raceway, box, or cabinet occupied by insulated conductors connecting life safety systems to the emergency power supply. An exception is allowed where necessary in busways, splitters, and other similar enclosures for the connection to the overcurrent device for an emergency power supply described in Subrule 1) of Rule 46-208.

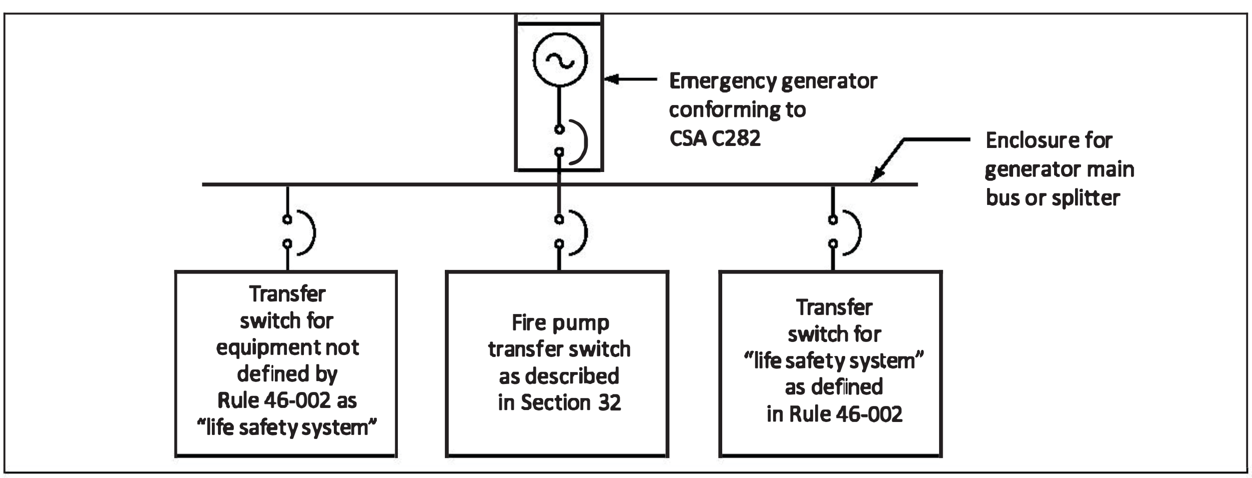
## Rule 46-200 Emergency power supply

Unless the *National Building Code of Canada* specifically mandates use of an emergency generator as the emergency power supply source, the emergency power supply can be provided either by a central battery system or by a generator. Rules 46-202 to 46-212 apply only to installations that use a central standby power source. Such installations are most common where emergency power is needed for more than just lighting (for example, for fire alarm systems and exit signs).

The Appendix B Note to Rule 46-200 refers to the *National Building Code of Canada* requirements pertaining to the location and fire protection of emergency power supplies.

See Figure 46-1.

**Figure 46-1**
**Emergency power supply**




## Rule 46-202 Types of emergency power supply

The *National Building Code of Canada*:

- allows the use of batteries or generators as the emergency power supply sources for such equipment as fire alarm systems, emergency lighting, and exit signs; and

- mandates the use of an emergency generator as the emergency power supply source for such life safety systems as elevators, smoke-control and smoke-venting equipment in high rise buildings, and electrically connected fire pumps.

Rule 46-202 reflects this requirement of the *National Building Code of Canada*.

**Note:** *No other types of alternate power supply sources are allowed to be used as the required emergency power supply by the* National Building Code of Canada *and by this Rule of the Code.*

A central battery system normally supplies only emergency lighting. When such a system is operating, the:

- battery gradually discharges; and
- amount of light given off by the lamps gradually decreases.

Eventually, the battery loses its capacity to provide the required amount of illumination. Where a storage battery is used, Item a) of Subrule 1) of Rule 46-202 requires that it be the rechargeable type, equipped with an automatic charging means to keep it fully charged; in addition, the battery must have sufficient capacity to supply the entire emergency load at 91% of full voltage for the time required by the *National Building Code of Canada* (at least 30 min and, depending on the type of occupancy, as long as 2 h during a power interruption).

**Note:** *If batteries are used as an emergency power supply long enough to drain the battery charge, the batteries need time to recharge to their full capacity before they can be used again. The recharging time for a battery, as well as its expected service life, needs to be considered when choosing an emergency power source.*

Subrule 2) prohibits the use of automobile batteries, except by special permission (in accordance with Rule 2-030) under special circumstances. The principal safety concern is that such batteries might be borrowed, especially in cold weather, to start cars, jeopardizing the safety of the building.

Many buildings (particularly high buildings) require emergency power for more than just lighting (for example, for fire pumps, elevators, and smoke-control equipment). When large amounts of power are required during an emergency, batteries are generally not a suitable emergency power source. A generator driven by an engine (fuel supply is prescribed by CSA C282) is the most common alternative. Subrule 3) requires that a generator:

- have sufficient capacity to carry the load;
- be capable of starting automatically, without undue delay, upon failure of the normal power supply to any transfer switch connected to the generator; and
- conform to the requirements of CSA C282.

**Note:** *CSA C282 provides further information on generator-supplied installations, including requirements for transfer equipment, prime movers, generators, reaction time, and control sequences. Although Rule 24-306 references CSA Z32 for emergency power supply in health care facilities, CSA Z32 mandates compliance with CSA C282 for installation of an emergency generator. Although it is not specified in Rule 46-202, the engine driving the generator is to be provided with enough fuel to allow the emergency system to operate for the required period of time (this requirement is specified in CSA C282).*

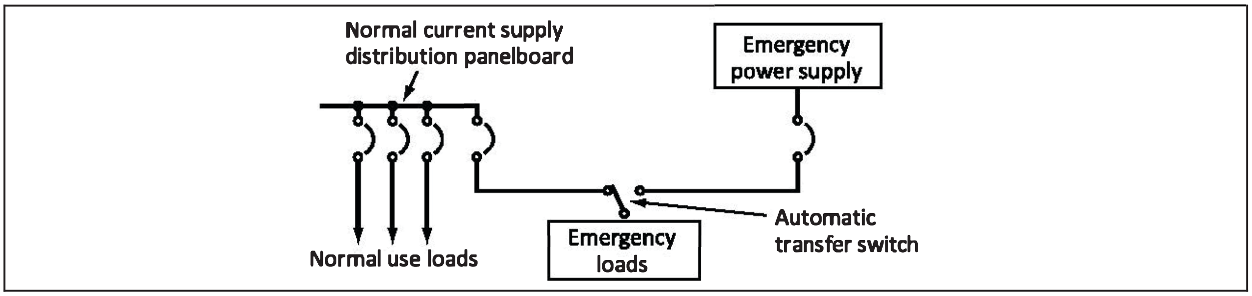
### Rule 46-204 Protection of electrical conductors and cables

CSA C282 requires that the wiring between the generator and associated equipment (such as an automatic transfer switch) located in the generator room be protected from exposure to fire for a period of not less than 1 h. Rule 46-204 requires that all power, control, and communication insulated conductors and cables between an emergency generator and continuous-operation electrical equipment installed as a part of the emergency power supply and located outside the generator room be protected against fire exposure as required by the *National Building Code of Canada* and CSA C282. The Appendix B Note to Rule 46-204 outlines some acceptable methods for achieving this fire protection.

## Rule 46-206 Control

As a means of automatically energizing the emergency power supply whenever there is a disruption to the normal power supply, automatic transfer equipment is to be provided for every emergency power supply (see Figure 46-2). Subrule 1) also requires that the automatic transfer equipment be accessible only to authorized personnel. Subrule 2) allows an exception during daylight hours in a well-lit area: an automatic light-actuated device located in an area with plenty of windows or natural daylight is allowed to be connected in the circuit controlling the emergency lights. This reduces the load on the generator or the drain on the battery.

**Figure 46-2**
**Typical transfer arrangement**




## Rule 46-208 Overcurrent protection

Given the critical role of emergency systems, they must always work when needed. Subrule 1) requires that the overcurrent device for the emergency power supply (see Figure 46-1) be coordinated with the overcurrent devices of the feeders and branch circuits supplying life safety systems and other electrical equipment connected to the emergency power supply. This ensures that the operation of a downstream overcurrent device due to a fault will not affect the upstream overcurrent device.

The overcurrent device is to be:

- locked in a room or cabinet; and
- accessible only to authorized personnel in order to minimize the possibility of inadvertent disconnection.

## Rule 46-210 Audible and visual trouble-signal devices

Rule 46-210 requires that trouble signals be provided to alert those responsible for a building of any failures or operational problems related to an emergency power supply. This enables the timely servicing, repair, and maintenance of the power supply. Trouble signals are to be both audible and visual so that problems (such as batteries not charging) are noticed as soon as possible. To minimize inconvenience to building occupants (and to prevent unnecessary alarm), Rule 46-210 allows the audible signals to be silenced by authorized personnel, provided that the trouble light (the visual signal) remains on, alerting the appropriate personnel that there is still a malfunction. Once the malfunction has been corrected:

- signal devices are to be returned to their normal condition; and
- both audible and visual signals are to be ready to operate in the case of another malfunction.

## Rule 46-212 Remote lamps

Where a generator or battery is used as a central emergency power supply, many of the emergency system lamps can be located far from the central unit. The lower the operating voltage of the emergency power supply, the more critical the effect of voltage drop on long runs of insulated conductor. Excessive voltage drop can reduce illumination below required levels and, in some cases, even cause luminaires to turn off. To maintain the required level of illumination, Rule 46-212 requires that voltage at the individual lamps not drop by more than 5% of the applied voltage.

# Unit equipment

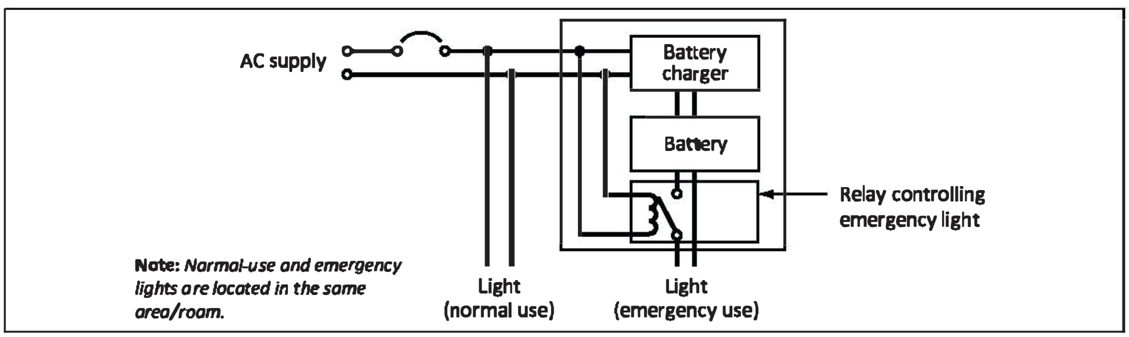
Article 3.2.7.4 (2) of the *National Building Code of Canada* recognizes the use of unit equipment as the emergency power supply source for emergency lighting in a building. An individual unit is used to provide automatically – in response to a failure of the normal power supply to which it is connected — a specified light output and a specified amount of power for illumination purposes for a specified period of time, but in any case not less than 30 min. Unit equipment typically consists of:

- a storage battery;
- a charging means to automatically maintain the battery in a charged condition;
- lamps or output terminals to which specifically listed lamps can be connected;
- a means to energize the lamps when the normal power supply fails and to de-energize the lamps when the normal power supply is restored; and
- a means to indicate and test the operating condition of the equipment.

Such unit equipment for emergency lighting is designed, constructed, tested, and certified in accordance with CSA C22.2 No. 141.

See Figure 46-3.

**Figure 46-3**
**Unit equipment diagram**




## Rule 46-300 Unit equipment

Rules 46-302 to 46-306 apply only to individual unit equipment used to supply emergency lighting in specific locations and not throughout the building. The Appendix B Note to Rule 46-300 refers to CSA C22.2 No. 141 to define unit equipment and to provide additional information on markings.

## Rule 46-302 Mounting of equipment

Unit equipment is usually located in halls and corridors. Rule 46-302 requires that the unit equipment be mounted a minimum of 2 m above the floor (see Figure 46-4), which is high enough to:

- provide general illumination over the area;
- prevent unauthorized tampering with the equipment; and
- avoid presenting a hazard to people using the hallway or corridor.

## Rule 46-304 Supply connections

The most common way of arranging supply connections is to connect unit equipment to a receptacle by means of a flexible cord and attachment plug supplied with the unit equipment (see Figure 46-4). Subrule 1) requires that receptacles used to supply unit equipment be located at least 2.5 m above the floor and close to the unit equipment so that extension cords do not have to be used. This ensures that the:

- point of connection is far enough out of reach that the unit cannot be inadvertently disconnected; and
- receptacle cannot be used for other purposes.

CSA C22.2 No. 141 allows construction of cord-connected unit equipment only when the rating of the unit equipment does not exceed 250 V, or 24 A.

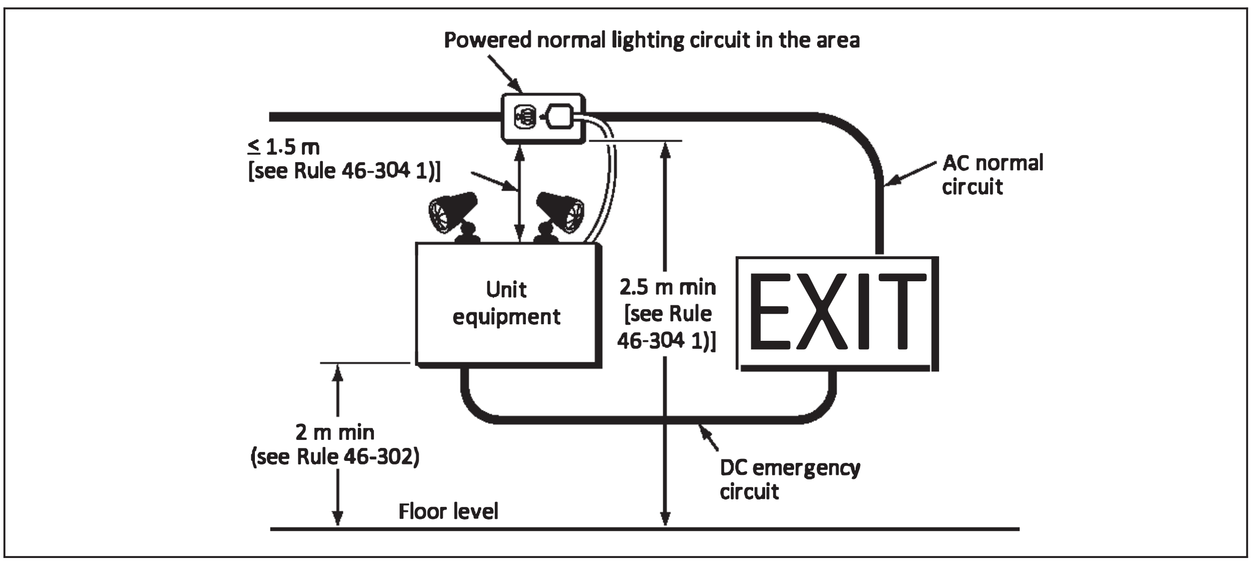
The flexible cords and attachment plugs suitable for unit equipment having input voltage and current ratings higher than 250 V and 24 A are large and heavy. Over time, they can be loosened by vibration, exposing bare live blades that can present a shock hazard and even disconnect the unit equipment from its power supply. Thus, Subrule 2) requires that unit equipment rated for more than 250 V or 24 A be permanently connected (directly connected).

Subrule 4) requires that unit equipment be installed in such a way as to automatically provide illumination to an area during loss of power to normal lighting in that area. For example, unit equipment installed in a corridor:

- is activated by a loss of power to the normal lighting in the corridor; and
- provides emergency lighting there.

Typically, this is accomplished by connecting the receptacle that supplies the unit equipment to the circuit that supplies normal lighting in the area so that the unit equipment detects the de-energizing of the circuit and operates to provide emergency lighting. If the normal lighting operates at 347 V and the unit equipment is plugged into a receptacle operating at 120 V, voltage sensing relays or similar equipment can be used to comply with Rule 46-208.

**Figure 46-4**
**Connection to unit equipment**




## Rule 46-306 Remote lamps

Unit equipment is sometimes self-contained, but some installations involve the use of remote lamps mounted at some distance from the unit's battery and charging means. Remote lamps are used in some cases to give a consistent level of illumination over an entire area, particularly a relatively large or irregularly shaped area. Remote lamps are also used to conform with Rule 46-106, which requires the use of more than one lamp in particular areas.

However, remote lamps are not to be located in an entirely different area. For example, where a unit has sufficient capacity to operate additional remote lamps located on another floor, this arrangement is acceptable only if the normal lighting on that floor is supplied by the same branch circuit as the unit (see Rule 46-304), which is very unlikely.

Where the unit equipment and remote lamps are far apart, voltage drop can be a concern because unit equipment typically uses extra-low-voltage power supplies. To ensure that the lamps provide the required levels of illumination for the appropriate length of time, the allowable voltage drop on conductors to remote lamps is limited to a maximum of 5% of the output voltage marked on the unit equipment. The Appendix B Note to Rule 46-306 1) observes that this requirement stems from CSA C22.2 No. 141. The requirements of CSA C22.2 No. 141 are meant to ensure that any lamps forming part of the unit equipment – or specified in a list provided with the unit equipment as suitable for remote connection – do not dim very much during the emergency period.

Certain lamps can conform to the illumination requirements despite a greater voltage drop and might be approved for use with a specific unit. The Appendix B Note to Rule 46-306 1) references Table D4 to determine approximate allowable circuit lengths. See Table 46-1.

**Table 46-1**
**Method of determining the maximum one-way conductor length using Table D4 of the Code**

| Step | Method |
|---|---|
| 1 | Determine the following characteristics:<br>• circuit voltage (*V*);<br>• allowable percentage of voltage drop (*P*);<br>• load current (*I*); and<br>• the size of conductor to be used. |
| 2 | From Table D4, determine the following:<br>• the current rating from Table D4 closest to the actual load current ($I_t$); and<br>• the one-way distance in metres from the power source, measured along the conductor, using the conductor size at the Table D4 current rating ($L_t$). |
| 3 | Use the values from Steps 1 and 2 in the following formula to calculate the maximum one-way length (*L*) for the size of conductor being used:<br>$L = (V/6) \times (P/5) \times (I_t/I) \times L_t$ |

## Exit signs

### Rule 46-400 Exit signs

Location requirements for exit signs are set out in the *National Building Code of Canada*. Rule 46-400 covers:

- the dedicated connection to a power supply for exit signs; and
- the connection of circuits supplying lighting in areas where externally illuminated exit signs are installed in accordance with the *National Building Code of Canada* requirements.

If an exit sign is required by the *National Building Code of Canada* and is electrically illuminated, Subrule 1) requires that the power for the exit sign be provided by a branch circuit that supplies only other exit signs.

Subrule 2) provides an exemption to Subrule 1) by allowing the circuit supplying the exit signs to supply emergency lighting in the area where the exit signs are located (see Figure 46-4).

However, in an area where exit signs are installed and where emergency lighting is required by the *National Building Code of Canada* or local building codes, Subrule 3) requires that exit signs also be illuminated by an emergency power supply. This allows the exit sign to be provided with a minimum illumination whenever the emergency lighting is energized.

Subrule 4) requires that the luminaires used to illuminate exit signs that are not connected to an electrical circuit (i.e., externally illuminated exit signs) meet the:

- circuit requirements of Subrules 1) and 2); and
- illumination requirements of Subrule 3).

The Appendix B Note to Rule 46-400 2) cautions that the circuit supplying both emergency lighting and exit signs are not to be controlled by a switch, time clock, or other disconnecting means.

# Section 48 — *Deleted*

# Section 50 — *Deleted*

# Section 52 — Diagnostic imaging installations

## Rule 52-000 Scope

Section 52 includes additional and specific requirements for diagnostic imaging equipment installations. Diagnostic imaging lets medical personnel look inside an individual's body for clues about a medical condition. A variety of equipment can create pictures of the structures and activities inside the body. This includes equipment such as X-ray, computerized tomography, and ultrasound.

During operation, diagnostic imaging equipment such as X-ray and computerized tomography generates high voltages, a variety of frequencies, and dangerous radiation levels. To ensure the safe installation of such electrical equipment, the Code sets out special requirements for the related high-voltage circuits, equipment, disconnecting means, transformers and capacitors, controls, supply conductors, and overcurrent protection. These requirements supplement, and in some cases differ from, the general requirements of the Code.

The control of X-ray and computerized tomography equipment radiation (direct, stray, or secondary) is determined by the design of the equipment, which must meet the standards specified by Health Canada. Consequently, radiation control is not addressed in the Code.

## Rule 52-002 Special terminology

By specifying *long-time* and *momentary ratings* for X-ray or computerized tomography equipment, the Code encourages manufacturers and installers to choose components that can handle the long-time load as well as the momentary peak surges of power that typically occur during operation of the equipment.

## Rule 52-004 High-voltage guarding

During operation, diagnostic imaging equipment can generate dangerously high voltages. To prevent any accidental contact with high-voltage components, the installation must be arranged so that all high-voltage parts are mounted in a grounded metal enclosure where the high-voltage parts are insulated from the grounded metal enclosure, or they are installed in a separate room or enclosure, with a door that when opened operates a switch disconnecting the power to the equipment's supply circuits.

High-voltage circuits must run exposed between different pieces of components of the diagnostic imaging equipment. These circuit conductors are run in a cable that allows the flexibility required for the operation of the different parts and are also constructed with extra provisions to make them "shockproof".

X-ray and computerized tomography equipment typically incorporates a milliammeter that displays the current that is flowing to the head of the X-ray tube, which is used by the operator to determine the correct exposure for a given X-ray procedure. Since the operator often needs to adjust the current level, the milliammeter is located near the control panel for convenient reference. Since the milliammeter is connected in the high voltage circuit and installed near the operator's control panel, the possibility of a shock hazard exists. Therefore, for operator safety, the requirements in Subrule 4) are to be followed.

## Rule 52-006 Connections to the supply circuit

Subrule 1) requires that permanently installed electrical equipment be connected to the power supply in accordance with the Code's general requirements. An exception to these general requirements is made when the rating of the branch circuit for diagnostic imaging equipment is 30 A or less, in which case the equipment may be connected by means of a suitable plug and hard-usage-rated cable or power supply cord.

Mobile diagnostic imaging equipment is intended to be moved easily to different locations and connected quickly to the power supply in each location. To allow this flexibility, Subrule 2) permits mobile diagnostic equipment to be connected to a power supply by suitable temporary direct connections and cable or cord rated for at least hard usage.

Suitable connections are temporary direct connections that meet the requirements for a disconnecting means, the size of overcurrent protection, the prevention of fire and shock hazards, and the guarding against mechanical damage, etc.

**Rule 52-008 Disconnecting means**
In emergencies and for normal servicing and maintenance, the operator and service personnel must have a readily accessible disconnecting means [see Subrule 2)]. The disconnecting means is to have a minimum rating capable of interrupting the supply circuit to the diagnostic imaging equipment [see Subrule 1)].

Subrule 3) gives the requirements for a receptacle and plug that are allowed to be used as the disconnecting means for permanent or mobile equipment.

**Rule 52-010 Transformers and capacitors**
Diagnostic imaging equipment is designed, manufactured, tested, inspected, and approved to the requirements in the individual safety standards that are part of the *Canadian Electrical Code, Part II*. To avoid duplication of tests and inspections, Subrule 1) states that transformers and capacitors in diagnostic imaging equipment are exempted from the requirements of Section 26.

However, Subrule 2) adds a special requirement for discharging and grounding the large capacitors typically found in the power supplies of diagnostic imaging equipment. These capacitors maintain a stored energy charge for a considerable period after the disconnection of power. To prevent the stored charge from becoming a shock hazard, it is required that the capacitor plates be automatically discharged and grounded when the source of supply is de-energized.

**Rule 52-012 Control**
The power supplies for stationary X-ray and diagnostic imaging equipment use step-up transformers to boost a lower supply voltage to the higher voltage required by the equipment. A fault occurring in the equipment, especially during the operational radiographic cycle, can have serious consequences, given the higher operating voltage. Therefore, Subrule 1) requires an overcurrent device in the low-voltage primary of the step-up transformer, either as part of the equipment or readily accessible near the equipment.

In some cases, the branch circuit overcurrent device can have a lower current rating than the rating required to protect the fluoroscopic and therapeutic circuits in the equipment. Where this occurs, Subrule 2) requires that additional overcurrent protection to protect these circuits be present at the equipment.

The low-voltage primary of the step-up transformers for portable diagnostic imaging equipment must also be protected in accordance with Subrule 1) and, where necessary, Subrule 2). Subrule 3) allows an exemption for portable diagnostic imaging equipment when all high-voltage parts are enclosed in a single metal enclosure bonded to ground.

In some cases, more than one piece of equipment is supplied by a common high-voltage source. For example, in a dental office, one X-ray generator might supply two X-ray heads, both of which could be in operation at the same time. To allow for independent operation, each piece of equipment must be capable of being independently switched, or have an individual disconnecting means from the high-voltage source.

**Rule 52-014 Bonding**
To protect patients from stray voltages, all the metal parts of diagnostic imaging equipment (e.g., tube stands, tables, fluoroscopes, and other ancillary equipment) are to be bonded to ground as required by Section 10. As a result, all exposed metal objects are at the same voltage-to-ground (i.e., have the same ground potential), which should prevent the operator and patient from receiving shocks when touching two separate metal objects at the same time.

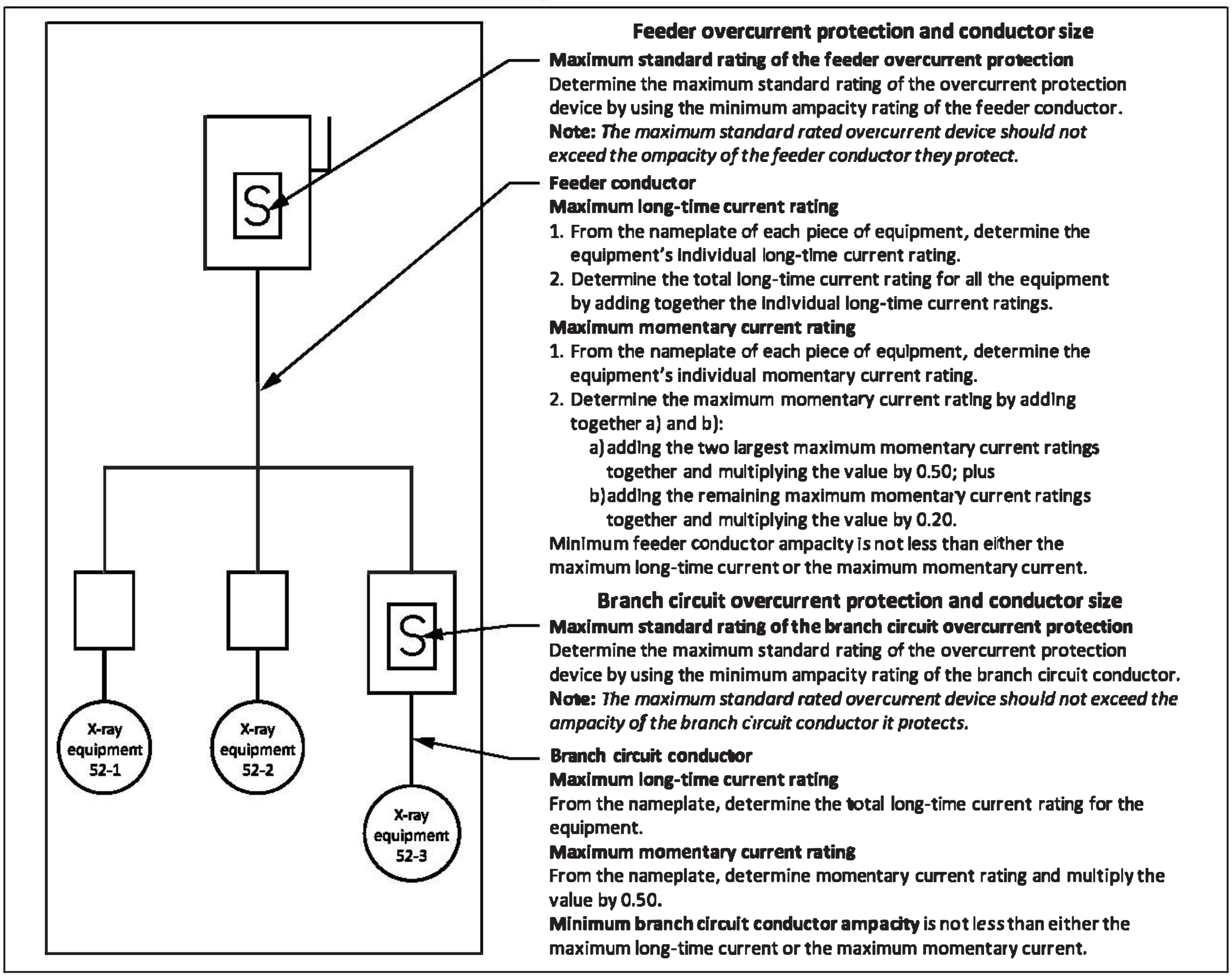
### Rule 52-016 Ampacity of supply conductors and rating of overcurrent protection

X-ray and computerized tomography equipment draws the highest line current during X-ray exposure cycles. This current draw can be several times the long-time current rating, but it lasts only for short periods (a maximum of 20 s but typically less than 5 s). Subrule 1) sets out requirements for sizing the supply conductors and overcurrent devices that handle the high current, based on the manufacturer's long-time or momentary ratings, as specified on the nameplate (see Figure 52-1).

Subrule 2) gives the requirements for sizing conductors and overcurrent devices used to supply more than one piece of X-ray or computerized tomography equipment. Once again, the sizing of the conductors and overcurrent devices is based on the manufacturer's nameplate values for long-time or momentary ratings.

**Note:** *This calculation is also used to size distribution equipment, such as feeder conductors and panelboards, when X-ray or computerized tomography equipment is combined with other loads.*

## Figure 52-1
## Sizing of conductors and overcurrent protection



# Section 54 — Community antenna distribution and radio and television installations

## Rule 54-000 Scope

Section 54 includes additional and specific requirements for:

- community antenna distribution systems (often referred to as cable TV, coaxial cable systems, or CATV systems);
- electrical equipment used to receive radio and television transmissions; and
- equipment used to operate experimental amateur radio stations licensed by the Government of Canada.

The equipment and electrical installations in major broadcasting facilities, such as commercial radio and television stations, are regulated and overseen by Canadian Radio-television and Telecommunications Commission (CRTC). However, smaller television and radio receiving systems, including cable TV distribution equipment and residential cable reception equipment, are not usually controlled by federal regulations or licensing. Such systems can present electrical shock and fire hazards when improperly installed.

Electrical equipment for television and radio transmission (one-way communication other than by community antenna distribution systems) and associated antennas are not covered by Section 54. Neither is equipment used to couple carrier current to power line conductors. A carrier current is a high-frequency alternating current superimposed on ordinary power-line frequencies. The current can be modulated to carry:

- a voice signal for telephone communication between points in a power system; or
- tones that operate switching relays or transmit data.

Examples include the use of power lines to transmit data on the sale of fuel from a gas pump to the cashier at a self-service gasoline station and intercom systems that use a building's power conductors to carry the voice signals.

Coaxial cables are often used as a transmission line for radio, television, and data frequency signals, called by the industry 0 V, 0 A signals (see the sketch in the Appendix B Note to Rule 54-102). Hypothetically, in an ideal coaxial cable the electromagnetic field carrying the signal would exist only in the space between the inner and outer conductors. In practice, coaxial cable achieves this objective to a high degree because it:

- provides protection of signals from external electromagnetic interference; and
- effectively guides signals with low emission along the length of the cable.

## Rule 54-002 Special terminology

The location of devices and equipment in a CATV system is a key factor in the requirements in Section 54. It is important to determine whether devices are on:

- public property where access is restricted to the trained and qualified employees of the CATV utility; or
- private property, where access is open to people who do not necessarily have any training in the systems or hazards involved.

The Appendix B Note to Rule 54-102 provides a schematic diagram of typical installations.

The *cable distribution plant* is located on public property. Its circuits are restricted to a maximum of 90 V and 16 A, which are levels that present a fire and shock hazard for people and structures.

The *customer distribution circuit* is located on private property. It carries the CATV signal from the customer service enclosure to equipment such as a television, radio, or computer. This signal, at 0 V and 0 A, does not present a fire or shock hazard.

A *multitap* is a connection terminal on the *cable distribution plant's* circuit in which *customer distribution circuits* are tapped into the utility's distribution plant and the signal strength is reduced to a value allowed by the requirements of Section 54 for supplying the *customer service enclosure*. The utility's 90 V, 16 A signal is to be reduced to a maximum of 90 V, 10 A when it is on private property and can be reduced to a level as low as 0 V, 0 A (the signal on the *customer distribution circuit*), depending on such factors as circuit distances, number of outlets, and type of occupancy, all of which can affect the signal strength. A *multitap* is:

- located on public property; and
- is accessible only to the CATV system's personnel.

At the *customer service enclosure*, the signal from the utility's distribution plant is terminated at the customer's building, on private property, and connected to the *customer distribution circuit*. Because this signal can be as high as 90 V and a maximum of 10 A, depending on the function of the building, it can constitute a fire and shock hazard. The *customer service enclosure* is, therefore, sealed so that it is not accessible to the customer.

A *power blocking device* is used to allow only the radio and television frequencies at 0 V and 0 A to enter the customer distribution circuit to prevent any shock or fire hazard on this circuit. The *power blocking device* can be installed in the *customer service enclosure* or anywhere on the line side of the *customer service enclosure*.

## Rule 54-004 Community antenna distribution

Community antenna distribution is considered a special type of receiving system because of the:

- complexity of its conductors and electrical equipment;
- multitude of interconnecting stations; and
- wide variety of information signals, frequencies, loads, and bandwidths related to the different voice, data, TV, and radio applications that the system can supply.

The Code distinguishes community antenna distribution systems from radio and television receiving stations because CATV systems use coaxial cable wiring systems (see the Appendix B Note to Rule 54-004). Subrule 2) requires that such CATV systems comply with Rules 54-100 to 54-704.

## Rule 54-006 Equipment

Almost all the electrical equipment installed on premises for a receiving or transmitting system is passive and does not present an electrical fire or shock hazard. Most of the equipment further offsets potential shock hazards through its design and method of operation (for example, a CATV distribution system is typically provided with a completely grounded system for its operations). Rule 54-006, therefore, exempts the electrical equipment installed in the systems covered by Section 54 from the requirement for approval in Rule 2-024. However, for special situations where it is known that equipment can present a fire or shock hazard, the Rules in Section 54 require approval of equipment.

## Rule 54-008 Receiving equipment and amateur transmitting equipment Rules

Separate Rules are needed for radio and television receiving equipment and amateur radio transmitting equipment because these systems have different electrical installation, fire and shock, and material requirements than CATV systems.

## Rule 54-010 Circuits in communication cables

When CATV distribution circuits are combined with communication circuits in a cable assembly, the more stringent Section 60 Rules governing communication systems apply. In general, the Rules applicable to the major function of a cable or conductor assembly take precedence, except when CATV conductors are bundled with other conductors. The coaxial cable used for a CATV distribution system cannot be protected in the same manner as paired communication conductors because of the different conductor designs and transmission methods. Therefore, when communication and CATV distribution conductors are combined in the same cable, Rule 54-010 requires that all circuits in the cable be:

- considered communication circuits; and
- installed in accordance with Section 60.

The protection and grounding of the coaxial cables is to conform to the requirements of Section 54 (see Rules 54-200 to 54-304).

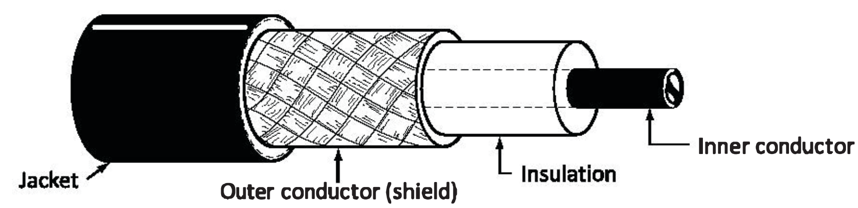
## Community antenna distribution

### Rule 54-100 Conductors

In both Canada and the United States, CATV distribution conductors use coaxial cables. The Rules for CATV systems (for example, for grounding methods and provision of protectors) are based on a standard coaxial cable (see Figure 54-1).

Subrule 2) reflects the development of standards to address the electrical shock hazards and flame spread ratings for coaxial cable placed within buildings; such conductors are to be selected in accordance with Subrule 3) of Rule 12-102.

**Figure 54-1**
**Typical coaxial cable**




### Rule 54-102 Voltage and current limitations

Subrule 1) gives requirements for coaxial cable used as the circuit conductor between:

- the cable distribution plant on public property and the customer service enclosure on private property;
- two customer service enclosures on private property; and
- the customer service enclosure and the associated community distribution circuits to equipment such as televisions, radios, and computers.

When installing coaxial cable between the cable distribution plant and the customer service enclosure, the type of occupancy determines the voltage and current restrictions. For single dwellings, Item a) of Subrule 1) restricts the signal to an open-circuit voltage of 90 V maximum, with current (in amperes) limited to 100/open-circuit voltage of the signal between the cable distribution plant and the customer service enclosure. For example, if the open-circuit signal voltage between the cable distribution plant and the customer service enclosure is 60 V, the current is limited to 1.67 A (100/60). For a multiple occupancy building, Item b) of Subrule 1) restricts the signal to an open-circuit voltage of 90 V maximum, with current limited to 10 A.

For any type of occupancy, shock and fire hazards on any coaxial cable circuit past the customer service enclosure are to be minimized by:

- restricting the signal to 0 V and 0 A;
- grounding the customer service enclosure;
- grounding the coaxial cable;
- providing the customer service enclosure with a lock or similar device to prevent unauthorized access; and
- providing the customer service enclosure with a power blocking device that prevents any signal above 0 V and 0 A from passing to equipment such as televisions, radios, and computers.

Item d) of Subrule 1) also references CSA C22.3 No. 1 and CSA C22.3 No. 7 for requirements for installing a cable distribution plant network on public property.

A long run of coaxial cable between the customer service enclosure and the customer's equipment, as well as a number of connection points on the coaxial cable circuit, can:

- increase the impedance of the coaxial cable; and
- cause the CATV distribution signal to decay.

Amplifiers are commonly used in such circumstances to boost the decaying signal to its proper strength. The amplifiers are Class 2, 0 to 30 V transformers that can be plugged into a 15 A, 120 V receptacle. To prevent any shock or fire hazard, Subrule 2) requires that these amplifiers:

- be installed at least 1 m away from the customer's equipment (for example, televisions, radios, and computers); and
- contain a power blocking device to prevent any signal above 0 V and 0 A from extending beyond the amplifier.

### Rule 54-104 Hazardous locations

Although CATV distribution circuits are not considered a source of electrical shock hazards during their normal operation, the conductors can present a fire, shock, or spark hazard if the circuit is accidentally energized by another electrical system (for example, by contact with an electric light circuit conductor, lightning, or a voltage surge).

Rule 54-104 requires that in cases where CATV distribution electrical equipment or conductors are placed in locations deemed hazardous according to Section 18, 20, 22, or 24, the installation of conductors and equipment conform to the applicable Rules of Section 18, 20, 22, or 24 to minimize the risk of fire or explosion.

### Rule 54-106 Inspection by an inspector

When an electric power utility or a communication/telephone utility that normally operates within the scope of Section 60 of the Code installs CATV distribution circuits as a part of its operating utility network, the installation need not be inspected. However, when the power source for a CATV circuit is provided by a transformer, amplifier, or other current-limiting device, and that device is connected to an electric supply circuit, the transformer, amplifier, or other device is to be subject to inspection.

### Rule 54-108 Supports

Devices used to attach CATV conductors to buildings are to be designed so that they neither damage the conductor nor pose an electrical shock or fire hazard. Rule 54-108 requires that such devices be acceptable for their intended use (for example, regarding the type and safety of the device and the location of use).

## Protection

### Rule 54-200 Grounding of outer conductive shield of a coaxial cable

The outer shield of a CATV distribution conductor (see Figure 54-1) is made of a conductive material that can become energized by accidental contact with power conductors or exposure to lightning or other electrical sources, resulting in a fire or shock hazard or damage to connected devices. Any electrical energy imposed on the shield is to be directed to ground, either through bonding of the shield or the use of a protector.

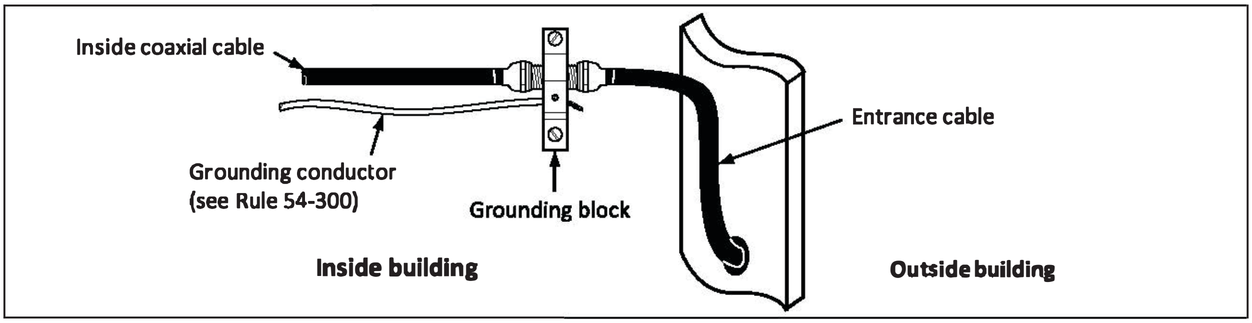
Where a coaxial cable enters a building and is exposed to lightning or to accidental contact with lightning rod or arrester conductors, or electrical conductors operating at voltages exceeding 300 volts-to-ground, Subrule 1) requires that the shield of the cable be bonded to ground at the point of entry to the building (see Figure 54-2). The Appendix B Note to Rule 54-200 1) defines the point of entry as the place where a coaxial cable emerges:

- through an exterior wall;

- through a concrete floor slab; or
- from a totally enclosed non-combustible entrance raceway.

Subrule 2) adds that if the outer shield of the coaxial cable is grounded, no other protective device is required.

**Figure 54-2**
**Grounding coaxial cable**



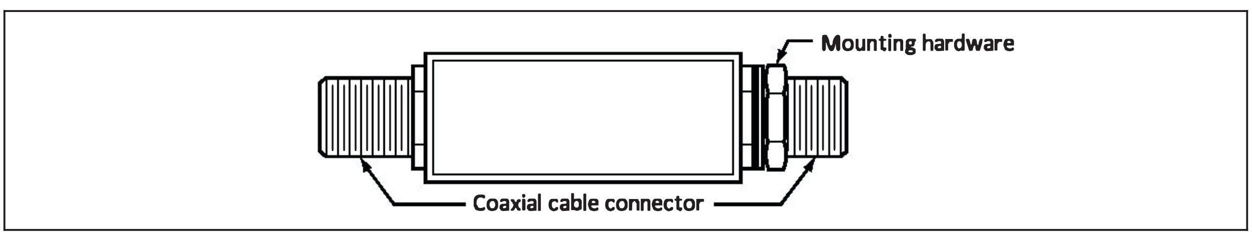

Subrule 3) states that, as an alternative to grounding the shield, a protector may be installed in line with the coaxial cable at the entry point to protect people and customer equipment from lightning and power-induced surges. These protectors can be inserted in a single coaxial cable or can be used to protect different systems, such as CATV, communication, and power systems. To avoid shock and equipment damage when these protectors are connected in the circuit with other system devices, they must not interrupt or interfere with the grounding of the other systems.

### Rule 54-202 Provision of protector

Protectors that break the centre conductor – and in some designs the outer shield – of a coaxial cable that has accidentally been energized prevent exposure to fire and shock hazards within a building (see Figure 54-3). These protectors are allowed to be installed on a CATV coaxial entrance cable as an alternative to the grounding required by Rule 54-200. Rule 54-202 requires that the protector be

- approved for its purpose;
- located on or within a building or structure;
- positioned as close as practicable to the point of cable entry to minimize the possibility of fire and shock hazards within the building;
- installed outside any hazardous location and away from any flammable or explosive materials;
- mounted on flame-retardant, absorption-resisting material (sparking or heat generation can occur when the protector operates); and
- covered if installed outdoors.

**Figure 54-3**
**CATV protector**



# Grounding

### Rule 54-300 Grounding conductor

The requirements for grounding conductors used to bond the outer conductive shield of a coaxial cable or a protector to ground are allowed, in certain instances, to vary from the standard requirements for electrical power systems bonding and grounding in Section 10. Subrules 1) to 7) of Rule 54-300 specify the requirements for the grounding conductor of the outer shield of a coaxial cable or a protector.

The grounding conductor is to:

- be insulated to prevent shock hazards if the cable is accidentally energized;
- be made of copper;
- not be smaller than No. 14 AWG, for physical strength;
- have a minimum ampacity equal to or greater than the maximum current-carrying capacity of the coaxial cable shield to which it is connected;
- have at a common connection point for two or more coaxial cables, a minimum ampacity equal to or greater than the maximum ampacity of the largest coaxial cable shield at the point of connection;
- be run in as straight a line as possible as this will minimize the length of the grounding conductor to reduce the conductor's ground path impedance and to reduce the possibility of electrical arcing to other conductive media (for example, during lightning strikes); and
- be physically protected where exposed to mechanical damage.

### Rule 54-302 Grounding electrode

Most of the requirements in Section 10 apply to the grounding electrodes installed for community antenna distribution systems. However, some of the Section 10 Rules do not apply because the grounding electrodes for CATV systems and radio and television installations covered in Section 54 are intended primarily to serve as a ground source for excess voltage from lightning strikes or accidental energizing that can damage equipment. The grounding electrode and the grounding conductor are not intended to establish a low-impedance path for fault currents (that is, for short-circuit currents) or an operating voltage reference point.

Rule 54-302 requires that the grounding electrodes for a CATV system conform to, and be installed in accordance with, Rules 10-102 and 10-104. However, Subrule 1) makes an exception to the Rule 10-102 requirement for a minimum of two 3-m lengths of manufactured rod electrode, allowing two 2-m rods to be used since the main function of the electrode is to drain off accidental energizing (such as lightning strikes). As required by Item a) of Rule 10-104, the grounding electrodes for a CATV system are to be:

- separated by at least 2 m from any grounding electrodes of another electrical system; and
- bonded to those electrodes to limit any voltage difference between the systems.

### Rule 54-304 Grounding electrode connection

Rule 54-304 requires that a grounding conductor be connected to a grounding electrode in accordance with Rule 10-118, with proper materials and in a manner that ensures that electrical integrity is maintained at all times (during both idle and active conditions). Item a) requires that a grounding conductor be directly attached to a grounding electrode.

As an alternative to the direct connection, a ground rod that incorporates a permanently connected wire lead is allowed to be used in accordance with Item b), provided that the rod, the lead, and the attachment of the lead to the rod conform to the requirements in CSA C83.

# Conductors within buildings

### Rule 54-400 Separation from other conductors

The design of conductors and electrical equipment for CATV distribution is based primarily on very low voltage and current levels. CATV cables are not normally rated for the higher voltage levels common in electrical power systems since their intended use is primarily to transmit information signals. As personnel who install or work on CATV distribution circuits might not be familiar with electrical power systems, CATV distribution conductors are to be separated or insulated from power system conductors to minimize the possibility of accidental contact with adjacent system conductors.

Rule 54-400 specifies the requirements for such a separation. This separation is made either by spacing or by placing other materials between CATV distribution conductors and the conductors of electric lighting, power, or Class 1 circuits.

Where bare electric circuit conductors are in the same room or space as CATV distribution conductors, Subrule 2) requires that the CATV distribution conductors be enclosed in a grounded metal raceway. To ensure safety during maintenance, no opening, such as an outlet box or enclosure, is permitted in the CATV distribution conductor raceway within:

- 2 m of bare electric circuit conductors operating at 15 kV or less; or
- 3 m of bare electric circuit conductors operating at more than 15 kV.

### Rule 54-402 Conductors in a vertical shaft

Materials placed in a vertical shaft are to be installed so that the possibility of an electrical fire or fire spread is minimized. Rule 54-402 requires that any type of CATV distribution circuit conductor placed within a vertical shaft be installed in a totally enclosed non-combustible raceway (such as rigid metal conduit or electrical metallic tubing).

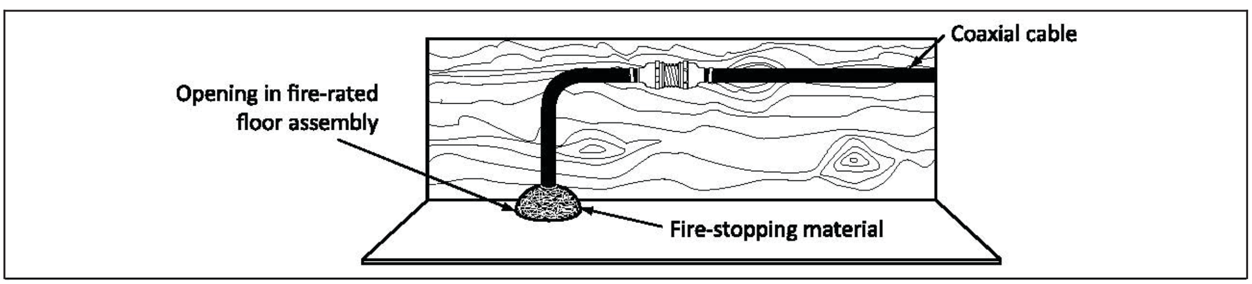
### Rule 54-404 Penetration of a fire separation

Any penetration of a fire separation is to:

- maintain the integrity of the separation; and
- ensure that flame and smoke cannot spread from one side to the other through the penetration.

Rule 54-404 requires that any penetration by a CATV distribution conductor through a building structure or assembly designed to act as a fire separation be closed or sealed in accordance with Rule 2-128 to reduce the possibility of flame spread through the separation (see Figure 54-4).

**Figure 54-4**
**Fire-stopping**




### Rule 54-406 Community antenna distribution conductors in ducts and plenum chambers

Rule 2-130 requires that conductors and cables in a building be installed in a way that minimizes the possibility of flame spread, as required by the *National Building Code of Canada* or local building legislation. Pay special attention to installations in ducts and plenums as they provide a pathway for the spread of flame, smoke, and gases to different areas of the building. In general, where the Code allows exposed cables to be placed in an air-handling plenum or duct, the cables are either to:

- have, and to be marked as having, a flame spread rating of FT4; or
- be totally enclosed in a non-combustible raceway.

Rule 54-406 allows coaxial cables to be placed only in the types of ducts and plenum chambers permitted by Rule 12-010. Such cables must meet the flame spread requirements of Rule 2-130.

### Rule 54-408 Raceways

In some installations, non-electrical-type raceways (for example, plastic water piping) are used to run coaxial cables. This raises safety concerns because a CATV distribution system is an electrical system that – under certain conditions – can present fire, shock, and operational hazards. Raceways that are not approved for electrical systems might be installed immediately adjacent to power systems (for example, to enclose associated optical fiber or electrical power systems). This can create fire, shock, or operational hazards and increase the potential for electrical interference and circulating ground currents. Rule 54-408 requires that a raceway used for coaxial CATV cables be installed in accordance with the requirements of Section 12.

## Equipment

### Rule 54-500 Community antenna distribution amplifiers and other power sources

Subrule 3) requires the following be bonded to the system ground:
- the chassis of a CATV amplifier or other power sources;
- the housing cabinet (where applicable);
- the outer shields of all coaxial cables associated with the power supply and cabinet; and
- all metal raceways attached to the power supply and cabinet.

This ensures that an equipotential plane exists (see Section 10 on equipotential bonding) so that there is no difference of potential (voltage level) between the exposed non-current-carrying metal surfaces of individual components and equipment of the CATV distribution system.

### Rule 54-502 Exposed equipment and terminations

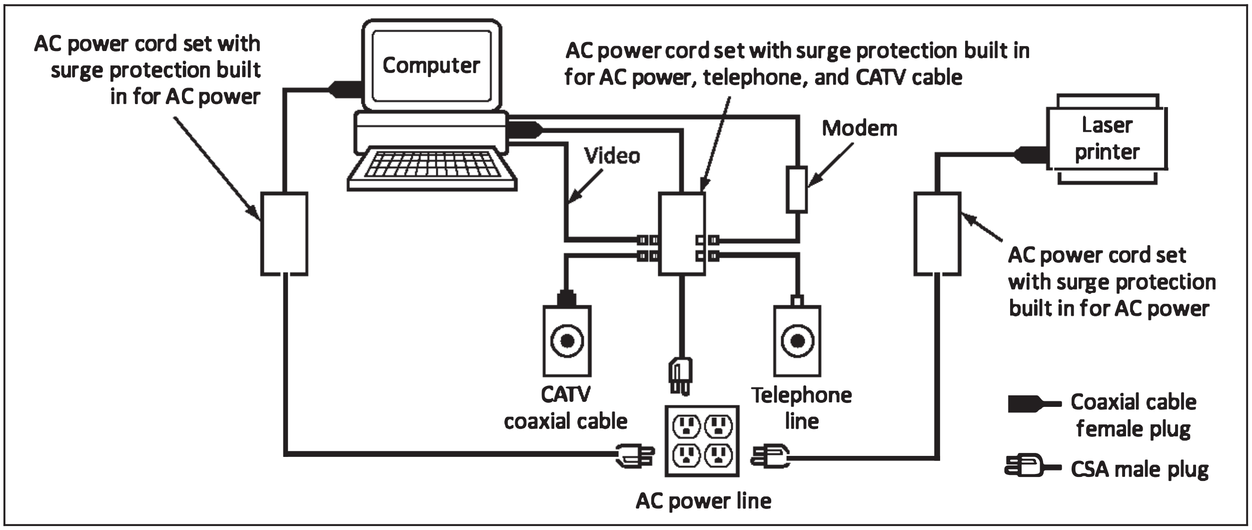
Since CATV distribution conductors are often exposed to lightning strikes or accidental contact with electric power sources, the following devices accessible to the public can present a shock hazard:
- related electrical equipment;
- terminals; and
- terminations.

When the bare live parts of electrical equipment, terminals, or terminations of a CATV distribution system are not enclosed within an approved cabinet or other approved enclosure, Rule 54-502 requires that — in accordance with Rule 2-202 — the exposed equipment, terminals, or terminations be located in a suitable room or similar enclosed area accessible only to qualified personnel familiar with the operations and hazards of the equipment. Where this room or area also contains electrical installations for lighting or power systems, a minimum spacing of 900 mm must be maintained between the exposed CATV equipment, terminals, or terminations and any other equipment requiring adjustment or maintenance. This reduces the likelihood that persons working in the room or space will be exposed to shock hazards caused by contact between the components of different systems.

### Rule 54-504 Equipment grounding

By design, the grounded outer conductive shield of a coaxial cable has an ampacity value that meets (or exceeds) the normal operating ampacity of the inner conductor. When CATV distribution equipment or enclosures are not connected to an electric supply system and receive information signals or internal power solely from the coaxial cable, Rule 54-504 considers them to be safely grounded provided that the equipment or enclosures are effectively connected to the coaxial cable shield, which is to be bonded to ground in accordance with Rule 54-200. Signal splitters are an example of non-powered equipment, and Rule 54-504 allows the coaxial cable shield to ground the exposed metallic surfaces. However, computers, VCRs, TVs, etc., to which they are connected are to be grounded as they are powered equipment. See Figure 54-5 for a typical installation.

**Figure 54-5**
**Equipment and coaxial cable installation**




## Conductors outside of buildings

### Rule 54-600 Overhead conductors on poles

The installation and maintenance of overhead community antenna conductors present safety considerations related to electric shock and other hazards. Detailed guidance on these topics is provided in the Part III Standards of the *Canadian Electrical Code*, in particular CSA C22.3 No. 1.
Rule 54-600 refers to the requirements of the *Canadian Electrical Code, Part III*, for the installation of CATV overhead distribution conductors in proximity to power conductors and in aerial spans between poles, buildings, and other structures. CSA C22.3 No. 1 also:

- provides requirements for clearance from ground, roadways, lakes, and rivers; and
- covers such safety considerations as proper working spaces between conductors of various electrical systems, span separations, and conductor sag.

### Rule 54-602 Overhead conductors on roofs

Where overhead community antenna conductors are installed over the roofs of buildings, the main concerns are to:

- prevent inadvertent damage to the conductors; and
- make them inaccessible to people standing or working on the roof.

Subrule 1) requires that CATV distribution conductors placed over the roofs of buildings be a minimum of 2.5 m above the highest point of the roofline.

In certain installations, structural designs or special circumstances can make it necessary to place the conductors less than 2.5 m above the roofline or even to attach them directly to the roof. In such cases, Subrule 2) requires that permission be obtained for a deviation in accordance with Rule 2-030.
Subrule 3) waives this requirement for special permission where CATV distribution conductors pass over a garage or a similar auxiliary building that is no more than one storey high.

### Rule 54-604 Conductors on buildings

When CATV distribution conductors are placed on the outside of buildings, give consideration to accidental contact with other electrical system conductors, possible fire hazards, and physical interference with conductors of other types of systems. Installations that conform with the Part III Standards of the *Canadian Electrical Code* typically address these concerns.

Where conductors, supporting stands, and electrical equipment of a CATV distribution system and of a communication system are installed together on a building, Subrule 3) requires that they:

- not interfere with each other during normal maintenance operations; and
- not be positioned such that the conductors of the systems can scrape against one another.

Interferences are to be avoided since typically each electrical system has a different operating voltage level and is maintained by personnel who are not fully familiar with the other systems.

### Rule 54-608 Lightning conductors

The conductors of a CATV distribution circuit usually provide a direct electrical path to a building's electrical equipment (for example, television sets or computers), as well as a good path to ground through the coaxial cable shield, which is bonded to ground. As a result, avoid contact with or proximity to lightning conductors considering the erratic paths and the magnitude of lightning discharges. Where both CATV distribution conductors and lightning conductors are placed on buildings, Rule 54-608 requires that they be separated by a minimum of 2 m to prevent a lightning surge from arcing between them.

### Rule 54-610 Swimming pools

Rule 54-610 requires that all CATV distribution conductors when installed either overhead or underground in the vicinity of a swimming pool meet the electrical installation requirements of Rules 68-054 and 68-056. The Section 68 Rules provide safe procedures for the installation of any type of electrical system conductors near swimming pools. These requirements relate mainly to preventing possible shock hazards from items such as contact with damaged conductors, leakage currents, and accidental energizing of the shield from other sources of energy.

## Underground circuits

### Rule 54-700 Direct buried systems

When CATV distribution conductors are direct buried, preserve their integrity and keep them separate from other buried electrical system conductors to minimize the shock hazards caused by accidental power contacts. Wherever possible, the requirements of CSA C22.3 No. 7 should be applied to ensure consistency with standards developed through proven field applications. Rule 54-700 requires that direct buried CATV distribution conductors have an outer sheath specifically designed for direct burial.

Item a) requires vertical separation of the conductors from other system conductors. The general intention of the installation requirements is to ensure that CATV distribution conductors are laid in a vertical plane that contains no other system conductors, except in some cases the conductors of a communication system. However, Item f) allows CATV conductors to be placed in a trench that also contains power supply cables, in the same vertical plane, when the following special conditions exist:

- the CATV distribution conductor (coaxial cable) is equipped with an electrically continuous metal shield/sheath;
- the power supply cables do not exceed 750 V;
- the CATV and power cables are generally not in direct contact, although zero separation might occur at random (this is known as random separation); and
- the CATV distribution cables do not cross under the power supply cables.

Item b) requires horizontal separation of the conductor from other system conductors. CATV distribution conductors are to be horizontally separated from other underground conductors by a minimum distance of 300 mm. Conductors of a communication system or of a power system for which random separation is allowed are exempt from this general requirement.

Item c) requires minimum coverage of the conductor under non-vehicular areas. CATV distribution conductors are to be direct buried at a minimum depth of 600 mm below final grade to give them adequate mechanical protection. However, there are two exceptions to the 600 mm requirement:

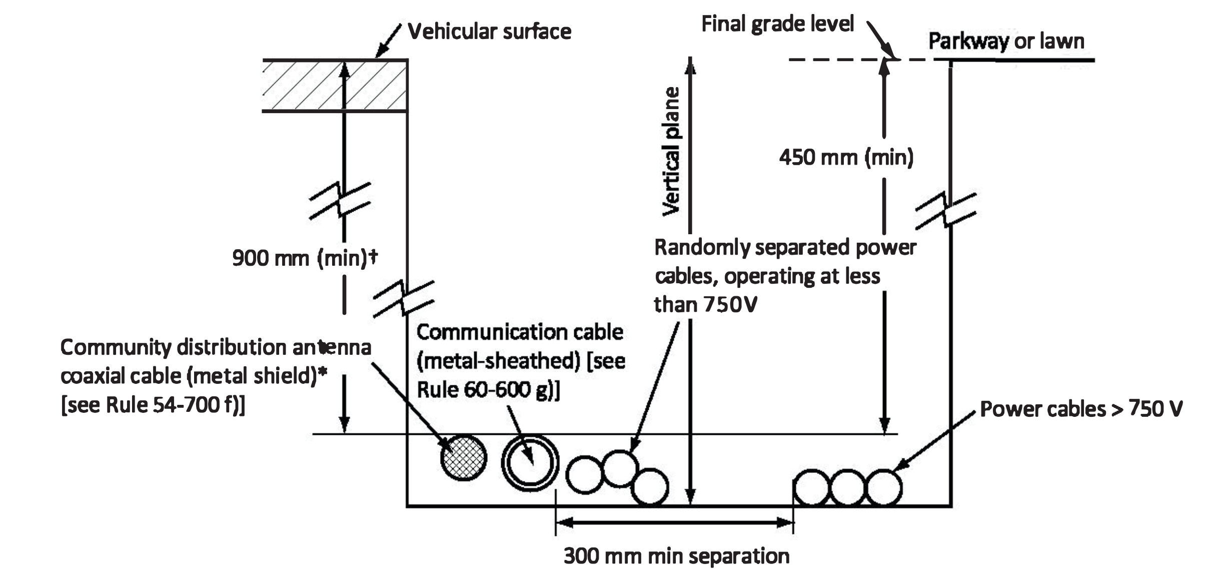
- when a rock bottom is encountered. In this case, the minimum depth is allowed to be reduced to 450 mm because the rock base provides greater stability than soil; and
- when a buried CATV distribution conductor providing service to a particular building is classed as a service conductor (that is, supplies a customer service enclosure). Service conductors buried under a parkway or lawn that is not subject to physical damage (for example, from vehicular traffic) are allowed to be placed at a reduced depth of 450 mm below final grade (see Figure 54-6).

Item d) requires that where CATV distribution conductors are direct buried in rocky or stony ground, they be laid in a layer of sand with a minimum depth of 75 mm both above and below the conductor. This prevents damage from sharp objects, mechanical vibrations, and compression.

Item e) requires that where CATV distribution conductors are direct buried under areas subject to vehicular traffic, they be placed at a minimum depth of 900 mm below final grade. This provides adequate protection from increased physical pressures, traffic vibrations, and possible surface damage such as deep tire ruts and potholes (see Figure 54-6). The minimum depth is allowed to be reduced to 600 mm if the conductors are:

- covered with a layer of sand or earth, containing no rocks or stones, at least 75 mm deep and then covered or mechanically protected by
  - continuous wooden planking at least 38 mm thick and chemically treated to prevent rot or decay; or
  - another material deemed suitable for the application; or
- enclosed in conduit suitable for burial in earth and placed in such a way that the cables are accessible for replacement and potential damage from traffic vibration is minimized.

**Figure 54-6**
**Separation for direct buried systems**




**A metal shield is required where* 300 mm *(min) horizontal separation from power cables cannot be maintained.*
*†The depth may be reduced to* 600 mm *where mechanical protection is provided in accordance with Rule 54-700 e).*

## Rule 54-702 Underground raceway

When CATV distribution conductors are placed in an underground raceway system, the integrity of the conductors must be preserved and the conductors must be kept separate from other electrical system conductors. The intent of Rule 54-702 is to minimize shock hazards caused by accidental power contacts.

Item a) requires that underground raceways used to house CATV distribution conductors be separated from raceways containing conductors of an electric power system by at least:

- 50 mm of concrete; or
- 300 mm of well-tamped earth.

This minimizes accidental power contacts caused by fault surges, improper excavation, and other occurrences.

Item b) requires that CATV distribution conductor raceways under non-vehicular areas be a minimum of 450 mm below final grade. Where the raceway is installed under areas subject to vehicular traffic, however, the minimum depth is to be increased to 600 mm to provide adequate protection from traffic vibrations, increased physical surface pressures, and possible surface damage (for example, deep tire ruts). Item b) also requires protection for the raceway where rock bottom is encountered at depths less than 450 mm (or 600 mm in vehicular areas). The raceway is to be totally encased in concrete to ensure adequate mechanical protection.

Item c) prohibits the conductors of a CATV distribution system and an electric power system to be placed in the same maintenance hole to minimize the possibility of accidental electrical contacts between the two systems and resulting shock hazards to personnel unfamiliar with one of the systems. However, installing CATV conductors and electric power conductors together in a maintenance hole is allowed, provided that the applicable requirements of CSA C22.3 No. 7 for construction, physical working barriers, proper working separations, separate raceway access, etc., are met.

Item d) does not allow under any circumstances a CATV conductor to be placed in the same underground raceway as the conductors of electric light, power, or Class 1 circuits. These three electrical systems:

- have voltage levels and conductor insulation types that differ from those of CATV distribution systems; and
- are to be physically separated to prevent accidental energizing of the CATV conductors.

Moisture (water or ice) can accumulate in underground raceways as a result of construction methods, materials, or locations. Item e) requires that all CATV distribution conductors and cables placed in underground raceways be provided with an outer cable sheath designed or suitable for wet locations.

Moisture can enter a building through underground raceways, causing corrosion of equipment. Underground gases can also enter the building, leading in some cases to health hazards and even explosions. Underground raceways entering a building are to be sealed with a compound in accordance with Item f) to prevent the entrance of moisture and gas.

## Rule 54-704 Underground block distribution

CATV distribution circuit conductors are often placed in an underground raceway system in a public street or right-of-way; they can also interconnect several buildings on either continuous or non-continuous property. Where such conductors are not likely to come in contact with electric light, power, or Class 1 circuits operating at more than 300 V, the requirement for an insulated bushing or raceway at the conductors' point of entry into a building (see Rule 54-606) is waived. The reason is that the potential for fire or electric shock is minimized at the point of entry either by the grounded shield of the cable or by a protector installed just beyond the cable's point of entry into the building (see Rules 54-200 and 54-202).

## Receiving equipment and amateur transmitting equipment

### Rule 54-800 Lightning arresters for receiving stations

Lightning arresters (surge arresters) are protective devices for limiting surge voltages due to lightning strikes, equipment faults, or other events to prevent damage to equipment and disruption of service. They are connected between ground/earth and the ungrounded conductor being protected. Once the voltage difference between ground and the ungrounded conductors goes above a predetermined rate, the arrester conducts the excessive voltage to ground (protecting against overvoltage damage).

Outdoor antennas for receiving stations are vulnerable to lightning strikes. Therefore, Subrule 1) requires that the lead-in conductors from an antenna be protected by a lightning arrester to minimize the possibility of transmitting shock and fire hazards both onto and within the building. However, the lightning arrester is allowed to be omitted where the lead-in conductor has an overall metal shield that is electrically continuous and bonded to ground as the bonded shield drains off any lightning surge voltages.

Subrule 2) allows the lightning arrester to be located either inside or outside the building. It is to be positioned as close as practicable to the point where the lead-in conductor enters the building.

Any lightning energy contacting an arrester might start a fire. Therefore, Subrule 3) requires that the arrester not be placed near combustible material or in a hazardous location.

### Rule 54-802 Lightning arresters for transmitting stations

Outdoor antennas for transmitting stations are also vulnerable to lightning strikes, and Rule 54-802 requires that the lead-in conductors from an antenna be provided with a lightning arrester or other suitable device to drain the excessive voltage from the antenna system.

## Grounding for receiving equipment and amateur transmitting equipment

### Rule 54-900 Material for grounding conductor

The type and materials of grounding conductors are to be adequate to handle potential electrical surges safely. Rule 54-900 amends the requirements of Rule 10-112 by allowing the use of copper, aluminum alloy, copper-clad steel, bronze, or other corrosion-resistant conductive material for the grounding conductor used with receiving equipment or amateur transmitting equipment.

### Rule 54-906 Mechanical protection of grounding conductor

Where grounding conductors are exposed to mechanical damage (for example, by people working nearby, the movement of equipment, etc.), Rule 54-906 requires that the conductors be adequately protected to prevent any damage or disruption of the grounding path. Mechanical protection can be provided from:

- adequately secured steel guards not less than 10 MSG;
- rigid PVC conduit;
- U-shaped steel channels; or
- another means that provides an equal level of protection.

### Rule 54-908 Grounding conductor to be run in a straight line

Give consideration to the potentially unpredictable directions or paths that various types of electrical discharge might take, as well as the impedance. Rule 54-908 requires that grounding conductors be run in as straight a line as possible. This reduces:

- the likelihood of electrical arcing to other conductive media; and
- as much as possible, the length of the conductor ground path, which lessens its impedance value.

### Rule 54-912 Grounding conductors

The grounding conductor is allowed to run either inside or outside a building, depending on the circumstances of the installation (for example, the location of the lightning arrester and the grounding electrode).

### Rule 54-914 Size of protective ground

Rule 54-914 refers to the requirements of Section 10 for sizing a grounding conductor connected to an antenna, lightning arrester, or other electrical equipment. The Section 10 requirements ensure that the conductor:

- conducts electrical surges and faults effectively; and
- has sufficient mechanical strength.

### Rule 54-916 Common ground

In many cases, receiving equipment or amateur transmitting equipment requires both a protective ground (for example, the bonding of the chassis of electrical equipment) and an operating ground (which acts as the operating voltage reference point for the equipment). Where both are supplied by a single grounding conductor, it is essential to ensure the integrity of the protective ground and the operating ground, limiting the possibility of electrical fire and shock hazards. Rule 54-916 requires that the common grounding conductor be installed in such a way that removing the operating ground does not affect the protective ground, and vice versa.

### Rule 54-918 Equipment in hospitals

To protect hospital patients in basic, intermediate, and critical care areas from stray voltages that might be imposed on the exposed conductive or metal parts of receiving equipment (for example, television and radio sets), these parts are to be bonded to a ground source. All other types of electrical equipment in the same room or area that have exposed metal parts are also to be bonded to a common ground source to avoid electrical shocks caused by differences in system ground potentials. Rule 54-918 requires the bonding to conform to Section 24 requirements.

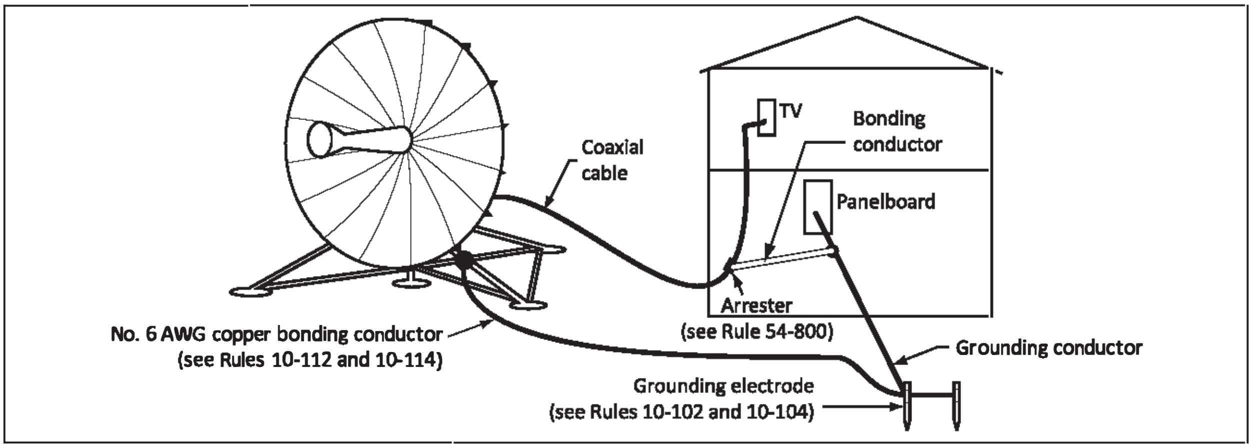
### Rule 54-920 Radio noise suppressors

The electrical equipment of a transmitting or receiving system connected to an ac power source is manufactured to standards that minimize or restrict the possibility of fire and shock hazards. The equipment can, therefore, be considered safe; its connection to the transmitting or receiving system, as well as the use of accessory devices, can pose risks. To ensure continued safety from electrical fire and shock hazards, Rule 54-920 requires that devices attached to the power supply conductors of a receiver or amateur transmitting system for such purposes as eliminating radio interference, suppressing radio noise, and acting as interference capacitors be approved for the purpose (for example, by compliance with a CRTC Standard). Such devices are not to be exposed to mechanical damage.

### Rule 54-922 Grounding of antennas

It has become increasingly common to install antennas on grade or on roofs at residential, commercial, and industrial installations. With antennas now more accessible to a variety of people (not just those who install or service them), preventing potential hazards is important. To protect people and property from damage (for example, lightning discharges), Rule 54-922 requires that the masts, metal support structures, and antenna frames for receiving stations be grounded in accordance with the requirements of Section 10 (see Figure 54-7).

**Figure 54-7**
**Grounding of antennas**




# Transmitting stations

## Rule 54-1000 Enclosure of transmitters

To prevent direct contact with bare live parts and electrical shock hazards, transmitters that consist of a component or a group of components having bare live parts are typically designed to be placed in an enclosed cabinet or other protective housing. Rule 54-1000 requires that transmitters be enclosed in a metal frame or grille or – where such an enclosure cannot be provided – completely shielded or surrounded by a suitable means or separated from the operating space by a barrier (for example, a fence, wall, or partition) or equivalent means.

## Rule 54-1002 Grounding of transmitters

Exposed metal parts of transmitting equipment can be energized by accidental contact with power circuits, lightning strikes, and other occurrences. To protect operating personnel likely to contact exposed metal parts of a transmitter, Rule 54-1002 requires that all accessible metal parts of transmitters, including handles, controls, and accessories (for example, microphone stands), be grounded.

## Rule 54-1006 Amplifiers

The operating voltage levels of an audio-amplifier can present a substantial shock hazard. Rule 54-1006 requires that an audio-amplifier of a transmitting system located outside the transmitter housing (see Rule 54-1000) be contained in such a way as to prevent accidental contact with bare live parts. To prevent potential fire hazards caused by overheating during operation, the audio-amplifier housing is to:

- allow ready access to the amplifier; and
- be adequately ventilated.

# Section 56 — Optical fiber cables

## Scope

### Rule 56-000 Scope

Section 56 includes additional and specific requirements for the installation of optical fiber cable adjacent to electrical conductors or electrical system equipment.

Optical fiber cables are used for control, signalling, and communications functions generally performed by electrical conductors.

Optical fibers:

- transmit modulated light patterns that are encoded and decoded by terminal equipment;
- do not transmit electrical voltages or currents; and
- are not affected by electrical contact or induction.

Shock and fire hazards, however, can arise from:

- the type of optical fiber cable being installed (for example, the physical cable components);
- the installation of cable near electrical systems and equipment; and
- inadvertent contact with electrical components (for example, power and lighting conductors and devices) by installers and service personnel not trained in the hazards of these electrical systems.

Section 56 is intended to ensure that optical fiber cables installed adjacent to, or in the same raceway or enclosures as, components of electrical systems do not pose or contribute to a fire or shock hazard.

## General

### Rule 56-102 Types

There are three types of optical fiber cable:

- non-conductive;
- conductive; and
- hybrid.

It is important to distinguish between cables that do not pose an electrical shock hazard and those that can present a shock hazard when conductive components are energized by accidental contact with electrical conductors, power induction, faults, or other causes.

A non-conductive cable consists of one or more optical fibers and an overall jacket, neither of which are electrically conductive (see Figure 56-1).

A conductive cable contains the components of a non-conductive cable and also a conductive member not designed to carry an electrical current that can be a transmitting path for electrical fault energy (see Figure 56-2).

A hybrid cable consists of an assembly of optical fibers in a sheath that also contains current-carrying conductors, such as lighting and power conductors, Class 1 or Class 2 conductors, or communications conductors (see Figure 56-3).

**Figure 56-1**
**Non-conductive optical fiber cable**

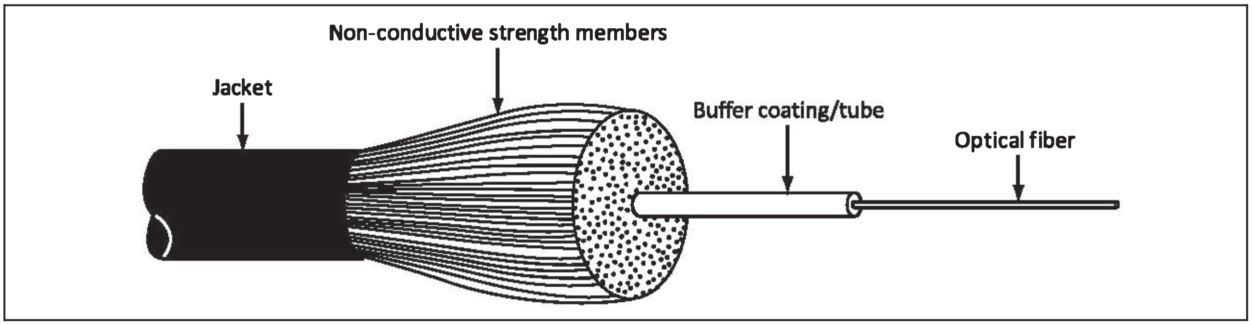



**Figure 56-2**
**Conductive optical fiber cable**

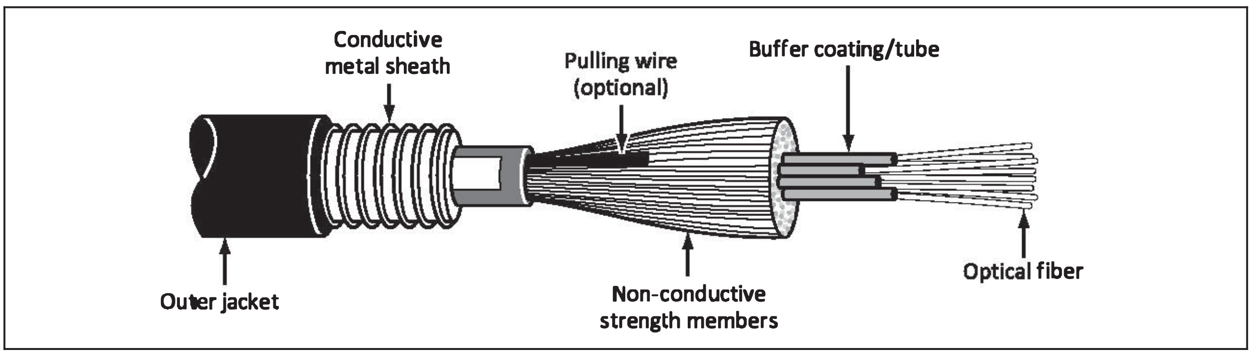
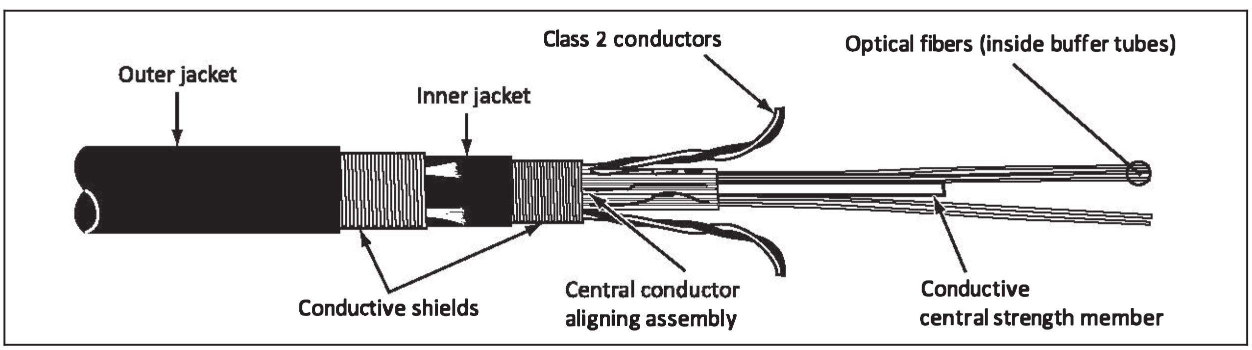



**Figure 56-3**
**Hybrid optical fiber cable (containing Class 2 circuit conductors)**




## Rule 56-104 Approvals

Under certain operating conditions, optical fiber cables can be subjected to electrical energies that can present potential fire and shock hazards. Optical fiber cables are to be designed and tested to minimize such potential hazards for users. Rule 56-104 requires that all optical fiber cables within a building be the approved types selected in accordance with Rule 12-102 3). Optical fiber cables that are placed outside of a building:

- need not be approved; and
- are to be of the outdoor type.

### Rule 56-106 Acceptance of inspector

Where an electrical or communication utility installs optical fiber cables as a part of its network, the electrical installation is performed by specially trained and qualified utility personnel. The Code recognizes this fact and Rule 56-106 specifically states that where an electric power utility or a telephone/communication utility installs optical fiber cable as a part of its operating network, the installation is exempt from requiring approval by the inspection department.

## Installation methods

### Rule 56-200 Non-conductive optical fiber cables

Rule 56-200 Subrules 1) and 2) require that non-conductive optical fiber cables not be placed in raceways, cabinets, panels, or similar enclosures that contain the conductors or terminals of electric light, power or Class 1 circuits.

This prevents inadvertent or unplanned contact with these circuits by installers and service personnel not trained in the hazards of these electrical circuits when energized.

However, Subrule 1) for raceways and Subrule 2) for enclosures allow all the electric light and power circuits, Class 1 circuits, and non-conductive optical fiber cables to be installed in the same raceways and enclosures when they are:

- functionally associated (that is, perform directly related functions, such as control, signalling, monitoring, and/or communications of these circuits) with electric light, power, or Class 1 circuits operating at 750 V or less, as individuals working on the optical cables will likely be familiar with the other cable uses; and
- installed in accordance with the maximum conductor fill requirements of Section 12 for cables.

Subrule 2) has an additional exemption for non-conductive optical fiber cables installed into factory-assembled enclosures that are built in accordance with applicable product standards and are considered to present minimal electrical fire and shock hazards.

On industrial sites, it has been demonstrated that people familiar with higher operating voltages and procedures can safely work on conductors and electrical equipment whose voltage limits exceed 750 V. Subrule 3) allows that, on industrial sites only, where there are procedures and systems in place that require electrical installations to be serviced only by authorized personnel, non-conductive optical fiber cables are allowed to be placed in a raceway, cabinet, panel, or other enclosure along with electric power, control, or instrumentation cables with no voltage limitations.

**Note:** *The intent of the Appendix 8 Note to Rules 56-200 1) and 56-202 1) is to allow installation of non-conductive and conductive optical fiber cables in raceways, including cable trays, provided that:*

- *the other requirements in Section 56 are met; and*
- *these types of fiber optical cables are listed in Table 19.*

### Rule 56-202 Conductive optical fiber cables

Conductive optical fiber cables are not designed to carry electrical currents, but their conductive components can be the transmitting path of electrical fault energy arising from accidental occurrences.

Subrule 1) allows conductive optical fiber cables to be placed in the same raceway as:

- Class 2 circuits installed according to Section 16;
- communications circuits installed according to Section 60; and
- community antenna distribution or radio and television circuits installed according to Section 54.

Any shock hazard arising in such low-energy electrical systems is likely to be compensated for by the insulation or shielding on the conductor.

Subrule 2) prohibits conductive optical fiber cables from being placed in the same raceway or enclosure as:
- electric light circuit conductors;
- power circuit conductors; or
- Class 1 circuit conductors.

The insulation and voltage ratings of the various cables can be incompatible and allow voltages and currents to cross over onto a fiber system that is not designed to handle the voltage and ampacity levels safely. The conductive components of the optical fiber cable can also be energized by accidental contact with the electrical systems, posing a shock hazard to people working on the optical fiber cables who are not necessarily qualified or trained to work on electrical power systems.

Subrule 3) requires that conductive optical fiber cables not be placed in a cabinet, panel, outlet box, or other enclosure that is also used to house any electrical terminals of a:
- Class 2 circuit;
- communication circuit;
- community antenna distribution circuit; or
- radio and television circuit.

Exceptions are made for conductive optical fiber cables that are:
- functionally associated with the circuits, or that perform directly related functions such as control, signalling, monitoring, and/or communications; or
- factory-assembled into the same enclosure.

Such equipment is built in accordance with applicable product standards and considered to present minimal fire and shock hazards.

To ensure that any voltages imposed on any conductive components are safely transferred to ground, Subrule 4) requires that all non-current-carrying conductive components of a conductive optical fiber cable be bonded to ground in accordance with Section 10.

### Rule 56-204 Hybrid cables

Subrule 1) allows optical fibers to be part of a hybrid cable that contains circuit conductors for an electrical light, power, or Class 1 circuit, or a hybrid cable that contains Class 2, communications, community antenna, or radio and television circuit conductors, provided that:
- the maximum voltage of the electrical conductors does not exceed 750 V; and
- the function of the optical fibers (such as monitoring, control, signalling) is directly associated with the function of the electrical conductors and that the optical fibers are not used for any other function. (People working on optical cables will likely be familiar with other cables that are functionally associated; however, they might not be qualified to work on other circuits.)

Subrule 2) requires that, for electrical installation purposes, hybrid cables be classed in accordance with the type of electrical circuit conductors in the cable (such as electric light, Class 1, communications, fire alarm) and that they be installed in accordance with the Code Rules applicable to that type of circuit.

### Rule 56-206 Penetration of a fire separation

In general, any penetration of a fire separation is to be made so that:
- the integrity of the separation is maintained; and
- flame and smoke cannot spread from one side to another through the penetration (see Rule 2-128).

Where an optical fiber cable penetrates part of a building structure or assembly designed to act as a fire separation, Rule 56-206 requires that the opening around the cable or raceway be properly closed or sealed in compliance with the *National Building Code of Canada* in order to reduce the possibility of fire and smoke spreading through the penetration.

### Rule 56-208 Optical fiber cables in a vertical shaft

Electrical systems within a vertical shaft are to be installed in such a way as to minimize electrical fire hazards and the spread of fire. A number of systems installed in vertical shafts can involve optical fiber cables (such as electrical systems, alarm systems, communications systems, and closed-circuit television). Optical fiber cables installed in vertical shafts are to be installed in a totally enclosed non-combustible raceway (such as rigid metal conduit or electrical metallic tubing) or meet the flame spread requirements of the *National Building Code of Canada* or local building legislation for buildings of non-combustible construction.

### Rule 56-210 Optical fiber cables in ducts and plenum chambers

Installation of optical fiber cables in ducts and plenums require special attention as they provide a pathway for the spread of flame, smoke, and gases. Where the Code allows cables to be exposed in an air-handling plenum or duct, the cables are to meet the requirements of the *National Building Code of Canada* and Rules 2-130 and 12-010 of the Code.

### Rule 56-212 Raceways

Non-electrical-type raceways (such as plastic water piping) have often been used to route optical fiber cables. This has raised some safety concerns since installations involving optical fiber cables can lead to fire spread. There is also concern that raceways not approved for electrical systems might be installed immediately adjacent to power systems to enclose associated optical fiber systems, creating problems such as fire or shock hazard and increasing the potential for electrical interference and circulating ground currents. Consequently, Rule 56-212 requires that, where a raceway is installed to enclose optical fiber cables of any type, the raceway be approved and be installed in accordance with the applicable requirements of Section 12.

### Rule 56-214 Grounding of entrance cables

Where a conductive optical fiber cable is exposed to lightning or accidental contact with other electrical systems, the conductive components of the cable can become energized and spread fire and electrical shock hazards throughout the building. Rule 56-214 requires that any conductive optical fiber cable that enters a building and is exposed to lightning or accidental contact with electrical light or power conductors have all of its conductive components bonded to ground. Provide grounding as close as possible to the point of entry to the building. The Appendix B Note to Rule 56-214 defines the point of entry to the building as the point of emergence of the cables:

- through an exterior wall;
- through a concrete floor slab; or
- from a totally enclosed non-combustible entrance raceway.

# Section 58 — Passenger ropeways and similar equipment

## Scope

### Rule 58-000 Scope

Section 58 includes additional and specific requirements for the electrical installations of passenger ropeways, tramways, gondolas, chairlifts, passenger conveyors, and similar equipment. It includes the additional and specific requirements for passenger ropeways and similar equipment as defined in CSA Z98, *Passenger ropeways and passenger conveyors*.

## General

### Rule 58-002 Special terminology

The definitions covered in this Rule apply only to Section 58.

A *station* is a location at which loading and/or unloading can take place. This definition should not be confused with the definition in Section 36.

## General requirements

### Rule 58-010 Working clearances

Working clearances and spaces around electrical equipment used in passenger ropeways, tramways, gondolas, chairlifts, passenger conveyors, and similar equipment must be large enough to allow maintenance, servicing, and troubleshooting to be performed safely and quickly. The clearances required by Rule 2-308 are allowed to be relaxed under the conditions specified in Rule 58-010. With the reduced working clearances and spaces, the hazards from contacting live equipment when examining, adjusting, servicing, or maintaining are greatly increased. Therefore, Item c) of Subrule 2) sets out the requirements for electrical equipment installed with the reduced working clearances and spaces.

### Rule 58-012 Grounding of circuits of less than 50 V

Rule 10-206 3) specifies the conditions under which circuits rated less than 50 V must be grounded. For installations within the scope of Section 58, Item a) of Rule 58-012 provides exceptions to Rule 10-206 3) for ungrounded isolated haul ropes that are used for communication, control, remote control, monitoring, supervision, and signal circuits, provided that the voltage is less than 50 volts-to-ground. Item b) provides an exception to Rule 10-206 3) for communication, control, remote control, monitoring, supervision, and signal circuits, provided that the voltage is less than 50 volts-to-ground and the circuit is grounded in accordance with Rule 10-212. The exceptions are intended to permit the use of electrically isolated circuits in accordance with accepted industry practice.

### Rule 58-014 Voltage limitations

Rule 58-014 sets out the maximum permitted voltages for various systems associated with the passenger ropeway or similar equipment (see Table 58-1).

**Table 58-1**
**Maximum permitted voltage**

| Equipment | Maximum permitted voltage |
|---|---|
| Communication, control, remote control, monitoring, supervision, or signal circuits other than hand-crank-type telephone signal bells | 48 volts-to-ground, nominal |
| Motors, machine brakes, motor-generator sets, floodlighting, or heaters | 750 volts-to-ground |

*(Continued)*

## Table 58-1 (Concluded)

| Equipment | Maximum permitted voltage |
|---|---|
| Motor control circuits | 120 volts-to-ground |
| Aerial conductors between towers that support passenger ropeways other than aerial conductors used for hand-crank-type telephone signal bell circuits | 30 volts-to-ground rms or 42 volts-to-ground peak |
| Circuits not identified in this Table | 300 volts-to-ground |

### Rule 58-016 Luminaires on towers and stations

Passenger ropeway towers and stations are used to support the weight of equipment and people that are suspended in the air when being transported (for example, from the bottom of a ski hill to the top). Rule 58-016 allows these tower and stations to support luminaires used for night skiing or similar floodlighting applications. To make sure there are no electrical hazards for individuals who service the equipment mounted on these structures, a ground-fault-circuit-interrupter-type circuit breaker in a lockable enclosure that disconnects all ungrounded conductors to the luminaires is to be provided at each tower or station.

## Conductors

### Rule 58-102 Minimum size of conductors

The minimum size of conductor for all communication, control, remote control, monitoring, supervision, and signal circuits is No. 26 AWG copper. Where these circuits are contained in travelling cables due to the flexing of the cables, the minimum size is increased to No. 20 AWG copper.

### Rule 58-104 Grouping of conductors

Optical cables (including conductive, non-conductive, and hybrid types), shielded cables, and conductors for operating devices, power, motor, heating, air-conditioning operating, signal, communication, control, safety, fire alarm, and lighting circuits may be run in the same raceway system, aerial cable, and travelling cable, provided that the insulation voltage rating for all the conductors is not less than the highest voltage rated on any of the conductors.

## Wiring methods

### Rule 58-200 Wiring methods

Passenger ropeways and similar equipment are systems that consist of fixed machines, moving parts, and equipment rooms. Rule 58-200 specifies the various wiring methods that are permitted (see Table 58-2).

## Table 58-2
## Permitted wiring methods

| Location or equipment | Permitted wiring methods |
|---|---|
| Machinery spaces<br>Control spaces | Rigid metal conduit<br>Electrical metallic tubing<br>Rigid PVC conduit<br>Wireways |
| In or on cabins | Rigid metal conduit<br>Electrical metallic tubing |

*(Continued)*

## Table 58-2 (Concluded)

| Location or equipment | Permitted wiring methods |
|---|---|
| Machine rooms<br><br>Control rooms | Rigid PVC conduit<br>Wireways<br>Mineral-insulated cable<br>Aluminum-sheathed cable<br>Armoured cable<br>Cable trays |
| For extra-low-voltage circuits (30 V or less) in machinery spaces, control spaces, cabins, machine rooms, control rooms, and in or on cabins | Jacketed flexible cords and cables that are:<br>• not greater than 2 m in length;<br>• supported; and<br>• provided with mechanical protection. |
| In machinery spaces, control spaces, cabins, machine rooms, control rooms, and in or on cabins:<br>• between raceways and<br>– limit switches;<br>– interlocks;<br>– operating devices; or<br>– similar devices.<br>• between control panels and<br>– motors;<br>– machine brakes;<br>– disconnecting means;<br>– motor-generator sets; or<br>– pumping unit motors and valves. | Flexible conduit or liquid-tight flexible conduit |
| Between raceways and signal equipment or operating devices in machinery spaces, control spaces, cabins, machine rooms, control rooms, and in or on cabins | Cables used in Class 1 extra-low-voltage and Class 2 low-energy circuits, including:<br>• travelling cables connecting the movable carriage or movable return carriage;<br>• extra-low-voltage control cable;<br>• communication cable;<br>• fire alarm and signal cable;<br>• multi-conductor thermoplastic-insulated cable;<br>• hard-usage cable; and<br>• extra-hard-usage cable. |
| In machinery spaces, control spaces, cabins, machine rooms, control rooms, and in or on cabins between controllers, starters, and similar apparatus | Auxiliary gutters |

### Rule 58-202 Location of and protection for travelling cables

A travelling cable is a cable that provides connection between movable equipment and fixed equipment for systems, used in a passenger ropeway. If the travelling cable is damaged, the signals or power that is necessary for operation, safety, and communication could be interrupted with disastrous results. Rule 58-202 requires that supports or guards be used for the travelling cable to keep the cable away from structures and equipment that could damage it.

## Protection and control

### Rule 58-304 Utilization equipment disconnecting means

In addition to the disconnecting means described in Rule 58-302, a disconnecting means is also required for each branch circuit for utilization equipment associated with the passenger ropeway or similar equipment. The disconnecting means must be capable of being locked in the open position and be marked or labelled to describe the connected loads and the location of the supply circuit overcurrent device. Each disconnecting means must be located in the machine room, control room, machine space, or control space.

### Rule 58-308 Ground fault circuit interrupter

For protection of service personnel, each 125 V, single-phase receptacle installed in machine rooms, control rooms, machine spaces, control spaces, and counterweight enclosures is required to be protected with a ground fault circuit interrupter (GFCI) of the Class A type. Where a circuit supplies both luminaires and receptacles, take care to ensure that luminaires required by Subrule 1) of Rule 58-400 are not connected to the load side of the GFCI required by Rule 58-308.

## Branch circuits

### Rule 58-400 Branch circuits for machine room, control room, machinery space, or control space luminaires and receptacle(s)

Rule 58-400 sets out the minimum requirements for the location, protection, and control of luminaires and receptacles in machine rooms, control rooms, machinery spaces, and control spaces. Unexpected loss of lighting could result in a hazard to maintenance personnel. For this reason, luminaires in these areas must not be connected to the load side of the GFCI required by Rule 58-308.

### Rule 58-404 Branch circuits for other utilization equipment

Where other utilization equipment is to be connected, Rule 58-404 requires that such equipment not be supplied from branch circuits supplying the receptacles and luminaires described in Rules 58-400 and 58-402. Also overcurrent devices protecting the utilization equipment branch circuits are required to be located in the machinery room, control room, machinery space, or control space where the equipment is located.

# Section 60 — Electrical communication systems

## Scope

### Rule 60-000 Scope

Section 60 includes additional and specific requirements for communication systems such as telephone, telegraph, data communication intercommunication, paging, and wired music systems. Electrical communication systems are designed primarily to carry information or signals in the form of audio, video, or data. They can also transmit signals for supervision and control.

Section 60 does not cover:

- alarm systems such as fire, smoke, and intrusion alarms; and
- radio and television broadcast communication equipment, closed-circuit television systems, and community antenna television systems (covered in Section 54).

The circuits for communication systems have different electrical characteristics and present different electrical hazards than those associated with lighting, power, grounding, bonding, and Class 1 circuits. Generally, communication circuits operate within the line-to-ground current and voltage limitations established for Class 2 circuits, as described in Rule 16-200. It is sometimes difficult to determine whether the Section 16 requirements for Class 2 circuits or the Section 60 requirements for communication systems apply to a given installation.

Determine which Section applies as follows:

- If the function of the circuit is to send only an ON or OFF signal over the circuit, then it is a signal circuit. Section 16 applies.
- If the function of the circuit is to send or transmit voice, sound, or data over the circuit, then it is a communication circuit. Section 60 applies.

## General

### Rule 60-100 Special terminology

The definition of *exposed plant* used in this Section applies only to Section 60.

To minimize potential shock and fire hazards, additional safety precautions related to voltage and current protection and bonding to ground are required with exposed plant(s).

### Rule 60-102 Use of approved equipment

Under certain operating conditions, communication equipment is subjected to electrical energies that can present potential shock and fire hazards. To minimize these hazards, Rule 60-102 requires that communication equipment be approved to the appropriate CSA Group Standard(s) where:

- the equipment is connected to an exposed plant;
- the equipment is connected to a telecommunication circuit operating at any voltage, unless specifically allowed by other Rules in Section 60; or
- other Rules in Section 60 require the equipment to be approved, regardless of the conditions of installation.

### Rule 60-104 Circuits in communication cables

Rule 60-104 addresses the extent to which other types of circuits can be placed in a communication cable assembly. Such combinations are not allowed when communication conductors or cables are installed inside a building for the purposes of distributing a communication service. However, a building entrance cable defined as a communication cable and installed for the purposes of entering or exiting a building can consist of an assembly of communication conductors and the conductors of a radio and television circuit, a remote control circuit, or a fire alarm circuit. The entrance cable assembly is considered a communication conductor [see Item b)] and is to be installed in accordance with the Rules of Section 60. Item c) requires that the point of interface (connection or crossing point) between the building entrance cable and the communication cables inside the building be protected (see Rule 60-200) to limit the voltage and current levels on all connected communication circuits and conductors to an acceptable level to protect the downstream equipment.

### Rule 60-106 Hazardous locations

In some modes of operation, a communication circuit accidentally energized by a lightning strike or contact with an electric power conductor of another electrical system can cause an electrical spark, fire, or shock hazard. Give special consideration to installations in hazardous locations (such as a gasoline storage area or a grain elevator building). Rule 60-106 requires that communication equipment or conductors placed in locations classified as hazardous by Section 18, 20, 22, or 24 be installed in accordance with the requirements of Section 18, 20, 22, or 24, respectively.

### Rule 60-110 Approved transformers

In communication circuits, transformers or similar devices are sometimes required for powering or operation of the circuit(s). Rule 60-110 requires such transformers or similar devices to be approved in accordance with the appropriate CSA Group Standard(s) and for the type of service to which they supply power (such as providing power to a telephone-answering unit).

## Protection

CAN/CSA-C22.2 No. 226, *Protectors in telecommunication networks*, distinguishes between two types of protectors — primary and secondary — as follows:

- The primary protector is designed to protect users or premises from electrical fire or shock hazards resulting from excessive voltage (caused by induced surges, contact with circuits of higher voltage, or lightning) propagating via external communication networks.
- The secondary protector is intended to limit overcurrent and over-voltage levels in the communication equipment and wiring.

Section 60 pertains only to primary protectors. The requirements for secondary protectors fall under the requirements of the utility and vary considerably depending on the design and type of communication system.

### Rule 60-200 Provision of primary protectors

Until recently, communication systems were usually installed by large utilities (such as telephone companies) that had specific internal operating requirements for primary protectors and qualified personnel to install them. Now, a wide range of private operators install and service communication systems. Subrule 1) requires that an approved communication system primary protector be installed in each exposed communication circuit to minimize electrical fire or shock hazards.

Subrule 2) specifies that the protector is to be located in, on, or immediately adjacent to the structure or building served and as close as practicable to the point at which the conductors enter or where the protector is placed adjacent to a structure (for example, a communication service pedestal in a trailer park), as close as possible to the point where the cable or conductors are attached.

Since the primary protector can be a source of ignition in hazardous locations, Subrule 3) prohibits installing a primary protector:

- in the hazardous locations specified in Sections 18, 20, 22, and 24; or
- immediately adjacent to flammable or explosive materials (for example, in a propane storage area).

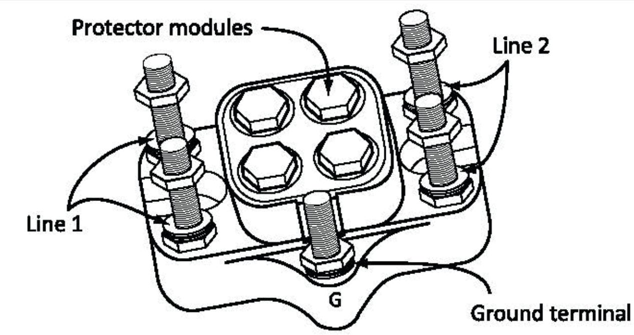
Subrule 4) waives the requirement for a primary protector if the communication circuit is not considered an exposed plant. For example, a communication circuit located outdoors in an underground raceway (as specified in Rule 60-602) is not considered an exposed plant. Overhead or direct buried communication circuits, however, are generally classed as exposed plants because they are susceptible to lightning strikes, induced voltage, or contact with other system conductors.

### Rule 60-202 Primary protector requirements

Two types of primary protectors — fused and fuseless — can be used in communication circuits to minimize electrical fire or shock hazards from external sources. A fused primary protector is to have an integral fuse connected in series in each communication line conductor to prevent overheating caused by excess voltages from lightning strikes, induced voltage, or contact with other system conductors. Under certain conditions of installation, where potential fire hazards are minimized, a fuseless protector may be used.

Subrule 1) requires that the primary protector, either fused or fuseless, be installed between each communication line conductor and ground, minimizing possible fire or shock hazards. See Figure 60-1.

**Figure 60-1**
**Communication primary protector**




Subrule 2) specifies the circumstances in which fuseless primary protectors are allowed to be used. In general, fuseless protectors are allowed to be used where the external incoming line conductors safely fuse at a current level lower than the rating of the primary protector to which they are connected. A fuse in the incoming communication circuit protects the conductors as it contains a strip of wire made of easily melted metal that opens the circuit or interrupts the flow of current in it by melting when an excessive current passes through it. Adequate fusing is provided by the following designs [see Items a) to d) of Subrule 2)]:

- The communication entrance cable that connects to the primary protector has a metal sheath or shield that is bonded to ground. The primary protector and protector grounding conductor have an ampacity rating greater than that of the conductors in the exposed plant cable. The result is that the exposed conductors are safely fused at current levels less than those of the protector rating and its grounding conductor.
- The communication entrance conductor connecting to the primary protector consists only of insulated conductors extending from an exposed plant cable. The exposed plant cable has a metal shield or sheath that is bonded to ground. The primary protector and protector grounding conductor have an ampacity rating greater than that of the conductors within the exposed plant cable. The result is that the exposed conductors are safely fused at current levels less than those of the protector and its grounding conductor. Additionally, the conductors in the exposed plant cable are to be fused at current levels less than the ampacity of the insulated conductors (of the communication system).
- The communication entrance conductor connecting to the primary protector consists only of insulated conductors extending from an exposed plant communication cable that does not have a metal sheath or shield bonded to ground, and the following conditions apply:
  - insulated conductors are protected by a primary protector with a primary protector grounding conductor grounded in compliance with Rule 60-704; and

– the exposed plant conductors are safely fused at an ampacity rating less than that of the protector, its grounding conductor, and the associated insulated conductors.

- The communication entrance conductors are in a cable with a grounded metal sheath or shield and are exposed to lightning but are not exposed to accidental contact with power or lighting conductors or other sources of electrical energy and are not classified as an exposed plant.

Exposed live parts (such as the terminals of a primary protector) can present an electrical shock hazard during the:

- normal operation of the communication circuit (line operation only); or
- operation of the protector.

To prevent accidental contact with such exposed parts, Subrule 4) requires primary protectors with exposed live parts to be placed in a suitable room (for example, a locked communication or telephone room) or similar area that is accessible only to qualified personnel familiar with the hazards and operations of the communication circuit and its protector. The room or area must comply with the requirements of Rule 2-202. Where the room or area is designed to house both electrical and communication systems (for example, a joint-use electrical room), there is to be a minimum separation of 900 mm between the protectors and any electrical equipment requiring adjustment and maintenance. This separation is intended to prevent accidental electrical contacts between systems operating at different voltage levels. Subrule 4) does not apply where the protector is guarded against accidental contact by an approved cover, cabinet, or other enclosure [see Subrule 1) of Rule 2-202].

### Rule 60-204 Protection for communication circuits in high-voltage stations

When communication circuits provide service to a high-voltage power station (for example, an electric transformer switching station), specially designed communication protection is required. The protection equipment is usually of the non-interruptible type so that essential communication circuits for signalling and switching at stations or substations do not fail or open during power disruptions (for example, fault conditions). The protectors approved for normal communication circuits are of the interruptible type.

Communication circuits installed in high-voltage stations are subject to high ground potential rises and/or electromagnetic induction from faults on high-voltage power lines terminating at the station. This can cause:

- unnecessary cable stresses and transferred ground potential rises; and
- hazardous electrical surges to the communication equipment or personnel at remote locations outside of the high-voltage stations.

Rule 60-204 requires that equipment installed for the protection of communication circuits serving a high-voltage station be suitable for the particular application. Such equipment:

- is usually of the non-interruptible type (such as an isolating transformer and/or other electronic devices); and
- does not need to be approved as a communication protector.

The Appendix B Note to Rule 60-204 references ANSI/IEEE 487 to provide guidance on determining suitability for specific applications.

## Inside conductors

### Rule 60-302 Raceways

Rule 60-302 refers to two Sections of the Code:

- Section 12, containing installation requirements for raceway systems used to house communication conductors; and
- Section 10 containing requirements for grounding the metal raceways so that the potential shock hazards from induced or accidental power contacts and electromagnetic interference (EMI) are eliminated.

Raceways should be provided where large quantities or large sizes of communication conductors are to be installed or where future access for conductor additions or alterations might be necessary.

### Rule 60-304 Insulation

Communication conductors are capable of carrying voltage and current at levels that can present an electric fire or shock hazard. There are many types of communication conductors (for example, building cables, inside distribution wires, communication flat cables, and specialty data cables) for different applications. Rule 60-304 requires that all communication system conductors installed inside a building be of approved types selected in accordance with Subrule 3) of Rule 12-102 to meet the requirements of the appropriate CSA Group Standards and ensure they are designed to minimize possible hazards.

### Rule 60-306 Grounding of conductors with an outer metal covering

A communication conductor cable that has a grounded outer metal shield or sheath can be used to protect circuits from induced voltages or accidental contact with the conductors of another electrical system. Rule 60-306 requires that the metal covering be bonded to ground so that any induced voltage or accidental contact with an electrical source (an electric light or power circuit) is safely transferred to ground.

### Rule 60-308 Separation from other conductors

Communication system conductors are designed and manufactured for operation at specific voltage and current levels. They are not normally rated for the higher operation voltage levels used in electrical power systems, as their function is primarily to transmit low-power communication and information signals. Consequently, accidental contact with higher-power conductors can cause damage and propagate fire and shock hazards in the communication system and the building. Also, communication system conductors can be installed and serviced by people unfamiliar with the safe operation and maintenance of normal electrical power systems. Hence, Rule 60-308 requires that the conductors of a communication circuit be separated from those of an electric lighting, power, or Class 1 circuit — either by spacing or by suitable materials — to prevent the accidental energizing of the communication system conductors.

### Rule 60-310 Penetration of a fire separation

The general Rules of the Code and the *National Building Code of Canada* require that any penetration of a fire separation be made in such a way that the:

- integrity of the separation is maintained, and
- flame does not spread from one side to the other through the penetration.

Rule 60-310 requires that any penetration by a communication circuit conductor through a building structure or assembly designed as a fire separation be closed or sealed in accordance with Rule 2-128 to reduce the possibility of flame spread.

### Rule 60-312 Communication cables in hoistways

Since hoistways can allow the rapid vertical spread of fire within a building, electrical installations in hoistways are addressed as possible fire hazards. Under certain conditions, conductors installed in hoistways are prone to accidental mechanical damage. Electric supply cables operating at various voltage and current levels can move or travel in hoistways and come into contact with other conductors when a failure in one of the wiring systems occurs. Therefore, Subrule 1) prohibits the installation of communication conductors in hoistways unless special permission is obtained in writing from the inspection department (AHJ). Subrules 2) and 3) give additional requirements for communication conductors and cables allowed in a hoistway.

### Rule 60-314 Communication conductors in ducts and plenum chambers

Conductor and cable installations in a building are to satisfy the flame spread requirements of the Code and the *National Building Code of Canada*. Since ducts or plenum chambers offer an easy path for the spread of flame, smoke, and gases, Rule 60-314 requires that communication conductors and cables:

- be placed only in the ducts and plenum chambers allowed by Rule 12-010; and
- meet the flame spread requirements of Rule 2-130.

## Rule 60-316 Data processing systems

Cables designed for interconnecting data processing equipment might contain conductors for both data or communication circuits and electric power supply circuits. To prevent voltage crossovers and other electromagnetic disturbances, Rule 60-316 requires that the cables be specifically approved for the purpose according to the appropriate CSA Group Standard.

## Rule 60-318 Conductors under raised floors

One of the main purposes of a raised floor installation in a building is to provide an area for the installation of electrical and communication conductors and cables serving the floor area above. When these different systems are installed beneath raised floors, there are to be separations between communication and other electrical system conductors. The potential for combustion and flame spread and the possibility that a raised area might be used for air transfer should be taken into account as well.

When communication conductors are placed in the space under a raised floor, Rule 60-318 allows them to be directly installed without any additional mechanical protection because such protection could encapsulate any fumes or smoke produced by a fault. Detection of smoke or fumes produced by a fault helps to ensure that faults are located and corrected quickly.

When there are communication conductors installed under a raised floor:

- the raised floor is to be of non-combustible construction;
- the communication conductors connected to data processing systems are to be separated by a minimum of 50 mm from any power supply conductors; and
- when the space under the raised floor is also used as an environmental air plenum supplying air to the room, the communication conductors within that space below the raised floor are to serve only equipment located above it. Then, if a fault that results in smoke or fumes occurs, the source can be identified quickly.

## Rule 60-320 Conductors in concealed installations

Sometimes, the conductors of a concealed communication circuit can present a potential fire and shock hazard (for example, where the bare conductor ends are exposed and likely to come into contact with other metallic or conductive building components, such as a metal wall frame or a plumbing fixture). These bare exposed components can become energized upon contact, presenting a possible shock hazard. When communication conductors are not terminated on a device (for example, at a terminal block), Rule 60-320 requires that the bare conductor ends be taped or capped with an insulating device (for example, an enclosing plastic sleeve) to prevent electrical contact with other components or materials.

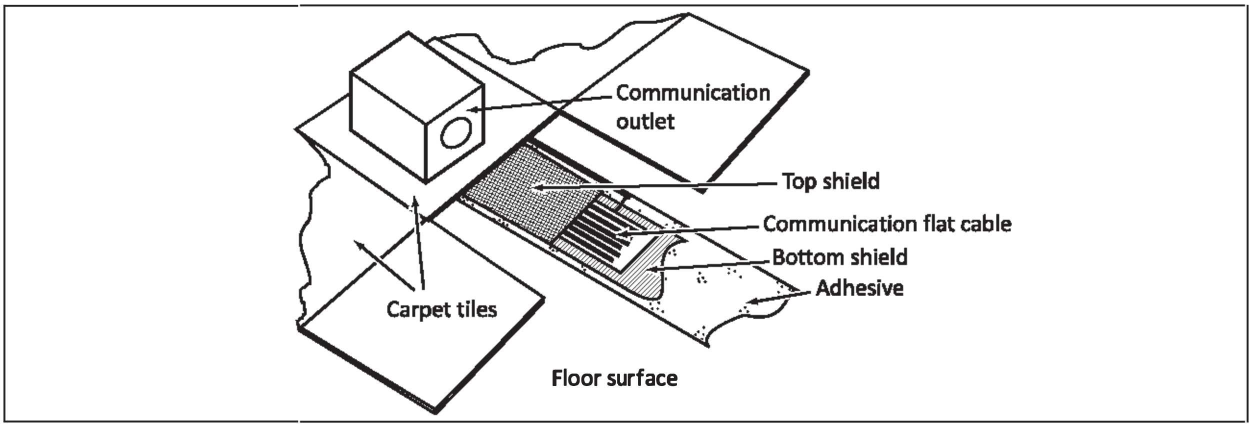
## Rule 60-322 Type CFC under-carpet wiring system Rules

A communication flat cable (CFC) system is specifically designed for direct installation on a floor surface having an overall covering of removable carpet squares (see Figure 60-2). There are special Rules in this Section to address the safety aspects of installing CFC systems of this nature and design. The communication products used in CFC systems are manufactured to meet the applicable safety standards to minimize fire and shock hazards.

**Note:** *Similar Rules are included in Section 12 to cover flat conductor cables (FCC) designed for power circuits operating at 750 V or less.*

Rule 60-322 requires that an installation of a CFC system comply with Rules 60-324 to 60-334. All conductors and equipment associated with the communication flat cable system, if connected to a telecommunication network, are to be approved in accordance with the appropriate CSA Group Standards (see Rule 60-102).

## Figure 60-2
## CFC installation




### Rule 60-324 Use permitted

CFC is designed for specialized applications. Because of its physical design and limitations, it cannot be installed in all types of construction or building conditions. Certain minimum installation requirements (for example, easy accessibility and protection from cable abrasions) apply to ensure that the CFC operates safely and poses minimal electrical fire and shock hazards. Rule 60-324 allows CFC to be installed only when the following conditions are met:

- The CFC wiring system is to be installed under carpet squares.
- The carpet squares are to be:
  - not larger than 750 mm; and
  - readily removable to provide easy access to CFC conductors.

Adhesive used to install the carpet squares is to be a release type that easily allows the carpet squares to be pulled up, leaving no portion of the carpet square adhering to the floor or to the CFC conductors. Regardless of any proposed access method (for example, slit lines), under no circumstances is CFC allowed to be placed under normal carpeting, such as rolled carpet or wall-to-wall installations, which is not designed to cover CFC systems. In addition, the following conditions apply to CFC wiring systems:

- The CFC conductors are installed exclusively to extend a conventional system of communication conductors in the building.
- The CFC conductors do not exceed 15 m in length from the point of connection to the conventional communication system wiring.
- The floor surface on which the CFC conductors are to be placed is a hard, smooth, and continuous surface, such as sealed concrete, ceramic flooring, composition flooring (such as terrazzo), wood, or similar material. The CFC conductors are to be firmly affixed to the surface to prevent any movement or possible abrasion (see Rule 60-328). Non-sealed concrete, rough surfaces, and non-continuous surfaces are not acceptable because the CFC conductors cannot be fixed in a permanent position.
- The floor surface is in an interior area classified as a dry or damp location. The CFC conductors are not to be used in an area that is subject to liquid spillage, which can lead to electrical shorting or the possible release of the system-securing tapes.
- The floor surface temperature does not exceed 30 °C. If the floor is heated in excess of 30 °C, the CFC conductors are to be approved and marked as suitable for the anticipated temperature range.

### Rule 60-326 Use prohibited

CFC conductors are not to be installed:

- outdoors or in wet locations (CFC conductors are not designed for exposure to uncontrolled liquids or wet conditions, or in areas subject to extremes of temperature and movement);

- in areas subject to corrosive vapours or liquids (CFC conductors are not designed to survive in these environments);
- in hazardous locations (because CFC conductors can be a source of ignition);
- in dwelling units, hospitals, or institutional buildings (to minimize electrical shock and fire hazards); however, CFC conductors are allowed to be placed in the office/administration areas of hospitals and institutional buildings where hazards are known to be minimal;
- on walls (as a general wiring method), except where the CFC emerges from under the carpet squares to extend to a transition point located on a wall; or
- under permanent partitions or walls (where the conductors are not readily accessible and might be damaged through structural shifting).

### Rule 60-328 Floor protective coverings

Physical movement on carpeted floors is usually transferred to the CFC conductor surface below the carpet. To prevent abrasion damage to the CFC, Rule 60-328 requires that all types of CFC be covered with an abrasion-resistant tape. Firmly secure the tape to the floor and cover all portions of the CFC, including any bare conductor ends. This covering product is usually specified as a part of the overall CFC assembly.

### Rule 60-330 Coverings

In some installations, CFC conductors have to cross over or under each other, or over or under the flat conductor cables of a power system. Where CFC crosses over or under power system cables, possible friction between the cables can result in accidental electrical contact. Rule 60-330 requires that CFC conductors crossing over or under each other, or over or under FCC, be separated by a layer of grounded metal shielding in accordance with Rule 12-820 to minimize accidental electrical contact between the two systems.

### Rule 60-332 System height

A CFC system is designed to limit the overall height of the cable assembly under the carpet squares, minimizing the possibility of damage resulting from physical forces applied at the floor level.
Rule 60-332 prohibits placing CFC cables on top of each other (in parallel runs), except where the cables enter the transition point to conventional communication wiring (for example, a wall jack or a monument-type floor outlet).

### Rule 60-334 Grounding of shields

In some installations, a CFC system is provided with a metal shield for mechanical protection or design considerations (for example, prevention of induced signals). Rule 60-334 requires that the shield be grounded so that any electrical energy that might be induced or imposed through accidental contact with another power source (for example, an electric power circuit) is safely removed.

## Equipment

### Rule 60-400 Communication equipment in bathrooms and in areas adjacent to pools

No communication equipment is to be accessible from a bath or shower enclosure or in an area near a pool since in wet areas, contact with such equipment can result in electrical shock.

Subrule 1) requires that communication equipment in a bathroom (for example, a telephone or intercom) be permanently attached to a wall so that it cannot be easily moved. Locate so that no portion of the equipment can be reached from, extended to, or used in a bath or shower enclosure. This ensures that it cannot come into contact with water or be held or used by a person in a tub or shower. In certain instances (for example, in the patient care area of a hospital or nursing home) where access to a communicating device is necessary in a bath or shower enclosure for emergency purposes, an insulated device or link (for example, a pull string) that extends to the communication equipment may be placed in the bath or shower enclosure. The communication equipment attached to the insulated link is to remain out of reach.

Subrule 2) prohibits the installation of communication jacks in bathrooms since the attachment cord or cord set of communication equipment connected to these jacks can easily extend into a tub or shower enclosure.

Subrule 3) requires that communication equipment and communication jacks in areas around pools be installed in accordance with Rule 68-070.

### Rule 60-402 Equipment in air ducts, plenums, or suspended ceilings

Placing communication equipment and terminals in an air duct, plenum, or hollow space is not a good safety practice since such locations are not usually readily accessible. During fault conditions, such equipment can pose fire and shock hazards, as the flame spread and smoke development in ducts or plenums can increase the dangers.

Rule 60-402 prohibits the installation of communication equipment or terminals in ducts, plenums, or hollow spaces:

- used to transport environmental air; and
- in suspended ceiling areas.

An exception is allowed for a suspended ceiling area in which lay-in panels or removable tiles form a duct, plenum, or hollow space. In such an area, communication splitters (connecting blocks) that function only as non-protective electrical connections are allowed to be installed in an accessible enclosure (see the Appendix B Note to Rule 60-402 for more information about non-protective connecting blocks). Other types of communication equipment and terminals are not to be placed in this type of suspended ceiling space.

### Rule 60-404 Exposed equipment and terminations

Exposed bare live parts of communication equipment and terminals can present an electrical shock hazard both during normal operation (line operation) and during fault conditions (for example, imposed voltages caused by accidental power contacts or inductions). To prevent contact with exposed bare parts, Rule 60-404 requires that communication equipment or terminals having exposed bare live parts be placed in a suitable room (for example, a locked communication or telephone room) or similar area that is accessible only to qualified personnel familiar with the hazards and operations of the communication circuits. The room or area is to comply with Rule 2-202 regarding the types of rooms allowed, the separations required between systems, authorized access, and the posting of warning signs.

If the room or area is a joint-use electrical room designed to house both electrical and communication systems, Rule 60-404 requires a minimum separation of 900 mm between any exposed communication equipment or terminals and any other electrical equipment requiring adjustment and maintenance. This separation is intended to prevent accidental electrical contact between systems operating at different voltage levels.

The requirement for a separate room or area does not apply when the live parts of communication equipment or terminals are protected against accidental contact by means of an approved cover, cabinet, or other type of approved enclosure.

### Rule 60-406 Ground start circuits

Some types of communication equipment have telecommunication circuits that, during operation, have a path to ground (ground start circuits). For example, the ring conductor of a tip-ring connection is momentarily grounded to get a dial tone from the telephone company in the event of a power failure. Such an interface is preferred for PBX telephone equipment because of its more reliable operation. In certain circumstances (for example, high ground fault conditions or induced voltages), the return ground path for the communication circuit can create an electrical fire hazard in either the associated equipment or the wiring.

Rule 60-406 requires that communication circuits (in a telecommunication network) that use a ground source as part of the operating path be connected to a current-limiting device that can limit the current under both normal operating and fault conditions to prevent any fire hazards due to excessive currents. The device is to be:

- installed either in or immediately adjacent to the equipment establishing the communication circuit; and
- of a type (size and rating) recommended by the equipment manufacturer, based on the circuit and its safe limits.

### Rule 60-408 Communication systems in hospitals

To protect hospital patients in the basic, intermediate, and critical care areas of hospitals from stray voltages that can be carried on the exposed conductive metal parts of communication equipment (that is, parts that a patient might touch), Rule 60-408 requires that all such metal parts be bonded to a common ground source. In accordance with Subrule 7) of Rule 24-104, connect the bonding conductor to a common ground point for all the electrical equipment in a room or area to prevent electrical shocks or ground loops caused by differences in ground potentials. Telephone sets, which are typically made of plastic, do not need to be bonded to ground because they do not present a possible ground shock hazard.

## Outside conductors

### Rule 60-500 Overhead conductors on poles

The installation and maintenance of overhead and outdoor conductors present important safety issues related to electric shock and other hazards (for example, accidental contacts between communication and power conductors, accidental personnel contacts with power conductors, and induced voltages). CSA C22.3 No. 1 – developed through many years of operating field experience – provides requirements and guidance to address these concerns.

When communication conductors are placed overhead or aerially – in spans or attached to poles – and in proximity to power conductors, Rule 60-500 requires that they be installed in accordance with the requirements of CSA C22.3 No. 1. This Standard covers safety considerations such as proper working spaces between conductors of various electrical systems, span separations, and conductor sag.

### Rule 60-502 Overhead conductors on roofs

When communication conductors are installed over the roofs of buildings, inadvertent damage to the conductors and electrical fire or shock hazards to the public and premises are to be prevented. In general, the safety rules for clearances in such installations correspond to those set out in CSA C22.3 No. 1.

Subrule 1) requires communication conductors passing over the roofs of buildings to be placed at a minimum height of 2.5 m above the highest point of the roof line to minimize possible contact with, or damage by, people standing or working on the roof.

Structural designs or locations can make it necessary to place communication conductors less than 2.0 m above a roof, measured vertically, or to attach conductors directly to the roof. In such cases, Subrule 2) requires a deviation under Rule 2-030.

Subrule 3), allows the installation over a garage or a similar auxiliary building that is no more than one storey in height without requiring a deviation under Rule 2-030 when the communication conductors are less than 2.0 m above a roof, measured vertically, or attached directly to the roof.

### Rule 60-504 Circuits requiring primary protectors

When communication conductors are placed outside and/or enter a building, the following should be taken into account when determining their construction, design, and method of installation:

- the measures necessary for the protection of the communication circuits; and

- any possible fire and shock hazards (for example, where the communication conductors are in contact with a structure or are in proximity to electrical power conductors).

Rule 60-504 states any communication circuit requiring a primary protector in accordance with Rule 60-200 is to meet all the applicable requirements of Rules 60-506 to 60-514, which address fire and shock hazards related to cable constructions, separations from other electrical systems, methods of attachment, and methods of entry into buildings.

### Rule 60-506 Wire insulation

When a communication conductor is placed outside a building, the physical and operating environments should be taken into account. The flame spread rating of the conductor is not as much of a concern as it is for indoor conductors. However, the conductor must be capable of withstanding outdoor conditions — such as sunlight, wind, extremes of temperature, moisture, and other weather conditions — without presenting an electrical fire or shock hazard.

Communication cable (also called communication wire in the industry, but not in the Code) usually refers to the service drop conductor that runs from the main communication feeder plant to the building to which it is attached and enters. A communication cable can:

- consist of two or more conductors; and
- have an overall jacket in addition to the individually insulated conductors.

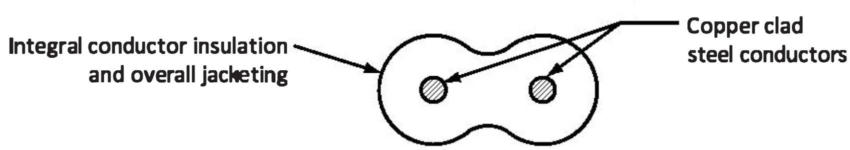
Outside communication cables are usually installed to provide communication service to single dwellings and small commercial buildings (for example, retail stores and service stations).

When a communication cable is installed for a circuit that requires a primary protector, Rule 60-506 requires that:

- each conductor have rubber or thermoplastic insulation; and
- an individual conductor or a group of conductors also have an additional protective jacket.

This additional jacket is allowed to be integral with the conductor insulation, as is usually the case where the cable consists of one or two conductors (see Figure 60-3).

**Figure 60-3**
**Cross-section of communication cable**




### Rule 60-510 Communication conductors on buildings

When communication conductors are placed on the outside of buildings, the principal safety concerns are the risk of accidental contact with other electrical conductors, fire hazards, and physical interference with other systems' conductors. Supplement the requirements of Rule 60-510 with the requirements of CSA C22.3 No. 1 as applicable (for example, the requirements for minimum separations) to adequately address these concerns.

When communication conductors and insulated conductors of an electric light or power system are both placed on a building, Subrule 1) requires that they be separated from each other by at least 300 mm to minimize the possibility of electric shock and accidental power contact. However, if either the communication conductors or the electric light or power conductors are totally enclosed in a conduit or other fixed non-metallic raceway, the minimum separation is not required since the conduit or raceway protects against accidental cross-contacts.

When communication conductors and bare light or power conductors are both installed on a building, Subrule 2) requires that:

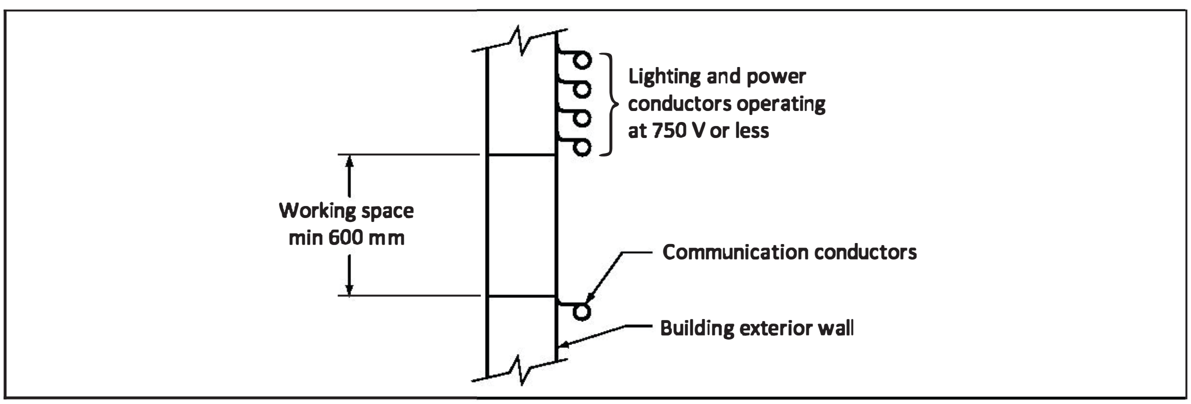
- the communication conductors be located in the lower position (thereby providing a working space and minimizing the possibility of accidental contact between the communication and power conductors); and
- there be a minimum separation of not less than 600 mm between the communication conductors and light or power conductors operating at 750 V or less (to minimize the possibility that personnel working in the communication space might accidentally contact the power conductors).

See Figure 60-4.

When the communication conductors are exposed on a building surface and subject to accidental contact with electric light or power conductors that operate at voltages exceeding 300 V, they can present a fire hazard. Subrule 3) requires that the communication conductors be separated from any combustible building surface by supports made of glass, porcelain, or another suitable insulating material.

Subrule 3) does not apply to communication conductors serving a circuit that does not require an integral fuse in accordance with Subrule 2) of Rule 60-202. In such an installation, fusing is provided by the outside or exposed plant, which minimizes the fire hazards to the building. The requirement also does not apply when the conductors extending circuits to the building are from a cable having a grounded metal sheath or shield.

**Figure 60-4**
**Attachment to building communication entrance (service drop) cable**




## Rule 60-514 Communication conductors entering mobile homes

People can receive an electrical shock while drilling sleeves to provide for the entrance of communication conductors in a mobile home. As a result, both Section 70 and the *Canadian Electrical Code, Part II* Standards on mobile homes require that a mobile home have an entrance facility for communication system conductors that is installed during the home's construction. Rule 60-514 requires that this entry point be part of the entrance raceway required by Rule 70-106. To avoid accidental contact with concealed electrical power conductors, no other entrance sleeve is to be drilled.

## Rule 60-516 Lightning conductors

Since conductors of a communication circuit usually provide a direct electrical path to a building's communication equipment, and communication cable with a metal sheath or shield bonded to ground is a good path to ground, avoid contact with or proximity to lightning conductors because of the erratic paths that lightning discharges can take. Rule 60-516 requires that when both communication and lightning conductors are placed on buildings, they be separated by a minimum of 2 m to prevent possible arcing of a lightning surge between the two conductor types.

### Rule 60-518 Swimming pools

Rules 68-054 and 68-056 give the installation requirements for aerial and underground conductors near swimming pools. They address safety concerns such as possible shock hazards, conductor damage, leakage currents, and accidental energizing. Rule 60-518 requires that communication system conductors comply with Rules 68-054 and 68-056. The minimum clearance requirements for swimming pools are illustrated in the Appendix B Note to Rule 68-054.

## Underground circuits

### Rule 60-600 Direct buried systems

When communication circuits are direct buried, preserve the integrity of the circuits. It is essential to keep them separate from other buried electrical system circuits to minimize shock hazards caused by accidental power contacts. Wherever possible, apply the requirements of CSA C22.3 No. 7 for consistency with standards developed through proven field applications. Rule 60-600 requires that direct buried communication conductors or cable assemblies be suitable for direct burial (see Figure 54-6).

Item a) requires vertical separation of the communication conductors from other system conductors. The installation requirements state that the communication circuit conductors be laid in a vertical plane that contains no other types of conductors. In a shared trench, conductors of a communication system and power supply cables are allowed to be in the same vertical plane when the following conditions in Items f) and g) are met:

- The communication conductors are equipped with an electrically continuous metal sheath.
- The power supply cables do not exceed 750 V.
- The communication and power system cables are generally not in direct contact, although zero separation might occur at random (known as random separation).
- The communication conductors do not cross under the power supply cables. (Locating the communication conductors above the power supply cables would reduce the likelihood of contacting the power supply cables if the communication conductors needed to be accessed.)

Item b) requires horizontal separation of the communication conductors from other system conductors. Communication conductors are to be horizontally separated from other underground conductors by a minimum distance of 300 mm. Conductors of a community antenna distribution system [see Item f) of Rule 54-700], or of a power system for which random separation is allowed, are exempt from this general requirement.

### Rule 60-602 Underground raceway

When communication conductors are placed in an underground raceway system:

- the integrity of the conductors is to be preserved; and
- the conductors are to be kept separate from other electrical system conductors.

The intent is to minimize conductor damage and shock hazards caused by power contacts.

Separation from other systems' underground raceways is required by Item a). Underground raceways used to enclose communication conductors are to be separated from raceways containing conductors of an electric power system by at least:

- 50 mm of concrete; or
- 300 mm of well-tamped earth.

This minimizes accidental power contacts caused by fault surges, improper excavation, and other occurrences.

Item c) does not allow the conductors of a communication system and an electric power system to be placed in the same maintenance hole. This minimizes the possibility of accidental electrical contact between the two systems and accidental shock hazards to personnel unfamiliar with one of the systems. However, communication and electric power conductors are allowed to be installed together in a maintenance hole, provided that the applicable requirements of CSA C22.3 No. 7 for construction, physical working barriers, proper working separations, separate raceway access, etc., are met.

Item d) does not allow a conductor of a communication system to be placed in the same underground raceway as conductors of electric light, power, or Class 1 circuits, under any circumstance. These three electrical systems have different voltage levels and conductor insulation types from communication systems. They are to be physically separated to prevent accidental energizing of the communication conductors.

Moisture can enter a building through underground raceways, causing corrosion of equipment to which they are connected. Underground gases can also enter the building, leading in some cases to health hazards and even explosions. Underground raceways entering a building are to be sealed with a suitable compound to prevent the entrance of moisture and gas into the building. Item f) also requires that the raceways enter the building above grade, if practicable, or be suitably drained.

### Rule 60-604 Underground block distribution

Communication conductors are often placed in an underground raceway system in a public street or right-of-way; they can also interconnect several buildings on either continuous or non-continuous property. When such conductors are not likely to come in contact with electric light or power circuits operating at more than 300 V, Rule 60-604 gives the following allowances:

- The primary protector specified in Rule 60-200 need not be provided as the communication conductors are not exposed to the electrical fire and shock hazards that the protectors are designed to prevent.
- The insulation requirements for outside conductors set out in Rules 60-506 and 60-508 do not apply.
- Conductors do not require the insulating supports specified in Subrule 3) of Rule 60-510.
- Where the conductors emerge from an underground entrance to a building, the entrance raceway or insulated bushing which Rule 60-512 requires is not needed. The potential for fire or electric shock is minimized at the point of entrance since the:
  - conductors are not exposed to electrical contact hazards; and
  - service entrance communication conductors are protected by insulation as required.

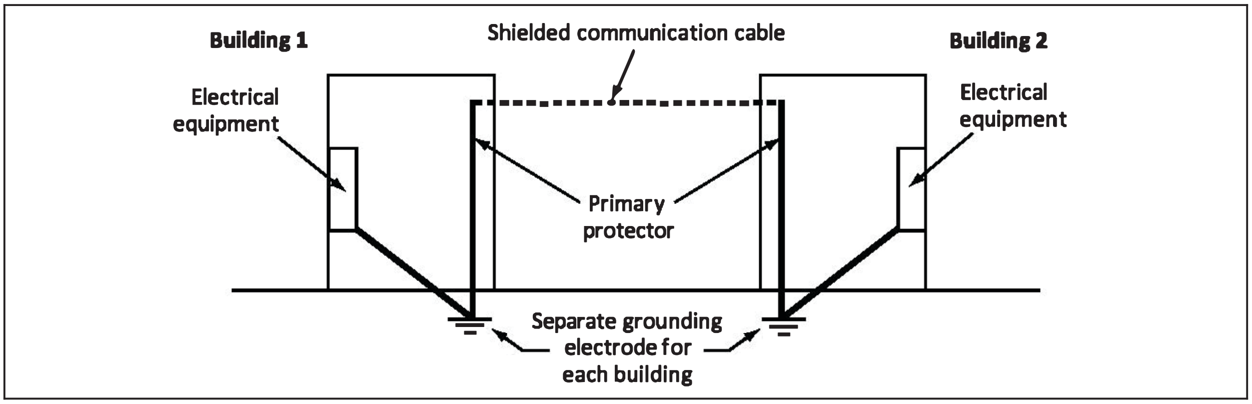
## Grounding

### Rule 60-700 Bonding of cable sheath

In most installations, the metal sheath or shield of a communication entrance cable is to be grounded since it can be prone to accidental power contacts, induced voltages, or other electrical disturbances. The grounding or bonding of the sheath or shield to ground is to be located so that the entrance cable sheath or shield does not conduct any electrical energy into a building. Rule 60-700 requires that the metal sheath or shield of a communication cable be bonded to ground as close as possible to its point of entry inside a building. The Appendix B Note to Rule 60-700 defines the cable point of entry as the point of emergence (see Figure 60-5):

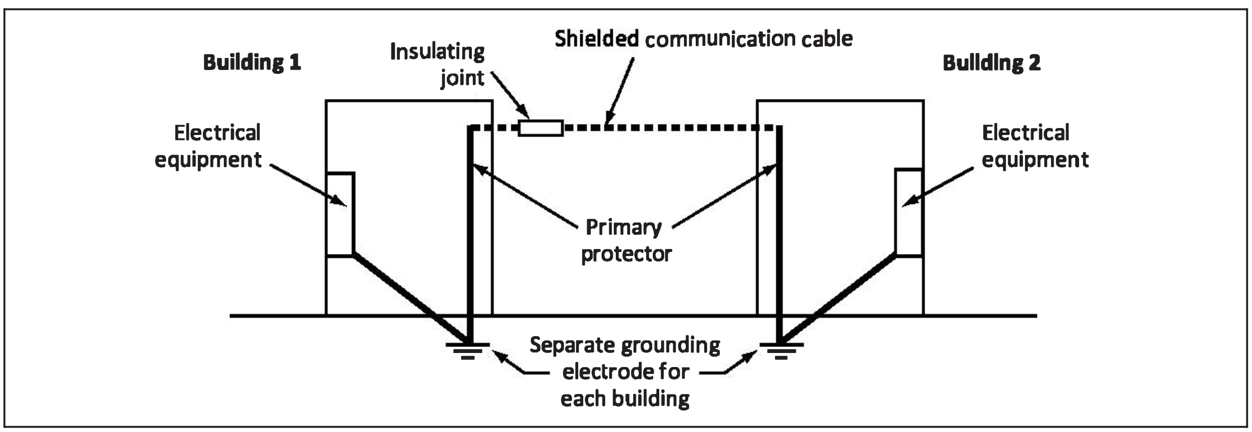
- through an exterior wall or a concrete floor slab; or
- from a totally enclosed non-combustible entrance raceway.

**Figure 60-5**
**Bonding of cable sheath**




In an installation where the communication entrance cable shield or sheath connects together grounding systems in two or more separate buildings, an insulating joint is allowed to be placed as close as practicable to the point of entrance. This prevents current caused by fault conditions or lightning strikes at one building from flowing over the communication entrance cable's metal shield or sheath to the other grounding system (see Figure 60-6).

**Figure 60-6**
**Bonding of cable sheath — Insulation joint**




## Rule 60-702 Cable sheath bonding conductor

Although the Code specifies the minimum sizes of bonding and grounding conductors for communication protectors (see Rule 60-704), there are no detailed guidelines for bonding and grounding conductors used for metal shields or sheaths of communication cables. Rule 60-702 requires that these bonding conductors have an ampacity equal to or greater than the ampacity of the sheath or shield to which they are connected. A properly sized conductor safely removes any currents imposed on the sheath or shield, without fusing to an open condition and presenting a potential fire or shock hazard. The bonding conductor – which is to be of copper – need not exceed No. 6 AWG, a limit determined by field experience and manufacturers' recommendations for operating systems.

## Rule 60-704 Primary protector grounding conductor

The grounding conductors for a communication systems primary protectors are to have adequate ampacity to safely drain off electrical currents without failing and be installed so that they are physically safe and offer the lowest-impedance path to ground. Rule 60-704 requires that these conductors be:

- copper;
- insulated with rubber or thermoplastic material, to prevent accidental electrical contacts with other systems that can impose stray voltages on the communication circuit;
- sized in accordance with Table 59, which lists the minimum size required for any given number of communication circuits being protected;
- installed in as straight a line as possible between the protector and the point of connection to ground to provide an electrical path with the lowest possible impedance value and – in case of lightning strikes – to minimize the possibility of electrical arcing at sharp or complex conductor bends; and
- physically guarded against mechanical damage to provide a continuous electrical path to ground. This protection can be provided by running boards, guard strips, or metal conduit.

## Rule 60-706 Grounding electrode

The key factor in grounding a communication system is to secure a grounding electrode that has the lowest impedance value.

When the building water supply is provided by a buried metal water pipe extending at least 3 m from the exterior of the building, Subrule 1) recommends that the pipe be used as the communication grounding electrode (see the Appendix B Note to Rule 10-102). This type of grounding electrode is the most effective since it offers both a low impedance value and a high degree of reliability. Attach the grounding conductor as close as possible to the point at which the water pipe enters the building to avoid any possible future disruptions to the pipe and to the ground path. When the water pipe has a meter attached to it, the point of attachment for the grounding conductor is to be on the street or exterior side of the meter so that the removal or disconnection of the meter does not disrupt the ground path.

Subrule 2) covers installations in which a metal water-supply pipe is used as the building's grounding electrode but is neither readily available nor in close proximity to the communication primary protector (for example, it might be located in a remote section of the building). If the grounding conductor of the building's consumer service is close to the communication primary protector — and the building's grounding conductor is connected to the metal water-supply pipe — the communication system protector is allowed to be grounded to the service grounding conductor. In this case, the primary protector grounding conductor is permitted to be directly connected to the consumer service grounding conductor. In cases where the service conductors are run within a metal conduit or the service grounding conductor is not readily accessible, the primary protector grounding conductor is allowed to be connected to the metal service conduit. If this is not possible, the primary protector grounding conductor is allowed to be attached to an electrical equipment enclosure of the consumer electrical service.

In the absence of a water pipe grounding electrode, Subrule 3) allows the primary protector grounding conductor to be connected to a:

- ground rod or a metal pipe driven into permanently damp earth; or
- a metal structure that is effectively grounded.

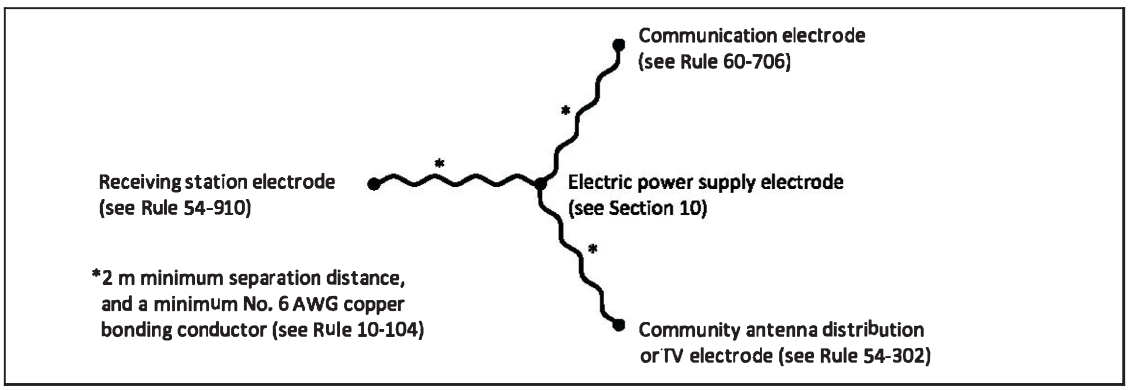
Steam pipes, gas pipes, and hot water pipes are not acceptable as grounding electrodes, even though they can appear to provide a path to ground. Under certain conditions, these types of building service pipes might not provide a continuous consistent or low-impedance ground path.

In general, driven ground rods or pipes that are installed as the grounding electrode for the building power circuits are not to be used as the grounding electrode for a communication primary protector.

A connection must be made in accordance with Rule 10-104 to the power grounding electrode. An exception is allowed when the grounding conductor of a multi-grounded power neutral system is connected to a driven ground rod or pipe. In this case, the ground and impedance level is common throughout all points of that system as well as for a connected communication primary protector.

When a separate driven ground rod or pipe is installed as the grounding electrode for a communication system, Subrule 4) requires that the rod or pipe be separated at least 2 m from any other grounding electrode for another electrical system (for example, a power, television, or lightning system). The communication grounding electrode is to be connected to a power system grounding electrode so that the two systems are connected to the ground that has the lowest impedance value. If the incoming communication entrance circuit is accidentally energized, the energy is transferred from the protector to ground as close as possible to the electrode having the least impedance. If the communication system and power system electrodes are not interconnected, the energy can appear within the building and possibly be transferred to the power system (via arcing, etc.). Subrule 4) requires that the bonding conductor between the communication and power ground electrodes be placed in accordance with the requirements of Rule 10-104, which covers the size of conductor, the prevention of mechanical damage, and the method of connection to the electrodes (see Figure 60-7).

**Figure 60-7**
**Bonding of electrodes**




## Rule 60-708 Grounding electrode connection

Reliable connections in a grounding circuit allow the ground path to be available and ensure that the ground path will neither deteriorate nor increase in impedance. Rule 60-708 requires that a grounding conductor be connected to a grounding electrode in accordance with Rule 10-118, with proper materials and in such a manner that the electrical integrity is maintained at all times, during both idle and active conditions. Item a) requires that a grounding conductor be directly attached to a grounding electrode.

Alternatively, a ground rod that incorporates a wire lead is allowed to be used in accordance with Item b), provided that the rod, the lead, and the attachment of the lead to the rod conform to CSA C83.

## Rule 60-710 Bonding of electrodes

The Rules of Sections 10 and 60 are consistent with the bonding requirements for grounding electrodes. These requirements provide an effective, common electrical path to ground.

When separate grounding electrodes are installed for a communication circuit and a power circuit, Rule 60-710 requires that the bonding conductor between the two electrodes be copper and not smaller than No. 6 AWG. This reflects the requirement of Item b) of Rule 10-104 that all bonding conductors between grounding electrodes of differing systems have the same design and operating characteristics.

# Section 62 — Fixed electric heating systems

## Scope

Section 62 includes additional and specific requirements for the installation of fixed electric heating systems. These fixed electric heating systems are used to heat:

- rooms or areas for the comfort of occupants;
- surfaces of containers to prevent freezing of liquid contents, which can lead to the rupturing of tanks, pipes, and vessels, the stoppage of processes, and health and safety hazards. It should also be noted that there are different design requirements for surface heating systems when they are being used to thaw frozen containers or pipes;
- surfaces to melt ice or snow in order to reduce accidents, falls, etc.;
- storage tank water heaters, including the bare-element type;
- infrared drying lamps; and
- induction and dielectric heating.

### Rule 62-000 Scope

Space heating is the application of any fixed electric heating equipment and technology that results in adding heat to an enclosed space or room. This is normally done to increase the comfort of persons or animals, but space heating can also be used in storage spaces or rooms where it is important to keep the stored material above a certain temperature.

Some examples of space heating are:

- central heating units;
- baseboard heaters;
- radiant heaters;
- wall and ceiling heaters; and
- floor warming heaters.

**Note:** *Many heating technologies add heat to a room by convection, conduction, or radiation.*

Surface heating is the application of fixed electric heating equipment and technology that results in increasing the temperature of a surface to heat material. Some examples of surface heating are:

- pipe heating;
- storage tank or vessel heating; and
- snow and/or ice melting on, or embedded in, a surface (for example, on roofs and gutters or embedded in concrete, asphalt, or soil).

Other electric heating systems are applications of fixed heating equipment that are not space or surface heating systems. Some examples of these systems are:

- pipe internal heaters, often referred to as "gut" heating;
- immersion heaters; and
- hot water tanks.

**Notes:**

1) *This Section frequently uses the terms "non-heating conductors" and "non-heating leads" (sometimes referred to as "cold leads"). These are the conductors that connect directly to the heating elements. Since they connect directly to the element, they experience very high temperatures. In most cases, the non-heating conductors on heating panels or heating panel sets are provided on the equipment from the factory.*
2) *Surface heating systems do not provide process heat unless specifically designed for it.*

# General

## Rule 62-100 General Rules

Rules 62-102 to 62-132 give general requirements that apply to fixed space heating, fixed surface heating, and other types of fixed heating installations, except where specifically noted.

## Rule 62-102 Special terminology

Rule 62-102 defines a number of terms that apply only to Section 62. These definitions are consistent with those provided in the *Canadian Electrical Code, Part II*, specifically CSA C22.2 No. 130 and CSA C22.2 No. 46. The following are among the terms defined.

*Bare element water heater* is a self-contained, factory-assembled water heater that heats water by having bare heating elements submersed in the water of a tank. The water is then heated by the direct contact with the bare/uninsulated heating elements.

*Dielectric heating* is the generation of heat within insulating materials and semiconductor materials when they are placed within a high-frequency field (generally a frequency between 1 and 300 MHz, depending on the material to be heated).

*Induction heating* is the process of heating an electrically conductive object (usually metal) by placing a coil of conductors around an electrically conductive object to be heated or running a coil of conductors parallel to the object. The passage of ac current through this coil generates a very intense and rapidly changing magnetic field in the space within the coil and induces a current flow in the conductive object that is short-circuited, which heats up the object. The frequency of ac used depends on the object size, material type, coupling (between the coil and the object to be heated), and the penetration depth.

*Impedance heating* is the process of connecting a low ac voltage across the electrically conductive object to be heated. Current then flows in the conductive object between the two connection points, resulting in the current directly heating the object.

*Skin effect heating* is the process of connecting an ac circuit conductor to the end of a ferromagnetic envelope (heating tube) that has been attached to a material to be heated (for example, a pipe). Another ac circuit conductor is placed inside the tube to conduct the current up to the end of the heat tube where it is connected. The rapidly changing magnetic field that surrounds the conductor carrying flowing current inside the ferromagnetic envelope heats up the material of the envelope. When the return current flows in the ferromagnetic envelope (heating tube) through the internal thickness of the envelope/tube, it provides conductive heating which is transferred directly to the material it is in contact with (for example, process piping). The heat produced by this type of heating comes from two sources: one from the flow of the return current in the ferromagnetic envelope (heating tube) on the inner surface of the envelope/tube; and the other from the magnetic field associated with the current flow through the supply conductor run inside the envelope/tube. This has the effect of increasing the electrical resistance of the heat tube, thereby increasing the heating. Supply connections are made in special boxes.

## Rule 62-104 Installation of heating devices and bonding

Manufacturer's instructions are incorporated into the Part II certification process of heating equipment and form an important part of the overall safety of the final installation. Subrule 1) requires that, as well as meeting the requirements of the Rules in this Section, the assembly and installation of electric heating devices meet the requirements specified in the manufacturer's instructions.

A person touching the ungrounded metal casing of an electrical device while also in contact with a grounded metal object or earth/ground is exposed to an electric shock hazard if the device has a fault. If all metal objects are connected together and connected to earth/ground (bonded to ground), all the exposed non-current-carrying metal parts of objects will be at the same potential. It will therefore not be possible to get a shock by touching two grounded objects at once or touching one while in contact with the earth/ground. Therefore, in order to prevent shock hazards, Subrule 2) requires that all electrical conductive shields, braids, coverings, and exposed metal surfaces be bonded to ground.

### Rule 62-108 Terminal connections

Subrule 1) requires that terminal connections be accessible so that the quality of the termination can be checked and the operation of the heating device sets tested without disturbing the wiring system. Subrule 2) requires a termination fitting, which might be installed next to the heating equipment, to be constructed of a non-combustible material to prevent fire hazards.

If the temperature at the point of connection of the branch circuit to the heating device exceeds 60 °C, Subrule 3) requires that the temperature rating of the conductor's insulation meet or exceed the temperature rating specified by the manufacturer. For example, the branch circuit's insulated conductors with higher insulation temperatures may be installed for the complete installation. However, if an insulated conductor with a temperature rating lower than that specified by the manufacturer is used, Subrule 4) allows the lower-temperature-rated insulated conductor to be tapped to an insulated conductor with a temperature rating equal to or greater than that of the device sets, provided that the length of the tapped conductors is at least 500 mm from the connection to the heating equipment leads. This requirement is intended to prevent damage to the insulation on the branch circuit conductors connected to the heating equipment.

### Rule 62-110 Branch circuits

Heating device sets are to be connected to branch circuits used for no other purpose. Interconnecting high loads such as heating devices with lighting or other types of electrical loads can cause nuisance tripping of the overcurrent device protecting the supply circuit. Also, it is desirable to turn off circuits serving heating devices during the non-heating season. Subrule 1) requires that the branch circuit conductors supplying heating device sets are to:

- be used only to supply the heating device sets, no other loads;
- have an ampacity not less than that of the connected load supplied to the device sets; and
- have insulation suitable for the temperature encountered when connecting to the heating device sets.

Subrule 2) requires that a unit that combines heating with ventilating or lighting or both be considered a heating device set.

Subrule 3) makes an exception to the requirements of Subrule 1) for a heat lamp that is not the only source of heat for an area. The lamp is allowed to be used in a luminaire or in a luminaire mounted on an outlet box and connected to a branch circuit installed in accordance with Rule 8-304 (for example, when a heat lamp is used in a bath or shower room as a supplementary heating source).

### Rule 62-112 Temperature of adjacent combustible materials

To prevent damage to or fires in combustible surface materials, Rule 62-112 requires that combustible material not be subjected to temperatures in excess of 90 °C when installed adjacent to heating devices.

### Rule 62-114 Overcurrent protection and grouping

Rule 62-114 specifies the minimum size of overcurrent protection for electric heating systems. The requirements are intended to protect electric heating equipment and service, feeder, and branch circuit conductors from damage caused by short-circuits and excessive current. The size of the overcurrent protection is more strictly limited when more than one heating fixture or cable set is installed on a circuit in a residential occupancy; higher overcurrent ratings are allowed for circuits in non-residential buildings.

Subrule 2) allows two or more heating devices installed in a residential occupancy to be grouped on a branch circuit, provided that the branch circuit overcurrent device is not rated at more than 30 A. This exception takes into consideration:

- the size of the area to be heated;
- the use of combustible materials;

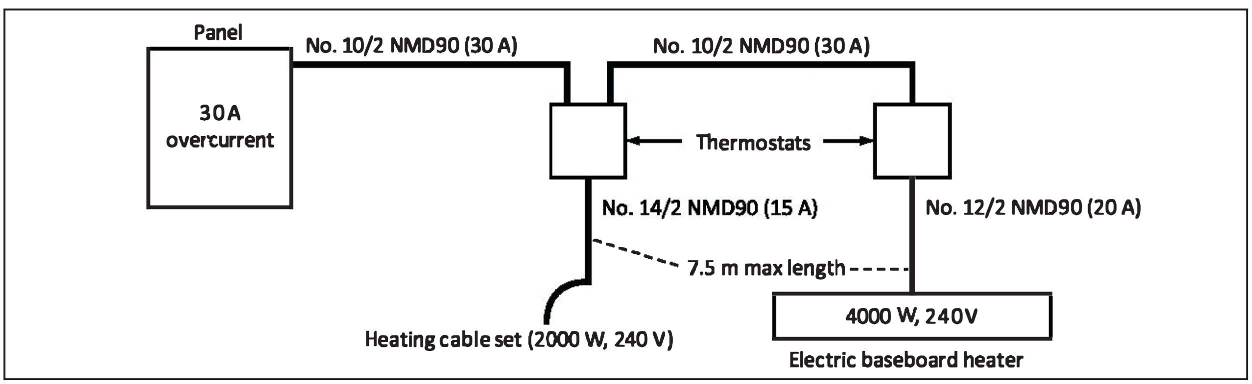
- the type of construction;
- the use of individual room thermostats for controlling the heating equipment; and
- the size of the heating equipment.

In other types of occupancies:
- the heated areas can be larger;
- the use of combustible materials can be reduced; and
- the heating equipment, thermostats, and control line contactors can be larger than the individual units in residential installations.

In buildings not intended for residential occupancy, Subrule 3) allows two or more of these larger heating systems to be grouped on a single branch circuit, with an overcurrent device rated at a maximum of 60 A. A rating higher than 60 A is allowed to be used when:
- a deviation in accordance with Rule 2-030 is obtained; or
- three heating units are grouped on a three-phase system and the units are connected to provide a balanced circuit with equal loads on each line/phase conductor.

Subrule 4) allows non-heating conductors connected to heating devices to be smaller than the branch circuit conductors, provided that:
- they have a minimum ampacity not less than one-third of the rating of the overcurrent devices; and
- they are not more than 7.5 m in length (see Figure 62-1). For further information on overcurrent protection and tap conductor sizing, see Rule 14-100.

**Figure 62-1**
**Overcurrent protection and grouping**




Subrule 5) allows an exception to the restrictions on the tap conductor's length as specified in Subrule 4) b) where there are two or more fixtures, cable sets, heating panel sets, or parallel heating sets connected to a single branch circuit and the rating of the overcurrent device protecting the circuit is equal to or less than the ampacity of the non-heating leads and the tap to each of the heating devices.

Subrule 6) requires that the connected load on a service, feeder, or branch circuit used only to supply heating device sets be:
- 80% of the rating of the overcurrent device when the fused switch or circuit breaker is marked for continuous operation at 80% of the overcurrent device's rating or setting, or is unmarked (see the Appendix B Note to 62-114 ); and

- 100% of the rating of the overcurrent device when the fused switch or circuit breaker is marked for continuous operation at 100% of the overcurrent device's rating or setting.

  **Note:** *A fuse is certified and tested to be loaded to 100% of its continuous ampere rating; it is the rating of the fused switch that has to have the correction factors for continuous operation applied to it.*

When the 80% and 100% factors are applied to the connected heating load (in amperes) to calculate the minimum rated fused switch or circuit breaker, the calculation is as follows:

- for 80% continuous operation rating or unmarked fused switch or circuit breaker:
  the minimum calculated rated overcurrent device = total connected heating load in amperes × 1.25; and
- for 100% continuous operation rating: the minimum calculated rated overcurrent device = total connected heating load in amperes.

If the minimum calculated rating does not correspond to any standard rating for overcurrent devices in the manufacturer's tables, a device with the next higher standard rating (referred to as the minimum standard-rated overcurrent device) is to be used; otherwise, more heating load is connected to the overcurrent device than Subrule 6) allows.

Subrule 7) allows the service, feeder, or branch circuit conductors supplying only fixed (permanently connected) resistance heating loads to have an ampacity rating less than the rating or setting of the overcurrent device, provided that the conductors' ampacity rating is not less than:

- the connected electric heating load; and
- 80% of the rating or setting of the overcurrent device when other than the minimum standard-rated device is used.

Subrule 8) makes an exception for conductor sizing. When the heating load or minimum conductor ampacity multiplied by 1.25 does not correspond to a standard-rated overcurrent device, the next higher standard-rated device (that is, the minimum standard-rated overcurrent device) is to be used, without the need to increase the conductor ampacity as sized in accordance with the total connected electric heating load.

**Note:** *When rounding up from the overcurrent device's minimum rating calculated in accordance with Subrule 7), and choosing an overcurrent device with a standard rating above the next standard rating (above the overcurrent device's minimum rating), calculate the conductor size by using Subrule 7) b), which is 80% of the standard rated overcurrent device.*

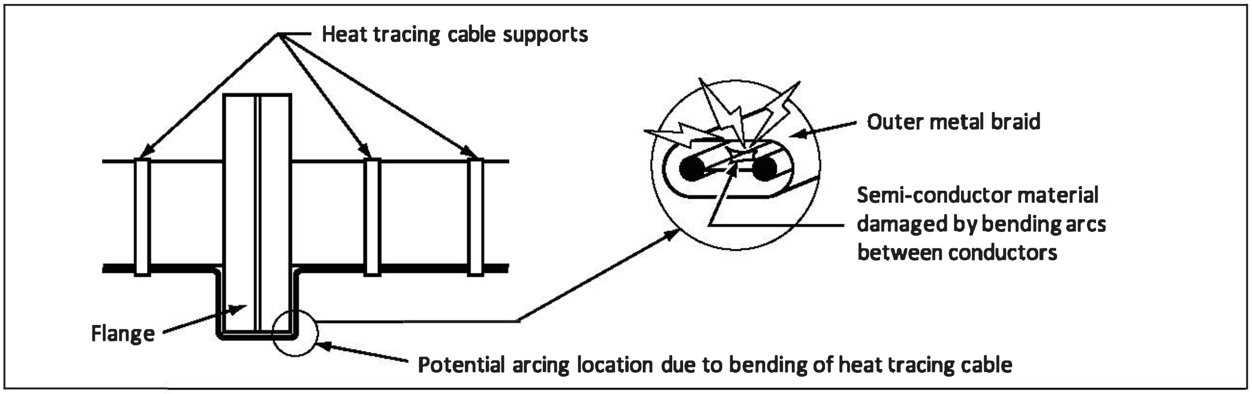
## Table 62-1
## Method to determine minimum overcurrent device size and minimum conductor size for electric heat circuits

| Step | Method |
|---|---|
| 1 | Convert the electric heat load/equipment rating, expressed in watts, to amperes:<br>Single-phase: watts / volts<br>Three-phase: watts / (volts × 1.73)<br>**Notes:**<br>**1)** *The voltage divisors to be used are specified in Rule 8-100.*<br>**2)** *The accepted industry standard value for the square root of 3 is 1.73.* |
| 2 | Determine the equipment's rating for continuous operation. If the equipment's rating is not marked, the rating is assumed to be 80% of the overcurrent device rating (see the Appendix B Note to Rule 62-114).<br>**Note:** *This applies only to equipment such as fusible disconnect switches, circuit breakers, and panelboards, which contain overcurrent devices. Equipment such as fuses, thermostats, or cantactors used to switch electric heating loads have no ratings for continuous use.* |
| 3 | Determine the minimum ampere rating of the calculated overcurrent device size required to protect the circuit as follows [see Rule 62-114 6) a) and b)]:<br>• for equipment marked for continuous operation at 100% of the overcurrent device rating, the minimum calculated overcurrent device size equals the load in amperes calculated in Step 1; and<br>• for equipment marked for continuous operation at 80% of the overcurrent device rating and for unmarked equipment, the minimum calculated overcurrent device size equals 125% of the load in amperes calculated in Step 1 (load × 1.25). |
| 4 | Determine the minimum standard rating of the overcurrent device listed in the manufacturer's tables, rounding up if necessary. The minimum standard rating is not to be less than the minimum calculated rating from Step 3. |
| 5 | Determine the minimum conductor ampacity as follows:<br>• when the overcurrent device used has the minimum standard rating determined in Step 4, the minimum conductor ampacity equals the load in amperes from Step 1 [see Rule 62-114 7) a)]; and<br>• when the overcurrent device used has a higher rating than the minimum standard rating determined in Step 4, the minimum conductor ampacity equals 80% of the higher overcurrent device's rating (overcurrent device rating × 0.8) [see Rule 62-114 7) b)]. |
| 6 | Determine the minimum conductor size from the appropriate ampacity Table in the Code, taking into account<br>• the conductor's material (copper or aluminum);<br>• the installation method (that is, free air, raceway, multi-conductor cable, or direct buried); and<br>• the lowest temperature rating of either the conductor's insulation temperature rating or the conductor's termination temperature rating. |

### Rule 62-116 Ground fault protection

The design of heating cable sets, heating panel sets, and fixed infrared radiant heaters of the metal-sheath glowing element type requires that they be made with a grounded metal braid or sheath to give a path for leakage current caused by damage or a fault. The resistance in arcing plus the resistance of the heating cable on either side of the fault may limit the current flow so that the overcurrent protection will not trip, since it will not see it as a fault. The arcing then becomes a potential fire hazard. Since there will be leakage to the ground, usually via the grounded shield, properly set ground fault protection can detect this leakage current and de-energize the circuit before the arcing can cause a fire (see Figure 62-2).

**Figure 62-2**
**Potential arcing location in surface heating systems**



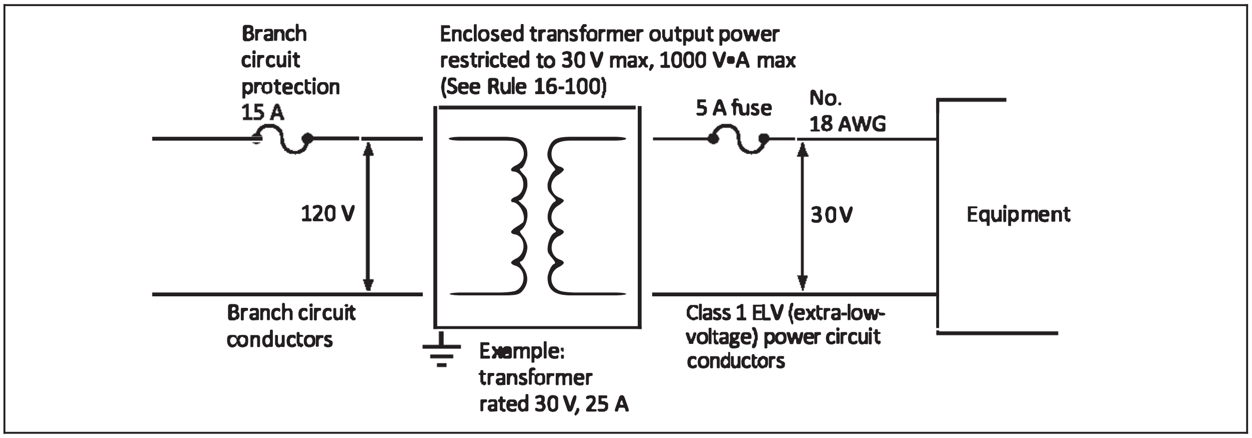

Subrule 1) requires that ground fault protection, with a trip setting sufficient to allow normal operation, be installed on the ungrounded conductors feeding heating cable sets, heating panel sets, and fixed infrared radiant heaters of the metal-sheath glowing element type, to de-energize the conductors in the event of a ground fault. The ground fault protection is intended to prevent a fire hazard by giving a path for the leakage current and thus avoiding arcing; however, it does not restrict the leakage current to a level that prevents a shock hazard.

The Appendix B Note to Rule 62-116 provides guidance on the trip setting of the ground fault protection so it will allow the start up and running of the heater without nuisance trips yet still provide ground fault protection for the equipment and supply conductors. The industry has typically used a fixed trip setting of 30 mA for many systems. For higher leakage current circuits, the trip level for adjustable devices is typically set at 30 mA above any inherent capacitive leakage current.

Subrule 2) allows an exception to the requirement to de-energize the circuit when a ground fault occurs in industrial establishments where only qualified personnel service the heating system, and where continuous operation of the heating system is necessary for the safety of equipment or processes. In such cases, ground fault detection is allowed. Ground fault detection devices (or devices and remote current sensors making up a detection system) are devices that detect a ground fault and provide an indication or alarm, or both, that a ground fault has been detected. They do not necessarily control or interrupt ground fault current and are therefore not considered a form of ground fault protection.

Subrule 3) exempts heating cable sets and heating panel sets from ground fault protection when they are connected to a Class 1 extra-low-voltage power circuit, and:
- the Class 1 extra-low-voltage power circuit is supplied from the secondary of an isolating transformer having no direct electrical connection between the primary and secondary windings;
- the isolating transformer is supplied from a branch circuit operating at not more than 150 volts-to-ground; and
- the Class 1 extra-low-voltage power circuit is not grounded. See Figure 62-3.

## Figure 62-3
## Requirements for a Class 1 extra-low-voltage power circuit for overcurrent protection of heating cable sets and heating panel sets




### Rule 62-118 Demand factors for service conductors and feeders

The demand factor is defined as the ratio between the maximum load used at any one time and the total connected load, expressed as a single digit or a percentage.

Different kinds of loads have different demand factors. For example, all of the lights in an installation are likely to be on at the same time, so the demand factor for lighting is usually taken to be 1 or 100%. It seldom happens that all the motors in an installation run at the same time or all run simultaneously at full load. As a result, the demand factor for motor loads is less than 1 or 100%.

Rule 62-118 addresses the demand factors for electric heating loads, which vary according to the type of occupancy in which heating systems are installed. These factors are used to size the service conductors and feeders for heating devices. The requirements are general and do not take into consideration very specific circumstances that might exist in a given installation. The demand factors in the Code might need to be modified, taking into account climatic conditions, building usage, heat loss, etc.

Subrule 1) requires that the conductors supplying electric heating loads have an ampacity not less than the sum of the loads installed.

Cables supplying heating equipment are to be suitable for the full current that they will be required to carry at any given time. Controllers that cycle loads on and off limit the maximum load that will be connected at any one time. Therefore, Subrule 2) allows the ampacity of service conductors or feeders that are used solely for the supply of energy to heating devices to be based on the maximum load that is to be connected at any one time in cases where the heating loads are of a cyclic or similar nature so that the total connected heating load will not operate at the same time.

Subrule 3) makes an exception for an installation in a residential occupancy that has a thermostat in each room or heated area. In such a case, the ampacity of the service conductors or feeder conductors is allowed to be reduced by applying demand factors of 100% for the first 10 kW of load, and 75% for the remainder. For example, if the total load of installed residential heating equipment is 18 000 W, supply conductors are allowed to be sized for a factored load of 16 000 W, the total of:

- 10 000 W, 100% of the first 10 000 W; and
- 6 000 W, 75% of the remaining 8 000 W (8 000 × 0.75).

The reduction is based on the assumption that not all heating units are on simultaneously.

Thermal storage heaters are becoming popular where utilities offer time-of-use rates. The heaters are controlled by a timer so that they are connected to the source of supply during off-peak hours, during which time they heat a large heat storage mass. During peak hours, heat retained by this storage mass is gradually dissipated and blown into the living area by fans in the heater. Storage heaters are designed for simultaneous operation (all heaters on at the same time); therefore, the variation provided by individual thermostats is lost. Since thermal storage heaters can be charging for long periods of time depending on the amount of heat loss, their loading is to be calculated with a 100% demand factor in all types of occupancies. Electric duct heaters and furnaces are similar in operation, with one thermostat connecting the total load and the length of operation time depending on the amount of heat loss. Subrule 4) requires that the connected heating load used to determine the minimum ampacity of service conductors and feeders supplying electric thermal storage heaters, electric duct heaters, and electric furnaces in all types of occupancies be calculated at 100%.

Subrule 5) a) requires that service or feeder conductors supplying combined loads of heating and other electrical equipment in residential occupancies be sized for the total of:

- the electric heating loads as calculated in accordance with Subrules 3) and 4); and
- the other loads as calculated in accordance with Section 8.

In buildings not intended as residential occupancies, Subrule 5) b) allows supply conductors to be sized for the total of:

- 75% of the total electric heating load; and
- the other loads as calculated in accordance with Section 8.

**Field consideration:** *When applying the 75% demand factor, it is important to consider the amount of the other loads that might be in operation at the same time as the total electric heating load, especially in situations such as the restoration of power after a major interruption, when a 100% demand factor should be used.*

Subrule 6) prohibits the application of the demand factor allowed in Subrule 5) b) for other than residential occupancies to be applied to the heating load when the total calculated load of other electrical equipment is less than 25% of the heating load. This is intended to keep the heating load from overloading the service or feeder conductors.

**Calculating minimum load for feeders**

## Example

To determine the minimum calculated load on a feeder to a barber shop, in a strip mall, with the following characteristics:

- area: 4 m × 12.5 m = 50 m$^2$
- electric heating load: 5 kW
- air-conditioning load: 3 kV•A
- water heating: 4500 W

The main service in the strip mall has a system voltage of 120/208 V, three-phase, 4-wire.

The loads for the barber shop are calculated as follows:

- basic load: area × W/m$^2$ = 50 × 30 (see Rule 8-210 and Table 14) = 1500 W;
- factored basic load: basic load × demand factor = 1500 × 0.9 (see Rule 8-210 and Table 14) = 1350 W; and
- special loads: 8250 W, the total of:
  - electric heating load: 5000 × 0.75 = 3750 W; and
  - water heater load: 4500 W.

**Note:** *Rule 8-106 4) requires that, since the electric space-heating and air-conditioning loads are not used at the same time, only the larger of the two loads be taken into consideration. In this case, it is the electric heating load of 3750 W. The total of the other loads, 5850 W (1350 + 4500), is greater than 25% of the electric heating load (5000 × 0.25 = 1250 W), and the barber shop is not a residential occupancy. Therefore, a 75% demand factor may be applied to the total electric heating load.*

The total calculated load for the barber shop is
9600 W (1350 W + 3750 W + 4500 W)

Expressed in amperes, the total load is
26.7 A [watts / volts = 9600 / (208 × 1.73)] (see Rule 8-210)

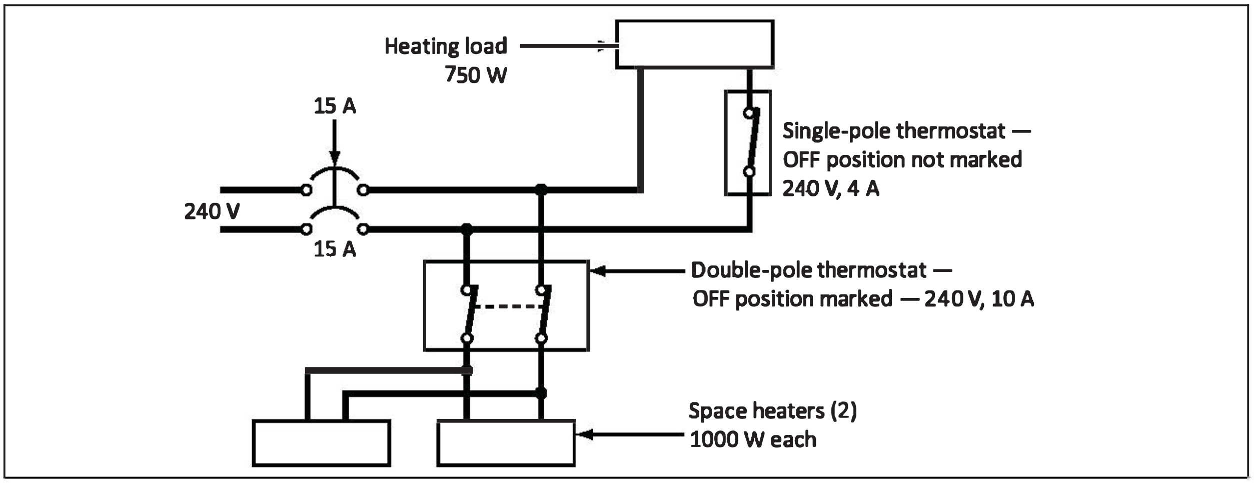
Since the equipment has a continuous rating of 80% and the wiring method uses conductors in a raceway, the minimum calculated load on the feeder is 33.4 A (26.7 / 0.8) [see Rule 8-104 6)].

### Rule 62-120 Temperature control devices

Temperature control devices (such as thermostats), which provide automatic control for heating equipment, are to be selected and installed to provide satisfactory and safe operation and protection against fire. They are also to be easily accessible for adjustment and maintenance. Subrule 1) requires that a line voltage temperature control device, or thermostat, have a rating in amperes at least equal to the total current rating of the electrical equipment that it controls. Temperature control contacts can weld together or burn if subjected to currents above the rated levels (see Figure 62-4).

Subrule 2) allows a single-pole temperature control device to be connected in a heating branch circuit consisting of two ungrounded live conductors, provided that the control device does not indicate a marked OFF position. A device with a marked OFF position can be mistaken for a disconnecting means in the OFF position, presenting a danger to personnel, since only one line is disconnected at the heater.

**Figure 62-4**
**Temperature control devices**




## Rule 62-122 Construction of series heating cable sets

Rule 62-122 requires that voltage, wattage, and current ratings be provided on the non-heating leads within 75 mm of the supply end so that systems can be properly designed, installed, repaired, serviced, and replaced.

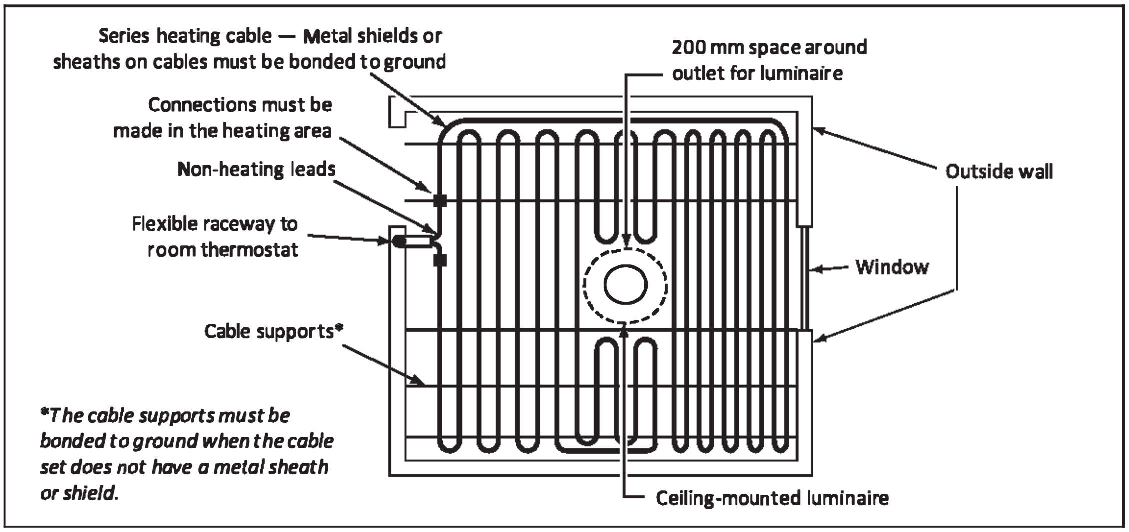
## Rule 62-124 Installation of series heating cable sets

Rule 62-124 sets out requirements for series heating cable sets intended to ensure a safe installation and satisfactory performance. To avoid problems with overheating of an installation using series heating cable sets, Subrule 1) requires that the heating portion of the cable set not be shortened. Also, when the series heating cable set does not have the original marking of length put on by the manufacturer of the cable set, the length is to be considered to be shortened unless it can be verified by testing that the cable set has not been shortened.

To make sure the heating takes place in the area required, Subrule 2) requires that the entire length of the heating portion of the cable set, as well as the connections to the non-heating leads, be installed in the area to be heated.

The installation instructions are summarized in Figure 62-5.

**Figure 62-5**
**Series heating cable set installation**




**Rule 62-126 Field repair, modification, or assembly of series heating cable sets**
Modern industrial establishments make extensive use of heat tracing to maintain production process temperatures at specified levels and to prevent the freezing of pipes carrying fluids such as water and oil in below-zero temperatures. During the lifetime of most plants, the heat tracing requires repair or modification due to plant modifications. Only qualified personnel are allowed to repair, modify, and field-assemble series heating cable sets.

If modifications or repairs of the tracing reduce the length of the series heating cables, the voltage drop over the remaining length of cable is increased on a per metre basis. For example, a series cable set with an application voltage of 120 V, rated at 1200 W, and a total heating element length of 60 m has a voltage drop along the length of the element of 2 V/m. If 6 m is cut from the cable set, the voltage drop over each metre is 2.222 V, and the total wattage increases to 1333 W from 1200 W. In such circumstances, the series heating cable set runs hotter than designed and has the potential to start a fire or ignite hazardous material in a hazardous location.

Rule 62-126 provides an exemption to Rule 62-124 to allow field repairs, modifications, and assembly of series heating cable sets at industrial establishments where the owner ensures that the work is done by qualified persons. When the work involves a field repair, Rule 62-126 a) requires that the repair or splice kits be supplied by the cable manufacturer and, to prevent overheating, that the total length of the heating cable not be reduced by more than 3% from the original total length. Rule 62-126 b) requires that field-modified or field-assembled series heating cable sets use design tools, splice and termination kits, and instructions, and fulfill the following conditions:

- a permanent tag with the new design information is installed;
- a permanent record of the new design information is maintained;
- the modified or repaired heating cable insulation resistance and cable resistance are tested and verified;
- the repair, modification, or assembly of the series heating cable is done by qualified persons and reviewed by the manufacturer; and
- the electrical ratings are permanently marked:
  - in or on the junction box that is provided as part of the system;
  - on the cable; or
  - on a permanent tag within 75 mm of the power connection or power connection fitting.

### Rule 62-128 Non-heating leads of heating device sets

Subrule 1) requires that the non-heating leads of heating device sets be installed:

- in compliance with the Rules in Section 62;
- in accordance with the manufacturer's requirements; and
- with all electrical conductive shields, braids, coverings, and all exposed metal surfaces bonded to ground.

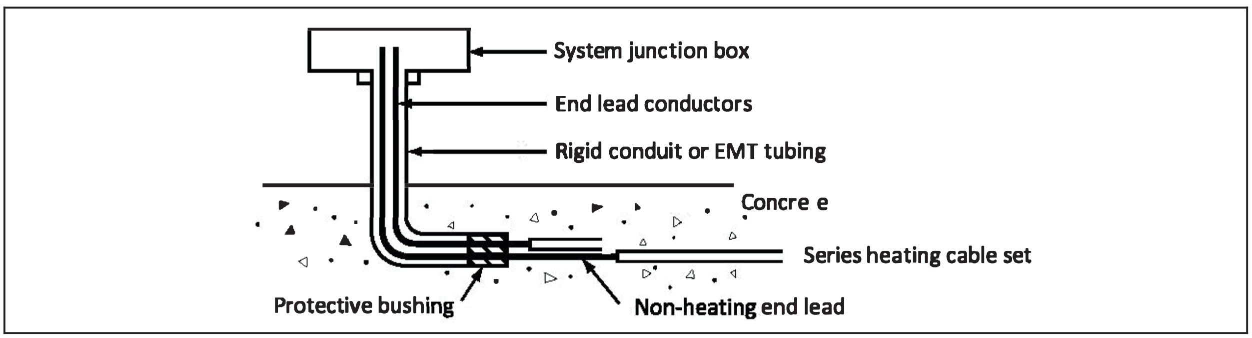
The non-heating leads of heating device sets that are not integral to or supplied with the heating device set are required by Subrule 2) to be installed in accordance with the requirements of Section 12 for the wiring method used.

To protect the non-heating leads from damage when the heating device set is embedded in concrete or a subfloor assembly, or is under a floor covering, Subrule 3) requires that the non-heating leads be run in a raceway from the junction box and terminate in the concrete or subfloor assembly, or under the floor covering. See Figure 62-6.

Where the non-heating leads are contained within a wood base plate and effectively protected from mechanical damage, Subrule 4) allows the raceway containing the non-heating leads to terminate no more than 50 mm from the floor instead of terminating in the floor.

Subrule 5) allows the connection between the heating portion and the non-heating leads of a heating device set to be installed in the supply junction box that is part of the system, provided that the heating portion of the heating device set is contained within a raceway between the point where it leaves the concrete, subfloor, or non-combustible material and enters the box.

**Figure 62-6**
**Typical series heating cable set embedded in concrete indoors**




### Rule 62-130 Heater controls installed in proximity to sinks, tubs, or shower stalls

To reduce the potential shock hazard where a manually operated temperature control is located in rooms or areas that contain a sink (wash basin complete with drainpipe), tub, or shower stall, Subrule 1) requires that the control be located at least 1 m from these items. This distance is to be measured horizontally between the control and the sink, tub, or shower stall without piercing a wall, partition, or similar obstacle.

The exemption in Subrule 2) allows the distance required in Subrule 1) to be reduced to a minimum of 500 mm, provided that the manually operated control is:

- protected by a ground fault circuit interrupter of the Class A type; or
- supplied by an extra-low-voltage Class 2 circuit.

### Rule 62-132 Heating devices installed in proximity to sinks, tubs, or shower stalls

To reduce the potential shock hazard where a heating device is installed less than 1.8 m above the floor, Subrule 1) requires that it not be installed less than 1 m horizontally from a sink (wash basin complete with drainpipe), tub, or shower stall. The distance is to be measured horizontally between the heating device and the sink, tub, or shower stall without piercing a wall, partition, or similar obstacle.

Subrule 2) allows an exemption from the 1 m minimum distance required by Subrule 1), provided that the heating device is protected by a ground fault circuit interrupter of the Class A type.

## Electric space-heating systems

### Rule 62-200 Electric space heating

Space heating is the application of electric heater technology that results in adding heat to an enclosed space or room. It is normally used to increase the comfort of persons or animals, but it can also be used in storage spaces or rooms where it is important to keep the stored material above a certain temperature. Some examples of space heating are:

- central heating units;
- baseboard heaters;
- radiant heaters;
- floor-warming heaters (while the primary purpose is usually for the comfort of persons walking on the floor, heat is added to the room); and
- wall and ceiling heaters.

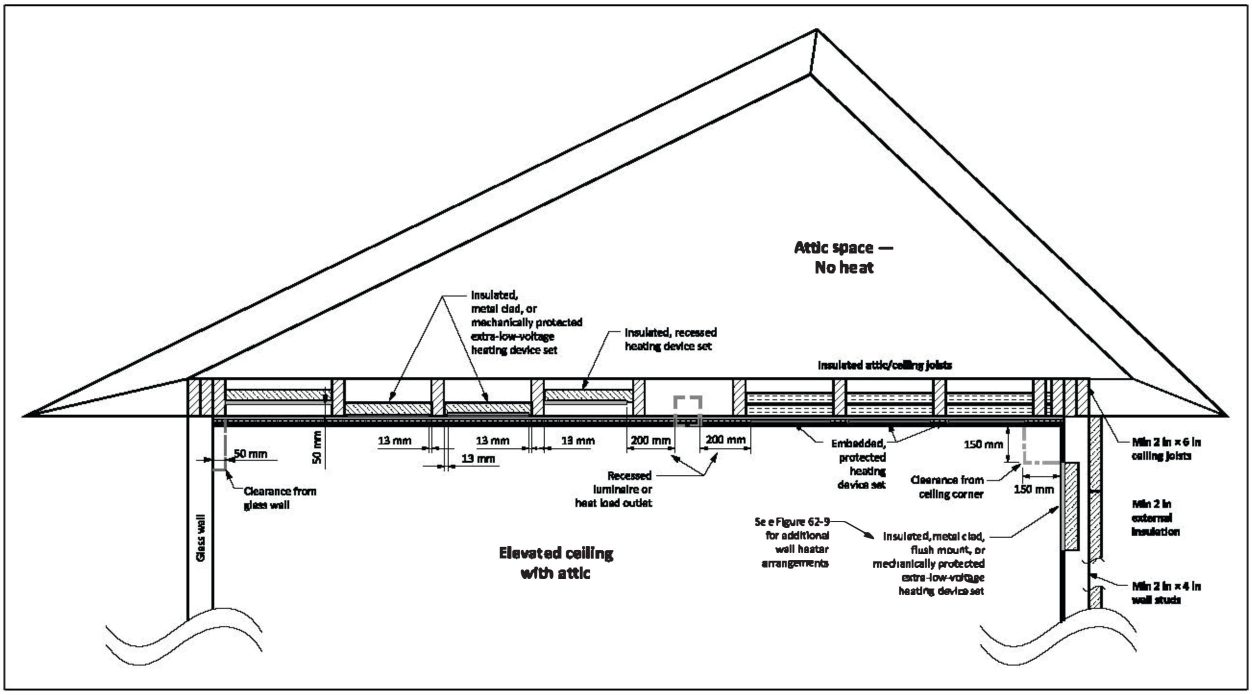
**Note:** *Many heater technologies add heat to a room by convection, conduction, or radiation.*

Rules 62-200 2) and 62-202 to 62-222 relate to fixed electric space-heating systems for heating rooms and similar areas.

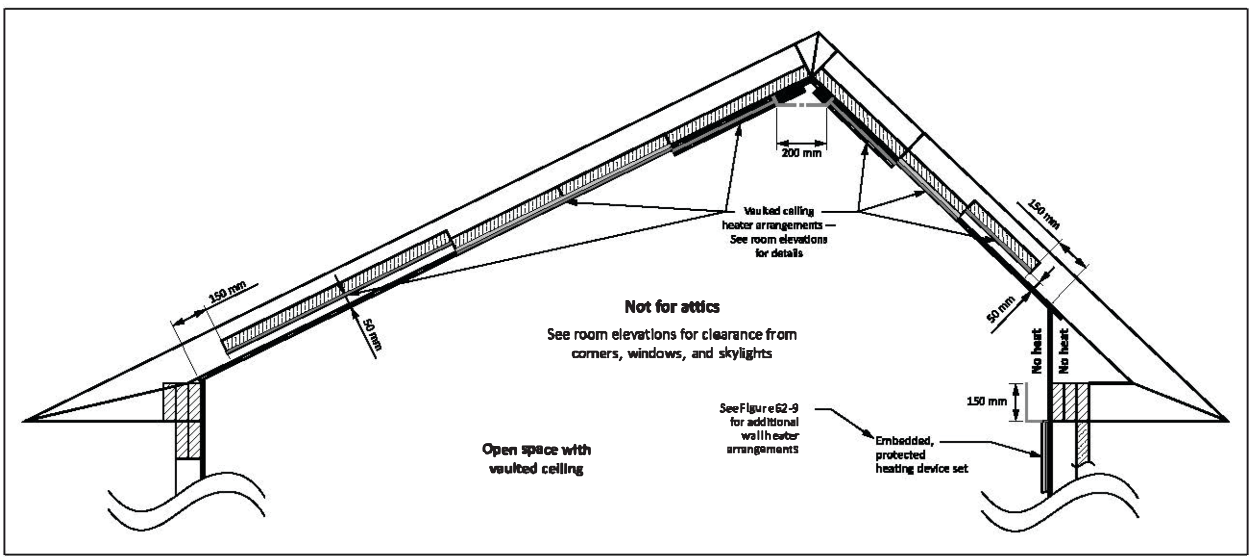
Table 67 specifies the minimum installation requirements and clearances of space-heating systems (heating devices and heating device sets) from physical obstructions and protrusions in and along heated floors, walls, and ceilings. The primary purpose of Table 67 is to identify the minimum safe and effective installation limits. Table 67 gathers all clearance distances from various Rules into one place for easier understanding of the requirements.

Figures 62-7 to 62-11 provide examples of minimum installation clearance distances for heaters to clarify the requirements that are specified in Table 67.

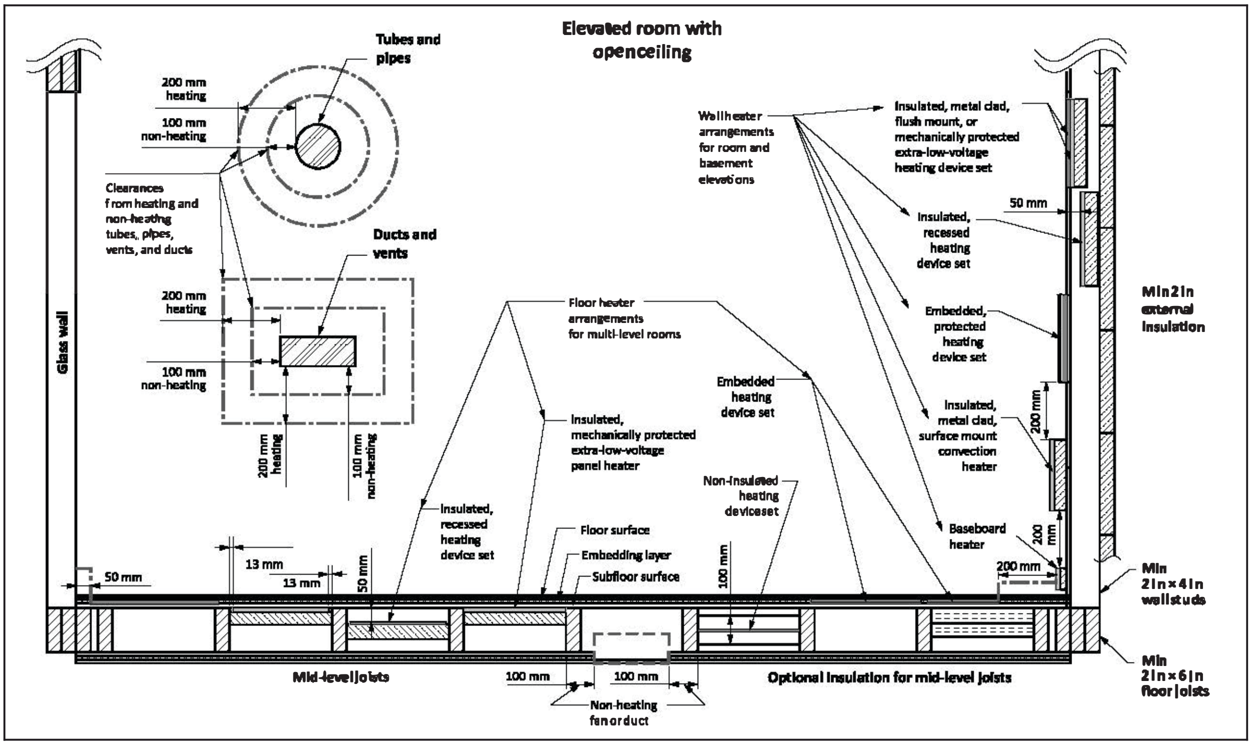
## Figure 62-7
## Table 67 clearances — Elevated ceiling heating arrangement



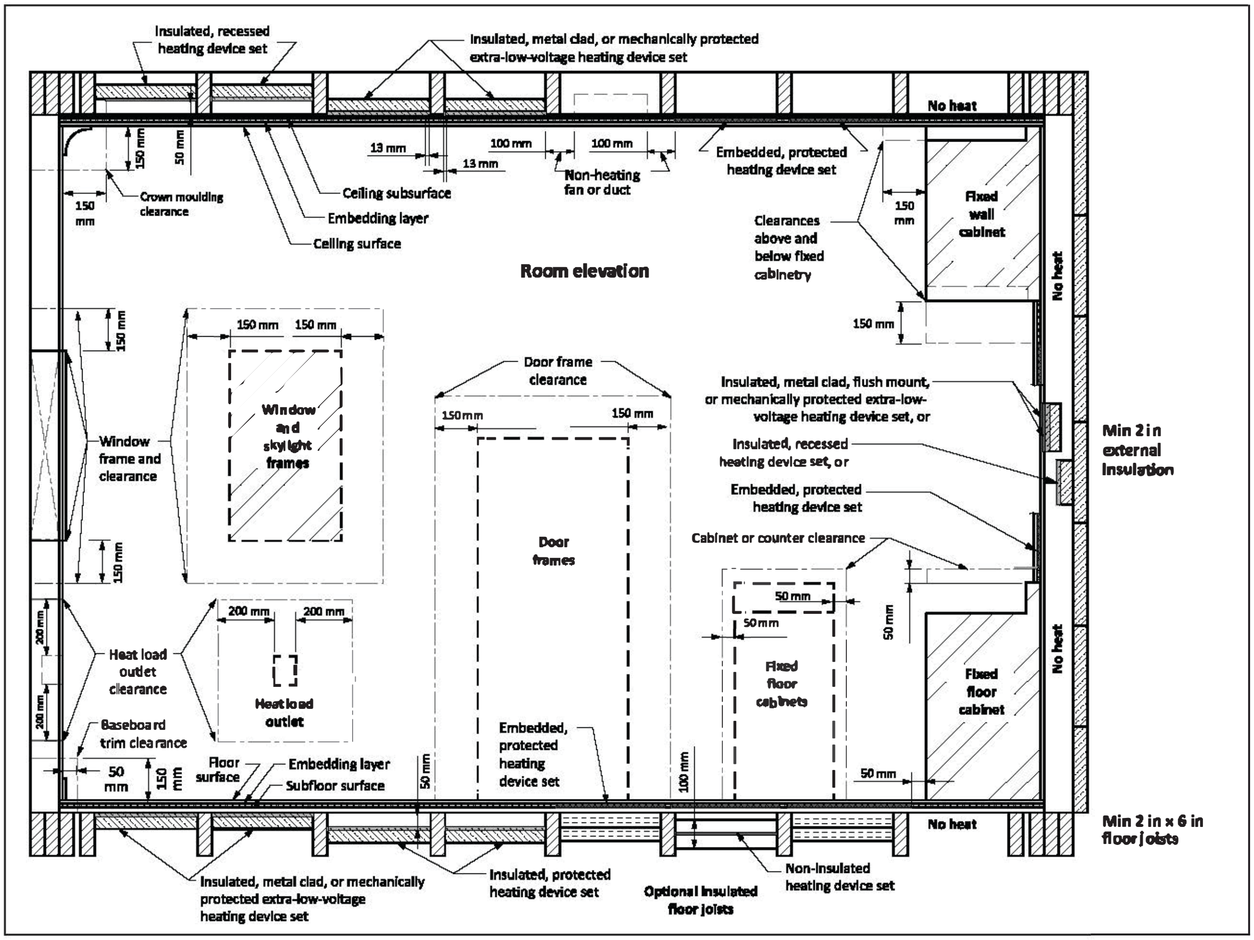

## Figure 62-8
## Table 67 clearances — Vaulted ceiling heating arrangement



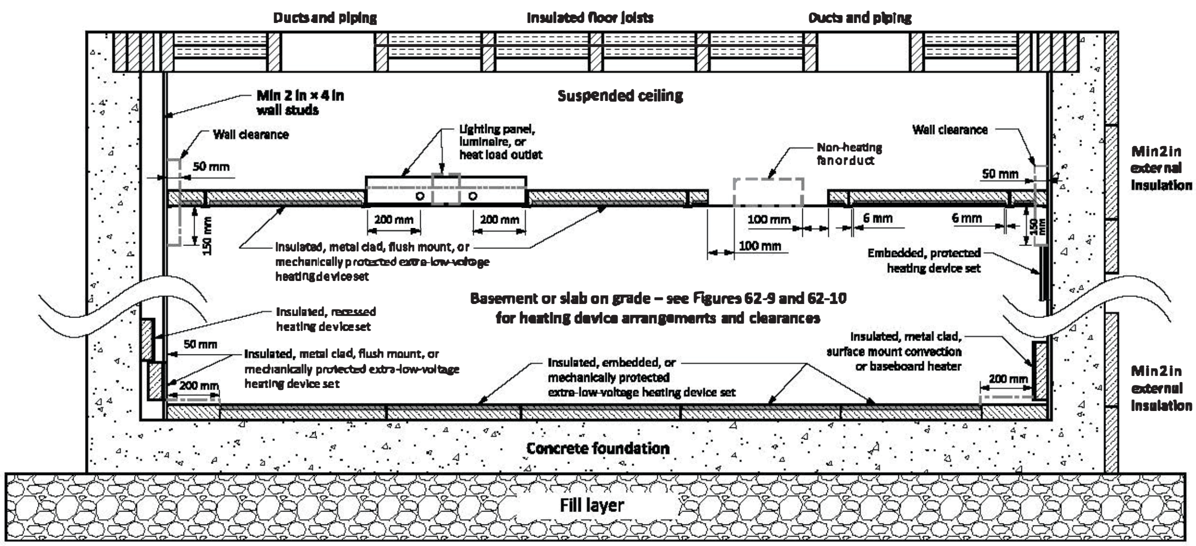
## Figure 62-9
## Table 67 clearances — Elevated floor and wall heating arrangements



## Figure 62-10
## Table 67 clearances — Main elevation — Floor, wall, and ceiling heating arrangements



## Figure 62-11
## Table 67 clearances — Basement and suspended ceiling heating arrangements




### Rule 62-202 Temperature control

Rule 62-202 requires that a temperature control device (thermostat) be installed in each enclosed area that has a heating device to allow occupants to control the temperature of the atmosphere.

### Rule 62-204 Proximity to other wiring

Heat produced by heating devices on or in a ceiling raises the temperature surrounding any branch circuit wiring located above the ceiling. Subrule 1) requires that such wiring be spaced at least 50 mm above the ceiling and be considered to be operating at an ambient temperature of 50 °C, unless at least 50 mm of thermal insulation is installed between the source of heat and the wiring, or the heating device is marked for a clearance less than 50 mm. If no insulation is placed between the wiring system and the ceiling, or a heating device with a smaller clearance is used, the correction factors listed in Table SA are to be applied to reduce the heating in the wiring by reducing its ampacity.

Subrule 2) requires that branch circuit wiring embedded in heated concrete slabs also be spaced at least 50 mm from the heating cables and be considered to be operating at an ambient temperature of 40 °C, which leads to the application of correction factors from Table SA.

### Rule 62-206 Installation of central units

Subrule 1) requires that when central units are installed, access to components for testing, maintenance, and repair is to be provided.

To allow for the safe operation of the central unit, Subrule 2) requires that it be installed:

- in an area that is large in comparison to the actual size of the unit, unless the unit is designed for installation in an alcove or closet; and
- to meet the clearances from combustible materials, as given on the nameplate by the manufacturer.

It is now common to see a central unit with several branch circuits supplying power and/or control circuits. These units include multiple circuits for heating, air conditioning, and controls. To provide protection from shock and mechanical hazards for personnel installing, servicing, repairing, or attempting to de-energize central units, Subrule 3) requires that a single disconnecting means be provided that will simultaneously open all ungrounded conductors supplying the controller and the central unit, thereby ensuring that all power has been disconnected.

Where the supply to the central unit and controller requires more than one circuit, Subrule 4) requires that the disconnecting means required by Subrule 3) be grouped together and signage installed on the central unit and controller to indicate that multiple circuits are to be isolated before work can be done on the central unit and controller.

For the safety of individuals operating, servicing, and maintaining the central unit, Subrule 5) requires that the required disconnecting means be located within sight of and within 9 m of:

- the central unit and the controller; or
- the alcove or closet when such a space is used for the installation of the central unit and the controller.

### Rule 62-208 Location of heating cable sets and heating panel sets

Rule 62-208 requires that heating cable sets and heating panel sets be protected from damage during and after installation. Subrule 1) requires that the location of heating cable sets and heating panel sets not be run through or penetrate into any portions of walls, partitions, floors, or similar structures.

To prevent heating cable sets and heating panel sets from overheating due to a lack of heat dissipation, Subrule 2) allows one side of the set to be in contact with thermal insulation but prevents the sets from running in or through the insulation.

### Rule 62-210 Installation of heating fixtures

To ensure that the electrical installation enables the heating fixture to function at the highest efficiency and that it protects the surrounding structure, Subrule 1) requires that the heat transfer from the fixtures not be obstructed by any part of the building structure.

Subrule 2) requires that when a heating fixture is recessed in non-combustible material in a building of non-combustible construction, the non-combustible material is not to be subjected to temperatures exceeding 150 °C. Also, the heating fixture is to be marked for this application.

To allow for servicing and inspection of heating fixtures weighing more than 4.54 kg, Subrule 3) requires that the installation of the heating fixture be such that the outlet box where the connections to the building's electrical system are located or its equivalent be accessible for servicing and inspection without having to remove any heating fixture supports.

Subrule 4) allows a wall-mounted heating fixture that weighs 13 kg or less to be supported directly by a wall outlet box attached directly to the building structure or by a wall outlet box attached to a bar hanger.

**Note:** *This support should not be limited to wall coverings, sheeting, or cladding but should go through the wall covering, sheeting, or cladding into the structural members.*

Subrule 5) allows a ceiling-mounted heating fixture weighing 23 kg or less to be supported by a ceiling outlet box attached directly to the building structure. A bar hanger is also allowed to be used to attach a ceiling outlet box to the building structure when the heating fixture weighs 23 kg or less.

Subrule 6) requires that a wall-mounted heating fixture that weighs more than 13 kg or a ceiling-mounted heating fixture weighing more than 23 kg are to be supported:

- independently of the outlet box; or
- by a fixture hanger provided with an integral outlet box suitable for the purpose.

To prevent damage to heating fixtures when they are installed less than 5.5 m above the floor in an arena, gymnasium, or similar location where they may be exposed to damage from flying objects (for example, basketballs), Subrule 7) requires that heating fixtures installed in these locations be suitable for the application or be protected from mechanical damage and not obstruct the flow of heat from the fixture.

Unless the manufacturer has provided a wiring channel as a safe, integral part of the heating fixture, the use of a heating device as a raceway for branch circuit conductors might expose the circuit conductors to the heating element, causing damage to the conductor's insulation. Subrule 8) requires that the heating fixture not be used as a raceway unless the fixture is marked for this use.

Subrule 9) allows the wiring channel of a baseboard heating fixture to contain only the conductors that supply adjacent fixtures on the same branch circuit, provided that the fixtures are marked for the purpose.

### Rule 62-212 Installation of heating cable sets and heating panel sets

Rule 62-212 is intended to ensure that heating cable sets and heating panel sets are installed correctly in ceilings, walls, and above or below subfloors.

Subrule 1) allows field-made connections, such as connections to old leads or non-heating portions necessary to assemble an individual heating panel set, to be inaccessible, provided that they are accessible before the surface finishing materials are applied and the connectors and enclosures are part of the heating panel sets.

Careful installation is required to prevent arcing or damage to the heating cable sets and heating panel sets, which might cause the heating system to fail, resulting in costly repairs, or create a fire or shock hazard. Subrule 2) requires that cutting, nailing, or stapling of the heating panels and heating panel sets is to be done only through the area(s) provided for this purpose.

Subrule 3) requires that the branch circuits supplying heating cable sets and heating panel sets be marked by a warning label supplied by the manufacturer and affixed to the panelboard by the installer. The warning label is to state that the applicable surface and location supplied by the branch circuit contains energized wiring and is not to be penetrated by nails, screws, or similar devices, as this could cause the heating system to fail, resulting in costly repairs, or create a fire or shock hazard.

### Rule 62-214 Installation of heating cable sets in plaster or other cementitious material

Subrule 1) requires that heating cable sets in plaster or other cementitious material be secured in place by fastening devices that are suitable for the temperatures to which they are exposed. The fastening devices are also to be designed so that their application does not damage the heating cable.

Subrule 2) requires that the entire heating portion of the cable, including the connections to the non-heating leads, be embedded in the plaster or cementitious non-combustible material. If any of the heated portion is exposed to air, it can overheat and fail since the conductivity of heat through air is higher than that through plaster or cementitious material.

### Rule 62-216 Heating cable sets and heating panel sets in gypsum board and other cementitious ceiling and wall installations

Where heating cable sets are installed between two layers of gypsum board (drywall), to prevent damage to the cable or panel sets, Subrule 1) requires that they:

- be run parallel to the joist, studs, or nailing strips; and
- have a clearance of 13 mm on each side of the joist, stud, header, or nailing strip.

Subrule 2) requires that, after the heating cable sets or heating panel sets are installed, the entire area below the cable or panel set be covered by gypsum board (drywall) or cementitious material not exceeding 13 mm in thickness.

### Rule 62-218 Installation of heating cable sets and heating panel sets under floor coverings

Specific types of heating cable sets and heating panel sets have been designed and approved for use between a floor and the floor covering.

To prevent fire, shock, or damage to the floor covering or heating cable or heating panel sets, Subrule 1) requires that heating cable sets and heating panel sets under floor coverings be:

- installed on a smooth and flat floor; and

- completely covered by the floor covering material for which they are intended.

Subrule 2) allows the use of flat conductor cable (FCC) in residential applications for connecting the non-heating leads of heating cable sets and heating panel sets to the branch circuit conductors.

**Rule 62-220 Infrared radiant heaters of the metal-sheath glowing element type**
Mineral-insulated tubular heating elements have been manufactured for nearly 100 years and have been proven to provide many years of safe, trouble-free operation. The normal life expectancy of a heating element depends mainly on the operating temperature of the resistance coil, which is a function of the sheath operating temperature and the watt density of the heating element surface.

Occasionally, element failure occurs by means of a direct short-circuit to ground or to an ungrounded metal part at a different potential. This failure occurs due to a breakdown of the element's dielectric insulating material, MgO (magnesium oxide). The first failure mode is a low-energy, direct short-circuit to ground, in which the resistance wire melts, creating a direct connection between the resistance wire and ground. Often this type of failure causes an increase in current that is detected by a circuit protection device (fuse or circuit breaker), and the circuit is de-energized. Another type of failure, an arc fault failure, is more catastrophic since the circuit protection device:
- does not operate fast enough or does not detect the failure; and
- allows the energy to reach a point where an arc is developed and sheath rupture occurs.

This type of catastrophic failure can occur in both grounded sheath and ungrounded sheath designs; however, in ungrounded sheath applications, two separate faults would have to occur to cause this type of failure. Instances of such failures have occurred in both grounded and ungrounded sheath designs, and although it is somewhat less likely, an ungrounded sheath design can still fail by dielectric breakdown, causing an arc fault failure.

Leakage currents in insulated electrical components will always exist; however, they are often very low and do not create the conditions for an arc fault failure. It is only when the leakage current of the heating element overcomes the dielectric strength of the insulating material that unsafe conditions that could lead to an arc fault failure can develop.

Environmental and operational factors are unpredictable and can result in one or more of the following conditions:
- overvoltage or voltage spikes;
- overtemperature of resistance coil due to high operating temperatures;
- degradation of the dielectric material;
- degradation of resistance coil due to extended life;
- moisture in dielectric material;
- transformation of MgO to $Mg(OH)_2$ (magnesium hydroxide) due to moisture contamination;
- mechanical damage; or
- increased element temperature due to reduced airflow (less than design airflow) caused by faulty fan performance (in forced air heaters).

One proven method of continually monitoring and controlling leakage current is through the use of a ground fault protection device that monitors leakage current and de-energizes the heater when unsafe conditions occur. Rule 62-116 requires the use of ground fault protection with a ground fault setting that is sufficient to allow normal operation of the heater but that will de-energize all ungrounded conductors to the heater when leakage current reaches unsafe values.

Where multiple heaters are connected on the same branch circuit, Rule 62-220 allows a single means of ground fault protection to be used to protect the circuit.

### Rule 62-222 Heaters for sauna rooms

Rule 62-222 requires that a sauna heating unit be:

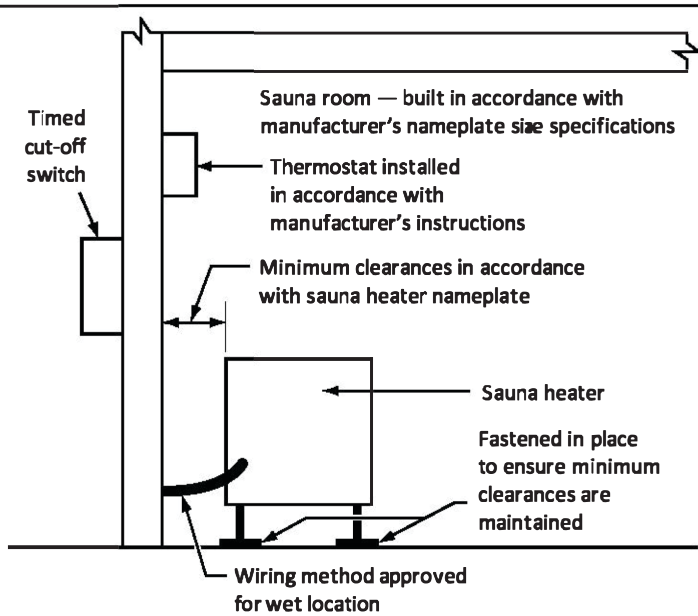
- permanently fastened in place;
- marked and suitable for the purpose; and
- installed in a sauna room that is built in accordance with the manufacturer's specifications.

Additionally, a sauna heating unit is not to be installed below shower heads or water spray devices.

Essential installation information is also provided in the Appendix B Note to Rule 62-222. See Figure 62-12 for the installation requirements.

For the safety of the occupants using the sauna, Subrule 4) requires that a timed cut-off switch having a maximum one-hour setting, with no override feature, be mounted on the outside wall of the sauna room to disconnect all ungrounded conductors supplying the sauna heater (see Figure 62-12).

**Figure 62-12**
**Typical sauna heater installation**




**Note:** *The sauna heater must not be installed below shower heads or water spray devices.*

## Electric surface heating systems

### Rule 62-300 Electric surface heating

Electric heating cables for surface heating are placed in direct contact with the surfaces to be heated and can be exposed to dry, wet, damp, chemical, and corrosive environments. The type of surface to be heated (metal, non-metallic material, concrete, asphalt, soil, etc.) is to be considered when installing heating cables with respect to the expansion and contraction characteristics of the surface material, and its potential to crack.

### Rule 62-302 Installation of fixtures

If electric heating fixtures are exposed to rainfall, they can deteriorate and become shock or fire hazards. To extend the life of electric heating fixtures, Rule 62-302 requires them to be provided with a weatherproof enclosure.

### Rule 62-304 Heating cables and heating panels installed below the heated surface

When heating cables or heating panels are installed outdoors below a surface to be heated, the surface is usually concrete or asphalt. The installation is to be designed and installed so that the heating cables or heating panels are:

- surrounded by non-combustible material throughout their length, including the point of connection to the non-heating leads; and
- embedded or covered to a depth of 50 mm minimum below the finished surface to prevent cracking or spalling of the surface caused by the expansion and contraction of the heating cable during the heating cycle.

See Figure 62-13.

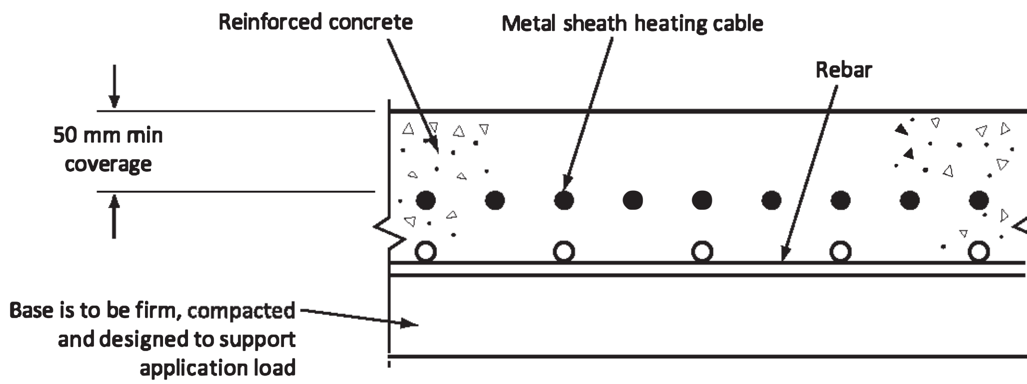
When installing heating cables or heating panels outdoors below a surface to be heated, the Appendix B Note to Rule 62-304 recommends the following:

- mechanical protection, such as metallic or non-metallic conduit, is provided to enclose the non-heating leads of the heating cable or panels where they exit the medium;
- adjacent heating cable runs have a minimum spacing of not less than 25 mm;
- to provide for even heat distribution on the heated surface, adjacent runs of heating cable are spaced between 25 mm and 200 mm apart;
- to prevent their damage, the heating cables or panels are to be secured in place by frames, spreaders, or other means, while being covered or embedded with the non-combustible material (concrete or asphalt);
- the heating cables or panels are installed on a base that is firm, compact, and able to support the maximum load without crumbling, settling, or extensive movement that will cause cracking or breaking of the heating cables or panels; and
- the installation of heating cables or panels does not cross expansion joints unless provision is made for expansion and contraction.

It is recommended that when heating cables are embedded in asphalt, they be rated at not more than 82 W/m to prevent them from softening or warping the asphalt surface. Also, to prevent spreading at the edges where no curbs are provided, the cables should be installed 300 mm or more from the edge of the asphalt.

In indoor applications, non-metallic heating cables and heating panels installed below the surface to be heated can energize uninsulated metal bodies, presenting a shock hazard. Subrule 2) requires that non-metallic heating cables or heating panels installed indoors be kept at least 25 mm from any uninsulated metal bodies located below the surface to be heated.

**Figure 62-13**
**Surface heating**




### Rule 62-306 Heating cable sets installed on or wrapped around surfaces

To protect the heating cable during and after installation, Subrules 1) and 2) require that heating cable sets be secured to surfaces by suitable fasteners. This will help to prevent damage to the heating cable and allow slack in the cable in areas that might undergo some movement (for example, valves and expansion joints).

### Rule 62-308 Heating cable sets or heating panel sets installed on non-metallic pipes, ducts, or vessels

Installing heating cables on non-metallic pipes, ducts, or vessels without considering possible overheating of the pipes, ducts, or vessels can cause them to deteriorate and leak. Rule 62-308 requires the provision of a heat sensor (thermostat) in the branch circuit that is set below the temperature at which the material being heated would be damaged (that is, softened).

### Rule 62-310 Heating panel sets installed on tanks, vessels, or pipes

Facilities often use heating panel sets on tanks, vessels, or pipes to protect equipment and to facilitate certain processes. These heating panel sets can be subjected to more severe environmental conditions and more potential for damage than heating units in other types of installations. Rule 62-310 requires that heating panel sets be secured by suitable fasteners. Surface heating units vary in purpose and design to such an extent that it is difficult to provide specific installation requirements. Systems are to be installed and maintained by qualified personnel, and the personnel working near them are to be familiar with their operation and hazards.

### Rule 62-312 Caution labels

Electric heat tracing for surface heating is often not visible due to the presence of thermal insulation. It is a necessary safety practice to alert personnel who may need to service the equipment, piping, vessels, valves, and other equipment where there is electric heat tracing hidden under the thermal insulation or other outer covering.

Subrule 1) requires that permanent labels be posted on the outer surface (outside any covering, insulation, etc.) to indicate pipes, vessels, or ducts that are heated from an electrical source, in order to caution personnel working on or servicing the equipment about the potential shock hazard and to avoid damaging the heating system.

Subrule 2) provides specific directions as to where the permanent caution labels used to indicate electric heating installations are to be located. The labels are to be placed on the outermost surface so that they are visible before an individual commences work on the pipes, vessels, or ducts. Since pipes or ducts can be very long, it is required that the labels be visible after installation and not more than 6 m apart.

For tanks and vessels, a minimum of two labels visible after installation are required to be installed. For tanks or vessels with a large circumference, the labels are required to be no more than 6 m apart, which may increase the number of labels required.

Subrule 3) requires that additional caution labels be placed on associated equipment that may require servicing, such as valves and sensors, in a visible location on or near the equipment.

### Rule 62-314 Skin effect trace heating

In skin effect trace heating, heat is generated in the ferromagnetic envelope (or heat tube) wall by the $I^2R$ loss of the return current flow in the envelope, and by hysteresis and eddy currents induced by the alternating magnetic field around the insulated conductor. Additional heat is produced by the $I^2R$ loss in the insulated conductor.

The inductive interaction between the current in the insulated skin effect conductor and the return current in the envelope causes the current in the envelope to concentrate at its inner surface (skin).

IEEE 844.2/CSA C293.2 provides design, construction, and performance requirements for skin effect trace heating systems. Maximum current limitations for insulated skin effect conductors are based on the calculated value of the operating temperature of the insulated skin effect conductor established by the manufacturer and usually verified by a third-party certification body. Subrule 2) requires that IEEE 844.2/CSA C293.2 be used for the installation of a skin effect trace heating system.

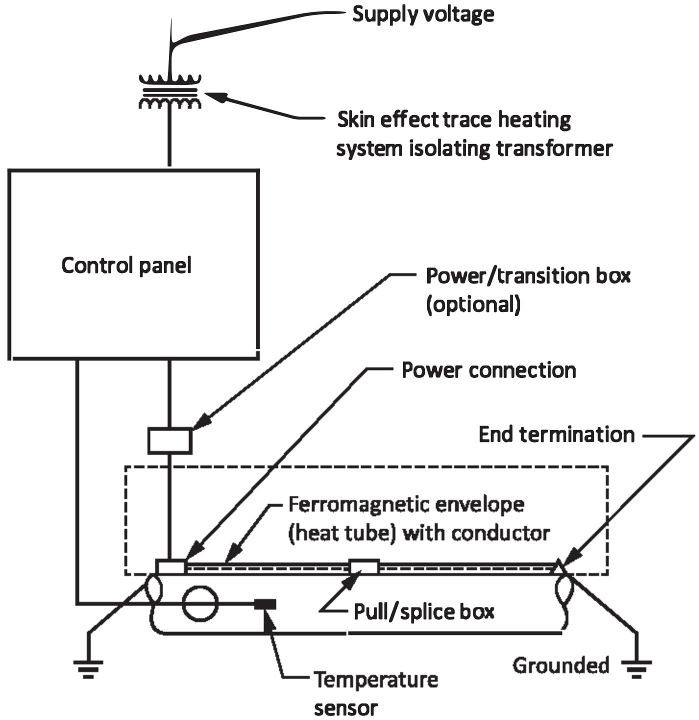
All components are to be properly protected from corrosion with coatings or materials suitable for the location.

Skin effect trace heating systems include overcurrent devices upstream and downstream of the supply transformer. In addition, trace heating system current monitoring is recommended. See Figure 62-14.

Subrule 1) sets out the following requirements and allowances for the installation of skin effect trace heating:

- The ferromagnetic envelopes, ferrous or nonferrous metal raceways, boxes, fittings, supports, and support hardware are allowed to be installed in concrete or in direct contact with the earth.
- The ferromagnetic envelope is to be grounded at the power connection and at the end termination enclosure(s).
- The skin effect trace heating system is to be supplied from an isolating transformer.
- The grounding of ac systems outlined in Rule 10-206 does not apply to the installation of skin effect trace heating systems.
- The secondary system of the required isolating transformer is not to be grounded.
- Parts of a skin effect trace heating system, such as the power connection, splice, or terminations for specific applications, are allowed to be buried, embedded, or otherwise inaccessible except for the junction box containing the connection to the distribution wiring, which is to be accessible.
- Where single-conductor cables or conductors enter metal boxes through separate openings, the requirements of Rule 12-3022 7) do not apply to the installation of a single conductor in a ferromagnetic envelope (metal enclosure).

## Figure 62-14
## Typical skin effect trace heating system




**Notes:**
1) *The overall system consists of an isolating transformer, control panel, temperature sensor, and field-assembled skin effect trace heating system.*
2) *The field-assembled skin effect trace heating system is approved separately from the other components.*
3) *Optionally, the ferromagnetic envelope (heat tube) may be grounded at intermediate points along its length as required by the design.*
4) *The optional power/transition box is for applications where the power connection box is not accessible.*

### Rule 62-316 Impedance heating

Impedance heating is a method used to heat pipes, vessels, or structures and the substances they encase by using their impedance as a heating element. Rule 62-316 sets out the electrical installation requirements for these impedance heating systems. In practice, it is advisable to prepare a drawing of the complete installation and check each requirement against it. Pipe, vessel, or structure impedance heating is not to be installed without the assistance or direction of people familiar with such systems, and people performing maintenance on these systems are to be familiar with their operation.

## Other heating systems

### Rule 62-400 Heating cable sets and heating panel sets installed within pipes, ducts, or vessels

Heating cables sets and heating panel sets installed inside pipes, ducts, or vessels are typically in direct contact with liquids, so it is imperative to select the correct cable for the application [see Subrule 1)].

To prevent the substance (usually a liquid or gas) from leaking out of the pipe, duct, or vessel where the cable enters to feed the heating equipment, Subrule 2) requires that the cable pass through a suitable gland.

Where a metal raceway is used to protect the non-heating leads of the heating cable set where it enters the pipe, duct, or vessel, Subrule 3) requires that the raceway be installed so that if the gland fails, the raceway will not become flooded, which could lead to shorting or damage of the electrical system.

When a heating cable set or heating panel set is installed within a non-metallic pipe, duct, or vessel, Subrule 4) requires that a thermostat or other suitable temperature-limiting system be used to prevent overheating and the damage it can cause.

## Rule 62-402 Overcurrent protection of storage-tank water heaters and conductors

Overcurrent protection of storage-tank water heaters and their associated service, feeder, or branch conductors is to comply with Rule 62-114. See Table 62-1 for the method of calculating the minimum size of overcurrent device and the minimum size of conductor for storage-tank water heaters.

## Rule 62-404 Infrared drying luminaries

Rule 62-404 provides basic requirements for electrical installations involving infrared drying luminaires. When there is a need for a drying process using infrared luminaires, electrical equipment specifically designed for the purpose is to be used. There are situations, however, where it is preferable to field-construct the equipment. Rule 62-404 lists a few basic requirements relating primarily to the types of luminaires that are allowed to be used.

To prevent damage to the luminaire caused by the heat produced in an infrared drying lamp, Item a) requires that for 300 W or less, medium-base luminaires be used with infrared drying lamps.

To avoid problems with the screwshell lampholder in the luminaire, such as premature failure or overheating due to the heat from the lamp, Item b) restricts infrared drying lamps to a maximum of 300 W when used in screwshell luminaires unless the luminaire is intended for higher wattages.

In industrial establishments, Item c) allows luminaires with infrared lamps to be operated in series on circuits with a voltage rating higher than 150 V, provided that adequate spacing is provided for the voltage used. For adequate spacing, consult the luminaire or lamp manufacturer.

## Rule 62-406 Induction and dielectric heating

Induction heating usually involves the treatment of metal, which is accomplished by exposing the metal to an alternating magnetic flux. The frequency utilized generally depends on the size and type of furnace used and can range from 60 cycles to many hundreds of kilocycles.

Dielectric heating is frequently used for elevating to moderate temperatures certain materials that have low thermal conductivity (for example, rubber for vulcanizing, wood for drying and setting glue in plywood manufacturing, textiles for drying, and plastics for softening). This process involves placing the material between metal plates or electrodes and applying the appropriate voltage and frequency (very high). The current flowing through the material between the plates causes it to heat up, facilitating the process of drying, hardening, or softening the material.

Subrule 1) requires that circuits supplying non-motor generator equipment be protected by an overcurrent device having a maximum rating or setting of not more than 200% of the ampacity of the circuit conductors.

Subrule 2) requires that induction and dielectric equipment be provided with a readily accessible disconnecting means that:

- can disconnect each heating device from its supply circuit;
- is rated not less than the nameplate rating of the heating device; and
- is located within sight and within 9 m of the heating device unless the disconnecting means can be locked in the open position.

Subrule 3) requires that each generator or group of generators at a single location have a readily accessible disconnecting means with a rating in accordance with Section 28.

Subrule 4) allows the supply circuit disconnecting means to be used as the disconnecting means if the circuit supplies only one motor-generator, vacuum tube, or solid state converter.

Remember, Rule 62-406 does not apply to the induction heaters for surface heating of pipes and vessels; that application is covered in Rule 62-314.

## Rule 62-408 Bare element water heater

Bare element water heaters have bare heating elements submersed in the water of a tank. The water in the tank is heated by the direct contact with the bare uninsulated heating element. If properly installed and grounded, these heaters present no safety hazard. To that end, Subrule 1) requires that bare element water heaters be:

- supplied from a grounded system;
- permanently connected to a separate branch circuit of a grounded system; and
- protected by a Class A GFCI.

The bare element is also to be installed a minimum of 1.5 m from the heated water outlet, in accordance with Subrule 2). These heaters are to be grounded in accordance with the requirements in Section 10 to eliminate the presence of any electrical charge on the water as it drains from the tank.

# Section 64 — Renewable energy systems

The intent of Section 64 is to keep pace with technological change by providing requirements for the safe installation of renewable energy systems. These Rules supplement or amend the general Sections of the Code.

Section 64 does not cover installations where renewable energy systems operate as Class 2 circuits [with voltage and current limited in accordance with Rule 16-200 1) a) and b)].

Section 64 covers general installation requirements for renewable energy systems and provides specific requirements for individual types of renewable energy systems, based on their application and operational characteristics. These requirements are presented in the following subsections:

- Rules 64-000 and 64-002 define the Scope of Section 64 and the terminology used in it. These Rules identify the types of renewable energy systems covered in the Section and the terms that are specific to them.
- Rules 64-050 to 64-078 are general Rules common to all types of renewable energy systems. This Subsection provides the minimum installation requirements applicable to all types of renewable energy systems covered in Section 64. These Rules are intended to ensure that renewable energy installations do not create fire or shock hazards. This Subsection also contains Rules for markings, warning notices, and interconnections.
- Rules 64-100 to 64-112 provide Rules applicable to inverters. Inverters convert/invert direct current (dc) into alternating current (ac) either at a fixed voltage and frequency in a stand-alone system or following an imposed waveform in an interactive system. The following types of inverters are covered in Section 64:
  - combination inverter/power conditioning units (PCUs);
  - power conditioning units (PCUs); and
  - interactive inverters.
- Rules 64-200 to 64-222 apply to solar photovoltaic (PV) systems. These are the total components and subsystems that in combination convert solar energy into electrical energy suitable for connection to a utilization load.
- Rules 64-300 to 64-320 apply to small wind systems. These are systems consisting of one or more wind turbines with a rated output of 100 kW or less.
- Rules 64-400 to 64-414 apply to large wind systems. These are systems consisting of one or more wind turbines with rated power output exceeding 100 kW.
- Rules 64-500 to 64-512 apply to micro-hydropower systems. A micro-hydropower system has a rated output of 100 kW or less and consists of one or more hydraulic turbines that convert energy derived from flowing and falling water. A micro-hydropower system can be either an interconnected system or a stand-alone system.
- Rules 64-600 to 64-612 apply to hydrokinetic power systems. A hydrokinetic power system consists of one or more hydrokinetic turbines that convert the kinetic energy of flowing water into electrical energy. A hydrokinetic power system can be either an interconnected system or a stand-alone system.
- Rules 64-700 to 64-716 apply to stationary fuel cell systems. These are permanently installed fuel cell power systems that generate dc electrical current by the electrochemical combination of a continuously supplied fuel and oxidant.
- Rules 64-800 to 64-814 apply to storage batteries used in renewable energy systems.

See Table 64-1 for a summary of the requirements applicable to different types of renewable energy systems.

# General

### Rule 64-050 General
Rule 64-050 allows a renewable energy system to supply power to a building or other structure as well as to buildings or structures supplied by service(s) from another supply system(s), or other renewable energy systems.

### Rule 64-052 Insulated conductors of different systems
Rule 64-052 requires that where insulated conductors of renewable energy systems are installed in the same raceways and enclosures as insulated conductors from different systems, the requirements for separation given in Rules 12-904 2) and 12-3030 are to be followed.

The Appendix B Note to Rule 64-052 adds that where one generation source has multiple inverters and associated components connected to it, the associated insulated conductors are considered as one system (source) and may be contained in the same raceway.

### Rule 64-054 Common return conductor
Rule 64-054 requires that, where a renewable energy power source has multiple supply circuit voltages and employs a common return conductor, the ampacity of the common return conductor is to be not less than the sum of the ampere ratings of the overcurrent devices protecting the individual supply circuits.

### Rule 64-056 Bipolar systems
A monopole solar PV system is an array or portion of an array that has two source circuit insulated conductors, one positive (+) and one negative (–). A bipolar PV system is a solar PV system that has two monopole photovoltaic source/output circuits, each having opposite polarity to a common reference point or centre tap. Rule 64-056 intends that the voltage in a 4-wire bipolar (two monopole voltages) PV system does not exceed the voltage rating of the insulated conductors and connected equipment. Subrule 1) requires that if the sum of the two monopole voltages exceeds the voltage rating of the connected electrical equipment used outside the inverter to prevent fault due to overvoltage, the insulated conductors associated with each monopole are to be run in separate raceways back to the inverter. The inverter is to have a minimum voltage rating equal to or greater than the sum of the two monopoles.

To prevent overvoltage problems with the disconnecting means and overcurrent devices used in the monopole circuit of the bipolar source/output circuit, Subrule 2) requires that the disconnecting means and the overcurrent devices for each monopole source/output circuit are to be in separate enclosures.

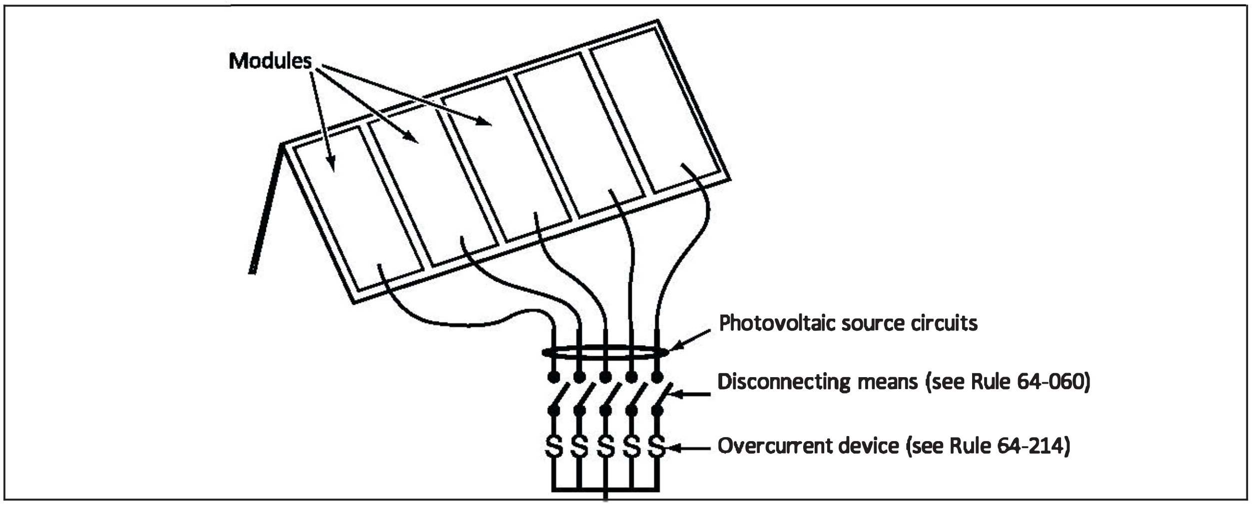
Subrule 3) allows an exemption from each monopole circuit having its own disconnect and overcurrent device enclosure when:
- the equipment is rated for the maximum voltage between the monopole circuits; and
- the enclosure contains a physical barrier separating the disconnecting means for each monopole circuit.

To prevent miswiring and overvoltages, Subrule 4) requires that all the insulated conductors from each separate monopole circuit are to be routed in the same raceway.

To prevent overvoltages if the grounded conductor(s) are inadvertently opened, Subrule 5) requires that a bipolar system be clearly marked with a permanent, legible warning notice indicating that the disconnection of the grounded conductor(s) may result in overvoltage on the equipment.

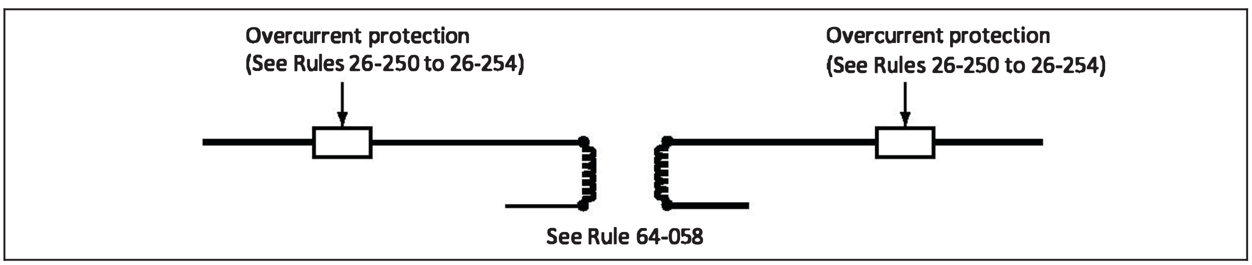
### Rule 64-058 Overcurrent protection
Where circuit conductors are connected to more than one source, as shown in Figure 64-1, Subrule 1) requires that overcurrent devices be located in such a way that they provide overcurrent protection from all sources.

**Figure 64-1**
**Overcurrent protection for individual source conductors**




Subrule 2) requires that, where a transformer is fed from both sides, as shown in Figure 64-2, overcurrent protection be provided on both sides of the transformer. The overcurrent device size is to be calculated in accordance with Rule 26-250, 26-252, or 26-254, by taking each side of the transformer, in turn, as the primary.

**Figure 64-2**
**Overcurrent protection sizing when a transformer is fed by two sources**




DC fault currents are considerably harder to interrupt than ac faults. Overcurrent devices marked for ac use only are not to be used in dc circuits. Overcurrent devices acceptable in some dc applications (for example, automotive, marine, telecommunications) are not suitable for use in permanent renewable energy systems as covered in the Code. Subrule 3) requires that overcurrent devices used in the dc portion of a renewable energy system are to be marked for the purpose.

When circuit breakers are marked "Line" and "Load", they have been evaluated for current flowing only in the direction from line to load. Circuit breakers without "Line" and "Load" markings have been evaluated for current flow in both directions. Subrule 4) requires that circuit breakers that are fed from both directions (backfed) be suitable for such an application.

### Rule 64-060 Disconnecting means

When electrical equipment is supplied from more than one power source, hazards can exist if the equipment cannot be completely de-energized by opening a single disconnecting means. In such circumstances, a person servicing the electrical equipment might accidentally contact live parts, under the mistaken impression that all power sources to the equipment have been disconnected.

Subrule 1) requires that a single disconnecting means be provided in renewable energy systems. The disconnecting means is intended to ensure that all ungrounded conductors of a renewable energy system can be simultaneously disconnected from all other insulated conductors in a building or structure.

Subrule 2) requires that the disconnecting means referred to in Subrule 1):
- be capable of being energized from both sides;
- indicate whether it is in the open or closed position;
- have provision for being locked in the open position;
- conform to Section 14;
- be capable of being opened at rated load;
- be capable of being closed with a fault on the system; and
- be located within sight of and within 9 m of the equipment, or be integral to the equipment.

Since renewable energy systems are electric power production sources, Rule 64-060 requires the disconnecting means in the renewable energy source [see Subrule 1)] to:
- be suitable for service entrance equipment when used as a service disconnecting means [Subrule 3)];
- disconnect equipment such as inverters, batteries, and charge controllers from all ungrounded conductors of all sources [Subrule 4)];
- not be connected in any grounded conductor if the opening of the disconnecting means would cause the grounded conductor to become ungrounded and live/energized [Subrule 5)];
- comply with Rules 14-414 and 14-700, where the equipment is supplied from more than one source [Subrule 6)];
- be able to disable and isolate output circuits rated 48 V and above [Subrule 7)];
- be able to disconnect a fuse from all sources in accordance with Rule 14-402 if the fuse can be energized from both directions [Subrule 8)];
- be marked for the purpose when used on dc circuits [Subrule 9)]; and
- be labelled with a warning that the line and load terminals may both be energized when the disconnecting means is in the open position [Subrule 10)].

**Note:** *The Appendix B Note to Rule 64-060 10) gives sample wording for the warning label required by Subrule 10). See Figure 64-3.*

**Figure 64-3**
**Sample wording of warning label for disconnecting means**


Subrule 11) requires that the disconnecting means for a hydrokinetic power system be allowed to be located beyond the limits defined in Subrule 2), provided that it is capable of being locked in the open position.

For installations with combiners, a single disconnecting means is to be capable of being opened at the ampere rating of its photovoltaic output circuit in accordance with Rule 64-206 and is to be installed for the photovoltaic output circuit [Subrule 12)] as follows:

- for photovoltaic combiners equipped with fuses protecting photovoltaic source circuits, the disconnecting means is to be:
  - integral with the photovoltaic combiner and interlocked with the door; or
  - installed within 2 m of the photovoltaic combiner and interlocked with the combiner door; and
- for photovoltaic combiners equipped with circuit breakers protecting photovoltaic source circuits, the disconnecting means is to be:
  - integral with the photovoltaic combiner; or
  - located not more than 2 m from each photovoltaic combiner.

For installations with recombiners, where the recombiner is installed in excess of 7.5 m from the inverter, Subrule 13) requires that a single disconnecting means capable of being opened at the ampere rating of the inverter input circuit in accordance with Rule 64-206 be installed for the inverter input circuit as follows:

- for photovoltaic recombiners equipped with fuses protecting photovoltaic output circuits, the disconnecting means is to be:
  - integral with the photovoltaic recombiner and interlocked with the door; or
  - installed within 2 m of the photovoltaic recombiner and interlocked with the recombiner door; and
- for photovoltaic recombiners equipped with circuit breakers protecting photovoltaic output circuits, the disconnecting means is to be:
  - integral with the photovoltaic recombiner; or
  - located not more than 2 m from each photovoltaic recombiner.

### Rule 64-062 Wiring methods

Where insulated conductors for dc renewable energy sources or supply circuits of interactive inverters are installed inside a building or structure, Subrule 1) requires that they are to be installed in metallic raceways, metal enclosures, or cables with a metal armour or metal sheath.

To prevent a fire or shock hazard, Subrule 2) requires that the metallic raceways, enclosures, and cables used for the dc renewable energy sources or supply circuits be provided from the point of penetration of the building or structure to the first readily accessible disconnecting means.

### Rule 64-064 System grounding

Rule 64-064 1), 2), and 3) require that for renewable energy systems, the following be grounded:

- ac systems when required by Rule 10-206 1);
- one conductor of a 2-wire dc renewable energy system with a voltage 50 V and greater [Subrule 2)]; and
- the reference (centre tap) conductor of a bipolar dc renewable energy system supply circuit [Subrule 3)].

**Note:** *The Appendix B Note to Rule 64-064 6) explains that when a renewable energy dc supply system is equipped with a ground fault protection device, the required grounded conductor is allowed to be connected to the ground via the ground fault protection device. Connections internal to the ground fault equipment are not duplicated by an external connection.*

Subrule 4) requires that the dc supply circuits that are listed in Subrules 2) (2-wire dc circuits) and 3) (bipolar systems) are to be provided with ground fault protection that:

- detects a ground fault;
- indicates that a ground fault has occurred; and

- interrupts the fault current by either:
  - automatically disconnecting all conductors of the dc supply circuit, or just the faulted portion of the dc supply circuit; or
  - causing the inverter or charge controller to disconnect the faulted circuit(s).

Subrule 5) requires that the dc circuit grounding connection be made at a single point on the renewable energy supply circuit and be located as close as practicable to the supply source.

A renewable energy dc supply system that is equipped with a ground fault protection device is allowed by Subrule 6) to have the grounding conductor connected to the grounding electrode via the ground fault protection device.

Some equipment may have the grounding connection to a ground fault protection device inside the equipment. Subrule 7) does not require the grounding connection to be duplicated by an additional external connection that would make the connection visible without opening the equipment.

**Note:** *The Appendix B Note to Rule 64-064 explains that inverters used in renewable energy power systems usually contain a transformer that isolates the dc grounded circuit conductor from the ac grounded circuit conductor, making both a dc and an ac grounding system necessary. The two grounding systems are bonded together or have a common grounding electrode so that all ac and dc grounded circuit conductors and equipment grounding conductors have the same near-zero potential to earth.*

## Rule 64-066 Ungrounded renewable energy power systems

Subrule 1) allows renewable energy systems to operate with ungrounded source and supply circuits where the system complies with the following:

- overcurrent protection is provided for all source and supply circuit conductors except as permitted by Rule 64-214 1) [Item a)];
- the power source is labelled in a conspicuous, legible, and permanent manner with a suitable warning at each junction box, disconnecting means, and device where the ungrounded circuits can be exposed during service [Item b)];
- inverters or charge controllers suitable for the purpose are used [Item c)]; and
- the system is provided with a ground fault protection device or system that:
  - detects a ground fault;
  - indicates that a ground fault has occurred; and
  - automatically disconnects all conductors or causes the inverter or charge controller connected to the faulted circuit to automatically cease supplying power to inverter output circuits [Item d)].

Subrule 2) allows renewable energy power systems used with ungrounded battery systems that comply with the installation requirements of Rule 64-800 to be ungrounded.

## Rule 64-068 Grounding electrodes and grounding conductors

The requirements for grounding electrodes and grounding conductor connections for renewable energy power systems are as follows:

- the power system is to be connected to a grounding conductor by one of the following means:
  - the dc grounding conductor and ac grounding conductor are connected to a single electrode, with the separate grounding conductors sized as required by Rule 10-114 [Item a)]; or
  - the dc grounding conductor is connected to a separate electrode by:
    - ♦ the grounding conductor connected between the identified dc grounding point and a separate dc grounding electrode; or
    - ♦ bonding the dc grounding electrode to the ac grounding electrode when required by Rule 10-104 b) [Item b)]; or
- a combined dc grounding conductor and ac equipment bonding conductor is to be:
  - installed in accordance with Rule 10-116; and
  - sized by the larger grounding conductor specified in Rules 10-114 and 10-614 [Item c)].

See Figure B64-7 in Appendix B for a summary of the grounding electrode requirements given in Rule 64-068.

### Rule 64-070 Equipment bonding

To prevent voltage differences between the grounding conductor and exposed conductive surfaces of the renewable energy source or supply circuit equipment, the bonding system connections are to be made so that the disconnection or removal of the equipment will not interfere with or interrupt bonding continuity.

### Rule 64-072 Marking

Electrical equipment has markings to provide direction for installation, servicing, maintenance, testing, repair, replacement, and evaluation of the equipment. These markings ensure that a device has the proper rating for voltage, current, frequency, etc., for the circuit to, or in, which it is to be connected. Subrule 1) requires that all interactive system points of interconnection with other sources, where two-way flow of energy occurs, be marked with the maximum ac output operating voltage and current. Subrule 2) requires that the marking be provided at the disconnecting means for each interconnecting power source.

### Rule 64-074 Warning notice and diagram

When a structure or building is not connected to a supply service source of electrical power, electrical hazards can arise for personnel responsible for:

- servicing and maintaining the building's electrical system; and
- disconnecting the building's electrical system during emergencies such as floods, fires, explosions, wind damage, or rock or mud slides.

Subrule 1) requires that any structure or building with a stand-alone renewable energy power system is to have a warning notice or diagram indicating in a conspicuous, legible, and permanent manner the location of the stand-alone power system disconnecting means and stating that the structure or building contains a stand-alone power system.

Similar to Rule 6-102 for a structure or building that has two or more supply services, Subrule 2) requires that buildings and structures with both a utility supply service and a renewable energy system are to have, where practicable, their disconnecting means grouped in accordance with Rule 6-102 2). Where grouping is not practicable, a permanent plaque is to be posted in accordance with Rule 6-102 3) on or near each disconnecting means, indicating the location of all other service boxes supplying power to the building.

Subrule 3) requires that a permanent plaque or directory identifying all electrical power sources on or in the premises (building or structure) is to be installed at each service equipment location and at the supply authority meter location.

Renewable energy power systems that store electrical energy can present a safety (shock) hazard to service and emergency personnel since one side ofthe equipment could be energized from the stored electrical energy. Subrule 4) requires that renewable energy systems that store energy be identified in a conspicuous, legible, and permanent manner with a suitable warning sign at the location of the service disconnecting means. The Appendix B Note to Rule 64-074 4) recommends that the following or equivalent wording be provided on or adjacent to the disconnecting means:

**WARNING**
**RENEWABLE ENERGY SYSTEM CONTAINS**
**ELECTRICAL ENERGY STORAGE DEVICES**

**AVERTISSEMENT**
**CE SYSTÈME À ÉNERGIE RENOUVELABLE**
**CONTIENT DES ACCUMULATEURS**
**D'ÉNERGIE ÉLECTRIQUE**

## Rule 64-076 Interconnections to other circuits

Where an installation is supplied from a renewable energy system that has more than one energy source, for example, a wind and solar photovoltaic system, but is not intended to be interconnected with a supply authority, the switching equipment is to be constructed or arranged so that it will be impossible to accidentally switch on power from one source before power from another has been cut off (that is, there is isolation between the different systems).

## Rule 64-078 Loss of interactive system power

With renewable energy systems, multiple sources can feed into a system fault or feed a portion of the supply authority system. For example, if a disconnecting means is opened for some reason (for example, as a result of a temporary fault or during a maintenance procedure) and isolates a portion of the supply authority system or other production sources, the interconnected renewable energy system can continue to feed the load side of the open disconnecting means, endangering personnel who expect the load side to be de-energized. Also, if the supply authority or other production source's disconnecting means is closed, but the system is de-energized due to a fault or maintenance, and the renewable energy system is still energized, the renewable system will feed into the de-energized system, which can cause damage to the electrical systems and injury to personnel working on the system. Subrule 1) requires that the renewable energy system be provided with a means to detect when the production and distribution network with which it is connected in parallel (be it a supply authority or another type of energy source) is de-energized. The renewable energy system is to be isolated from the production and distribution side of the common coupling (interconnection point) until the other system has been re-energized.

After the clearance of a fault, the supply authority equipment sometimes recloses automatically to avoid a long interruption due to a temporary fault. When the supply authority equipment recloses, the interconnected source is to be out of service. The automatic reclosing time is to be long enough to ensure that the interconnected source is disconnected from the supply authority system. Since there is often more than one automatic reclosing, it is important to wait until the normal voltage of the supply authority is restored before reconnecting the interconnected source. Subrule 2) requires that the renewable energy system remain disconnected until the normal voltage and frequency of the supply authority system has been restored. The Appendix B Note to Rule 64-078 2) adds that the supply authority could specify a delay period to ensure system stability of the grid and the restoration of normal voltage and frequency before the renewable system interconnection is restored.

Subrule 3) allows a renewable energy system that is usually connected in parallel with a supply authority's system to operate as a stand-alone system to supply loads that have been disconnected (isolated) from all other production and distribution networks.

## Table 64-1
## Summary of the requirements for different types of renewable energy systems

| | Rule references | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Requirement** | **General** | **Inverters** | **Solar PV systems** | **Small wind systems** | **Large wind systems** | **Micro-hydro-power systems** | **Hydroki-netic power systems** | **Stationary fuel cell systems** | **Storage batteries** |
| Marking | 64-072<br>64-074 | — | 64-200<br>64-212 | 64-300 | 64-400 | 64-500 | 64-600 | 64-700 | — |
| Maximum voltage | — | — | 64-202 | 64-302 | — | — | — | — | — |
| Conductors | 64-052 | — | 64-204<br>64-206 | 64-304 | 64-402 | 64-502 | 64-602 | 64-702 | — |
| Return/neutral conductor | 64-054 | 64-108 | — | — | — | — | — | — | — |
| Overcurrent protection | 64-058 | — | 64-214 | 64-308 | 64-404 | 64-506 | 64-606 | 64-704 | 64-802 |
| Disconnecting means | 64-060 | — | — | 64-310 | 64-406 | 64-508 | 64-610 | 64-706 | 64-806 |
| Wiring methods | 64-062 | — | 64-210 | 64-306 | — | 64-504 | 64-608 | — | 26-512 and 26-514 |
| Grounding and bonding | 64-064<br>64-068<br>64-070 | — | 64-222 | 64-312 | 64-408 | 64-512 | 64-612 | 64-708 | — |
| Interconnections | 64-076 | 64-110 | — | — | — | — | — | — | 64-810 |
| Stand-alone systems | 64-078 | 64-102 | — | — | — | 64-510 | 64-604 | — | — |
| Connections | — | 64-106<br>64-112 | 64-220 | — | — | — | — | — | — |
| Mounting/location | — | 64-104 | 64-208 | — | — | — | — | 64-710 | 26-504 |
| Other requirements | 64-056 | 64-100 | 64-216<br>64-218 | 64-314<br>64-316<br>64-318<br>64-320 | 64-410<br>64-412<br>64-414 | — | — | 64-712<br>64-714<br>64-716 | 26-500 to 26-514<br>64-804<br>64-808<br>64-812<br>64-814 |

# Section 66 — Amusement parks, midways, carnivals, film and TV sets, TV remote broadcasting locations, and travelling shows

## Scope and application

### Rule 66-000 Scope

Section 66 includes additional and specific requirements for temporary installations of electrical equipment in amusement parks; midways; carnivals; fairs; film, TV, or radio productions; remote broadcasting or recording locations; trade/home shows; live performance and entertainment events; touring shows and productions; concerts; sporting events; or similar events. Requirements for these locations are collected in one Section to ensure the consistency of installation requirements. For permanent installations, the regular Rules of the Code apply.

Electrical equipment employed in these installations is typically exposed to abnormal conditions of use. Due to the temporary nature of the installations and the need to dismantle and reinstall electrical equipment repeatedly in various locations, the equipment needs to be inspected for safety. During and after the dismantling of electrical equipment, and before reassembly, equipment should be carefully inspected; damaged, worn, frayed, or broken equipment and cables should be repaired or replaced.

Section 66 does not cover the safety and control of amusement rides, which are under the jurisdiction of other regulatory authorities. Section 66 also does not apply to coin-operated devices mounted on a non-movable base and designed to accommodate one person.

### Rule 66-002 Special terminology

Section 66 has definitions of *amusement park*, *amusement ride*, and *concession* that only apply to this Section.

## General

### Rule 66-100 Supporting of conductors

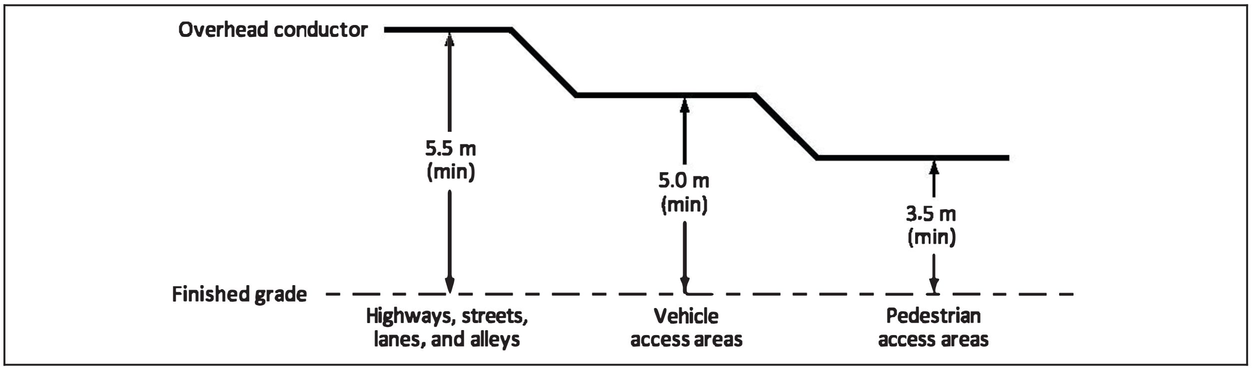
Although an electrical installation covered by Section 66 is temporary, the lighting, power supply, signal, communication, and control circuits require the same degree of safety as those used in a permanent installation.

To prevent shock hazards and backfeeds from other structures associated with the installation, only conductors for decorative lighting, signal, communication, and control circuits are allowed to be supported on the structures that support amusement rides.

Subrule 2) specifies that decorative lighting and control circuits associated with a ride are required to be attached only to the structure of that particular ride.

The supply conductors for rides and concessions may be installed either overhead or on the ground. Overhead supply conductors are to have the minimum clearances given in Subrule 3) (see Figure 66-1).

**Figure 66-1**
**Overhead conductors**




### Rule 66-102 Protection of electrical equipment

Electrical equipment installed temporarily in the settings specified in Rule 66-000 is more accessible to the general public and to vehicles than electrical equipment in permanent installations. The equipment is more likely to be exposed to abnormal conditions related to crowds, the environment, and the lack of permanent facilities; the people working with or near the equipment might not be trained in the hazards associated with a temporary electrical installation. Rule 66-102 cites Rule 2-200, which requires that all electrical equipment and the associated wiring be installed and guarded to maintain a level of safety adequate to protect people, property, and the equipment.

## Grounding

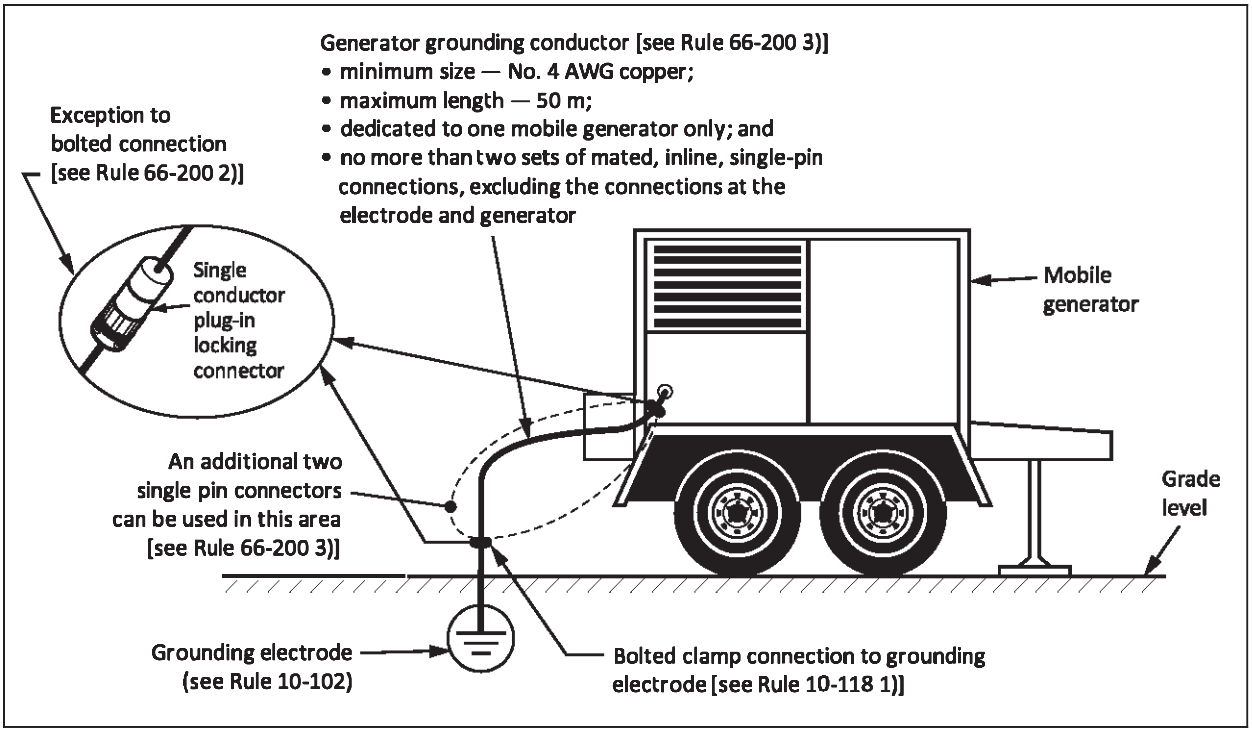
### Rule 66-200 Grounding

To eliminate potential shock hazards created by induced or accidental contact with power supplies or by differences of potential between ground and the electrical installation, Subrule 1) requires that service and electrical distribution equipment be grounded in accordance with Section 10.

Section 10 specifies the requirements for connecting the grounding conductor to the grounding electrode. Since the service and distribution equipment for temporary installations is dismantled and reinstalled at many different sites and needs to accommodate different types of grounding electrodes, Subrule 2) allows an exception to the Rule 10-118 1) a) requirement by allowing the grounding conductor for a mobile or portable generator to be connected to a grounding electrode by a single-conductor plug-in locking-type connector at both the mobile generator and the grounding electrode connection points (see Figure 66-2).

Subrule 3) specifies the minimum requirements for the mobile generator grounding conductor (see Figure 66-2 for these requirements).

## Figure 66-2
## Grounding of a mobile generator




### Rule 66-202 Equipment bonding

In installations in amusement parks, midways, carnivals, film and TV sets, TV remote broadcasting locations, and travelling shows, all electrical equipment, whether permanent or portable, stationary or movable, must be bonded to ground, with attention given to the following factors:

- the need for repeated assembly and disassembly of the equipment's wiring systems;
- the environmental conditions in which the electrical equipment is used, including exposure to weather and wet or damp locations; and
- the possibility that people standing on the ground might come into contact with electrical equipment.

Rule 66-202 specifies additional requirements for the bonding to ground of exposed non-current-carrying metal parts of fixed and remote electrical equipment.

## Services and distribution

### Rule 66-300/66-302 Service equipment/Mounting of service equipment

To prevent fire and shock hazards, avoid the nuisance tripping of overcurrent devices, and be protected against the weather and mechanical damage, service equipment is to:

- have sufficient current-carrying capacity to supply the connected load;
- be mounted on a solid backing;
- be in a location inaccessible to unauthorized personnel or located in a lockable enclosure to prevent unauthorized personnel from coming into contact with live components; and
- be protected from the weather, installed in a weatherproof enclosure, or of weatherproof construction (for example, CSA enclosure Type 3R).

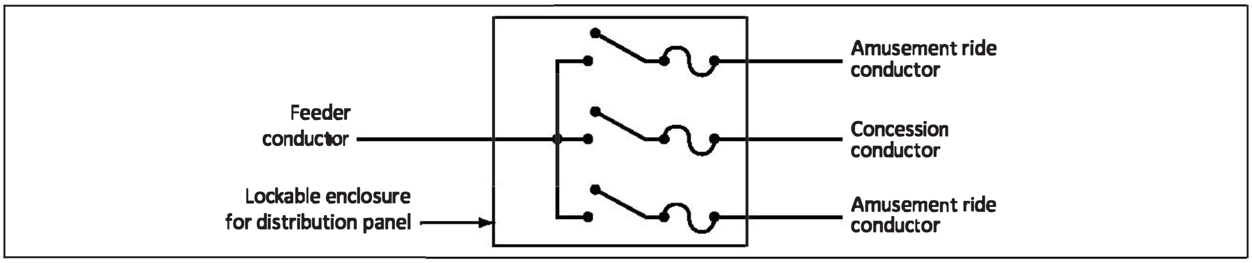
Generators have moving parts and can present a mechanical hazard as well as an electrical hazard to unauthorized personnel. Therefore, to minimize any possible hazards to the public, generators are to be accessible only to authorized personnel.

**Rule 66-304 Distribution equipment**

To allow for the disconnection of the power supply to a concession or amusement ride during servicing, maintenance, or emergencies, Subrule 1) requires that a disconnecting means be provided.

Where distribution equipment is located in an area accessible to unauthorized personnel, a means of locking the equipment or the equipment enclosure must be provided (see Figure 66-3).

**Figure 66-3**
**Distribution equipment**



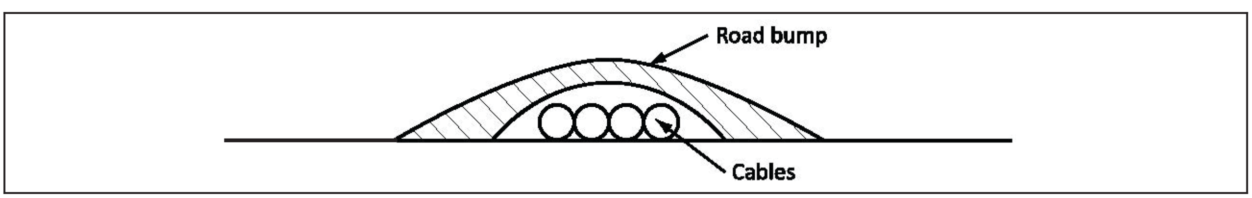

## Wiring methods and equipment

Whether an electrical installation is temporary or permanent, the Code requires that the wiring methods described in Section 12 be used to safeguard against fire and shock hazards and to allow for proper maintenance and operation of the installation. For the temporary installations covered by Section 66, however, a number of exceptions and additions to the requirements of Section 12 are necessary.

**Rule 66-400 Wiring methods**

All flexible cords, cables, conduits, and electrical equipment are to be protected from damage. For example, conductors laid on the ground to cross roadways or walkways can be supported and protected by road bumps that are supplied with a channel in which the conductors can be laid (see Figure 66-4).

**Figure 66-4**
**Protection for conductors on the ground**




Flexible cords used in the temporary installations are:

- to be designated for hard usage (see Table 11);
- when exposed to the weather, to be approved for outdoor use (see Table 11); and
- when entering an enclosure or plug-in connectors, to be provided with a strain-relief device for the cords (for example, a wire grip).

**Note:** *Suitable strain-relief devices are designed to prevent any tension or twisting forces from being transmitted to the conductor terminations.*

When plug-in connections are used to connect flexible cords or connect flexible cords to equipment, the plug-in connections must
- be designed so that devices of different systems or ampacity ratings cannot be connected together;
- have the female connector attached to the load end of the cord so that there is no shock hazard to a person who comes into contact with the exposed blades of a male connector; and
- be polarized when connected to multi-conductor ac circuits to avoid cross connections, such as between live and grounded or bonding conductors.

Where single-conductor cables are used as the wiring method for a circuit, an exception is allowed: the female half of a connector is permitted to be connected to the supply end of the grounded conductor and the bonding conductor.

Except in amusement parks, midways, carnivals, home shows, or tent meetings, Subrule 5) allows the use of a maximum 20 A overcurrent device to protect 5-15R, 120 V, hospital-grade receptacles used to supply temporary lighting installations where the load is of an intermittent type.

**Note:** *Hospital-grade receptacles are identified by a green dot on the face of the receptacle and are manufactured to stringent requirements.*

The temporary wiring for portable stage equipment is to conform to the requirements listed in Rules 44-350, 44-352, and 44-356 for theatre installations.

### Rule 66-402 Equipment

Lighting streamers (that is, a string of lights) consist of lampholders or luminaires connected by means of a flexible cord that can be used temporarily indoors or outdoors to provide decoration, task lighting, or general lighting. They can be run along walls, attached to ceilings or overhangs, run between supports and structures, or attached to amusement rides, concessions, and other types of equipment that are capable of limited physical movement. The flexible cord will be subjected to a variety of vibration, flexing, impact, and pulling forces, and as a result, it is required to be of the extra-hard-usage outdoor type (see Table 11). The lampholders are to be weatherproof and may be the pigtail type or have terminals that puncture the cable insulation and make contact with the circuit conductors.

Rule 66-402 also gives the requirements for the use of fluorescent luminaires, screwshell lampholders, and bayonet-type lampholders.

Utilization equipment (defined in the Code as any equipment that uses electrical energy for electronic, electromechanical, chemical, heating, lighting, or similar purposes) installed outdoors is to be suitable for the location and protected from inclement weather.

### Rule 66-404 Receptacles

Most itinerant/travelling midways, carnivals, fairs, and festivals are set up in temporary locations, and the supply cords for 5-15R and 5-20R receptacles are often used to supply loads outdoors or in damp locations, run through mud or water, or strung around the metal barricades or poles, etc. However, the cords used in some installations are not of the hard-usage type as required by Rule 66-400 3). By requiring that the supply of power to these receptacles be protected by a ground fault circuit interrupter of the Class A type, Rule 66-404 reduces the risk of a possible breakdown of or damage to the cords, which could result in an electrical shock hazard.

## Single-conductor cables

Multi-conductor cables are generally used for services, feeders, and branch circuits rated over 100 A. However, multi-conductor cables of the length required for temporary installations in the settings specified in Rule 66-000 are usually large and heavy, can require special equipment for installation and removal, and might not be available in the sizes required. For greater ease of handling, installation, and removal, single-conductor cables may be used to supply electrical equipment in these installations.

Rules 66-450 to 66-458 set out special requirements for single-conductor cable installations aimed at preventing:

- damage to single-conductor cables;
- overheating and increased impedance due to mismatched cable lengths; and
- injury to people caused by:
  - tripping over cables;
  - shock hazards; and
  - the uncontrolled movements of a single-conductor cable that can occur during normal operations and fault-clearing operations.

### Rule 66-452 Fault current limiting

When a single-conductor cable is shorted due to a fault on the electrical system, the flow of fault current or short-circuit current along the cable causes the single-conductor cable to move. The larger the fault current flowing in the single conductor, the more violent the movement. In permanent installations, such movement, which can injure people or damage equipment and structures, is prevented by permanently securing cables at required intervals to the structure or installing them in an approved raceway. In temporary installations, however, the movement of single-conductor cables can be prevented only by limiting the potential fault current or short-circuit current.

Limiting of the fault current can be achieved in temporary installations by using current-limiting-type overcurrent devices in single-conductor cable installations where the available fault current exceeds 10 000 A. These devices are designed to open so that the available fault current flowing in the conductor is stopped or cleared in less than one-half cycle, thus limiting the actual magnitude of the fault current flow that causes the unintended movement of the cable.

### Rule 66-454 Free air ampacity

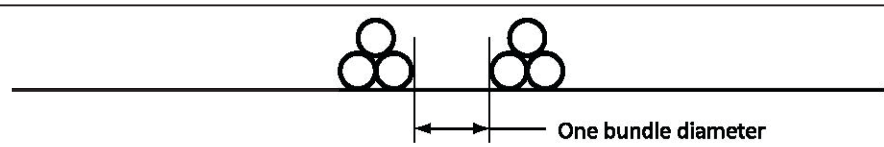
For single-conductor cables that are run in free air, the ampacity rating and installation methods are covered in Rule 4-004.

Rule 66-454 allows the single-conductor cables of one circuit to be bundled, with no spacing between them, and to be rated for free air without any correction factor to lower the ampere rating, provided that there is a maximum of four conductors (one per phase plus the neutral).

An exception to the four conductor maximum is permitted by Rule 66-456 in cases where connecting the conductors in parallel is required to reduce voltage drop (such as where a single conductor carrying the total load of the circuit is so long that its resistance causes the voltage drop of the conductor to exceed the maximum allowed in Rule 8-102). The spacing between the two bundles of parallel conductors must be at least the diameter of one bundle.

Where other circuits supplied by bundled single-conductor cables rated for free air are used in the installation, each circuit bundle must be separated by the diameter of the bundle so that it is not necessary to apply the correction factor for single-conductor cables run in contact (see Figure 66-5).

**Figure 66-5**
**Free air ampacity**




**Note:** *Single-conductor cables spaced one bundle diameter apart are rated "free air".*

## Rule 66-456 Single-conductor cable connections

Single-conductor cable should be installed and serviced by qualified personnel, as dangerous situations can result from open connectors under load, improper connection and cross-connections, the wrong size of conductor, or the use of different sizes or lengths of conductor in the same circuit. Subrules 1) and 2) require that single-conductor connections:

- be inaccessible to unqualified personnel;
- be of the plug-in locking type;
- have a mechanical interlocking system or colour coding that prevents improper connections; and
- be covered when not in use with a cover or cap that provides environmental and ingress protection suitable for the location.

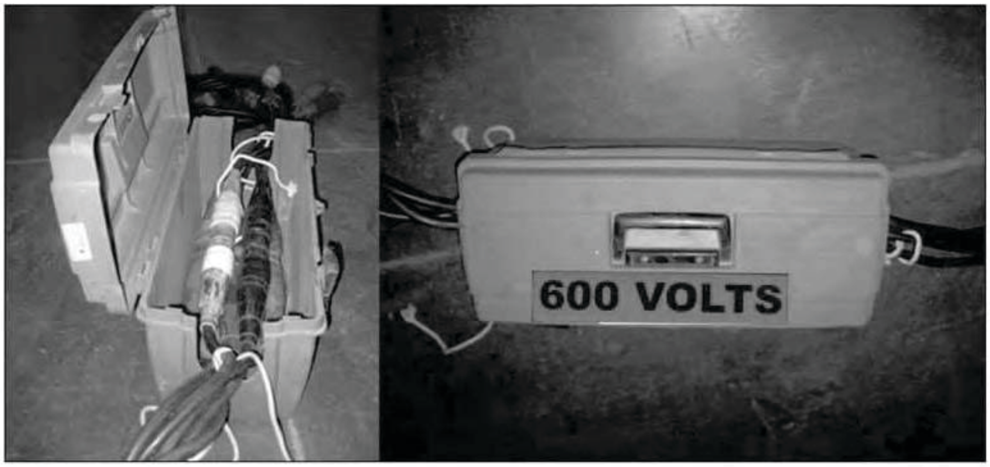
Subrule 3) allows single-conductor cables to be run in parallel only where the given distance between the supply and the utilization equipment requires the use of larger-sized single-conductor cable to reduce voltage drop to the limits specified in Rule 8-102. Increasing the size of the conductor offsets the increased resistance of a long conductor. Where single-conductor cables are run in parallel due to voltage drop requirements, the rating of the overcurrent devices for the circuit must be sized so that the ampacity of each individual conductor used in parallel is not exceeded if one of the parallel conductors is disconnected.

To prevent terminal failure when making terminations using tapping tees, paralleling tees, or rigid turnarounds, Subrule 4) requires that:

- they not be connected to a single-pin plug or connector that is rigidly secured or mounted in a multiple connection device as the panels or multiple connection devices are constructed in such a way that attempting to rotate a tee or other rigid tapping device in a panel-mounted outlet can result in a short-circuit between the tee and the panel. Spacing between panel-mounted connectors or multiple connection devices generally does not include any allowance for the amount of rotation necessary to fully engage the locking cam to ensure proper contact of tapping tees, paralleling tees, or rigid turnarounds while also ensuring against unintentional disengagement. Also, this requirement is intended to ensure that there is no undue strain on the panel-mounted connectors, and that the weight of the added termination point is on an appropriate support and is not mechanically supported by the interface with the panel-mounted connection;
- the cable length terminating at the panel-mounted connection or at a multiple connection device is at least 2 m in length to provide for flexibility at the connection; and
- no mechanical strain is imposed on the connection. The stress created by the length of the inline connector — in addition to the weight of the cable — puts enormous pressure on the panel mount to the inline contact point. The strain applied to the panel mount connectors might be linear or in the form of shear — both of which are highly undesirable — leading to deformation and potential failure of the connection.

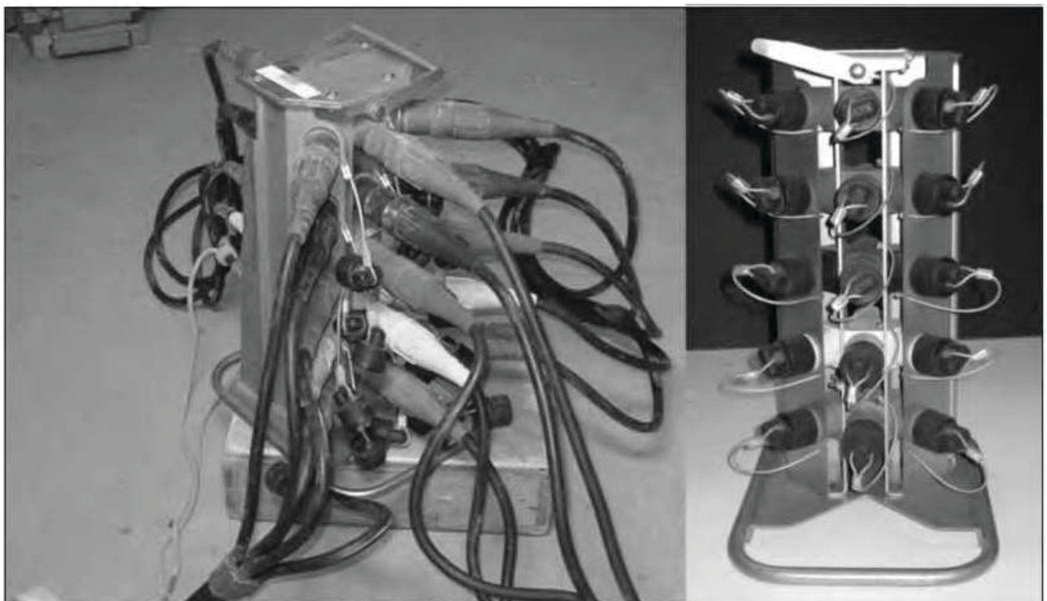
Inline single-pin connectors are available in ratings above 150 volts-to-ground. These devices, which are common in the entertainment field, are rated up to 600 V and are used in certain situations to carry other than 120/208 V on an entertainment set or location. Because the same connector can be used on different voltage systems, there is a potential hazard arising from cross-connecting different voltage systems. For mechanical protection, Subrule 5) requires that connections forming part of a circuit of more than 150 volts-to-ground be enclosed in a lockable, non-conductive box or similar enclosure. Subrule 6) a) requires that the lockable enclosure be labelled on the outside with the system voltage, while Subrule 6) b) requires that the enclosure be acceptable to the AHJ (see Figure 66-6).

**Figure 66-6**
**Inline non-conductive lockable enclosure for single-pin connectors over 150 volts-to-ground**




The practice of joining tees together to create splitting points was necessary in the past when the tee was the only splitting device available in the system. However, there are now splitting device assemblies or boxes, known generically as "tee towers", with one male connector to three, five, or six female connectors per conductor, allowing safe, organized, and secure splitting. There is now no need to create the unsafe condition of ganging tees together. Subrule 7) requires that no more than one tapping or parallel tee per conductor be used at any one point in a power distribution system (see Figures 66-7 and 66-8).

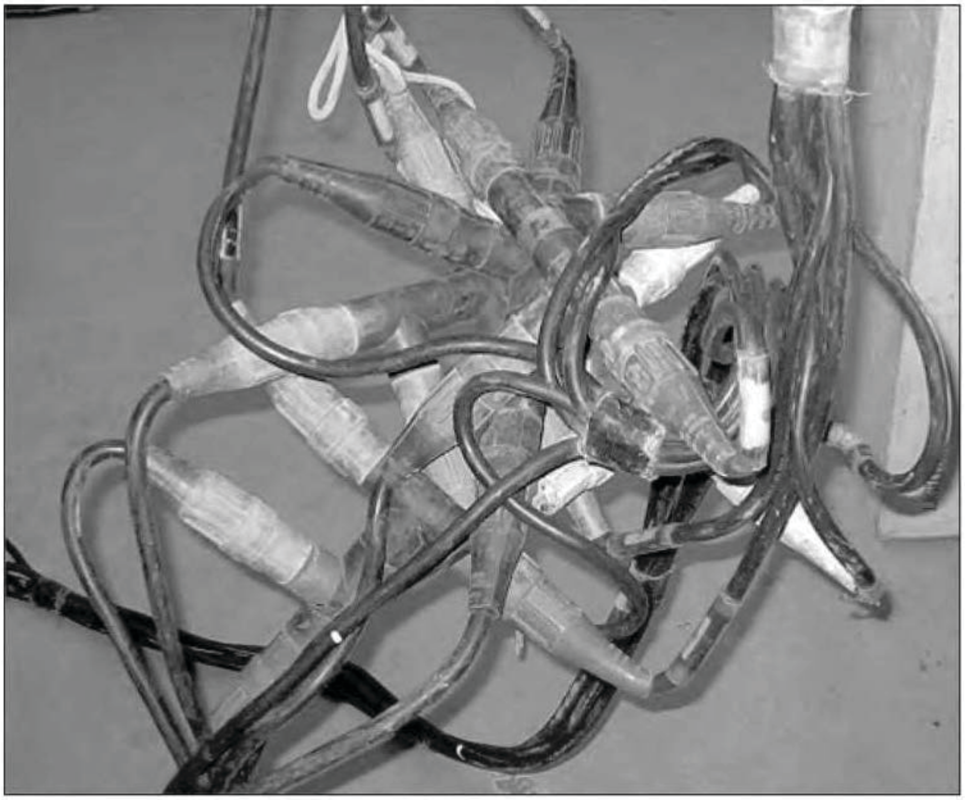
**Figure 66-7**
**Tee towers**



Loaded and unloaded 1 × 5 wire feed in 3 × 5 wire feed out

1 × 5 wire feed in 5 × 5 wire feed out

**Figure 66-8**
**Unsafe condition of ganging tees together**



The practice of appending tees to tees creates an octopus that is hazardous due to its size and unpredictable arrangement of connection orientations. Subrule 8) requires that any distribution splitting or combining devices requiring more than two load connections per conductor shall use a single approved multiple connection device at that point.

### Rule 66-458 Bonding
In temporary installations, given the varying environmental conditions and the differences of potential that can exist between ground and the electrical installation, Rule 66-458 requires that a separate bonding conductor be installed for each single-conductor cable circuit and that the bonding conductor follow the same path as the circuit cables. If the bonding conductor does not follow the same path, then an unacceptably high ground impedance can occur during fault conditions.

## Motors

### Rule 66-500 Motors
Rule 66-500 requires that the electrical installation of motors and their controls conform to the general requirements given in Section 28 for the type of conductor, overcurrent and overload protection, control, disconnecting means, and wiring method. See the requirements in Section 28.

### Rule 66-502 Location
Rule 66-502 requires that motors be located in dry locations. This is often impractical, however, in temporary installations such as amusement parks, midways, and film and TV sets. An exception to Rule 66-502 is allowed where the motor is:

- certified for the specific environment in which it is to be used, and the motor nameplate indicates its suitability for such a location [for example, drip-proof (DP) or weatherproof (WP)]; or

- protected from contact with moisture and from the weather or other sources of dampness by an enclosure or covering.

### Rule 66-504 Portable motors

The supply connections for portable motors are made using flexible cords designed for mechanical serviceability and the intended environment. Portable motors and the wiring methods used in temporary installations are often subjected to more physical and environmental damage than other types of installations using flexible cords. As a result, Rule 66-504 requires that flexible cords used with portable motors have a minimum rating of not less than Type SOW for wet locations, extra-hard usage, and outdoor use, as is specified in Table 11.

# Section 68 — Pools, tubs, and spas

## Scope

### Rule 68-000 Scope

Section 68 includes additional and specific requirements for electrical installations near or in pools, tubs, and spas. People standing, sitting, or swimming in water can receive a severe electric shock by:

- touching the energized casing of a faulty appliance;
- coming into contact with a voltage gradient in the water itself; or
- coming into contact with the voltage gradient between the metal parts and equipment associated with the pool, tub, or spa.

Section 68 sets out requirements for electrical wiring methods and equipment installed in or adjacent to pools, tubs, and spas. It also specifies bonding and grounding requirements for metal accessories that can become energized.

The requirements of Section 68 apply to both the:

- installation of electrical wiring methods and equipment near or in pools, tubs, and spas; and
- non-electrical metal accessories in a pool or within 3 m of the inside wall of a pool.

The scope of Section 68 extends to any manufactured and field-assembled devices or structures that can hold enough water for a person to stand in or be immersed in, either intentionally or accidentally, except for conventional bathtubs. For the purposes of Section 68, the term *pool* includes permanently installed and storable swimming pools, hydromassage bathtubs, spas and hot tubs, wading pools, baptismal pools, decorative pools, and splash pads.

**Note:** *Although not specifically mentioned in Section 68, fountains fall under the definition of a decorative pool (i.e., a pool that could be used as a wading pool, that is larger than 1.5 m in any dimension, and that that is readily accessible to the public).*

## General

### Rule 68-052 Electrical wiring or equipment in pool walls or water

A breakdown in electrical equipment in or near a pool can pose a hazard to a person immersed in the pool. Even small amounts of current in the water can be fatal by rendering a person immobile and susceptible to drowning. The intent of the requirements in Section 68 is to ensure that both:

- electrical equipment installed and used in and around pools is properly controlled; and
- electrical installations are safe.

### Rule 68-054 Overhead wiring

The intent of Rule 68-054 is to minimize or even eliminate the possibility that either:

- energized conductors from an overhead wiring system might fall into a pool; or
- a person in or near the pool might come into contact with an overhead energized conductor.

Subrule 1) states that:

- pools are not to be installed under or near existing overhead wiring; and
- overhead wiring is not to be installed over or near an existing pool.

Subrule 2) applies to outdoor pools and indoor pools. The Subrule also prohibits any overhead wiring above the pool, which includes wiring on the elevated surfaces of items associated with the pool, unless it falls under the exceptions allowed in Subrules 3) and 4).

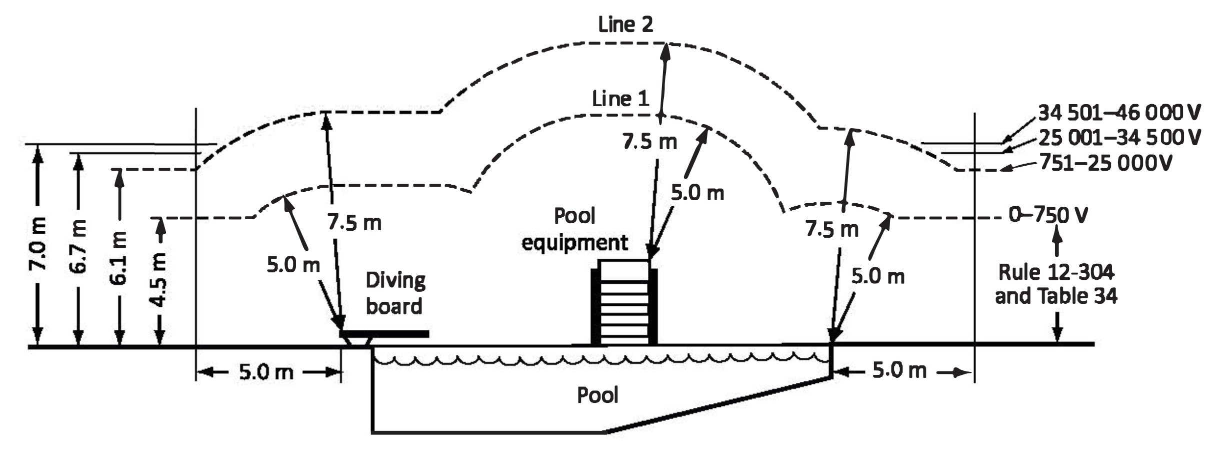
For outdoor pools, Subrule 3) allows insulated communication conductors, communication antenna distribution conductors, and neutral supported cables not exceeding 750 V to be installed over a pool, provided that there is:

- a 5 m minimum vertical clearance from any elevated platform, such as a slide, diving board, or lifeguard tower; and
- a 4.5 m vertical clearance at a horizontal setback of 5 m from the edge of the pool (see Figure 68-1).

These clearances are intended to ensure that no one standing around a pool, jumping off a diving board, or sitting or standing on a slide or lifeguard platform can come into contact with any overhead conductors, even while holding a rod or pipe, such as a vacuum pole or shepherd's hook.

Subrule 4) recognizes that a supply authority might have the right to run high-voltage distribution lines (up to 50 kV phase-to-phase) over private property. If so, a vertical clearance of 7.5 m must be provided from any elevated platform, such as a slide, diving board, or lifeguard tower. The requirement for a 5 m horizontal setback from the edge of a pool also applies.

**Figure 68-1**
**Overhead clearance from outdoor pool and accessories**




**Note:** *Clearances shown beyond* 5 m *from the pool edge are found in Rule 12-304 and Table 34.*

## Rule 68-056 Underground wiring

Underground wiring not directly associated with a pool can present a potential hazard to the users of the pool. The underground wiring referred to in Rule 68-056 includes conductors supplying services to a residence (for example, for power, telephone, cable TV), as well as underground circuits supplying detached garages, equipment sheds, yard lighting, and other similar applications. Each of these circuits is protected against possible overloads and short-circuits by a fuse or a circuit breaker. However, if the conductors are installed closer than the Table 61 distances, it is possible for leakage current – while not high enough to cause the overcurrent devices to function – to create a hazard if the current finds a conductive path through the pool. Underground wiring associated with the pool and installed within 3 m of the inside walls of the pool requires Class A ground fault circuit interrupter (GFCI) protection against shock hazards from any possible stray leakage currents. The specific requirements are covered by other Rules in this Section.

Bonding conductors and conductors supplying pool equipment that are protected by a Class A GFCI are exempt from the clearances given in Table 61.

It is also advisable to separate underground power, telephone, and coaxial cable installations from a pool. When excavating for a pool, the soil underneath these wiring installations can be undermined, often resulting in a break or failure of the conductors after the pool has been completed. This can require costly repairs to adjacent decks, platforms, and patios.

### Rule 68-058 Bonding

Bonding offers a low-resistance (low-impedance) conductive path that permanently connects all metal parts of the pool to create an equipotential plane. This limits differences in voltage that could occur in the vicinity of the pool. Although the equipotential plane is not intended to provide a path for ground fault current, it helps to eliminate voltage gradients due to stray currents flowing in the ground or electrical equipment brought into the pool area that could cause shock hazards for individuals in the pool and areas adjacent to the pool.

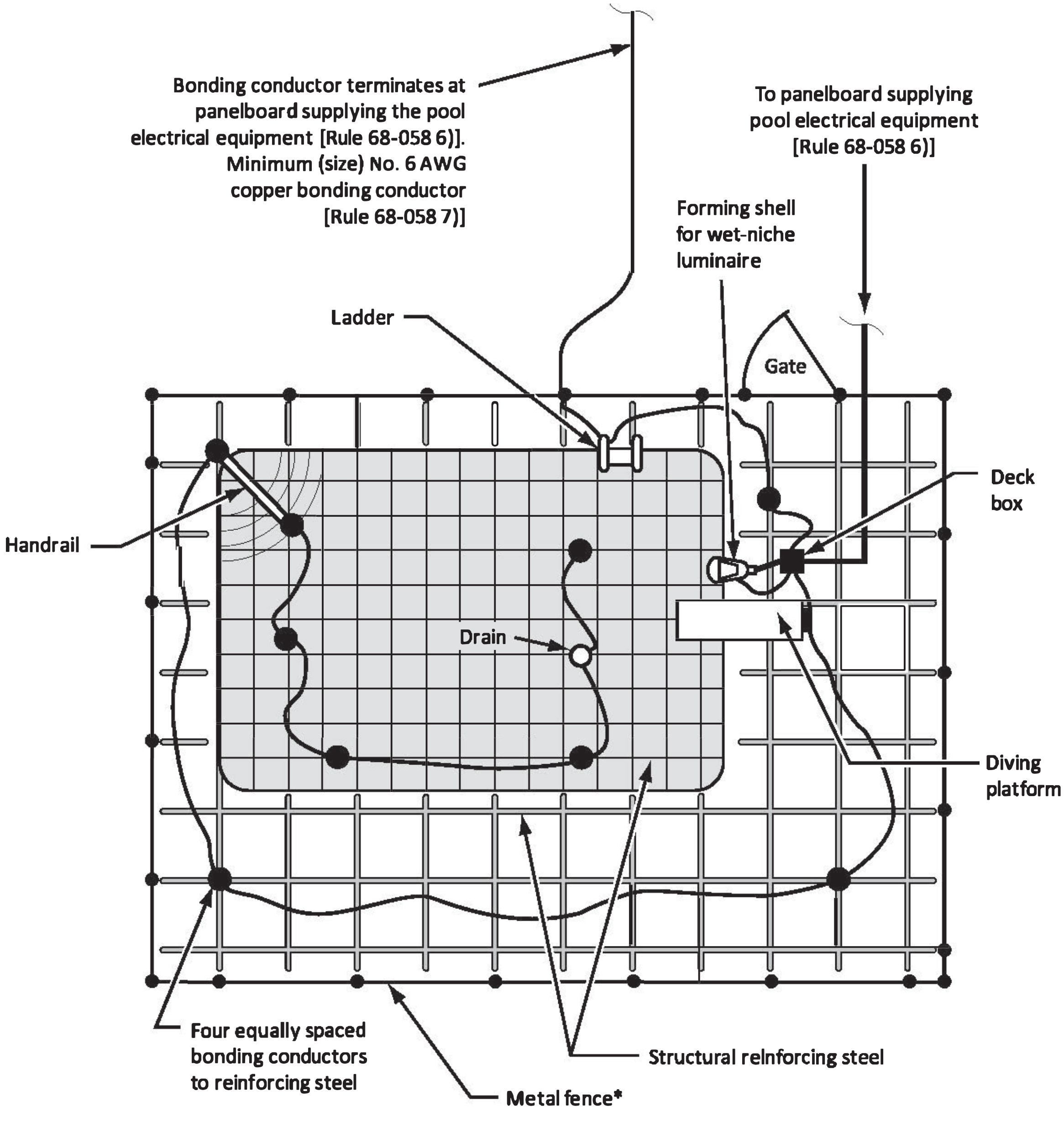
To ensure an effective equipotential plane around a pool installation, Rule 68-058 requires that the metal parts of the pool and of non-electrical pool equipment — such as piping, pool reinforcing steel, ladders, diving board supports, and fences within 1.5 m of the pool — be bonded together and to the non-current-carrying metal parts of electrical pool equipment.

The non-current-carrying metal parts of electrical equipment associated with the pool — such as pool luminaires and lighting equipment, forming shells, metal screens of shields for underwater speakers, conduit, pool pumps, and junction boxes — are to be bonded together using a copper bonding conductor. The minimum size of the copper bonding conductor depends on the type of pool. Subrule 4) requires the bonding conductor to be:

- not smaller than No. 6 AWG for permanently installed pools and in-ground pools; and
- sized by Table 16 for all other pools.

The bonding conductor is to bond the metal parts of both the pool and the other non-electrical equipment to the non-current-carrying metal parts of electrical equipment. The bonding conductor must then extend to the bonding bus of the panelboard used to supply the electrical equipment for the pool (see Figure 68-2).

## Figure 68-2
## Bonding to ground



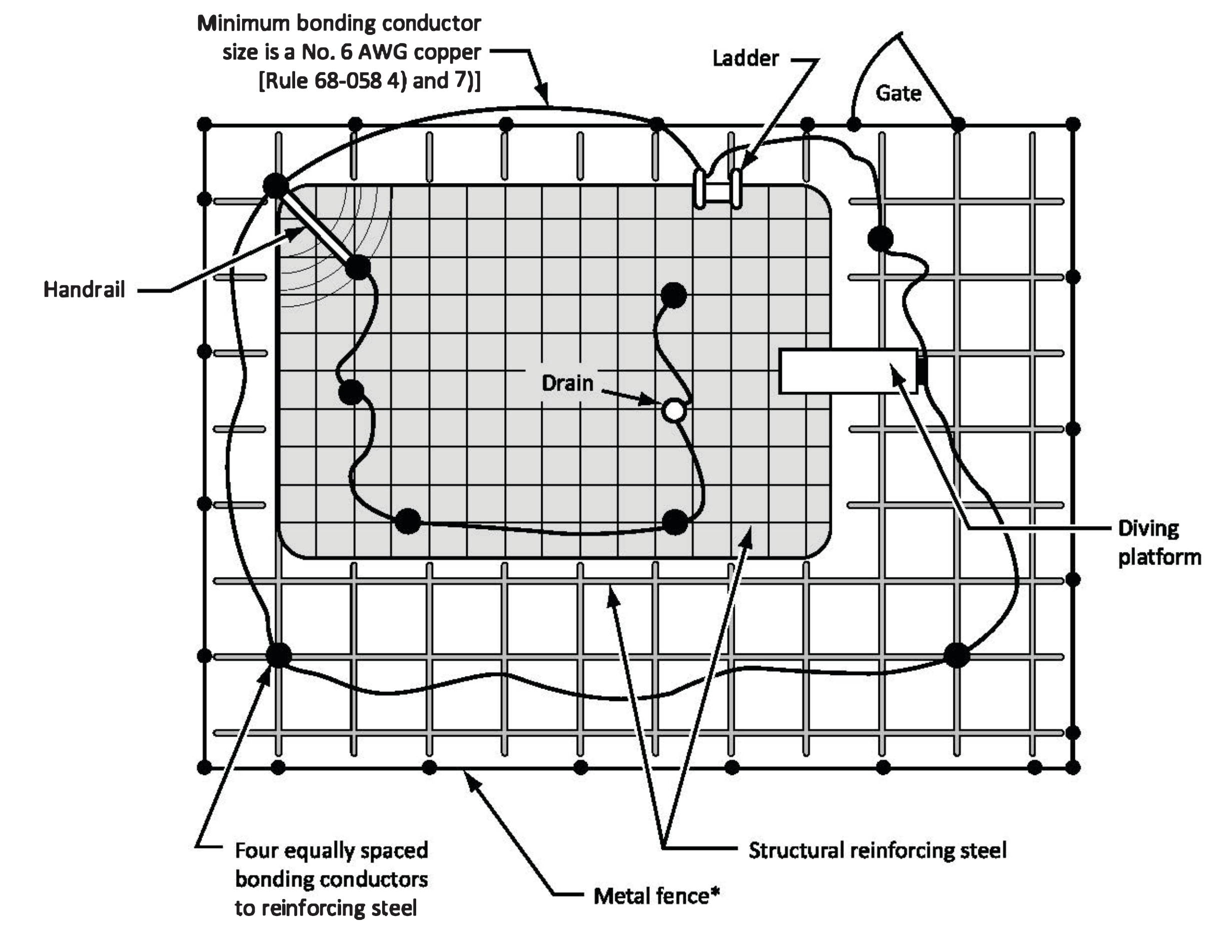

*Metal fence is to be bonded when it is within 1.5 m of the pool.

The bonding conductor that bonds together the metal parts of the pool and of other non-electrical equipment does not need to extend back to the panelboard bonding bus. Doing so can create a safety hazard because the pool reinforcing steel and concrete shell could become a much better grounding electrode than the grounding electrode of the electrical system, thus inadvertently introducing a path for fault current occurring somewhere in the electrical equipment for the pool.

To help to eliminate voltage gradients, the pool reinforcing steel is to be bonded with a minimum of four connections equally spaced around the perimeter of the pool (see Figure 68-3).

**Note:** *The Appendix B Note to Rule 68-058 3) recommends a loop around the pool of a minimum No. 6 copper conductor as an alternative means of eliminating voltage gradients where reinforcing steel encapsulated in a non-conductive compound is used in pool construction.*

**Figure 68-3**
**Bonding of metal parts of a pool with no electrical equipment present**




*Metal fence is to be bonded when the fence is within 1.5 m of the pool.

## Rule 68-060 Junction and deck boxes

Rule 68-060 provides requirements for installing junction boxes (commonly known as deck boxes) for electrical equipment in or near a pool. Common electrical equipment includes underwater lighting and, in some decorative pools, an underwater pump for a fountain. A deck box must be provided to enclose the connection between the branch circuit wiring and the equipment in question.

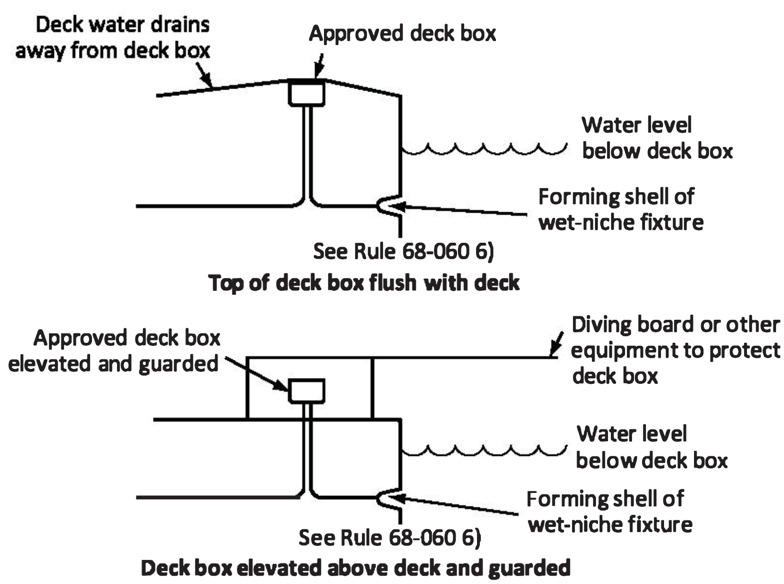
Subrule 1) allows a deck box to be submerged in a decorative pool only when it is marked for that purpose.

The typical installation covered by Rule 68-060 involves a deck box installed on the supply side of the conduit, extending to a forming shell for a wet-niche underwater lighting luminaire. In such an installation, the bonding path between the forming shell and the deck box is to be reliable, as it must carry any fault current from the luminaire and ensure the exposed metal of the luminaire and deck box are part of the equipotential plane of the pool required by Rule 68-058. To ensure the reliability of the bonding path, use a copper bonding conductor to provide this connection and make the provision inside the deck box for terminating the copper bonding conductors.

Deck boxes must be located and sealed in a way that prevents pool water from getting into the boxes, which contain electrical joints. If chemically treated pool water leaks into a box, electrical joints can break down over time, allowing a small current flow (leakage current) that might not trip the overcurrent device, creating a shock hazard. To supplement electrical and mechanical protection, Subrule 4) requires that the deck box contain only circuits feeding underwater equipment.

To prevent water from getting into the deck box through the conduit from the forming shell, Subrule 7) requires a watertight seal around the cord used to supply the luminaire. To prevent undue water pressure on this seal, the bottom of the deck box is to be above the normal water level of the pool. When this is achieved by elevating the box above the pool deck, it can create an obstacle for persons walking the pool. Therefore, an elevated deck box must be guarded or placed out of the way (such as under a diving board). In many cases, the top of the deck box can be installed flush with the surface of the deck, as the Appendix B Note to Rule 68-060 6) suggests. The deck area in the vicinity of the deck box can then be sloped up to the top of the deck box from the normal deck level to prevent water from collecting on the top of the deck box (see Figure 68-4).

**Figure 68-4**
**Deck box installation requirements**




### Rule 68-062 Transformers and transformer enclosures

Power transformers and audio transformers used with the electrical equipment for a pool but installed too close to the pool can present a shock hazard to people in the pool area. Subrule 1) requires that transformers and special enclosures for transformers be located at least 3 m away from a pool wall unless they:

- are on the other side of a fence, wall, or other permanent barrier; and
- are inaccessible to people using the pool area.

Subrule 2) requires that where a metal shield is provided between the primary and secondary windings of a transformer, it is to be bonded to ground in order to:

- prevent any leakage current or stray flux from becoming a shock hazard or created noise in the primary and secondary windings; and
- improve power quality by reducing higher frequency noise currents.

Audio transformers used to supply underwater speakers or regular loudspeakers can be installed within 3 m of a pool wall. Isolating the audio transformer circuits from ground under a fault condition prevents any current from flowing to the grounded metal parts of the pool. Subrule 3) requires audio transformers to:

- be connected between the audio output terminals and any loudspeakers that are installed within 3 m of the pool wall;
- be installed in or located adjacent to the amplifier with which they are used; and
- have a maximum output voltage of 75 V rms.

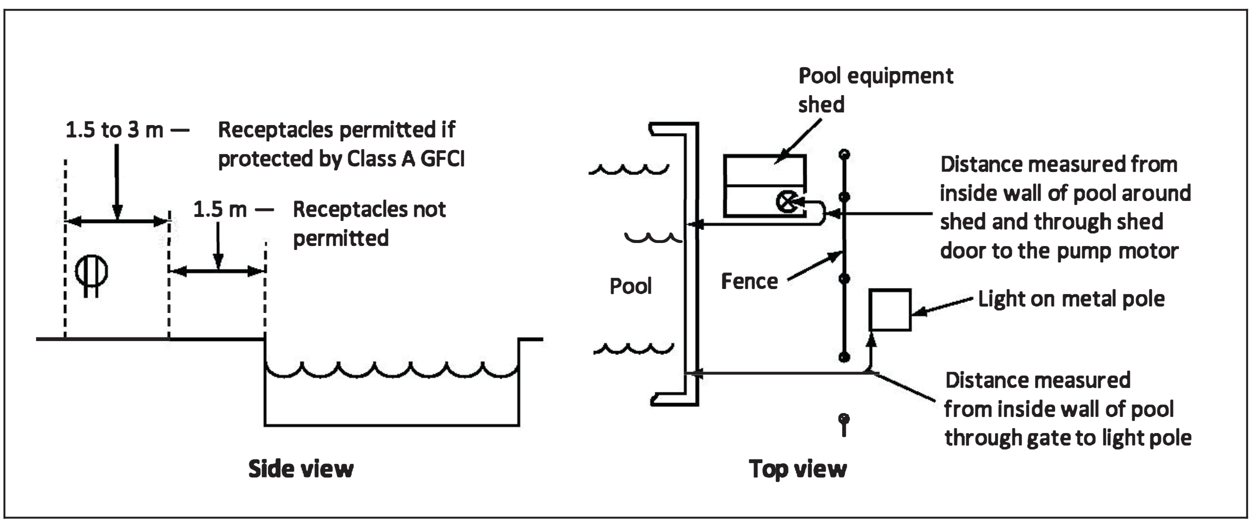
### Rule 68-064 Receptacles

The intent of Rule 68-064 is to discourage and restrict the use of appliances near a pool's edge so that people using the pool are unlikely to come into direct contact with an appliance. Direct or even indirect contact with the energized casing of a faulty appliance (such as a radio or portable tool) can result in a severe electric shock.

Subrule 1) prohibits receptacles from being installed within 1.5 m of the inside wall of a pool. Subrule 2) allows receptacles to be located between 1.5 m and 3 m from the inside wall of a pool, provided that they are protected by Class A GFCIs (see Rule 68-068). Receptacles may be installed without Class A GFCIs provided that they are more than 3 m from the pool (see Figure 68-5). However, Rule 26-722 requires that all receptacles installed outside of residential occupancies and located within 2.5 m of finished grade be protected by Class A GFCIs.

Rule 2-138 specifies that Class A GFCIs are permitted as extra protection from shock hazard. A Class A GFCI is an electromechanical device that requires regular testing at intervals specified by the manufacturer to ensure proper operation.

**Figure 68-5**
**Typical receptacle and light installations near pools**



Subrule 3) stipulates that the distances specified in Subrules 1) and 2) between receptacles and the inside walls of pools are measured by using the length that a supply cord would follow without going through a building floor, wall, or ceiling and not a straight line (see Figure 68-5). However, using extension cords to supply electrical devices and appliances in pool areas from non-GFCI protected receptacles located beyond the distance required in Rule 68-064 defeats the purpose of the shock protection provided by Class A GFCIs.

### Rule 68-066 Luminaires and lighting equipment

The Code gives no requirements for illumination in or around a pool. Given the possibility that stray electrical currents from lighting equipment can get into pool water, it seems logical to simply prohibit lighting in the water or in the immediate vicinity of a pool. However, a pool presents hazards other than severe electric shock. If used after dark, a pool needs adequate illumination for the safety of the people using it. Despite the apparent risks, underwater lighting is preferable because above-ground lighting can reflect off the surface of the water and make it difficult to see an individual who is having problems.

Rule 68-066 covers three types of lighting:

- underwater lighting provided by submersible luminaires (wet-niche luminaires in contact with the pool water);
- underwater lighting provided by dry-niche luminaires (luminaires not in contact with the pool water); and
- above-water area lighting.

Wet-niche or submersible luminaires are the type most commonly installed in private swimming pools, and Item a) of Subrule 1) requires that wet-niche or submersible luminaires be mounted in a forming shell. Subrule 2) exempts decorative pools from this requirement because people are unlikely to swim in them.

The metal forming shell of a wet-niche luminaire must be grounded so that it is capable of draining off stray currents imposed by a fault in the luminaire and maintaining the equipotential plane (see Rule 68-058). This bonding-to-ground can be considered a second line of defence if the Class A GFCI required by Rule 68-068 fails to operate. Item c) of Subrule 1) states that the maximum voltage for the operation of any submersible luminaire is 150 V.

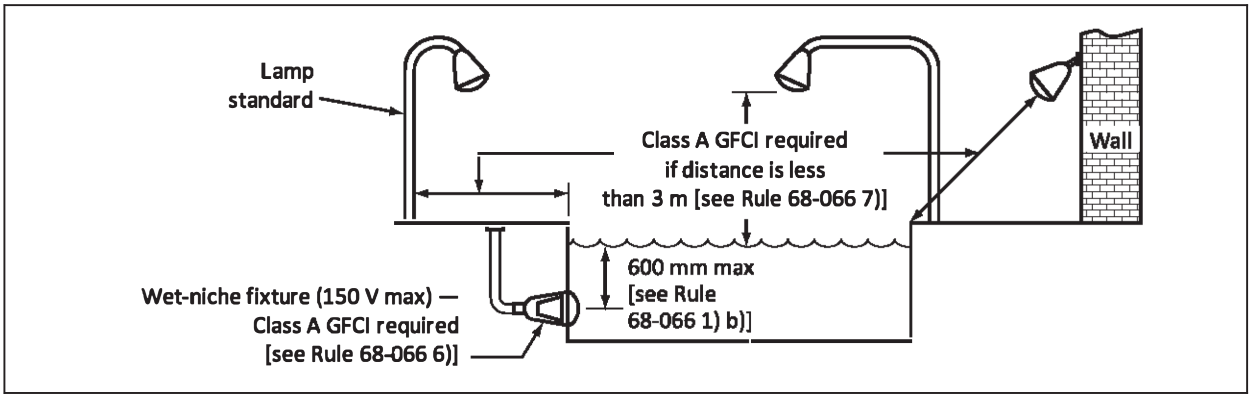
Wet-niche luminaires are provided with an extra length of cord so that the luminaire can be removed from the forming shell and placed on the pool deck for servicing.

Dry-niche luminaires are usually found in larger pools, where the supply voltage can be as high as 300 V. These luminaires are not in direct contact with the pool water, as they illuminate the pool through a transparent barrier. All lighting equipment must be accessible for servicing and maintenance. Subrule 4) permits access to dry-niche luminaires from a tunnel or walkway around the outside walls of the pool or through a handhole in the deck of the pool.

Subrule 6) requires that luminaires in pool water or within 3 m of the pool surface or walls be protected by Class A GFCIs, unless the luminaires are separated from the pool area by a fence, wall, or other permanent barrier (for example, in the case of area lighting) (see Figure 68-6).

Lighting equipment – including standards or supports – can present a shock hazard to anyone in the pool area who contacts it directly or even indirectly (for example, through metal tools used for pool servicing). Subrule 7) requires that standards and supports for luminaires are to be installed more than 3 m from the inside walls of a pool, except when the luminaires are protected by Class A GFCIs.

## Figure 68-6
## Typical luminaire installation




### Rule 68-068 Ground fault circuit interrupters

The prime function of a Class A GFCI is to provide protection against hazardous electric shocks caused by leakage current flowing to ground from defective circuits or defective electrical equipment. Subrule 1) requires that GFCIs in pool installations be of the Class A type, which limits the acceptable amount of leakage current to less than 6 mA. If the leakage current is 6 mA or more, the circuit is interrupted (see the entry on *Ground fault circuit interrupter, Class A,* in the Appendix B Note to Section 0).

Where a Class A GFCI is not available in the rating required for the electrical equipment, Subrule 2) allows the use of ground fault protection that can clear a ground fault within the time specified for a Class A GFCI. (For the tripping values of GFCIs, see the Appendix B Note to Section 0.)

Subrules 3) and 4) require that Class A GFCIs be permanently connected to a feeder, branch circuit, or individual device. Because they perform an important safety function, Class A GFCIs should be tested regularly. To remind pool operators of this requirement, Subrule 5) requires that a warning sign be posted beside the switches that control the Class A GFCI-protected circuits indicating that Class A GFCI protection is provided and should be tested regularly.

People testing and resetting Class A GFCIs can encounter a shock hazard if they are standing in water or in a wet area near the pool because an unprotected circuit feeds the interrupter. In addition, moisture, along with the corroding effect of chemically treated pool water, can interfere with the mechanical operation of Class A GFCIs. Therefore, Subrule 6) requires that Class A GFCIs be installed more than:

- 3 m from the water in a pool;
- 3 m from the water in a spa or hot tub; and
- 1.5 m from a hydromassage bathtub.

An exception is allowed if Class A GFCIs are an integral part of an approved factory-built spa, hot tub, or hydromassage bathtub, or located behind a barrier that prevents the user of the pool or tub from contacting the receptacles.

The combination of water and faults in the electrical equipment can create a shock hazard. Thus, Subrule 7) lists the following equipment and devices that must be protected by a Class A GFCI:

- electrical equipment placed in the water in the pool;
- spas and hot tubs;
- audio amplifiers connected to loudspeakers in the pool water;

- electrical equipment, such as pool pumps, heaters, and heat pumps, located within the confines of the pool walls or within 3 m of the inside walls of the pool and not suitably separated from the pool area by a fence, wall, or other permanent barrier; and
- receptacles located in wet areas of a building, and associated with the pool, such as locker and change rooms.

**Note:** *Long runs of a conductor can cause the nuisance tripping of a Class A GFCI protecting it. A certain amount of capacitive leakage is always present between the live conductor and the grounded conductor of a grounded electrical system. Nuisance tripping can result when the leakage current to ground is large enough to trip the Class A GFCI. Limiting the length of the protected cable to 75 m can help to reduce this nuisance tripping. This might involve locating the Class A GFCI closer to the outlet it protects.*

### Rule 68-070 Other electrical equipment

When pools are equipped with underwater loudspeakers, Rule 68-070 requires that the output from the associated amplifier be put through an isolation transformer. Subrule 1) prohibits the wiring to such loudspeakers from being grounded, as this defeats the purpose of the isolating transformer. To prevent an individual in the pool from contacting the speaker itself, Subrule 1) also requires that speaker to be both:

- mounted in a recess; and
- guarded by a rigid, corrosion-resistant, metal screen that is bonded to ground.

Communication equipment can present a shock hazard when used near pools. Subrule 2) requires that communication equipment installed within 3 m of the inside walls of a pool be permanently mounted on a wall, with no part of the equipment located within 1.5 m of the inside walls of the pool unless it is made inaccessible by a wall or other permanent barrier. Where it is necessary for a person in a pool to have access to a communicating device (such as for safety reasons), an insulated device or link that activates the communication equipment (such as a pull string) can be used. However, the communication equipment attached to the insulated link must remain out of reach of a person in the pool.

Subrule 3) prohibits the location or installation of communication jacks within 3 m of the inside walls of a pool. These types of jacks allow the connection of communication equipment (for example, telephones, computers, or other types of communication devices ) with attachment cords or cord sets that can extend into the pool.

## Permanently installed swimming pools

### Rule 68-100 Wiring method

The electrical equipment most commonly installed in a pool is underwater lighting. Rule 68-100 requires that a wet-niche luminaire be installed in a forming shell embedded in the pool wall [see Subrule 1) of Rule 68-066]. Rule 68-060 requires the installation of a junction box (deck box) for the connection of the flexible cord that connects the luminaire to the branch circuit wiring. Subrule 1) of Rule 68-100 requires that the forming shell and the deck box be connected by a rigid conduit made of copper, rigid PVC, or other corrosion-resistant material.

Subrule 4) requires that the conductors for wet-niche luminaires be kept isolated from all other wiring so that the protection provided by Class A GFCIs is not defeated.

Water can collect in conduits installed in the walls and deck of a pool, either from leakage due to the failure of a gasket or seal or (as is most often the case) from condensation. Subrule 5) requires proper drainage for any such moisture to help reduce shock hazards and leakage currents.

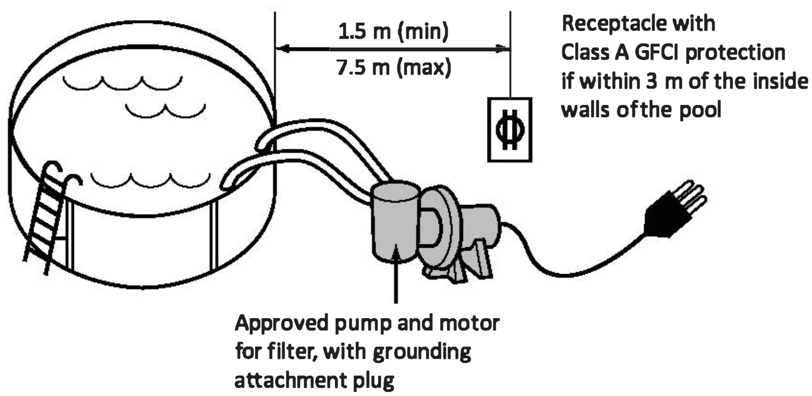
## Storable swimming pools

### Rule 68-202 Pumps

A pool large enough for swimming contains a substantial quantity of water, and it is not practical to continually change the water. Without proper filtering of the water, it can become a health hazard. Therefore, filter pumps are normally supplied as part of the pool. These pumps are to be specifically approved for the purpose and are usually mounted close to the side wall of the pool.

Typically, the pumps are provided with a flexible cord and an attachment plug so that they can be plugged into a receptacle. Item a) of Subrule 1) requires that such a receptacle be permanently installed not less than 1.5 m and not more than 7.5 m from the pool (see Figure 68-7). This distance is intended to discourage the use of extension cords. Item b) of Subrule 1) requires that where the pump is within 3 m of the inside walls of the pool and not suitably separated from the pool area (and so can be touched by someone in the pool area), it be protected by a Class A GFCI and be approved for such an installation as required by Subrule 2).

**Figure 68-7**
**Typical pump installation**




## Hydromassage bathtubs

### Rule 68-302 Protection

A person submerged in water is at considerable risk if exposed to even small amounts of electric current (that is, amounts in excess of 6 mA). To reduce this risk, Rule 68-302 requires that hydromassage bathtubs that are equipped with electrical components be protected by a Class A GFCI.

### Rule 68-304 Control

Rule 68-304 specifies the location of controls for a hydromassage bathtub, in order to eliminate the potential for shock hazards. Unless the controls are part of an approved factory-built hydromassage bathtub, they are to be installed behind a barrier or be located at least 1 m horizontally from the wall of the hydromassage tub to prevent an occupant from reaching them.

### Rule 68-306 Receptacle for a cord-connected hydromassage bathtub

The Part II product standard for hydromassage bathtub appliances, CSA C22.2 No. 218.2, allows up to 3 cord connections per appliance. This means that more than one receptacle is required for a unit with 3 cord connections.

Therefore, Subrule 1) requires that the receptacle for a cord-connected hydromassage bathtub with more than one power supply cord be:

- supplied by at least one branch circuit that supplies only the hydromassage bathtub;

- located at least 300 mm above the floor; and
- inaccessible to the occupant(s) of the hydromassage bathtub.

Subrule 2) requires that when more than one receptacle is required due to the number of power supply cords, the receptacles be located in close proximity to each other so that it is apparent to the person servicing or using the hydromassage bathtub that there is more than one power supply cord.

Subrule 3) requires that if the hydromassage bathtub is not equipped with Class A GFCIs, each receptacle is to be protected by a Class A GFCI.

Subrule 4) requires that a warning label be affixed to the receptacles for the cord-connected hydromassage bathtub to warn against and prevent the connection of any other equipment not associated with the hydromassage bathtub to the receptacles.

### Rule 68-308 Other electric equipment

Rule 68-308 indicates that a room containing a hydromassage bathtub be classified as a bathroom, and that all other Rules regarding the installation of electrical equipment in bathrooms apply.

## Spas and hot tubs

### Rule 68-402 Bonding to ground

Different voltage gradients between the metal parts of a spa or hot tub can become shock hazards to people in the tub. Subrule 1) requires that the metal parts of spas and hot tubs be bonded together and to ground, in accordance with Rule 68-058.

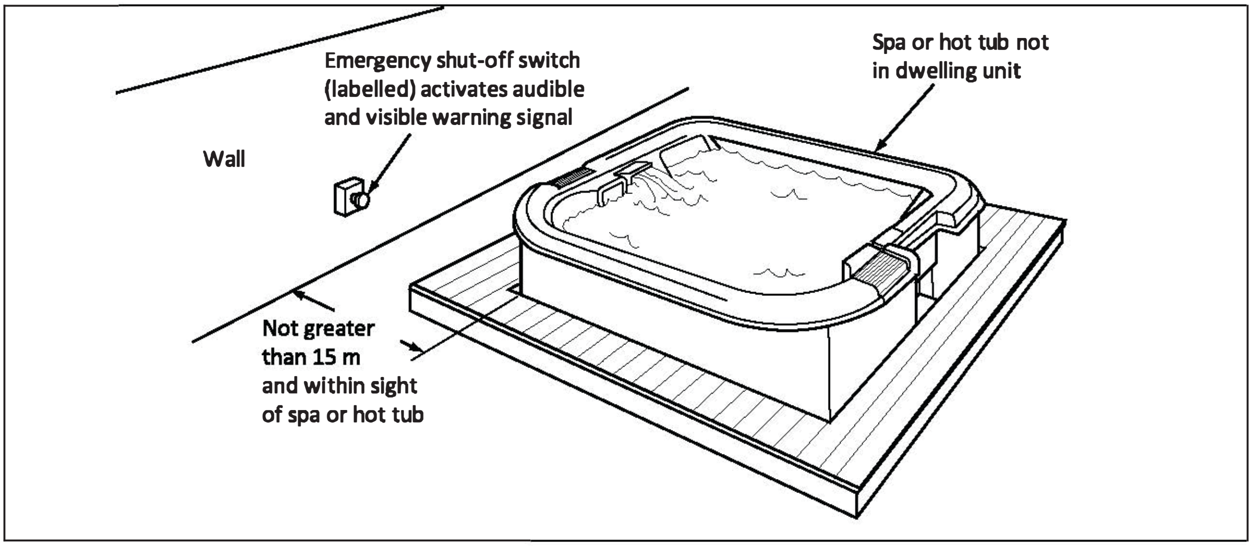
Subrule 2) notes that metal rings or bands used to secure the staves of a wooden hot tub need not be bonded to ground since it is highly unlikely that they would become energized.

### Rule 68-404 Controls and other electrical equipment

Subrule 1) aims to reduce the risk of shock hazard by requiring that the controls be located so that a person in the spa or hot tub cannot reach them.

In emergencies, the circulating pumps for spas or hot tubs might have to be shut down quickly. When spas and hot tubs are installed in locations other than dwelling units (for example, in health clubs, hotels, or resorts), persons trained in emergency procedures might not be readily available. In such locations, Subrule 4) requires that an emergency shut-off switch be installed that activates an audible and visual trouble-signal device(s) that gives immediate warning upon actuation of the emergency shut-off switch (see Figure 68-8).

## Figure 68-8
## Emergency shut-off switch




### Rule 68-406 Leakage current collectors

For safety reasons, field-assembled spas and hot tubs must meet the same safety standards as factory-assembled units. Unlike factory-assembled spas and hot tubs, field-assembled units:

- have not been fully tested for continuity and insulation resistance; and
- can present a shock hazard to users if there is leakage current from electrical devices in contact with the water.

Since spas and hot tubs use non-metallic piping and tubs that isolate the water from ground, there needs to be a path to ground for the leakage current from electrical devices in contact with the water so that a lethal potential does not develop between the water in the spa or hot tub and any grounded surface not connected to the spa or hot tub.

Subrule 1) requires that a leakage current collector designed to provide a path to ground for the leaking current from electrical equipment and devices be installed. A separate leakage collector is to be installed in all water inlets and outlets. Since the leakage current collector provides a path for the leakage current to flow to ground, when the leakage current reaches a specific level (6 mA or more) a Class A GFCI will trip the circuit feeding the spa or hot tub and eliminate the shock hazard.

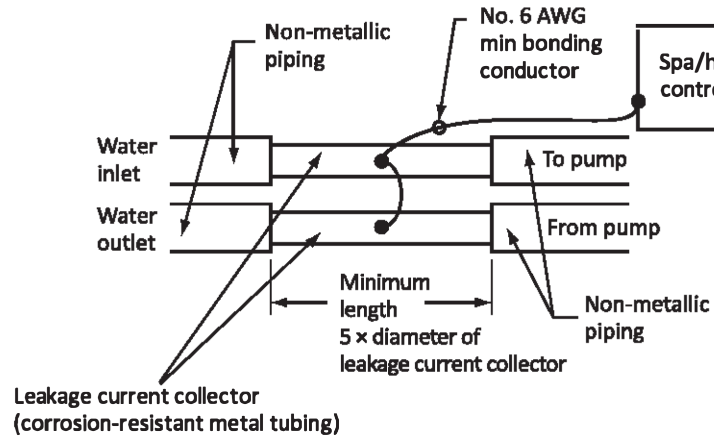
Subrule 4) allows an exception to this requirement where the only electrical component in the system in contact with the water is a pump marked as an insulated wet end pump. By design and construction, this effectively keeps the water from contacting any metallic part of the pump.

Subrule 2) requires that a leakage current collector be:

- a section of corrosion-resistant metal tubing at least five times as long as its diameter;
- provided with a corrosion-resistant lug; and
- inserted in the runs of non-metallic pipe (see Figure 68-9).

In a spa or hot tub that is factory-built for field assembly, an integral device that provides equivalent protection may also be used. This device can be part of the electric water heater used to heat the spa water.

## Figure 68-9
## Leakage current collector (typical field-assembled installation)




### Rule 68-408 Field-assembled units

Because some units are custom designed, Rule 68-408 requires that individual components be specifically approved for their intended purpose and assembled in the proper manner. Since field-assembled units cannot be certified in the same way as factory-assembled units, additional requirements are provided.

Subrule 3) requires that water be prevented from contacting the live parts of air blowers (air pumps), where they are used. Air blowers are used to introduce air into the spa through a series of injectors in the side of the footwell and seats or into the water coming out of the jets to modify the massaging action of the spa. The Appendix B Note to Rule 68-408 3) suggests that, as a means to prevent water from contacting a blower's live parts, an inverted U-shaped pipe be installed in the air pipe so that the bottom of the top loop of the pipe is not less than 300 mm above the tub rim.

**Table 68-1**
**Summary of requirements for pools, tubs, and spas**

| | Permanently installed swimming pool | Storable swimming pool | Hydromassage tub | Spa or hot tub |
|---|---|---|---|---|
| Requirements for GFCI protection | When electrical equipment is installed within the confines of the pool walls within 3 m of the inside walls of the pool [see Item d) of Subrule 7) of Rule 68-068] | When the pump or pump receptacle is located within 3 m of the inside walls of the pool [see Item b) of Subrule 1) of Rule 68-202] | Always required on electrical equipment associated with the tub (see Rule 68-302) | Always required on factory-assembled units; requirements for field-assembled are the same as for permanently installed swimming pools [see Item d) of Subrule 7) of Rule 68-068] |
| Requirements for the location of GFCIs | Not closer than 3 m from the pool water and in a location that facilitates testing [see Subrule 6) of Rule 68-068] | Requirements are the same as for permanently installed swimming pools [see Subrule 6) of Rule 68-068] | Not closer than 1.5 m from the tub, unless it is part of an approved factory-built tub or located behind a barrier that prevents the occupant from contacting it [see Subrule 6) of Rule 68-068] | Not closer than 3 m from the pool water, unless it is part of an approved factory-built spa or hot tub, or behind a barrier that prevents the occupant from contacting it [see Subrule 6) of Rule 68-068] |
| Requirements for the installation of receptacles | • No receptacles are allowed within 1.5 m of the inside walls of a pool<br>• Receptacles installed between 1.5 m and 3 m of the inside walls of a pool require Class A GFCI protection<br>(see Rule 68-064) | • Pump receptacle must be installed between 1.5 m and 7.5 m of the pool<br>• Receptacles installed within 3 m of the inside walls of the pool require Class A GFCI protection<br>(see Rule 68-202) | For cord-connected hydromassage tubs, one receptacle located not less than 300 mm from the floor and inaccessible to the tub occupant (see Rule 68-306) | Same as for permanently installed swimming pools (see Rule 68-064) |

*(Continued)*

## Table 68-1 (Concluded)

| | Permanently installed swimming pool | Storable swimming pool | Hydromassage tub | Spa or hot tub |
|---|---|---|---|---|
| Requirements for the installation of luminaires | Luminaires and supports or standards for luminaires installed within 3 m of the pool surface or walls require Class A GFCI protection [see Subrule 6) of Rule 68-066] | No requirements in Section 68 | No requirements in Section 68 | Same as for permanently installed swimming pools (see Rule 68-066) |
| Requirements for the installation of other types of electrical equipment | Class A GFCI protection is required where the electrical equipment is located within 3 m of the inside walls of the pool [see Subrule 7) of Rule 68-068] | No requirements in Section 68 | No requirements in Section 68 | In other than dwelling units, an emergency shut-off switch is to be installed that disconnects the circulating water pump motor and also activates an audible and visual trouble-signal device(s) that gives immediate warning upon actuation of the emergency shut-off switch.<br>For other items, the requirements are the same as for permanently installed swimming pools [see Subrule 7) of Rule 68-068] |

# Section 70 — Electrical requirements for factory-built relocatable structures and non-relocatable structures

## Scope

### Rule 70-000 Scope

Section 70 includes additional and specific requirements for the following:

- factory-built relocatable structures built on a movable chassis, including:
  - mobile structures such as mobile homes manufactured in accordance with the CAN/CSA-Z240 MH Series; and
  - mobile structures built specifically for commercial or industrial use, such as construction offices, bunkhouses, wash houses, kitchen and dining units, libraries, TV units, industrial display units, laboratory units, and medical clinics; and
- factory-built non-relocatable structures intended to be permanently located on a fixed foundation.

Mobile equipment — such as generators, welders, and substations — are not covered by this Section. Also, recreational vehicles (RVs) covered by the CAN/CSA-Z240 RV Series are not subject to the requirements of Section 70. Code requirements for electrical supply to such vehicles are set out in Section 72.

## Relocatable structures

### Rule 70-100 Equipment

The *Canadian Electrical Code, Part II*, is a collection of safety standards for the construction and, in some cases, the performance of electrical equipment. As a general requirement, Rule 70-100 states that where any electrical equipment — including equipment and devices on Class 1 and Class 2 circuits — is used in structures within the scope of Section 70, the equipment must meet the requirements of any applicable Part II standards and must be appropriate for the purpose.

### Rule 70-102 Method of connection

The majority of the electrical work on relocatable structures is done in the factory and inspected and approved under the *Canadian Electrical Code, Part II*, requirements. However, when connecting these structures to the supply circuit at the site, the requirements are subject to the site location. These requirements for connection are covered by this Section. Subrule 1) states the methods of connection to the supply circuits to be used for relocatable structures other than mobile homes. Subrule 2) requires that mobile homes only be connected directly to an overhead or underground supply, unless special permission is obtained to use a different method.

### Rule 70-104 Connection to an overhead or underground supply

Subrule 1) of Rule 70-104 provides the requirements for a common wiring method, location, and size of rigid conduit for relocatable structures.

Subrules 2) and 3) provide the specific requirements (accessibility and size) for the rigid conduit used for the direct connection of a mobile home to an overhead or underground supply.

Subrule 4) requires that when the system grounding conductor is to be run separately for a relocatable structure including a mobile home, a non-metallic raceway is to be installed at the time of manufacture for this purpose.

### Rule 70-106 Service for communication systems

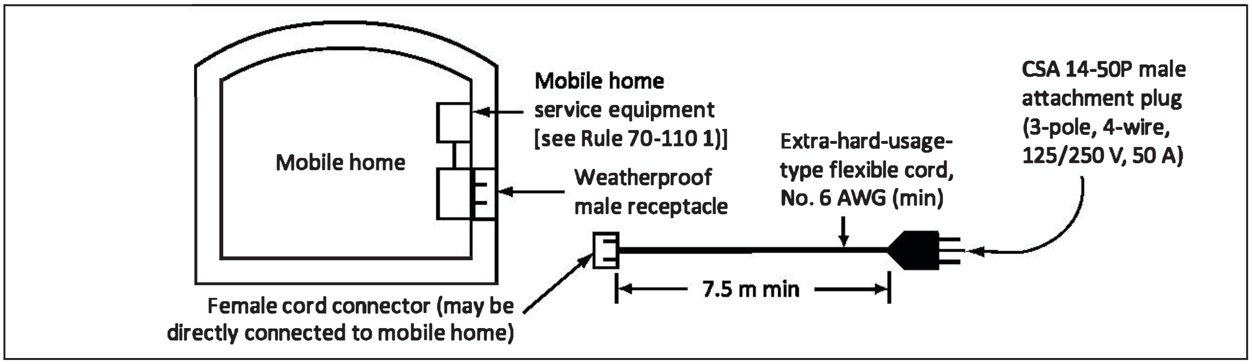
Rule 70-106 specifies the location and minimum size of raceway to be provided for a communication outlet so that an on-site installer does not have to drill holes in a new mobile home or mobile structure. When using metal raceways and metal boxes, take care to ensure that they are bonded to the frame of the mobile unit; this places the raceway, outlet box, and the frame at the same potential and reduces the electric shock hazard in the event of a fault.

The Appendix B Note to Rule 70-106 gives further suggestions about locations and raceway size, especially for raceways that are to contain both telephone and cable television services.

### Rule 70-108 Power supply cord or cord set

Rule 70-102 requires that certain methods be used to connect mobile homes and mobile commercial and industrial relocatable structures to a supply circuit. Because these relocatable units can be moved from place to place, special requirements are provided for power supply cords or cord sets to allow the units to be conveniently connected at a site. The receptacle at a site supplies the required power and provides the protection needed to prevent fire and shock hazards. Subrules 1) to 3) of Rule 70-108 set out requirements for cords and receptacles. Subrule 4) focuses on special requirements for mobile homes where a deviation has been permitted in accordance with Subrule 2 of Rule 70-102 (see Figure 70-1).

**Figure 70-1**
**Mobile home with cord set**




### Rule 70-110 Disconnecting means and main overcurrent protection

The service requirements for relocatable commercial and industrial structures and mobile homes are essentially the same as for any other building or structure. Subrule 1) gives the requirements for the disconnecting means and main overcurrent protection.

**Note:** *An identified conductor is the return or common conductor in a circuit and is identified by a white or grey covering. Rule 10-208 requires that the identified conductor be grounded to limit the voltage on the circuit, facilitate the operation of overcurrent protection, and help eliminate shock hazards (for example, by ensuring that there is no voltage or difference in potential between the screwshell of a lampholder and the ground). See Rule 10-210 and Section 30.*

In relocatable structures other than mobile homes, Subrule 2) allows the service box or service disconnect to be located outside the structure on the circuit that supplies distribution equipment installed inside the structure.

### Rule 70-112 Location of service or distribution equipment

Rule 70-112 summarizes the requirements for the location of electrical service or distribution equipment. The requirements of Rule 70-112 are more stringent to account for the fact that mobile structures are designed to be moved from one site to another, and movement or vibration during transport can loosen fuses in their holders. Fuses should be checked by a qualified person at each new site because loose fuses can lead to nuisance tripping or overheating. Therefore, Item e) requires that only circuit-breaker-type overcurrent devices be used for all circuits except extra-low-voltage circuits.

### Rule 70-114 Wiring methods — General

Rule 70-114 references Rules in other Sections of the Code, such as Sections 2, 12, and 16, that apply to the selection and use of wiring methods. In determining the correct wiring method, the principal concern is that relocatable structures are designed to be moved from site to site. To address the potential problem of mechanical damage due to vibrations, wiring must be kept away or protected from sharp edges and burrs that might compromise the integrity of the insulation on the conductors.

### Rule 70-116 Wiring methods — Swing-out and expandable room sections

Some mobile homes and mobile commercial and industrial structures have swing-out or expandable room sections. Rule 70-116 specifies a procedure for establishing electrical connections between such sections and the main body of the relocatable structure. The requirements vary from the general requirements in other Sections of the Code because electrical connections between a swing-out or expandable section and the main unit might have to be disconnected in order to transport the structure.

### Rule 70-120 Branch circuits — Mobile homes

Rule 70-120 covers the installation of special electrical equipment (for example, fresh air supply, exhaust fans, and small pumps) and its connection to branch circuits in a mobile home. Additional outlets — such as fans or permanent luminaires — but not receptacles may be connected to circuits that supply permanently connected appliances, provided that these appliances are not:

- heating and cooking appliances exceeding 1500 W;
- storage-tank water heaters;
- fossil-fuel (that is, gas or oil) heating equipment; or
- electric heating equipment.

Subrule 2), which is similar to Rule 8-304, restricts the number of outlets that can be connected to a circuit by setting a limit for the assumed total loads.

Subrule 3) provides an exemption from the continuous rating of loads in Rule 8-104 for electric water heaters sized 1500 W or less at 115 V, or 3000 W or less at 230 V. These units are smaller than standard commercial or residential water heaters, so their load cycles do not present the same heating and termination connection problems as the larger units.

Subrules 1) and 2) of Rule 62-110 require that combination oil or gas heating and ventilating equipment be considered heating equipment and, as such, be connected on a separate branch circuit used only for that particular piece of equipment.

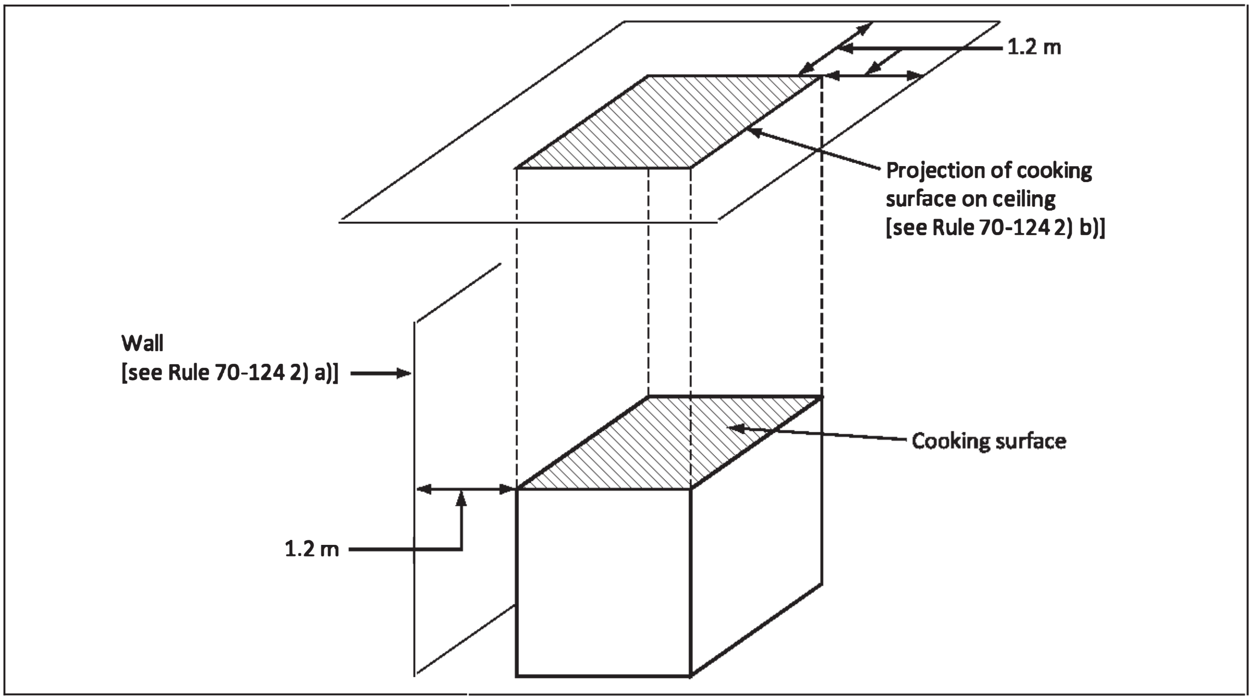
### Rule 70-122 Receptacles, switches, and luminaires

Rule 70-122 refers to requirements in Sections 26 and 30 related to receptacle mounting heights and location, as well as luminaire controls and guarding. Rule 26-722 requires that all outdoor receptacles mounted within 2.5 m of grade level be protected by a Class A GFCI, with the exception of receptacles used for automobile heaters. However, Subrule 4) requires that, when a receptacle is installed on the underside of a mobile home to supply heating cable sets in order to prevent plumbing pipes from freezing, the receptacle be provided with ground fault protection that has a ground fault setting sufficient to allow normal operation of the heater, and be labelled in a conspicuous, legible, and permanent manner, identifying its purpose.

### Rule 70-124 Ventilating fans used in kitchen areas

The lower ceiling heights and smaller floor areas in relocatable structures make it necessary to restrict the type of fan motor used in the ventilation airstream in an area containing cooking equipment. Fan motors in the airstream around cooking equipment can become coated with grease and other combustible materials, and some types of motors can be a fire hazard. Rule 70-124 specifies the dimensions of the area above or in the vicinity of cooking equipment (see Figure 70-2) and requirements for fan location and type in such areas.

**Figure 70-2**
**Cooking equipment area**




## Rule 70-126 Grounding and bonding

While Section 10 sets out general requirements for grounding and bonding, Rule 70-126 elaborates on the required procedures. Because relocatable structures are towed from one site to another, they are often isolated from the surface of the earth by rubber tires, or they might contact the earth only in a few places where supports are used. Therefore, take special care to ensure proper grounding and bonding. Rule 70-126 requires that all exposed metal parts including metal roofs, metal exterior coverings, and metallic water, gas, and waste systems be in good electrical contact. This reduces the shock hazards for people in contact with the earth who might also come into contact with the structure.

Item b) of Subrule 5) permits the grounding and bonding connection terminals to be used for bonding the mobile home or recreational vehicle skin (siding) to its grounded chassis.

Subrule 7) specifies the requirements for bonding the metal chassis to which all exposed metal parts of the relocatable structure are connected. The bonding conductor from the metal chassis connects to the:

- neutral terminal of the service box (disconnect) for mobile homes and other types of relocatable structures that have service equipment; or
- bonding terminal in the distribution equipment for structures other than mobile homes.

Subrules 8) and 9) provide specific requirements for the size, type, location, and mechanical protection of bonding conductors.

## Rule 70-128 Marking

Rule 70-128 stipulates a standard location for all markings, which is an important requirement for multiple-section mobile homes and relocatable structures. The information provided by the markings must be in accordance with the requirements of Rule 2-100 and should be sufficient to allow for proper installation, maintenance, troubleshooting, and repair.

Markings required by Rule 70-128 are placed on the main section of a multi-section unit. If it is not clear which is the main section, it can be assumed to be the section that has the main or primary service panelboard.

### Rule 70-130 Tests

Since not all standards require continuity and insulation resistance testing, Rule 70-130 requires that factory-installed electrical systems in mobile homes and mobile commercial and industrial structures be tested to ensure that the systems are in good working condition and free from shorts and grounds. Continuity and insulation resistance tests must be performed on the completed assembly at the factory. Rule 70-130 specifies critical testing criteria.

The Appendix B Note to Rule 70-130 adds precautions, as testing can damage some special electrical equipment.

## Non-relocatable structures (factory-built)

### Rule 70-202 Connection to overhead and underground supply

Non-relocatable structures are not intended to be moved from place to place but are factory-built at an off-site location and then moved to their final location. Information about the intended electrical requirements, including whether the service supply is overhead or underground, must be supplied to the factories where such structures are built.

The minimum service size is to be determined in accordance with the Rules of Section 8. Where additional services are required for a factory-built non-relocatable structure, the requirements of Rules 6-102 and 6-200 apply.

### Rule 70-204 Service and distribution equipment

Provision must be made for the installation of a service box or other electrical service equipment in the building structure, either at the factory or on site. Electrical service and distribution equipment must be:

- in a readily accessible location inside the building;
- as close as practicable to the point where the service conductors enter the building; and
- located within each unit in cases where the structure is a multiple-occupancy residential condominium or row house, or in all other cases, in a central location accessible to all occupants.

Each complete structure must have its own electrical distribution equipment.

# Section 72 — Mobile home and recreational vehicle parks

## Scope and application

**Rule 72-000 Scope**

Section 72 includes additional and specific requirements for electrical installations in mobile home and recreational vehicle parks. Mobile homes and recreational vehicles include a variety of factory-built, relocatable structures that are either towed or self-propelled on their own chassis and that have provisions for connecting to an electrical supply. Electrical connections to commercial and industrial trailers or vehicles are not covered by Section 72 because they are not moved as frequently and are usually direct-connected, not cord-connected. Connections to commercial and industrial trailers or vehicles are covered in the general Rules of the Code.

## General

A mobile home and recreational vehicle park is property divided into lots. Each lot is intended to serve a single mobile home or recreational vehicle and is equipped with an electrical receptacle to provide the power to a mobile home or recreational vehicle.

**Rule 72-102 Demand factors for service and feeder conductors**

Service and feeder conductors must have sufficient ampacity for their intended use. Rule 72-102 specifies requirements for the sizing of service and feeder conductors in mobile home parks and in recreational vehicle parks.

A mobile home is defined in CAN/CSA-Z240.0.1 as a transportable single- or multiple-section single dwelling. Subrule 1) requires that the service or feeder conductors supplying an individual mobile home be sized in accordance with Rule 8-200 and service or feeder conductors supplying two or more mobile homes be sized in accordance with Rule 8-202.

Recreational vehicles — which include camping trailers, fifth-wheel trailers, motor homes, slide-in campers, and travel trailers — typically have lower power requirements. Subrule 2) requires that service and feeder conductors serving recreational vehicles be sized on the basis of the ampere rating of the receptacles used to supply the vehicles and lists the demand factors to be applied to receptacles on multi-wire branch circuits and lots with multi-receptacle installations.

Subrule 3) requires that, when calculating the load for a recreational vehicle park, each duplex receptacle supplied by a multi-wire branch circuit be considered two receptacles because two recreational vehicles often plug into the same duplex receptacle.

The individual lots of a recreational vehicle park are commonly supplied with both a 30 A and 15 A receptacle. Subrule 4) requires that the receptacle with the highest rating on a recreational vehicle lot be used as the basis for the demand calculation because it is unlikely that the demand will exceed the rating of the largest receptacle, even if all receptacles are in use (see Table 72-1).

## Table 72-1
## Method to determine minimum size of service or feeder conductors or cable

| Step | Method |
|---|---|
| 1 | Determine the ampere rating and the voltage rating of each type receptacle connected in the circuit. |
| 2 | Convert the ampere rating of each type of receptacle connected in the circuit to a rating in watts as follows:<br>• for single-phase receptacles, multiply the receptacle's ampere rating by its voltage rating; and<br>• for three-phase receptacles, multiply the product of the receptacle's ampere rating and its voltage rating by 1.73. |
| 3 | Determine the calculated load for the receptacles connected in the circuit by adding the following:<br>• the sum of the load in watts of the first 5 receptacles having the highest rating, multiplied by 1.00;<br>• the sum of the load in watts of the next 10 receptacles having the same or next smaller rating, multiplied by 0.75;<br>• the sum of the load in watts of the next 10 receptacles having the same or next smaller rating, multiplied by 0.50; and<br>• the sum of the load in watts of the remaining receptacles, multiplied by 0.25. |
| 4 | Determine the load in watts of other calculated loads (not receptacles connected in the circuit) in accordance with the applicable Rules of the Code for such loads. |
| 5 | Determine the load in watts for equipment loads, not deemed to be calculated loads or receptacle loads (see definition of *calculated load* in Rule 8-002), connected in the circuit. |
| 6 | Calculate the total load in watts connected on the circuit by adding together the total loads from Steps 3, 4, and 5. |
| 7 | Calculate the total value of all continuous calculated loads connected in the circuit that are specified in Steps 3 and 4 (see Rule 8-104). |
| 8 | Calculate the total of all non-continuous and equipment loads connected on the circuit by subtracting the total continuous calculated load (Step 7) from the total load in watts (Step 6). |
| 9 | Determine the continuous operating rating of the fusible switch or circuit breaker used in the circuit (see Rule 8-104). |
| 10 | Determine the wiring method for the installation of the circuit conductors used for the circuit (that is, single conductor in free air or in raceways, multi-conductor cables, or direct buried) to determine the conductors or cable ampacity rating in Section 4. |
| 11 | Determine the demand factor from Subrules 5) and 6) of Rule 8-104 using the continuous operating rating of the fusible switch or circuit breaker used in the circuit (Step 9) and the method used to determine the conductor's or cable's ampacity rating (Step 10). |
| 12 | Calculate the minimum continuous calculated load to be added to the total load for the circuit by applying the demand factor from Subrules 5) and 6) of Rule 8-104 to the total continuous calculated load calculated in Step 7. |
| 13 | Determine the total circuit load in watts by adding the values from Steps 8 and 12. |

*(Continued)*

## Table 72-1 (Concluded)

| Step | Method |
|---|---|
| 14 | Calculate the total circuit load in amperes using the total wattage from Step 13 and voltage ratings (see Steps 1 and 2). |
| 15 | Determine the minimum standard size of the circuit overcurrent protection device from manufacturer's tables [see Subrule 2) of Rule 8-104]. |
| 16 | Determine the minimum size of conductor or cable [see Rule 4-004, Rule 4-006, Subrule 2) of Rule 8-104, and Rule 14-104]. |

### Rule 72-104 Feeders

Feeders when not used as service conductors in recreational vehicle parks are allowed to be installed in accordance with the appropriate requirements for service conductors provided in other Sections of the Code (for example, see Rules 6-300 and 6-302).

### Rule 72-106 Overcurrent devices and disconnecting means for recreational vehicles

Recreational vehicle lots serve many types of units, including camping trailers, fifth-wheel trailers, motor homes, slide-in campers, and travel trailers. To ensure that any problem affecting a single unit is confined to that unit, Rule 72-106 requires that the branch circuit for each receptacle for a recreational vehicle lot have its own overcurrent device and an accessible disconnecting means.

### Rule 72-108 Overcurrent devices and disconnecting means for mobile homes

The supply circuit for each mobile home lot must have a means of disconnection and overcurrent protection that does not exceed the rating of the equipment involved. Subrules 2) and 3) require that the disconnecting means be accessible and, where installed in an outdoor location, be in an enclosure of weatherproof construction.

### Rule 72-110 Connection facilities for recreational vehicles and mobile homes

Mobile homes and recreational vehicles move from one park to another on a frequent basis, and they must be connected to the electrical system at each site in a safe manner.

Subrule 1) specifies those receptacles that are commonly used in equipment and installations. Diagram 1 and the Appendix B Note to Rule 72-110 provide additional information on the receptacle configurations listed in Subrule 1). These receptacle configurations are:

- 15 A, 125 V, 2-pole, 3-wire Type 5-15R receptacle;
- 20 A, 125 V, 2-pole, 3-wire Type 5-20R receptacle;
- 30 A, 125 V, 2-pole, 3-wire Type TT-30R receptacle; and
- 50 A, 125/250 V, 3-pole, 4-wire Type 14-50R receptacle.

Larger mobile homes, due to their larger calculated load, sometimes require a permanent connection rather than a cord connection to a receptacle. Subrule 2) requires that each mobile home lot have provision for a permanent connection to a mobile home. An exception is made for mobile homes that have a main overcurrent protection of 50 A or less, as connecting or disconnecting under load will not result in an arc that is dangerous. These may be cord-connected to a 50 A, 125/250 V, 3-pole, 4-wire Type 14-50R receptacle where a deviation has been permitted in accordance with Rule 2-030.

Subrule 3) requires that receptacles that are not mounted horizontally be oriented so that the U-ground slot of the receptacle is in the uppermost position. This helps prevent an unsafe condition if the cord has been in service for a period of time and partially separates from the receptacle. With the U-ground slot in the uppermost position, it is the grounded blade of the plug that could become exposed rather than the plug blades of the live circuit, thus avoiding a potential shock hazard.

Subrule 4) requires that all Type 5-15R and Type 5-20R receptacles be protected by a Class A GFCI to prevent a shock hazard.

### Rule 72-112 Power supply cords

Subrule 1) requires that power supply cords for recreational vehicles not be subject to physical damage or extended periods of use since they might not be inspected regularly for damage.

Subrule 2) permits mobile homes to be connected using cords or cord sets only where the mobile home lot is equipped with a 50 A, 3-pole, 4-wire Type 14-50R receptacle and a deviation has been granted in accordance with Rule 2-030.

# Section 74 — Airport installations

## Rule 74-000 Scope

Section 74 includes additional and specific requirements for airport visual aid systems, including runway, taxiway, and approach lighting. A separate Section is required because of the special electrical characteristics of the series-type visual aid circuits used in airport installations and the burial depth of their associated cables.

A series-type visual aid circuit uses a constant current and variable voltage source to supply electrical energy to the connected loads. This is different than the more common use of constant voltage, variable current circuits. The constant current regulator, isolation transformer, and series circuit wiring are the three major components of series-type visual aid circuitry.

Series-type circuitry also differs from common-use circuitry because the supplying constant current regulator does not respond to short-circuits and ground faults. These types of faults are not designated as abnormal conditions that cause the circuit to be interrupted (de-energized by a protective device) but as variations in load so the circuit can remain energized. Therefore, a single ground fault does not affect the overall operation of the series-type visual aid system. When two or more ground faults occur, they result in the loss of only a portion of the series-type system equipment or a reduction in the intensity of airport visual aids in that portion of the circuit. Open circuits, however, are seen as abnormal so that when an opening occurs in the primary circuit it presents a load of very high impedance. The regulator will attempt to compensate by increasing its output voltage, which can cause damage to electrical equipment and shock hazards to personnel unless the system is automatically de-energized by the regulator’s protective devices.

The role of the constant current regulator is to adjust output voltage in order to maintain a constant current as loads change. Since the circuit has a constant current throughout, each load receives power equally and each visual aid operates at the same brightness. As a result, there is no brightness variation due to voltage drop, as would be expected with constant voltage circuits. To lower the brightness, simply lower the output current of the constant current regulator. The reason for illumination control is to allow adjustments for both good and poor visibility conditions (see Table 74-1). In fact, constant current regulators (used for airport visual aid applications) with three- and five-step brightness controls are widely available on the market for this purpose.

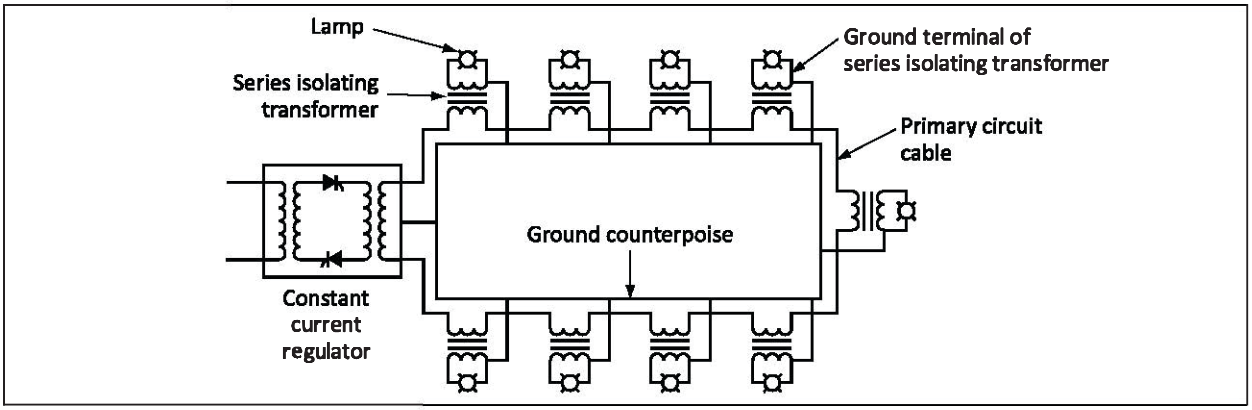
For example, when an aircraft pilot needs help identifying the airport runway, the illumination level needs to be high. But as the aircraft approaches the airport, the pilot might ask air traffic control to lower illumination to a more comfortable level for final approach and landing. When airports do not have a control tower, or if an air traffic controller is not available, the pilot accomplishes the on-off and brightness control of the systems through air-to-ground radio.

**Table 74-1**
**Examples of visual aid intensity levels**

| Visual aid intensity setting | % of effective lumination | Regulator output current (A) |
|---|---|---|
| 1 | 0.2 | 2.1 |
| 2 | 1 | 3.4 |
| 3 | 5 | 4.1 |
| 4 | 25 | 5.2 |
| 5 | 100 | 6.6 |

A series-type lighting circuit with isolating transformers and ground counterpoise is shown in Figure 74-1.

**Figure 74-1**
**Airport series-type visual aid system**




## Rule 74-002 Special terminology

The definitions in Rule 74-002 apply only to Section 74.

A *ground counterpoise* is a conductor that is installed above the underground series circuit conductors to provide a means for interconnecting all items listed in Subrule 3) of Rule 74-010. The counterpoise conductor is also used to protect the series-type circuit conductors buried below it from direct lightning strikes. It also provides an immediate point of grounding for cables subject to ground faults. The counterpoise conductor lessens but does not prevent the possibility of damage. If the cables of two circuits are damaged and electrically bonded together by a ground fault, the damaged circuit can be maintained by voltage from the regulator of the circuit to which it is linked. Therefore, all circuits must be de-energized when repairs are made.

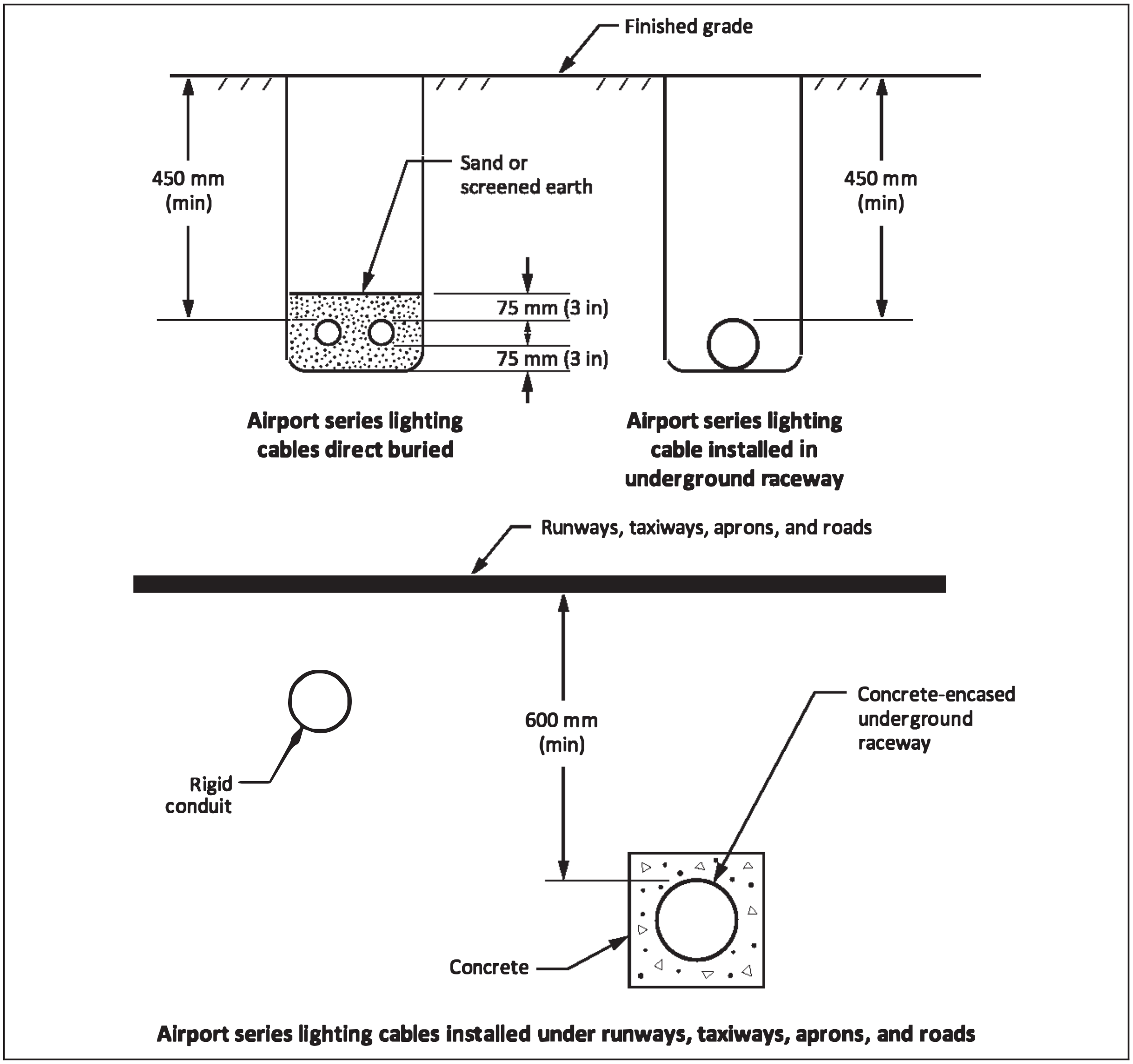
**Note:** *A series-type circuit is designed so that neither the output terminals of the constant current regulator nor the primary winding of isolating transformers is bonded to ground. However, a grounding network is provided for the secondary side of the isolating transformers by a network that includes a ground anchor and a ground counterpoise (see Figure 74-1).*

## Rule 74-004 Wiring methods

Airport series-type visual aid systems use a special type of cable called airport series lighting cable (ASLC), which is manufactured and certified under CSA C22.2 No. 179. ASLC is intended for use above and below ground, in dry or wet locations, in accordance with the Rules of the *Canadian Electrical Code, Part I*, at a nominal voltage of 5000 V and a maximum temperature of 90 °C.

The public areas of airport underground installations are to meet the requirements in Rule 12-012 and Table 53. However, airport maintenance personnel cannot use the large mechanized digging apparatus commonly used in other industrial applications, as it cannot be readily removed from the airfield and presents a hazard to aircraft. Rule 74-004 intends to facilitate quick access to buried conductors, particularly in frozen soil during winter months. Subrule 3) allows for a shallower burial depth in airport areas not accessible to the public, such as runways, taxiways, and aprons, to allow for the timely repair of failed conductors. Figure 74-2 illustrates the wiring methods and burial depths to be used for the installation of airport series-type visual aid systems.

## Figure 74-2
## Burial depths to be used for the installation of airport series-type visual aid systems

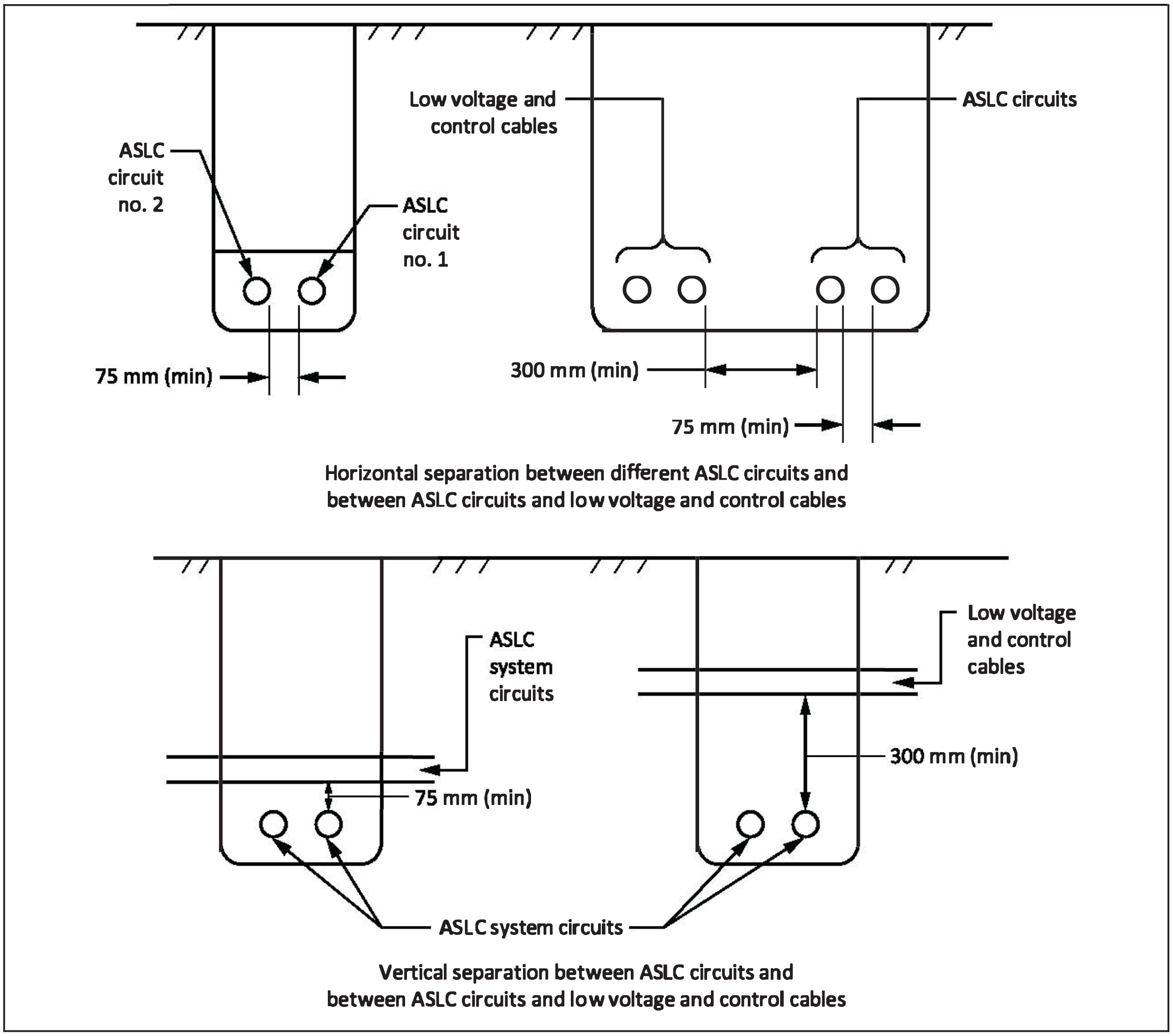



Where ASLC is embedded in a concrete or asphalt surface, Subrule 4) requires that it be installed in a raceway to allow easy replacement and timely repair. This will prevent flight diversions that can result in significant costs and inconvenience to the public. The Appendix B Note to Rule 74-004 cautions designers and installers that:

- the installation of raceways within the material of the airport runways, taxiways, or aprons should not cause damage to the surface material;
- the installation should be designed by a civil engineer following good engineering practices; and
- the design should be acceptable to the airport authorities.

In a series-type system, the occurrence of a ground fault does not cause the regulator to turn off, and the current, following the path of least resistance, continues to flow through the point of failure. A low-resistance path can be created by wet soil or, in dry soil, by the cable insulation, which can be burnt by the current (cables that are too close to the affected cable might also be burnt). To limit potential damage, Subrule 5) gives the minimum separations for ASLC as shown in Figure 74-3.

**Figure 74-3**
**Horizontal and vertical underground clearances**




At points where the cable of a series circuit is accessible (e.g., in maintenance holes, transformer housings, etc.), the cable must be identified by a marker that specifies the circuit's origin. Maintenance or service personnel can make safer and faster repairs when they can easily determine the cable's supply point.

### Rule 74-006 Direct burial transformers

In an airport visual aid system, each luminaire is intended to emit the same intensity of light so that a uniform display is presented to aircraft landing or taking off. The luminaires are designed in accordance with the precise requirements of photometric distribution, with a low-voltage lamp filament that is small enough to simulate a point source and that can be easily controlled by lensing. The luminaires are then connected in series, through isolating transformers that provide low voltage to each luminaire from the buried high-voltage supply circuit. Each luminaire is supplied with the same current, regardless of any voltage drops along the cable. The isolating transformer also serves to maintain the operational continuity of the system in the event of lamp failure.

Subrule 1) requires that the series isolating transformers when directly buried in a trench be at a minimum depth of 450 mm to provide adequate protection from damage while ensuring the accessibility to the cables. Quick access is critical because the series isolating transformer is more likely to be the point of a circuit failure than the cables installed between the transformers.

The series isolating transformer is to have no electrical connection between its primary and secondary windings. However, this isolation is defeated when a primary-to-secondary shorting fault occurs. The high voltage of the primary is connected through the short to the low-voltage secondary, causing serious damage and shock potential. Therefore, proper grounding is necessary on the secondary side of the transformer. Subrules 2) to 4) specify requirements for the series isolating transformer's secondary conductors, which must be:

- colour-coded, with one secondary conductor identified;
- polarized, with the identified conductor connected to the larger terminal of a pin-type connector or a receptacle; and
- grounded, by means of a ground counterpoise conductor.

### Rule 74-008 Series lighting systems

Series-type visual aid lighting systems must offer protection against electrical shock hazards and damage to electrical equipment caused by lightning strikes and burning ground faults. To ensure that no difference of potential occurs, an equipotential plane is created by using the ground counterpoise conductor to connect the exposed non-current-carrying metal of the equipment, the accessible electrode of the lamp socket, and the soil upon which maintenance personnel might be standing.

### Rule 74-010 Ground counterpoise

Without a ground counterpoise conductor, primary-to-secondary shorting within the isolating transformer can create a high voltage difference between the lamp socket and surrounding soil. Even if the mounting stake remains in the soil, it would not ground a luminaire that had broken free of it but would remain connected to the transformer secondary, exposing service personnel to a shock hazard if they pick up the luminaire to restore it to its mounting. Therefore, airport series-type visual aid lighting systems must be provided with a counterpoise conductor that is connected to the secondary side of the series isolating transformer as well as to the mounting stake.

Subrule 1) requires that the ground counterpoise conductor:

- be a solid, bare, soft copper conductor so that when installed in the earth it can be bent and flexed when installing it in the trench without damage, or be insulated with green-coloured insulation for identification and to prevent damage to the insulated circuit conductors if it is installed in a raceway underground;
- not be smaller than No. 8 AWG, to ensure that its mechanical strength is suffiicient for the intended use; and
- be resistant to corrosion.

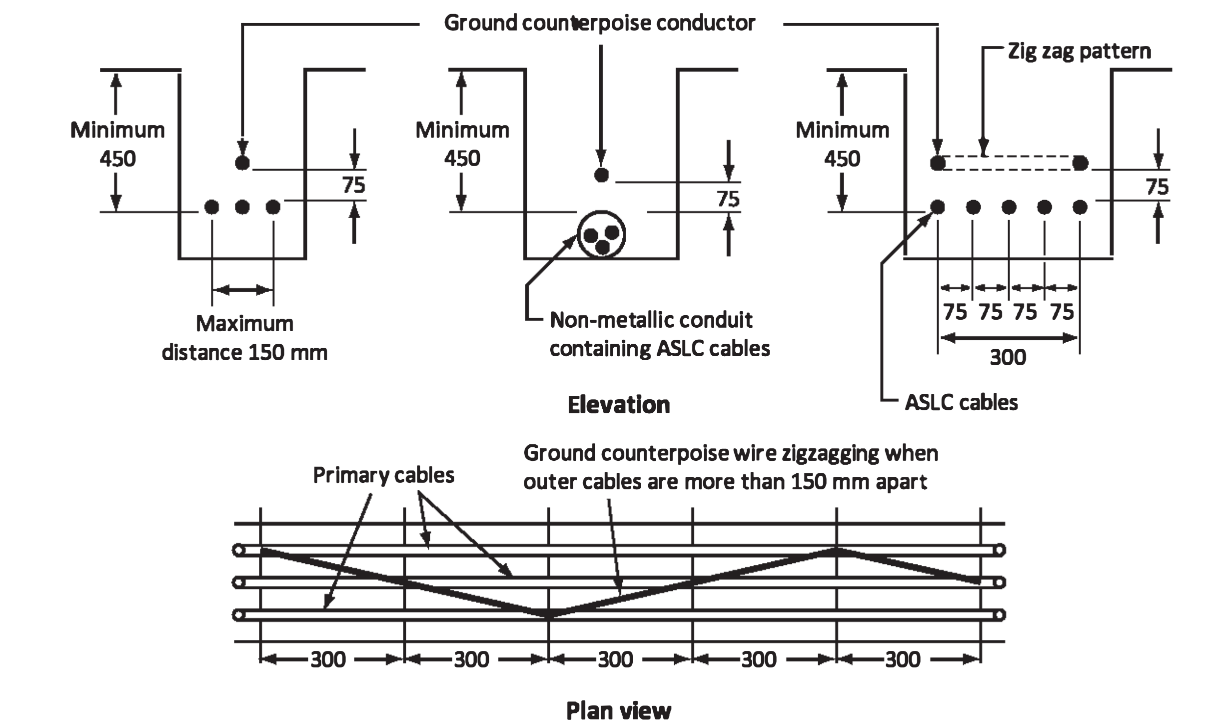
Subrule 2) requires that the ground counterpoise conductor be placed so that it fully covers all the cables in the trench (see Figure 74-4).

The effectiveness of the counterpoise conductor depends on its contact with the soil; therefore, Subrule 2) c) and d) require that it be placed outside, over non-metallic conduit containing airport series-type visual aid conductors and under any covering used for protection from mechanical damage.

In order to create an effective grounding system, Subrule 3) lists the components to which the grounding counterpoise must be connected.

Subrule 4) requires that the counterpoise conductors be arranged as a network. Because the series visual aid lighting system cables are installed at a shallow depth to facilitate timely repair, the counterpoise conductor might not be fully effective at all points on the airfield due to varying moisture content in the soil. Bonding the counterpoise conductors of different systems where they come together or cross each other creates a network that enhances the effectiveness of the grounding system.

**Figure 74-4**
**Cables and ground counterpoise in a trench**




**Note:** *All measurements given are in millimetres.*

# Section 76 — Temporary wiring

## Rule 76-000 Scope

Section 76 includes additional and specific requirements for temporary electrical installations used to provide power for lighting, power, tools, heating, etc., in building structures or other premises that are under construction or demolition. Section 76 also specifies requirements for temporary electrical installations used to provide power for temporary experimental or testing facilities and similar short-duration installations. Section 76 does not apply to temporary installations of electrical equipment in amusement parks, midways, carnivals, film and TV sets, TV remote broadcasting locations, home shows, live theatre, and travelling shows that are held indoors, outdoors, or in tents. These installations are covered in Section 66.

The wiring methods for permanent electrical installations are often impractical, and in some cases impossible, to follow in temporary installations, where wiring methods need to be:

- portable;
- flexible; and
- easily modified.

The challenges presented by temporary installations are different from those associated with permanent installations. For example, extra-hard-usage flexible cords are required because they offer more flexibility/durability than cables used in a permanent installation.

## Rule 76-002 Conductors

As temporary wiring can be subjected to excessive abuse and severe environmental conditions, Rule 76-002 requires that conductors be:

- the appropriate type for the conditions of use specified in Section 12;
- portable power supply cables of the extra-hard-usage outdoor type; or
- flexible cords of the extra-hard-usage outdoor type.

All conductors used in installations covered by Section 76 are to be insulated; however, bare conductors may be used for neutral conductors in services and grounding conductors.

Overhead conductors are often used on construction and demolition sites to keep the conductors out of the way of machinery and operations, and to provide the required flexibility necessary at different times during a construction and demolition project. Where overhead conductors are used, Subrule 4) requires the use of suitable supports, spaced at intervals that do not exceed the distances allowed for the type of overhead conductor being used.

## Rule 76-004 Grounding and bonding

Due to the different activities during a construction or demolition project, a reliable grounding and bonding system is required on a temporary installation to provide protection against shock hazards and to allow overcurrent devices to perform their necessary function of clearing faults on the system. As a result, Rule 76-004 requires that all bonding and grounding be in accordance with Section 10 with no deviations.

## Rule 76-006 Service entrance equipment

Service entrance equipment, especially in temporary installations, must be in a location that is free from environmental hazards, moving equipment, and other operations that might have an impact on the equipment. If this equipment is damaged, fire or shock hazards can result. A large number of people often work in the immediate vicinity of electrical equipment on a construction or demolition project; when they are working in adverse conditions, there is an increased probability that a fault condition in improperly located or maintained service equipment will create an electrical shock hazard.

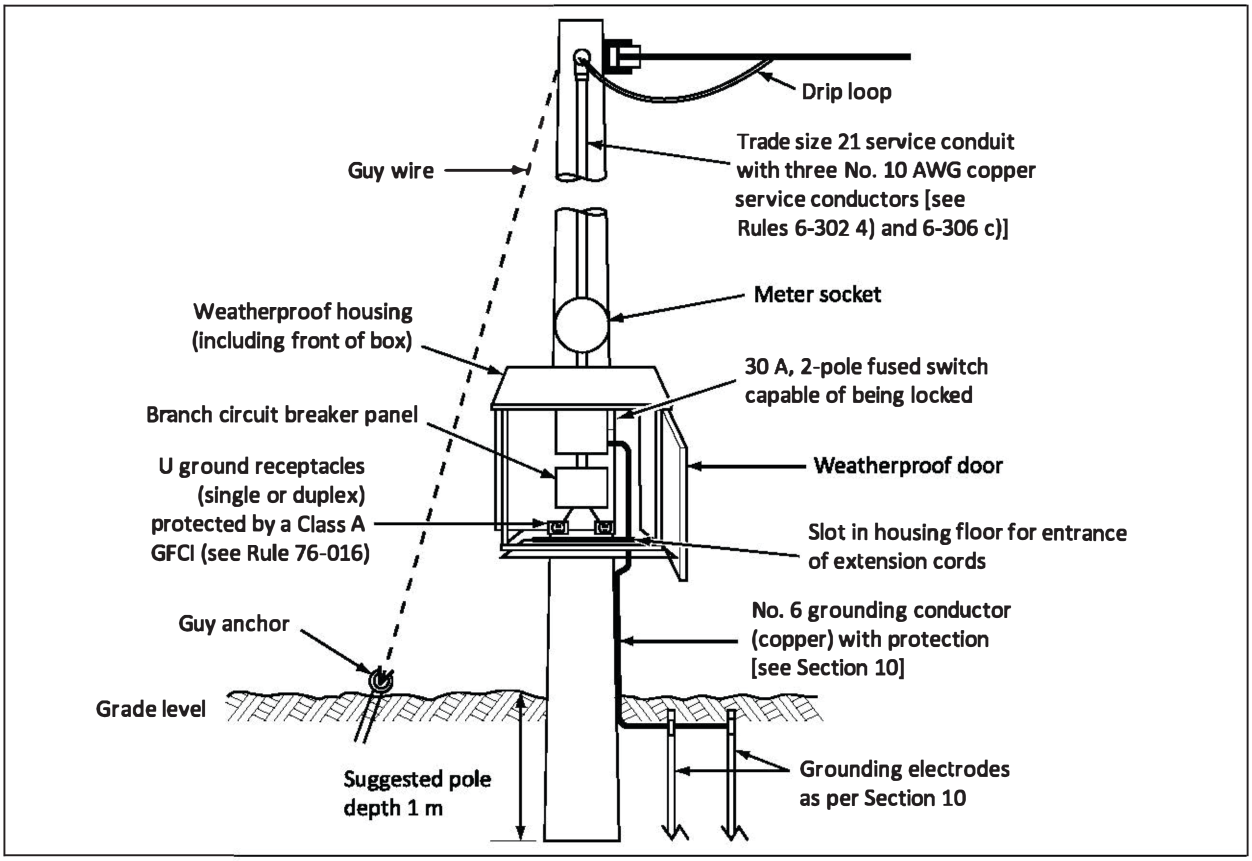
Rule 76-006 requires that service entrance electrical equipment located outdoors be:

- inaccessible to unauthorized personnel;
- lockable, to prevent access by unauthorized personnel, especially after working hours;

- protected from weather and mechanical damage; and
- where mounted on a single pole, no larger than a 200 A service (anything larger than a 200 A service is too heavy and/or large for single-pole support).

Figure 76-1 illustrates a typical installation.

**Figure 76-1**
**Typical temporary service installation**



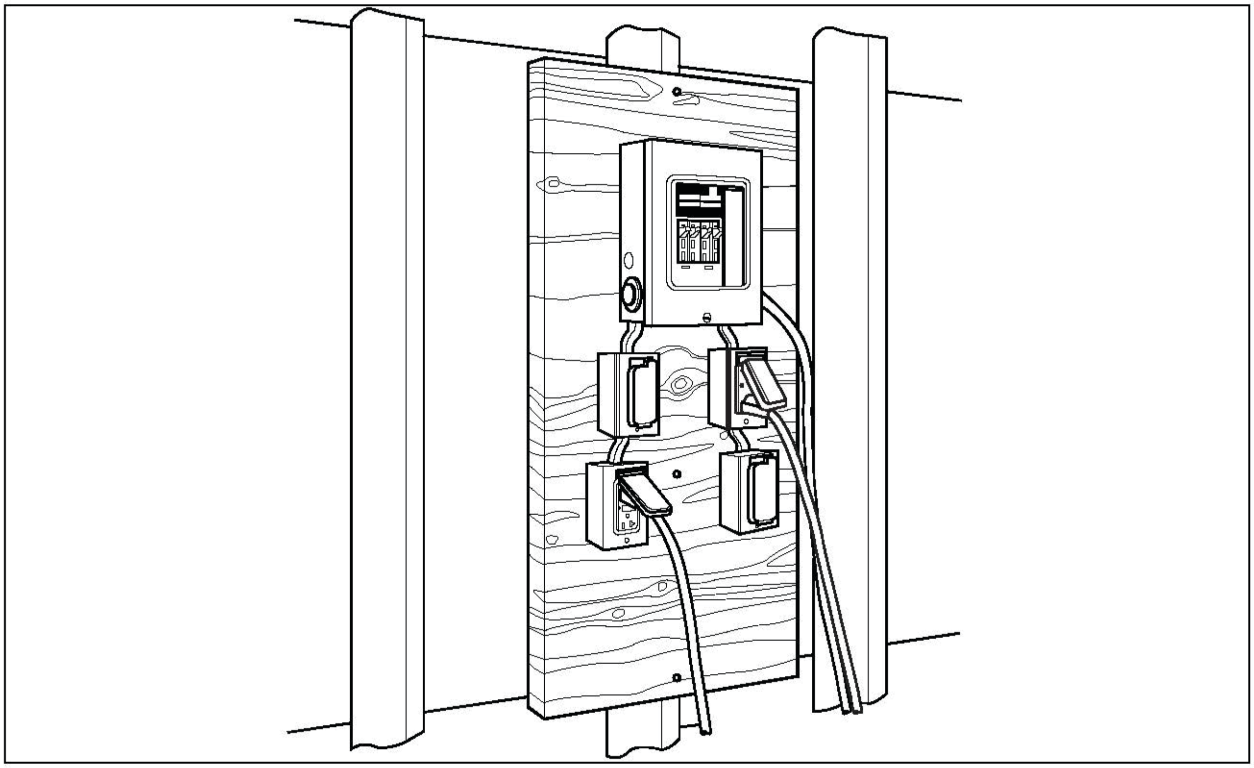

## Rule 76-008 Distribution centres

Distribution equipment must be suitably located and maintained. It is generally used to connect electrical tools and equipment by a variety of workers, some of whom are not trained or qualified in the use of electrical distribution equipment. It is also subject to misuse after working hours, as work sites are often not well secured. Damage to a distribution centre can create fire and shock hazards.

Rule 76-008 requires that distribution electrical equipment be:
- located in a weatherproof building or in a weatherproof enclosure;
- mounted in the erect position; and
- be sized adequately and with sufficient branch circuits for the types and sizes of loads that will be connected to it.

Distribution centres must also be protected from mechanical damage, controlled by a disconnecting means, and protected by an overcurrent device. Figure 76-2 shows a typical installation.

**Figure 76-2**
**Indoor temporary distribution centre**



### Rule 76-010 Feeders

Feeders supplying distribution panelboards require protection from mechanical damage due to the locations in which they are typically installed. Rule 76-010 requires armoured cables or cables with equivalent mechanical protection to be used as feeders. An exception in Subrule 2) allows extra-hard-usage outdoor-type flexible cord or portable power cable to be used for portable panelboards.

Subrule 3) requires feeders to be protected from mechanical damage, controlled by a disconnecting means, and protected by an overcurrent device.

### Rule 76-012 Branch circuits

Subrule 2) requires that lighting not be connected to power branch circuits. This prevents safety hazards that result where an overload or a fault in a cord or in equipment causes the overcurrent device to trip, leaving a worker in an unlit or dark area.

Luminaires used to supply lighting for workers are often moved from place to place on a work site and are subject to damage from wind, materials, and equipment. To prevent shock and fire hazards from lampholders and luminaires, Subrule 3) requires that the installation comply with the requirements of Section 30.

On construction and demolition projects, luminaires are often used for long periods of time, so the lighting loads are considered to be continuous loads. Subrule 4) requires that the maximum connected lighting load not exceed 80% of the circuit breaker rating. Also, to prevent oversizing and to allow for the resetting of tripped lighting overcurrent devices by untrained individuals, only circuit-breaker-type overcurrent devices are to be used.

### Rule 76-014 Interconnections

Temporary electrical installations must not be connected to the permanent circuits of a building, ensuring that a circuit cannot be energized by two separate power sources (the temporary and the permanent source). Such connections present a shock hazard to workers who might think the new installation is not connected to a power source.

Rule 76-014 allows exceptions by special permission from the authority having jurisdiction. These exceptions are limited to certain clearly marked circuits and before the permanent power source is energized, as the temporary supply must be removed.

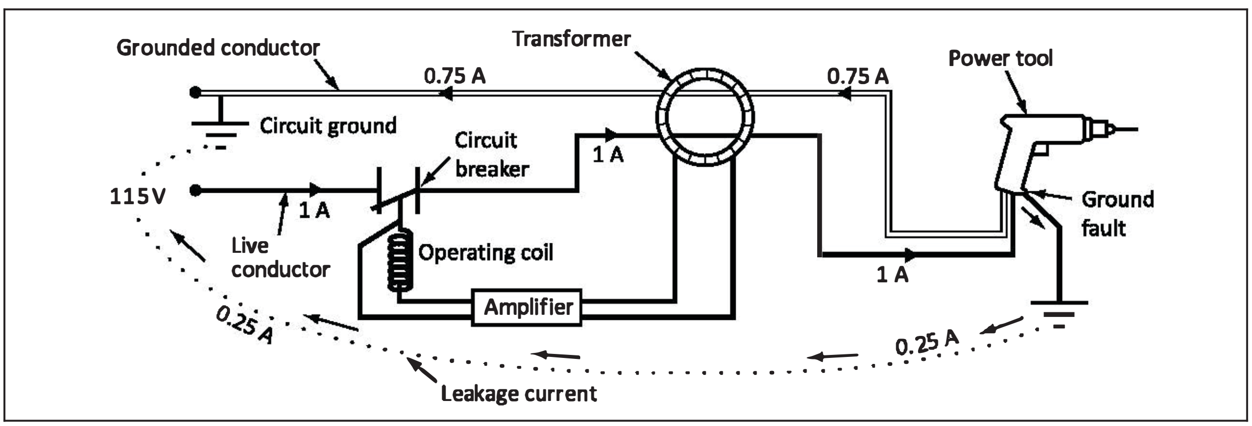
## Rule 76-016 Receptacles

Long runs of extension cord or long assemblies of connected short extension cords are often used on construction or demolition sites. These lengths increase the impedance of the bonding conductor.

One way to reduce the impedance of the bonding conductor in extension cords is to use extension cords with larger conductors; however, larger extension cords also result in extra weight and higher cost. Not all workers are informed about the potential shock hazards of long lengths of flexible cords or the increased potential for damage to cords and equipment caused by changing site and environmental conditions. In addition, unstable grounding conditions caused by site and environmental conditions can create areas where workers are using electrical equipment with a bonding conductor connected to the electrical system that could have a higher resistance to ground than the potential to ground at a different area on the site. Thus, Rule 76-016 requires that receptacles on a construction or demolition site having CSA configurations 5-15R or 5-20R be protected by a Class A ground fault circuit interrupter (GFCI).

A GFCI monitors the leakage current on circuits supplying long runs of extension cord by measuring the current flowing out on the live (black) conductor and the current returning on the identified (white) conductor (see Figure 76-3). When the leakage current is greater than 5 mA (which, due to manufacturer's tolerances, includes all values between 4 and 6 mA), the GFCI de-energizes the circuit. Leakage currents less than 4 mA are not considered potential shock hazards. For a more detailed explanation, see Section 10 requirements for GFCI protection.

**Figure 76-3**
**Example of a ground fault circuit interrupter**



# Section 78 — Marine wharves, docking facilities, fixed and floating piers, and boathouses

### Rule 78-000 Scope

Section 78 includes additional and specific requirements for the installation of electrical equipment and wiring methods on marine wharves, fixed or floating piers, docking facilities, and boathouses that are used for construction, repair, storage, launching, berthing, and fuelling of watercraft.

### Rule 78-002 Special terminology

The definitions in the Code help to clarify the intent of the requirements and are to be consulted regularly. The following definitions clarify the terminology used only in Section 78:

- boathouse;
- docking facility;
- fixed pier;
- floating pier; and
- marine wharf.

## General

### Rule 78-050 Receptacles

Subrule 1) requires that all receptacles installed outdoors to supply shore power to boats, as well as all receptacles on fixed or floating piers, docking facilities, marine wharves, or boathouses, fulfill the following conditions:

- for 15 A or 20 A receptacles, the CSA configuration for non-locking and locking receptacles shown in Diagrams 1 and 2 is to be used;
- for receptacles rated over 20 A up to 60 A, the CSA configuration for locking receptacles shown in Diagram 2 or a pin-and-sleeve-type configuration is to be used; and
- for receptacles rated over 60 A, a pin-and-sleeve-type receptacle is to be used.

This provides for a wide range of loads and ensures consistent connection facilities at all marine wharves, structures, and docking facilities.

Subrule 2) requires that receptacles used in these areas be made of corrosion-resistant materials and provided with weatherproof enclosures. Even though the enclosure is only required to be weatherproof, it would be a good practice to make sure the enclosure was also made of corrosion-resistant materials to match the receptacle.

Where the receptacles are to be exposed to the weather, Subrule 3) requires that the receptacle cover plates comply with Rule 26-708.

To protect the receptacles from damage, shorting out, and premature failure by being immersed in water, Subrule 4) requires that the receptacles be located above the permanent or maximum normal water level. Subrule 4) also requires that the receptacles be protected from damage or premature failure caused by splashing water, which can be achieved by the use of items such as cover plates, enclosures, barriers, etc.

Since there are potential shock hazards to individuals using equipment connected to receptacles, Subrule 5) requires that all receptacles rated at 125 V, 15 A, or 20 A installed outdoors to supply shore power to boats, and all receptacles on fixed or floating piers, docking facilities, marine wharves, and boathouses be protected by a ground fault circuit interrupter of the Class A type.

Subrule 6) allows an exemption from the receptacle types listed in Subrule 1) where the receptacle configurations are not suitable for the specific application.

## Rule 78-052 Branch circuits and feeders

A branch circuit supplying shore power to electrical equipment on a boat is not to be used to supply power to another boat or the equipment located on another boat. The electrical systems on each boat can differ and a fault on one boat could lead to an interruption of service for the other boat. Therefore, Subrule 1) requires that a separate branch circuit be used to supply each receptacle used to supply shore power to boats and that the branch circuits that supply shore-based facilities not also supply shore power to boats.

Distribution equipment located on fixed or floating piers, docking facilities, and boathouses can present potential shock hazards to individuals using it. Subrule 2) requires that the feeder supplying the equipment provide ground fault protection. Since the Class A type of ground fault circuit interrupter (GFCI) can cause nuisance tripping in this application, the ground fault protection is to have the ground fault setting low enough to allow the normal operation of the distribution equipment and, in no case, greater than 30 mA.

Where ground fault protection is installed in the feeder supplying the distribution equipment for the branch circuits installed in or on fixed or floating piers, docking facilities, and boathouses, Subrule 3) allows additional ground fault protection to be omitted.

## Rule 78-054 Demand factors

The demand factors required for calculating the load to be used to size the minimum feeder or service for receptacles that supply shore power to boats and that are installed on fixed or floating piers, docking facilities, boathouses, or marine wharves is to be based on the ampere rating of the receptacles and the demand factors listed in Subrule 1). These demand factors have been developed through studies and consultation with industry and users.

The Subrule 1) demand factors for receptacles that supply shore power to boats are to be as follows:

- 100% of the sum of the first 4 receptacles having the highest ampere ratings in the group connected on the feeder or service; plus
- 65% of the sum of the ampere ratings of the next 4 receptacles having the same or next smaller ratings in the group connected on the feeder or service; plus
- 50% of the sum of the ampere ratings of the next 5 receptacles having the same or next smaller ratings in the group connected on the feeder or service; plus
- 25% of the sum of the ampere ratings of the next 16 receptacles having the same or next smaller ratings in the group connected on the feeder or service; plus
- 20% of the sum of the ampere ratings of the next 20 receptacles having the same or next smaller ratings in the group connected on the feeder or service; plus
- 15% of the sum of the ampere ratings of the next 20 receptacles having the same or next smaller ratings in the group connected on the feeder or service; and
- 10% ofthe sum of the ampere ratings of the remainder of the receptacles in the group connected on the feeder or service.

Subrule 2) requires that the calculations be based on the ampere rating of the receptacles plus other intended loads and allows the calculations to be used for both single- and three-phase systems.

**Note:** *Rule 78-054 specifies the demand factors in terms of the ampere ratings of the receptacles being used. In practice, however, calculating the size of the service or feeder should begin with the conversion of the ampere ratings of the receptacles into wattage ratings. With this conversion, it is no longer necessary to take into consideration the balancing of the load on each phase at the time of calculation and whether the ampere ratings of the receptacles are line-to-neutral or line-to-line. Once the receptacle ratings have been converted to watts, the demand factors from Rule 78-054 can be applied as required to determine the calculated load and the calculated load can be converted back into amperes, based on the characteristics of the supply system (i.e., single-phase, 2-wire; single-phase, 3-wire; or three-phase, 4-wire).*

## Rule 78-056 Wiring methods

Rule 78-056 requires that the wiring methods used where they are exposed to the weather or to splashing water take into account the possibility of mechanical damage and severe weather conditions, including corrosion from exposure to moisture and splashing water (see Figure 78-1).

Subrule 1) lists the wiring methods to be used.

To allow for tidal movement, or where flexibility is required, Subrule 2) requires the use of an outdoor flexible cord that is suitable for wet locations; that is, at least, hard usage; and that is selected in accordance with Rule 12-402 1).

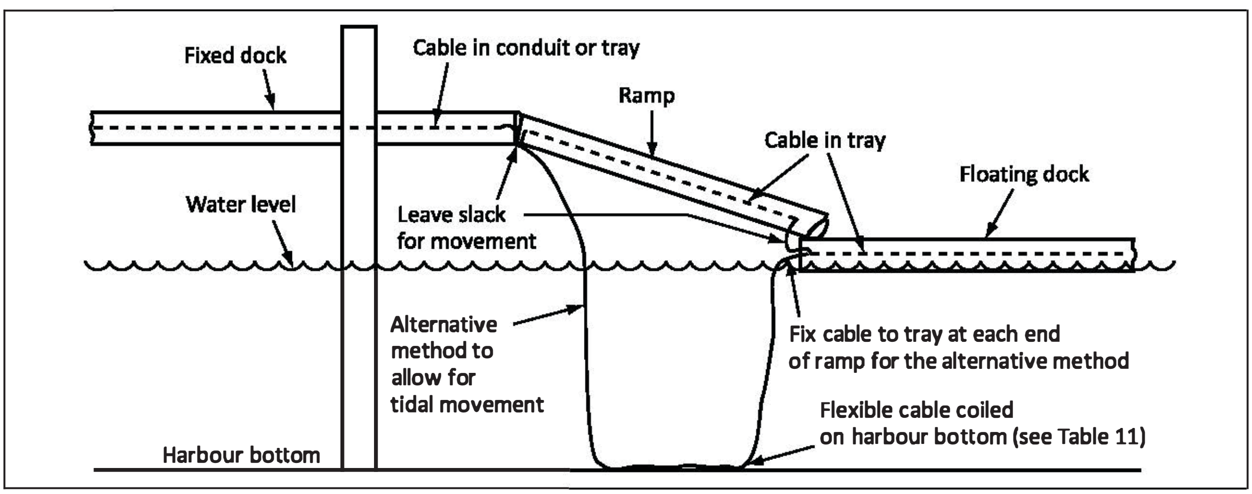
To prevent the flexible cords from being pulled out of the cord connectors, Subrule 3) requires that they be supported at both ends of the cable by a connector capable of gripping the cable. These types of cable connectors are not required where the end of the cable is securely fastened to a structure in which relative motion will not occur.

To avoid mechanical damage to, and interference with the users of, the wharf, pier, or docking facility, Subrule 4) requires that conduit, cable, and overhead wiring be located and installed to avoid such potential damage or interference.

Wave action, ice, storms, and potentially damaging activities and equipment (such as mooring lines or vehicles) can cause damage to conduit, cable, and wiring systems. Subrule 5) requires that these factors be taken into consideration when laying out and installing these systems.

Subrule 6) requires that in order to avoid the failure of fastening hardware used for supporting and securing the wiring methods and equipment, this hardware be made of galvanized steel, stainless steel, PVC-coated steel, brass, or other materials with similar corrosion-resistant properties.

**Figure 78-1**
**Typical route for cable from fixed dock to floating dock**




## Rule 78-058 Grounding and bonding

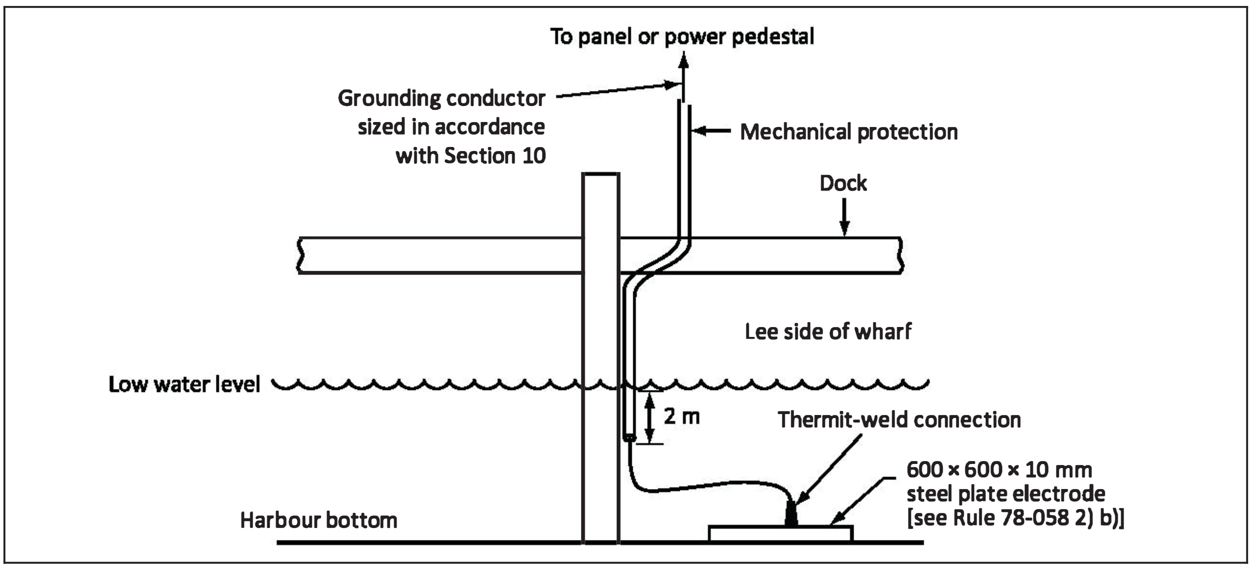
Copper is a material that has excellent moisture- and corrosion-resistant properties when exposed to damp or wet locations or when direct buried in the earth. Due to the moisture and corrosive influences typically found in marine environments, Subrule 1) requires that grounding and bonding conductors of electrical equipment in these environments meet the installation requirements of Section 10, be made of copper, and have a minimum size of No. 12 AWG in areas subject to splashing and salt water or salt spray. This maintains the integrity of the grounding system on all circuits, thereby preventing shock hazards.

For electrical systems on marine wharves located in areas where it is impractical to install a shore-based grounding electrode due to poor earth conductivity, Item a) of Subrule 2) allows an underwater grounding grid on structures with steel pilings where the bases of the pilings are installed on the harbour bottom and continually immersed in salt water, and where the grounding conductor connected to the piling is readily accessible and mechanically protected throughout its length.

Item b) of Subrule 2) allows the grounding conductor to be connected to a 10 mm thick steel plate electrode with a 0.36 $m^2$ area where the structure does not conform to Item a) of Subrule 2) and:

- the grounding conductor is connected to the plate electrode using a thermit-weld connection;
- the grounding conductor is mechanically protected to a point 2 m below the normal low tide elevation; and
- the plate electrode is established on the harbour bottom on the lee side of the wharf, where the lee side is determined from the prevailing winds. See Figure 78-2.

**Figure 78-2**
**Grounding and bonding**




### Rule 78-060 Wiring over and under navigable water

So as not to interfere with boats on navigable waters, the installation of electrical wiring that runs over and under navigable water is to conform to the Government of Canada's *Navigation Protection Act*, R.S.C. 1985, c. N-22.

### Rule 78-062 Gasoline dispensing stations

The areas immediately surrounding docks or other locations where gasoline is dispensed are considered to be hazardous locations and can be subject to explosion and fire.

Gasoline dispensing stations in marine environments are subject to the requirements of Section 20, with the highest water surface considered equivalent to grade or ground level. Water levels can change dramatically in the course of a day and the designated hazardous area is to reflect these changes. While such changes are most prevalent in tidal locations, smaller variations can occur in other water systems, including dams and reservoirs. The requirements of Rule 78-062 are to be considered in all such locations.

### Rule 78-064 Communication systems
Section 60 sets out the requirements for the installation of communication systems and circuits. Rule 78-064 requires that, where communication systems and circuits are installed in a marine environment, the installation conform to Section 60.

## Marine wharves, fixed and floating piers, and docking facilities

### Rule 78-102 Protection of electrical equipment
The activities involved with the docking of vessels, the unloading and loading of vessels, and the operation of wharf equipment and vehicular traffic present potential hazards to the electrical installation and equipment that is required to be on location to support these activities. Subrule 1) requires that all the electrical equipment and associated electrical systems be located to avoid interference with the activities required to be performed in these locations.

Subrule 2) requires electrical equipment to be located:
- above the wharf, pier, or docking facility deck, and protected from wave action, ice, storm damage, and mooring lines;
- in such a manner as to minimize risk of damage from wave action and splashing; and
- to avoid impact with docking vessels and vehicular traffic on the wharf.

Subrule 3) requires that receptacles, communication systems, equipment, and other electrical apparatus that have the potential to be subject to mechanical damage from boats, vehicles, or other apparatus be protected by:
- mounting the equipment in robust shrouds or kiosks constructed of metal, concrete bollards, plywood, or fibreglass; or
- other equivalent methods of protection.

# Section 80 — Cathodic protection

## Rule 80-000 Scope

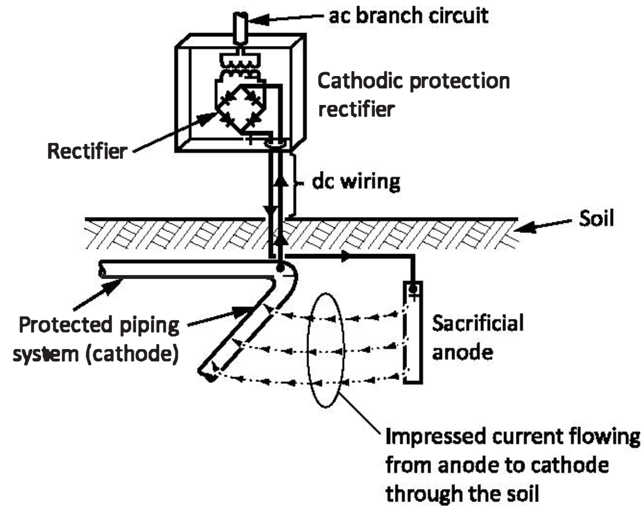
Section 80 includes additional and specific requirements for the installation of impressed current cathodic protection systems. Section 80 recognizes that the wiring methods used in installing such systems are sometimes inconsistent with the requirements of other Sections of the Code. NACE International's industry standards are recommended as guides to the design, specifications for materials, installation, and operation of cathodic protection systems.

Cathodic protection systems are used to prevent the corrosion of metal piping systems, steel pilings, and other underground metal structures. Cathodic protection is also used on above-ground metallic structures that are in an electrically conductive environment. It is a simple method of protection that connects the metal to be protected to a more easily corroded "sacrificial metal", which acts as the anode.

Corrosion is an electrochemical reaction, similar to the operation of an electrochemical cell of a battery, that occurs between two sites (cathode and anode). The metal loss or change to the metal's molecular structure occurs where the current leaves the metal at the anode site and goes into the electrolyte. The corroding area is the anode. The region where the current returns from the electrolyte is the cathode site and usually does not corrode. During this reaction, a current leaves the surface at the anode site by passing through an electrolyte and re-enters the surface at the cathode site. When anode and cathode sites occur, they cause a voltage difference between the two sites on the metal surface so that dc electrical current flows from the metal at the anode site into the electrolyte and back into the metal at the cathode site.

Since cathodic protection systems are used to protect underground metal piping systems, steel pilings, and other underground metal structures, they need to be the cathode, while the electrolyte in these cases is the soil. The soil in these applications is used as the electrolyte for the current flow from the anode to the cathode (see Figure 80-1). Cathodic protection systems also require the introduction of an external "sacrificial" anode(s) where current can be discharged through the soil to the metal surface to be protected (the cathode). This can be achieved by using a dc power source (e.g., a rectifier) and connecting the positive lead to the "sacrificial" anode(s) and the negative lead to the metal surface to be protected (the cathode). The process is designed to force current (called an "impressed current") from the anode(s) to the structure to be protected through the soil. The process typically results in shifting the potential on the structure by 0.5 to 1.0 V to achieve a protected structure. The protected metal structure becomes the cathode, hence the term "cathodic protection".

**Figure 80-1**
**Cathodic protection**




Power supplies having ratings of hundreds of amperes or hundreds of volts are possible. These voltages and currents can reach dangerous levels in larger systems if the cathodic protection system is not properly installed and maintained: for example, if suitable precautions are not taken, when a section of protected pipeline is removed for servicing, a break in the continuity of the cathode can occur and a small difference of potential across the gap can result. This difference of potential is easily avoided by installing a temporary bypass conductor around the removed section to maintain the electrical continuity of the protected structure.

**Rule 80-002 Wiring methods for dc conductors**

Most cathodic protection dc conductors are special conductors that must be direct buried or installed in a direct buried raceway and meet the burial depths specified in Subrule 1). These burial depths may be shallower than the requirements specified in Table 53.

In special cases, such as conductors slotted into paved or concrete pads, Rule 80-002 relaxes the requirements of Section 12, and particularly Rule 12-012 for "Underground installations", as it might not be possible to bury the metal deeply enough to allow the dc conductors to satisfy the burial depth requirements in Table 53.

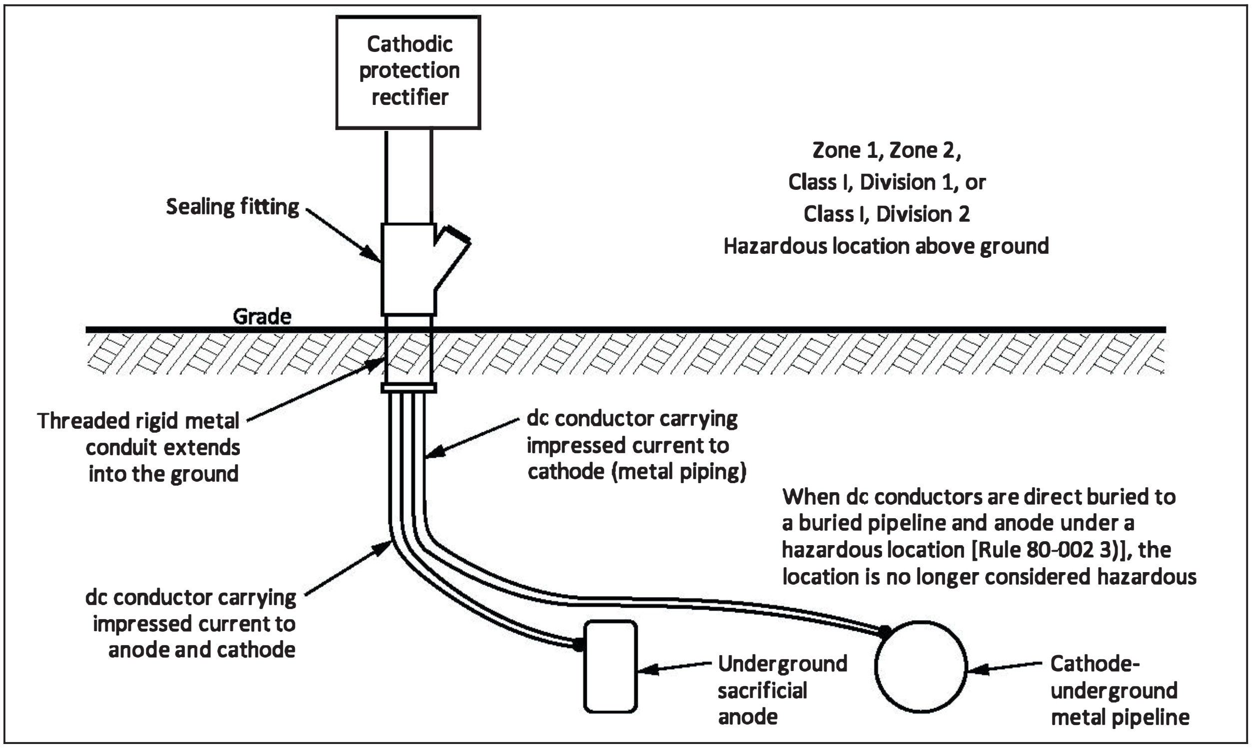
Another reason that the requirements for depth of burial are relaxed is that the voltage on the dc conductors of a cathodic protection system are typically not high enough to constitute a shock hazard to people inadvertently coming into contact with the system components (the dc conductors, the anode, and the cathode). Nevertheless, the electrical energy in the system can still be sufficient to produce an arc that can cause ignition in a hazardous location.

To prevent the dc wiring of cathodic protection systems from becoming a source of ignition, Subrule 2) requires that the dc wiring for the systems installed in hazardous areas conform to the appropriate requirements of Sections 18, J18, 20, and J20. However, because the underground portion of the dc conductor operates at almost ground potential, and the conductor and materials are encased in the earth, it is extremely unlikely for an arc to occur underground that has sufficient energy to cause ignition. Therefore, Subrule 3) indicates that the dc conductors are not considered to be installed in a hazardous location when they are installed in the ground below the Zone 1, Zone 2, and Class I hazardous locations. However, when the dc conductors emerge from the ground, Subrule 3) requires that they be installed in a threaded rigid metal conduit that extends into the ground (see Figure 80-2). Since the area in the ground where the cathodic protection system is installed is a Zone 1, Zone 2, or

Class I hazardous location, the conduit is to be sealed where it emerges from the ground (see Figure 80-2) in accordance with Rules 18-104 for Zone 1, 18-154 for Zone 2, and J18-108 and J18-154 for Class I.

**Figure 80-2**
**DC conductors under a hazardous location**




## Rule 80-004 Conductors

A break in a dc conductor of a cathodic protection system can go undetected for some time. Although such a break does not result in a shutdown or other major disruption, the system provides no protection against corrosion until the break is repaired. If the break goes undetected for a prolonged period, the resulting corrosion could be serious. Subrule 1) requires that conductors smaller than No. 12 AWG not be used for the dc circuits of the cathodic protection system even though the current itself can be carried by a smaller size of conductor. On larger systems that carry larger currents, conductors having the appropriate ampacity must be used. Also, the conductors must be suitable for the conditions of use and selected in accordance with Rule 12-102 3) for the particular location where they are installed.

Subrule 2) allows the use of conductors smaller than No. 12 AWG for circuits that do not actually carry the dc cathodic protection current but are used for system instrumentation and reference electrode leads. The rationale is that these circuits are not essential to corrosion protection, and it can be difficult to connect some instruments to large conductors.

## Rule 80-006 Splices, taps, and connections

Rule 12-112 requires that splices and taps in conductors be accessible. Subrule 1) of Rule 80-006, however, allows splices and taps in the dc cathodic protection systems to be made in the ground where they are not accessible. Item 1) a) of Rule 80-006 requires them to be secure and to remain in place over a long period of time by:

- welding;
- a positive compression tool;

- crimping and soldering; or
- using copper, bronze, or brass cable connectors.

Splices, taps, and connections in the dc conductors that carry the current from the rectifier to the metal that is to be protected should be isolated from the earth so that they carry the negative charge or potential to the point where the protection is required. If the bare conductor is exposed to the earth at some point before reaching the metal to be protected, the exposed conductor splices, taps, and connections will become a cathode and be protected by the cathodic protection system. If the insulation on the positive conductor splices, taps, and connections is compromised, the current will discharge from the exposed area becoming a sacrificial anode and will rapidly corrode to failure. The bare conductor splices, taps, and connections can also be corroded by exposure to moisture. Subrule 1) also requires that splices in the conductor, taps, and connections to piping, tanks, and other structures be secure and sealed against moisture.

Subrule 3) specifies the requirements for connection to metal piping. Subrule 4) specifies the requirements for connections to tanks or other types of structures. Subrule 5) specifies the requirements for sealing against moisture.

The Appendix B Note to Rule 80-006 provides additional information on electrical connections and references CAN/CSA-Z662 regarding welding connections to oil or gas piping.

### Rule 80-008 Branch circuit

Cathodic protection is a passive process that operates without visible evidence that it is working. A primary concern is that the branch circuit supplying the system is as secure against interruption as possible. Rule 80-008 requires that the wiring method for the branch circuit meet the requirements in Section 12 and that nothing be connected to the supply branch circuit except the rectifier so that the circuit cannot be opened by a fault in some other device or interrupted by service work not directly involving the cathodic protection system.

### Rule 80-010 Disconnecting means

The dc portion of a cathodic protection rectifier should not be serviced by technicians who are not trained in electrical hazards associated with the ac voltages supplying the unit.

Cathodic protection units do not always have barriers to prevent inadvertent contact with the ac portion of the rectifier unit. Therefore,

- Subrule 1) requires that a separate disconnecting means for a rectifier unit of a cathodic protection system be installed at a point readily accessible to the users, within sight of, and within 15 m of, the unit.
- Subrule 2) allows the disconnecting means to be integral with the rectifier unit provided that the disconnecting means is equipped with barriers or other suitable means to protect service personnel from contacting live parts on the line side and that the rectifier enclosure is rendered inaccessible to unauthorized persons by a lockable cover.

Subrule 3) requires that the disconnecting means be labelled in a conspicuous, legible, and permanent manner, identifying it as the disconnecting means for a cathodic protection system.

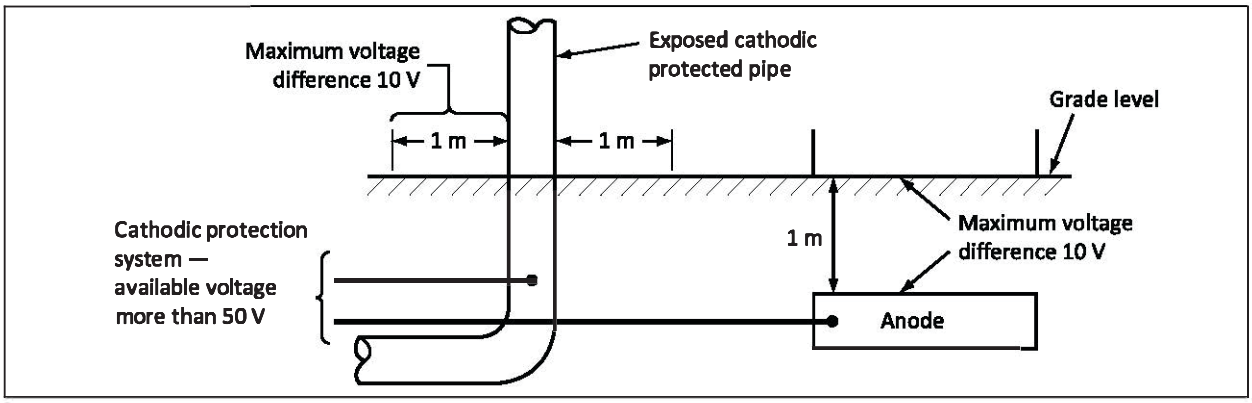
### Rule 80-012 Operating voltage

The requirements of this Section are very cautious, given that probably 99% of cathodic protection systems have structure-to-earth potentials ranging from 1.0 to about 5.0 V as most of the voltage drop occurs in the vicinity of the anodes. To impress a suffiicient difference of potential on large underground metal structures, it is sometimes necessary to use voltages above 50 V that can present a distinct shock hazard to a person coming into contact with them. However, even voltage systems above 50 V create only a negligible voltage difference between the metal that is being protected and the surrounding earth. In most cases, most of the rectifier's applied voltage will indeed appear between the anode and the soil, sometimes resulting in large voltage gradients around the anodes. The principal safety concern is establishing a sufficient separation between the metal being protected, the cathode, and the anode, so that the touch voltage (i.e., the voltage to which a person might be exposed) is kept to a safe level.

Rule 80-012 sets no maximum on the dc voltage that may be used for a cathodic protection system but does restrict the available touch voltage to 10 V dc, which is a level that is considered unlikely to cause a shock hazard. The touch voltage is measured between any exposed point on the protected system, or any point in the vicinity of the anodes, and a point 1 m away on the earth's surface (see Figure 80-3).

For a particular electrical installation, the expected voltage drop can be calculated between adjacent points where touch voltage might be experienced and then confirmed by measurement after the system is in operation.

**Figure 80-3**
**Touch voltage measurements**




### Rule 80-014 Warning signs and drawings

When a cathodic protection system is in operation, a constant flow of current is set up through the dc conductors, through the metal pipeline or other metal structure being protected, the cathode, the anode, and ground (see Figure 80-1). This current can be anywhere from 1 to 100 A, and interruption in the current can result in an arc that can be dangerous especially in a hazardous location. Also, there is a gradual voltage gradient throughout the system when it is complete and operating. If the circuit is inadvertently broken and the current ceases to flow, a dangerous voltage can be experienced at the break. This is more of a concern for cathodic protection systems than for ordinary wiring as cathodic protection systems impress electric current onto structures that people might not think of as being electrically charged and that are often maintained by people not trained to recognize electrical hazards.

Subrule 1) requires that anyone intending to carry out maintenance or modification of metal piping, a metal tank or vessel, or any metal structure protected by a cathodic protection system be made aware that there is a cathodic protection system in operation and that the system be disconnected before any work is begun.

To prevent shock and arcing hazards when equipment or piping is replaced or modified, Subrule 2) requires that there be a sign at the disconnecting means for any electrical equipment/apparatus connected to the protected structures to indicate that the power source is to be turned off and that the installation of a temporary bypass conductor sized for the maximum available current is required. This prevents arcing across the break when the equipment or pipeline is replaced or modified. This requirement is very important as turning off the rectifier does not eliminate a possible difference in potential at the point where the work occurs since other, more distant, rectifiers might create such a difference.

Subrule 3) allows, as an alternative to turning off the cathodic protection in non-hazardous locations, using a temporary bypass conductor sized for the maximum available current of the cathodic protection system across the modification or replacement being made. Subrule 3) recognizes that it is often impractical to turn off cathodic protection on a pipeline that is hundreds of kilometres long, and that modification, repair, and replacement of equipment or piping can take a long time to complete. Without cathodic protection, serious corrosion can occur on equipment or piping not involved in the servicing. Where it is practical to keep the rectifier on, the temporary bypass conductor maintains the cathodic protection for the rest of the system and continues to prevent corrosion.

After a cathodic protection system is installed (usually buried in the earth), it can operate for many years without further attention. For that reason, Subrule 4) requires that a drawing of the system be permanently located in or near the rectifier control cabinet so that maintenance or service personnel can safely service the cathodic protection system and the metal structure it protects.

To provide cathodic protection to a storage or process vessel, such as a water storage tank, the anode is suspended inside the tank. When the vessel is empty, it is sometimes possible for a person standing on the bottom of the empty vessel to touch the suspended anode. If the cathodic protection is not turned off, this person can be exposed to the full output voltage of the power supply. Subrule 5) requires that a notice be placed in a conspicuous location adjacent to the entrances of such vessels, warning that power to the cathodic protection system must be turned off before any personnel are allowed to enter the container.

# Section 82 — *Deleted*

# Section 84 — Interconnection of electric power production sources

## Rule 84-000 Scope

Section 84 includes additional and specific requirements for the interconnection of electric power production sources and supply authority systems. These power production sources consist of consumer-owned electrical power generation equipment such as generators, photovoltaic systems, fuel cells, and micro-turbines that supply power to a local load and optionally to the supply authority system. This Section provides special requirements for the electrical installation of consumer-owned electric power generation equipment that typically operates in parallel with the supply authority system (see Figure 84-1).

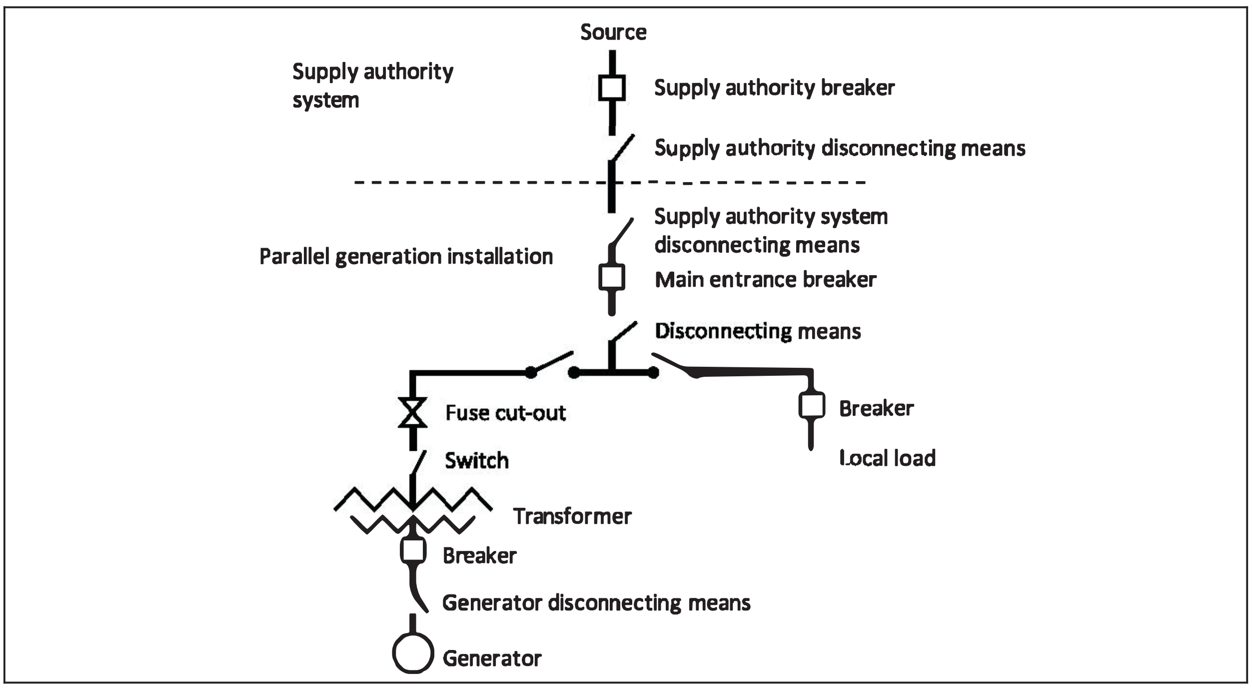
## Rule 84-002 General requirement

Consumer-owned electric power generation equipment is interconnected (operates in parallel) with the supply authority system. These two systems must be coordinated to ensure that:

- they are compatible; and
- there is no hazard to personnel or to the general public from a fault on either the supply authority system or the consumer-owned installation.

Rule 84-002 requires that the arrangement of the interconnection conform to the supply authority system requirements. See the Appendix B Note to Rule 84-002 for details.

**Figure 84-1**
**Typical interconnection of electric power production sources**




## Rule 84-004 Interconnection

A supply authority system is subject to a variety of hazards that can result in faults. These electrical problems require the supply authority system to be de-energized as soon as possible. The parallel consumer-owned electric power generation source adds another source of power to the supply authority system. Rule 84-004 requires that the consumer-owned generation system have adequate protective devices to de-energize the feed to the supply authority system to avoid back-feeding into a fault on that system. This protection may be simple (for example, overcurrent protection only) if the generation installation is small or more elaborate for larger installations. It can include overvoltage and undervoltage protection, over- and under-frequency protection, or other, more sophisticated, protection schemes. This requirement does not specify the method of protection because:

- each type of electrical installation has its own methods; and
- supply authority system requirements differ.

### Rule 84-006 Synchronization

Consumer-owned power production sources that are designed to be interconnected with the supply authority system are to be synchronized before the connection is established. This synchronization is to be maintained for the duration of the interconnection. Each power production source must be able to produce electricity in synchronization — which includes items such as frequency, voltage, number of phases, phase rotation, and voltage phase angle — with the supply authority system. Without a synchronization process, the consumer-owned power generation system can be perceived as a fault on the supply authority system, which can result in damage to the electrical equipment or de-energizing of the supply authority system. This synchronization mechanism varies with the:

- type and size of the power production source; and
- method of interconnecting the source and the system.

Supply authorities may choose manual or automatic synchronization; however, most require automatic synchronization.

To ensure proper synchronization, pay special attention to the phase relationship of the two sources, especially if there is a voltage transformation between the two sources. The synchronization must be maintained once it is established, and in some cases voltage regulation is needed.

This Rule does not specify the means of synchronization because each supply authority system has its own requirements.

### Rule 84-008 Loss of supply authority voltage

A consumer-owned interconnected power generation system is a source that can either feed into:

- a supply authority system fault; or
- a portion of the supply authority system.

If the system or part of the system is de-energized, disconnected, or isolated for some reason (for example, as a result of a temporary fault or during a maintenance procedure), the interconnected consumer-owned electric power generation system can continue to feed the fault or the system being isolated. This would endanger personnel working on a system that they expected to be de-energized. If the supply authority re-energizes the system while the isolated section is still energized by the consumer-owned system, the two systems will likely be out of synchronization. This can cause severe damage to the consumer-owned system and other connected electrical equipment. When the supply authority equipment re-energizes, the interconnected consumer-owned power source is to be disconnected. Synchronization of the interconnected consumer-owned power production source is to be in effect before reconnection.

The requirements for the separation of the interconnected consumer-owned power production sources from the supply authority system depend on the type and size of the interconnected source. For example, line-commutated inverters and induction generators are not usually capable of supplying loads in isolation from the supply authority power system because they need the supply authority voltage to operate. In the case of self-commutated inverters and synchronous generation, a means of protection such as undervoltage or overvoltage relays, under- or over-frequency relays, or a more sophisticated means can be required, depending on the size of the interconnected source.

Subrule 1) requires that, in the event of a loss of voltage in the supply authority system, the power sources of an interconnected consumer-owned system are to be automatically disconnected and not be reconnected until normal voltage is restored unless the supply authority has approved an alternative procedure. Subrule 2) allows an approved and suitable inverter to be used.

The Appendix B Note to Rule 84-008 identifies those situations where after the loss of one phase in a three-phase supply authority system, some transformer configurations allow a voltage on all phases to remain. In such cases, voltage loss is often not detected, and the consumer-owned electric power generation system does not cease to energize the supply authority system.

### Rule 84-010 Overcurrent protection

Electrical equipment and conductors in an interconnected system must have the same overcurrent protection as those in any other electrical installation. When there are two power sources connected to a circuit and a fault occurs in the circuit, both power sources will feed the fault. In such cases, the fault current can flow to the fault from two directions. To prevent fire and shock hazards and damage to equipment and conductors, both power sources must have overcurrent protection. Rule 84-010 requires electrical equipment and conductors to have overcurrent protection from each source of supply.

### Rule 84-012 Transformer overcurrent protection

Transformers used on an interconnected system (supply authority and consumer-owned) will be energized from both directions (primary and secondary sides) by each source of supply. Rules 26-250, 26-252, and 26-254 give the requirements for primary side overcurrent protection of the transformer. Rule 84-012 requires that when a transformer is energized from both directions (primary and secondary sides), both sides of the transformer must meet the requirements of these Rules for primary side overcurrent protection. Rule 84-012 requires that transformer overcurrent protection be chosen in accordance with Section 26, considering first one side of the transformer as the primary with the source on that side and then the other side of the transformer as the primary with its source.

### Rule 84-014 System protection devices

In larger interconnected consumer-owned power system installations, additional devices are sometimes necessary to ensure stability and adequacy of protection of the electrical equipment. For example, ferroresonance (switching surges) can produce very high voltage in transformers with a wye-delta connection, requiring a surge arrester and/or a high-speed overvoltage relay. Other types of protection (such as loss-of-excitation protection and over-excitation protection) are sometimes required to ensure the stability of the system in the interest of public safety and equipment protection.

Rule 84-014 requires that interconnected consumer-owned system installations be properly protected to ensure:

- system stability; and
- safe operation of electrical equipment.

### Rule 84-018 Loss of electric power production source voltage

When there is a loss of power in any phase, the consumer-owned power production system is to:

- monitor all its phases; and
- automatically disconnect all phases from the interconnected system.

### Rule 84-020 Disconnecting means — Electric power production source

For the safety of personnel, each interconnected consumer-owned power production source must have a disconnecting means so that it can be disconnected when personnel are working on the electrical installation or on the source itself. Rule 84-020 requires the disconnecting means to:

- disconnect simultaneously all ungrounded conductors to avoid imbalanced system voltages and false trips by protection devices; and
- provide safety to personnel servicing the equipment.

### Rule 84-022 Disconnecting means — Supply authority system

Rule 84-022 requires that a disconnecting means be provided so that all ungrounded conductors in a consumer-owned electric power production source can be disconnected simultaneously. For the safety of supply authority personnel, all interconnected consumer-owned power production sources are to be simultaneously disconnected from the supply authority system when personnel are working on it. The disconnection is to be done by one disconnecting means, usually located at the connection point to the supply authority system. In this location, the interconnected consumer-owned source is able to feed the consumer's own loads during a power interruption on the supply authority system. If it is acceptable to the supply authority, the disconnecting means may be located at the points where all the interconnected consumer-owned power sources are connected to the installation's electrical system. If there is only one interconnected source and its disconnecting means is capable of separating the source from the supply authority system, the disconnecting means of the source may be used if it is acceptable to the supply authority. Acceptance by the supply authority is essential because this protection is intended for the safety of supply authority personnel.

The Appendix B Note to Rule 84-022 is intended to ensure that the supply authority disconnecting means allows the supply authority a single point of access to simultaneously isolate one or more of the consumer-owned electric power production sources at each location. The main service box or its equivalent usually performs this function. Rule 84-008 requires that the consumer-owned production source be automatically disconnected on loss of the supply authority system voltage.

### Rule 84-024 Disconnecting means — General

Rule 84-024 is intended to provide general requirements for all disconnecting means used in an interconnected consumer-owned electric power production source installation. Personnel working on the electrical installation are to be able to disconnect simultaneously all ungrounded conductors of the circuit. They also must be able to:

- verify visually that the contact of the disconnecting means is open; and
- lock it in the open position.

This ensures that the electrical installation is de-energized and will not become energized while being worked on. Since the disconnecting means can be energized from both line and load sides, even in the open position the electrical equipment must be provided with a visual warning to that effect.

In order to function during an emergency, the disconnecting means is to be capable of being closed on a fault without putting the electrical equipment or personnel at risk of harm (see Rule 14-012). In some cases, the disconnecting means is a fusible disconnect. Since the disconnect can be energized from both sides, provide an isolating switch on the fuse side (load side) to allow replacement of the fuse with both sides of the fuse de-energized. In such cases and when overcurrent devices are used, the requirements for overcurrent devices in Sections 14, 28, 36, and 64 apply.

### Rule 84-026 Isolating means

Electrical equipment (for example, transformers, distribution equipment, fusible switches, and circuit breakers) that is energized from both directions cannot be serviced if there is no isolating switch to isolate it from both sources. The disconnecting means often acts as an isolating switch. Rule 84-026 requires that electrical equipment be isolated from both sources of supply if it is energized from both directions. The means of achieving this isolation vary according to the specific circumstances. Also see the requirements in Rule 14-414.

### Rule 84-028 Grounding

Subrule 1) requires that the grounding of an interconnected consumer-owned power production source installation meet the requirements of Sections 10 and 36 for service entrance grounding means. For renewable energy consumer-owned systems, see the Rules in Section 64. The ground at the consumer's service equipment entrance may be used for the interconnected consumer-owned production source (see Section 10).

Subrule 2) requires that in the case of a dc system connected to an ac system through a solid-state inverter, the dc system not be grounded as this presents a direct ground connection to the ac system, which might not be desirable. An isolating transformer on the ac system would:

- separate the two systems; and

- eliminate any unwanted ground connection on the ac system caused by a dc system connected to ground.

## Rule 84-030 Warning notice and diagram

An interconnected power production source installation is a special electrical installation. It represents a hazard for the qualified personnel who service and operate it. Subrule 1) requires a warning notice at the consumer's service equipment and at each interconnected power source installation. To enable safe operation of this system, Subrule 2) requires that the physical location of the interconnected sources, interlocks between the switching equipment, and isolation points be shown in a diagram at each location so that personnel are able to isolate the section being serviced.

The Appendix B Note to Rule 84-030 requires that the single-line diagram specified in Subrule 2) identify related components of the interconnected system, including switching arrangements, interlocks, isolation points, and their relative locations. Figure B64-4 in the Appendix B Note to Rule 64-002 illustrates an interconnected photovoltaic system.

# Section 86 — Electric vehicle charging systems

## Scope

### Rule 86-000 Scope

Section 86 contains additional and specific requirements applicable to installations supplying power for charging electric vehicles intended for use on public roads. The use of electric vehicles has grown rapidly, and as a result the technology for electric vehicle charging has developed significantly, resulting in products that are capable of not only rapidly charging the energy storage devices (generally batteries) on the electric vehicles but also doing so without a physical connection to the vehicle, using inductive or magnetic means of power transfer. In addition, some of these systems have the potential to convert and transfer power back to the grid when desired, using the energy stored in the electric vehicle as a source of power.

Specific requirements related to electric vehicle supply equipment are consolidated in this Section to make it easier for designers, manufacturers, installers, and inspection departments to find the unique requirements and specific Rules for installation of these products, or to propose new or amended Rules resulting from their experiences. The use of this Section is expected to grow as some municipalities implement mandatory requirements for the provision of an electric vehicle charging infrastructure in certain new construction.

## General

### Rule 86-100 Special terminology

The following definitions apply only to Section 86.

*Electric vehicle* refers to a vehicle — such as a car, truck, van, bus, or motorcycle — that is:

- designed and built to be driven on public roads and thoroughfares; and
- powered by a fuel cell, photovoltaic array, or rechargeable energy storage system (such as a battery or capacitor) that feeds an electric motor or motors.

Also considered electric vehicles are plug-in hybrid electric vehicles, which have another source of propulsion, such as a gasoline engine, to provide electrical energy to the vehicle, in addition to the electric energy source of the electric vehicle.

For the purposes of Section 86, electric means of transportation not intended for use on public roads and thoroughfares (such as scooters for mobility-impaired people; industrial and commercial trucks, hoists, lifts, and transports; golf carts; airline ground support equipment; tractors; and boats) are not considered electric vehicles for the application of these Rules.

*Electric vehicle supply equipment* consists of all the electrical equipment needed to connect the vehicle to a site's electrical system. "Electric vehicle supply equipment" (EVSE) is terminology generally used in the industry and in national and international product standards. The definition does not place limitations on the type of power transfer and allows for ac or dc output from the electric vehicle supply equipment to the electric vehicle to charge the vehicle's energy source. It also allows connection to the vehicle physically using a cord or using a wireless "connection" (for example, through inductive or magnetic coupling). This is clarified in the Appendix B Note, which also clarifies that the main purpose of electric vehicle supply equipment is for electric vehicle charging. This links to the term "electric vehicle charging" used elsewhere in the Code. However, the definition also recognizes that this equipment provides additional control and personnel and equipment protection safety functions (for example, it signals the vehicle when it is plugged in for charging to ensure that the vehicle cannot be started up and driven away while still connected to the supply). The definition also accommodates the function of bi-directional power flow, to charge the energy storage system on the vehicle and to allow the electric vehicle to act as a power production source (see requirements in Rule 86-308).

The *electric vehicle connector* electrically couples the site's electrical system to the electric vehicle through a mating device that is built into the vehicle. This enables power flow and communication between the electric vehicle supply equipment and the electric vehicle. The connector can provide a physical means of connecting to the electric vehicle, such as a receptacle at the end of a cord, or can be a device that wirelessly transfers power, by inductive or magnetic means, to a receptor on the electric vehicle.

### Rule 86-102 Voltages

Electric vehicles are designed to be connected to the charging system by the general public who ordinarily use the vehicles. The Code restricts the supply voltage to the charging equipment to a maximum of 750 V in order to:

- prevent possible shock and injury to people who connect their vehicles to charging equipment by means of cords and connectors; and
- comply with requirements for readily accessible electrical equipment as defined in the Code.

### Rule 86-104 Permanently connected and cord-connected equipment

The requirements for the installation of permanently connected and cord-connected electric vehicle supply equipment are found in Rules 86-300 to 86-404.

## Equipment

### Rule 86-200 Warning sign

The rechargeable energy sources on modern electric vehicles, such as lithium ion or nickel metal hydride dry cells, or sealed lead-acid batteries, usually do not emit hazardous gases. Occasionally, however, as in the case of some lead-acid batteries, the energy source is not sealed, so adequate ventilation is to be provided when these energy sources are being charged. This is to prevent the accumulation of hydrogen or other hazardous gases to the point that they could cause an explosion. Even some sealed batteries can require ventilation during charging. The manufacturer of the rechargeable energy source should specify whether, and how much, ventilation is required and what type and quantity of gas might be released during recharging. Refer to recommendations in the installation instructions provided by the manufacturer.

Warning signs are required to alert the user to these requirements for ventilation when operating the charging system. The warning signs are to be permanently installed at the point of connection between the electric vehicle supply equipment and the branch circuit wiring.

## Control and protection

### Rule 86-300 Branch circuits

Electric vehicle supply equipment (EVSE) requires a dedicated circuit to prevent overload and subsequent nuisance tripping of overcurrent protection on the branch circuit that supplies the charging system. Since ventilation equipment might have to be operated while the charging equipment is being used, Subrule 1) allows the ventilation system and the charging equipment to be connected to the same dedicated circuit so that power is available for the ventilating equipment whenever power is available for vehicle charging as required by Rule 86-400.

EVSE can draw high currents for fast charging. If Level 2 EVSE requiring a 240 V, 20 A circuit is to be installed, there might not be enough capacity remaining to add this new branch circuit to an existing 100 A panel, thus requiring a costly service and/or panel upgrade. Recognizing that there might not be sufficient capacity in the power distribution system/panel to accommodate a new dedicated branch circuit solely for this purpose, there is an exception provided in Subrule 2). It allows the EVSE to be connected to a branch circuit supplying another load(s) provided that an electric-vehicle energy management system is installed in accordance with Subrule 10) or 11) of Rule 8-106 to prevent the calculated demand of the circuit from being exceeded and causing an overload.

Subrule 3) requires that for the exception allowed in Subrule 2) the requirements in Section 8 be used to calculate the demand. Subrule 2) of Rule 8-106 requires that where two or more loads are switched so that only one can be used at a time, the load with greatest demand be used to determine the calculated demand.

### Rule 86-302 Connected load

To size the service, feeder, or branch circuit that supplies the EVSE and, in some cases, the ventilation equipment, the circuit loading is determined in accordance with Rule 8-104. Due to the operational characteristics of an EVSE system and its related ventilation system, the connected loads of the two systems are to be treated as continuous loads when determining how much load can be connected to an overcurrent device in the service, feeder, or branch circuit.

### Rule 86-304 Disconnecting means

To ensure safe servicing of EVSE, a separate, accessible, visible disconnecting means is essential. Subrule 1) requires that a separate disconnecting means for each EVSE be provided when the supply equipment is rated at 60 A or more or has a voltage rating of more than 150 volts-to-ground.

Subrule 2) requires that the disconnecting means required for each EVSE:

- be on the supply side of the point of connection of the electric vehicle supply equipment;
- be located within sight of the electric vehicle supply equipment;
- be accessible to the electric vehicle supply equipment; and
- be capable of being locked in the open position.

### Rule 86-306 Receptacles for electric vehicle supply equipment

Each receptacle that is to be used for charging an electric vehicle is to be:

- labelled in a conspicuous, legible, and permanent manner identifying it as an electric vehicle supply equipment receptacle;
- a minimum CSA 5-20R single receptacle;
- supplied by a 20 A, 125 V branch circuit;
- an appropriate CSA configured receptacle from either Diagram 1 or 2 when the branch circuit is rated more than 20 A or more than 125 V; and
- protected by a Class A Type ground fault circuit interrupter when installed outdoors and within 2.5 m of finished grade.

### Rule 86-308 Electric vehicle as electric power production source

When marked for the purpose, electric vehicles and electric vehicle supply equipment, whether installed on or apart from the vehicle, are allowed by Subrule 1) to serve as an optional standby system or an electric power production source, or provide for bi-directional power feed.

When an electric vehicle is to be used as a power production source or provide for bi-directional power feed, Subrule 2) requires that the requirements of Section 84 apply.

## Electric vehicle supply equipment locations

### Rule 86-400 Indoor charging sites

Subrule 1) allows the following to be used as indoor charging sites:

- integral, attached, and detached residential garages;
- enclosed or underground parking structures;
- repair and non-repair commercial garages;
- agricultural buildings; and
- similar rooms or locations where the electric vehicle connector can couple to the electric vehicle.

Where electric vehicles are charged indoors, ventilation is to be provided if required by the manufacturer's instructions for the electric vehicle or the EVSE. Check the manufacturer's instructions regarding ventilation requirements. Dry-type battery cells used in many modern electric vehicles do not generally require ventilation. If the electric vehicle uses vented batteries, ventilation will probably be required. When vented batteries are being charged, hydrogen gas is given off, and adequate ventilation is to be provided to prevent any dangerous accumulation of this gas.

Therefore, Subrule 2) requires that, where ventilation is required, the following conditions be met:
- The ventilation is adequate according to Rule 26-506. See the Appendix B Note to Rule 26-506 for additional information on ventilation.
- There is an electrical interlock that ensures the ventilation equipment is operating when the electric vehicle supply equipment is operating.
- The electric vehicle supply equipment is turned off if the supply to the ventilation equipment is interrupted.

### Rule 86-402 Outdoor charging sites

Rule 86-402 lists various types of outdoor sites at which electric vehicles can be charged. These outdoor charging sites should be located where:
- they are readily accessible;
- the vehicle will be undisturbed during the charging period; and
- there are no safety hazards for the individuals who are connecting or disconnecting the charging equipment.

### Rule 86-404 Hazardous locations

The location where the EVSE is installed does not make it a hazardous location. However, EVSE and its supply connections might need to be installed in hazardous locations, which are defined by the Code as locations where flammable gas or vapours, combustible or conductive dust, or easily ignitable fibres are present. Such locations include gas service centres, fuel transfer stations, and certain industrial areas.

In hazardous locations, the EVSE and supply connections are to be:
- certified for use in the type of hazardous location that is present; and
- installed in accordance with the requirements for hazardous locations.

Refer to Section 18 of the Code for more information and requirements applicable to hazardous locations.

# Appendix J — Rules and Notes to Rules for installations using the Class and Division system of classification

## Annex J18 — Hazardous locations classified using the Division system

Annex J18 is a supplementary Annex of the Code. It sets out the mandatory requirements for Class I hazardous locations based on the Division system of classification of these locations. Section 18 of the Code also sets out requirements for Class I hazardous locations, but it uses the Zone system of classification, which is the classification system that has been adopted in North America for new installations. The general relationship between the Zone and Division systems for gas installations is as follows:

| Division | Zone |
|---|---|
| Division 1 | Zones 0 and 1 |
| Division 2 | Zone 2 |

The Code allows either classification system to be used, enabling the user

- to continue to use the Division system (in which equipment is marked with the applicable class, division, and group) for existing facilities or for renovations to existing facilities; and
- to adopt the IEC Zone system (in which equipment is marked with the methods used to obtain explosion protection).

Rule 18-000 3) allows the continued use of the Division system of classification for additions, modifications, renovations to, or the operation and maintenance of, existing facilities employing the Division system of classification. For these hazardous locations, the Rules for Class I locations in Annex J18 apply. Table 18 shows where Division equipment is allowed to be used in a new installation classified under the Zone system.

When using equipment marked for a Division 1 location in a Zone 1 location, the gas grouping ratings for the equipment are to be checked to ensure that the Division gas group is compatible with the Zone gas group rating. See the Appendix B Note to Rules 18-050 and 18-064 for data on gas groupings; additional information is available from manufacturers.

Although the Zone and Division systems of area classification provide equivalent levels of safety, the Code has been written to require the Zone system of area classification for new installations. It does not, however, give preference to the IEC type of equipment. Equipment approved as Class I or as Class I, Division 1, is acceptable in Zone 1 and Zone 2 and equipment marked Class I, Division 2, is acceptable in Zone 2. See Rules 18-100 and 18-150 and Table 18.

The change from the Division system of classification to the Zone system of classification also applies to Annex J20.

# Class II and Class III hazardous locations classified using the Division system

Section 18 of the Code also sets out requirements for Class II and III hazardous locations. It uses the Zone system of classification, which is the classification system that has been adopted in North America for new installations. The general relationship between the Zone and Division systems for dust, fibres, and flyings is as follows:

| Division | Zone |
|---|---|
| Class II, Division 1 and Class III, Division 1 | Zones 20 and 21 |
| Class II, Division 2 and Class III, Division 2 | Zone 22 |

The Code allows either classification system to be used, enabling the user to

- continue to use the Division system (in which equipment is marked with the applicable class, division, and group) for existing facilities or for renovations to existing facilities; and
- adopt the IEC Zone system (in which equipment is marked with the methods used to obtain explosion protection).

Rule 18-000 3) allows the continued use of the Division system of classification for additions, modifications, renovations to, or the operation and maintenance of, existing facilities employing the Division system of classification. For these hazardous locations, the Rules for Class II and III locations in Annex J18 apply.

# Annex J20 — Flammable liquid and gasoline dispensing, service stations, garages, bulk storage plants, finishing processes, and aircraft hangars

The Rules for the Division system were moved from Section 20 to Appendix J, to give users the opportunity to continue to apply this system where it is necessary. The general relationship between the Zone and Division systems is as follows:

| Division | Zone |
|---|---|
| Division 1 | Zones 0 and 1 |
| Division 2 | Zone 2 |

Consequently, the Rules in Section 20 and Annex J20 are similar, except that those in Section 20 apply to the Zone system and those in Annex J20 apply to the Division system.

The change from the Division system of classification to the Zone system of classification also applies to Annex J18.

# Index

**Note:** *This Index contains terms from both the* CE Code Handbook *and the* Canadian Electrical Code, Part I.

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